Santos

WA-20-L Environment Plan

Project / facility	WA-20-L
Review interval (months)	No Review Required
Safety critical document	NO

Rev	Owner	Reviewers		Approver
	Senior Environment Adviser	Environment Manager WA, NA & TL	Offshore Decommissioning and Well Services Manager	General Manager Subsurface WA, NA & TL
4	Simon Philippides	Dawn MacInnes	Radek Dolecki	David Jamieson
	Simon Philippides	Dawn Macinnes	[illegible]	DJamieson

Any hard copy of this document, other than those identified above, are uncontrolled. Please refer to the Santos Business Management System for the latest revision.

Rev	Rev Date	Amendment
0	22/02/2022	Submitted to NOPSEMA
1	10/08/2022	Update in response to NOPSEMA RFFWI 1
2	13/09/2023	Update in response to NOPSEMA RFFWI 2, 3 and 4
3	30/08/2024	Update in response to NOPSEMA OMR (A1024118)
4	19/12/2024	Update in response to NOPSEMA RFFWI (A1138710)

Contents

Tables

Figures

Definitions

The following terms as used within this environment plan have definitions used in the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023.

Activity (a) a petroleum activity; or (b) a greenhouse gas activity; and includes, where the context permits, a reference to a proposed activity or any stage of an activity.

Control measure means a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks of an activity.

Environment means:

(a) ecosystems and their constituent parts, including people and communities; and

(b) natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas; and

(d) the heritage value of places;

and includes the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).

Environmental impact, of an activity, means any change to the environment, whether adverse or beneficial, that wholly or partially results from the activity.

Environmental management system for an activity, includes the responsibilities, practices, processes and resources used to manage the environmental aspects of the activity.

Environment Minister means the Minister administering section 1 of the EPBC Act.

Environmental performance means the performance of a titleholder in relation to the environmental performance outcomes and environmental performance standards mentioned in an environment plan.

Environmental performance outcome for an activity, means a measurable level of performance required for the management of environmental aspects of the activity to ensure that environmental impacts and risks of the activity will be of an acceptable level.

Environmental performance standard means a statement of the performance required of a control measure.

Environment plan for an activity, means a plan that is submitted to NOPSEMA under section 26.

Environment plan acceptance criteria has the meaning given by section 34.

EPBC Act means the Environment Protection and Biodiversity Conservation Act 1999.

Facility includes a structure or installation of any kind.

Petroleum activity means operations or works in an offshore area undertaken for the purpose of: (a) exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or(b) discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act.

Petroleum titleholder means any of the following: (a) a petroleum exploration permittee; (b) a petroleum retention lessee; (c) a petroleum production licensee; (d) a pipeline licensee; (e) an infrastructure licensee; (f) the registered holder of a petroleum access authority; (g) the registered holder of a petroleum special prospecting authority; (h) the holder of a petroleum scientific investigation consent.

Recordable incident for an activity for which there is an environment plan in force, means a breach of an environmental performance outcome for the activity, or an environmental performance standard relating to the activity, that is not a reportable incident.

Reportable incident for an activity, means an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage.

Title means: (a) a petroleum title; or (b) a greenhouse gas title.

Titleholder means: (a) a petroleum titleholder; or (b) a greenhouse gas titleholder.

Abbreviations

Term	Definition
3D	Three-dimensional
AC125	Ancient coastline at 125m KEF
ACHIS	Aboriginal Cultural Heritage Inquiry System
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHO	Australian Hydrographic Office
AIS	Automatic Identification System
ALARP	As Low as Reasonably Practicable
AMC	Australian Maritime College
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZG	Australian & New Zealand Guidelines
API	American Petroleum Institute
AEP	Australian Energy Producers
AUSREP	Australian Ship Reporting System
BIA	Biologically Important Area
TEX	Benzene, toluene, ethylbenzene, and xylene
C	carbon
CAES	Catch and Effort System
CALM	Catenary anchor leg mooring
CH_4	Methane
CM	Control Measure
CO_2	Carbon Dioxide
Cr	Chromium
CSIA	Compound specific isotopic analyses
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Commonwealth Department of Agriculture, Fisheries and Forestry (formerly DAWE)
DAWE	Commonwealth Department of the Agriculture, Water and the Environment
DAWR	Department of Agriculture and Water
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Commonwealth Department of Climate Change, Energy, Environment and Water (formerly DAWE)
DEH	Department of Environment and Heritage (now DEWHA)
DEW	Department of Environment and Water Resources (now DEWHA)
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (previously DEW, DEH)
DGV	Default guideline values
DISER	Department of Industry, Science, Energy and Resources

Term	Definition
DMIRS	Government of Western Australia Department of Mines, Industry Regulation and Safety
DMP	Western Australia Department of Mines and Petroleum
DMP	WA Department of Mines and Petroleum
DoAWE	Department of Agriculture, Water and Environment
DoE	Department of the Environment (previously DSEWPC)
DoEE	Department of the Environment and Energy
DOIR	WA Department of Industry and Resources
DOT	Western Australian Department of Transport
DP	Dynamic Positioning
DPIRD	WA Department of Primary Industry and Regional Development
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
DWS	Diamond-wire saw
EHS	Environment, Health and Safety
EMBA	Environment that may be affected
ENVID	Environmental Hazard Identification
EOFL	End of field life
EP	Environmental Plan
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standards
ERIA	environmental risk and impact assessment
ESD	Ecologically sustainable development
FPSO	Floating, Production, Storage and Offloading
GC	Gas chromatography
GHG	Greenhouse gas
HSE	Health, Safety and Environment
HSEA	Health, Safety and Environment Advisor
IAPP	International Air Pollution Prevention
IFT	Indonesian Flowthrough Current
ILUA	Indigenous land use agreement
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IMSMP	Invasive Marine Species Management Plan
IPA	Indigenous Protected Areas
IPR	Inflow Performance Relationship

Term	Definition
JRCC	Joint Rescue Coordination Centre
KEF	Key Ecological Feature
LMS	Listed Migratory Species
LN-1H	Legendre North 1H
LTS	Listed Threatened Species
MAMF	Marine Aquarium Managed Fishery
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MMF	Mackerel Managed Fishery
MMO	Marine Mammal Observer
Mn	Manganese
MNES	matters of national environmental significance
Mo	Molybdenum
MOC	Management of Change
MOPU	mobile offshore production unit
NATA	National Association of Testing Authorities
NBPMF	Nickol Bay Prawn Managed Fishery
NDSMF	Northern Demersal Scalefish Managed Fishery
NEBA	Net Environmental Benefit Assessment
Ni	nickel
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NORM	Naturally occurring radioactive material
NWMR	North West Marine Region
NWS	North West Shelf
NWSTF	North West Slope Trawl Fishery
OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS(E)R	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
OPLEF	Onslow Prawn Limited Entry Fishery
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
OSV	Offshore support vessel
P	Phosphorous
P and A	Plugged and abandoned
PAH	Polyaromatic hydrocarbons
PAM	Passive Acoustic Monitoring
PCMF	Pilbara Crab Managed Fishery
PDTMF	Pilbara Demersal Trap Managed Fishery

Term	Definition
PFITMF	Pilbara Fish (Interim) Trawl Managed Fishery
PLF	Pilbara Line Fishery
PLONOR	Pose Little or No Risk to the Environment
PMS	Planned Maintenance System
PMST	Protected Matters Search Tool
POB	Personnel on Board
PSD	Particle size distribution
PSZ	Petroleum Safety Zone
PTS	Permanent threshold shift
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
ROV	Remotely Operated (underwater) Vehicle
RPS	RPS Australia West
Santos	Santos WA Northwest Pty Ltd
SBES	Single-beam acoustic system
SBTF	Southern Bluefin Tuna Fishery
SDS	Safety Data Sheet
SEL	Sound exposure level
Si	Silicon
SLT	Senior Leadership Team
SME	Subject matter expert
SPL	Sound pressure level
SQ	Sediment Quality
SSMF	Specimen Shell Managed Fishery
ST	Sidetrack
TBT	Tributyltin
TGB	Temporary guide base
TMS	Tether management system
TRH	Total Recoverable Hydrocarbons
TSS	Total Suspended Solids
TTS	Temporary threshold shift
UAV	Unmanned Aerial Vehicle
UCH Act	*Underwater Cultural Heritage Act 2018*
USBL	Ultra-short baseline
UVS	Underwater video systems
VLF	very low frequency
VLP	Vertical Lift Profiles
WA	Western Australia
WAF	Water-accommodated fraction

Term	Definition
WAFIC	WA Fishing Industry Council
WASCF	Western Australian Sea Cucumber Fishery
WASF	Western Australian North Coast Shark Fisheries
WCC	Worst credible case
WGR	Water to gas ratios
WHA	World Heritage Area
WOMP	Well Operations Management Plan
WQ	Water Quality
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna and Billfish Fishery

Units of measurement

Term	Definition
µg	Microgram
bbl	Barrels
Bscf	Billion standard cubic feet
Bq	Becquerel
cm	Centimetre (10 mm)
cm^2	Square centimetre
cm^3	Cubic centimetre
Hr	Hour
kHz	Kilohertz
kL	Kilolitre (1,000 litres)
km	Kilometre (1,000 m)
kPa	Kilo Pascal
ksm^3	Thousand standard cubic meters
L	Litre (1000 ml)
m	Metre (100 cm)
m^2	Square metre
m^3	Cubic metre
mcf	Million cubic feet
mg/L	Milligrams per litre
ml	Millilitre
mm	Millimetre
MMboe	Million barrels of oil equivalent
MMSCFD	Millions of Standard Cubic Feet per Day
MMstb	Million stock tank barrels

Term	Definition
Mscf	Million standard cubic feet
nm	Nautical mile (1.856 km)
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million (volume)
ppt	Parts per thousand
psig	Pounds per Square Inch Gauge
scf	Standard cubic feet
scf/d	Standard cubic feet per day
stb	Stock tank barrels
t	Tonne
°C	Degrees centigrade

1 Introduction

1.1 Environment plan summary

Offshore Petroleum and Greenhouse Gas (Environment) Regulations 2023 Requirements
Section 35 Notice of decision on environment plan, publication of accepted plan and submission and publication of summary
Submission of summary of accepted plan 35(6) Within 10 days after receiving notice that NOPSEMA has accepted an environment plan (whether in full, in part or subject to limitations or conditions), the titleholder must submit a summary of the accepted plan to NOPSEMA for public disclosure. 35(7) The summary: + a) must include the following material from the environment plan for the activity: - i) the location of the activity; - ii) a description of the receiving environment; - iii) a description of the activity; - iv) details of environmental impacts and risks of the activity; - v) a summary of the control measures for the activity; - vi) a summary of the arrangements for ongoing monitoring of the titleholder's environmental performance; - vii) a summary of the response arrangements in the oil pollution emergency plan; - viii) details of consultation already undertaken, and pans for ongoing consultation; - ix) details of the titleholder's nominated liaison person for the activity; and + b) must be to the satisfaction of NOPSEMA.

A summary of the accepted plan will be prepared as per Regulation 35(6)(7) of the Offshore Petroleum and Greenhouse Gas (Environment) Regulations 2023 (OPGGS(E)R), drawing on the information contained in this EP, as per **Table 1-1**.

Table 1-1: EP summary requirements and relevant sections of the EP

Environment Plan (EP) summary material requirement	Relevant section of EP containing EP Summary material
The location of the activity	**Section 2**
A description of the receiving environment	**Section 2.3**
A description of the activity	**Section 2**
Details of the environmental impacts and risks of the activity	**Section 6** and **7**
The control measures for the activity	**Section 6** and **7**
The arrangements for ongoing monitoring of the titleholder's environmental performance	**Section 7.2**
Response arrangements in the oil pollution emergency plan	WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01)
Consultation already undertaken and plans for ongoing consultation	**Section 4**
Details of the titleholder's nominated liaison person for the activity	**Section 1.6.2**

1.2 Activity overview

The activities covered under this EP include the following:

+ Gas seepage in the form of small bubbles (1-11mm in diameter) emanating from the seabed into the water column (**Section 2.1**).

- The Legendre-1 wellhead remaining permanently decommissioned in situ on title (**Section 2.2**).
- Vessel-based surveillance, monitoring and inspection activities (**Section 2.3**).

Santos will address Section 270 of the OPGGS Act for WA-20-L in a future EP or revision of this EP (**Section 6.1.3**).

1.3 Background

Santos WA Northwest Pty Ltd (Santos) and Santos Limited hold the title for WA-20-L in Commonwealth waters of the North West Shelf, which has had petroleum exploration and production activity from circa 1968 to 2011.

Production from the Legendre field within WA-20-L commenced in 2001 and finished in 2011. This production phase involved multiple wells providing hydrocarbons to a Mobile Offshore Production Unit 'Ocean Legend' (MOPU) and the Floating Storage and Offloading tanker 'Karratha Spirit' (FSO).

The wells within WA-20-L were gradually plugged and abandoned between 1968 and 2011, in accordance with relevant legislation and regulatory approvals at the time. **Table 1-2** provides a summary of the WA-20-L wells, including when the wells were plugged and abandoned.

Exploration and appraisal wells (including sidetracks) within WA-20-L were plugged and abandoned under various approvals and environment plans between 1968 and 2010, submitted by Woodside Energy or Apache Energy, being the Titleholder at the time of the activity.

Production wells were plugged and abandoned between 7 January and 14 April 2011 under bridging documents to the North West Shelf Drilling Programme 2007 to 2011 State and Commonwealth Waters Generic Environment Plan (EA-00-RI-164). This Environment Plan was submitted by Apache Energy, being the operator at that time and accepted by the regulator, the WA Department of Industry and Resources (DOIR) at that time.

Decommissioning the WA-20-L facilities was performed under the Legendre Field Decommissioning Environment Plan (LR-00-RI-063), which was was submitted by Apache Energy, being the operator at that time and accepted by the WA Department of Mines and Petroleum (DMP), the regulator at that time. Decommissioning activities of the Legendre Field Decommissioning Environment Plan included but were not limited to the following:

- MOPU and FSO moved off permit.
- Removal of subsea infrastructure. With the exception of anti-scour mats and piles with pad eyes which were abandoned in situ.
- Placing concrete caps over the pad-eyes and shackles.
- Conducting a post-decommissioning remotely operated (underwater) vehicle (ROV) survey after completion of the removal activities.

As part of the decommissioning activities, a seabed survey of the area was conducted in August 2011. The scope of the survey included viewing the Legendre-1 wellhead, as well as the presence of pin-piles around the wellhead, and scattered debris in the area. A bridging document was prepared to accompany the accepted EP (LR-00-RI-063). The purpose of the bridging document was to describe and address any additional risks not previously identified in the Legendre Field Decommissioning Environment Plan, posed by the removal and recovery activities of the pin-piles, anchors, anchor chains and other debris. On 22 November 2011, DMP accepted the document, stating 'the bridging document was determined to meet the requirements for an Environment Plan under Regulation 11(1) of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations, and has been accepted'.

The removal of the subsea infrastructure and placement of the anti-scour mats and concrete caps was completed in two offshore campaigns between the 24 April 2011 and 5 February 2012.

The decommissioning activities were also referred under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC 2010/5681) and determined to be a 'not controlled action' if undertaken in a manner as follows:

- "1. All infrastructure and materials from the Legendre facility will be removed from the site for reuse or onshore disposal, with the exception of the anti-scour mats, piles, pad eyes and shackles and abandoned production wells below the seabed, which will be left in-situ as described in referral [EPBC 2010/5681] and
- 2. A concrete construction mat or grout bag will be placed over each of the pad eyes and shackles."

The two-year post decommissioning ROV survey (the Legendre Decommissioning Compliance survey) was completed on 25 December 2013. During this survey, it was recorded that small gas bubbles were emanating from under the anti-scour mats at the Legendre Hub. The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) was informed of the gas bubbles through the submission of a Recordable Incident Report in January 2014, within which a commitment was made to perform additional monitoring of the gas seepage. Dedicated seepage monitoring activities campaigns have since been performed by Santos, as described in **Section 2.1**.

As a result of communications in 2020 and 2021 between the National Offshore Petroleum Titles Office (NOPTA), NOPSEMA and Santos, it was confirmed that a new EP is required to cover WA-20-L. In the NOPSEMA letter to Santos (ID: KCI-086 A814316, December 2021) Santos Ltd is requested to address the following matters in the proposed Legendre decommissioning EP:

+ The removal of the Legendre 1 wellhead and any other remaining property in the title area, or making alternative arrangements that are satisfactory to NOPSEMA; and
+ An evaluation of the impacts and risks associated with the identified seeps/leaks in the title area.

Monitoring activities have also been since also been included in this EP.

Table 1-2: History of WA-20-L Wells

Well name	Well Type	Latitude (GDA94)	Longitude (GDA94)	Spud date	Year of P and A
Legendre-1	Exploration	-19.673007	116.736220	07/06/1968	1968
Titan-1	Exploration	-19.701936	116.722741	20/05/1995	1995
Jaubert-1	Exploration	-19.694263	116.721731	02/11/1997	1997
Jaubert-1 (sidetrack 1)	Exploration	-19.694263	116.721731	25/11/1997	1997
Legendre South-1	Exploration	-19.721768	116.697925	25/04/1998	1998
Legendre North-1H	Production	-19.703930	116.708692	21/01/2001	2011
Legendre North-1H (sidetrack 1)	Production	-19.703930	116.708692	22/05/2002	2011
Legendre North-1H (sidetrack 2)	Production	-19.703930	116.708692	23/05/2001	2011
Legendre North-2H	Production	-19.703916	116.708706	24/10/2001	2011
Legendre North-3H	Production	-19.703930	116.708719	23/01/2001	2008
Legendre North-3H (sidetrack 1)	Production	-19.703930	116.708719	25/04/2001	2008
Legendre North-3H (sidetrack 2)	Production	-19.703930	116.708719	26/04/2001	2008
Legendre North-3H (sidetrack 3)	Production	-19.703930	116.708719	29/04/2001	2008
Legendre North-3H (sidetrack 4)	Production	-19.703930	116.708719	30/04/2001	2008
Legendre North-4H	Production	-19.703945	116.708734	05/05/2003	2011
Legendre North-4H (sidetrack 1)	Production	-19.703945	116.708734	26/05/2003	2011
Legendre North-4H (sidetrack 2)	Production	-19.703945	116.708734	31/05/2003	2011
Legendre North-5H	Production	-19.703956	116.708717	10/05/2004	2011
Legendre North-5H (sidetrack 1)	Production	-19.703956	116.708717	10/05/2004	2011
Legendre North-6H	Production	-19.703930	116.708719	31/03/2008	2011
Legendre South-2H	Production	-19.703952	116.708690	23/01/2001	2011
Legendre South-3	Exploration	-19.721678	116.691550	05/05/2010	2010
Legendre West-1	Production	-19.703939	116.708678	22/01/2001	2011
Legendre-3	Appraisal	-19.678905	116.732591	11/08/2005	2005
Legendre-3 (sidetrack 1)	Appraisal	-19.678905	116.732591	16/08/2005	2005

Well name	Well Type	Latitude (GDA94)	Longitude (GDA94)	Spud date	Year of P and A
Legendre-4	Appraisal	-19.678905	116.732591	23/08/2005	2005
Taj-1	Exploration	-19.707319	116.739016	02/02/2006	2006

1.4 Purpose of this environment plan

This EP has been prepared in accordance with the OPGGS(E)R for acceptance by NOPSEMA.

This EP details the environmental impacts and risks associated with the activity and demonstrates how these will be reduced to as low as reasonably practicable (ALARP) and to an acceptable level. The EP provides an implementation strategy (**Section 8**) that describes how Santos will measure and report on environmental performance during planned activities and unplanned events to ensure impacts and risks are continuously reduced to ALARP and are at an acceptable level. The environmental management of the activity described in the EP complies with the Santos Environment, Health and Safety Management Policy (**Appendix A**) and with all relevant legislation (**Appendix B**). This EP documents and considers all relevant stakeholder consultation performed during the planning of the activity.

1.5 Environment plan validity

This EP remains valid from the date of NOPSEMA until NOPSEMA has accepted an end-of-activity notification under Section 46, or until a revision is accepted. Santos will be required to revise this EP in the event a significant change to the activity or level of impact or risk occurs as required under Section 39 of the OPGGS(E)R 2023 or at the end of a 5 year period under Section 41.

Santos may revise the EP, using the Management of Change (MoC) process described in **Section 8.10.2**. Any changes made under this process will not affect the validity of this EP.

1.6 Titleholder

OPGGS(E)R 2023 Requirements
Section 23. Details of titleholder and liaison person
23(1) The environment plan must include the following details for the titleholder: + a) name; + b) business address; + c) telephone number (if any); + d) fax number (if any); + e) email address (if any); + f) if the titleholder is a body corporate that has an ACN (within the meaning of the *Corporations Act 2001*)—ACN. 23(2) The environment plan must also include the following details for the titleholder's nominated liaison person: + a) name; + b) business address; + c) telephone number (if any); + d) fax number (if any); + e) email address (if any).

1.6.1 Details of the titleholder

In accordance with Section 23(1) of the OPGGS(E)R, the titleholder details are as follows:

<table>
<tr><th>Titleholder</th><th>ACN</th><th>Interest (%)</th><th>Address</th></tr>
<tr><td>Santos WA Northwest Pty Ltd</td><td>009 140 854</td><td>77.44</td><td rowspan="2">Business Address: Level 7, 100 St Georges Terrace, Perth, Western Australia, 6000
Telephone number: (08) 6218 7100
Fax number: (08) 6218 7200
Email address: offshore.environment.admin@santos.com</td></tr>
<tr><td>Santos Ltd</td><td>007 550 923</td><td>22.56</td></tr>
</table>

1.6.2 Details for nominated liaison person

Details for the Santos Nominated Liaison Person for the activity are as follows:

- Name: Dawn MacInnes
- Position: Environment Manager WA, NA & TL
- Address: Level 7, 100 St Georges Terrace, Perth, Western Australia, 6000
- Telephone number: (08) 6218 7100
- Email address: offshore.environment.admin@santos.com

1.6.3 Notification procedure in the event of changed details

If there is a change in the titleholder, the titleholder's nominated liaison person, or a change in the contact details for the titleholder or liaison person, Santos will notify NOPSEMA in writing and provide the updated details.

1.7 Environmental management framework

OPGGS(E)R 2023 Requirements
Section 21. Environmental assessment
Requirements 21(4) The environment plan must: + a) describe the requirements, including legislative requirements, that apply to the activity and are relevant to the environmental management of the activity; and + b) demonstrate how those requirements will be met.
Section 24(a). Other information in environment plan
The environment plan must contain the following: 24(a) a statement of the titleholder's corporate environmental policy.

1.7.1 Santos Environment, Health and Safety Policy

The activities will be conducted in accordance with the Santos Environment, Health and Safety Policy (**Appendix A**) and relevant legislative requirements presented within **Appendix B** inclusive of the relevant EP sections where the legislation may prescribe or control how an activity is undertaken.

Sections 6 and **7** reflect the Santos Environmental Management Policy, detailing and evaluating impacts and risks from planned and unplanned events, providing control measures with set performance outcomes, standards, and measurement criteria to ensuring environmental performance is achieved. **Section 8** also details processes for monitoring changing laws / regulations and site activities, and assigning responsibilities to help assure compliance with legal requirements (e.g. laws, regulations, permits or project approvals and commitments made in permit applications) and standards of operation (e.g. relevant Santos and industry standards and/or design codes) applicable to the activities.

1.7.2 International conventions and agreements

Australia is signatory to numerous international conventions and agreements that obligate the Commonwealth government to prevent pollution and protect specified habitats, flora and fauna. Those which are relevant to the activity are detailed in **Appendix B.**

1.7.3 Commonwealth and state legislation

All activities within WA-20-L will comply with legislative requirements established under relevant Commonwealth legislation. These are further detailed in **Appendix B**.

1.7.3.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) is the principal legislation managing petroleum activities in Australian Commonwealth waters. The OPGGS Act and supporting regulations address all licensing, health, safety environmental and royalty issues for offshore petroleum and gas exploration and production operations in Commonwealth waters.

Section 572

Section 572 of the OPGGS Act places duties on titleholders in relation to the maintenance and removal of structures, equipment and property brought onto title. Specifically, sub-section 3 stipulates the requirement of a titleholder to remove “structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations”. NOPSEMA policy Section 572 Maintenance and removal of property (N-00500-PL1903 A720369) and the Offshore Petroleum Decommissioning Guideline (Department of Industry, Innovation and Science, 2018) provide additional guidance under Section 572 of the OPGGS Act.

The NOPSEMA Section 572 Maintenance and removal of property policy (N-00500-PL1903 A720369) sets out the principles that NOPSEMA will apply in the administration of section 572 of the OPGGS Act which requires titleholders to:

+ *maintain all structures, equipment and other property in a title area in good condition and repair*
+ *remove all structures, equipment and other property that is neither used nor to be used in connection with operations authorised by the title*
+ *or make arrangements that are satisfactory to NOPSEMA in relation to those structures, equipment and other property.*

Table 1-3: Duties and requirements under section 572

Duties and requirements under section 572	
Maintenance of property etc. (section 572(2))	*A titleholder must maintain in good condition and repair all structures that are, and all equipment and other property that is:* *a. in the title area; and* *b. used in connection with the operations authorised by the permit, lease, licence or authority.*
Removal of property etc. (section 572(3))	*A titleholder must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations:* *a. in which the titleholder is or will be engaged; and* *b. that are authorised by the permit, lease, licence or authority.*
Obligations of maintenance and removal of property etc. are subject to other provisions (section 572(7))	*Section 572(7) of the OPGGS Act allows for titleholders to make other arrangements that are satisfactory to NOPSEMA with respect to property etc. for the purposes of section 270 of the OPGGS Act via an accepted permissioning document. Other arrangements in the context of this regulatory policy include where a titleholder intends to do something that is different from the requirements of section 572(2) and (3).* *Maintenance and removal of property etc. requirements are subject to other provisions of the OPGGS Act, the regulations, directions given by NOPSEMA or the responsible Commonwealth Minister, and any other law.* *The maintenance and removal requirements do not substitute for, or override other provisions of, or arrangements made under, the OPGGS Act or regulations.* *If a titleholder intends to make other arrangements in relation to property etc. under section 572(7), the proposed approach should be included in permissioning documents and accepted by NOPSEMA prior to the property etc. being brought into the title area. Any changes in the titleholders’ approach should be addressed in subsequent revisions of permissioning documents.*

National decommissioning framework and the DISER guideline

The DISER Guideline: Offshore petroleum decommissioning, refers to Australia's enhanced decommissioning framework. Some of the key principles of this framework that are relevant to this EP include:

- *3.3. Decommissioning activities are the responsibility of the registered holder of the title under which the activities take place.*
- *3.4. This includes timely and effective planning, obtaining necessary approvals, and executing the activities in compliance with the OPGGS Act, the regulations (including accepted permissioning documents) and other applicable domestic and international laws.*
- *3.14. All decommissioning requirements are subject to other provisions of the OPGGS Act and regulations, directions given by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) or the responsible Commonwealth Minister, and other applicable laws. Further information on the maintenance and removal of property can be found in NOPSEMA's Section 572 Maintenance and Removal of Property Policy.*
- *3.15. Options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws.*

The NOPSEMA decommissioning website [accessed 01 December 2024, https://www.nopsema.gov.au/offshore-industry/decommissioning] reinforces the DISER principles with the following summary:

Decommissioning involves the timely, safe, and environmentally responsible removal of, or otherwise satisfactorily dealing with, infrastructure from the offshore area that was previously used to support oil and gas operations. Decommissioning is a normal and inevitable stage in the lifetime of an offshore petroleum project that should be planned from the outset and matured throughout the life of operations.

There are numerous ways of addressing the challenges and opportunities of decommissioning offshore oil and gas infrastructure when it is no longer required. However, regardless of the process, the Australian government and NOPSEMA are fully committed to ensuring decommissioning is carried out in a timely, safe, and environmentally responsible way.

As the regulator for Australia's offshore energy industry NOPSEMA plays a key role in implementing the Australian Government's decommissioning framework. It ensures this by promoting a heightened focus on the planning and execution of decommissioning during the assessment of permissioning documents and also by monitoring and enforcing titleholders' compliance to ensure they meet their decommissioning obligations. The key principles of this framework, as outlined in the Offshore Petroleum: Decommissioning Guidelines, are:

- *Decommissioning is the responsibility of titleholders*
- *Early planning for decommissioning is encouraged*
- *Removal of all property is the "base case"*
- *Decommissioning must be completed before the end of title*

Exceptions to full removal may apply if titleholders can demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws.

Section 270 Consent to surrender title

Section 270 of the OPGGS Act provides that the Joint Authority (JA) may consent to the surrender of petroleum exploration permits, production licences, retention leases, infrastructure licences and pipeline licences, if it is satisfied there are sufficient grounds to warrant giving consent.

For this revision of the EP, Santos is not seeking to surrender the title, as additional activities are occurring in the form of an environmental monitoring survey. Surrendering the title does not apply to this revision of the EP, it will be applicable to a future version of the WA-20-L EP, following the conclusion of further monitoring.

Under subsection 270(3) of the OPGGS Act, before title surrender, all property brought into the surrender area must be removed to the satisfaction of NOPSEMA, or arrangements that are satisfactory to NOPSEMA must be made relating to the property. The Legendre-1 wellhead activity is relevant to this aspect of Section 270, as summarised in **Table 1-4**.

The NOPSEMA letter (A817590) states: *Santos is requested to consider developing the EP so that it demonstrates obligations under sections relating to the consent to surrender title requirements have been satisfied (i.e. section 270(3)(b)(iii) & (v) and 270(3)(c) to 270(3)(f) of the OPGGS Act). This will facilitate the provision of NOPSEMA's advice to the Joint Authority when Santos consider requesting consent to surrender the title in the future.*

Table 1-4: Criteria in section 270 of the OPGGS Act

Criteria in section 270 of the OPGGS Act		EP Section
(3)(b)(iii) & (v)	*The registered holder of the permit, lease or licence has complied with the provisions contained in Chapter 6 of the OPGGS Act and in the regulations made under the OPGGS Act*	*Section 2.2, 6.9, 7.1*
3) The Joint Authority may consent to the surrender sought by the application only if the registered holder of the permit, lease or licence:		
(3)(c)(i) & (ii)	*has, (i) to the satisfaction of NOPSEMA, removed or caused to be removed from the surrender area all property brought into the surrender area by any person engaged or concerned in the operations authorised by the permit, lease or licence; or (ii) made arrangements that are satisfactory to NOPSEMA in relation to that property*	*Section 2.2.*
(3)(d)	*has, to the satisfaction of NOPSEMA, plugged or closed off all wells made in the surrender area by any person engaged or concerned in the operations authorised by the permit, lease or licence*	*Section 2.2 and 6.1.1.8.*
(3)(e)	*has provided, to the satisfaction of NOPSEMA, for the conservation and protection of the natural resources in the surrender area*	*Section 2.2, 6.9, 7.1*
(3)(f)	*has, to the satisfaction of NOPSEMA, made good any damage to the seabed or subsoil in the surrender area caused by any person engaged or concerned in the operations authorised by the permit, lease or licence*	*Section 2.2, 6.9, 7.1*
(3)	*but, if the registered holder has complied with those requirements, the Joint Authority must not unreasonably refuse consent to the surrender.*	

Section 569

Section 569 of the OPGGS Act places duties on titleholders in relation to the work practices within a title area. Specifically, sub-section 1(c) stipulates the requirement of a titleholder to "control the flow, and prevent the waste or escape, in the permit area, lease area or licence area, of petroleum".

The OPGGS(E)R prescribe the requirements for management of environmental impacts associated with petroleum activities and require proponents to submit an EP to the Regulatory Authority, for approval prior to the commencement of activities. Within the EP, the proponent is required to document an assessment of the impacts and risks associated with the activities and demonstrate that the proposed control measures reduce these impacts and risks to ALARP and acceptable levels.

1.7.3.2 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is administered by the Commonwealth Department of Climate Change, Energy, Environment and Water (DCCEEW). The EPBC Act protects matters of national environmental significance (MNES) across Australia and protects the environment in relation to actions on (or impacting upon) Commonwealth land or waters. When a person proposes to take an action that they consider may need approval under the EPBC Act, they must refer the proposal to the Commonwealth Minister for Environment. However, following a strategic assessment of NOPSEMA's environmental management authorisation process under the EPBC Act, the Minister endorsed NOPSEMA's process as a program that meets the requirements of Part 10 of the EPBC Act. The Minister subsequently approved a class of actions which, if undertaken in accordance with the endorsed program, will not require separate referral, assessment and approval under the EPBC Act.

In relation to EPs, NOPSEMA must be reasonably satisfied that the EP meets the criteria for acceptance under Section 34 of the OPGGS(E)R. The criteria for acceptance apply to the management of all impacts and risks including those matters protected under Part 3 of the EPBC Act.

1.7.3.3 Environment Protection (Sea Dumping) Act 1981

The Sea Dumping Act 1981 requires sea dumping permits to be obtained for particular activities and gives effect to the United Nations Convention on the Law of the Sea and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and associated Protocol.

In instances where infrastructure is proposed to be left on the seabed, the activity may be considered a dumping activity that is regulated under the Sea Dumping Act. In these instances, permits are required from Department of Climate Change, Energy, the Environment and Water (DCCEEW) prior to these activities. Santos has provided written notification to DCCEEW and NOPSEMA confirming that the Legendre-1 wellhead was plugged and abandoned before 1983 when the Sea Dumping Act 1981 was enacted.

2 Activity description

OPGGS(E)R 2023 Requirements
Section 21(1)
Description of the activity 21(1) The environment plan must contain a comprehensive description of the activity including the following: + the location or locations of the activity; + general details of the construction and layout of any facility that is used in undertaking the activity; + an outline of the operational details of the activity (for example, seismic surveys, exploration drilling or production) and proposed timetables for undertaking the activity; + any additional information relevant to consideration of environmental impacts and risks of the activity. Note: An environment plan will not be capable of being accepted by NOPSEMA if an activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, will be undertaken in any part of a declared World Heritage property (see Section 34).

The activity occurs in Production License WA-20-L, approximately 105 km north of Dampier in Commonwealth waters of the North West Shelf (**Figure 2-1**).

As described in **Section 1.3**, in accordance with legislation the WA-20-L wells have previously been plugged, abandoned and decommissioned over a period of many decades, with the final plug and abandonment campaign occurring in 2011.

The WA-20-L activities covered under this EP are:

+ Gas seepage in the form of small bubbles emanating from the seabed into the water column (**Section 2.1**).
+ The Legendre-1 wellhead remaining in situ (**Section 2.2**).
+ Vessel-based surveillance, monitoring and inspection activities (**Section 2.3**).

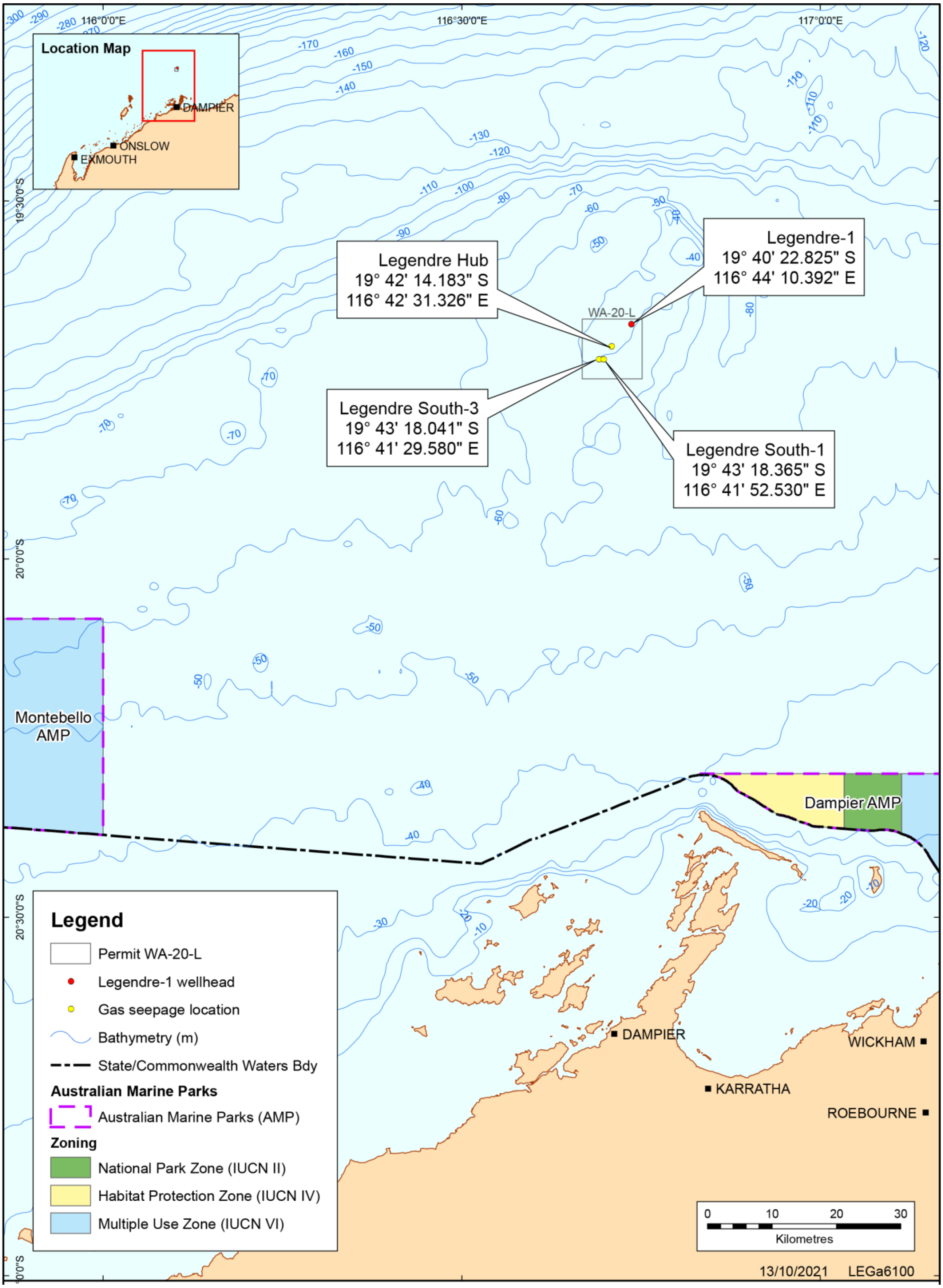


Figure 2-1: WA-20-L Location map

2.1 Seabed gas seepage

The Legendre production wells were plugged and abandoned in 2011 as a part of a decommissioning campaign under an EP which was accepted by the Western Australia Department of Mines and Petroleum in 2011. The production wellheads were removed during P&A activities, and some concrete stabilising structures and sections of pipe were left in situ, as approved under the EP.

After the abandonment of the production wells and subsequent removal of the platform and associated infrastructure, small gas bubbles were observed in the vicinity of the plugged and abandoned wells during a post-decommissioning ROV survey in 2013.

Additional seepage surveys were conducted at WA-20-L in 2013 and 2016, however these surveys could not determine whether the seeps were emanating from inside or outside of the casing, and the gas seepage flux rates could not accurately be quantified. The 2013 survey concluded that the gas bubbles that were sampled and analysed were thermogenic in nature.

Two targeted field surveys have since been conducted to inspect and analyse any gas seeps, as described in this section:

+ Legendre field environmental survey (referred to as the ‘RPS 2021 survey’, RPS 2021a/b)
+ NWS offshore gas seeps and leakage characterisation project survey (referred to as the ‘CSIRO 2022 survey’, Talukder et al. 2024).

During the RPS 2021 survey it was confirmed that gas seepage at WA-20-L was occurring at three well locations: Legendre Hub, Legendre South-1, Legendre South-3. The majority of seepage was at Legendre Hub, with smaller amounts emanating from Legendre South-1 and Legendre South-3 (see **Table 2-1** and **Table 2-2**).

The CSIRO 2022 survey confirmed seabed gas seepage at Legendre Hub, and while small gas bubbles were observed in the water column of Legendre South-1 and Legendre South-3, there was no confirmation of gas seeps emerging from the seafloor for these sites.

The gas bubbles are estimated to be 1-11mm in diameter in size. **Table 2-1** summarises the detected gas seeps across the two surveys. Further information regarding the surveys is included in **Appendix F**.

Table 2-1: Gas seeps summary

Parameter	Survey	Legendre Hub	Legendre South-1	Legendre South-3
Estimated number of bubble seeps	RPS 2021	20	4	2
	CSIRO 2022	13	N/A	N/A
Bubble diameter at sea floor (mm)	RPS 2021	1 – 10	1	5 - 10
	CSIRO 2022	2 - 11	N/A	N/A
Site depth (m)	RPS 2021	50.7	54.1	53.3
	CSIRO 2022	51	53	53

The findings of the CSIRO survey were presented by CSIRO to NOPSEMA and Santos in a meeting on 5 June 2024, and are listed below.

+ Key objectives were achieved, despite some technical challenges with the landers.
+ Three areas of seepage at Legendre hub.
+ The amount, rate and size of bubbles is similar to the previous RPS study which was conducted in 2021. Same reservoir gas, no escalation.
+ The amount of methane reaching the surface is a very low percentage as it reduces in concentration up through the water column.

2.1.1 Flux rates

RPS 2021 survey

Flux rates were estimated from bubble counts per unit time at the Legendre Hub, Legendre South-1 and Legendre South-3 locations. The calculated rates are provided in **Table 2-2**. These rates are the total rates across all seeps in each well group. The rate of release of gas bubbles at each seep site was measured to estimate the total rate of gas being emitted from each well location. The total estimated flux rate from the 20 gas seeps at Legendre Hub was approximately 338 mL/min.

CSIRO 2022 Survey

The CSIRO estimated flux rates are provided in **Table 2-3**. The estimates from ROV measurement and acoustic backscatter-based calculation are at the same order of magnitude. The estimated flux rate at a single seep varies between 33.48 ml/min to 71.64 ml/min. If these seep fluxes are multiplied by the total number of seeps observed during CSIRO survey, the estimated total flux rate at Legendre Hub would be approximately 435 ml/min to 931.32 ml/min. Note that the CSIRO estimated flux rate is a maximum possible flux rate assuming that flux is constant over time, however both acoustic and ROV observations have shown that the seeps are highly intermittent (Talukder et al., 2024). Without knowing the periodicity of the bubble releases, it is not possible to accurately estimate actual flux rates (Talukder et al. 2024).

There were no observations of gas emerging from the seafloor at the time of the Legendre South-1 and Legendre South-3 surveys, however, there were three instances of likely rising gas bubbles in the water column. The estimates for the three observations were small at 12.7, 1.5 and 3.7 kg/annum.

Flux rates summary

The CSIRO estimated flux rate at Legendre Hub are the same order of magnitude as the flux estimation made during the RPS survey 2021 (Talukder et al., 2024).

The CSIRO estimated flux rate is based on the seep being active for the entire time span. While the RPS estimation from the earlier survey is an average during the time span to take into account that the seep is active and inactive. As a result, the rates estimated in the CSIRO are higher than the RPS estimation. The CSIRO estimated flux rate is highly conservative, as both acoustic and ROV observations have shown that the seeps are highly intermittent (Talukder et al. 2024). On this basis, the RPS 2021 estimated flux rates are considered more representative of the actual flux rates.

Based on the data obtained through the two surveys, the estimated flux rates have not significantly changed. The CSIRO 2022 survey results are the same order of magnitude as the flux estimation made during the RPS 2021 survey (Talukder et al., 2024).

Table 2-2: RPS 2021 estimated flux rates

Survey	Parameter	Comments	Legendre Hub	Legendre South-1	Legendre South-3	WA-20-L Total
RPS 2021	Gas flux rate (mL/min)	Rate accounts for intermittency; active and inactive (on/off) nature of the seeps	338.4	12.2	6.1	356.8
	Gas flux rate (L/day)		487.4	17.6	8.8	513.8
Notes: The above rates include all seeps for each of the three well hubs. i.e. the Legendre Hub rate of 338.4 mL/min is a total of the ~20 seeps at that hub.						

Table 2-3: CSIRO 2022 estimated flux rates

Survey	Parameter	Comments	Legendre Hub	Legendre South-1	Legendre South-3	WA-20-L Total
CSIRO 2022	Gas flux rate (mL/min)	Rate assumes constantly active seeps	435 - 931	N/A	N/A	N/A
	Gas flux rate (L/day)		626 - 1341	N/A	N/A	N/A
Notes: The above rates include all seeps for the Legendre hub.						

2.1.2 Gas seepage composition

The compounds that contributed greater than 1% to the gas composition are listed in **Table 2-4**.

Table 2-4: Compounds contributing 1% or greater to the composition of the gas sampled

Compound	Cas Number	Reported concentrations, as mole %		
		Legendre Hub (RPS 2021)	Legendre Hub (CSIRO 2022)	Legendre South-1 (RPS 2021)
Methane (CH_4)	74-82-8	84.51	84.22	84.79
Nitrogen (N_2)	7727-37-9	0.98	1.57	1.01
Ethane (C_2H_6)	74-84-0	7.30	7.08	6.92
Propane (C_3H_8)	74-98-6	3.86	3.81	3.76
n-Butane (C_4H_{10})	106-97-8	1.3	1.17	1.21

2.1.3 Gas seepage source

Gas chromatography (GC) and compound specific isotopic analyses (CSIA) of the gas from the two locations (Legendre Hub and Legendre South-1) concluded that the two gases were very similar in molecular and isotopic composition (Murray Partners PPSA, 2021). The CSIA indicated that the samples were also very similar to solution gases from oils collected from both the Legendre North and Legendre South pools of the Legendre Field during the production life of the field, with the closest match being to solution gas from the Legendre North pool (RPS 2021a). The lack of biodegradation in the gas samples indicated that it is not migrating to the seabed over geological periods of time.

The possibility that the gas originated from a shallow source was investigated by examining reprocessed seismic data over the Legendre field. Whilst geological faults extend from the level of the Legendre Field reservoir to very close to the present-day seabed within the WA-20-L permit, the shallow, near seabed, part of these faults is not at or near the surface location of the gas seepages. This suggests the sampled gas has not migrated up fault lines. Further, if gas was migrating up the faults, the slow rate of migration would result in higher biodegradation of the gas than was measured in the samples taken in 2021.

The level of consistency in the composition indicates a high likelihood that, between the 2021 and 2022 surveys the gas composition has not changed significantly, and the source of the gas has remained the same (Talukder et al 2024).

2.2 Legendre-1 wellhead

The review of the plug and abandonment history of wells in WA-20-L concluded that the Legendre-1 well was drilled, plugged and abandoned in 1968, in accordance with the plan submitted to the regulator of the day. The well completion record indicates that the wellhead was left in situ, with no further correspondence from the regulator at that time (Santos, 2020).

The location of the Legendre-1 wellhead site was inspected in 2021 using an ROV. The survey found a wellhead and Permanent Guide Base (PGB) structure. The wellhead top was found to sit approximately 3.6 m above the seabed while the PGB was estimated to be 3 to 5 m wide (RPS 2021b).

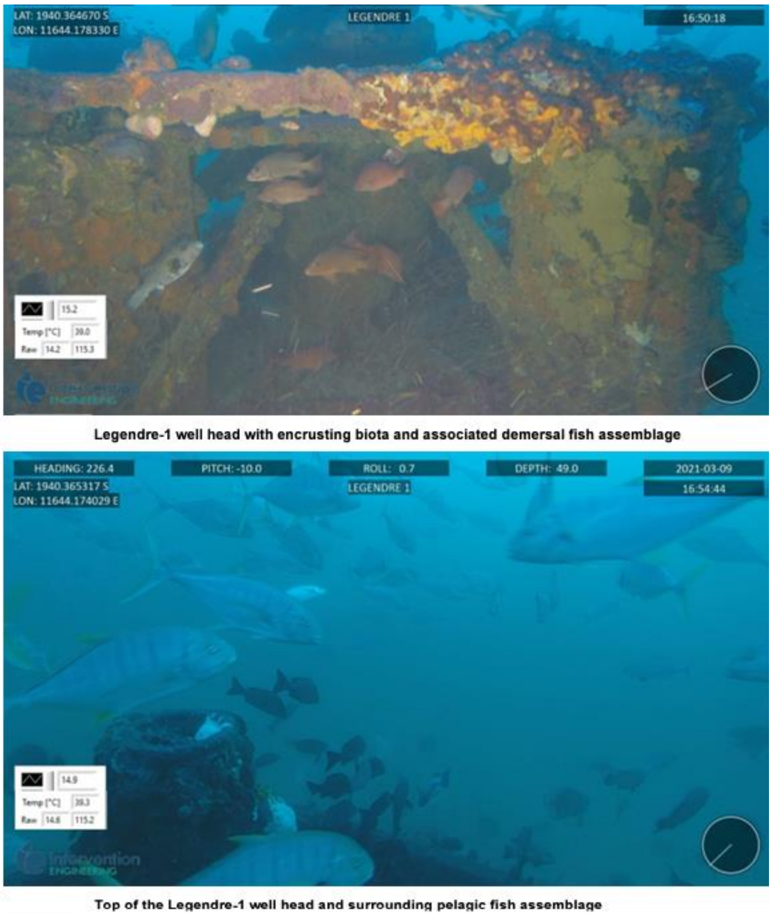


Figure 2-2: Legendre-1 wellhead

As the wellhead was installed in 1968, information on the material used in its construction cannot be located, however, typically wellhead material would be one of the following material specifications:

Table 2-5: Typical wellhead material specifications

	AISI 8630		AISI 4130		ASTM A182 F22	
Element	min	max	min	max	min	max
Fe	96.745	98.02	97.03	98.22	95.04	96.78
C	0.28	0.33	0.28	0.33	0.05	0.15
Cr	0.4	0.6	0.8	1.1	2	2.5
Mo	0.15	0.25	0.15	0.25	0.87	1.13
Mn	0.65	0.95	0.4	0.6	0.3	0.6
Ni	0.35	0.75	0	0	0	0
Si	0.15	0.3	0.15	0.35	0	0.5
S	0	0.04	0	0.04	0	0.04
P	0	0.035	0	0.035	0	0.04

Wellhead material is low-alloy steel. Low-alloy steel used for wellheads typically includes chromium (Cr), molybdenum (Mo) and manganese (Mn) as alloying agents in varying amounts, and in some compositions also nickel (Ni) and/or silicon (Si). Carbon (C) is present in the steel, and trace amounts of sulphur (S) and phosphorous (P) are permissible.

Table 2-6 summarises the range of minimum and maximum percentage compositions across the three commonly used wellhead materials. The dominant component of the wellhead is iron, with the remaining elements individually contributing 1% or less to the overall total material.

Table 2-6: Typical wellhead material composition ranges

Element	min %	max %	Element	min %	max %	Element	min %	max %
Fe	95.04	98.22	Mo	0.15	1.13	Si	0	0.5
C	0.05	0.33	Mn	0.3	0.95	S	0	0.04
Cr	0.4	2.5	Ni	0	0.75	P	0	0.04

2.2.1 Assessment of decommissioning options

Santos have conducted a decommissioning options assessment of the Legendre-1 wellhead, considering base case removal and the alternative arrangement of leaving the wellhead in situ.

The assessment considered Section 572(3), 572(7) and Section 270(3) of the OPGGS Act, as well as NOPSEMA policy Section 572 Maintenance and removal of property (N-00500-PL1903 A720369) and the Offshore Petroleum Decommissioning Guideline (Department of Industry, Science, Energy and Resources, 2022).

The NOPSEMA policy Section 572 Maintenance and removal of property (N-00500-PL1903 A720369) states:

+ *Alternative arrangements may be proposed by a titleholder and accepted (or otherwise) by NOPSEMA via an EP. NOPSEMA will apply the following principles where approval for alternative arrangements to removal of property etc. required under section 572(3) is sought:*
  - *titleholders should demonstrate in permissioning documents how the alternative arrangements will satisfy NOPSEMA for the purposes of section 270(1)(c)(ii) of the OPGGS Act6*
  - *an EP must demonstrate that the alternative arrangement proposed delivers environmental performance outcomes that ensure that environmental impacts and risks will be reduced to ALARP, be of an acceptable level and are carried out in a manner consistent with the principles of ecologically sustainable development.*

The Offshore Petroleum Decommissioning Guideline (DISER) states:

+ *3.7. The removal of all property and the plugging and abandonment of wells in line with the provisions of s572 of the OPGGS Act is the default decommissioning requirement under the OPGGS Act (i.e. the 'base case').*
+ *3.15. Options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws.*

The assessment of decommissioning options included:

+ Base case, removal of the wellhead.
+ Leaving the wellhead in situ.

The assessment of options comprised the following:

+ A technical feasibility assessment to look at the options for how the wellhead could be removed to implement the base case (**Section 2.2.1**).
+ A wellhead options comparative environmental assessment which compared the wellhead removal option and the leave in situ option (**Section 2.2.2**).

2.2.1.1 Wellhead removal options

Santos commissioned an independent wellhead removal study, Legacy Subsea Wellhead Removal Options Study (Add Energy, 2021) to evaluate the technical feasibility of the removal of the Legendre-1 wellhead. The study assessed the methods for removal:

+ (i) internal cutting, which may remove the wellhead to below the mudline.

- (ii) external cutting above the mudline, which would be employed in the event that wellhead corrosion or the wellhead profile prevented internal access to the wellhead.

The scope of the study included the following requirements:

- Review and summarise the above two methods for Legendre-1 removal.
- Conduct and document offset review of wellhead removal activities in the region using either method.
- Assess and document complexity/risks associated with each of these methods – particular in context of age (~50 years +) (e.g. retrieving/handling at surface of cut and pull components etc.).
- Work-up budgetary time and cost estimate for each of the proposed method(s).

During 2024, Santos assessed the Legacy Subsea Wellhead Removal Options Study (Add Energy, 2021) used external Principal Well Engineers to review the report and provide technical input. This latest information has been integrated into this **Section 2.2.1.1** and **Table 2-7**.

The Legendre-1 wellhead is located in 53m water depth which is outside the maximum operating depth for air diving (max 50m). Therefore, ROV operations are considered the only commercially viable option for wellhead recovery.

Table 2-7: Base case removal options assessment

Removal Method	Description	Technical Feasibility
External cutting above the mudline	External cutting uses tools deployed from the outside of the wellhead to sever the wellhead, conductor and internal casing strings from the casing stump. This would result in a cut above the mudline. Two potential methods of external cutting, a conventional diamond-wire saw (DWS) and Subsea ROV deployed DWS methods (currently existing) or a prototype in-line 155” Blakemere DWS.	Conventional tools have technical issues likely to prevent them from being a suitable option for making the cut, summarised below: + The wellhead has a PGB installed which prevents direct access to the wellhead conductor outside diameter for external diamond-wire saw mounting. + There is no clearance between the seabed and the PGB. The PGB typically penetrates a short distance into soft seabed sediments under the loads of its own weight and the conductor casing, thereby preventing access below the PGB for any external cutting to the wellhead without dredging approximately 5 m x 3 m of seabed material from around the outside (i.e., an external cut will leave a stump protruding from mudline). + Given 1) there is minimal to no clearance between the PGB and the seabed, 2) any hard sediments or cement from surface 30” cement job would prevent effective dredging below the PGB, and 3) the PGB is not fixed to the conductor and therefore likely to slump, regaining access below the PGB for deployment of conventional external cutting equipment is assessed as highly unlikely. + The extent of cement at seabed level, and below the PGB is unknown. It is considered likely that a cement porch is present below seabed which would prevent dredging to enable a cut below the mud line. To confirm the extent of cement in the region of the PGB would entail using suction or water jetting to mobilise seabed sediments. Presence of firm seabed sediments (e.g. limestone) or cement from the Legendre-1 well operations would prevent mobilisation of these sediments. + If excavation or dredging beneath the PGB was successful, it would likely result in subsidence of the PGB. The conductor was only landed in the PGB gimbal., Therefore other than 50 years pf marine encrustation, there is nothing fixing the PGB to the conductor to prevent its subsidence. An alternative external cutting method that was assessed by Add Energy in the 2021 study is an in-line 155” Blakemere DWS which has been developed cut subsea structures. If this tool can be installed around the PGB it could possibly cut 100 mm above seabed.

Removal Method	Description	Technical Feasibility
		This tool presents the best external cut option. However, it has specific challenges: + ROV survey estimated PGB width to be 3 to 5 m while the tool has maximum cut diameter of 4 m therefore uncertainty exists whether the tool is sufficiently large for this application. + The tool would need to cut not only the conductor and internal strings but also the PGB around the conductor + The tool has only been used for caisson and fender cuts and never been used in this application (PGB + conductor + internal casing strings) + The tool is not designed specifically for cutting wellheads and PGBs therefore its ability to clamp onto and cut a PGB is unknown and untested, and modifications are likely required to effect PGB and wellhead severance. + The tool is large and bulky, which means it is difficult to handle and deploy and introduces additional safety risks. Considering the above, the option to remove the wellhead above the mudline by external cutting was considered a low chance of success given the only viable method utilises tooling that has never before been used in this application.
Internal cutting below the mudline using an internal abrasive water jet cutting tool	Removing the wellhead by internal cutting would involve entering the well and cutting the well casing from inside the well using hydraulic cutters. The hydraulic cutters would be powered either by an ROV or by a hydraulic power unit on the vessel and associated down-line. Internal cutting uses cutting tools deployed from the inside of the wellhead below the mudline to sever the wellhead and internal casing string from the inside of the casing stump. The severed wellhead and casing/conductor stumps (and any surrounding cement attached) are then pulled and recovered to a vessel. This method should leave nothing protruding from the sea floor. It may be necessary to use a vibration hammer to loosen the well casing and grouting concrete from the well annulus to allow it to be extracted from the hole.	There is significant uncertainty in the feasibility of this method, a number of risks associated with this type of removal, and high costs without guarantee of successful removal, as summarised below: + There is a shallow cement plug installed in the well with the cement top reported to be 16m below the seabed. While this should leave sufficient clearance for internal cutting tools the cement was never tagged to verify its location therefore there remains a risk that any internal cutting tool will not be able to access the wellbore deep enough to cut below the mudline without removing this internal cement. Removal of the internal cement would require drill-out operations (i.e. not feasible with a vessel). + There is a risk an internal obstruction exists in the wellbore which may prevent access to internal cutting tools to cut casing at a depth at or below the mudline. This is due to the reported placement of a shallow cement plug set within the 9 5/8” casing with the top being a short distance below the mudline. + The wellhead is a 13-5/8” 5000psi National Sea King subsea wellhead. The wellhead upper hub interface profile is unknown. There is a temporary abandonment (TA) cap installed on the wellhead. Internal cut requires removal of the TA cap, given the age of the wellhead and the cap there is significant risk the cap may require significant force to remove and gain access to the inside of the wellhead, if it can be removed at all. + HP housing Temporary Abandonment (TA) cap type and latching mechanism is unknown which presents a project risk for gaining access to the wellbore for any internal cutting operations. + Due to the age of the wellhead, limited engineering details are available, and the high pressure (HP) housing upper hub interface profile is unknown. This presents a challenge and project risk for the internal cutting options that require a collet connector to interface with the HP housing for tool operation. + Internal cutting requires use of heave compensated crane (or in-line compensator on the crane). This option has significant

Removal Method	Description	Technical Feasibility
		equipment requirements, e.g., 150 m2 of deck space and 30 – 45 tonne equipment spread. The option to remove the wellhead below the mudline by internal cutting is considered to have a low chance of success and is high cost as it requires the use of heavy-duty vessels and equipment. + The risk of costs escalating is also high due to the unknown condition of the wellhead.

2.2.1.2 Conclusion

Both internal cutting and external cutting options to remove the Legendre-1 wellhead may be technically feasible, however there are technical risks, and low chances of success. The complexities and challenges listed in the sections above mean there is a high risk failed removal attempts.

2.2.2 Environmental risk and impact assessment of options

The option to remove the wellhead or to leave it in place are considered feasible, and an assessment of environmental impacts and risks of each option (**Section 2.2.2.3**) using the Santos environmental assessment method described in **Section 5** has been conducted.

The assessment includes consideration of:

- planned and unplanned aspects related to each option;
- control measures necessary to manage the impacts and risks associated with each option to ALARP, including the benefit of long-term monitoring;
- an assessment, of whether the option to leave the wellhead in situ provides an equal or better environmental outcome for each aspect;
- an assessment, based on the comparative environmental assessment outcomes of whether the option to leave the wellhead in situ provides an overall equal or better environmental outcome; and
- consultation with stakeholders on the preferred option (**Section 4**).

2.2.2.1 Activity and aspect descriptions

Leave wellhead in-situ

Leaving the Legendre-1 wellhead in-situ would not involve additional activity. The wellhead was plugged and abandoned in 1968 and would remain in place in perpetuity.

Removal of the wellhead

Regardless of the wellhead removal method, the activity would likely be undertaken using a manned offshore support vessel (OSV) using dynamic positioning (DP). The number of personnel onboard (POB) is expected to be less than 50. Should the OSV be unsuccessful at removing the wellhead a mobile offshore drilling unit (MODU) with POB over 100 may be required to complete the removal scope.

The wellhead is located in 53 m of water which exceeds maximum safe operating depth for air diving operations, consequently ROV operations would be required for wellhead removal.

Due to the high level of corrosion on the PGB and wellhead, lifting these in one piece is considered too hazardous to the safety of the vessel and crew on board. The PGB and wellhead would need to be cut into pieces and lifted directly or placed in a basket and then lifted to the surface. The pieces of the wellhead and PGB framing may need to be cleaned of marine growth prior to recovery to reduce the weight of the lifts.

Whilst undertaking the activity, a gazetted 500 m Petroleum Safety Zone (PSZ) would be maintained around the vessel, as required under the OPGGS Act. Additional support vessels, anchoring and refuelling at sea would not be required.

Based on estimated duration of the activity crew changes are not expected to be required but cannot be ruled because of the significant uncertainty associated with the activity operational success. Therefore helicopters will be in the scope of this activity for both contingency crew change support and emergency response capacity.

If access to the well can be established, it is estimated it would take approximately seven days in field to perform internal cutting and removal of the wellhead below the mudline.

The aspects considered in the ERIA are detailed in **Table 2-8**.

Table 2-8: Aspects considered in options assessment for Legendre-1 wellhead

Aspect	Removal	Leave in-situ
Planned events		
Presence of wellhead: wellhead degradation	√*	√
Removal operations: Seabed disturbance	√	✗
Removal operations: Discharges from cuttings	√	✗
Removal operations: Noise and vibration from cutting activity	√	✗
Removal operations: Disturbance of artificial habitat	√	✗
Removal operations: Disturbance to other users from presence of vessels	√	✗
Removal operations: Planned operational discharges from vessels	√	✗
Removal operations: Planned operational atmospheric emissions from vessels	√	✗
Removal operations: Anthropogenic noise from vessels	√	✗
Removal operations: Anthropogenic light from vessels	√	✗
Removal operations: Hydrocarbon spill response operations	√	✗
Unplanned events		
Release of solid objects	√	✗
Marine fauna interaction	√	✗
Hazardous liquid releases	√	✗
Release of hydrocarbons from vessel	√	✗
Vessel presence: Introduction and establishment of IMS	√	✗
Presence of wellhead: disturbance to other users	√*	√
Gas seepage	✗	✗

* In the event of removal above the mudline.

2.2.2.2 Snagging risk study

Santos engaged the Australian Maritime College (AMC) to undertake an independent assessment of the potential impacts of the Legendre-1 wellhead on trawl fishers potentially operating in the area (**Appendix I**). The study examined the historical trawl fishing effort near the wellhead and found that the majority of fishing activity is associated with the Pilbara Demersal Scalefish Fisheries which is consistent with the data presented in Fishery Status Reports (Newman et al. 2019, 2020) and WA Department of Primary Industry and Regional Development (DPIRD) catch and effort data (see **Section 3.6.1**). This includes the Pilbara Fish (Interim) Trawl Managed Fishery (PFITMF) which targets cod and emperor via the demersal trawl method. Fishing activity in the PFITMF has increased overall in the last five years (Newman et al. 2020).

To determine the likelihood of a snag occurring if a fisher were to operate in the area, the study examined the equipment and experience on the four vessels used by the PFITMF. Some of the key findings included of the study included the following:

+ All four vessels have equipment and systems that are upgraded frequently in response to safety concerns, changes in regulations, and opportunity.
+ All four vessels have passed AMSA stability examinations and a trawl operator in this area, using the available technologies of trawl monitoring systems, sonar obstacle detection, single-beam echo sounders, integrated GPS platters and seabed mapping software, is likely to be aware of the fixed location of the wellhead and therefore will avoid the obstacle in a timely manner and therefore avoid snagging.
+ Evidence provided by fishers to AMC indicated that trawlers currently pass the wellhead at a distance of at least 0.5 nm.
+ Further, the wellhead is within the Glomar Shoal, which is ‘for the best part untrawlable ground’.
+ The size of the wellhead is small when compared to the total amount of trawlable ground in the fishery (less than 0.002 % of the total trawlable area). Therefore, given the position is known (marked on charts), the advanced level of equipment and experience on the vessels and that the wellhead is actively avoided due to the ground type, the study concluded it is unlikely that trawlers would interact with the wellhead into the future.
+ In the unlikely event of a snag occurring, the study determined that a demersal trawler coming into contact with the wellhead would likely snag and that some net and wires (bridle gear) would have to be left behind, with recovery of this gear unlikely.
+ In the event of unfavourable weather the severity of a snag event would increase, however the study concluded that due to the technology employed on the four vessels and experience of the vessel operators a snag event is unlikely to result in capsize, as demonstrated by nil capsize events due to snagging in the last three decades in the fishery.

2.2.2.3 Outcomes of the environmental assessment

Table 2-9 and **Table 2-10** compare the environmental impacts and risks associated with the options of wellhead removal and of leaving the wellhead in-situ.

Table 2-9: Legendre-1 wellhead options comparative environmental assessment – planned events

Aspect	Removal Description and Potential Impact	Leave in situ Description and Potential Impact	Assessment Outcome
Presence of wellhead: degradation	No impact if wellhead removed below the mudline. External cutting of the wellhead above the mudline would result in a portion (up to 100 mm) of the wellhead remaining present and exposed to degradation. This will allow the small amount of remaining wellhead to continue to introduce contaminants (mainly iron oxides) to the water column and sediment surrounding the wellhead as it degrades over time (i.e., over hundreds of years). Breakdown of compounds into the water column and accumulation in sediments may affect marine fauna. Dissolved contaminants are expected to disperse rapidly in currents.	Degradation of the entire remaining wellhead introduces contaminants (predominantly iron oxides) to the water column and sediment surrounding the wellhead as it degrades over time (i.e., over hundreds of years). Breakdown of compounds into the water column and accumulation in sediments may affect infauna species surrounding the wellhead. Only low levels of elevated iron were noted within 20 m of the wellhead when compared to the reference sites surveyed in 2021 (RPS 2021b). Contaminants are expected to disperse rapidly in currents.	As there would be no remaining wellhead following removal below the mudline it would deliver an equal or better environmental outcome as compared to the wellhead remaining in situ. Even partial removal of the wellhead (i.e., in the event that removal below the mudline fails and 100 mm of the wellhead remains in situ above the mudline) would deliver an equal or better environmental outcome as compared to the wellhead remaining in situ on the basis that less contaminants would be generated.
	Consequence Level: N/A (in the event of below the mudline removal) I - Negligible (in the event of removal above the mud line)	Consequence Level: I - Negligible	
	Consequence Level: I – Negligible		
Removal operations: Seabed disturbance	Seabed disturbance during removal of the wellhead (estimated at 7 days), including the creation of plumes in the water column from removal operations (for example cutting, grinding), lifting wellhead pieces to the vessel, and vessel thrusters. Potential impacts include smothering or alteration of the benthic habitat, increased turbidity and decreased water quality from plumes. Plumes are expected to dissipate rapidly (minutes to hours) in currents and be localised around the discharge point.	None associated with option.	As there would be no seabed disturbance associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the removal of the wellhead.
	Consequence Level: I – Negligible	Consequence Level: N/A	
Removal operations:	Release of cuttings/ filings of the wellhead during removal to the seabed and water column.	None associated with option.	As there would be no discharges of cuttings/filings associated with the option

Aspect	Removal Description and Potential Impact	Leave in situ Description and Potential Impact	Assessment Outcome
Discharges from cuttings	Compounds would disperse into the water column and may accumulate in sediment, impacting on marine fauna, particularly infauna species surrounding the wellhead. Contaminants are expected to disperse rapidly in currents and low to no impact is expected.		to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the removal of the wellhead.
	Consequence Level: I – Negligible	Consequence Level: N/A	
Removal operations: Noise and vibration from cutting activity	Noise and vibrations from the operation of machinery used to remove the wellhead, including from grinders and water jet cutters (hydroblaster). Noise from a hydroblaster was measured approximately 1 m from the source to be 147.0 dB re 1µ Pa at 125 Hz and 142 dB re 1µPa at 125 Hz respectively (Wolgemuth 2008). Potential impacts include injury to hearing or other organs of marine fauna (including EPBC Act listed species), disturbance leading to displacement or behavioural changes, or masking for the short term (days) duration of the cutting activity.	None associated with option.	As there would be noise or vibration associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the removal of the wellhead.
	Consequence Level: I – Negligible	Consequence Level: N/A	
Removal operations: Disturbance of habitat	Permanent removal of artificial habitat if wellhead removed below mudline. In areas where hard substrates are rare, even a small increase in structural complexity of the benthic habitat was observed to attract a rich resident fish assemblage (RPS 2021b). Since 1968, the Legendre-1 wellhead has become a stable benthic habitat with higher marine life abundance and diversity than the surrounding naturally flat, sandy sediments, creating a 'reef effect' (RPS 2021b). The historic Legendre-1 wellhead structure provide an ecologically valuable, high-relief, hard substrate habitat which is otherwise uncommon in the area. The structural	None associated with option. The wellhead will provide a habitat until the wellhead breaks down and degrades over many hundreds of years. Degradation is considered above in this table.	The wellhead will provide a habitat for many hundreds of years and deliver an equal or better environmental outcome as compared to the base case of wellhead removal.

Aspect	Removal Description and Potential Impact	Leave in situ Description and Potential Impact	Assessment Outcome
	complexity of the wellhead has enabled the development of a high successional stage marine growth assemblage which supports an elevated abundance of fish, including commercial and non-commercial fishes. The wellhead structure supports demersal fish assemblages, including black-spotted rockcod (Epinephelus malabaricus), stars and stripes pufferfish (Arothron hispidus), passionfruit cod (Plectropomus areolatus), mangrove jacks (Lutjanus argentimaculatus), juvenile emperor angelfish (Pomacanthus imperator), as well as pelagic fish, for example golden trevally (Gnathanodon speciosus) (RPS 2021b). If the wellhead was removed above the mudline, a small area of hard substrate will remain that provides benthic habitat and associated demersal species.		
	Consequence Level: II – Minor	Consequence Level: N/A	
Removal operations: Disturbance to other users from presence of vessels	Presence of vessel during the removal of the wellhead and the creation of temporary exclusion zones (500 m) around the wellhead for approximately 7 days. This would lead to the displacement of commercial fishers and other users.	None associated with option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Consequence Level: I – Negligible	Consequence Level: N/A.	
Removal operations: Planned operational discharges from vessels	Discharges of sewage and food waste, desal brine, cooling water, deck drainage and bilge water of the vessel for approximately 7 days. The potential impacts include localised nutrient enrichment, organic and particulate loading, toxic impacts to marine fauna, thermal impacts and increased salinity for the duration of the activity.	None associated with option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.

Aspect	Removal Description and Potential Impact	Leave in situ Description and Potential Impact	Assessment Outcome
	Consequence Level: I - Negligible	Consequence Level: N/A	
Removal operations: Planned operational atmospheric emissions from vessels	Greenhouse gas (GHG) emissions discharged to the atmosphere during continued operation of the vessels for approximately 7 days. The impact includes the localised reduction in air quality for the duration of the activity.	None associated with option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Consequence Level: I - Negligible	Consequence Level: N/A.	
Removal operations: Anthropogenic noise from vessels	Noise from the operation of on-board machinery, including diesel engines, ventilation fans (and associated exhaust) and electrical generators of the vessel for approximately 7 days. Injury to hearing or other organs of marine fauna. EPBC Act listed species include pygmy blue whale (migration corridor to the north of wellhead (76 km); and wedge-tailed shearwater reproduction /foraging area overlaps permit, is possible for individuals to be present; and whale shark, WA-20-L overlaps foraging BIA, likely to be present. Impacts to species could include: Disturbance leading to behavioural changes or displacement to fauna. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation; and Masking or interfering with other biologically important sounds (including vocal communications, echolocation, signals and sounds produced by predators or prey).	None associated with option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Consequence Level: I - Negligible	Consequence Level: N/A	
Removal operations: Anthropogenic	External lighting to facilitate navigation and safe operations at night of the vessels for approximately 7 days. Localised alterations to normal marine fauna behaviours for fish, sharks, marine turtles	None associated with option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as

Aspect	Removal Description and Potential Impact	Leave in situ Description and Potential Impact	Assessment Outcome
light from vessels	and seabirds that can alter foraging and reproduction activity in marine turtles, seabirds, fish and sharks.		compared to the base case of wellhead removal.
	Consequence Level: I - Negligible	Consequence Level: N/A	
Removal operations: Hydrocarbon spill response operations	Impacts to the environment from the implementation of hydrocarbon spill response operations, including from vessels and oiled wildlife response activities.	None associated with N/A option.	As there would be no vessel presence associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Consequence Level: II - Minor	Consequence Level: N/A	

Table 2-10 Legendre-1 wellhead options comparative environmental assessment – unplanned events

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
Release of solid objects	Solid objects can be accidentally released to the marine environment during a vessel survey. All non-buoyant waste material or dropped objects are expected to remain within WA-20-L. Buoyant objects could potentially move beyond WA-20-L. Solids have the potential to affect benthic environments and to harm marine fauna through entanglement or ingestion. Release of hazardous solids may result in the pollution of the immediate receiving environment, leading to detrimental health impacts to marine flora and fauna.	None associated with option.	As there would be no risk of dropped solid objects associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk Level: Low	Risk level: N/A	
Marine fauna interaction	During a wellhead removal activity there is the potential for vessels or equipment (for example, ROV) involved in removal to interact with marine fauna, including potential strike or collision, potentially resulting in severe injury or mortality.	None associated with option.	As there would be no risk of marine fauna interaction with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk level: Low	Risk level: N/A	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
Hazardous liquid releases	Accidental release of 100s of litres of hydraulic fluids from cutting system umbilicals that are hazardous to the marine environment due to equipment failure.	None associated with option.	As there would be no risk of hydraulic fluid release associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk level: Medium	Risk level: N/A	
Release of hydrocarbons from vessel	Release of Marine diesel oil (MDO)/ Marine Gas Oil (MGO) to the marine environment could occur between a passing 3rd party vessel and the OSV vessel. The worst credible case (WCC) spill volume is 700 m^3 over six hours.	None associated with option.	As there would be no risk of a vessel hydrocarbon spill associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk level: Medium	Risk level: N/A.	
Vessel presence: Introduction and establishment of Invasive marine species (IMS)	IMS could be introduced from biofouling (on vessel(s) within external/internal (e.g., sea chests, seawater systems) niches and on equipment that is routinely submerged in water (e.g., ROVs) and via discharge of ballast water.	None associated with option.	As there would be no risk of a vessel introducing IMS associated with the option to leave the wellhead in-situ, it would deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk level: Medium	Risk level: N/A.	
	Risk level: Very low	Risk level: Very low	
Gas seepage	Seeps/Bubbles have not been detected in Legendre-1. The potential for seepage at Legendre-1 has been investigated and assessed by internal and external SMEs. Refer to **Section 6.1.1.8** for further details of the assessment. Using the Santos risk matrix, the likelihood of gas seepage bubbles is assessed as remote. This assessment suggests that if the wellhead was removed, or is left in situ and eventually degrades, there is a remote likelihood that bubbles may occur. Based on the well barriers and subsurface formations, in the remote chance that this occurred, the bubbles would be similar to the existing seeps, with a small amount of gas being released to the environment. The potential consequence is negligible.		Leaving the wellhead in-situ is considered to deliver an equal or better environmental outcome as compared to the base case of wellhead removal.
	Risk level: Very Low	Risk level: Very Low	
Presence of wellhead: disturbance to other users	No impact if wellhead removed below the mudline. External cutting of the wellhead above the mudline would result in a portion (up to 100 mm) of the wellhead remaining present and resulting in wellhead	The wellhead is marked on nautical charts and trawlers have been documented to historically avoid the wellhead by at least 0.5 nm, resulting in loss of 0.002% of their trawlable fishery area.	As there would be no remaining wellhead following removal below the mudline it would deliver an equal or better environmental outcome as

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
	remaining on nautical charts and trawl fishers avoiding the area by at least 0.5 nm, resulting in loss of 0.002% of the fishery area. The minor avoidance behaviour of the wellhead may result in a Negligible increase in vessel fuel use and time. External cutting of the wellhead above the mud line would result in the snag risk remaining as a smaller wellhead profile would reduce the ability for fishers to detect the presence of the wellhead on sonar. However, there is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground. The likelihood of interaction with the wellhead by commercial fishers is considered to be Remote.	Trawlers are very unlikely to have an interaction with the wellhead (Wakeford 2021). The minor avoidance of the wellhead may result in a Negligible increase in vessel fuel use and time. During stakeholder consultation, WAFIC provided feedback regarding the potential risks to commercial fisheries. This feedback has been assessed in **Section 4.6** and **7.1**. Due to the size, location and structure of the wellhead, it is a known fixed hazard that has been marked on nautical charts for many years. There is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground. The likelihood of interaction with the wellhead by commercial fishers is considered to be Remote. There is no record of interaction with commercial fishers to date.	compared to the wellhead remaining in situ. In the event of partial removal of the wellhead (i.e., in the event that removal below the mudline fails and 100 mm of the wellhead remains in situ above the mudline) or if the wellhead is not removed, fishers are likely to avoid the area, resulting in a Negligible increase in fuel use and time. For either option the possibility of interaction with the wellhead by commercial fishers is considered to be Remote. There is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground. Whilst a smaller wellhead profile (i.e. in the event that cutting above the mudline occurred) would reduce the ability for fishers to detect the presence of the wellhead on sonar, the location of the wellhead is marked on charts. Either option would result in Negligible impact to other users.
	Risk Level: N/A (in the event of below the mudline removal) I – Very low (in the event of removal above the mud line)	Risk Level: I – Very low	
	Consequence Level: I – Negligible	Consequence Level: I - Negligible	

Table 2-11: Ecologically Sustainable Development

No.	ESD Principle	Relevance
(a)	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	Santos' environmental impact and risk assessment determines impact consequence levels considering the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem, or industry level. The Santos Environment Consequence Descriptors highlights the integration of long-term and short-term environmental, and socio-economic considerations (**Appendix J**). The assessment of impact consequence levels for the proposed activity simultaneously assesses of the activity's potential implications against this principle. The assessment in **Section 2.2.2, 6.1, 6.9** and **7.1** integrates long-term and short-term considerations.
(b)	If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	For planned activities, assessment of this ESD principle is inherent in Santos' environmental impact and risk assessment process, as Santos does not proceed with activities if the consequence of a planned event is ranked III (Moderate) or above. For unplanned events, if the residual risk is ranked between Medium and Very High, an assessment against this principle is required. If the residual risk is Medium to Very High and there is significant scientific uncertainty associated with the aspect, additional assessment against this principle is required. Degradation of the entire remaining wellhead introduces contaminants (predominantly iron oxides) to the water column and sediment surrounding the wellhead as it degrades over time (i.e., over hundreds of years). Breakdown of compounds into the water column and accumulation in sediments may affect infauna species surrounding the wellhead. Only low levels of elevated iron were noted within 20 m of the wellhead when compared to the reference sites surveyed in 2021 (RPS 2021b). Contaminants are expected to disperse rapidly in currents. The wellhead degradation is assessed as having a consequence Level: I – Negligible. No threat of serious or irreversible damage.
(c)	The principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	For planned activities, assessment of this ESD principle is inherent in Santos' environmental impact and risk assessment process, as Santos does not proceed with activities if the consequence of a planned event is ranked III (Moderate). For an unplanned event, if the residual risk is ranked between Medium and Very High, an assessment against this principle is required. The assessment of this principle is implemented through further details on ALARP assessment highlighting assurance that potential impacts and risks are managed, and the environment is maintained for the benefit of future generations. Evaluation of the importance and relevance of stakeholder interest for this principle, if triggered, is fundamental in demonstrating that the environment is maintained for the benefit of future generations. Leaving the wellhead in place will not have significant impacts on future generations. The wellhead degradation is assessed as having a consequence Level: I – Negligible. The presence of the wellhead (interaction with marine users) has been ranked as having a consequence Level I – Negligible. The health, diversity and productivity of the environment may be enhanced by the presence of the structure. The wellhead structure supports demersal fish assemblages, including black-spotted rockcod (Epinephelus malabaricus), stars and stripes pufferfish (Arothron hispidus), passionfruit cod (Plectropomus areolatus), mangrove jacks (Lutjanus argentimaculatus), juvenile emperor angelfish (Pomacanthus imperator), as well as pelagic fish, for example golden trevally (Gnathanodon speciosus) (RPS 2021b).

No.	ESD Principle	Relevance
		Leaving the wellhead in situ does not compromise the health, diversity and productivity of the environment.
(d)	The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Leaving the wellhead in situ will provide a hard-substrate for marine flora and fauna. In areas where hard substrates are rare, even a small increase in structural complexity of the benthic habitat was observed to attract a rich resident fish assemblage (RPS 2021b).

2.2.2.4 Conclusion - assessment of equal or better environmental outcomes

Table 2-8 shows that the option of leaving the wellhead in situ delivers an equal or better environmental outcome than removing the wellhead. Whilst the environmental consequences of either option are ranked as Negligible and Very Low for the identified impacts in common (contamination from material degradation, disturbance to other users), the removal option results in localised and direct environmental impacts, which would be avoided by leaving the wellhead in situ.

The removal operations would cause localised seabed disturbance, generate metal cuttings, vessel emissions, displacement of other marine users and remove artificial habitat. Removal of the wellhead would displace the rich resident fish assemblage, potentially resulting in mortality of many of the individuals so displaced.

Two aspects are common to the wellhead removal (above the mudline) and wellhead in situ options, being impact from wellhead degradation and disturbance to other users. Only the full removal below the mudline of the wellhead avoids these environmental aspects.

The option of leaving the wellhead in situ results in the slow release of contaminants due to degradation of the wellhead over time, however this would also continue to a lesser extent if the wellhead was removed above the mudline. Degradation of the wellhead will gradually introduce contaminants (predominantly iron oxides) to the water column and sediment surrounding the wellhead over time (i.e., over hundreds of years). Ocean currents are expected to rapidly disperse breakdown products dissolved in the water column and negligible environmental impact is expected.

Sediment sampling in 2021 confirmed that iron concentrations in sediments around the wellhead were slightly elevated above the background concentrations (RPS 2021b). Contaminants are expected to disperse to below Australian and New Zealand Toxicant default guideline values for water quality in aquatic ecosystems (ANZG, 2018) within 100 m (RPS 2021a) and negligible environmental impact is expected.

The ongoing presence of the wellhead may present a snagging risk for fishing nets, leading to gear damage or loss to commercial trawl fishers, until the wellhead has completely degraded. It is also noted that a minor snag risk will remain in the event that wellhead removal below the mudline cannot be achieved and the contingency method of removal above the mudline is employed. However, an independent snag risk study concluded that it is unlikely that snagging will occur in the future.

Non-trawl commercial fishers within the region may see increased catch in close proximity to the wellhead due to the 'reef effect' (Schramm et al. 2021, Reeves et al. 2018, Sommer et al. 2019), and recreational fishers may target the area (consultation feedback from King Bay Fishing Club, 2021).

2.2.3 Conclusion

The results of the above assessments, show that leaving the Legendre-1 wellhead in situ is the preferred decommissioning option. It meets subsection 572(3), 572(7) and 270(3)(c) of the OPGGS Act, if accepted by NOPSEMA.

The leave in situ option also aligns with the NOPSEMA policy on Section 572 (NOPSEMA, 2020) and DISER Decommissioning Guideline (DISER, 2022), which allows for consideration of alternatives to removal if those alternatives deliver equal or better environmental, safety and well integrity outcomes.

The wellhead removal study concluded that whilst there are internal and external cutting options available, there is a low chance that they will be successful. There is significant uncertainty in the feasibility of regaining sufficient well access to execute an internal cutting method and the external cutting tool most likely to succeed has never been used in this application.

It is estimated that wellhead removal costs would be in the range of AUD 10 to 15 M for a single dedicated campaign. This cost would be reduced if the campaign can be combined with an additional Santos offshore campaign, with the Legendre-1 costs of a combined campaign estimated to be 5 to 10 M. The complexities and challenges associated with the wellhead removal could likely result in the activity duration and cost escalating through failed removal attempts. This would extend the duration of environmental impact for no gain in terms of environmental outcomes.

The removal of the wellhead carries technical, safety and environmental risks that are not introduced should the wellhead remain in situ. Loss of complex habitat will reduce the biodiversity and productivity of the area.

The costs and risks to the environment to remove the wellhead are considered disproportionately high to the negligible environmental impact of leaving the wellhead in-situ. The Legendre-1 wellhead has been in place for >50 years, and the assessment of options (Section 2.2.2) shows that leaving the Legendre-1 wellhead permanently in situ has been demonstrated to provide an equal or better environmental outcome in comparison to removing the wellhead. As per Item 3.15 of the DISER 'Guideline - Offshore petroleum decommissioning', this EP demonstrates that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws.

Table 2-12: Legendre-1 wellhead leave in situ

Topic	Description	Summary
Legislation	*OPGGS Act* Section 572 requires titleholders to remove from the title area all structures, equipment and property that are neither used nor to be used in connection with the operations. Section 572(7) of the OPGGS Act allows for titleholders to make other arrangements that are satisfactory to NOPSEMA with respect to property etc. for the purposes of section 270 of the OPGGS Act via an accepted permissioning document. Other arrangements in the context of this regulatory policy include where a titleholder intends to do something that is different from the requirements of section 572(2) and (3). Maintenance and removal of property etc. requirements are subject to other provisions of the OPGGS Act, the regulations, directions given by NOPSEMA or the responsible Commonwealth Minister, and any other law. Section 270 requires titleholders to remove all property before the title can be surrendered or to make alternative arrangements that are satisfactory to NOPSEMA in relation to that property.	Leaving the wellhead in situ needs to be approved by NOPSEMA. This EP demonstrates that the alternative decommissioning approach (i.e. leave in situ) meets all applicable requirements under the OPGGS Act and regulations, any other legislative requirement, and relevant international obligations.
Guidelines	*The Offshore Petroleum Decommissioning Guideline (DISER)* Removal of all property is the "base case", 3.7. The removal of all property and the plugging and abandonment of wells in line with the provisions of s572 of the OPGGS Act is the default decommissioning requirement under the OPGGS Act (i.e. the 'base case'). The Guideline also states: 3.15. Options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity	This EP demonstrates that leaving the wellhead in situ has equal or better environmental outcomes to removal.

Topic	Description	Summary
	and safety-related matters, and other applicable laws.	
	The NOPSEMA Policy Section 572 Maintenance and removal of property Arrangements other than removal of property etc. will only be accepted where they are appropriate having regard to applicable legislation, relevant Australian Government guidelines and policy. Specifically, the titleholder must demonstrate that the alternative decommissioning approach meets all applicable requirements under the OPGGS Act and regulations, any other legislative requirement, and relevant international obligations.	This EP demonstrates that the alternative decommissioning approach (i.e. leave in situ) meets all applicable requirements under the OPGGS Act and regulations, any other legislative requirement, and relevant international obligations.
Technical / engineering risks	Section 2.2.1, 6.9.3 and 7.1.3.	This EP demonstrates that the wellhead removal option carries significant technical and engineering challenges and risks.
Health and safety	Removal activities carry the standard health and safety risks associated with an offshore vessel campaign, particularly handling the wellhead onboard. The wellhead would also have to be taken ashore for treatment and waste management processes.	Leaving the wellhead in situ avoids the health and safety risks associated with handling and disposing the materials.
Delivers equal or better environmental outcome	Section 2.2.2.	This EP demonstrates that leaving the wellhead in situ has equal or better environmental outcomes to removal.
Principles of Ecologically Sustainable Development	Table 2-11.	Leaving the wellhead in situ is consistent with the Principles of ESD.
Environmental risks	Section 6.9.4: Overall worst-case consequence I – Negligible. Section 7.1.4. The residual risk associated with this event is Very Low.	The environmental risks associated with leaving the wellhead in situ are negligible and very low.
ALARP	Section 6.9.5 and 7.1.5.	The EP demonstrates the environmental risks and impacts are ALARP.
Acceptable	Section 6.9.6 and 7.1.6.	The consequence is ranked as I or II. No further information is required in the consequence assessment. Risks and impacts consistent with the principles of ecologically sustainable development (ESD). Risks and impacts are consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives).

Topic	Description	Summary
		Risks and impacts are consistent with the Santos's Environmental Management Policy. Risks and impacts are consistent with stakeholder expectations. Performance standards ensure the impact or risk is considered to be ALARP.

2.3 Vessel-based support activities

Vessel-based surveillance, monitoring and inspection activities will occur at WA-20-L. Vessel activities may occur at any time within the period that this EP is in force. Vessel activities may be performed during any season, over days to weeks, within permit WA-20-L and may include 24-hour operations. Vessel-based activities may include the use of ROVs and various sampling and monitoring equipment, such as that described in this section.

2.3.1 Vessels

Typically, a single vessel will be used to undertake the monitoring and inspection activities. The actual vessel will be determined according to the purpose of the support activity, however for environmental assessment purposes, the Bhagwan Dryden has been considered a representative vessel, noting that the actual vessel to be used is likely to be smaller; the intent being to assess impacts and risks of the largest typical vessel so that the assessment is conservative and allows for flexibility in vessel selection at the time. The Bhagwan Dryden is a 57 m long, 1,475-tonne multi-purpose support vessel with accommodation for up to 42 people. Previous surveys in 2021 were conducted from a 24 m vessel.

The vessel will typically use thruster propellors to maintain station and is not expected to need to anchor as part of the support activity. Due to the short duration of the activity refuelling at sea will not be required.

Liquid discharges from the vessel may include treated sewage, greywater, cooling water, oily water (bilge), deck run-off and desalination brine (from reverse osmosis system). Atmospheric emissions will include exhaust gases from fuel combustion. Other environmental emissions include light emissions from vessel decks, accommodation, navigation and safety systems; and noise emissions from above and below the water (for example, engine noise).

2.3.2 Support activities

Possible monitoring and inspection activities at WA-20-L are described below and include a range of methods for monitoring the seabed, infrastructure, water, sediments and the marine environment. Water, sediment and other items may be collected from WA-20-L.

Other similar surveillance, monitoring and inspection activities to those described in this section may also be required.

Section 6.1.1.9 includes further details about a monitoring and inspection campaign that will occur during the course of this EP.

2.3.2.1 ROV surveys

ROVs can be used for several reasons including visual observations, inspections and sampling. The ROVs will be linked directly to the vessel by a neutrally buoyant tether or via a tether management system (TMS). Depending on the ROV selected, it may carry equipment such as torque tools and manipulator arms, which are typically powered by hydraulics or electricity. Most ROVs are equipped with at least a video camera and lights. Additional equipment can include sonars, multi-beam echo sounders, magnetometers, still cameras, a manipulator or cutting arm, laser pointers, various sensors and water and sediment samplers. The ROV may be equipped with specialised equipment for collecting or characterising gas seepages. The class and size of the ROV used will be dependent on the operational objectives of the survey.

2.3.2.2 Towed or drop camera

A towed or drop camera system may be used for visual observations and inspections. The camera is linked directly to the vessel and usually has a USBL (ultra-short baseline) system allowing position fixes.

2.3.2.3 Water sampling

Water samples may be taken from desired water depths using a Niskin or Van Dorn water sampler, or similar device. The samplers are deployed to the desired depth by hand or using a hydraulic winch or capstan. Once at the desired depth a weight will be sent down the deployment line to trigger the sampler. Additionally, integrated samples may be collected using a small submersible pump with a hose to the surface, or a bucket.

2.3.2.4 Water profiling

Water profiling may be used to measure water pressure (depth), temperature, conductivity (salinity), turbidity, pH, light, fluorescence, hydrocarbon concentration and pumped dissolved oxygen concentration. Typically, the profiler is lowered from the sea surface to the desired depth by a hydraulic winch, capstan or by hand. After the desired depth is reached and measurements taken the profiler is slowly recovered to the deck.

A methane sensor (‘sniffer’) may be used to detect dissolved and entrained hydrocarbons in the water column at gas seepage sites. The sniffer can be secured to the ROV and the live data monitored onboard the vessel.

2.3.2.5 Sediment sampling

Sediment samples may be taken to provide geotechnical data and for analysis of contaminants such as hydrocarbons and metals within surface sediments. An ROV-based coring system is set up on deck prior to being lowered to the seafloor where it is deployed, and a sediment sample collected. It is then recovered to deck where the sample is sub-sampled as appropriate. Alternatively, a benthic grab sampler such as a van Veen, Smith-Macintyre or Day grab system may be used to collect sediment samples from a small area of the seabed.

2.3.2.6 Gas flow rate monitoring

Flow rates of gas at the seepage sites may be measured. This can be done by using suitable gas collection apparatus operable from the ROV at depth. A transparent funnel is fitted to the ROV to collect the gas bubbles as they rise in a stream from the seep site. Acoustic gas detection and data collection may also be conducted using Single-Beam Acoustic System (SBES) or similar.

3 Description of the environment

OPGGS(E)R 2023 Requirements
Section 21. Environmental Assessment
Description of the environment 21(2) The environment plan must: + describe the existing environment that may be affected by the activity; and + include details of the particular relevant values and sensitivities (if any) of that environment. Note: The definition of environment in section 5 includes its social, economic and cultural features. 21(3) Without limiting paragraph (2)(b), particular relevant values and sensitivities may include any of the following: + the world heritage values of a declared World Heritage property; + the national heritage values of a National Heritage place; + the ecological character of a declared Ramsar wetland; + the presence of a listed threatened species or listed threatened ecological community; + the presence of a listed migratory species; + any values and sensitivities that exist in, or in relation to, part or all of: + a Commonwealth marine area; or + Commonwealth land.

3.1 Environment that may be affected

This section summarises the key physical, biological, socio-economic and cultural characteristics of the existing environment that may be affected (the EMBA) by the activity, both from planned events associated with the wellhead remaining in situ, the gas seepage, and vessel-based monitoring of the gas seepage, and unplanned events associated with vessel-based monitoring of the gas seepage. The description of the environment applies to two areas:

+ The permit area WA-20-L (**Figure 2-1**),
+ The EMBA, described in **Section 3.1.2**.

The potential area impacted by planned activities includes the area immediately adjacent to each gas seepage locations (Legendre Hub, Legendre South-1 and Legendre South-3) and the Legendre-1 wellhead site. No activity will occur at the Legendre-1 wellhead location, it is described purely for environmental impact assessment purposes only.

A description of the environmental values and sensitivities present is provided in this chapter. The Environmental Values and Sensitivities reference document (Version 10) has been referenced in the EP and included in **Appendix E**. As the reference document has recently been updated (to Revision 11), it has been reviewed, and any relevant new information or changes have been included this EP where applicable, to ensure the latest information is included in the EP.

3.1.1 Protected matters search tool reports

A desktop search of WA-20-L was undertaken using the Protected Matters Search Tool (PMST) to identify MNES listed under the EPBC Act. The results of these searches, undertaken on 5 July 2024 are provided in **Appendix F**. The co-ordinates are provided within the PMST report to allow for duplication of the search and verification if required. Santos do not have control over the PMST search tool output, but instead have provided the reports and coordinates to ensure transparency.

3.1.2 Determining the environment that may be affected

Stochastic hydrocarbon dispersion and fate modelling of the worst case spill scenario for vessel-based monitoring (**Section 7.6**), was undertaken to inform the EMBA (**Figure 3-1**).

Stochastic modelling is created by overlaying hundreds of individual hypothetical oil spill simulations from an oil spill into a single map, with each simulation subject to a different set of metocean conditions drawn from historical records. Stochastic modelling is completed to reduce uncertainty in risk assessment and spill response planning.

The modelling considered three key physical or chemical phases of hydrocarbons that pose differing environmental and socioeconomic risks: surface, entrained, and dissolved aromatic hydrocarbons. The modelling used defined hydrocarbon exposure values, as relevant, to identifying an area that might be contacted by hydrocarbons, environment risk assessment and oil spill response planning, for the various hydrocarbon phases. Refer to **Table 3-1** for the exposure values used and to **Section 7.6** for the reasons why these exposure values have been selected and how they relate to the risk assessment.

3.1.2.1 Hydrocarbon exposure values

The EMBA is based on the low exposure values used in stochastic modelling (**Table 3-1**). The EMBA encompasses the outermost boundary of the worst-case spatial extent of the four hydrocarbon phases listed in **Table 3-1** for the worst-case credible spill scenario selected and is displayed on **Figure 3-1**.

The low exposure values are used as a predictive tool to set the outer boundaries of an EMBA and may not necessarily result in ecologically significant impacts. To inform the evaluation of potential environmental consequences of a hydrocarbon release (impact assessment), modelling is undertaken using higher exposure values (in other words, the concentrations at which environmental consequences may result). The higher exposure values are known as 'moderate' and 'high' are further explained in **Table 3-1**.

A low exposure threshold, which represents a visible oil (rainbow) sheen, has been used to provide an indication of the extent to which stakeholders may visually observe oil on the sea surface. This is considered to provide a conservative extent of potential impacts to visual amenity. Biological impacts are expected to occur within the moderate and high exposure values which represent a subset of the EMBA. Refer to **Section 7.6** for further information about the spill trajectory modelling thresholds that have been selected.

Table 3-1: EMBA hydrocarbon exposure values

Hydrocarbon phase	Exposure Value		
	Low	Moderate	High
Floating (g/m²)	1	10	50
Shoreline accumulation (g/m²)	10	100	1,000
Dissolved aromatics (ppb)	10	50	400
Entrained (ppb)	10	100	-

3.2 Environmental values and sensitivities

This section summarises environmental values and sensitivities including physical, biological, social, economic and cultural features within the marine environment that are relevant to WA-20-L and the EMBA.

A summary of the information derived from the PMST, Bioregional Plans and Fauna Recovery Plans relevant to WA-20-L and the EMBA is provided in this section. A comprehensive description of the environment (in accordance with section 21(1)(2) of the OPGGS(E)R) is available in **Appendix E**. This draws upon existing knowledge and a comprehensive review of information about the marine environmental values and sensitivities in the region.

The figures presented in this section of the EP have been zoomed to the extent of the data boundaries to show all relevant data layers in a legible manner. Some data layers that sit within the map area but are not present within the EMBA are not displayed.

3.3 Physical environment

3.3.1 Bioregions

Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0, the bioregion overlapped by WA-20-L is the North West Shelf (NWS) Province. The EMBA overlaps the NWS Province, Northwest and Northwest Transition IMCRA bioregions (**Figure 3-2**). The provincial bioregions are described in **Appendix E**.

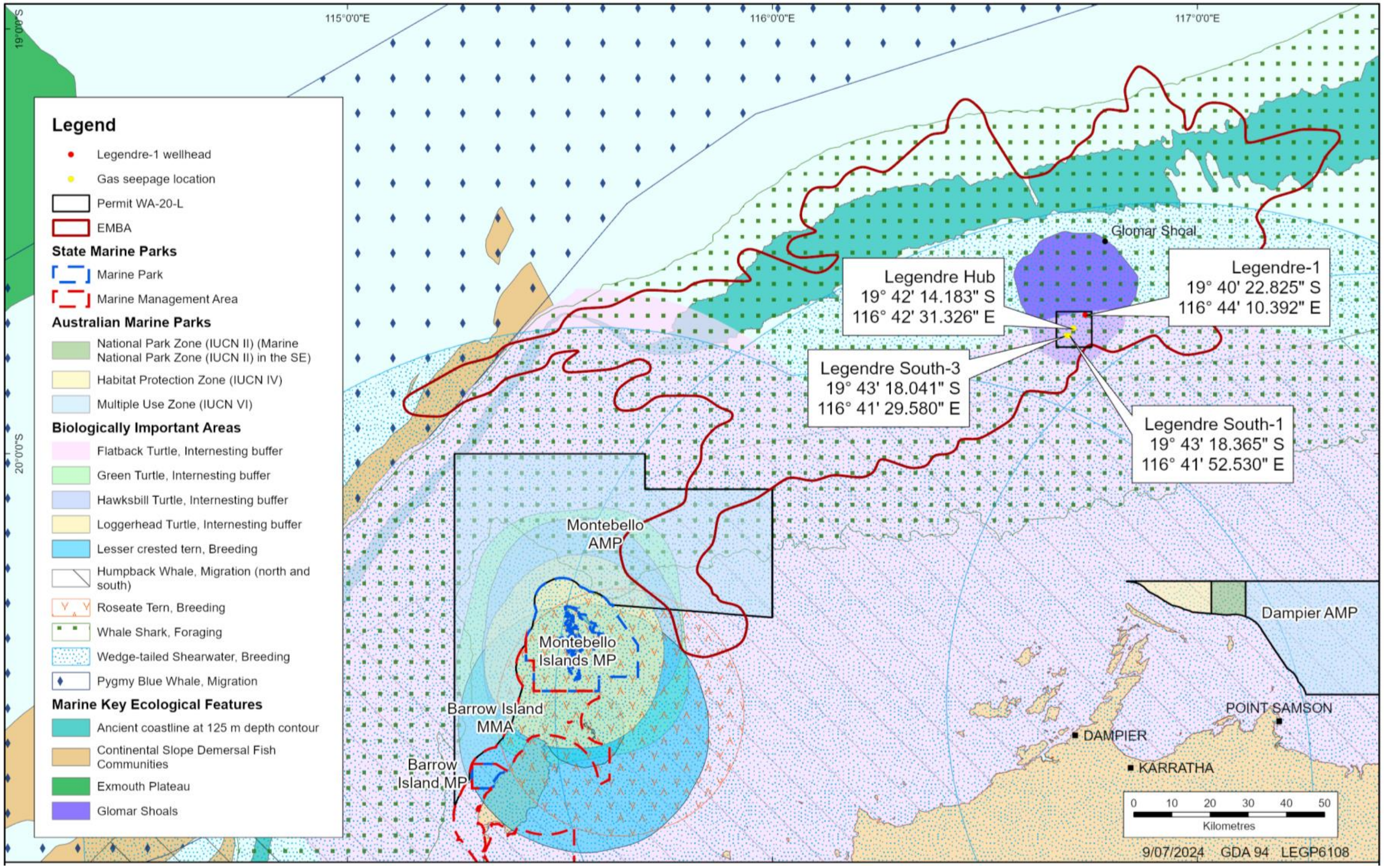


Figure 3-1: WA-20-L EMBA

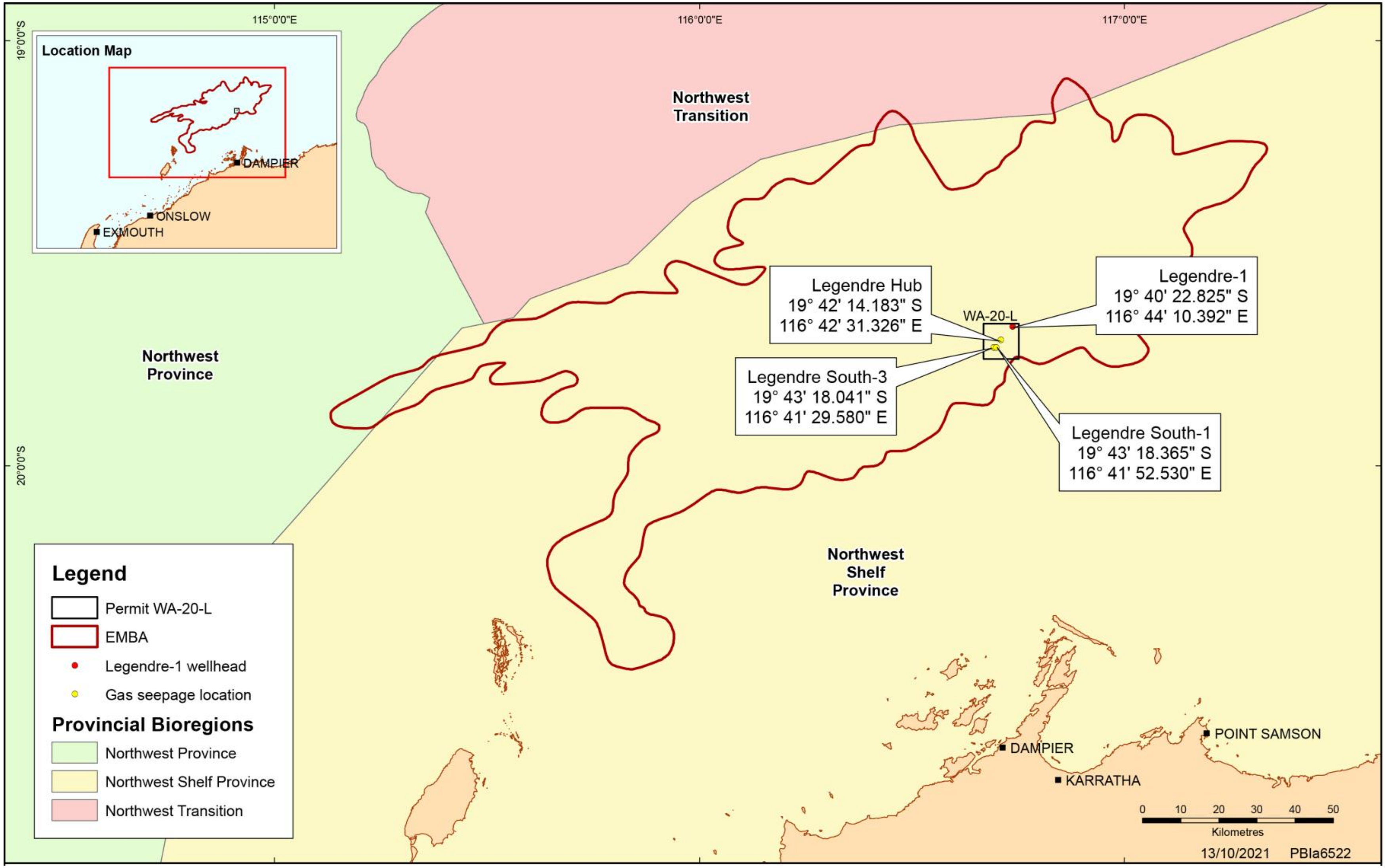


Figure 3-2: IMCRA 4.0 provincial bioregions within WA-20-L and the EMBA

3.3.2 Climate and meteorology

The climate of the North West Marine Region (NWMR) is dry tropical, exhibiting a hot summer season from October to April and a milder winter season between May and September (BoM 2021a). There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds (Pearce *et al.* 2003).

Air temperatures in the region, as measured at the Dampier Port platform (approximately 120 km south of WA-20-L), indicate maximum average temperatures during summer of 34.8 °C and minimum temperatures of 17.3 °C in winter (BoM 2021a).

The region experiences a tropical monsoon climate, with distinct wet (October to April) and dry (May to September) seasons (Pearce *et al.* 2003). Rainfall in the region (measured at the Dampier Port platform) typically occurs during the wet season (summer), with highest falls observed during late summer, and often associated with the passage of tropical low-pressure systems and cyclones (BoM 2021a; Pearce *et al.* 2003). Rainfall outside this period is typically low (BoM 2021a).

Winds vary seasonally, with a tendency for winds from the south-west quadrant during summer and the south-east quadrant in winter. The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. During winter months, the relative position of the high-pressure cells moves further north, leading to prevailing south-easterly winds blowing from the mainland. Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, generally between April and August (Pearce *et al.* 2003).

Tropical cyclones are a relatively frequent event for the region, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast (BoM 2021b). Tropical cyclone activity can occur between November and April and is most frequent in the region during January to March, with an annual average of approximately one storm per month. Cyclones are less frequent in the months of November, December and April but historically the worst storms have occurred in April (DEWHA 2008a).

3.3.3 Hydrography and oceanography

Tides in the NWS Province are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards then north-west (Pearce et al. 2003). Within the NWS Province, tidal activity is considered a significant factor for the oceanography. Tides in this part of the bioregion are large and tend to increase in magnitude from south to north (from an amplitude of 2 m at Exmouth to over 6 m at Broome during the spring tides (BOM 2021c). In shallower waters, the tides contribute to the vertical mixing of the surface water layer and sediments. It should be noted that in the shallower coastal waters there is a high evaporation rate, which results in slower offshore movement of denser, more saline waters across the NWS Province. This dense, more saline water is typically found as a bottom layer of coastal water out as far as the 200 m depth contour (DEWHA 2008a).

The oceanography of this bioregion is generated by the movement of surface currents from the waters of the Indonesian Flowthrough (IFT) Current. The IFT waters are circulated from the NWMR through the South Equatorial and Eastern Gyral currents. Within the NWS Province water circulation is highly seasonal. During winter, the ITF's southern flow is at its strongest and tends to dominate the water column. Conversely, during summer, the throughflow is weaker and strong winds from the south-west causes intermittent reversal of the currents, which generates upwellings of colder and deeper water (DEWHA 2008a). Also during summer, monsoon winds are highly influential in driving water movement and water column mixing (O'Hara 2023).

The offshore oceanic sea water characteristics of the NWS Province exhibit seasonal and water depth variation in temperature and salinity, being greatly influenced by major currents in the region (DEWHA 2008a). Surface waters are relatively warm year-round due to the tropical water supplied by the ITF and the Leeuwin Current, with temperatures reaching 30 °C in summer and dropping to 22 °C in winter (Pearce et al. 2003). Variation in surface salinity along the NWS Province throughout the year is minimal (between 35.2 and 35.7 PSU), with slight increases occurring during the summer months due to intense coastal evaporation (Pearce et al. 2003; James et al. 2004). This small increase in salinity during summer is then countered by the arrival of the lower salinity waters of the Leeuwin Current and IFT in autumn and winter (James et al. 2004).

Water depth across WA-20-L ranges from 51-57 m (RPS 2021b).

3.3.4 Water quality

The offshore waters in WA-20-L are relatively clear, although an increase in turbidity in summer (primarily due to increase in plankton productivity) is common (Apache 2011). Regional scale events such as the flooding of northwest rivers, associated with cyclonic rainfall, may also cause occasional periods of prolonged increase in turbidity.

Plankton consists of microscopic organisms typically divided into phytoplankton (algae) and zooplankton (fauna including larvae). Plankton play a major role in the trophic system with phytoplankton being a primary producer and zooplankton being a primary consumer. Phytoplankton rapidly multiply in response to bursts of nutrient availability and are subsequently consumed by zooplankton that in turn are consumed by other fauna species (Thompson *et al.* 2015).

Spatial distribution of phytoplankton and zooplankton is irregular, both vertically and horizontally. Sporadic/short-lived and potentially localised episodes of nutrient upwelling can occur as a result of internal waves (the rising and sinking of sea water layers of different densities) at the shelf break, wind-driven currents, or cyclonic activity, which influence higher plankton concentrations (Thompson *et al.* 2015).

As a key indicator for ecosystem health and change, plankton distribution and abundance has been measured for over a century in Australia. The compilation of this data has been made publicly available through the Australian Ocean Data Network (2022) and has been used in the Australia State of the Environment 2021 report (Trebilco et. Al 2021) to nationally assess marine ecosystem health. According to their findings, production has decreased in the north-west and north-east shelf and offshore in the Indian Ocean.

Plankton within WA-20-L are expected to reflect the conditions of the wider upper continental slope. Surface waters of the NWS Province have low nutrient availability, with phytoplankton occurring in higher concentrations near areas where upwelling of deeper, nutrient-rich water occurs (Thompson 2015). The most common plankton in the offshore waters of the NWS Province are diatoms, single-cell algae with cell walls made of silica. Sampling by the Thompson *et al.* (2015) across the NWMR found that large summer blooms of diatoms occur in Pilbara offshore waters west of Broome. These blooms occur at the junction of stratified cool and warm water mass at depths of at least 45 m.

3.3.4.1 Oceanic methane

Oceanic methane seeps are widespread globally, and sources include seeps from near surface hydrocarbon deposits, decomposition of methane hydrates, methanogenesis to seeps from volcanic vents (Reeburgh 2007).

Studies have been conducted in the North-West region of Australia to infer or detect the presence of natural hydrocarbons, including methane, through the detection of gas seeps, oil slicks, and oil seeps. Burns *et al.* (2001) used sediment traps on the NWS Province (Exmouth shelf to Exmouth Plateau) to assess vertical fluxes in hydrocarbons and found both biogenic and petroleum derived hydrocarbons present. The Yampi Shelf on the NWS was surveyed using a variety of methods including seismic amplitudes, hydrocarbon sniffer, satellite and fluoro sensors (O'Brien *et al.* 2005). They detected natural dry gas and oil seepage, and concluded that the spatial distribution, concentration and relative composition of the seepage was controlled by the regional seal's thickness. Stalvies *et al.* (2017) searched for hydrocarbon seeps along the margins of the Ashmore Platform and found one persistent and two episodic natural thermogenic seeps.

Specific studies for the presence of methane across the NWS include that by Ross *et al.* (2017) who detected low to very low concentrations of methane in waters of the Browse Basin and surmised that this may indicate low level methane gas seepage in the area. Evidence of a subsurface natural gas hydrate system was also found on the Exmouth Plateau (NWS Province) using 3D seismic data, with the origin of the hydrocarbon thought to be thermogenic (Paganoni *et al.* 2019) which may be the origin of seeps within that region.

Evidence for natural microbial production of methane has been recorded in the Arafura Sea where isolated sediment sample sites had methane concentrations of more than 100 ppm where background levels were generally less than 10 ppm. The isotopic composition of samples indicated that the methane was of biogenetic origin (Grosjean *et al.* 2007).

3.3.5 Sediment quality

Sediment differentiation in the NWS Province occurs on a north–south gradient and is thought to differ from the rest of the NWMR. Sediment in the region is broadly characterised by calcareous gravel, sand and silt (DEWHA 2008a).

Sediments have been sampled using a van Veen grab at four locations, Legendre- 1, Legendre Hub, Legendre South-1, and Legendre South-3 for analysis of contaminants of concern (RPS 2021a). The well site samples were collected within approximately 50 m from the wells and reference site samples were taken approximately 100 m away from the well sampling sites. Three replicate samples were collected from each site. Particle size analysis was undertaken using a combination of laser diffraction and sieving, with the results combined to provide a full particle size distribution (PSD) curve and chemical parameters. The analysis revealed that sediment in the Legendre field was predominately gravely sand, with low levels of clay and silt (RPS 2021b). Of the metals and metalloids in the sediments sampled from the Legendre field permit, none were recorded at concentrations above the relevant Australian & New Zealand Guidelines (ANZG) (2018) default guideline value. Where no guideline values were available a trigger value was calculated by doubling the average reference values for each site (ANZECC & ARMCANZ 2000). Barium concentrations were above the calculated trigger value at the Legendre-1 wellhead and Legendre Hub locations The results from sediment quality sampling from surveys completed in 2021 are summarised below:

+ concentrations of aluminium, barium and iron were all elevated (exceeded recommend guidelines) at the Legendre Hub well sites compared with the reference sites and other locations;
+ barium concentrations at the Legendre Hub site were higher than other sites, up to 250 mg/kg in one sediment sample, exceeding the calculated trigger values. Barium concentrations were also elevated at one Legendre-1 site;
+ TRH concentrations were higher at the Legendre Hub than at the other locations, with two sites sampled within the Legendre Hub having TRH concentrations of 490 mg/kg and 430 mg/kg compared to the guideline value of 280 mg/kg. Other sites sampled within the Legendre Hub (>20 m) had TRH concentrations below the guideline value;
+ other locations surveyed (Legendre-1, Legendre South-1, Legendre South-3) had TRH concentrations below the reporting limit;
+ There were no detections of benzene, toluene, ethylbenzene, xylenes, naphthalene (BETXN) in any samples; and
+ the combined values for radium and thorium were below the guideline value of 35,000 Bq/kg at all sampled locations (RPS 2021b).

The patterns of sediment contamination are consistent with localised contamination from drilling muds and fluids and possibly decommissioning activities (RPS 2021b).

3.3.6 Benthic habitats

Santos commissioned RPS to coordinate and conduct a visual survey at the historic Legendre- 1 wellhead, to characterise the benthic habitats and any remaining sea floor infrastructure at all eight well locations. RPS completed the surveys in March 2021 using a ROV.

In general, the benthic habitats across WA-20-L comprised bare sands with very sparse macrophytes and filter-feeders attached to underlying hard substrate, as well as sediment epibiota such as mobile echinoderms (RPS 2021b). Small boulders in these areas were colonised by sparse assemblages of sessile filter-feeders and transient mobile fauna. In areas of low-profile reef or denser patches of small boulders, the epibiotic communities were richer but still in low density. The hard substrate habitats tended to have low structural complexity (flat) and supported sparse assemblages of filter-feeders, sponges, soft corals and other invertebrates and low abundances of demersal fish. Wherever hard substrates (wellhead, concrete, mattresses, debris) stood higher above the seabed and created complex physical shelter, the fish assemblages were visibly much more abundant.

Since 1968, the Legendre-1 wellhead has become a stable benthic habitat with higher marine life abundance and diversity than the surrounding naturally flat, sandy sediments, creating a ‘reef effect’ (RPS 2021b). The historic Legendre-1 wellhead structure and debris on the adjacent seabed provide an ecologically valuable, high-relief, hard substrate habitat which is otherwise uncommon in the area. The structural complexity of the wellhead has enabled the development of a high successional stage marine growth assemblage which supports an elevated abundance of fish, including commercial and non-commercial fishes. The wellhead structure supports demersal fish assemblages, including black-spotted rockcod (*Epinephelus malabaricus*), stars and stripes pufferfish (*Arothron hispidus*), passionfruit cod (*Plectropomus areolatus*), mangrove jacks (*Lutjanus argentimaculatus*), juvenile emperor angelfish (*Pomacanthus imperator*), as well as pelagic fish, for example golden trevally (*Gnathanodon speciosus*) (RPS 2021b).

At the Legendre Hub the abandoned infrastructure supports an abundant fish assemblage, including; blackspot rock cods, rankin cods, stars and stripes pufferfish, black-tail snapper (*Lutjanus fulvus*), longnose emperor (*Lethrinus olivaceus*), and mangrove jacks, (refer to **Section 3.6.1.5**). A cowtail stingray (*Pastinachus sephen*), flatback turtle (*Natator depressus*) and tawny nurse shark (*Nebrius ferrugineus)* were also observed near the structure (RPS 2021b).

The Glomar Shoals (of the Glomar Shoals Key Ecological Feature (KEF), described in **Appendix E** on the outer Western Shelf of the West Pilbara, has bathymetrically complex features (Azmi Abdul Wahab et al 2018). The Glomar Shoals includes a plateau region at 40 m in depth, and at the 60 m depth contour covers an area of approximately 14,700 ha. The benthic taxa at the Glomar shoals includes macroalgae, coral, sponges, and other organisms, highest in the depth region of 40 m, with the proportion of cover decreasing with depth up the 80 m (Azmi Abdul Wahab et al 2018).

3.4 Protected and significant areas

The PMST search identified that there are no protected areas present within WA-20-L (no Australian Marine Parks, World Heritage Areas (WHA), Ramsar sites or National and Indigenous Heritage Areas). Four significant areas overlap WA-20-L: one key ecological feature (KEF) and three Biologically important areas (BIAs). An additional KEF, six BIAs and an Australian Marine Park is overlapped by the EMBA (**Table 3-2**).

A description of these protected areas is provided in **Appendix E**. Where a description is not provided in **Appendix E** it has been included below **Table 3-2**.

Table 3-2: Protected and significant areas within WA-20-L and the EMBA

Value/ sensitivity	Name	Within WA-20-L	Within EMBA	Distance to Wellhead	Distance to gas seep
Key Ecological Features	Ancient coastline at 125 m contour	✗	✓	26 km	30 km
	Glomar Shoals	✓	✓	Overlaps	Overlaps
	Continental Slope Demersal Fish Communities	✗	✓	131 km	127 km
Biologically important areas	Whale Shark Foraging	✓	✓	Overlaps	Overlaps
	Wedge-tailed shearwater reproduction	✓	✓	Overlaps	Overlaps
	Humpback whale migration	✗	✓	Overlaps	Overlaps
	Flatback turtle Internesting buffer	✓	✓	Overlaps	Overlaps
	Green turtle internesting buffer	✗	✓	119 km	112 km
	Hawksbill turtle internesting buffer	✗	✓	124 km	117 km
	Pygmy blue whale migration	✗	✓	76 km	75 km
	Roseate tern reproduction	✗	✓	123 km	116 km
	Lesser crested tern reproduction	✗	✓	132 km	125 km
	Loggerhead turtle Internesting buffer	✗	✓	127 km	120 km
Australian Marine Parks	Montebello Multiple Use Zone	✗	✓	89 km	83 km

The Multiple Use (IUCN VI) management zone of the Montebello Australian Marine Park is "managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park values." Oil and gas operations and associated oil spill response may be conducted in a Multiple Use Zone (IUCN VI) subject to the class approval and prescriptions in the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

3.4.1 Ancient coastline at 125 m depth contour

The continental shelf of the North-west Marine Region contains several terraces and steps which reflect changes in sea level that occurred over the last 100,000 years. The most prominent of these features occurs at a depth of 125 m as an escarpment along the North West Shelf and Sahul Shelf (DSEWPC 2012). Where the ancient, submerged coastline provides areas of hard substrate it may contribute to higher biological diversity in areas otherwise dominated by soft sediments. Little detailed knowledge was available at the time of its designation, but it was thought that the hard substrate of the escarpment is likely to support sponges, crinoids, molluscs, echinoderms (DSEWPC 2012) and that changes in topography at these depths are critical points for the generation of internal waves (Holloway et al. 2001 cited in DEWHA 2008c), playing a minor role in aiding localised upwelling or at least regional mixing associated with the seasonal changes in currents and winds. It was hypothesised that this prominent floor feature could be important as a migratory pathway for cetaceans and pelagic species such as the whale shark and humpback whale, as they move north and south between feeding and breeding grounds (DEWHA 2008c). Enhanced productivity could potentially be attracting baitfish, which in turn provide food for the migratory species. The pressures of potential concern on the biodiversity value of this feature generally include ocean acidification as a result of climate change (DoEE 2019a).

Currey-Randall et al. (2021) investigated drivers of fish species richness and assemblage composition spanning six degrees of latitude along sections of the ancient coastline, categorised as ‘on’ and ‘off’ the ancient coastline at 125m KEF (AC125) based on depth, across a range of habitats and seafloor complexity (~60–180 m depth). While some surveyed sections of the AC125 had hard bottom substrate and supported enhanced fish diversity, including over half of the total species observed, species richness and abundance overall were not greater on the AC125 than immediately adjacent to the AC125. Instead, depth, seafloor complexity and habitat type explained patterns in richness and abundance, and structured fish assemblages at both local and broad spatial scales. Fewer fishes were associated with deep sites characterized by negligible complexity and soft-bottom habitats, in contrast to shallower depths that featured benthic biota and pockets of complex substrate. Drivers of abundance of common species were species-specific and primarily related to sampling areas, depth and substrate. Fishes of the ancient coastline and adjacent habitats are representative of mesophotic fish communities of the region, included species important to fisheries and conservation, and several species were observed deeper than their currently known distribution.

Wakeford et al. (2023) investigated the bathymetry, sedimentology and benthic habitats at 5 locations across the AC125 using multibeam sonar, sediment samples and towed video imagery. Approximately 98% of the seabed surveyed was comprised of unconsolidated soft sediment habitat (mud/sand/silt) supporting negligible epibenthic biota. The prevalence of soft sediment suggests that post-glacial sediments have infilled parts of the ancient coastline), with cross-shelf, probably tidal currents in the northern section of the study area responsible for some of the sediment mobilisation and southern study areas more influenced by oceanic conditions. Within study areas, total biotic cover ranged from 0.02% to 1.07%. Of the biota encountered, most comprised filter feeder organisms (including gorgonians, sponges, and whip corals) whose distribution was associated with pockets of consolidated hard substrate. Benthic community composition varied with both study area and position in relation to the predicted AC125. In general, consolidated substrate was proportionally higher in water shallower than the AC125 compared to on the AC125 or deeper than the AC125. Spatially continuous maps of predicted benthic habitat classes (pre-determined benthic communities) in each study area were developed to characterise biodiversity. Spatial modelling corroborated depth and large-scale structural complexity of the seafloor as surrogates for predicting likely habitat class. The study provided an important assessment of the AC125 and concluded that if a distinct coastline exists in the areas surveyed, it is now largely buried and as such does not provide a unique hard substrate habitat.

3.5 Threatened and migratory fauna

A summary of the Listed Threatened Species (LTS) and Listed Migratory Species (LMS) identified by the PMST for WA-20-L and the EMBA is shown in **Table 3-3** (note: the EMBA species’ totals include those of WA-20-L).

Table 3-3: Summary of the LTS and LMS identified by the PMST

Category	Within WA-20-L	Within the EMBA
LTS	24	26
LMS	33	40

Category	Within WA-20-L	Within the EMBA
Total	57	66

BIAs such as an aggregation, reproduction, resting, nesting or feeding area or known migratory routes for these species within WA-20-L and the EMBA are shown in **Figure 3-1** and are further described in **Appendix E**. The relevant BIAs that occur within WA-20-L and the EMBA are identified in **Table 3-2**.

Those listed as threatened or migratory species groups and which have been identified as potentially being present within WA-20-L or the EMBA, including their relevant recovery plans, are listed in **Table 3-4**. Threatened and migratory species within these species' groups are described in **Appendix E**. Those not described in **Appendix E** are described below **Table 3-4**.

Roseate tern

The roseate tern (*Sterna dougallii*) is listed as a migratory species under the EPBC Act and may be found within the EMBA, including a designated reproduction BIA for the species. In Western Australia, the subspecies is regularly recorded from north of Mandurah to around Eighty Mile Beach, in the Pilbara Region. Around the Kimberley coastline the subspecies occurs at scattered sites, north to the Bonaparte Archipelago and possibly further. Records in south-west Western Australia indicate that the subspecies used to be a sporadic visitor to the region, but occurs regularly at present. In addition, breeding colonies have been established on Lancelin Island and Second Rock, off south-west Western Australia (Higgins & Davies 1996).

Scalloped hammerhead shark

The scalloped hammerhead shark (*Sphyrna lewini*) is listed as conservation dependent under the EPBC Act and may be found within the EMBA. Globally distributed, in Australia, scalloped hammerhead sharks are found in both coastal and oceanic environments, in warm-temperate to tropical waters typically across the northern coastline. There are no aggregation sites identified for scalloped hammerhead sharks in the EMBA, however juveniles of the species utilise shallower nearshore habitats of northern Australia, and there are some indications that there may be important nursery habitats in the area. As a species that is slow to mature and has low fecundity, the scalloped hammerhead shark is vulnerable to overfishing, with its unique head morphology also increasing its likelihood of capture as bycatch in net fisheries. Although no longer targeted by commercial fisheries, global population declines have prompted recent changes to national and state-based approaches to stock management, including total allowable catch limits (Northern Territory) or complete prohibition of take (Queensland) (DCCEEW, 2024a). No scalloped hammerhead shark BIAs were identified in the EMBA.

Table 3-4: Threatened and migratory marine fauna

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events
			WA-20-L	EMBA		
Birds						
Calidris acuminata	Sharp-tailed Sandpiper	V Migratory	✓	✓	Conservation Advice for Calidris acuminata (sharp-tailed sandpiper) (DCCEEW 2024)	Planned + Gas seepage + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations Unplanned + Release of hydrocarbons
Calidris canutus	Red Knot	E Migratory	✓	✓	Conservation Advice Calidris canutus Red knot (TSSC 2016a)	
Calidris ferruginea	Curlew Sandpiper	CE Migratory	✓	✓	Conservation Advice for Calidris ferruginea (curlew sandpiper). (DCCEEW 2023a)	
Numenius madagascariensis	Eastern Curlew	CE Migratory	✓	✓	Conservation Advice for Numenius madagascariensis (DoE 2015a)	
Phaethon lepturus fulvus	Christmas Island White-tailed Tropicbird	E	✓	✓	Conservation Advice Phaethon lepturus fulvus white-tailed tropicbird (Christmas Island). (DoE 2014a)	
Phaethon rubricauda westralis	Red-tailed Tropicbird (Indian Ocean)	E	✓	✓	Conservation Advice for Phaethon rubricauda westralis (Indian Ocean red-tailed tropicbird). (DCCEEW 2023b)	
Sternula nereis nereis	Australian Fairy Tern	V Migratory	✓	✓	Approved Conservation Advice for Sternula nereis nereis (DSEWPC 2011a)	
Actitis hypoleucos	Common Sandpiper	Migratory	✓	✓	-	
Anous stolidus	Common Noddy	Migratory	✓	✓	-	
Calidris melanotos	Pectoral Sandpiper	Migratory	✓	✓	-	
Calonectris leucomelas	Streaked Shearwater	Migratory	✓	✓	-	
Fregata ariel	Lesser Frigatebird	Migratory	✓	✓	-	

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events
			WA-20-L	EMBA		
Fregata minor	Great Frigatebird	Migratory	✓	✓	-	
Phaethon lepturus	White-tailed Tropicbird	Migratory	✓	✓	-	
Macronectes giganteus	Southern Giant Petrel	E	✗	✓	National recovery plan for threatened albatrosses and giant petrels 2011-2016. Department of Sustainability, Environment, Water, Population and Communities (2011).	Unplanned + Release of hydrocarbons
Sterna dougallii	Roseate Tern	Migratory	✗	✓	-	
Sharks and Rays						
Carcharias taurus (west coast population)	Grey Nurse Shark	V	✓	✓	Recovery plan for the Grey Nurse Shark (*Carcharias taurus*) (DoE 2014)	Planned + Gas seepage + Wellhead degradation + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations Unplanned + Release of hydrocarbons
Carcharodon carcharias	Great White Shark	V Migratory	✓	✓	Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPC 2013)	
Pristis pristis	Freshwater Sawfish	V Migratory	✓	✓	Approved Conservation Advice for Pristis pristis (largetooth sawfish). (DoE 2014b)	
Pristis zijsron	Green Sawfish	V Migratory	✓	✓	Approved Conservation Advice for Green Sawfish (DEWHA 2008b), Listing Advice for Pristis zijsron (Green Sawfish) (TSSC 2008), Sawfish and River Sharks Multispecies Recovery Plan (DoE 2015b)	
Rhincodon typus	Whale Shark	V Migratory	✓	✓	Conservation Advice for Rhincodon typus (whale shark) (TSSC 2015a), Listing advice on Rhincodon typus (Whale shark) (TSSC 2001)	
Sphyrna lewini	Scalloped Hammerhead	CD	✓	✓	Listing Advice for Sphyrna lewini (scalloped hammerhead). (DCCEEW 2024a).	
Anoxypristis cuspidata	Narrow sawfish	Migratory	✓	✓	-	
Carcharhinus longimanus	Oceanic Whitetip Shark	Migratory	✓	✓	-	

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events
			WA-20-L	EMBA		
Isurus oxyrinchus	Shortfin Mako	Migratory	✓	✓	Listing Advice Isurus oxyrinchus shortfin mako shark (TSSC 2014)	
Isurus paucus	Longfin Mako	Migratory	✓	✓	-	
Manta alfredi	Reef Manta	Migratory	✓	✓	-	
Manta birostris	Giant Manta	Migratory	✓	✓	-	
Pristis clavata	Dwarf sawfish	V	✗	✓	Approved Conservation Advice for Pristis clavata (Dwarf Sawfish). Department of the Environment, Water, Heritage and the Arts (2009)	Unplanned + Release of hydrocarbons
Thunnus maccoyii	Southern Bluefin Tuna	CD	✗	✓	Commonwealth Listing Advice on Thunnus maccoyii (Southern Bluefin Tuna). (TSSC 2010).	
Marine turtles						
Caretta caretta	Loggerhead Turtle	E Migratory	✓	✓	Recovery Plan for Marine Turtles in Australia (DoEE 2017)	Planned + Gas seepage + Wellhead degradation + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations Unplanned + Release of hydrocarbons
Chelonia mydas	Green Turtle	V Migratory	✓	✓	Recovery Plan for Marine Turtles in Australia (DoEE 2017)	
Dermochelys coriacea	Leatherback Turtle	E Migratory	✓	✓	Approved Conservation Advice on Dermochelys coriacea (DEWHA 2008c), Recovery Plan for Marine Turtles in Australia (DoEE 2017)	
Eretmochelys imbricata	Hawksbill Turtle	V Migratory	✓	✓	Recovery Plan for Marine Turtles in Australia (DoEE 2017)	
Natator depressus	Flatback Turtle	V Migratory	✓	✓	Recovery Plan for Marine Turtles in Australia (DoEE 2017)	
Sea snakes						

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events
			WA-20-L	EMBA		
Aipysurus apraefrontalis	Short-nosed Seasnake	CE	✓	✓	Approved Conservation Advice on Aipysurus apraefrontalis (DSEWPC 2011b)	Planned + Gas seepage + Wellhead degradation + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations Unplanned + Release of hydrocarbons
Aipysurus foliosquama	Leaf-scaled Seasnake	CE	✗	✓	Approved Conservation Advice for Aipysurus foliosquama (Leaf-scaled Sea Snake) (DSEWPC 2011c)	Unplanned + Release of hydrocarbons
Mammals						
Balaenoptera borealis	Sei Whale	V Migratory	✓	✓	Conservation Advice for Balaenoptera borealis (sei whale) (TSSC 2015b)	Planned + Gas seepage + Wellhead degradation + Light emissions + Atmospheric emissions + Operational discharges
Balaenoptera musculus	Blue Whale	E Migratory	✓	✓	Conservation management Plan for the Blue Whale (DoE 2015) Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021)	
Balaenoptera physalus	Fin Whale	V Migratory	✓	✓	Conservation Advice for *Balaenoptera physalus* (fin whale) (TSSC 2015c)	
Megaptera novaeangliae	Humpback Whale	Migratory	✓	✓	Conservation Advice for *Megaptera novaeangliae* (humpback whale) (TSSC 2015d)	

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events
			WA-20-L	EMBA		
Balaenoptera edeni	Bryde's Whale	Migratory	✓	✓	-	+ Spill response operations Unplanned + Release of hydrocarbons
Delphinus delphis	Common Dolphin	Migratory	✓	✓	-	
Grampus griseus	Risso's Dolphin	Migratory	✓	✓	-	
Orcinus orca	Killer Whale	Migratory	✓	✓	-	
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted Bottlenose Dolphin	Migratory	✓	✓	-	
Dugong dugon	Dugong	Migratory	✗	✓	-	Unplanned + Release of hydrocarbons
Physeter macrocephalus	Sperm Whale	Migratory	✗	✓	-	
Sousa sahulensis	Australian Humpback Dolphin	Migratory	✗	✓	-	
Threatened species (EPBC Act Status): E = Endangered, V = Vulnerable, CE = Critically Endangered, CD = Conservation Dependant						

3.6 Socio-Economic receptors

Socio-economic activities that may occur within WA-20-L and the EMBA include commercial fishing, oil and gas exploration and production, recreational fishing and tourism as summarised in **Table 3-5**. Further detail on these can be found in the sections below.

Table 3-5: Summary of socio-economic activities within WA-20-L and the EMBA

Receptor	Description	WA-20-L Presence	EMBA Presence	Relevant events within permit area	Relevant events within the EMBA
Commercial fisheries: Commonwealth managed fisheries	Four Commonwealth fisheries have the licence to operate within WA-20-L and the EMBA. None of these were actively fished in WA-20-L recently. See **Section 3.6.1** for further detail. Effort in the North West Slope Trawl Fishery has occurred historically within the EMBA.	✗	✓	N/A	Unplanned + Release of hydrocarbons

Receptor	Description	WA-20-L Presence	EMBA Presence	Relevant events within permit area	Relevant events within the EMBA
Commercial fisheries: State-managed Fisheries	Management boundaries of twelve state managed fisheries intersect WA-20-L. Four fisheries actively fished within WA-20-L for the period 2009-2019: + Mackerel Managed Fishery + Pilbara Fish Trawl (Interim) Managed Fishery + Pilbara Demersal trap Managed Fishery + Pilbara Line Fishery. See **Section 3.6.1** for further detail.	✓	✓	Planned + Gas seepage + Presence of wellhead: displacement or interaction with other users + Spill response operations Unplanned + Presence of wellhead: snagging + Release of solid objects + Introduction of invasive marine species + Hazardous liquid releases	Unplanned + Release of hydrocarbons
Cultural Heritage	A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System was undertaken and indicated there are no registered cultural heritage sites within WA-20-L or the EMBA. A search of the National Native Title Tribunal database was undertaken and indicated there are no Native Title determinations or applications within WA-20-L or the EMBA. There are no Indigenous Protected Areas, registered cultural heritage sites or Native Title determinations identified within WA-20-L or the EMBA. See **Section 3.6.2** for further detail. The potential values and sensitivities related to sea country were sought via the consultation. No feedback regarding sea country has been provided at the time of consultation for this EP.	✗	✗	N/A	N/A
Defence	There are no Defence restricted areas within WA-20-L or the EMBA.	✗	✗	N/A	N/A
Petroleum industry	Oil and gas facilities are present within the EMBA, operated by other titleholders.	✗	✓	N/A	Unplanned + Release of

Receptor	Description	WA-20-L Presence	EMBA Presence	Relevant events within permit area	Relevant events within the EMBA
					hydrocarbons
Shipping	No designated shipping fairways are within WA-20-L. Large commercial vessels mostly associated with the oil and gas industry and Western Australian major ports may move through the EMBA in transit. See **Section 3.6.4** for further detail.	✗	✓	N/A	Unplanned + Release of hydrocarbons
Shipwrecks	A search of the department of Agriculture, Water and the Environment Australasian Underwater Cultural Heritage Database was undertaken and indicated there are no registered shipwrecks within WA-20-L or the EMBA.	✗	✗	N/A	N/A
Tourism and recreation	The open waters of WA-20-L support some recreational fishing activity over the Glomar shoals. See **Section 3.6.2** for further detail.	✓	✓	N/A	Unplanned + Release of hydrocarbons
Submarine cables	The Darwin-Jakarta-Singapore Cable intersects the EMBA (see **Figure 3-9**).	✗	✓	N/A	N/A

3.6.1 Commercial fisheries

Commonwealth and State fisheries that have management areas overlapping with WA-20-L are listed in **Table 3-6** and **Table 3-7.**

An analysis of ABARES Fishery status reports was undertaken to assess the historical effort of Commonwealth commercial fisheries in WA-20-L and the EMBA. The result of the assessment is provided in **Table 3-6.**

State commercial fishing catch and effort (FishCube) data was assessed to identify where the greatest fishing effort in each state-managed fishery occurred and the relative importance of waters within WA-20-L from 2009-2019. Due to confidentiality reasons, DPIRD is unable to release catch and effort data for data blocks where less than three vessels fished during the period of interest (i.e., less than three vessels per month). Where this applies, the Vessel Count is marked ‘Less than 3’, while Weight and Fishing Day Count are marked as ‘N/A’. Data blocks where the results are provided in this way confirm that fishing effort did occur within the block during that period, but the associated catch and effort values are not available. Data blocks where no fishing is recorded do not return any data.

Review of at least five years of historical fishing effort within WA-20-L is considered appropriate to describe the relative importance of the waters to commercial fisheries as this aligns with the five-year review cycle of Commonwealth fisheries harvest strategies. Five years of data is analysed to manage performance of the fishery through time and the scale of inter-annual variability of environmental parameters that affect fisheries resources (DAWR 2018), both indicating the suitability of this time scale to fishing decision of individual fishers.

It is important to recognise the limitations of referring to blocks with less than three vessels; although the number of vessels may be less than three, a block may experience high catch or effort by just one or two vessels. However, these blocks may experience less effort than other blocks where three or more vessels frequent the area to fish.

An analysis of FishCube data to demonstrate the historical effort of state commercial fisheries in WA-20-L and the EMBA is provided in **Table 3-7**.

Commercial fisheries that have historical effort within WA-20-L are described in **Sections 3.6.1.1** to **3.6.1.4**, summarised as:

+ Commonwealth fisheries with historical effort within WA-20-L:
+ Nil
+ State fisheries with historical effort within WA-20-L:
+ Mackerel Managed Fishery (MMF)
+ Pilbara Demersal Trap Managed Fishery (PDTMF)
+ Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF)
+ Pilbara Line Fishery (PLF)

Table 3-6: Commonwealth fisheries that overlap WA-20-L and the EMBA

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within WA-20-L
					WA-20-L	EMBA	
Southern Bluefin Tuna Fishery (SBTF)	Southern bluefin tuna (*Thunnus maccoyii*)	2016–2017: 5,334 t	Purse seine, pelagic longline and some minor line	Effort is concentrated in the Great Australian Bight and no catch or effort from the SBTF occurs in WA.	✓	✓	**No** - No effort from the SBTF occurs in Western Australia. Therefore, the activities of the SBTF are considered to be outside the scope of this EP.
Western Skipjack Tuna Fishery (WSTF)	Skipjack tuna (*Katsuwonus pelamis*)	2017-18: None in either zone	Purse seine	The WSTF is located in all Australia waters west of 142° 30' 00°E, out to 200 nm from the coast.	✓	✓	**No -** There has been no fishing effort in the Skipjack Tuna Fishery since the 2008-09 season, and in that season, activity concentrated off South Australia (DAWR, 2018).
Western Tuna and Billfish Fishery (WTBF)	Bigeye and yellowfin tuna, albacore (*T obesus, T alacares, T alalunga*), striped marlin (*Kajikia audax*), swordfish (*Xiphias gladius*)	2018: 278 t	Pelagic, longline, minor line and purse seine	Extends westward from Cape York Peninsula (142°30' E) off Queensland to 34° S off the WA west coast. It also extends eastward from 34° S off the west coast of WA across the Great Australian Bight to 141° E at the South Australian–Victorian border.	✓	✓	**No -**WA-20-L overlaps with the management area of the WTBF; however, the proposed survey is not expected to affect the actual activities of this fishery as fishing effort from 2014 to 2020 has been recorded from offshore Point Cloates (Exmouth) and south along the WA coast to Augusta in the south-west of WA (DAWR, 2020).
North West Slope Trawl Fishery (NWSTF)	Scampi (*Metanephrops australienis, M boschmai, M velutinus*)	2016-17: 57.8 t	Demersal trawl	The NWSTF comprises one or two vessels each year. Effort is concentrated mostly towards the 200 m isobaths boundary of the NWSTF from north of the Montebello Islands to Scott Reef (DAWR, 2018).	✗	✓	**No -** The management area of the NWSTF does not overlap the permit area.

Table 3-7: State fisheries that overlap WA-20-L and the EMBA

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within WA-20-L
					WA-20-L	EMBA	
Mackerel Managed Fishery (MMF)	Spanish mackerel (*Scomberomorus commerson*)	2019/20: 291 t	Trolling	The MMF is divided into three management areas, Area 1 (Kimberley), Area 2 (Gascoyne), and Area 3 (Gascoyne-West Coast). Each area has its own management arrangements.	✓	✓	**Yes -** WA-20-L overlaps with the management area of the MMF. There is lower catch and fishing effort within WA-20-L, relative to other areas within the fishery (refer to **Section 3.6.1.1**).
Marine Aquarium Managed Fishery (MAMF)	Over 250 target species of finfish (228 species caught in 2012). Fishermen can also take coral, live rock, algae, seagrass and invertebrates.	2019: 69,446 fishes, 36.325 t of coral, live rock & living sand and 12 L of marine plants and live feed.	Hand harvest while diving or wading. Hand-held nets	Dive based fishery operating all year throughout WA waters but restricted by diving depths. The MAFMF is able to operate in all State waters (between the Northern Territory border and South Australian border). The fishery is typically more active in waters south of Broome with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth and Dampier (Gaughan & Santoro 2021).	✓	✓	No - WA-20-L overlaps with the management area of the MAMF; however, there is not expected to impact to fishery activities due to the water depth of WA-20-L.
Nickol Bay Prawn Managed Fishery (NBPMF)	Primarily targets banana prawns (*Penaeus merguiensis*)	2019/20: 254 t	Otter trawl	Operates along the western part of the North-West Shelf in coastal shallow waters. The boundaries of the NBPMF are 'all the waters of the Indian Ocean and Nickol Bay between 116°45' east longitude and 120° east longitude on the landward side of the 200 m isobath'.	✓	✓	No - WA-20-L overlaps with the management area of the NBPMF, however, there is no catch or fishing effort within WA-20-L
Northern Demersal Scalefish Managed Fishery (NDSMF)	Red emperor, Goldband snapper	2019/20: 1507 t	Trap and line techniques	The Northern Demersal Scalefish Managed Fishery operates off the north-west coast of Western Australia. The NDMSF is divided into an inshore sector (Area 1), and an offshore sector (Area 2). Area 2	✓	✓	No - WA-20-L overlaps with Area 2 of the NDSMF, however there is no historical fishing effort in WA-20-L from 2009-2019 (DPIRD fish cube data). Therefore, there are no predicted impacts to this fishery.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within WA-20-L
					WA-20-L	EMBA	
				extends from the 30 m isobath the AFZ (Gaughan & Santoro 2021).			
Onslow Prawn Limited Entry Fishery (OPLEF)	Brown tiger (*Penaeus esculentus*) and Western king prawns (*P. monodon*)	2019/20: < 50 t	Trawl	The OPLEF (now known as the Onslow Prawn Managed Fishery) Area 3 overlaps WA-20-L. Only one vessel operates in the fishery, close to the Dampier and Onslow ports.	✓	✓	No - WA-20-L overlaps with the management area of the OPLEF, however, there is no historical catch or fishing effort within WA-20-L.
Pearl oyster Managed Fishery	Indo- Pacific silver-lipped pearl oyster (*Pinctada maxima*).	2019: 611,816 shells	Diving	Pearl oyster fishing vessels operate from the Lacepede Islands north of Broome to Exmouth Gulf in the south, with the fishery is separated into three zones (Gaughan & Santoro 2021).	✓	✓	No - WA-20-L overlaps with the WAPOMF zone 3 area, however, catch in 2019 was only taken from zone 2. Therefore, there are no predicted impacts to this fishery.
Pilbara Crab Managed Fishery (PCMF)	Blue Swimmer (*Portunus armatus*) Mud Crab (*Scylla* spp.)	2019: 29.5 t	Commercial crab pots	Crabbing activity along the Pilbara coast is centred largely on the inshore waters from Onslow through to Port Hedland, with most commercial and recreational activity occurring in and around Nickol Bay.	✓	✓	No - WA-20-L overlaps with permitted area of the PCMF; however, fishery effort is concentrated in inshore waters. Therefore, there are no predicted impacts to this fishery.
Pilbara Demersal Trap Managed Fishery (PDTMF)	Red emperor, bluespotted emperor and Rankin cod	2019/20: 680 t	Traps	This fishery is licensed to fish in the offshore waters of the Pilbara region, subject to specific closure areas (Gaughan & Santoro 2021).	✓	✓	**Yes -** WA-20-L overlaps with the management area of the PFTIMF, and trap fishers may be active within this overlap. There is lower catch and fishing effort within WA-20-L, relative to other areas within the fishery (refer to **Section 3.6.1.3**).
Pilbara Fish Trawl (Interim) Managed	Red emperor, bluespotted emperor and Rankin cod and other demersal	2019/20: 2,142 t	Demersal trawl	This fishery is licensed to fish in the offshore waters of the Pilbara region, subject to specific closure areas (Gaughan & Santoro 2021).	✓	✓	**Yes -** WA-20-L overlaps with the management area of the PFTIMF, and trawl fishers may be active within this overlap. There is lower catch and fishing

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within WA-20-L
					WA-20-L	EMBA	
Fishery (PFTIMF)	snappers, emperors and groupers.						effort within WA-20-L, relative to other areas within the fishery (refer to **Section 3.6.1.2**).
Pilbara Line Fishery (PLF)	Pink snapper (*Chrysophrys auratus*), red emperor (*Lutjanus* seibae); bluespotted emperor (*Lethrinus punctulatus*); and Rankin cod (*Epinephelus multinotatus*)	2019/20: 148 t	Pole-and-line techniques	This fishery is licensed to fish in the offshore waters of the Pilbara region and operates as an exemption-based fishery (Gaughan and Santoro 2021).	✓	✓	**Yes -** WA-20-L overlaps with the management area of the PLF, and line fishers may be active within this overlap. There is low catch and fishing effort within WA-20-L, relative to other areas within the fishery (refer to **Section 3.6.1.4**).
Specimen Shell Managed Fishery (SSMF)	Shells (cowries, cones)	2019: 7,232 shells	Hand harvest while diving or wading. ROV at depths between 60 and 300 m.	Dive based fishery operating all year throughout WA waters but restricted by diving depths. There is a concentration of effort in areas adjacent to population centres such as Broome, Karratha, Exmouth, Shark Bay, Perth, Mandurah, the Capes area and Albany (Gaughan & Santoro 2021).	✓	✓	No - The SSMF management boundary overlaps with WA-20-L, however the presence of the wellhead is not anticipated to impact on this fishery.
Western Australian North Coast Shark Fisheries (WASF)	Sandbar (*Carcharhinus plumbeus*), hammer head (*Sphyrnidae*), blacktip (C *melanopterus*) and lemon shark (*Negaprion brevirostris*)	2019/20: 0 (closed since 2008/09)	Gill net, longline	The WASF management area The WANCSF extends from longitude 114°06´E (North West Cape) to 123°45´E (Koolan Island), however the area between North-West Cape and 120°E and all waters south of latitude 18°S has been closed indefinitely (Gaughan & Santoro 2021).	✓	✓	No - The fishery has not been active since 2008. Therefore, there are no predicted impacts to this fishery.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within WA-20-L
					WA-20-L	EMBA	
Western Australian Sea Cucumber Fishery (WASCF)	Sandfish (*Holothuria scabra*) and deep water redfish (*Actinopyga echinites*)	2019/20: 2 t sandfish, 5 t Redfish	Hand-harvest fishery of diving/wading	Fishing occurs in the northern half of the State from Exmouth Gulf to the Northern Territory border.	✓	✓	No - WA-20-L overlaps with the management area of WASCF. Since the WASCF is shore-based, there are no predicted impacts to this fishery.

3.6.1.1 Mackerel Managed Fishery

The MMF targets Spanish mackerel using trolling techniques (Gaughan & Santoro 2021). Analysis of FishCube data shows that WA-20-L overlaps with approximately 10 km^2 of the area of fishing effort for the period between 2009-2019 (**Figure 3-4**). This effort was 'less than 3 vessels' at three time points (April 2014, August 2016 and February 2017). The MMF have a higher fishing effort west of WA-20-L, with fishing effort temporally distributed from zero effort in 2015 to being present across five months in 2017. The MMF fish in the vicinity of WA-20-L with fishing effort occurring relatively consistently across the entire year with no identified peak periods.

3.6.1.2 Pilbara Fish Trawl (Interim) Managed Fishery

The PFTIMF targets red emperor, bluespotted emperor, and rankin cod using demersal trawl techniques (Gaughan & Santoro 2021). Analysis of FishCube data shows that WA-20-L overlaps with approximately 10 km^2 of the area of fishing effort for the period between 2009-2019 (**Figure 3-5**). The PFTMF had a maximum of three active vessels overlapping the WA-20-L permit area in 2009-2019, with active vessels in WA-20-L across all years ranging from 6 months in 2017 to 11 months in 2018. Fishing day count was 231-304 within the WA-20-L permit area, with a higher fishing effort in the surrounding area (**Figure 3-5**). Fishing effort occurs relatively consistently across the entire year with no identified peak periods.

Santos engaged a Subject Matter Expert, AMC, to undertake an assessment of the potential impacts of the wellhead on commercial fisheries (**Section 2.2.2.2**). This included a review of fisheries that potentially operate near the wellhead and therefore may have to actively avoid the wellhead (**Figure 3-3**). The study examined the historical trawl fishing effort near the wellhead specifically and found that the main fishing activity is associated with the Pilbara Demersal Scalefish Fisheries which is consistent with the data presented in Fishery Status Reports (Newman et al. 2019, 2020) and DPIRD catch and effort data.

Figure 3-3: PTIMF trawl tracks around the Legendre-1 wellhead location (AMCS 2021)

3.6.1.3 Pilbara Demersal Trap Managed Fishery

FishCube data for the PFTIMF was only available in a coarse 60 nm Catch and Effort System (CAES) block resolution. As such, the area of fishing effort and overlap is likely to be overestimated, as fishing is likely limited spatially to discrete locations rather than over the entire area of the 60 nm blocks.

The PDTMF targets red emperor, bluespotted emperor, and rankin cod using trawling methods (Gaughan & Santoro 2021). Analysis of FishCube data shows that WA-20-L overlaps with approximately 10 km^2 of the area of fishing effort for the period of 2009-2009 (**Figure 3-6**). The PDTMF had 'less than 3 vessels' across the WA-20-L permit area in 2009-2019, with active vessels across all years ranging from being present in 5 months in 2009 to 12 months in 2017 and 2018. In the surrounding area there was more than three active vessels, suggesting higher effort outside of WA-20-L. Fishing effort occurs relatively consistently across the entire year with no identified peak periods.

3.6.1.4 Pilbara Line Fishery

FishCube data for the PLF was only available in a coarse 60 nm CAES block resolution. As such, the area of fishing effort and overlap is likely to be overestimated, as fishing is likely limited spatially to discrete locations rather than over the entire area of the 60 nm blocks.

The PLF targets pink snapper, red emperor, bluespotted emperor, and rankin cod using pole-and-line techniques (Gaughan & Santoro 2021). Analysis of FishCube data shows that WA-20-L overlaps with approximately 10 km^2 of fishing effort for the period of 2009-2019 (**Figure 3-7**). The PLF had ‘less than 3 vessels’ overlapping the WA-20-L permit area in 2009-2019. The PLF didn’t have any active vessels in WA-20-L in 2010 and 2012-2014, with fishing effort presence ranging from 3 months in 2011 to 10 months in 2017. Fishing effort occurred sporadically across years, with varied effort within a year with no identified peak periods.

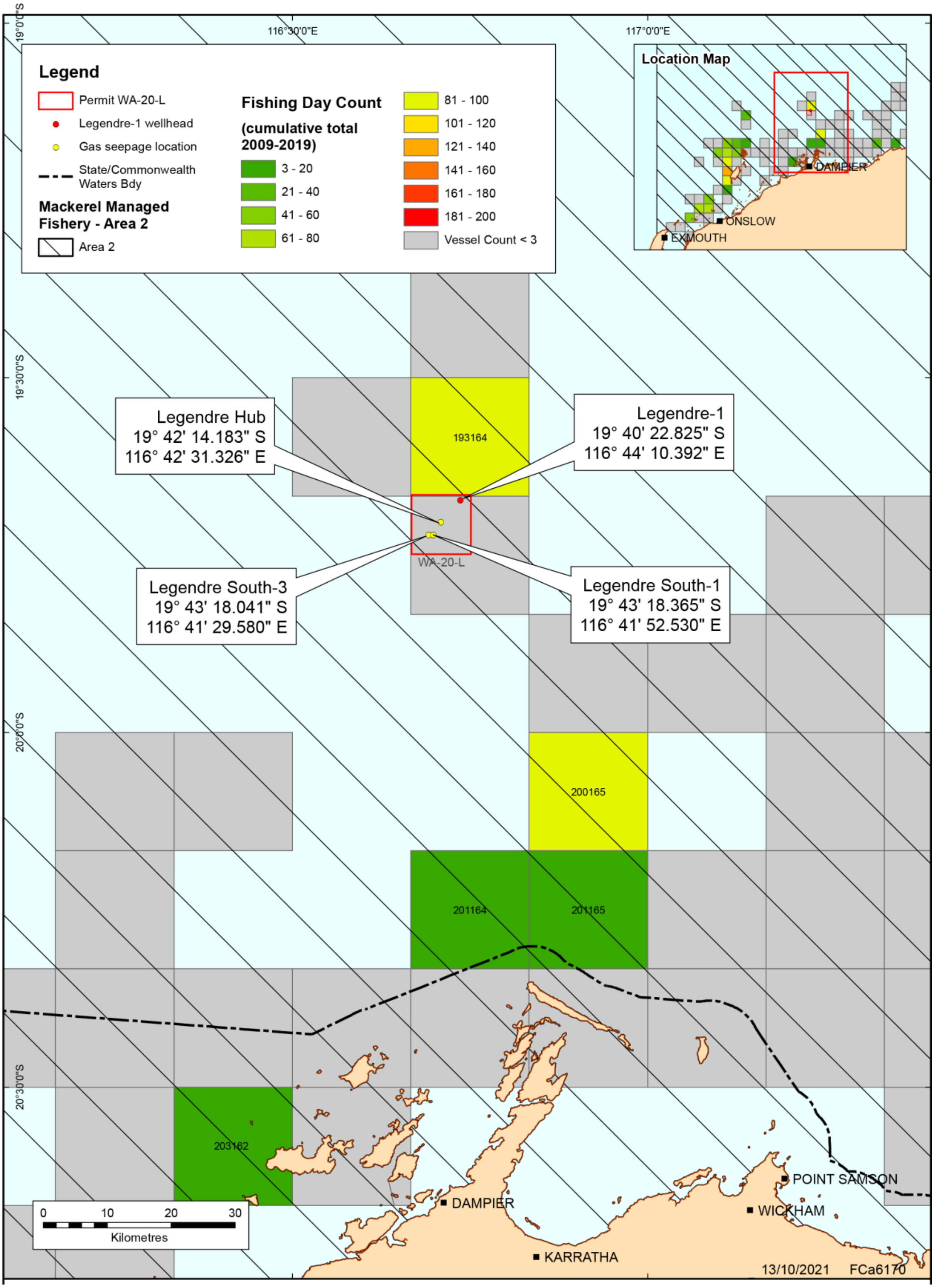


Figure 3-4: Mackerel Managed Fishery Fishing Day Count (2009-2019)

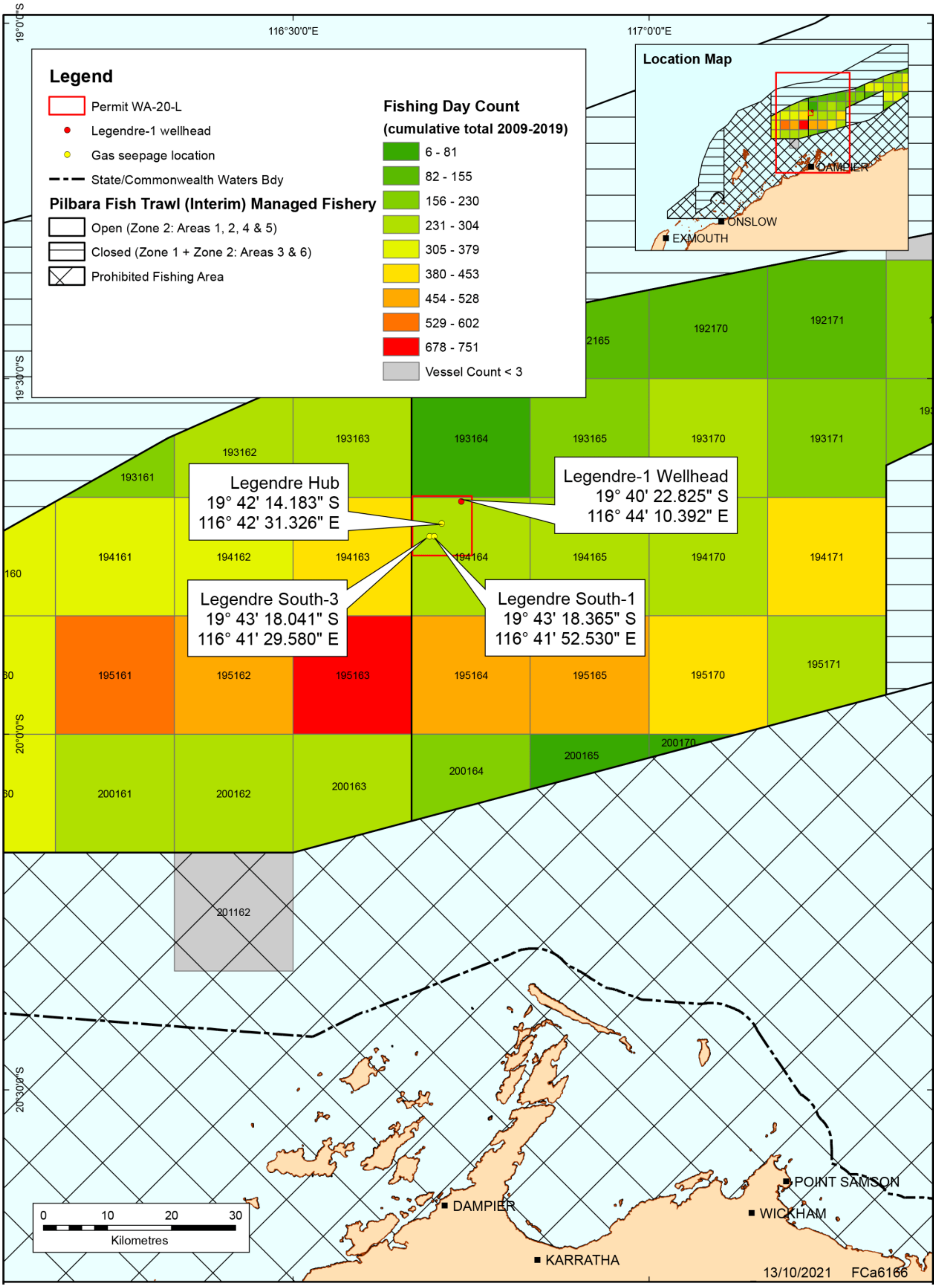


Figure 3-5: Pilbara Fish Trawl (Interim) Managed Fishery Fishing Day Count (2009-2019)

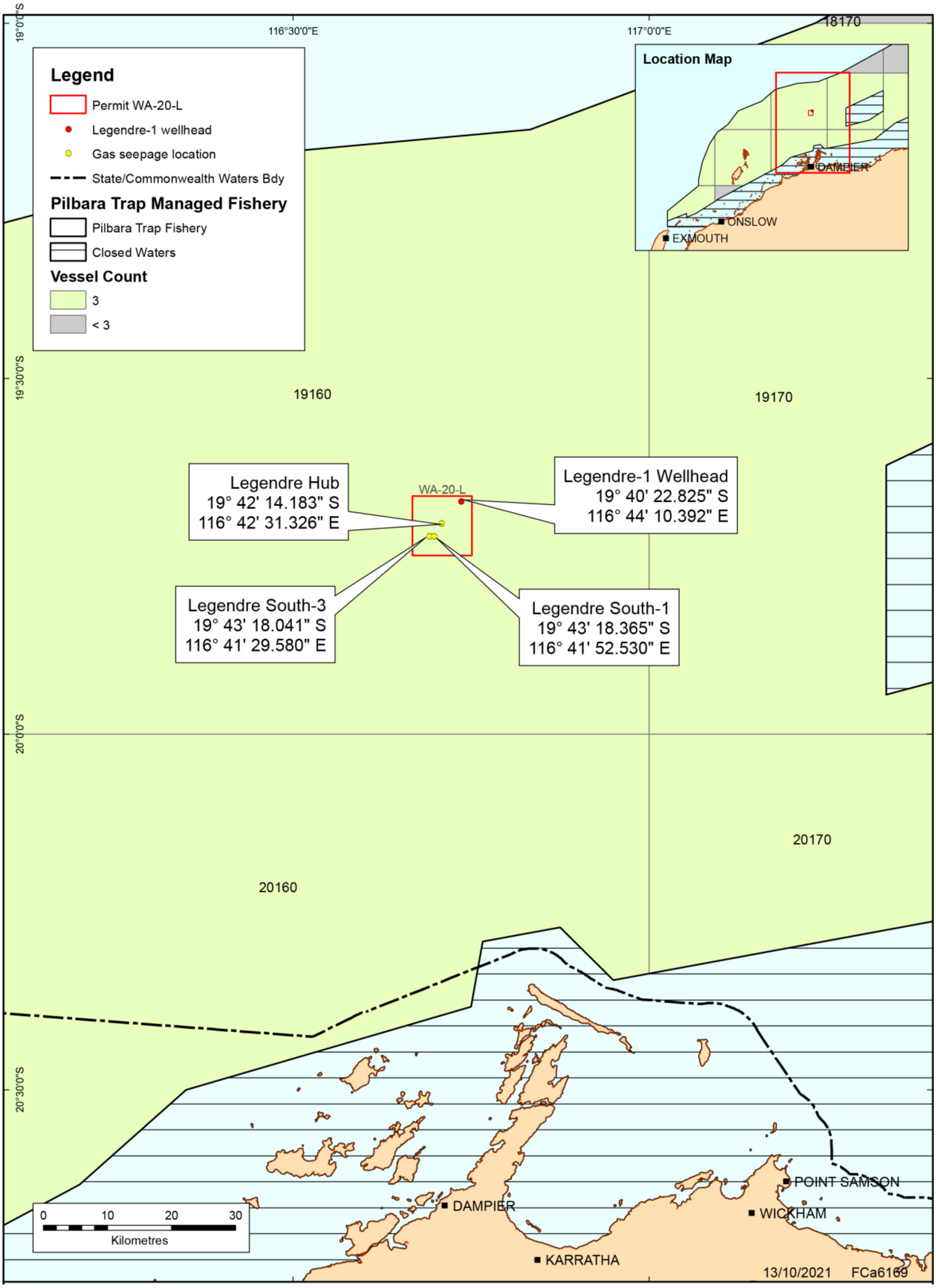


Figure 3-6: Pilbara Trap Managed Fishery Vessel Count (2009-2019)

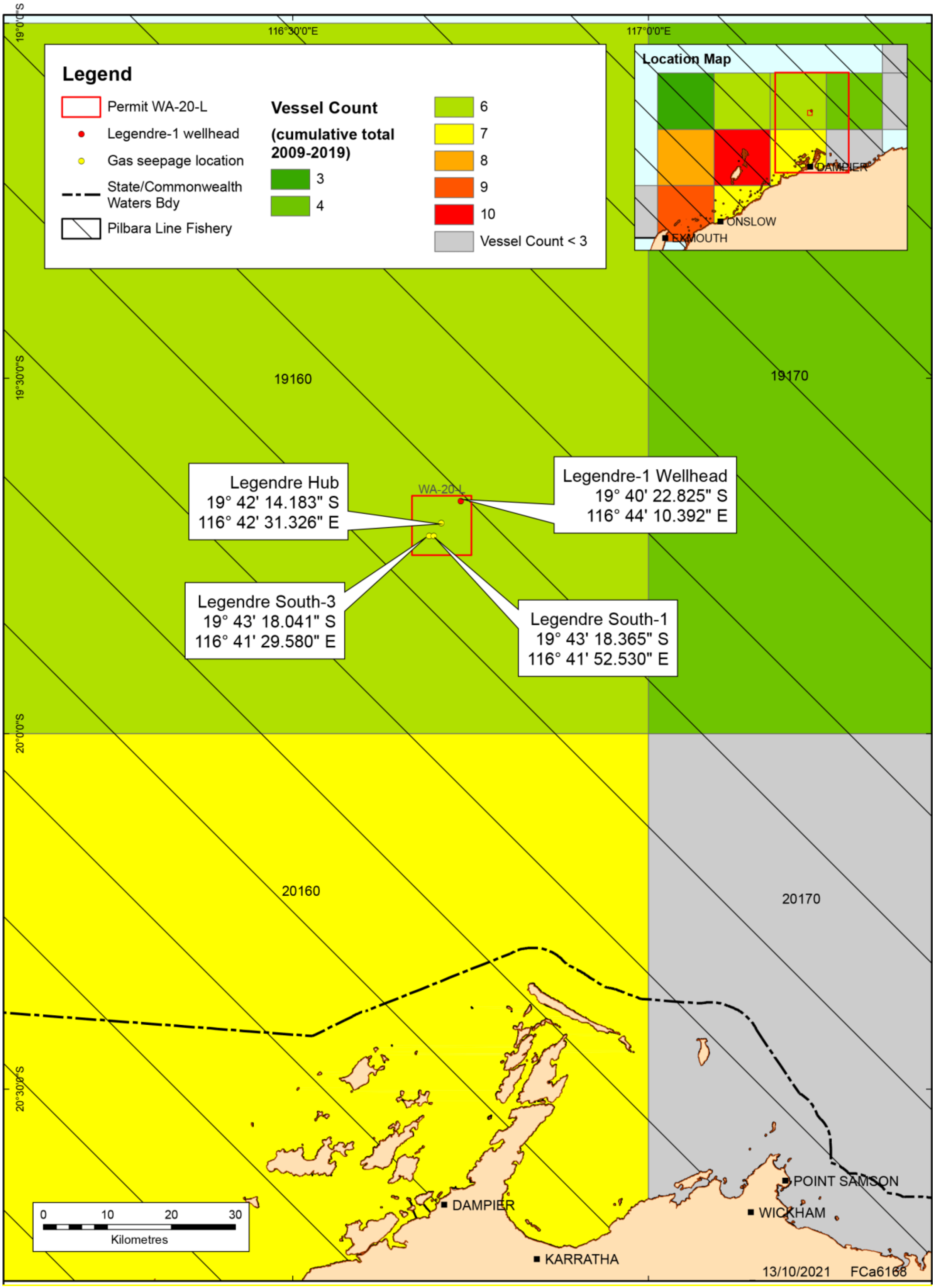


Figure 3-7: Pilbara Line Fishery Vessel Count (2009-2019)

3.6.1.5 Commercially Important Fish Species

The NWMR provides fishing grounds for commercial fisheries which target a variety of demersal and pelagic fish species. In each region key indicator species are identified that provide an indication of targeted fish stocks. Key indicator species are selected from the suite of commercially targeted finfish (based on their inherent vulnerability, management importance and overall risk to sustainability) for assessing the status of the overall resource. DPIRD provided information on the spawning and distribution of key indicator fish species of commercial fisheries that are historically active within WA-20-L (refer **Section 3.6.1**).

The three demersal indicator species for the Pilbara region are red emperor (*Lutjanus sebae*), rankin cod (*Epinephelus multinotatus*), and bluespotted emperor (*Lethrinus punctulatus*). The status of ruby snapper (*Etelis* sp.) is also used as an indicator species for the offshore demersal scalefish resources targeted by the Pilbara Line Fishery (Newman *et al.* 2019). Spanish mackerel (*Scomberomorus commerson*) is the principal target species and single indicator species for the Mackerel Managed Fishery.

Appendix E provides a comprehensive description of species that may be present within WA-20-L.

3.6.2 Cultural heritage

Santos acknowledges that the tradition of the First Nations people of Australia includes a cultural and spiritual connection to their land and waters. These connections are rooted in traditional communal beliefs and practices. First Nations people view their land and waters as integral to their identity, culture, and spirituality and they have a deep respect for the natural world. First Nations persons and groups that identify as saltwater people/groups have a complex relationship with sea country, based, for the most part, on inherited rights, including totemic affiliation, and ceremonial duties. Santos understands that First Nations groups are generally aware of the nature and geographic extent of their areas of responsibilities over sea country.

The cultural heritage of First Nations peoples includes a vast array of tangible and intangible cultural artefacts, practices and beliefs. The protected heritage of First Nations peoples is also of cultural value to Australia and the global community. The cultural value of First Nations heritage to Australia is evidenced and given force by a range of factors, including the laws, regulations and institutions that are designed to protect First Nations rights and interests in relation to sacred sites and other aspects of First Nations cultural heritage, including the *Native Title Act 1993* (Cth), *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Cth)*, Underwater Cultural Heritage Act 2018* (Cth) (UCH Act).

Country is an important concept to First Nations people and the term is often to describe family origins and associations with particular parts of Australia, both land and sea (Smyth, 2007). The expressions Country and Sea Country are used to refer to the land and waters which constitute Aboriginal traditional areas as ancestrally distinct and linguistically bounded geographic areas (Kearney et al, 2023).

Country is inclusive of many environments that are ecologically, geographically, ancestrally and socially configured (Kearney et al 2023). For First Nations people, Country is a combination of the land, sea, rivers and islands and all that they contain and sustain. Country refers to more than just a geographical area: it is shorthand for all the values, places, resources, stories and cultural obligations associated with that geographical area (Smyth, 2007).

Although many Indigenous People do not live permanently on traditional Country, families and individuals retain close personal connections with their Country and visit regularly for extended trips, to care for Country, find traditional foods and connect with important sites. First Nations people in northwest WA continue to rely on coastal and marine environments and resources of the region for their cultural identity, health and wellbeing, and their domestic and commercial economies (Smyth, 2007).

Numerous different First Nations groups have connections to different parts of Country. These family groups are representative of many different language groups.

Santos recognises the potential for marine ecosystems to include cultural features as well as environmental values. This is one aspect of the broader concept of Sea Country.

3.6.2.1 Sea country

The Australian Marine Parks North-west Marine Parks Network Management Plan 2018 (DMP, 2018) defines Sea Country as “the areas of the sea that Aboriginal and Torres Strait Islander groups are particularly affiliated with through their traditional lore and customs”. Sea Country is valued for Aboriginal cultural identity, health and wellbeing. Aboriginal people of north-western Australia have been sustainably using and managing their Sea Country for tens of thousands of years, in some cases since before rising sea levels created these marine environments.

A common feature of coastal Aboriginal cultures is the connectedness of land and sea: together they form a country of significant cultural sites and dreaming tracks of the creation ancestors (NOO, 2002). As a result, coastal environments are an integrated cultural landscape/seascape that is conceptually different from the broader Australian view of land and sea (NOO, 2002).

Animals can be totems for Aboriginal people. They share the land and water with animals and their relationship with totem animals is fundamental to continued practice and cultural responsibility; for food, health, shelter, cultural expression and spiritual wellbeing (VAHC, 2021). Caring for plants, animals and their habitats is therefore seen as a key way of expressing culture.

Aboriginal people use and actively manage the coastal and marine environments as a resource and to maintain cultural identity, health and wellbeing. Fishing, hunting and the maintenance of culture and heritage through ritual, stories and traditional knowledge continue as important uses of nearshore and adjacent areas.

Sea Country is described in both State, Territory and Commonwealth Marine Park Management Plans. The Australian Marine Park Management Plans include the objective to provide for the protection and conservation of biodiversity and other natural, cultural and heritage values of marine parks. The plans define cultural values as “living and cultural heritage recognising Indigenous beliefs, practices and obligations for country, places of cultural significance and cultural heritage sites”. Australian Marine Park Management Plans list the Aboriginal people who have responsibilities for Sea Country in the Marine Parks, and the Native Title Representative Body for the region.

The Australian Marine Parks North-west Marine Parks Network Management Plan 2018 states: *Sea country refers to the areas of the sea that Aboriginal people are particularly affiliated with through their traditional lore and customs. Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years.*

The EMBA overlaps the Montebello Marine Park. The Montebello Marine Park ‘Cultural values’ section of the Australian Marine Parks North-west Marine Parks Network Management Plan 2018 states: *Sea country is valued for indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for then of thousands of years. At the commencement of this plan, there is limited information about the cultural significance of the Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Pilbara region.* The Yamatji Marlpa Aboriginal Corporation has been consulted for this EP as outlined in **Section 4.**

3.6.2.2 Indigenous land use agreements

An Indigenous Land Use agreement (ILUA) is a voluntary agreement between native title parties and other people or bodies about the use and management of areas of land and/or waters. An ILUA can be made over areas where:

- native title has been determined to exist in at least part of the area.
- a native title claim has been made.
- no native title claim has been made.

While registered, ILUAs bind all native title holders to the terms of the agreement. ILUAs also operate as a contract between the parties. The Register of ILUAs is kept by the Native Title Registrar in accordance with s199A of the *Native Title Act 1993* and includes a description of the ILUA area, the parties' names, the term of the ILUA and other information as the Registrar considers is appropriate (s199B of the *Native Title Act 1993*).

Registration confers a contractual effect on the ILUA and binds all persons holding native title regardless as to whether they are already parties to the ILUA (s24EA of the *Native Title Act 1993*).

A search of the National Native Title Tribunal database was undertaken (see record in 320) and indicated there are no Native Title determinations or applications within WA-20-L or the EMBA.

A search of the Native Title Register did not identify any ILUAs within WA-20-L or the EMBA.

3.6.2.3 Indigenous protected areas

Indigenous Protected Areas (IPAs) are areas of land and sea that Traditional Owners have agreed to manage for biodiversity conservation. IPAs represent more than 50% of the National Reserve System. The Sea Country IPA Program seeks to increase the area of sea in IPAs to strengthen the conservation and protection of Australia's unique marine and coastal environments, while creating employment and economic opportunities for Indigenous Australians. None have yet been identified within WA-20-L or the EMBA.

In addition to considering Sea Country IPA's the potential values and sensitivities related to sea country were sought via the consultation. No feedback regarding sea country has been provided for this EP.

3.6.2.4 Aboriginal cultural heritage inquiry system

The Aboriginal Cultural Heritage Inquiry System (ACHIS) provides information about Aboriginal cultural heritage in Western Australia. The ACHIS provides details, such as the location and extent of each Aboriginal cultural heritage place and cultural landscape.

A search of the Department of Planning, Lands and Heritage ACHIS was undertaken and indicated there are no registered cultural heritage sites within WA-20-L or the EMBA.

3.6.3 Energy Industry

Vessels servicing oil and gas operations in the region may pass through WA-20-L and the EMBA enroute to facilities. Previously, various petroleum exploration and production activities have been undertaken within WA-20-L (**Table 1-2**). Various infrastructure related to these activities remain within WA-20-L (**Table 3-8**:**, Figure 3-8**). The substrate and infrastructure associated with the remaining wells in WA-20-L were surveyed using ROV in 2021 (RPS 2021b). Anchor chains, piles and other debris was collected during the 2011-2012 decommissioning process under the EP and bridging document (**Section 1.3**).

Table 3-8: Remaining seabed infrastructure in WA-20-L

Well name	Substrate	Remaining infrastructure
Legendre-1	Pavement with rubble	Abandoned wellhead infrastructure. The top of the wellhead was found to sit 3.6 m above the seabed, with an estimated width of 3–5 m. Scattered debris (small sections of steel, shackles, rope, and concrete).
Legendre Hub	Pavement	The well location is covered by anti-scour mattresses.
Legendre-3 / Legendre 4	Pavement	The well location is covered by anti-scour mattresses.
Jaubert-1	Concrete	Well casing had been cut off approximately 0.5 m above the sea floor and was uncapped.
Titan-1	Pavement/concrete covered most of the survey area	No visible well infrastructure.
Taj-1	Pavement	Concrete.
Legendre South-1	Pavement/concrete	No visible well infrastructure.
Legendre South-3	Pavement/concrete	No visible well infrastructure.

Oil and gas facilities are present within the EMBA, operated by other titleholders (**Figure 3-9**).

3.6.4 Shipping

AMSA has established a network of shipping fairways off the north-west coast of Australia to manage traffic patterns (AMSA 2020). AMSA shipping routes within and close to WA-20-L are shown in (**Figure 3-10**). No shipping routes overlap WA-20-L however there are several shipping fairways through the EMBA.

Commercial shipping using NWS waters includes iron ore carriers, oil and LNG tankers and other vessels proceeding to or from the ports of Dampier, Port Walcott, Port Hedland, Barrow Island and VI, and Onslow. Large cargo vessels carrying freight bound or departing from Fremantle also transit along the WA coastline heading north and south in deeper water.

Large commercial vessels mostly associated with the oil and gas industry and Western Australian major ports are expected to move through the EMBA in transit.

3.6.5 Tourism and Recreation

Recreation such as boating, diving and fishing activities are generally concentrated in the vicinity of the population centres such as Dampier, Onslow, Point Samson and Port Hedland. The open waters of WA-20-L support some recreational fishing activity over the Glomar shoals (feedback obtained from RecfishWest during consultation, see **Section 4**).

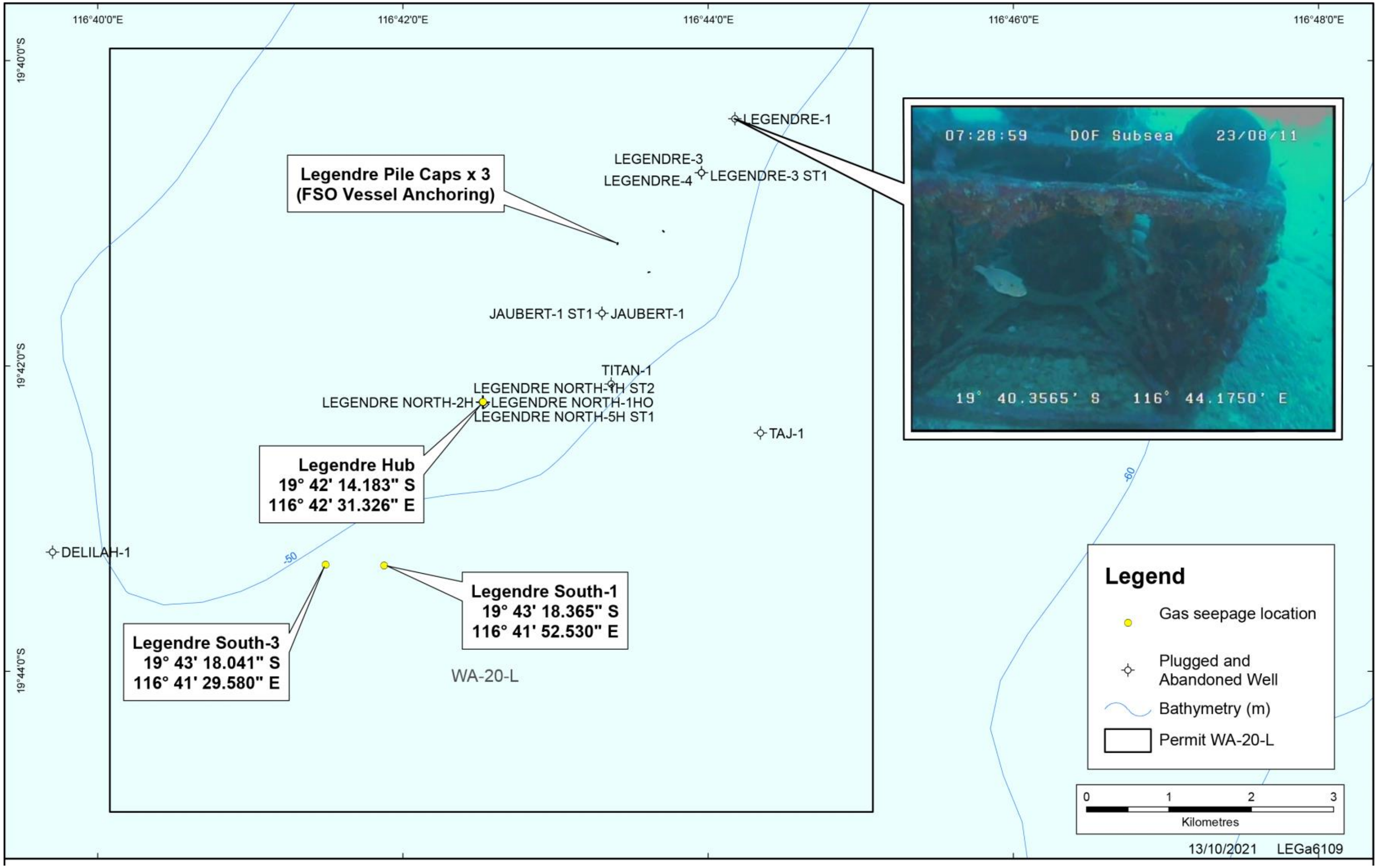


Figure 3-8: Petroleum infrastructure remaining in WA-20-L

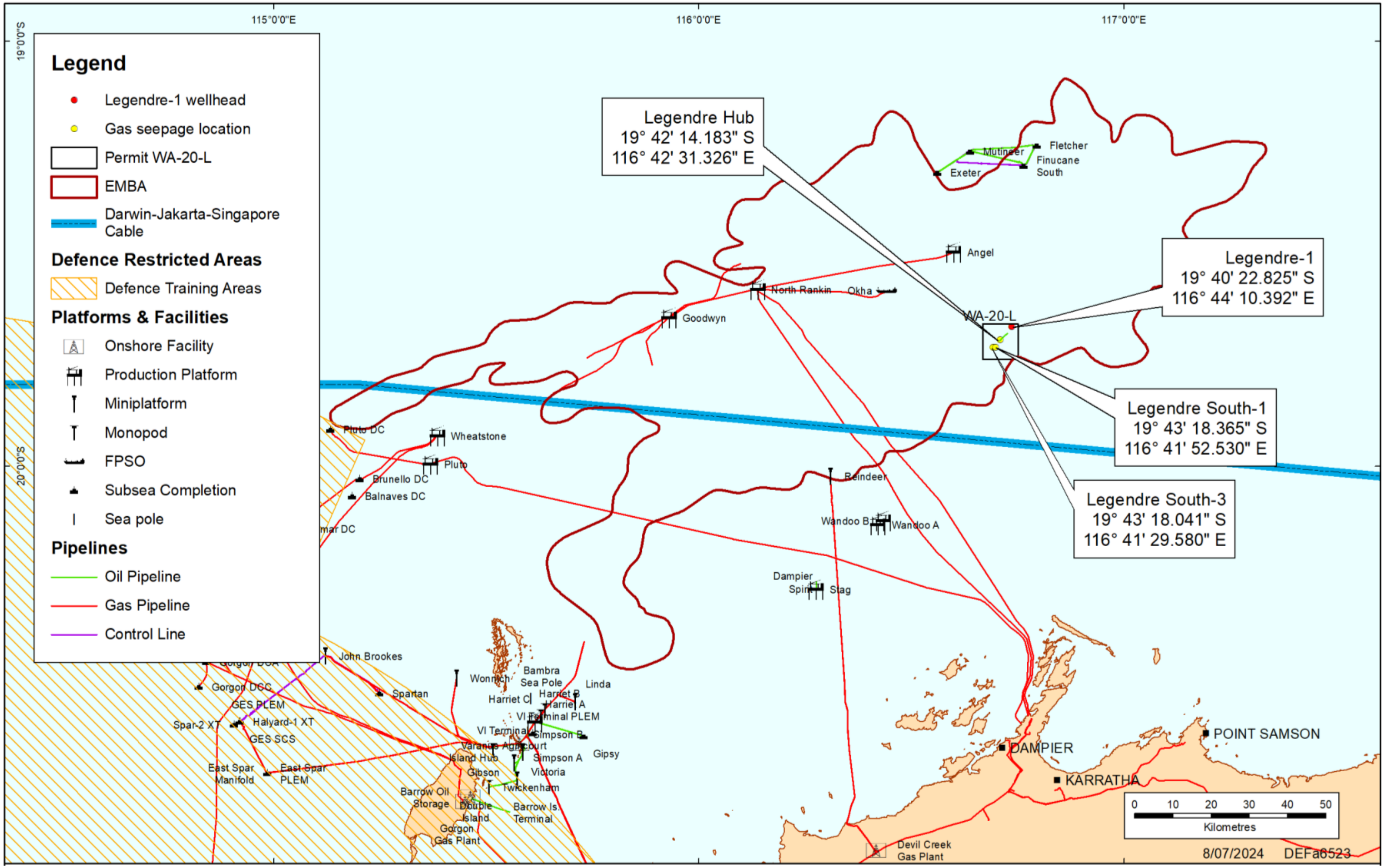


Figure 3-9: Petroleum and submarine cable infrastructure and Defence areas

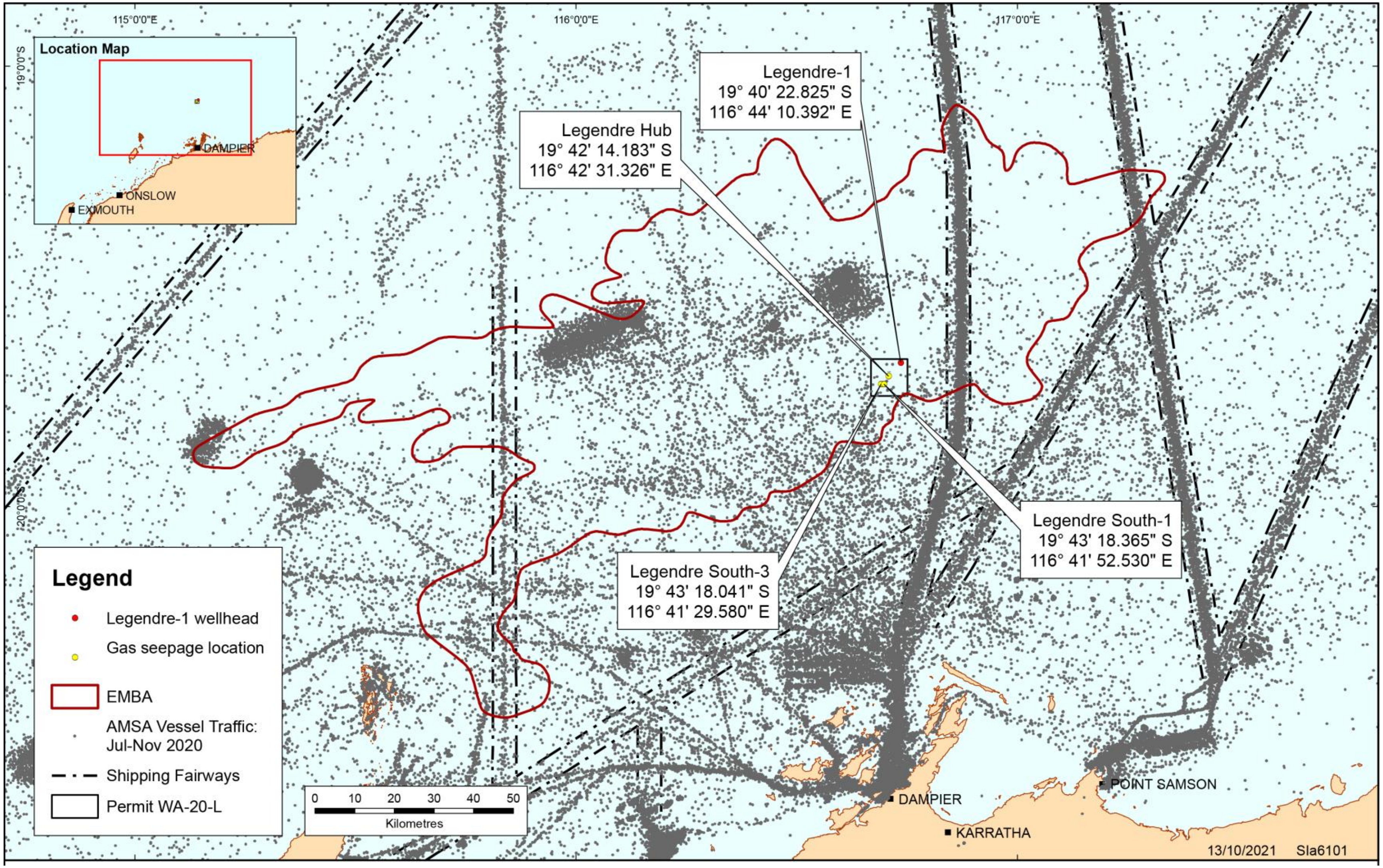


Figure 3-10: Shipping presence within WA-20-L and the EMBA

4 Stakeholder consultation

OPGGS(E)R 2023 Requirements
Section 28 Publishing environment plan and associated information
28(1) If NOPSEMA's provisional decision under section 27 is that the environment plan includes material apparently addressing all the provisions of Division 2 (Contents of an environment plan), NOPSEMA must publish on NOPSEMA's website as soon as practicable: (a) the plan with the sensitive information part removed; and (b) the name of the titleholder who submitted the plan; and (c) a description of the activity or stage of the activity to which the plan relates; and (d) the location of the activity; and (e) a link or other reference to the place where the accepted offshore project proposal (if any) is published; and (f) details of the titleholder's nominated liaison person for the activity.
Section 25 Consultation with relevant authorities, persons and organisations etc
25(1) In the course of preparing an environment plan (including a revised environment plan referred to in Division 5) a titleholder must consult each of the following (a relevant person): (a) each Commonwealth, State or Northern Territory agency or authority to which the activities to be carried out under the environment plan may be relevant; (b) if the plan relates to activities in the offshore area of a State - the Department of the responsible State Minister; (c) if the plan relates to activities in the Principal Northern Territory offshore area- the Department of the responsible Northern Territory Minister; (d) a person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan; (e) any other person or organisation that the titleholder considers relevant. 25(2) For the purpose of the consultation, the titleholder must give each relevant person sufficient information to allow the relevant person to make an informed assessment of the possible consequences of the activity on the functions, interests or activities of the relevant person. 25(3) The titleholder must allow a relevant person a reasonable period for the consultation. 25(4) The titleholder must tell each relevant person the titleholder consults that: (a) the relevant person may request that particular information the relevant person provides in the consultation not be published; and (b) information subject to such a request is not to be published under this Part.
Section 22(15) Implementation strategy for environment plan
Consultation and compliance 22(15) The implementation strategy must provide for appropriate consultation with: (a) relevant authorities of the Commonwealth, a State or Territory; and (b) other relevant interested persons or organisations.
Section 24 Other information in environment plan
The environment plan must contain the following: (b) a report on all consultations under Section 25 of any relevant person by the titleholder, that contains: (i) a summary of each response made by a relevant person; and (ii) an assessment of the merits of any objection or claim about the adverse impact of each activity to which the environment plan relates; and (iii) a statement of the titleholder's response, or proposed response, if any, to each objection or claim; and (iv) a copy of the full text of any response by a relevant person;

4.1 Consultation background

Initial relevant person consultation under section 25 of the OPGGS(E)R commenced in December 2021 to support development of this EP, which was submitted to NOPSEMA in February 2022 for assessment.

Additional consultation under section 25 of the OPGGS(E)R was undertaken by Santos from June 2023 to comply with NOPSEMA's *Guidance GL2086 – Consultation in the course of preparing an environment plan*, applicable regulations and recent caselaw.

This is reflected in Santos' consultation methodology outlined in **Section 4.5**, with additional consultation activities for this EP undertaken in two phases:

+ Preliminary consultation (29 May – 26 June 2023) – This included:
  - activities to allow authorities, persons and organisations opportunities to self-identify as relevant persons; and
  - engagement with potential relevant persons to confirm consultation expectations. Potential relevant persons that did not provide any feedback during preliminary consultation were still carried into the consultation phase.
+ **Consultation (26 June – 26 July 2023)** – activity-based consultation activities seeking feedback from relevant persons to inform development of this EP.

A summary report of the additional consultation carried out under section 25 of the OPGGS(E)R is included at **Table 4-8**, acknowledging that the list of relevant persons has changed (compared to initial consultation in 2021) due to the reduced activity scope for this EP (vessel-based activities have been removed). For reference, a summary of initial consultation is included at **Appendix G**.

Table 8-4 includes Santos' post acceptance consultation implementation strategy for the Activities covered by this EP in accordance with section 22(15) of the OPGGS(E)R.

4.2 Regulatory requirements

Table 4-1 outlines the applicable regulatory requirements for consultation with relevant persons for this EP.

Table 4-1: Consultation requirements under the OPGGS(E)R

OPGGS(E)R 2023 Requirements
Section 24. Other information in the environment plan
The environment plan must contain the following: (b) a report on all consultations under section 25 of any relevant person by the titleholder, that contains: (i) a summary of each response made by a relevant person; and (ii) an assessment of the merits of any objection or claim about the adverse impact of each activity to which the environment plan relates; and (iii) a statement of the titleholder's response, or proposed response, if any, to each objection or claim; and (iv) a copy of the full text of any response by a relevant person.
Section 25. Consultation with relevant authorities, persons and organisations, etc
(1) In the course of preparing an environment plan (including a revised environment plan referred to in Division 5) a titleholder must consult each of the following (a relevant person): (a) each Commonwealth, State or Northern Territory agency or authority to which the activities to be carried out under the environment plan may be relevant; (b) if the plan relates to activities in the offshore area of a State—the Department of the responsible State Minister; (c) if the plan relates to activities in the Principal Northern Territory offshore area—the Department of the responsible Northern Territory Minister; (d) a person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan; (e) any other person or organisation that the titleholder considers relevant.

OPGGS(E)R 2023 Requirements
(2) For the purpose of the consultation, the titleholder must give each relevant person sufficient information to allow the relevant person to make an informed assessment of the possible consequences of the activity on the functions, interests or activities of the relevant person. (3) The titleholder must allow a relevant person a reasonable period for the consultation. (4) The titleholder must tell each relevant person the titleholder consults that: (a) the relevant person may request that particular information the relevant person provides in the consultation not be published; and (b) information subject to such a request is not to be published under this Part.
Section 26. Submission of environment plan
Form of environment plan (8) All sensitive information (if any) in an environment plan, and the full text of any response by a relevant person to consultation under section 25 in the course of preparation of the plan, must be contained in the sensitive information part of the plan and not anywhere else in the plan. Note: Subparagraph 24(b)(iv) requires the plan to contain a copy of the full text of any response by a Relevant person to consultation under section 25 in the course of preparation of the plan.
Section 28. Publishing environment plan and associated information
(1) If NOPSMEA's provisional decision under section 27 is that the environment plan includes material apparently addressing all the provisions of Division 2 (Contents of an environment plan), NOPSEMA must publish on NOPSEMA's website as soon as practicable: (a) the plan with the sensitive information part removed; and (b) the name of the titleholder who submitted the plan; and (c) a description of the activity or stage of the activity to which the plan relates; and (d) the location of the activity; and (e) a link or other reference to the place where the accepted offshore project proposal (if any) is published; and (f) details of the titleholder's nominated liaison person for the activity.

4.3 Government and industry guidance

Santos has considered the following NOPSEMA guidance in developing its consultation activities and approach:

+ GL2086 – Consultation in the course of preparing an environment plan (EP Consultation Guideline) (NOPSEMA, 2023; 2024).
+ GN1847 – Responding to public comment on Environment Plans (NOPSEMA, 2022a).
+ GL1887 – Consultation with Commonwealth agencies with responsibilities in the marine area (NOPSEMA, 2024).
+ GL1721 – Environment plan decision making (NOPSEMA, 2024c).
+ GN1344 – Environment plan content requirement (NOPSEMA, 2024b).
+ GN1488 – Oil Pollution Risk Management (NOPSEMA, 2021).
+ Supporting cooperative coexistence of seismic surveys and commercial fisheries in Australia's Commonwealth marine area (Australian Government, 2022) jointly released by NOPSEMA, the Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF), the Commonwealth Department of Industry, Science and Resources (DISR), and the Commonwealth Australian Fisheries Management Authority (AFMA).
+ Petroleum activities and Australian Marine Parks: A guidance note to support environmental protection and effective consultation (Australian Government, 2023) jointly released by NOPSEMA and Parks Australia.

Santos has also considered other government and industry guidance, including:

+ International Standards Organisation
+ ISO14001:2015 Environmental Management Systems
+ Australian Fisheries Management Authority

- Petroleum industry consultation with the commercial fishing industry
- Australian Heritage Commission
- Ask First - A guide to respecting Indigenous heritage places and values
- Commonwealth Department of Agriculture, Fisheries and Forestry
- Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006
- Offshore Installations Biosecurity Guide
- Commonwealth Department of Climate Change, Energy, the Environment and Water
- Interim Engaging with First Nations People and Communities on Assessments and Approvals under the Environment Protection and Biodiversity Conservation Act 1999
- Commonwealth Ministerial Council on Mineral and Petroleum Resources
- Principles for Engagement with Communities and Stakeholders
- International Association for Public Participation
- Quality Assurance Standard for Community and Stakeholder Engagement
- WA Department of Primary Industries and Regional Development
- Guidance statement for oil and gas industry consultation with the Department of Fisheries
- WA Department of Transport
- Offshore Petroleum Industry Guidance Note - Marine Oil Pollution: Response and Consultation Arrangements
- WA Incident Management Plan: Marine Oil Pollution, September 2023
- Western Australian Fishing Industry Council
- Commercial Fishing Consultation Framework for the Offshore Oil and Gas Sector

4.4 Applicable case law and guidance

In addition to considering the regulatory requirements and guidance set out above, in developing this EP Santos has considered the judgments of:

- Justice Bromberg in Tipakalippa v National Offshore Petroleum Safety and Environmental Management Authority (No. 2) [2022] FCA 1121 and the Full Federal Court in Santos NA Barossa Pty Ltd v Tipakalippa [2022] FCAFC 193 (Appeal Judgement).
- the Full Federal Court in Santos NA Barossa Pty Ltd v Tipakalippa [2022] FCAFC 193 (Appeal Judgement); and
- Justice Calvin in Cooper v National Offshore Petroleum Safety and Environmental Management Authority (No 2) [2023] FCA 1158.

The EP Consultation Guideline referred to above provides a summary of the Full Federal Court's interpretation of "functions", "activities" and "interests" referenced in section 25(1)(d) of the OPGGS(E)R, adopted by NOPSEMA to assist in informing who may be a relevant person and how relevant persons may be identified, as follows:

Term	Definition
Functions	Refers to "a power or duty to do something"
Activities	To be read broadly and is broader than the definition of "activity" in Regulation 4 of the OPGGS(E)R and is likely directed to what the relevant person is already doing
Interests	To be construed as conforming with the accepted concept of "interest" in other areas of public administrative law Includes "any interest possessed by an individual whether or not the interest amounts to a legal right or is a proprietary or financial interest or relates to reputation"

Santos has also had regard to the purpose of consultation as outlined in the Appeal Judgment and EP Consultation Guideline, the emphasis that superficial or tokenistic consultation is not sufficient and that:

- consultation must be appropriate and adapted to the nature of each relevant person;

+ for each relevant person, the appropriate manner and method of consultation (including the nature of information, time periods for consultation and mode of communication) may differ; and
+ there is good reason to adopt pragmatic and practical approaches to consultation conducted in accordance with section 25 of the OPGGS(E)R.

4.5 Santos consultation methodology

4.5.1 Overview

Santos consults to ensure that any activity it is proposing under an EP is carried out in a manner:

+ consistent with the principles of ecologically sustainable development set out in section 3A of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act);
+ by which the environmental impacts and risks of the activity will be reduced as low as reasonably practicable (ALARP); and
+ by which the environmental impacts and risks of the activity will be of an acceptable level.

The consultation process is designed to assist Santos to further ascertain, understand and assess values and sensitivities of the environment that may be affected by a proposed activity, and the potential environmental impacts and risks, through information obtained during consultations.

Santos may then refine or change its proposed control measures to address potential environmental impacts and risks of the activity based on that information or any claims or objections raised through consultation.

Santos' consultation methodology and process adopted in developing this EP comprised the following key steps:

+ identifying potential relevant person categories;
+ identifying relevant persons;
+ providing opportunities for relevant persons to identify themselves if they wished to be consulted (e.g. through advertising);
+ consultation planning and preliminary consultation activities;
+ consulting relevant persons;
+ assessing the merits of objections or claims made by relevant persons about the adverse impact of each activity to which the EP relates; and
+ providing responses to queries, requests and feedback.

As described below, Santos considered the spatial extent of the EMBA and the particular aspects of the relevant environment outlined in **Section 3** as part of its process for identifying relevant persons. However, the EMBA includes large areas where only unplanned activities such as a spill event with an unlikely probability of occurrence, could have any impact on the environment.

There is also significant conservatism associated with the EMBA based on low exposure values (as described in **Section 3.1.2**) which Santos has used in identifying the EMBA, and especially given the modelling process which combines a large number of individual unmitigated spill simulations.

The modelling at low exposure values is primarily used to inform Santos preparedness for potential spill response, and does not take into account any spill response mitigation activities which would be implemented and reduce the EMBA extent in the unlikely event of a spill.

Santos' methodology outlined in **Section 4** demonstrates a very broad capture of potential relevant persons, providing ample opportunities, as outlined in **Section 4.5.3** and **Section 4.5.4**, for relevant persons to self identify and provide input to the development of the EP if they feel they may be impacted by the activities.

Santos notes that there is a very low likelihood of impacts from planned activities or unplanned events to the respective functions, interests and activities of those relevant persons identified at the extremities of the EMBA. In recognition this, our direct consultation effort has focused on those relevant persons most proximate to the Operational Area.

4.5.2 Identifying relevant persons

This Section outlines the methodology and steps that Santos has used to identify relevant persons.

As described in **Table 4-2** Santos considered the spatial extent of the environment that may be affected by the activity and the particular aspects of the relevant environment as part of its process for identifying relevant persons.

Table 4-2: Relevant person identification process steps.

Process steps
1. Identify the impacts of the planned activities and the risks and impacts of unplanned events.
2. Consider the spatial extent of the environment that may be affected by the Activity impacts and risks.
3. Consider and identify aspects of the environment within the environment that may be affected, having regard to: (a) ecosystems and their constituent parts, including people and communities (b) natural and physical resources (c) the qualities and characteristics of locations, places and areas (d) the heritage value of places (e) the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).
4. Identify relevant person categories, having regard to: (a) aspects of the environment identified at Item 3 (b) the departments or agencies of Commonwealth and Western Australian Governments that could therefore be relevant (c) the kinds of functions, interests or activities of people or organisations that could therefore be affected (d) submissions received in response to Santos' activities to allow authorities, persons and organisations to self-identify relevant persons. Update during consultation based on new information, if appropriate.
5. Identify relevant persons within relevant person categories, having regard to items 1-4 above.

Santos considered the nature of the activity (and key component activities) (described in **Section 2** and the location of the activity (described and depicted in **Section 2**), the impacts of planned activities (described in **Section 6**) and the risks and impacts of unplanned events (described in **Section 7**).

Santos also considered the spatial extent of the environment that may be affected by the activity impacts and risks (described in **Section 2.3** and **Appendix E**).

Table 4-3 outlines the environmental aspects (described in detail in **Section 2.3** and **Appendix E**) that Santos considered for the purpose of identifying relevant person categories.

Table 4-3: Environmental aspects considered for relevant person category identification.

Aspects of the environment	EP Reference
Physical environment	Section 3.3
Provincial Bioregions	Section 3.3.1
Benthic habitats	Section 3.3.6
Australian marine parks and state marine parks, management areas, reserves	Section 3.4
Key Ecological Features	Section 3.4
Commonwealth Heritage Areas (Indigenous and Non- Indigenous)	Section 3.4
Wetlands of International and National Significance	N/A
Biologically Important Areas and Critical Habitat	Section 3.4
Recovery Plans	Section 3.4
Commercial fisheries	Section 3.6.1
Energy industry	Section 3.6.3
Telecommunication cables	N/A

Aspects of the environment	EP Reference
Defence activities	Section 3.6
Shipping	Section 3.6.4
Recreation and tourism	Section 3.6.5
Cultural Heritage	Section 3.6.2

Consideration of the above environmental aspects resulted in the identification of the following relevant person categories:

Section 25(1)(a)

- Commonwealth Government Departments/Agencies

Section 25(1)(a) and (b)

- Western Australian Government Departments/Agencies

Section 25(1)(d) and (e)

- Academic and research organisations
- Commercial fishing (Commonwealth-managed)
- Commercial fishing (Western Australian-managed)
- Energy industry titleholders / operators
- Environmental conservation organisations
- First Nations peoples and groups
- Infrastructure operators
- Industry associations
- Local government and recognised community reference/liaison groups
- Recreational fishing
- Shipping
- Tourism operators

Santos then undertook the actions outlined below to identify relevant persons within those categories.

Table 4-4: Actions for identifying relevant persons by category.

Relevant person category	Actions to identify relevant persons
All relevant person categories	Review of Santos' historical consultation in the region. Review of identified relevant persons in publicly available EPs submitted by other Operators that may be relevant to proposed activities to be managed under this EP. Conducting key-word searches using online search engines and reviewing media coverage and organisation websites to identify persons and organisations with reasonably ascertainable functions, interests and activities that may be affected by the activities under this EP.
Section 25(1)(a)	
Commonwealth Government Departments/Agencies	Review of government agency websites and directories to understand agency roles, functions and responsibilities. Review of NOPSEMA and government agency guidance on consultation expectations.
Section 25(1)(b) and (c)	
Western Australian Government Departments/Agencies	Review of government agency websites and directories to understand agency roles, functions and responsibilities. Review of NOPSEMA and government agency guidance on

Relevant person category	Actions to identify relevant persons
	consultation expectations.
Section 25(1)(d)(e)	
Academic and research organisations	Desktop review of publicly available and reasonably ascertainable published research having regard to the region, activities or risks/impacts under this EP.
Commercial fishing	Review of EMBA overlap with commercial fisheries managed by the Commonwealth and Western Australian Governments. Review of potential presence in the activity location.
Energy industry	Review of EMBA overlap with petroleum, greenhouse gas and any other NOPTA issued titles.
Environmental conservation organisations	Conduct key-word searches of publicly available online search engines, review media coverage and review organisation websites to identify organisations with reasonably ascertainable functions, interests and activities that may be affected, having regard to the region, activities or risks/impacts under this EP. Review of other publicly available information, e.g. websites of conservation organisations whose functions, interests or activities within the EMBA may be affected.
First Nations peoples and groups	Review of EMBA overlap with Native Title determined areas and claims, Indigenous Land Use Agreements and Indigenous Protected Areas to identify areas over which a First Nations group may have functions, interests or activities that may be affected. Conduct searches of public cultural heritage databases relative to the EMBA. Review of prescribed bodies corporate on the Native Title website. Review of marine park management plans. Review of publicly available studies and reports that may assist in identifying or mapping relevant cultural heritage interests in the EMBA.
Industry associations	Review of industry representation of the following relevant person groups: + Commercial fishing + Energy industry + Local government + Local industry + Recreational fishing + Shipping + Tourism.
Infrastructure operators	Review of EMBA overlap with offshore and onshore infrastructure, such as submarine telecommunications cables or ports. Review of potential presence in the activity location.
Local Government and recognised community reference/liaison groups	Review of EMBA overlap with boundaries of Local Government Areas and community reference/liaison groups that operate within these boundaries.
Recreational fishing	Review of EMBA overlap with areas of interest to recreational fishing. Review of potential presence of recreational fishing club members in the activity location. Review of website information of relevant agencies/organisations that represent recreational fishing interests.
Shipping	Review of EMBA overlap with shipping fairways or areas of high marine traffic
Tourism operators	Review of EMBA overlap with areas of interest to charter and tourism operators.

Relevant person category	Actions to identify relevant persons
	Review of potential presence in the activity location. Review of website information of relevant operators/organisations that represent commercial tourism interests.

4.5.3 Public awareness campaign and self-identification opportunities

In addition to undertaking the process for identification of potential relevant persons, as described above, Santos undertakes a range of activities to promote opportunities for other organisations or individuals to self-identify as potential relevant persons if they feel that their functions, interests or activities may be affected.

These promotional activities include public information campaigns using a range of delivery methods, including, radio, print media, targeted social media with links (where appropriate) to information about the proposed activities, risk and impacts.

Details of the public information campaign for this EP, including targeted efforts to ensure First Nations organisations and individuals are provided the same opportunities, are described in **Section 4.5.4** and a schedule of advertising is included in **Section 4.5.7**. Santos also has an online self-nomination form on its Consultation Hub website where fact sheets and other consultation materials are published and available for download.

Such activities and information provide a more than reasonable opportunity for organisations and individuals to self-identify as a relevant person for the purpose of OPGGS(E)R section 25 consultation, where they consider themselves to have interests, functions or activities that may be affected by the planned activities and for relevant persons to provide their input.

Santos’ process involves the provision of reasonable timeframes for the self-identification or nomination of others as relevant persons, for relevant persons to consider consultation information, ask questions and give their input and for Santos’ consideration and assessment of the merits of objections and claims.

4.5.4 Identification and consultation with First Nations people and groups

In addition to the public awareness campaign and self-identification opportunities outlined above, Santos has developed a comprehensive process for identifying and undertaking effective consultation with First Nations relevant persons.

As with Santos’ process for identifying relevant persons generally, this is an iterative process with multiple avenues of enquiry including, but not limited to, the following actions:

+ Active steps to identify First Nations people and groups as per actions outlined in **Table 4-5**, including advertising broadly to ensure that relevant persons that are not otherwise identified by Santos’ examination of the EMBA are given the opportunity to self-identify.
+ Providing opportunities for relevant persons to provide input in EP development, including:
+ Registered Native Title Prescribed Bodies Corporate (PBCs), groups associated with Native Title Determinations and groups in active Native Title Claims;
+ Native Title Representative Bodies;
+ Groups who may be parties to Indigenous Protected Areas, or named in Indigenous Land Use Agreements;
+ Existing liaison committees or reference groups, where these committees or groups have been established between Native Title Parties, Native Title Representative Bodies and industry/government;
+ Supporting the establishment of liaison committees or groups that are intended to be representative and able to speak on behalf communities where formal structures do not exist, and consulting such committees or groups;
+ Individual First Nations people who self-identify as relevant (if any).

For this EP, Santos has provided consultation opportunities and supporting information to First Nations representative organisations listed in **Table 4-5**, acknowledging the use of a highly conservative EMBA (as described in **Section 4.5.1**) for the purpose of assisting to identify potentially relevant persons.

Santos acknowledges the tradition of First Nations people of Australia includes a cultural and spiritual connection to their land and waters and that communal cultural interests, including sea country, could extend into the EMBA. When considering the remote possibility of any major unplanned spill event, and the inherent conservatism of the EMBA, the likelihood of First Nations people having an interest that may be affected by the proposed activities (if such groups do have sea country or other interests) becomes increasingly unlikely with increasing distance from the operational area, where planned activities will occur.

This conservative approach has ensured a very broad capture of potential interested relevant persons and provided them an opportunity to provide input if they feel they may be impacted.

4.5.5 Relevant persons

A list of potential relevant persons was developed through application of the above methodology for the purposes of undertaking preliminary consultation to confirm consultation expectations.

This consultation phase was supported by an advertising campaigned outlined in **Table 4-6** to raise public awareness about the proposed activity and provide opportunities for authorities, persons or organisations to self-nominate as relevant persons.

Relevant persons consulted for this EP are listed in **Table 4-5**.

Table 4-5: Relevant persons for this EP

Relevant person	Summary of relevance
Section 25(1)(a): each Commonwealth, State or Northern Territory agency or authority to which the activities to be carried out under the environment plan may be relevant	
Australian Fisheries Management Authority (AFMA)	AFMA is responsible for managing Commonwealth fisheries and is a relevant agency where the Activity has the potential to impact on fisheries resources in AFMA managed fisheries. AFMA expects petroleum operators to consult directly with fishing operators about all activities and projects which may affect day to day fishing activities. AFMA also provides industry association contacts for petroleum operators to use when consultation with fishing operators is required.
Australian Hydrographic Office (AHO)	AHO is responsible for maintaining and disseminating nautical charts, including the presence of the Legendre-1 wellhead, including the distribution of Notice to Mariners.
Australian Institute of Marine Science (AIMS)	AIMS is Australia's tropical marine research agency and is established under the *Australian Institute of Marine Science Act 1972* (AIMS Act).
Australian Maritime Safety Authority (AMSA) – maritime safety	AMSA is the statutory and control agency for maritime safety and vessel emergencies in Commonwealth Waters. AMSA is a relevant agency when proposed offshore activities may impact on the safe navigation of commercial shipping in Australian waters.
Department of Agriculture, Forestry and Fisheries (DAFF) – Fisheries	DAFF (fisheries) has primary policy responsibility for promoting the biological, economic and social sustainability of Australian fisheries.
Department of Industry, Science and Resources (DISR)	DISR is a relevant agency for consultation because its responsibilities include offshore

Relevant person	Summary of relevance
	oil and gas development and safety, and greenhouse gas storage.
Director of National Parks (DNP)	DNP is the statutory authority responsible for administration, management and control of Commonwealth marine reserves (CMRs). The DNP is a relevant person for consultation where: the Activity or part of the Activity is within the boundaries of a proclaimed Commonwealth marine reserve activities proposed to occur outside a reserve may impact on the values within a Commonwealth marine reserve; and / or an environmental incident occurs in Commonwealth waters surrounding a Commonwealth marine reserve and may impact on the values within the reserve.
Department of Biodiversity, Conservation and Attractions (DBCA)	DBCA is a relevant State agency responsible for the management of State marine parks and reserves and protected marine fauna and flora.
Department of Primary Industries and Regional Development (DPIRD)	DPIRD is responsible for managing West Australian fisheries.
Pilbara Development Commission (PDC)	PDC is a statutory authority of the WA Government that partners with communities, government, business and industry to identify and support projects that benefit its region of interest.
Section 25(1)(b): Department of the responsible Western Australian Minister	
Department of Energy, Mines, Industry Regulation and Safety (DEMIRS)	DEMIRS is the department of the relevant State Minister and is required to be consulted under subregulation 11A (1) of the Environment Regulations.
Section 25(1)(d): Persons or organisations whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan Section 25(1)(e): any other person or organisation that the titleholder considers relevant	
Academic and research organisations	
Australian Marine Sciences Association (WA Branch)	Marine research organisation
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Marine research organisation
Geoscience Australia (GA)	Marine research organisation
Charles Darwin University (CDU)	Marine research organisation
University of Tasmania - Marine Biodiversity Hub (UTAS)	Marine research organisation
University of Western Australia (UWA)	Marine research organisation
Western Australian Marine Science Institution (WAMSI)	Marine research organisation
Commercial fishing – Commonwealth managed	
Commonwealth fisheries: Australian Southern Bluefin Tuna Fishery North West Slope Trawl Fishery	Licence holders of these fisheries are entitled to fish within the EMBA and should

Relevant person	Summary of relevance
Western Skipjack Fishery Western Tuna and Billfish Fishery	be consulted based on published AFMA guidance.
Commercial fishing – Western Australian managed	
State fisheries: Mackerel Managed Fishery (Area 2) Pilbara Line Fishery Pilbara Demersal Trap Managed Fishery Pilbara Fish Trawl Interim Managed Fishery	Licence holders of these fisheries are active at the activity location and should be consulted based on published WAFIC guidance.
Energy industry – Petroleum Titleholders	
No titleholders identified as the EMBA does not adjoin other petroleum titles.	NA
Energy industry – Greenhouse Gas (GHG) Titleholders	
No titleholders identified as the EMBA does not adjoin GHG titles.	NA
Environmental conservation organisations	
Australian Conservation Foundation (ACF)	ACF is a peak conservation body with an interest in activities that may affect the marine environment
Conservation Council of WA (CCWA)	CCWA is a peak conservation body with an interest in activities that may affect the marine environment
Greenpeace Australia Pacific (GAP)	GAP is a peak conservation body with an interest in activities that may affect the marine environment
International Fund for Animal Welfare (IFAW)	IFAW is a peak conservation body with an interest in activities that may affect the marine environment
Wilderness Society (WS)	WS is a peak conservation body with an interest in activities that may affect the marine environment
World Wildlife Fund (WWF)	WWF is a peak conservation body with an interest in activities that may affect the marine environment
First Nations peoples and groups – Pilbara Region	
Yamatji Marlpa Aboriginal Council	Native Title Representative Body
Murujuga Aboriginal Corporation	Body Corporate
Ngarluma Aboriginal Corporation	Native Title Prescribed Body Corporate
Wirrawandi Aboriginal Corporation	Native Title Prescribed Body Corporate
Industry associations - Energy industry	
No industry association identified as the EMBA does not intersect any adjacent or proximate petroleum or greenhouse gas titles.	NA
Industry associations - Commercial fishing	
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	ASBTIA represents the interests of the Southern Bluefin Tuna Fishery and Western Skipjack Fishery

Relevant person	Summary of relevance
Commonwealth Fisheries Association (CFA)	CFA represents the interests of commercial fishers with licences in Commonwealth waters
Tuna Australia (TA)	TA represents the interests of the Western Tuna and Billfish Fishery
Western Australian Fishing Industry Council (WAFIC)	WAFIC represents the interests of the WA commercial fishing, pearling and aquaculture sector.
Industry associations - Local government	
No industry association identified as the EMBA does not intersect any Local Government Areas.	NA
Industry associations - Local industry	
No industry association identified as the EMBA does not intersect any Local Government Areas.	NA
Industry associations - Recreational fishing	
Recfishwest	Recfishwest represents the interests of Western Australia's recreational fishing sector. The open waters of the EMBA support some recreational fishing activity over Glomar shoals.
Industry associations - Commercial shipping	
No industry association identified as the EMBA does not intersect any shipping fairways or high traffic areas.	NA
Industry Associations – tourism	
No industry association identified as the EMBA does not intersect areas of interest to tourism operators.	NA
Infrastructure operators	
No infrastructure operators identified as the EMBA does not intersect the presence of submarine telecommunications cables or ports.	NA
Local Government Authorities	
No local government authorities identified as the EMBA does not intersect any Local Government Areas.	NA
Recreational fishers	
King Bay Game Fishing Club (KBFC)	KBFC is a Dampier based fishing club that represents local fishers who may be active in the EMBA. KBFC has been consulted previously at the request of Recfishwest.
Nickol Bay Sportsfishing Club (NBSC)	NBSC is a Dampier based fishing club that represents local fishers who may be active in the EMBA. KBFC has been consulted previously at the request of Recfishwest.
Tourism operators	
No tourism operators identified as the EMBA does not intersect areas of interest to tourism operators.	NA

4.5.6 Provision of sufficient information

Santos is required to give relevant persons sufficient information so they can make an informed assessment about the possible consequences of the Activity on their functions, interests or activities. Santos provided relevant persons with information regarding:

+ the Activity proposed under this EP;
+ the environment that may be affected by the Activity, including depictions of the modelled EMBA and explaining how the EMBA is determined;
+ the potential environmental impacts and risks of the Activity and proposed control measures;
+ the environmental approval process;
+ the purpose of consultation, who may be a relevant person and how to self-nominate as a potential relevant person;
+ the titleholder's obligations during consultation in the course of preparing an environment plan, including the obligation of the titleholder not to publish particular information if so requested by the relevant person; and
+ how to provide feedback.

At a minimum, this information was available on the Santos website and also included in the factsheets which Santos sent to relevant persons by email or made available during consultation sessions.

Relevant Persons were provided access to information using different mediums and platforms, including by telephone, email, website (www.santos.com/offshoreconsultation), hard copy and electronic materials, and in person and virtual meetings. Examples of the consultation material used are included in **Appendix H**.

4.5.7 Consultation approach

In developing this EP Santos has sought to work with authorities, persons and organisations on pragmatic and practical approaches to Section 25 consultation.

Santos sought feedback about consultation methods and information needs in its correspondence and via consultation meetings. Santos also sought information as to functions, interests or activities that may be affected by the Activity.

This approach has included:

+ Providing relevant persons access to information using different mediums and platforms, including by telephone, email, website, electronic materials, in person and virtual meetings.
+ Making information about proposed activities to be managed under this EP available on the Santos website at www.santos.com/offshoreconsultation. Hyperlinks to this website were included in consultation emails.
+ Recognising WAFIC's published guidance that petroleum titleholders consult directly with those licence holders historically active in Operational Areas, while providing a list of all entitled fisheries that overlap the EMBA. This approach acknowledges previous feedback from WAFIC regarding consultation fatigue among Western Australia's estimated 1500 fishing boat licence holders.
+ Using WAFIC fee-for-service arrangements to circulate Santos' consultation information via email to licence holders.
+ Making information available to potentially affected commercial fishing licence holders in Western Australian managed fisheries on the WAFIC web site at https://www.wafic.org.au/what-we-do/access-sustainability/oil-gas/consultationhubtrial/ for the duration of the consultation period.
+ Recognising previous feedback from Recfishwest that petroleum titleholders consult directly with those fishing clubs with regional proximity to Operational Areas, while providing information on activity EMBA's that may have broader implications for recreational fishers. This approach acknowledges DPIRD's estimated 620,000 recreational fishers in Western Australia.

Santos also circulated information to subscribers of the *WA Offshore Quarterly Update (July 2023)* during the consultation period for this EP, including to some relevant persons identified in this EP. This Update provides subscribers with a regular update on proposed, planned, current and completed activities.

All authorities, persons and organisations engaged during the preliminary consultation and consultation phases were provided a link to the NOPSEMA brochure: *Consultation on offshore petroleum environment plans.*

A schedule of consultation activities is included at **Table 4-6** and a schedule of advertising is included at **Table 4-7**.

Table 4-6. Additional consultation activities

Activity	Purpose	Timing
Preliminary Consultation		
Website Website content and activity fact sheets developed and made available at https://www.santos.com/offshoreconsultation/	Provide relevant persons with: + Information about Santos' consultation obligations and approach. + Descriptions of proposed activities, including potential activity impacts and risks, and proposed management measures. + Contact information to enable relevant persons to provide feedback. + Information about how to self-identify as a relevant person, including an on-line nomination form. + Details about how feedback will be managed, including provision of Santos' offshore Western Australia privacy notice.	From 26 May 2023
Advertising Advertisements in the following publications: + The West Australian + Mid West Times and Northern Guardian + Pilbara News + North West Telegraph	Promote awareness of proposed activities to create opportunities for relevant persons to self-identify and seek feedback from relevant persons in addition to those identified by Santos as part of its initial public review process.	From 29 May 2023
Consultation materials Email to identified relevant persons with a link to the fact sheet for this EP		From 29 May 2023
One-to-one meetings Meetings held with authorities, persons and organisations	Provide relevant persons with details on proposed activities and establish consultation expectations.	From 29 May 2023
Consultation		
Consultation materials Email to identified relevant persons advising the commencement of consultation	Reminder to Santos identified relevant persons of the commencement and closing dates for consultation.	From 26 June 2023
Advertising Advertisement confirming commencement of consultation in the following publications: + The West Australian + Mid West Times and Northern Guardian + Pilbara News + North West Telegraph	Promote awareness of proposed activities and seek feedback from relevant persons.	From 26 June 2023)
Consultation email Reminder email to identified relevant persons advising pending closure of consultation period	Reminder to Santos identified relevant persons of the closing dates for consultation.	From 19 July 2023

Activity	Purpose	Timing
Community meetings + Exmouth Community Liaison Group meeting	Information provided to the Group on a number of Santos proposed activities, including for this EP.	27 July 2023

Table 4-7. Additional consultation advertising (May – June 2023)

Publication date	Advertising type	Towns / Communities	Reach
Preliminary consultation			
Tuesday, 29 May 2023	Press ad – The West Australian	WA State-wide	341,000
Wednesday, 31 May 2023	Press ad – Midwest Times and Northern Guardian	Carnamah, Carnarvon, Chapman Valley, Coorow, Coral Bay, Cue, Dongara, Eneabba, Geraldton, Greenough, Jurien, Kalbarri, Leeman, Meekatharra, Mingenew, Moonyoonooka, Morowa, Mount Magnet, Mullewa, Northampton, Perenjori, Port Denison, Shark Bay, Tardun, Tenindewa, Three Springs, Useless Loop, Walkaway, Wandina and Yalgoo	16,739
Wednesday, 31 May 2023	Press ad – Pilbara News	Dampier, Karratha, Onslow, Pannawonica, Paraburdoo, Point Samson, Port Hedland, Roebourne, South Hedland, Tom Price and Wickham	11,545
Wednesday, 31 May 2023	Press ad – North West Telegraph	Marble Bar, Newman, Nullagine, Port Hedland, South Hedland and Wedgefield	5,485
Tuesday, 6 June 2023	Press ad – The West Australian	As above	341,000
Wednesday, 7 June 2023	Press ad – Midwest Times	As above	16,739
Wednesday, 7 June 2023	Press ad – Pilbara News	As above	11,545
Wednesday, 7 June 2023	Press ad – North West Telegraph	As above	5,485
Consultation			
Monday, 26 June 2023	Press ad – The West Australian	As above	415,000
Wednesday, 28 June 2023	Press ad – Midwest Times	As above	16,739
Wednesday, 28 June 2023	Press ad – Pilbara News	As above	11,545
Wednesday, 28 June 2023	Press ad – North West Telegraph	As above	5,485
Friday, 30 June 2023	Press ad – Geraldton Guardian	As above	10,012

4.5.8 Reasonable period for consultation

Santos directly contacted relevant persons notifying them of the consultation process and consultation period. Emails were sent to relevant persons to invite feedback for the EP, confirming the date by which feedback was sought.

Santos provided approximately 30 days from the date of initial consultation information being provided to review and respond with feedback about the proposed activities. In some cases, more time was provided. Santos also sought to accommodate reasonable requests for additional time.

For most identified relevant persons, the consultation period followed a 30-day preliminary consultation period.

4.5.9 Consultation opportunities

Santos offered multiple avenues and mediums for consultation, including:

+ provision of a toll free 1800 number
+ dedicated email address
+ in-person or virtual meetings, as appropriate.

Attempts were made to follow up contact and a response if/where no response was received.

4.5.10 Ongoing consultation

Santos carries out ongoing consultation during the life of an EP, including after an EP has been accepted by NOPSEMA. Santos' post EP acceptance consultation is described in **Section 8.12** and the activity notifications are described in **Section 8.9.1.**

If, during the course of post acceptance consultation, Santos receives information demonstrating a new or increased environmental impact or risk that is not provided for in this EP, (as in force at the time) Santos will apply its Management of Change process outlined in **Section 8.10.2**.

4.6 Consultation report

Santos has considered and responded to feedback from relevant persons, which is summarised in Table 4-8, addressing the requirements of section 24(b)(i)-(iii). Santos has also included in this table feedback that was received during the preliminary consultation phase.

Table 4-8: Summary of consultation activities

<table>
<tr><th colspan="4">Section 25(1)(a): Each Commonwealth, State or Northern Territory agency or authority to which the activities to be carried out under the environment plan may be relevant</th></tr>
<tr><td colspan="4">Australian Fisheries Management Authority (AFMA)</td></tr>
<tr><td colspan="4">Summary of preliminary consultation effort:
+ On 29 May 2023 Santos emailed AFMA and provided information on several proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and included a link to an information fact sheet about proposed activities in this EP. [Con-2133]
+ On 31 May 2023 AFMA emailed Santos advising it would like to meet to discuss the proposed Carnarvon Basin activities. [Con-2110]
+ On 7 June 2023 Santos met with AFMA regarding the proposed activities and discussed opportunities to adopt pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries. [Con-2027]
Summary of consultation effort:
+ On 12 June 2023 Santos responds to Australian Fisheries Management Authority (AFMA), noting its consultation principles and requests if AFMA could suggest a contact at DAFF. [Con-2134]
+ On 29 June 2023 Santos emailed Australian Fisheries Management Authority (AFMA) seeking feedback and advised it had directly consulted licence holders entitled to fish in the EMBA for this activity and had also provided information to organisations that represent these fisheries. [Con-1778]
+ On 30 June 2023 AFMA emailed Santos advising it had no feedback. [Con-1773]</td></tr>
<tr><td>Summary of Objection or Claim</td><td>Assessment of Merits</td><td>Santos’ Response Statement</td><td>EP Reference</td></tr>
<tr><td>N/A</td><td>Santos has consulted with relevant fisheries.
AFMA did not raise and objection or claim about the activities covered by this EP.</td><td>No response required.</td><td>Commonwealth fisheries are described in Section 3.6.1 and assessed in Section 6 and 7 where relevant.</td></tr>
<tr><td colspan="4">Australian Hydrographic Office (AHO)</td></tr>
<tr><td colspan="4">Summary of consultation effort:</td></tr>
</table>

- On 26 June 2023 Santos emailed AHO seeking feedback on several proposed Carnarvon Basin activities, and included a link to an information fact sheet about proposed activities in this EP. [Con-1646]
- On 27 June 2023 Santos received a standard response email from AHO stating that the data supplied will be registered, assessed, prioritised and validated in preparation for updating our Navigational Charting products. [Con-1768]
- On 5 August 2024 Santos emailed AHO advising that at the time of the original consultation, no vessel-based activities were proposed to be managed under this EP. This position has changed, and the EP will now include occasional vessel activities at the WA-20-L location. Vessel-based surveillance, monitoring, inspection and research activities may be required approximately once within a period of several years. Vessel activity would typically be for a few days to a few weeks in duration. A single vessel is generally used to undertake the activity. [Con-5274]
- On 6 August 2024, Santos received an acknowledgement of receipt for email communication sent on 5 August 2024. AHO informed Santos that the data we supplied will now be registered, assessed, prioritised and validated in preparation for updating our Navigational Charting products. These adhere to International and Australian Charting Specifications and standards. These standards may result in some data generalisation or filtering due to the scale of existing charts, proximity to other features, and the level of risk a reported feature presents to mariners. [Con-5306]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
AHO provided its standard response on activity notifications that is issued to an operator developing an EP.	Santos notes the previous guidance from AHO and considers it relevant to the EP. The wellhead has remained in a fixed position since 1968 and is marked on AHO charts. Santos will provide notifications as requested.	In line with previous guidance received from AMSA and AHO, Santos will: Notify AMSA's Response Centre (ARC) through rccaus@amsa.gov.au (Phone: 1800 641 792 or +61 2 6230 6811) for promulgation of radio-navigation warnings 24-48 hours before operations commence. AMSA's ARC will require both the working vessel/s and support details (including name, callsign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation, requested clearance from other vessels and need to be advised when operations start and end. Contact the Australian Hydrographic Office no less than four working weeks before operations commence for the promulgation of related notices to mariners.	Control measure CM-28 relates to AHO charts. AHO notifications are included in **Table 8-4**.

		Ensure vessels exhibit appropriate lights and shapes to reflect the nature of operations – we are aware of the obligation to comply with the International Rules for Preventing Collisions at Sea (COLREGs), in particular, the use of appropriate lights and shapes to reflect the nature of operations (e.g. restricted in the ability to manoeuvre). Vessels will also ensure their navigation status is set correctly in the ship's AIS unit. Review and assess the merit of the proposed mitigation strategies and anti-collision measures as per our standard approach to all vessel activities. Notify AMSA and AHO on any changes to the intended operations.	

Australian Institute of Marine Science (AIMS)

Summary of preliminary consultation effort:

- On 12 June 2023 Santos emailed AIMS and provided information on several proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and provided a link to an information fact sheet about proposed activities in this EP. [Con-2135]

Summary of consultation effort:

- On 26 June 2023 Santos emailed AIMS seeking feedback on proposed activities. [Con-1657]
- On 19 July 2023 Santos emailed AIMS by way of reminder on the timeframe for providing feedback. [Con-1666]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation.	N/A	N/A

	Santos considers the Regulation 25 consultation requirements to have been met.		
Australian Maritime Safety Authority (AMSA) – maritime safety			

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed AMSA and provided information on several proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and provided a link to an information fact sheet about proposed activities in this EP. [Con-2136]

Summary of consultation effort:

- On 29 June 2023 Santos emailed AMSA seeking feedback on proposed activities. [Con-1659]
- On 19 July 2023 Santos emailed AMSA by way of reminder on the timeframe for providing feedback. [Con-1667]
- No further correspondence or feedback has been received.
- On 5 August 2024 Santos emailed AMSA advising that at the time of the original consultation, no vessel-based activities were proposed to be managed under this EP. This position has changed, and the EP will now include occasional vessel activities at the WA-20-L location. Vessel-based surveillance, monitoring, inspection and research activities may be required approximately once within a period of several years. Vessel activity would typically be for a few days to a few weeks in duration. A single vessel is generally used to undertake the activity. [Con-5273]

Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
AMSA requested Santos to notify AMSA's Joint Rescue Coordination Centre (JRCC) for promulgation of radio-navigation warnings 24-48 hours before operations commence and provided AMSA JRCC's communications expectations.	Santos notes the feedback and considers the feedback relevant to the EP.	Santos will notify AMSA's Joint Rescue Coordination Centre (JRCC for promulgation of radio-navigation warnings 24-48 hours before operations commence.	JRCC notifications are included in: **Table 8-4**.
AMSA requested Santos to contact the Australian Hydrographic Office no less than four working weeks before operations commence for related notices to mariners.	Santos notes the feedback and considers the feedback relevant to the EP.	Santos will contact the Australian Hydrographic Office no less than four working weeks before operations commence.	Australian Hydrographic Office notifications are included in **Table 8-4**.
AMSA advised that vessels should exhibit appropriate lights and shapes to reflect the nature of operations, noting	Santos notes the feedback and considers the feedback relevant to the EP.	Santos will ensure vessels exhibit appropriate lights and shapes to reflect the nature of operations – we are aware	**Section 6.2**.

Santos' obligation to comply with the International Rules for Preventing Collisions at Sea (COLREGs), in particular, the use of appropriate lights and shapes. AMSA requested that vessels also ensure their navigation status was set correctly in the ship's AIS unit.		of the obligation to comply with the International Rules for Preventing Collisions at Sea (COLREGs), in particular, the use of appropriate lights and shapes to reflect the nature of operations (e.g., restricted in the ability to man oeuvre). Vessels will also ensure navigation status is set correctly in the ship's AIS unit.	
AMSA advised that Santos should evaluate and implement adequate anti-collision measures, noting that collision risk mitigation measures may include: additional warnings and/or lights; offshore guard vessel/s.	Santos notes the feedback and considers the feedback relevant to the EP.	Santos will review and assess the merit of the proposed mitigation strategies and anti-collision measures as per our standard approach to all vessel activities.	Additional anti-collision measures are considered in **Section 7.7**.

Department of Agriculture, Forestry and Fisheries (DAFF) – Fisheries

Summary of preliminary consultation effort:

+ On 29 May 2023 Santos emailed DAFF and provided information on a number of proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and provided a link to an information fact sheet about proposed activities in this EP. [Con-2138]
+ On 15 June 2023 Santos met with DAFF (domestic fisheries branch) regarding the proposed activities and discussed opportunities to adopt pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries. [Con-2032]

Summary of consultation effort:

+ On 29 June 2023 Santos emailed DAFF seeking feedback on proposed activities. [Con-1671]
+ On 23 July 2023 Santos emailed DAFF by way of reminder on the timeframe for providing feedback. [Con-1672]
+ On 31 July 2023 DAFF emailed Santos and provided the following feedback: [Con-2121]
  - AFMA could provide information on fishing effort in areas likely to be directly impacted by proposed activities.
  - DAFF had no comment in relation to the activity location, further to Santos engaging AFMA on fishing effort and activity implications for licence holders.
  - DAFF noted broadly that there were increasing activities occurring in the marine space with numerous consultation processes, with the fishing industry reporting significant consultation fatigue and a lack of capacity to adequately respond to all consultations. DAFF suggested keeping this in mind when Santos conducts its consultations with the fishing industry.
+ On 9 August 2023 Santos emailed DAFF acknowledging that DAFF had no comments or objections regarding the proposed Carnarvon Basin activities. [Con-2216]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference

DAFF advised that AFMA could provide fishing effort data on areas that were likely to be impacted by proposed activities.	Santos notes DAFF advice on sourcing fishing effort data and considers the feedback relevant to the EP.	Santos has reviewed ABARES fishery status reports in the development of this EP.	**Section 3.6.1**.
DAFF commented on consultation fatigue in the fishing industry.	Outside the consultation scope of this EP.	N/A	No additional EP controls required.
Department of Industry, Science and Resources (DISR)			
Summary of consultation effort: + On 26 June 2023 Santos emailed DISR seeking feedback on proposed activities. [Con-1665] + On 19 July 2023 Santos emailed DISR by way of reminder on the timeframe for providing feedback. [Con-1669]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Director of National Parks (DNP)			
Summary of preliminary consultation effort: + On 30 May 2023 Santos emailed DNP and provided information on a number of proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and provided a link to an information fact sheet about proposed activities in this EP. [Con-2140] **Summary of consultation effort:** + On 26 June 2023 Santos emailed DNP seeking feedback on proposed activities. [Con-1664] + On 19 July 2023 Santos emailed DNP by way of reminder on the timeframe for providing feedback. [Con-1670]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**

Santos notes feedback from initial consultation that DNP did not have any claims and objections but indicated it would like to understand the research and monitoring program further. Specifically, if the gas bubbles were found to be impacting the environment, what steps would be taken to mitigate those impacts.	Santos has committed to the ongoing consultation of DNP. See **Table 8-4.**	Santos previously advised that monitoring of the gas bubbles would be fed into an adaptive management plan, taking account of any changes to measured environmental impacts over time as well as technical assessments to determine feasible mitigation measures. Santos advised it would provide more information to DNP as the program is matured, monitoring is undertaken, and results assessed.	Santos has committed to the ongoing consultation of DNP. See **Table 8-4.**

Section 251)(b): if the plan relates to activities in the offshore area of a State - the Department of the responsible State Minister

Department of Biodiversity, Conservation and Attractions (DBCA)

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed DBCA and provided information on a number of proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and provided a link to an information fact sheet about proposed activities in this EP. [Con-2144]

Summary of consultation effort:

- On 26 June 2023 Santos emailed DBCA seeking feedback on proposed activities. [Con-1647]
- On 19 July 2023 Santos emailed DBCA by way of reminder on the timeframe for providing feedback. [Con-1723]
- On 26 July 2023 DBCA emailed Santos advising it had no further comments regarding activities in production licence WA-20-L. [Con-1761]
- On 27 July 2023 Santos emailed DBCA acknowledging it had no comments regarding proposed activities. [Con-1752]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	DBCA emailed Santos advising it had no comments regarding activities in production licence WA-20-L. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

Department of Primary Industries and Regional Development (DPIRD)

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed DPIRD and provided information on a number of proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and included a link to an information fact sheet about proposed activities in this EP. [Con-2148]
- On 9 June 2023 Santos met with DPIRD regarding the proposed activities and discussed opportunities to adopt pragmatic and practical approaches for the consultation of licence holders entitled to fish in Western Australian fisheries. [Con-2035]

Summary of consultation effort:

- On 29 June 2023 Santos emailed DPIRD seeking feedback on proposed activities. [Con-1710]
- On 19 July 2023 Santos emailed DPIRD by way of reminder on the timeframe for providing feedback. [Con-1742]
- On 20 July 2023 DPIRD emailed Santos and advised it noted Santos' advice that it was actively consulting with relevant commercial fishing sectors and had no further comments at this time regarding proposed activities. [Con-1759]
- On 26 July 2023 Santos emailed DPIRD acknowledging DPIRD had no comments on proposed activities. [Con-1749]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	DPIRD emailed Santos and advised it noted Santos' advice that it was actively consulting with relevant commercial fishing sectors and had no further comments at this time regarding proposed activities	N/A	Commercial fisheries are described in **Section 3.6.1**.

Pilbara Development Commission (PDC)

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed PDC and provided information on a number of proposed Carnarvon Basin activities, seeking to discuss opportunities for consultation and included a link to an information fact sheet about proposed activities in this EP. [Con-2150]

Summary of consultation effort:

- On 27 June 2023 Santos emailed PDC seeking feedback on proposed activities. [Con-1656]
- On 19 July 2023 Santos emailed PDC by way of reminder on the timeframe for providing feedback. [Con-1736]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities.	N/A	N/A

	Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.		
Department of Mines, Industry Regulation and Safety (DMIRS)			
Summary of preliminary consultation effort: + On 19 June 2023 Santos met with DMIRS to clarify consultation expectations on a number of proposed Carnarvon Basin activities. For those activities with vessel or rig-based activities it was agreed that Santos will provide DMIRS a commencement (10 days prior) and cessation (10 days after) notifications on EPs in Commonwealth waters that may impact state waters. [Con-2115] **Summary of consultation effort:** + On 29 June 2023 Santos emailed DMIRS seeking feedback on proposed activities. [Con-1712] + On 19 July 2023 Santos emailed DMIRS by way of reminder on the timeframe for providing feedback. [Con-1898]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Section 25(1)(d): Persons or organisations whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan			
Academic and research organisations			
Australian Marine Sciences Association (AMSA) (WA Branch)			
Summary of preliminary consultation effort:			

+ On 12 June 2023 Santos emailed AMSA (WA Branch) and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of AMSA may be affected. [Con-2179]

Summary of consultation effort:

+ On 27 June 2023 Santos emailed AMSA seeking feedback on proposed activities. [Con-1674]
+ On 19 July 2023 Santos emailed AMSA by way of reminder on the timeframe for providing feedback. [Con-1681]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Summary of preliminary consultation effort:

+ On 12 June 2023 Santos emailed CSIRO and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of CSIRO may be affected. [Con-2154]

Summary of consultation effort:

+ On 27 June 2023 Santos emailed CSIRO seeking feedback on proposed activities. [Con-1675]
+ On 29 June 2023 CSIRO emailed Santos and advised it was not able to pursue a collaboration. [Con-1806]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	CSIRO emailed Santos and advised it was not able to pursue a collaboration. Santos considers it has provided sufficient time and opportunity for consultation.	N/A	N/A

	Santos considers the Regulation 25 consultation requirements to have been met.		
Geoscience Australia (GA)			
Summary of preliminary consultation effort: + On 12 June 2023 Santos emailed GA and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of GA may be affected. [Con-2155] **Summary of consultation effort:** + On 27 June 2023 Santos emailed GA seeking feedback on proposed activities. [Con-1676] + On 14 July 2023 Santos received a response email from Geoscience Australia, GA advised it had no input or feedback. [Con-1808] + On 26 July 2023 Santos responded to the email from Geoscience Australia acknowledging it had no input or feedback for the proposed Carnarvon Basin activities. [Con-1797]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	GA advised it had no input or feedback. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Charles Darwin University (CDU)			
Summary of consultation effort: + On 27 June 2023 Santos emailed CDU seeking feedback on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of GA may be affected. [Con-1680] + On 19 July 2023 Santos emailed CDU by way of reminder on the timeframe for providing feedback. [Con-1682]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation.	N/A	N/A

	Santos considers the Regulation 25 consultation requirements to have been met.		
University of Tasmania - Marine Biodiversity Hub (UTAS)			

Summary of preliminary consultation effort:

- On 12 June 2023 Santos emailed UTAS and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of UTAS may be affected. [Con-2156]

Summary of consultation effort:

- On 27 June 2023 Santos emailed UTAS seeking feedback on proposed activities. [Con-1677]
- On 19 July 2023 Santos emailed UTAS by way of reminder on the timeframe for providing feedback. [Con-1683]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
University of Western Australia (UWA)			

Summary of preliminary consultation effort:

- On 12 June 2023 Santos emailed UWA and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of UWA may be affected. [Con-2157]

Summary of consultation effort:

- On 26 June 2023 Santos emailed UWA seeking feedback on proposed activities. [Con-1678]
- On 19 July 2023 Santos emailed UWA by way of reminder on the timeframe for providing feedback. [Con-1684]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference

N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Western Australian Marine Science Institution (WAMSI)			
Summary of preliminary consultation effort: + On 12 June 2023 Santos emailed WAMSI and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of WAMSI may be affected. [Con-2158] **Summary of consultation effort:** + On 27 June 2023 Santos emailed WAMSI seeking feedback on proposed activities. [Con-1679] + On 19 July 2023 Santos emailed WAMSI by way of reminder on the timeframe for providing feedback. [Con-1685]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Commercial fishing – Commonwealth managed			
Australian Southern Bluefin Tuna Fishery			
Summary of preliminary consultation effort: + As part of preliminary consultation activities Santos sought to engage with AFMA, DAFF and representative organisations on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries.			

Summary of consultation effort:

- On 29 June 2023 Santos emailed licence holders in the Australian Southern Bluefin Tuna Fishery and provided information on a number of proposed Carnarvon Basin activities (including a link to an information fact sheet about the WA-20-L activities); a licence holder responded and advised Santos to refer to the tuna industry association - Tuna Australia on consultation matters. [Con-2161]
- On 29 June 2023 Santos emailed the licence holder and advised it was consulting Tuna Australia as part of consultation activities. [Con-2166]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
A licence holder advised Santos refer to the tuna industry association - Tuna Australia – on consultation matters	Santos consulted Tuna Australia as part of consultation activities.	Santos advised the licence holder it was consulting Tuna Australia as part of consultation activities	Refer to Tuna Australia section.

North West Slope Trawl Fishery

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with AFMA, DAFF and representative organisations on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries.

Summary of consultation effort:

- On 29 June 2023 Santos emailed licence holders in the North West Slope Trawl Fishery and provided information on a number of proposed Carnarvon Basin activities. Santos provided a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. [Con-3057]
- On 28 July 2023 Santos emailed licence holders in the North West Slope Trawl Fishery by way of reminder on the timeframe for providing feedback. [Con-3058]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

Western Skipjack Fishery

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with AFMA, DAFF and representative organisations on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries.

Summary of consultation effort:

- On 29 June 2023 Santos emailed licence holders in the Western Skipjack Fishery and provided information on a number of proposed Carnarvon Basin activities. Santos provided a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. [Con-3062]
- On 28 July 2023 Santos emailed licence holders in the Western Skipjack Fishery by way of reminder on the timeframe for providing feedback. [Con-3063]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

Western Tuna and Billfish Fishery

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with AFMA, DAFF and representative organisations on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Commonwealth fisheries.

Summary of consultation effort:

- On 29 June 2023 Santos emailed licence holders in the North West Slope Trawl Fishery and provided information on a number of proposed Carnarvon Basin activities. Santos provided a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. [Con-3065]
- On 28 July 2023 Santos emailed licence holders in the Australian Southern Bluefin Tuna Fishery by way of reminder on the timeframe for providing feedback. [Con-3066]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation.	N/A	N/A

	Santos considers the Regulation 25 consultation requirements to have been met.		
Commercial fishing – Western Australian managed			
Mackerel Managed Fishery (Area 2)			

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with DPIRD and WAFIC on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Western Australian fisheries. Santos followed WAFIC guidance to consult licence holders who may be directly affected. Santos also used WAFIC fee-for-service arrangements to circulate consultation information to fishers.

Summary of consultation effort:

- On 29 June 2023 WAFIC emailed licence holders in the Mackerel Managed Fishery and provided information on a number of proposed Carnarvon Basin activities. WAFIC correspondence included a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. WAFIC also provided a summary of Santos consultation activities on a trial Consultation Hub on its web site. [Con-1891]
- On 24 July 2023 WAFIC emailed licence holders in the Mackerel Managed Fishery by way of reminder on the timeframe for providing feedback. [Con-2182]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received from licence holders for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	The fishery is considered in **Sections 3.6.1** and **7.1**.
Pilbara Line Fishery			

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with DPIRD and WAFIC on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Western Australian fisheries. Santos followed WAFIC guidance to consult licence holders who may be directly affected. Santos also used WAFIC fee-for-service arrangements to circulate consultation information to fishers.

Summary of consultation effort: + On 29 June 2023 WAFIC emailed licence holders in the Pilbara Line Fishery and provided information on a number of proposed Carnarvon Basin activities. WAFIC correspondence included a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. WAFIC also provided a summary of Santos consultation activities on a trial Consultation Hub on its web site. [Con-1891] + On 24 July 2023 WAFIC emailed licence holders in the Pilbara Line Fishery by way of reminder on the timeframe for providing feedback. [Con-2182]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received from licence holders for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for *consultation.* Santos considers the Regulation 25 consultation requirements to have been met.	N/A	The fishery is considered in **Sections 3.6.1** and **7.1**.
Pilbara Demersal Trap Managed Fishery			
Summary of preliminary consultation effort: + As part of preliminary consultation activities Santos sought to engage with DPIRD and WAFIC on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Western Australian fisheries. Santos followed WAFIC guidance to consult licence holders who may be directly affected. Santos also used WAFIC fee-for-service arrangements to circulate consultation information to fishers. **Summary of consultation effort:** + On 29 June 2023 WAFIC emailed licence holders in the Pilbara Demersal Trap Managed Fishery and provided information on a number of proposed Carnarvon Basin activities. WAFIC correspondence included a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. WAFIC also provided a summary of Santos consultation activities on a trial Consultation Hub on its web site. [Con-1891] + On 24 July 2023 WAFIC emailed licence holders in the Pilbara Demersal Trap Managed Fishery by way of reminder on the timeframe for providing feedback. [Con-2182]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received from licence holders for WA-20-L activities.	N/A	The fishery is considered in **Sections 3.6.1** and **7.1**.

	Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.		
Pilbara Fish Trawl Interim Managed Fishery			

Summary of preliminary consultation effort:

- As part of preliminary consultation activities Santos sought to engage with DPIRD and representative organisations on pragmatic and practical approaches for the consultation of licence holders entitled to fish in Western Australian fisheries. Santos followed WAFIC guidance to consult licence holders who may be directly affected. Santos also used WAFIC fee-for-service arrangements to provide consultation information to fishers.

Summary of consultation effort:

- On 29 June 2023 WAFIC emailed licence holders in the Pilbara Fish Trawl Interim Managed Fishery and provided information on a number of proposed Carnarvon Basin activities. WAFIC correspondence included a link to an information fact sheet about proposed activities in this EP and sought feedback on proposed activities. WAFIC also provided a summary of Santos consultation activities on a trial Consultation Hub on its web site. [Con-1891]
- On 24 July 2023 WAFIC emailed licence holders in the Pilbara Fish Trawl Interim Managed Fishery by way of reminder on the timeframe for providing feedback. [Con-2182]
- No correspondence or feedback has been received from licence holders.
- Notwithstanding the consultation information provided and the steps described above, no comments or input were received on this EP from licence holders.

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
No response was received from licence holders in the Pilbara Fish Trawl Interim Managed Fishery.	Santos has consulted with Pilbara Fish Trawl Interim Managed Fishery on WA-20-L since December 2021. Santos has undertaken a specific study to assess the potential snag risk associated with Legendre-1 in-situ wellhead and provided this to the fishery's representative organisation, WAFIC. Santos considers it has provided sufficient information and a reasonable period of time for consultation.	No response required.	The fishery is considered in **Sections 3.6.1** and **7.1**. Snagging risks are assessed in **Section 7.1**.

	Santos considers Section 25 consultation requirements to have been met.		
Environmental conservation organisations			
Australian Conservation Foundation (ACF)			
Summary of preliminary consultation effort: + On 2 June 2023 Santos emailed ACF and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of ACF may be affected. [Con-2159] **Summary of consultation effort:** + On 27 June 2023 Santos emailed ACF seeking feedback on proposed activities. [Con-1769] + On 19 July 2023 Santos emailed ACF by way of reminder on the timeframe for providing feedback. [Con-1783]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Conservation Council of WA (CCWA)			
Summary of preliminary consultation effort: + On 2 June 2023 Santos emailed CCWA and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of CCWA may be affected. [Con-2160] **Summary of consultation effort:** + On 27 June 2023 Santos emailed CCWA seeking feedback on proposed activities. [Con-1771] + On 19 July 2023 Santos emailed CCWA by way of reminder on the timeframe for providing feedback. [Con-1785]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**

Nil	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	Nil	No additional EP controls required.
Greenpeace Australia Pacific (GAP)			
Summary of preliminary consultation effort: + On 2 June 2023 Santos emailed GAP and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of GAP may be affected. [Con-2162] **Summary of consultation effort:** + On 27 June 2023 Santos emailed GAP seeking feedback on proposed activities. [Con-1774] + On 19 July 2023 Santos emailed GAP by way of reminder on the timeframe for providing feedback. [Con-1787]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
International Fund for Animal Welfare (IFAW)			
Summary of preliminary consultation effort: + On 2 June 2023 Santos emailed IFAW and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of IFAW may be affected. [Con-2163] **Summary of consultation effort:**			

- On 27 June 2023 Santos emailed IFAW seeking feedback on proposed activities. [Con-1775]
- On 19 July 2023 Santos emailed IFAW by way of reminder on the timeframe for providing feedback. [Con-1789]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

Wilderness Society (WS)

Summary of preliminary consultation effort:

- On 2 June 2023 Santos emailed WS and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of WS may be affected. [Con-2164]

Summary of consultation effort:

- On 27 June 2023 Santos emailed WS seeking feedback on proposed activities. [Con-1777]
- On 19 July 2023 Santos emailed WS by way of reminder on the timeframe for providing feedback. [Con-1793]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

World Wildlife Fund (WWF)

<table>
<tr><td colspan="4">Summary of preliminary consultation effort:
+ On 2 June 2023 Santos emailed WWF and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of WWF may be affected. [Con-2165]
Summary of consultation effort:
+ On 27 June 2023 Santos emailed WWF seeking feedback on proposed activities. [Con-1779]
+ On 19 July 2023 Santos emailed WWF by way of reminder on the timeframe for providing feedback. [Con-1794]</td></tr>
<tr><th>Summary of Objection or Claim</th><th>Assessment of Merits</th><th>Santos' Response Statement</th><th>EP Reference</th></tr>
<tr><td>N/A</td><td>No correspondence or feedback has been received for WA-20-L activities.
Santos considers it has provided sufficient time and opportunity for consultation.
Santos considers the Regulation 25 consultation requirements to have been met.</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="4">First Nations peoples and groups</td></tr>
<tr><td colspan="4">YMAC</td></tr>
<tr><td colspan="4">Summary of preliminary consultation effort:
+ On 29 May 2023 Santos emailed YMAC and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of YMAC may be affected. [Con-2181]
+ On 12 June 2023 Santos sent a follow up email to YMAC to discuss consultation expectations for proposed activities. [Con-2183]
+ On 19 June 2023 YMAC sent Santos an email with a proposed draft consultation framework in regard to oil and gas projects. [Con-2106]
+ On 20 July 2023 Santos sent an email to YMAC acknowledging the provision of the draft consultation framework. Santos suggested an initial meeting to progress discussions in accordance with YMAC's expectations. [Con-2075]
+ On 5 August 2024 Santos sent a follow up email to YMAC summarising previous consultations noted above. No further correspondence was received from YMAC to discuss the Draft Consultation Protocol, or the Legendre-1 Decommissioning. Santos noted that separate discussions have proceeded with PBCs who are using the YMAC Consultation Protocol. Santos advised it is grateful to YMAC for the work performed in catalysing this important step in consultation agreement. Santos advised YMAC that it now considers consultation in response to the Legendre-1 activity complete. [Con-5272]
Summary of consultation effort:</td></tr>
</table>

+ No feedback has been provided regarding WA-20-L activities.			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No feedback has been provided regarding WA-20-L activities for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	Santos is committed to ongoing consultation over the life of the activity. Santos will apply its consultation methodology.	**Section 3.6.2**.
Murujuga Aboriginal Corporation (MAC)			
Summary of preliminary consultation effort: + On 29 May 2023 Santos emailed MAC and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of MAC and its members may be affected. [Con-2184] + On 30 May 2023 MAC emailed Santos and advised it did not have the capacity to be involved in the consultation process. [Con-2105] + On 27 June 2023 Santos emailed MAC seeking feedback on proposed activities. [Con-2095] + On 20 July 2023 Santos emailed MAC by way of reminder on the timeframe for providing feedback. [Con-2067] + On 21 July 2023 MAC emailed Santos advising it did not consider itself a relevant person for consultation. [Con-2058] + On 21 July 2023 Santos emailed MAC CEO and received a reply email to follow up an alternate contact within MAC. [Con 2198]. **Summary of consultation effort:** + Not required.			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
MAC confirmed it did not consider itself a relevant person for the purposes of consultation.	Santos notes MAC's assessment of relevancy for the purposes of consultation.	Santos thanked MAC for its feedback.	No additional EP controls required.
Ngarluma Aboriginal Corporation (NAC)			

Summary of preliminary consultation effort:

+ On 29 May 2023 Santos emailed NAC and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of NAC and its members may be affected. [Con-2190]
+ On 30 May 2023 Santos emailed NAC to coordinate an in-person meeting as Santos was planning meetings in Karratha in early June. [Con-2191]
+ On 31 May 2023 NAC emailed Santos to advise that a Karratha-based meeting was not possible due to the availability of attendees. [Con-2192]
+ On 31 May 2023 Santos emailed NAC thanking NAC for its feedback. [Con-2193]
+ On 8 June 2023 Santos emailed NAC advising that its planning early June meetings did not proceed as planned and that Santos would be in Karratha later in June. Santos sought feedback if NAC me available at this time. [Con-2194]
+ On 26 June 2023 Santos emailed NAC to discuss consultation expectations for proposed activities. [Con-2103]
+ On 20 July 2023 Santos emailed NAC by way of reminder to set a meeting date. [Con-2079]
+ On 21 July 2023 NAC emailed and explained that the CEO was booked up next week and potentially available 28th July 3. [Con-2066]
+ On 25 July 2023 Santos emailed to confirm availability and requested a Teams meeting* to discuss a proposed onshore pipeline project that that would need a heritage survey as well as Environment Plan consultation more generally. [Con-2064] *The meeting did not pertain to WA-20-L activities.

Summary of consultation effort:

+ No feedback has been provided for the WA-20-L activities.

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No feedback has been provided for the WA-20-L activities for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	Santos is committed to ongoing consultation over the life of the activity. Santos will apply its consultation methodology as outlined in Section 4.5.	No additional EP controls required.
Wirrawandi Aboriginal Corporation (WAC)			

Summary of preliminary consultation effort:

+ On 21 June 2023 Santos met with WAC CEO and Directors. The purpose of the meeting was to introduce Santos and provide an overview of a number of proposed Carnarvon Basin activities. The meeting resulted in the decision that WAC and Santos develop a consultation framework to support ongoing consultation. :.

- On 17 August 2023 WAC emailed a subsequent acceptance letter for consideration to support a range of activities, including Environment Plan consultation. [Con 2314]
- On 20 August 2023 Santos responds to WAC and advising the consultation letter was being considered and also attached a presentation about a different project not relevant to WA-20-L activities. [Con-2315]
- On 23 August 2023 WAC emailed Santos about costs to be discussed in a planned meeting, which was not relevant to WA-20-L activities. [Con-2327].

Summary of consultation effort:

- No feedback has been provided for the WA-20-L activities.

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No feedback has been provided for the WA-20-L activities for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	Santos is committed to ongoing consultation over the life of the activity. Santos will apply its consultation methodology as outlined in **Section 4.5**.	No additional EP controls required.

Industry Associations - Commercial Fishing

Commonwealth Fisheries Association (CFA)

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed CFA and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of CFA may be affected, as well as consideration of CFA's expectation for consultation of licence holders. [Con-2170]

Summary of consultation effort:

- On 29 June 2023 Santos emailed CFA seeking feedback on proposed activities. [Con-1899]
- On 25 July 2023 Santos emailed CFA by way of reminder on the timeframe for providing feedback. [Con-1906]

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
N/A	No correspondence or feedback has been received for WA-20-L activities.	N/A	N/A

	Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.		

Tuna Australia (TA)

Summary of preliminary consultation effort:

- On 30 May 2023 Santos emailed TA and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of TA may be affected, as well as consideration of TA's expectation for consultation of licence holders. [Con-2172]
- On 31 May 2023 TA emailed Santos advising it required a service agreement to enable it to effectively manage its member base for consultation. [Con-2117]
- On 1 June 2023 Santos met with TA to provide information on proposed activities. [Con-2028]
- On 29 June 2023 Santos emailed TA regarding consultation for proposed Carnarvon Basin activities. [Con-1896]
- On 28 July 2023 Santos emailed TA and proposed an alternative approach to the service agreement and sought feedback on whether this approach would be acceptable to TA. [Con-1920]
- On 31 July 2023 TA emailed Santos and advised a TA representative would respond. [Con-1923]
- On 1 August 2023 Santos emailed TA advised it would discuss proposed consultation approaches with the TA representative. [Con-1926]
- On 1 August 2023 TA provided feedback to Santos advising it was disappointed that Santos was unable to enter a service agreement with Tuna Australia. [Con-2123]
- On 1 August 2023 Santos called the TA representative to provide further context on the service agreement and the alternate consultation approach. Santos committed to further reviewing the matter and its intent for meaningful consultation of tuna fishery licence holders.
- On 23 August 2023 Santos emailed TA about potential amendments to the service agreement. [Con-2316]
- No feedback has been provided regarding WA-20-L activities. The above-mentioned feedback is centred on service agreements and does not pertain to WA-20-L activities.

Summary of consultation effort:

- No feedback has been provided regarding WA-20-L activities.

Summary of Objection or Claim	Assessment of Merits	Santos' Response Statement	EP Reference
No objections or claims at the time of EP submission.	No feedback has been provided regarding WA-20-L activities. The above-mentioned feedback is centred on	Santos is committed to ongoing consultation over the life of the activity.	No additional EP controls required.

	service agreements and does not pertain to WA-20-L activities.	Santos will apply its consultation methodology as outlined in **Section 4.5**.	
Western Australian Fishing Industry Council (WAFIC)			

Summary of preliminary consultation effort:

- On 7 June 2023 Santos met with WAFIC regarding the proposed activities and discussed opportunities to adopt pragmatic and practical approaches for the consultation of licence holders, noting WAFIC's published guidance on this matter. [Con-2037]

Summary of consultation effort:

- On 29 June 2023 Santos emailed WAFIC to notify it of consultation for proposed Carnarvon Basin activities. [Con-1901]
- On 24 July 2023 WAFIC emailed all relevant title holders seeking feedback on any or all of the proposed activities. [Con-5590]
- On 27 July 2023 WAFIC emailed Santos with feedback regarding proposed activities. This is summarised as:
  - General comments on Carnarvon Basin activities.
  - Spar-Halyard Development well.
  - HJV Simpson Plug and abandonment.
  - HJV Gibson Plug and abandonment.
  - MEFF Plug and abandonment.
  - HJV Decommissioning.
  - MEFF Decommissioning.
  - Campbell Decommissioning.
  - WA-20-L Decommissioning.
  - WA-1-P Decommissioning. [Con-2149]
- On 9 August 2023 Santos emailed WAFIC and provided a detailed response to all Decommissioning activities. [Con-2212].
- On 5 August 2024 Santos emailed WAFIC advising that at the time of the original consultation, no vessel-based activities were proposed to be managed under this EP. This position has changed, and the EP will now include occasional vessel activities at the WA-20-L location. Vessel-based surveillance, monitoring, inspection and research activities may be required approximately once within a period of several years. Vessel activity would typically be for a few days to a few weeks in duration. A single vessel is generally used to undertake the activity. Santos further reviewed previous correspondence to us with respect to recreational fishing from support vessels. Santos confirmed that recreational fishing is prohibited from project vessels [Con-5275]
- On 7 August 2024 Santos received an email from WAFIC confirming the EP change regarding vessel activities, and for confirming recreational fishing is prohibited from project vessels. WAFIC requested ongoing communication with mariners regarding issuing notices on vessel activity commencement and distances around temporary exclusion zones. WAFIC asks to be included in any vessel operation look ahead associated with this EP. [Con-5307]
- On 12 August 2024, Santos emailed WAFIC in response to their requests received on 7 August 2024.Santos acknowledged WAFICs Consultation Feedback. Santos confirmed it will communicate with mariners regarding issuing notices on vessel activity commencement and distances around temporary exclusion zones. The potential

date of future vessel activity is not yet known; however, Santos will inform WAFIC prior to vessel activity. [Con-5308]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
WAFIC asked what compensation framework Santos has in place for marine users where infrastructure left in situ results in a permanent loss of fishing grounds and/or ocean access.	Santos does not have a compensation framework in place for decommissioning where infrastructure is proposed to be left in situ. The potential socio-economic consequence of leaving the wellhead in-situ has been assessed as I - Negligible. Given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery it is concluded that the likelihood of interaction between a trawler and the wellhead is low. The wellhead is located within largely untrawlable ground and there is low historical fishing effort in the region.	Santos does not have a compensation framework in place for decommissioning where infrastructure is proposed to be left in situ.	Santos has assessed the potential interaction with other marine users, including commercial fishers, as part of EP development. See **Section 2.2.2, 6** and **7.**
WAFIC asked what long-term plans Santos had in place to monitor the degradation of infrastructure to be left in situ.	Santos has considered WAFIC's feedback and considers the feedback relevant to the EP. The potential environmental consequence of leaving the wellhead in-situ has been assessed as I - Negligible. No control measures are considered necessary to further reduce the environmental impacts. The wellhead has been in situ since 1968 without any known environmental or stakeholder concerns regarding the impacts of its degradation. Santos has considered WAFIC's response and considers leaving the wellhead in situ is acceptable as toxic levels are not expected to occur at present or anytime in the future.	Santos decommissioning EPs include monitoring (if required) to address legislative requirements based on the scientific and engineering studies done to inform the end state. Santos considers that long-term monitoring of the Legendre-1 wellhead is not required for this EP.	Degradation risks are assessed in **Section 6.9**. The consideration of further monitoring is discussed in this section.

	No long term monitoring will be performed for wellhead degradation.		
WAFIC requested the prohibition of recreational fishing within the Operational Areas for proposed activities.	Santos has considered WAFIC's feedback and considers the feedback relevant to the EP. Fishing from vessels is not permitted.	Santos notes that recreational fishing shall be prohibited from project vessels. Santos reviewed previous correspondence and confirmed recreational fishing is prohibited from project support vessels	Recreational fishing shall be prohibited from project vessels. This has been adopted as per control measure CM-09.
WAFIC asked Santos to demonstrate how Santos had considered WAFIC's decommissioning guidelines.	Santos has considered WAFIC's feedback and considers the feedback relevant to the EP. The Commercial Fishing Consultation Framework for the Offshore Oil and Gas Sector has been reviewed and considered. The WAFIC position on decommissioning is noted. The potential socio-economic consequence of leaving the wellhead in-situ (physical presence) has been assessed as I - Negligible. Given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery it is concluded that the likelihood of interaction between a trawler and the wellhead is low. The wellhead is located within largely untrawlable ground and there is low historical fishing effort in the region. The potential environmental consequence of leaving the wellhead in-situ (degradation) has been assessed as I - Negligible. No control measures are considered necessary to further reduce the environmental impacts. The wellhead has been in situ since 1968	Santos notes WAFIC's position within the WA Commercial Fishing Consultation Guidance Framework July 2023 and considers that the EP addresses the potential risks and impacts associated with snagging, contaminants, benthic surveys, consultation processes, and reefing.	**Section 6.9** and **7.1** include an assessment of risks associated with the wellhead being left in situ.

	without any known environmental or stakeholder concerns regarding the impacts of its degradation. Santos has considered WAFIC's response and considers leaving the wellhead in situ is acceptable as toxic levels are not expected to occur at present or anytime in the future.		
Physical presence of the wellhead – WAFIC requested a copy of the Australian Maritime College (AMC) Legendre Snag Risk Report. WAFIC objected to infrastructure remaining in situ that presents a snagging risk to current and future fishing operations.	Santos has considered WAFIC's feedback and has advised it can provide a copy of the report. Santos has considered WAFIC's response and considers the snag risk associated with leaving the wellhead in situ is acceptable as: The location of the wellhead is for the best part untrawlable ground. The location of the wellhead is marked on nautical charts. The risk of trawlers snagging on Legendre-1 wellhead is very low for current and future fishing operators based on independent assessment.	The Australian Maritime College (AMC) Legendre Snag Risk Report (5415621901) has been appended to this revision of the Legendre EP. Santos agrees that flume tank simulations may not fully represent the marine environment. However, the AMC Report describes further detail and mitigation regarding vessel risk in the event of a hook up and specific to the vessels currently operating in the region, including but not limited to AMSA survey process as described below: "All four vessels operating in this fishery have passed their stability checks as part of the AMSA survey process. These tests include and consider hookup events occurring when the vessel loading condition is sub-optimal." Santos acknowledges WAFIC's position to objecting to infrastructure remaining in situ that presents a snag risk, though believe that the Legendre-1 wellhead represent very low snagging risk to current and future fishing operations. The EP and AMC Snag Report detail that the wellhead is within the Glomar Shoal, which is 'for the best part untrawlable ground' and the size of the wellhead is small when compared to the	**Section 7.1** includes the snagging risk assessment.

		total amount of trawlable ground in the fishery (less than 0.002 % of the total trawlable area). Therefore, given the position is known (marked on charts), the advanced level of equipment and experience on the vessels and that the wellhead is actively avoided due to the ground type, the study concluded it is unlikely that trawlers would interact with the wellhead into the future.	
Physical presence of the wellhead - WAFIC advised it was opposed to materials left in situ that result in toxic substances or contaminants presenting an unacceptable risk to aquatic resources or the marine environment.	Santos has considered WAFIC's response and considers leaving the wellhead in situ is acceptable as toxic levels are not expected to occur at present or anytime in the future.	Santos has assessed that toxic levels are not expected to occur at present or anytime in the future. Given this assessment Santos does not believe there is any unacceptable risk to aquatic resources or the marine environment.	Wellhead degradation is assessed in **Section 6.9**.
Gas release – WAFIC asked if Santos would continue to monitor the gas bubbles to ensure there is no long-term change to this issue?	Santos has considered WAFIC's response and considers the feedback relevant to the EP. Potential future gas monitoring activities are described in **Section 2.3.**	In addition to the Gas Bubble Review, CSIRO has completed a monitoring and research survey. Once this data interpretation and report has been finalised the outcomes will be shared with WAFIC. Santos has committed to undertaking further field monitoring of the gas bubbles to assess any noticeable changes. Santos has committed to providing outcomes of future monitoring and research programmes to WAFIC.	Potential future gas monitoring activities are described in **Section 2.3** and vessel activities are assessed in **Sections 6** and **7**.
WAFIC asks to be included in any vessel operation look ahead associated with this EP.	Santos has considered WAFIC's feedback and considers the feedback relevant to the EP. WAFIC will be informed prior to Santos vessel activities.	The potential date of future vessel activity is not yet known; however, Santos will inform WAFIC prior to vessel activity	WAFIC notifications are included in **Section 8.9.1**.
Industry Associations - Recreational Fishing			

<table>
<tr><td colspan="4">Recfishwest</td></tr>
<tr><td colspan="4">Summary of preliminary consultation effort:
+ On 30 May 2023 Santos emailed Recfishwest and provided information on a number of proposed Carnarvon Basin activities. Santos included a link to an information fact sheet about proposed activities in this EP and sought feedback on whether the functions, interests or activities of Recfishwest may be affected, as well as consideration of Recfishwest's expectation for consultation of regional fishing clubs for proposed activities. [Con-2211]
+ No correspondence or feedback has been received.
Summary of consultation effort:
+ On 30 June 2023 Santos emailed Recfishwest regarding consultation for proposed Carnarvon Basin activities. [Con-1902]
+ On 25 July 2023 Santos emailed Recfishwest as a reminder its consultation for proposed Carnarvon Basin [Con-1913]
+ On 27 July 2023 a representative from Recfishwest called Santos asking for an extension of time to provide feedback. Santos confirmed that an extension was acceptable.
+ On 16 August 2023 Recfishwest emailed Santos with feedback regarding a number of proposed Carnarvon Basin activities. Recfishwest has no objections to the proposed activities related to this EP. Recfishwest requested it be kept informed as the proposal progresses. [Con-2298]
+ On 22 August 2023 Santos emailed Recfishwest and acknowledged feedback and request to be kept informed. [Con-2311]</td></tr>
<tr><td>Summary of Objection or Claim</td><td>Assessment of Merits</td><td>Santos' Response Statement</td><td>EP Reference</td></tr>
<tr><td>Santos notes requests from previous consultation that:
+ Recfishwest be updated on proposed activities and continued discussions with Santos, as activities might have impacts on recreational fishers, charter operators, and marine ecosystems.
+ Santos consult recreational fishers via the two main fishing clubs in Karratha.</td><td>Santos acknowledges feedback from Recfishwest from previous consultation. Santos has fulfilled these requests.
Recfishwest requested to be kept informed of the activities. Section 8.9.1 includes notifications to Recfishwest. Recfishwest has no objections to the proposed activities.</td><td>Santos acknowledged Recfishwest's response of no feedback and request to be kept informed.</td><td>Section 8.9.1 includes notifications to Recfishwest.</td></tr>
<tr><td colspan="4">Recreational Fishers</td></tr>
<tr><td colspan="4">King Bay Game Fishing Club</td></tr>
<tr><td colspan="4">Summary of consultation effort:
+ On 29 June 2023 Santos emailed King Bay Game Fishing Club seeking feedback on proposed activities. [Con-1871]</td></tr>
</table>

+ On 19 July 2023 Santos emailed King Bay Game Fishing Club by way of reminder on the timeframe for providing feedback. [Con-1848]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A
Nickol Bay Sportsfishing Club			
Summary of consultation effort: + On 29 June 2023 Santos emailed Nickol Bay Sportsfishing Club seeking feedback on proposed activities. [Con-1874] + On 19 July 2023 Santos emailed Nickol Bay Sportsfishing Club by way of reminder on the timeframe for providing feedback. [Con-1851]			
Summary of Objection or Claim	**Assessment of Merits**	**Santos' Response Statement**	**EP Reference**
N/A	No correspondence or feedback has been received for WA-20-L activities. Santos considers it has provided sufficient time and opportunity for consultation. Santos considers the Regulation 25 consultation requirements to have been met.	N/A	N/A

5 Environmental impact and risk assessment methodology

OPGGS(E)R 2023 Requirements
Section 22. Environmental assessment
Evaluation of environmental impacts and risks 22(5) The environment plan must include: (a) details of the environmental impacts and risks for the activity; and (b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and (c) details of the control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level. 22(6) To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: (a) all operations of the activity; and (b) potential emergency conditions, whether resulting from accident or any other reason.

Environmental impact and risk assessment refers to a process whereby planned and unplanned events that will or may occur during an activity are quantitatively and/or qualitatively assessed for their impacts on the environment (physical, biological, and socio-economic) at a defined location and specified period of time. In addition, unplanned events are assessed on the basis of their likelihood of occurrence which contributes to their level of risk.

Santos has undertaken environmental impact and risk assessments for the planned events (including any routine, non-routine and contingency activities) and unplanned events in accordance with the OPGGS(E)R.

Provided in this section of the EP is the following information relating to the environmental impact and risk assessment approach:

+ terminology used; and
+ summary of the approach.

A full description of the process applied in identifying, analysing and evaluating the impacts and risks relating to the planned activity is documented in Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline (EA-91-IG-00004_5).

5.1 Impact and risk assessment methodology

Common terms applied during the impact and risk assessment process, and used in this EP, are defined in **Table 5-1**. For a more comprehensive listing of the terms and definitions used in environmental impact and risk assessment, refer to Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline (EA-91-IG-00004_5).

Table 5-1: Impact and risk assessment terms and definitions

Name	Definition
Acceptability	Determined for both impacts and risks. Acceptability of events is in part determined by the consequence of the impact following management controls. Acceptability of unplanned events is in part determined from its risk ranking following management controls. For both impacts and risks, acceptability is also determined from a demonstration of the ALARP principle, consistency with Santos Policies, consistency with all applicable legislation and consideration of relevant stakeholder consultation when determining management controls.
Activity	Specific tasks and actions undertaken throughout the life cycle of oil and gas exploration, production and decommissioning.
ALARP	As Low As Reasonably Practicable The term refers to reducing risk to a level that is ALARP. In practice, this means showing through reasoned and supported arguments, that there are no other practicable options that could reasonably be adopted to reduce risks further.

Name	Definition
Authorised Person	Person with authority to make the decision or take the action. Examples are Vessel Master, Field Superintendent, Supervisor, Person-in-charge, Company Authorised Representative, and Project Manager.
Control Measure	Means a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks[1].
DMIRS	Department of Mines, Industry Regulation and Safety
Environment	Includes the natural and socio-economic values and sensitivities which will or may be affected by the activity. Is defined by NOPSEMA and DMIRS as: (a) ecosystems and their constituent parts, including people and communities; and (b) natural and physical resources; and (c) the qualities and characteristics of locations, places and areas; and (d) the heritage value of places. (e) the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).
Environmental consequence	A consequence is the outcome of an event affecting objectives. Note 1 An event can be one or more occurrences and can have several cases. Note 2 An event can consist of something not happening. (Reference ISO 73:2009 Risk Vocabulary)
Environmental impact	Defined by NOPSEMA[1] as any change to the environment, whether adverse or beneficial, wholly or partly resulting from a planned or unplanned event[1]. Defined by DMIRS[2] as any change to the environment, whether adverse or beneficial, that wholly or partly results from a petroleum activity of an operator.
ENVID	Environmental hazard identification workshop
Environmental risk	Applies to unplanned events. Risk is a function of the likelihood of the unplanned event occurring and the consequence of the environmental impact that arises from that event.
Hazard	A situation with the potential to cause harm
Grossly disproportionate	Where the sacrifice (cost and effort) of implementing a control measure to reduce impact or risk, grossly exceeds the environmental benefit to be gained.
Impact assessment	The process of determining the consequence of an impact (in terms of the consequence to the environment) arising from a planned or unplanned event over a specified period of time.
Likelihood	The chance of an unplanned event occurring.
Non-routine planned event	An attribute of the planned activity that may occur or will occur infrequently during the planned activity. A non-routine planned event is intended to occur at the time.
Planned activity	A description of the activity to be undertaken including the services, equipment, products, assets, personnel, timing, duration and location and aspect of the activity.
Planned event	An event arising from the activity which is done with intent (i.e. not an unplanned event) and has some level of environmental impact. A planned event could be routine (expected to occur consistently throughout the activity) or non-routine (may occur infrequently if at all). Air emissions, bilge water discharge and drill cuttings discharge would be examples of planned events.

[1] Defined by the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009

Name	Definition
Receptor	A feature of the environment that may have environmental, social and/ or economic values.
Risk	The effect of uncertainty on objectives.
Risk assessment	The process of determining the likelihood of an unplanned event and the consequence of the impact (in terms of economic, human safety and health, or ecological effects) arising from the event over a specified period of time.
Routine planned event	An attribute of the planned activity that results in some level of environmental impact and will occur continuously or frequently through the duration of the planned activity
SLT	Senior Leadership Team
Unplanned event	An event that results in some level of environmental impact and may occur despite preventative safeguards and control measures being in situ. An unplanned event is not intended to occur during the activity.

5.2 Summary of the environmental impact and risk assessment approach

5.2.1 Overview

Santos operates under an overarching Risk Management Policy (QE-91-IF-10050). The company Risk Procedure (SMS MS1 ST01) underpins the Risk Management Policy and is consistent with the requirements of AS/NZS ISO 31000:2018, Risk Management – Guidelines (ISO, 2018).

The key steps to risk management are illustrated in **Figure 5-1**. The forum used to undertake the assessment is the environmental hazard workshop, referred to as an ENVID, which is described in Section 4 of Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline (EA-91-IG-00004_5).

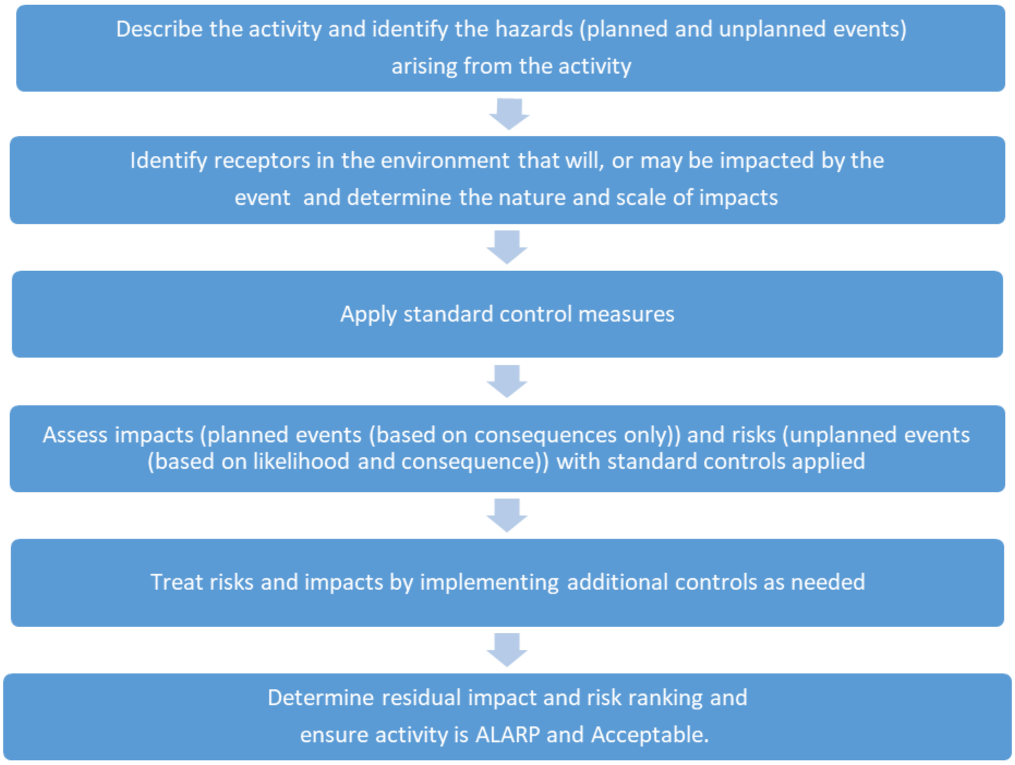


Figure 5-1: Environmental Impact and Risk Assessment Process

Santos' Offshore Division Environmental Hazard Identification and Assessment Guideline (EA-91-IG-00004_5) includes consideration of the following key areas in an impact and risk assessment:

+ description of the Activity (including location and timing);

- description of the environment (potentially affected by both planned and unplanned activities);
- identification of relevant persons;
- identification of legal requirements ('legislative controls') that apply to the activity;
- Santos policy and SMS requirements;
- principles of Ecologically Sustainable Development (ESD); and
- Santos acceptable levels of impact and risk.

These factors were considered in an environmental impact and risk assessment workshop held in May 2021 in which environmental impact identifications were made. The risk workshop involved participants from the Santos Health, Safety and Environment (HSE) and Operations departments and specialist environmental consultants.

5.2.2 Describe the activity and hazards (planned and unplanned events)

The decommissioning and gas release activities are described in **Section 2** of this EP. The location, timing and scope of the activity must be described in order to determine the impacts from planned events, and the impacts and risks from unplanned events since these have a bearing upon the EMBA by the activity.

The outcome of this assessment is detailed in the relevant sub-sections of **Sections 6** and **7.**

5.2.3 Identify receptors and determine nature and scale of impacts

A description of the environment (natural and socio-economic) within which hazards from the activity will, or may occur, is required. This constitutes a crucial stage of the risk assessment, as an understanding of the environment that will or may be affected is required to determine the type and consequence of impacts from the activity being assessed. The environment must be understood with respect to the spatial and temporal limits of the activity and key resources at risk that will or could be impacted by planned and unplanned events. Santos has developed a Values and Sensitivities of the Marine and Coastal Environment (EA-00-RI-10062) reference document which describes the existing environment that may be affected by Santos activities and is reviewed and updated on an annual basis.

Where the existing environment is being reviewed for regulatory approvals, a comparison shall be made against the Values and Sensitivities of the Marine and Coastal Environment (EA-00-RI-10062). A new protected matters search is required to ensure a thorough understanding of the existing environment to ensure all risks are assessed.

The extent of actual impacts from each planned activity or risks from each unplanned activity, are assessed using, where required, modelling (e.g. hydrocarbon spills) and scientific reports. The duration of the event is also described including the potential duration of any impacts should they occur

Receptors identified as potentially occurring within impacted area(s) are detailed in Section 3 and **Appendix F**.

5.2.4 Describe the environmental performance outcomes and control measures

For each planned and unplanned event, a set of Environmental Performance Outcome(s), Control Measures, Environmental Performance Standards and Measurement Criteria are identified. The definitions of the performance outcomes, control measures, standards and measurement criteria must be consistent with the OPGGS(E)R and the NOPSEMA EP Content Requirements Guidance Note (NOPSEMA, 2019).

For any hazard, additional controls, must also be considered and either accepted for use or rejected based on whether the standard controls reduce impacts and risks to levels that are ALARP and acceptable. Controls are allocated in order of preference according to **Figure 5-2**.

Control	Effectiveness	Example
Eliminate		*Removal of the risk.* Refueling of vessels at port eliminates the risks of an offshore refueling.
Substitute		*Change the risk for a lower one.* The use of low-toxicity chemicals that perform the same task as a more toxic additive.
Engineering		*Engineer out the risk.* The use of oil-in-water separator to minimise the volume of oil discharged.
Isolation		*Isolate people or the environment from the risk.* The use of bunding for containment of bulk liquid materials.
Administrative		*Provide instructions or training to people to lower the risk.* The use of Job Hazard Analysis to assess and minimise the environmental risks of an activity.
Protective		*Use of protective equipment.* Containment and recovery of spilt hydrocarbons.

Figure 5-2: Hierarchy of Controls

5.2.5 Determine the impact consequence level and risk rankings (on the basis that all control measures have been implemented)

This step looks at the causal effect between the aspect/hazard and the identified receptor. Impact mechanisms and any thresholds for impacts are determined and described, using scientific literature and modelling where required. Impact thresholds for different critical life stages are also identified where relevant.

The consequence level of the impact is then determined for each planned and unplanned event using the Santos Environment Consequence Descriptors (**Table 5-2** and **Appendix J**).

These detailed environmental consequence descriptions are based on the consequence of the impact to relevant receptors within the following categories:

+ threatened/migratory/local fauna;
+ physical environment/habitat;
+ threatened ecological communities;
+ protected areas; and
+ socio-economic receptors.

This process determines a consequence level, based on set criteria for each receptor category, and takes into consideration the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem or industry level.

The level of information required to complete the impact or risk assessment depends on the nature and scale of the impact or risk. This process determines a consequence level based on set criteria for each receptor category and takes into consideration the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem or industry level. Impacts to social and economic values are also considered based on existing knowledge and feedback from stakeholder consultation. As the result of historic consultation with stakeholders, the social and economic values in the region that are of interest are evident.

As planned events are expected to occur during the activity, the likelihood of their occurrence is not considered during the risk assessment, and only a consequence level is assigned.

Table 5-2: Consequence level description

Consequence Level		Consequence Level Description
I	Negligible	No impact or negligible impact.
II	Minor	Detectable but insignificant change to local population, industry or ecosystem factors.
III	Moderate	Significant impact to local population, industry or ecosystem factors.
IV	Major	Major long-term effect on local population, industry or ecosystem factors.
V	Severe	Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.
VI	Critical	Irreversible impact to regional population, industry or ecosystem factors.

For unplanned events, the consequence level of the impact is combined with the likelihood of the impact occurring (**Table 5-3**) to determine a residual risk ranking using the Santos corporate risk matrix (**Table 5-4**) For oil spill events, potential impacts to environmental receptors are assessed where they occur within the EMBA using results from modelling.

Table 5-3: Likelihood description

No.	Matrix	Description
f	Almost Certain	Occurs in almost all circumstances OR could occur *within days to weeks*
e	Likely	Occurs in most circumstances OR could occur *within weeks to months*
d	Occasional	Has occurred before in Santos OR could occur *within months to years*
c	Possible	Has occurred before in the industry OR could occur *within the next few years*
b	Unlikely	Has occurred elsewhere OR could occur *within decades*
a	Remote	Requires exceptional circumstances and is unlikely even in the long term

Table 5-4: Santos risk matrix

		Consequence					
		I	II	III	IV	V	VI
Likelihood	f	Low	Medium	High	Very High	Very High	Very High
	e	Low	Medium	High	High	Very High	Very High
	d	Low	Low	Medium	High	High	Very High
	c	Very Low	Low	Low	Medium	High	Very High
	b	Very Low	Very Low	Low	Low	Medium	High
	a	Very Low	Very Low	Very Low	Low	Medium	Medium

5.2.6 Evaluating if impacts and risks are ALARP

For planned and unplanned events, an ALARP assessment is undertaken to demonstrate that the standard control measures adopted reduce the impact (consequence level) or risk to ALARP. This process relies on demonstrating that further potential control measures would require a disproportionate level of cost/effort in order to reduce the level of impact or risk. If this cannot be demonstrated, then further control measures are adopted. The level of detail included within the ALARP assessment is based upon the nature and scale of the potential impact or risk. For example, more detail is required for a risk ranked as `Medium' compared to a risk ranked as `Low'.

5.2.7 Evaluating impact and risk acceptability

Santos considers an impact or risk associated with the activities to be acceptable if the following criteria are met:

+ the consequence of a planned event is ranked as I or II; or a risk of impact from an unplanned event is ranked Very Low to Medium;

+ an assessment has been completed to determine whether further information or studies are required to support or validate the consequence assessment;
+ that the acceptable levels of impact and risks have been informed by relevant species recovery plans, threat abatement plans and conservation advice can be demonstrated;
+ performance standards are consistent with legal and regulatory requirements;
+ performance standards are consistent with the Santos Environment Health and Safety Policy;
+ performance standards are consistent with industry standards and best practice guidance (e.g., National Biofouling Management Guidance Guidelines for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018));
+ performance outcomes and standards are consistent with stakeholder expectations; and
+ performance standards have been demonstrated to reduce the impact or risk to ALARP.
+ The consequence and risks associated with the proposed activity are not inconsistent with the outcomes of relevant principles of ecologically sustainable development (ESD) under the EPBC Act.

Review of the five principles of ESD under the EPBC Act in relation to acceptability against the activity is detailed in **Table 5-5**.

Table 5-5: Activity Relevant Principles of Ecologically Sustainable Development

No.	ESD Principle	Relevance
(a)	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	Santos' environmental impact and risk assessment determines impact consequence levels considering the duration and extent of the impact, receptor recovery time and the effect of the impact at a population, ecosystem, or industry level. The Santos Environment Consequence Descriptors highlights the integration of long-term and short-term environmental, and socio-economic considerations (Appendix J). The assessment of impact consequence levels for the proposed activity simultaneously assesses of the activity's potential implications against this principle. Additional assessment of this principle in relation to acceptability will not be conducted.
(b)	If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	For planned activities, assessment of this ESD principle is inherent in Santos' environmental impact and risk assessment process, as Santos does not proceed with activities if the consequence of a planned event is ranked III (Moderate) or above. For unplanned events, if the residual risk is ranked between Medium and Very High, an assessment against this principle is required. If the residual risk is Medium to Very High and there is significant scientific uncertainty associated with the aspect, additional assessment against this principle is required.
(c)	The principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	For planned activities, assessment of this ESD principle is inherent in Santos' environmental impact and risk assessment process, as Santos does not proceed with activities if the consequence of a planned event is ranked III (Moderate). For an unplanned event, if the residual risk is ranked between Medium and Very High, an assessment against this principle is required. The assessment of this principle is implemented through further details on ALARP assessment highlighting assurance that potential impacts and risks are managed, and the environment is maintained for the benefit of future generations. Evaluation of the importance and relevance of stakeholder interest for this principle, if triggered, is fundamental in demonstrating that the environment is maintained for the benefit of future generations.
(d)	The conservation of biological diversity and ecological integrity should be a fundamental	Evaluate if there is the potential to affect biological diversity and ecological integrity.

No.	ESD Principle	Relevance
	consideration in decision-making	
(e)	Improved valuation, pricing and incentive mechanisms should be promoted	This principle refers to activities which involve valuation, pricing and/or incentive mechanisms for the production, delivery, distribution or consumption of goods and services, especially those that are derived from natural or social capital or from ecological services. This principle is not relevant to the proposed activity as the proposed activity does not involve the production, delivery, distribution or consumption of goods and services.

6 Environmental assessment for planned events

OPGGS(E)R 2023 Requirements
Section 22(5)
The environment plan must include: + details of the environmental impacts and risks for the activity; + an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and + details of the control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level.
Section 22(6)
To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: + all operations of the activity; and + potential emergency conditions, whether resulting from accident or any other reason.
Section 22(7)
The environment plan must: + set environmental performance standards for the control measures identified under paragraph (5)(c); + set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and + include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

Results of the environmental assessment (**Section 5**) are summarised in **Table 6-1.**

Table 6-1: Summary of the residual consequence associated with the activities

EP Section	Event	Residual consequence
6.1	Gas seepage	I - Negligible
6.2	Interaction with other marine users – support vessel and monitoring equipment presence	I – Negligible
6.3	Acoustic emissions	I – Negligible
6.4	Vessel light emissions	I – Negligible
6.5	Vessel atmospheric emissions	I – Negligible
6.6	Seabed and benthic habitat disturbance	I – Negligible
6.7	Operational discharges	I – Negligible
6.8	Spill response operations	I - Negligible
6.9	Legendre-1 wellhead - degradation	I - Negligible

A comprehensive risk and impact assessment for each of the planned events, and subsequent control measures proposed by Santos to reduce the risk and impacts to ALARP and acceptable levels, are detailed in **Section 6.1** to **6.9.**

6.1 Gas seepage

6.1.1 Description of event

Event	Release of small gas bubbles to the sediment, benthic habitat at the seabed, water column and atmosphere.
Extent	**Localised**: Within tens of meters of the seepage locations
Duration	**Indefinite**: Ongoing gas seepage

As described in **Section 2.1**, gas seepage at WA-20-L is occurring at three well locations: Legendre Hub, Legendre South-1 and Legendre South-3. The majority of seepage is at Legendre Hub, with smaller seeps emanating from Legendre South-1 and Legendre South-3. The potential for seepage at Legendre-1 is also assessed in this section.

6.1.1.1 Overview of Studies

To inform the nature and scale of the seepage, and the potential risks and impacts, Santos has performed multiple investigations and assessments, as summarised in **Table 6-2** and detailed in this section.

Table 6-2: Relevant Studies

Topic	Study / Survey / Report Name	Year
Environmental monitoring surveys	RPS Survey	2021
	CSIRO Survey	2022
Environmental survey reports	Legendre field environmental survey report (RPS)	2021
	NWS offshore gas seeps and leakage characterisation project survey report (CSIRO)	2024
Engineering studies	Well Integrity Studies Part A – Independent Integrity Assessment Legendre P&A (2023). Part B – Global Offset Review – Gas migration post P&A (2022). Part C – Remedial Feasibility Assessment Legendre P&A (2022).	2021-2023
	Subsea Wellhead Removal Options Study	2021
	Legendre field seabed gas seepage – subsurface study	2024
SME assessments conducted post Revision 3 and pre Revision 4 of the EP	Santos Subsurface Assessment	2024
	SME Workshop	2024
	SME technical assessment - Legendre P&A Well Integrity and Bubble Escalation Potential	2024
	SME technical memo - monitoring	2024

Figure 6-1 summarises how the various surveys, studies and assessments combine to inform the potential risks and impacts of the gas seepage.

Figure 6-1: Seepage assessment process

6.1.1.2 Environmental monitoring surveys

Field monitoring is a key aspect of understanding the seepage characteristics and rates. As described in **Section 2.1** and **Appendix D**, two major surveys have been conducted, by RPS in 2021 and CSIRO in 2022.

The results of the surveys are presented in **Section 2.1.** Visual observation of the seepages by ROV surveys, bubble size distributions, gas flux rate and gas composition analysis indicate that, overall, the active seepages remain at the same order of magnitude as the RPS survey in 2021 (Talukder et al., 2024). The gas seepage characteristics and rates are similar across the two surveys and there has been no escalation.

6.1.1.3 Santos Reviews of P&A History

In 2020, Santos reviewed the plug and abandonment history of all wells of WA-20-L (Santos 2020. The review compiled all regulator correspondence and as-built drawings. It was confirmed that the Legendre Hub wells and Legendre South-3 well were abandoned in accordance with regulatory approved plug and abandonment programs.

The plug and abandonment history for Legendre South-1 was reviewed by Santos in 2021 and confirmed that this also went through a regulated abandonment process and concluded that it was abandoned in accordance with the regulatory approved plug and abandonment program.

Santos internal reviews concluded that it is not technically feasible to re-enter the abandoned wellbores with gas releases due to:

+ An inability to tie-back and re-establish a structural connection and a pressure envelope with the well because the production casing, surface casing, conductor and wellhead have been cut and removed; and
+ There is no safe “conduit” to re-enter the well because the multiple permanent cement plugs (across cut casing stumps and in the wellbore below) means the original wellbore no longer exists – any attempt to “drill

through" existing permanent cement plugs will be uncontrolled and is likely to result in inadvertent side-tracking into the surrounding shallow formation.

6.1.1.4 Well integrity and P&A Studies

In 2022 Santos engaged Add Energy to complete an independent study of Legendre wells. The study consisted of three parts as detailed below.

Part A – Independent Integrity Assessment Legendre P&A (2023)

The integrity assessment aimed to review of existing information to identify potential gas migration pathways that the observed gas bubbles may be migrating through from the produced reservoir to reach surface.

The study reviewed ten wells including Legendre South-1, Legendre South-3 and Legendre Hub development wells (Legendre North 1H, Legendre North-2H, Legendre North-4H, Legendre North-5H, Legendre North-6H, Legendre South-2H, and Legendre West-1). Exploration wells Legendre-1, Legendre South-1 and Legendre South-3 were later included in the study.

The study suggested that Legendre North 1H may be a possible sources for bubble seeps observed in the Legendre hub. The study also suggested possible gas pathways may be present at the exploration wells Legendre South-1, Legendre South-3 and Legendre-1. Further investigative studies have been undertaken by internal and external SMEs, as summarised in **Section 6.1.1.7** and **6.1.1.8**.

Part B – Global Offset Review (Gas Migration after P&A – Incidents and Solutions)

The intent / objective of the study was to conduct a global offset review / literature review to identify where the issue of gas migration (and bubbles) has occurred before after wells have been permanently abandoned (with wellheads removed etc.) and what, if any, solutions have been attempted to remediate.

The study revealed most operators surveyed confirmed cases of gas bubble seepage post P&A (with source mostly inconclusive), but did not identify a single case worldwide whereby an offshore P&A'd well with gas bubbles observed had been re-entered to rectify the P&A.

Part C – Remediation Feasibility Assessment

The purpose of this study was to assess the feasibility of remediating Legendre wells to stop gas bubble seepage. The study identified that re-entry options are limited, and did not identify any feasible re-entry options for the P&A'd Legendre wells.

6.1.1.5 Legendre field seabed gas seepage – subsurface study

The purpose of the 2024 study was to forecast gas seepage scenarios from the decommissioned Legendre Field. The study investigated the Legendre seabed gas seepage with the aim of understanding both the potential crack pathway diameter to seabed from a single well in the crest to match the observed seepage, and to understand the potential increase in seepage rates if there could be a future increase to the crack diameter.

The study investigated both current flux rates as well as potential escalation cases. A focus was placed on matching current measured flux rates with a simplistic single well model using parameters from the history-matched numerical model.

A well was modelled with a single, small cement crack to surface to match the observed seepage rate, before considering enlargement of this crack and resultant seepage escalation. First, a history-matched numerical model to EOFL was used to predict the reservoir properties at the start of seepage into the distant future. This involved placing a 'Legendre Hub' well at a crestal location then controlling this well over the period on gas rate control. The reservoir parameters were used to generate a range of IPR and VLP curves to model the potential crack pathway diameter from reservoir to seabed. This crack diameter was modelled as ~0.5mm in diameter, that matched the seepage rates within the range of the RPS and CSIRO studies. Pressures throughout the entire duration are predicted to remain relatively stable. Reservoir pressure is almost constant within ~5 years after EOFL.

The study concluded that the seepage pathway is miniscule and that it is highly unlikely (remote) that seepage can increase over time.

6.1.1.6 SME workshop

On 14 November 2024, an SME workshop was held with participation by independent SMEs from the speciality areas of subsurface reservoir engineering, well integrity and environmental science to evaluate the current gas seepage and assess possibility of future gas seepage escalation.

Prior to the workshop, participants were provided with the key documents listed in **Section 6.1.1.1** and tasked with reviewing the documents to inform the workshop discussions.

Table 6-3: SME Workshop Summary

Topic	Items	Conclusions	Actions
Gas seepage (Legendre Hub, Legendre South-1 and Legendre South-3)	+ Review and assess the seepage characteristics and rates. + Review the seepage risks. + Review and assess escalation potential.	+ Seepage characteristics and rates have not changed. + The gas characteristics of Legendre Hub and Legendre South gas seepage are very similar to the reservoir gas. + There is no credible risk of escalation, which will be further investigated by the external SMEs.	+ External well engineers to provide an additional assessment of the well barriers and seepage risks. This has been conducted, as outlined in **Section 6.1.1.7**.
Legendre-1 seepage risks	+ Review and assess the well and subsurface characteristics of Legendre-1 and seepage potential.	+ Further technical investigation by SMEs is required.	+ Santos subsurface SMEs to assess the Legendre-1 well and subsurface characteristics. This has been conducted, as outlined in **Section 6.1.1.8**. + External well engineering SME to provide an additional assessment of the Legendre-1 well barriers. This has been conducted, as outlined in **Section 6.1.1.7**.
Monitoring	+ Assess and determine when and how often monitoring should be undertaken. + What are the key requirements of the monitoring campaign.	+ An additional monitoring campaign will be conducted to confirm the seepage rates have not changed. + Conducting more than one survey during the five-year duration of the EP was not considered useful. Refer to **Table 6-8**.	+ External SME to provide additional information about the monitoring campaign. This has been conducted, as outlined in **Section 6.1.1.9**.
Legendre-1 wellhead removal options	+ Review the technical challenges and risks to remove the wellhead. + Consider the feasibility of marine growth cleaning and pressure assessments (hot-tapping or valve access)	+ Additional SME reviews and input are required to assess the Add Energy recommendations and removal options.	+ This has been conducted, as outlined in **Section 6.9.3**.

Table 6-4: SME Workshop Attendees

Role	Source	Expertise
Principal Advisor	External	Subsurface and wells
Principal Advisor	External	Subsurface and wells
Offshore Decommissioning and Well Services Manager	Santos	Subsurface and wells
Senior Staff Reservoir Engineer	Santos	Subsurface and wells
Manager Subsurface WA Gas and Liquids	Santos	Subsurface and wells
Technical Director - Marine Sciences	External	Environment
Senior Principal Environmental Engineer	External	Environment
Senior Research Scientist	External	Environment
Senior Environment Adviser	Santos	Environment
Lead Environment Adviser	Santos	Environment
Lead Environment Adviser Corporate	Santos	Environment

6.1.1.7 External SME Assessment - Legendre P&A Well Integrity and Bubble Escalation Potential

An independent assessment of the well integrity and associated P&A risk was completed by Add Energy, in 2022 (**Section 6.1.1.4**). The study assessed each of the Legendre wells individually, identifying the permanent plugs that were installed in each of the wells during the P&A activity. This study was carried out over the course of ~6 months and involved a detailed assessment of each well in the context of the observation of gas bubbles at surface at the Legendre well sites.

This study concluded that the P&A design and practices utilised at the time to P&A Legendre wells was not aligned with the current principals of “cap-rock restoration”. While this Add Energy study finding, may provide an explanation for the bubbles observed at the well-sites (Legendre Hub, Legendre South-1 and Legendre South-3), the study did not include commentary on the potential for future changes in the bubble seeps.

In 2024, Santos engaged external SMEs to review the Add Energy reports (**Table 6-2**), attend an SME Workshop conducted in November 2024 (**Section 6.1.1.6**) and assess the potential for future changes in the bubble seeps. The SME workshop concluded that the observed gas bubbles are likely due to a migration through a “minuscule” flow path through permanent cement plugs. These cement plugs are not susceptible to degradation over time or changes due to variation in well pressures.

Following the workshop, an external Principal Well Engineer provided further technical input to review the above conclusions. The assessment looked at the Legendre-Hub wells (Legendre North-1, Legendre North-2, Legendre North-4H, Legendre North-5H, Legendre North-6H, Legendre South-2H, Legendre West-1) and the exploration wells (Legendre South-1, Legendre South-3, Legendre-1).

+ Given the nature of the plugs and the tortuous path reservoir fluids would need to take to reach surface (i.e. through hundreds and in many cases over a thousand metres of cumulative cement plug), there is no reasonably credible scientific explanation to expect the bubble rate to increase.
+ This conclusion is due principally to the number of permanent cement plugs and the significant volume of cement reported to be installed into each of the wells.
+ The volume and depth of cement used, physically means that the further increase of gas migration to surface from the reservoir through these cement plugs is considered lower than ‘remote’ on the Santos matrix, and as such is considered as not credible.
+ A second external SME (Principal Advisor) concurred with the assessment conclusion, asserting that plausible routes to forecast increasing gas rates are absent.
+ It should be noted that the assessment only considers the cement plug barriers to flow as they are considered permanent over geological time. Uncemented casing has not been considered as a permanent barrier to lateral flow, consequently the potential for corroding steel is not relied upon in this assessment. This is further supported by the physical observation of no increase in bubble rate having been observed over the years that it has been monitored / measured since being plug and abandoned.
+ To support this assessment and provide further context regarding the volume of cement plugs in each well, a summary of the cement plugs installed in each well as identified and reported in the independent Add Energy 2022 Legendre well integrity study is summarised in **Table 6-5**.

Table 6-5: Cement Summary

Well	Cement Barrier
Legendre North-1	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 4430m i.e. ~559m of cement above top of reservoir (at ~4989m). Cement plug set across cemented 9 5/8" casing (i.e. casing shoe at 5009m). Primary 9 5/8" annulus cement top reported at 3200m (i.e. ~1000m+ annulus cement to reservoir). + Cement Plug #2 – cement plug installed from 1337m to 985m on a cement retainer i.e. additional 342m cement plug to reservoir. Cement plug set partially across second stage 9 5/8" annulus cement. Second stage annulus cement from 1120m – 985m i.e. 135m additional annulus cement to reservoir). + Cement Plug #3 – cement plug installed from 606m to 586m i.e. additional 20m cement plug to reservoir and annular cement squeeze 606m to 456m i.e. additional 150m of annular cement to reservoir. + Cement Plug #4 – cement plug installed from 400m to 194m i.e. additional 206m cement plug to reservoir and annular cement squeeze from 400m to 194m i.e. additional 206m annular cement to reservoir. + Cement Plug #5 – cement plug installed from 150-194m i.e. additional 44m cement plug to reservoir. + 13 3/8" EZSV - set above top of cut 9 5/8" casing stump at 121m + 20" AGE packer – set above top of cut 13 3/8" casing stump at 119m. + Cement Plug #6 – cement plug installed on top of 20" AGE packer (i.e. across top of the well) to seabed i.e. additional 10m cement
Legendre North-2	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 2904m i.e. ~246m of cement above top of reservoir (at ~3150m). Cement plug set across cemented 9 5/8" casing (i.e. casing shoe at 3144m). Primary 9 5/8" annulus cement top reported at 2827m (i.e. 323m annulus cement to reservoir). + Cement Plug #2 – cement plug installed from 1500m to 1296m on a cement retainer i.e. additional 204m cement plug to reservoir. Cement plug set across 2nd stage 9 5/8" annulus cement. Additional annulus cement squeeze also completed. + Cement Plug #3 – cement plug installed from 385m to 140m, "T-plug" cement plug set across 9 5/8" cut casing stump @355m i.e. additional 245m cement plug to reservoir including 215m additional cement above 9 5/8" x 13 3/8" annulus.
Legendre North-4H	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 1455m i.e. ~889m of cement above top of reservoir (at ~2344m). Cement plug set across cemented 9 5/8" casing (i.e. casing shoe at 2351m). Primary 9 5/8" annulus cement top reported at 1185m (i.e. 1000m+ annulus cement to reservoir). + Cement Plug #2 – cement plug installed from 1284m to 1036m on a cement retainer i.e. additional 248m cement plug to reservoir. Cement plug set cemented 9 5/8" casing. + Cement Plug #3 – cement plug installed from 390m to 140m, "T-plug" cement plug set across 13 3/8" casing stump cut at 154m and 9 5/8" cut casing stump @360m i.e. additional 250m cement plug to reservoir including 230m additional cement above 9 5/8" x 13 3/8" annulus.
Legendre North-5H	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 2273m i.e. ~625m of cement above top of reservoir (at ~2898m). Cement plug set across cemented 9 5/8" casing (i.e. 9-5/8" casing shoe at 2770m) and 7" cemented liner (top-of liner at 2739m). Primary 9 5/8" annulus cement top reported at 2451m. + Cement Plug #2 – cement plug installed from 1133m to 972m on a cement retainer i.e. additional 161m cement plug to reservoir and annular cement squeeze 1133m to 1033m i.e. additional 100m of annular cement to reservoir. + Cement Plug #3 – cement plug installed from 382m to 137m, "T-plug" cement plug set across 13 3/8" casing stump cut at 148m and 9 5/8" cut casing stump @352m i.e. additional 245m cement plug to reservoir including 215m additional cement above 9 5/8" x 13 3/8" annulus.
Legendre North-6H	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 3105m i.e. ~87m of cement above top of reservoir (at ~3192m). Cement plug set across cemented 9 5/8" casing (i.e. casing shoe at 3205m). Primary 9 5/8" annulus cement top reported at 1402m (i.e. ~1000m+ annulus cement to reservoir).

Well	Cement Barrier
	+ Cement Plug #2 – cement plug installed from 3105m to 2670m on a cement retainer (directly on top of Cement Plug #1) i.e. additional 435m cement plug to reservoir. Cement plug set across cemented 9 5/8” casing (i.e. casing shoe at 3205m). Primary 9 5/8” annulus cement top reported at 1402m (i.e. ~1000m+ + Cement Plug #3 – cement plug installed from 803m to 663m on a cement retainer i.e. additional 140m cement plug to reservoir and additional annular cement squeeze (cement volume details not reported). + Cement Plug #4 – cement plug installed from 578m to 482m on a cement retainer i.e. additional 96m cement plug to reservoir and additional annular cement squeeze (cement volume details not reported). + Cement Plug #5 – cement plug installed from 140m to 185m, “T-plug” cement plug set across 13 3/8” casing stump cut at 150m and 9 5/8” cut casing stump @153m i.e. additional 45m cement plug to reservoir including 10m additional cement above 9 5/8” x 13 3/8” annulus.
Legendre South-2H	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 2450m i.e. ~406m of cement above top of reservoir (at ~2856m). Cement plug set across cemented 9 5/8” casing (i.e. 9-5/8” casing shoe at 2892m). Primary 9 5/8” annulus cement top reported at 1728m (i.e. 1000m+ annulus cement above reservoir). + Cement Plug #2 – cement plug set in the completion tailpipe from 1185m to 1135m. + Cement Plug #3 – cement plug installed from 1125m to 922m on a cement retainer i.e. additional 203m cement plug to reservoir set across second-stage 9 5/8” annular cement reportedly from 1389m to 989m i.e. additional 400m of annular cement to reservoir. + Cement Plug #4 – cement plug installed from 374m to 140m, “T-plug” cement plug set across 13 3/8” casing stump cut at 149m and 9 5/8” cut casing stump @344m i.e. additional 234m cement plug to reservoir including 204m additional cement above 9 5/8” x 13 3/8” annulus.
Legendre West-1	+ Cement Plug #1 – cement plug bullhead into reservoir, top of cement reported at 3568m i.e. ~1000m of cement above top of reservoir (at ~4602m). Cement plug set across cemented 7” liner (i.e. 7” liner shoe at 4466m) and cemented 5” liner (5” liner top at 4407m). Primary 7” liner cement top reported at 3073m (i.e. 1000m+ annulus cement above reservoir). + Cement Plug #2 – cement plug installed from 3070m to 2848m on a cement retainer i.e. additional 222m cement plug to reservoir set across cemented 9 5/8” casing (9-5/8” casing shoe at 3292m). + Cement Plug #3 – cement plug installed from 375m to 139m, “T-plug” cement plug set 9 5/8” cut casing stump @345m i.e. additional 236m cement plug to reservoir including 206m additional cement above 9 5/8” x 13 3/8” annulus. + 20” AGE Packer – set across top of cut 13 3/8” casing stump at 139m + Cement Plug #6 – cement plug installed on top of 20” AGE packer (i.e. across top of the well) to just below seabed i.e. additional 27m cement.
Legendre South-1	+ Cement Plug #1 – open-hole cement plug set across and above the Flag Fm reservoir – top of cement plug reported at 1862m providing ~42m of “rock-to-rock” cement across the Muderong cap-rock directly above the reservoir. + Cement Plug #2 – combined open-hole / cased hole cement plug installed from 1102m to 1006m set across 9 5/8” casing shoe providing an additional 96m cement plug to reservoir (9-5/8” casing shoe at 1072m). Approx 30m of this plug set open-hole as “rock-to-rock” across the Withnell Fm (below 9 5/8” casing shoe), with remaining cement plug (i.e. approx. 66m) set across cemented 9 5/8” casing. + Cement Plug #3 – cement plug installed from 180m to 130m across partially cemented 9 5/8” casing (9 5/8” top of cement reported at ~144m) providing an additional 50m cement plug. + 20” CRMA plug – set across top of cut 9 5/8” casing stump at 106m + Cement Plug #4 – cement plug installed on top of 20” plug (i.e. across top of the well) to just below seabed i.e. additional ~10m cement.
Legendre South-3	+ Cement Plug #1 – open-hole cement plug set from TD across and above the reservoir – top of cement plug reported at 1830m providing ~100m of “rock-to-rock” cement across cap-rock directly above the reservoir. + Cement Plug #2 – combined open-hole / cased hole cement plug installed from 1150m to

Well	Cement Barrier
	1060m set across 13 3/8" casing shoe providing an additional 90m cement plug to reservoir (13-3/8" casing shoe at 1101m). Approx 49m of this plug set open-hole as "rock-to-rock" across the Withnell Fm (below casing shoe), with remaining cement plug (i.e. approx. 41m) set across cemented 13 3/8" casing. + Cement Plug #3 – cement plug installed from 600m to 500m set across cemented 13 3/8" casing (13 3/8" top of cement reported at ~245m) providing an additional 100m cement plug. + Cement Plug #4 – set below, across and above the 13 3/8 casing stump cut at 123m (i.e. across top of the well) from ~190m to just below seabed i.e. additional ~90m cement plug.
Legendre-1	+ Cement Plug #1 – cased-hole cement plug set on a solid base (bridge plug) at 1908mMD with a top of the cement plug at 1820m. This plug is set across the 9 5/8" annulus cement with a reported cement top of ~1400m MD. The top of the target reservoir (the BRET or B.Reticulatum sandstone) is at 1888mMD with the Forestier to Muderong formations directly over laying the BRET formation. The overlaying formation consists of predominantly shale lithology which exhibits negligible permeability. + The top perforation in the 9 5/8" casing is reported at 1893mMD. This provides for a 68m cement plug set directly above the reservoir across cemented casing and cap-rock (i.e. ~68m of "rock-to-rock" cement across cap-rock directly above the reservoir). + Further, based on the reported top of the cement in the 9 5/8" annulus, there is approximately 488m of cement behind the 9 5/8" casing above the top of the reservoir across the largely impermeable overlaying formations (Foriester to Muderong Fms). + Cement Plug #2 – surface cement plug set inside the 9-5/8" casing from 60m (i.e. directly below the seabed) to 146m (i.e. additional 86m cement plug). + The Add Energy report classified the cement as an effective barrier with acceptable placement based on the reported information (noting that cement placement data such as lift pressures etc. were not available given well was constructed ~50 years ago).

Additional Principal Well Engineer – technical review

A second external SME (a Principal Advisor) reviewed the various technical reports (**Table 6-2**), attended the SME workshop, and reviewed the technical assessment findings (**Section 6.1.1.7**).

The SME concurred with the findings and asserted that plausible routes for increasing gas rates are absent.

6.1.1.8 Legendre-1

The wellhead for the historic exploration well Legendre-1, drilled by Woodside in 1968, remains in situ at the northern end of the permit. The Legendre-1 well was drilled, plugged and abandoned in accordance with the plan submitted to the regulator of the day. The well completion record indicates that the wellhead was left in situ, with no further correspondence from the regulator at that time (Santos, 2020).

Seeps/Bubbles have not been detected from Legendre-1 well.

The Add Energy report (2022) recommended that Santos further review the risks associated with the potential for trapped wellbore pressure. The report also questioned whether the wellhead may be stopping gas bubbles being released. Santos investigated these two points as detailed below.

External SME assessment

The Legendre-1 well barriers were assessed in the SME Technical Input - Legendre P&A, Well Integrity and Bubble Escalation Potential (**Section 6.1.1.7**). The risk of gas seepage from the primary reservoir formation through the plugged and abandoned Legendre-1 well is assessed as not credible and future escalation is also assessed as not credible. There are no credible pathways for bubbles now or in the future. The gas migration path suggested in the Add Energy report is not credible, as it implies that reservoir gas would need to migrate through a significant cement column.

The risk of gas seepage at Legendre-1 from the primary reservoir is not credible with the cement plugs reported to be in place.

Santos subsurface assessment of Legendre-1

A detailed petrophysical analysis (Santos 2024a) was conducted on the Legendre-1 well data, focusing on the permeable formations situated above the primary reservoir level. Due to the absence of core data above the reservoir depth, permeability estimates for these formations were derived from a calculation using the spontaneous Potential (SP) log and porosity data. **Figure 6-2** provides a schematic diagram of the well, while **Figure 6-3** shows the petrophysical analysis.

Formation Analysis

- Forestier to Muderong Formation: Above the B.reticulatum reservoir (BRET) boundary, the formation consists predominantly of shale lithology, which exhibits negligible permeability. This section of the well is interpreted as non-permeable and registered a very low levels of drill gas based on petrophysical analysis and mudlogging data.
- Gearle Siltstone: This unit is primarily shale interval transitioning to a Calcilutite (or Calcareous Shale). A short interval between 1445-1510 mMDRT, characterized by low permeability, is observed. This section is considered to have limited reservoir potential based on petrophysical analysis and the lack of hydrocarbon shows observed while drilling this section.
- Toolonga Calcilutite: This formation is composed of low-permeability carbonate, overlaid and sealed by the Withnell Formation, which includes the Miria Marl. The Withnell Formation at Legendre-1 comprises of a thick shale sequence exhibiting no permeability.

Hydrocarbon Indicators

There is no evidence of hydrocarbons in any of the formations above the primary reservoir interval. The background gas levels remain consistently low throughout these units, further supporting the absence of a hydrocarbon column in these formations.

Additionally, there is no discernible pathway for hydrocarbon migration from the reservoir interval to the upper open casing annulus, ensuring that the hydrocarbon zone remains confined to the primary reservoir depth.

Special Considerations

- Trealla Formation (350-415 mMDRT): It is important to note that the apparent spike in water saturation (SW) observed between 350-415 mMDRT within the Trealla Formation is an artefact caused by the difference in log resolution. The resistivity log, which has a lower resolution compared to the density log, results in a misrepresentation of the formation properties in this narrow interval. These apparent spikes should not be interpreted as indicating permeable zones or hydrocarbon presence, but rather as a logging artifact due to resolution discrepancies across thin, tight bands.

Conclusion

Based on the petrophysical analysis, it is concluded that the formations above the primary reservoir level are largely impermeable, with no hydrocarbon presence observed.

The Trealla Formation's SW anomalies are attributed to log resolution artifacts and do not indicate any permeability or hydrocarbon-bearing zones. Consequently, no migration pathway exists from the reservoir to the casing annulus, and the integrity of the reservoir remains intact.

Santos considered if minor gas may be present in shallow overburden sediments above the cement plugs. The assessment concluded that while the petrophysical analysis indicates there are permeable zone within the Gearle & Toolonga formations, there were no hydrocarbons shows recorded on the mud-log, which confirms no significant hydrocarbon accumulation in the overburden formations and no risk of significant gas bubble seepage from these sediments.

SME assessment of the Santos subsurface assessment of Legendre-1

The external SME (Principal Well Engineer, **Section 6.1.1.7**) and additional Santos well SMEs reviewed the Santos subsurface petrophysical report. They concluded that while the report characterises the formation as a shale with no reservoir potential, extremely minor gas bubbles from an overburden formation may have a ‘remote’ likelihood. The overburden formations above the reservoir that are potentially open to the B-annulus. The rock properties and low permeability of the subsurface formations mean the ‘remote’ potential for miniscule seepage.

Legendre-1 potential seepage assessment conclusion

- The external SME assessment concluded that the risk of gas seepage from the primary reservoir formation through the plugged and abandoned Legendre-1 well is not credible and future escalation is also assessed as not credible. There are no credible pathways for bubbles now or in the future.
- The Santos assessments for Legendre-1 ranked a gas bubble seepage from the reservoir via Legendre-1 well as highly unlikely (remote) now and in the future.

- The likelihood of trapped wellbore pressure (below the wellhead) is assessed as ‘remote’.
- The likelihood of extremely minor gas seepage from overburden sediments is also assessed as remote. The presence of the wellhead is not expected to be a factor that influences the conclusion, so if the wellhead is removed, or left in situ and ultimately degrades, the assessed risk of gas seepage does not change.
- In the remote event that overburden gas enters the wellbore, the escalation potential is not credible over time, given the rock properties and low permeability of the subsurface formations.
- In the remote event that overburden gas enters the wellbore, any trapped gas below the wellhead would reach a limit and plateau, therefore trapped wellbore pressure will not influence the potential for gas bubbles now or in the future. The gas in these zones would be largely background i.e. small volumes.
- In the remote event that extremely minor gas seepage pathways exist, the seepage would be similar to the other seeps in WA-20-L.

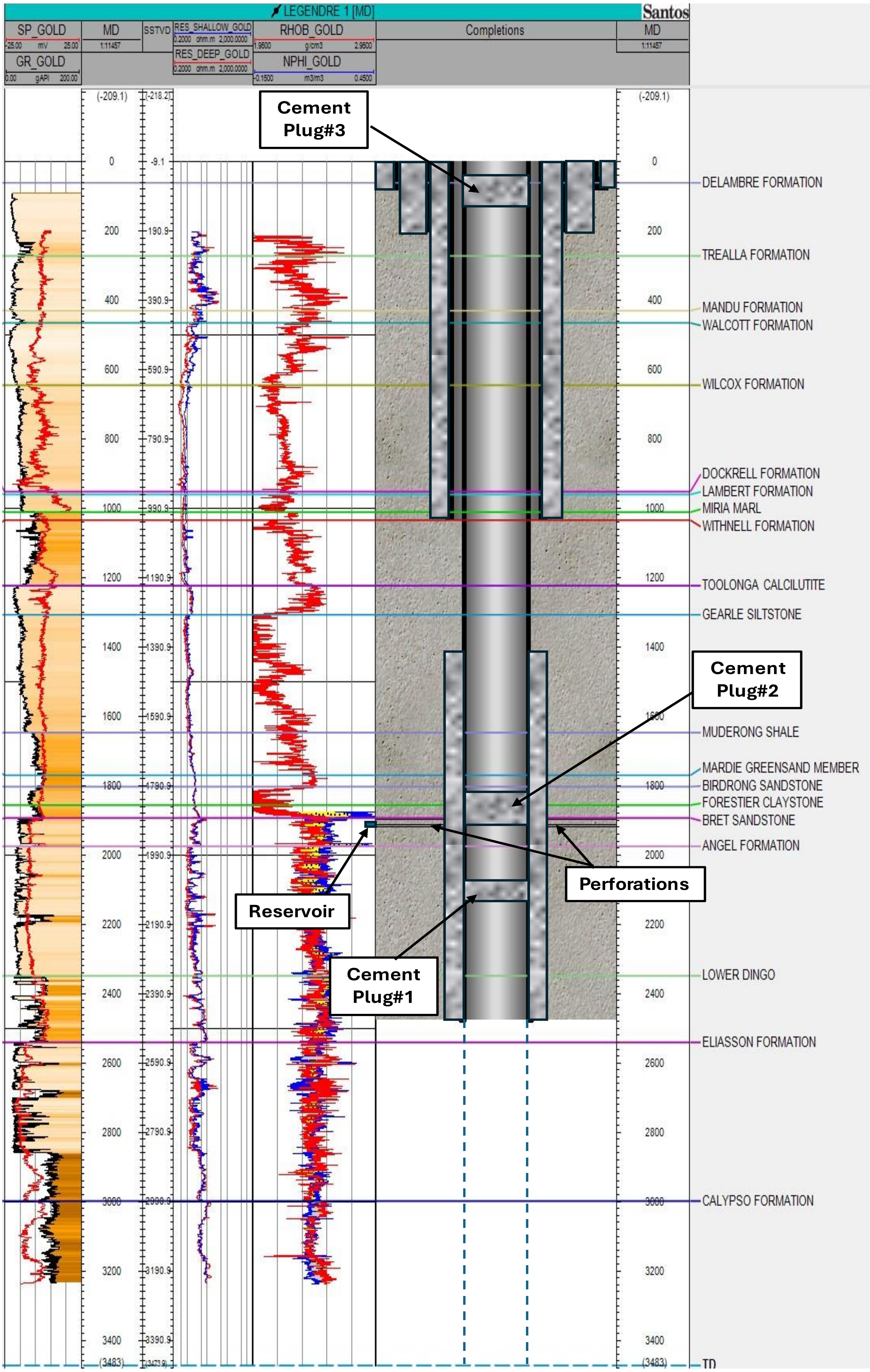


Figure 6-2: Legendre-1 Well Schematic

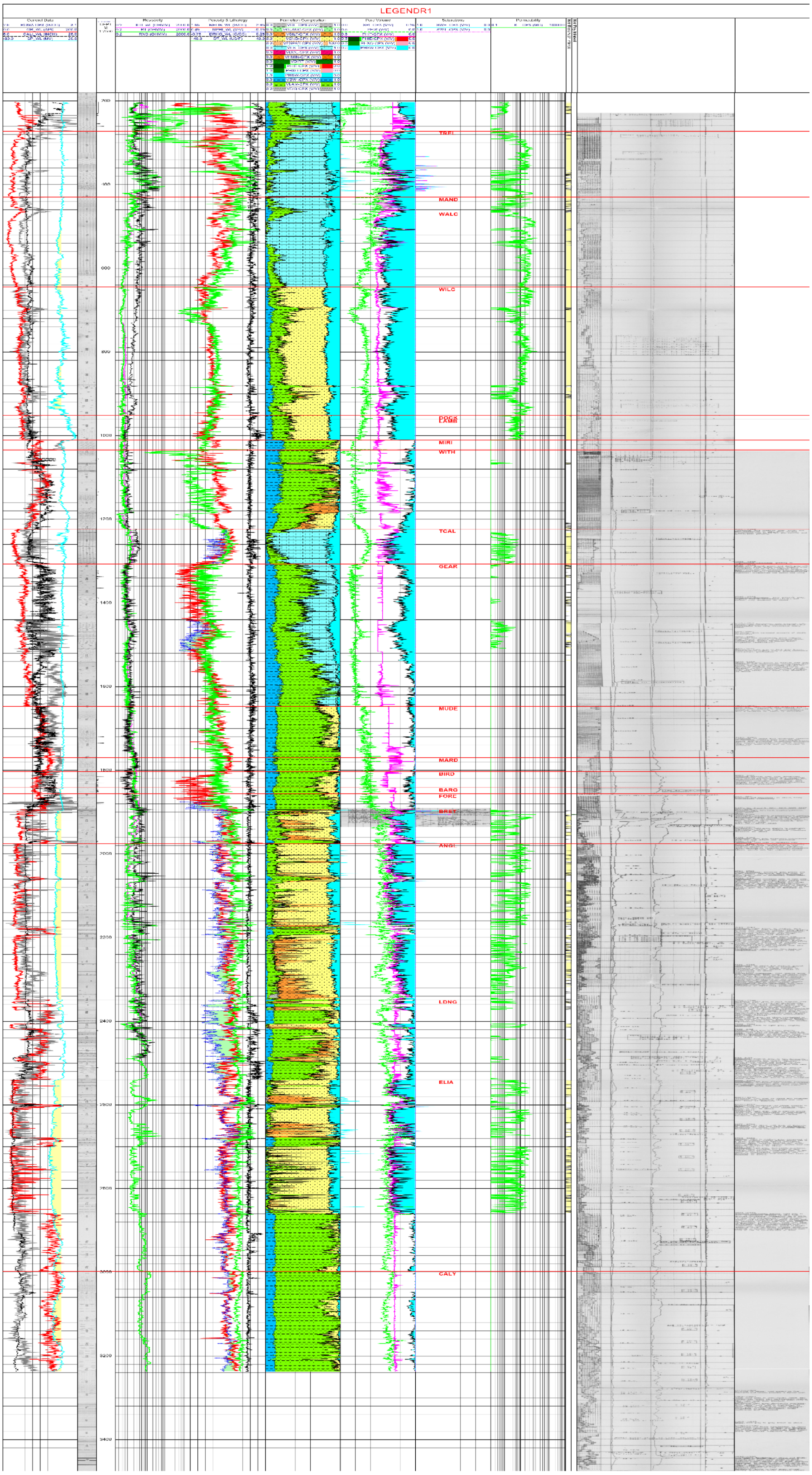


Figure 6-3: Legendre-1 Petrophysical Interpretation Plot

6.1.1.9 Future monitoring

As outlined in **Section 6.1.1.6**, the SME Workshop (2024) included discussion and assessment of the frequency and type of future monitoring required. The conclusions were that one monitoring campaign will be sufficient to further understand the seepage within WA-20-L.

Following the workshop, Santos engaged RPS to provide a technical memo for the future monitoring campaign; to consider purpose, scope, locations, type of vessel, proposed schedule, and justification for why a single campaign has been chosen and ensures risks are ALARP and acceptable.

Purpose

The purpose of seepage monitoring is to enable the quantitative assessment of any changes in gas composition and gas release rates from the Legendre Hub, Legendre South-1 and Legendre South-3 wells and contaminants released into the surrounding marine environment to that previously described.

Scope

The monitoring program will include the measurement of:

+ Gas release rates.
+ Gas composition.
+ Contaminants in water (methane, total recoverable hydrocarbons, BTEXN, PAHs).
+ Contaminants in sediments (particle size distribution, metals, total recoverable hydrocarbons, BTEXN, PAHs, nutrients, total organic carbon).

The monitoring program will also provide for a qualitative description of benthic habitats and fish communities and the condition of the remaining infrastructure. ROV footage will also be collected at the Legendre-1 wellhead location.

The monitoring program excludes (with justification):

+ Continuous monitoring over a lunar cycle using acoustics – CSIRO attempts to safely deploy landers and record gas releases over a lunar cycle failed in 2022 and were costly relative to the information and insights gained regarding the gas plumes.
+ Acoustic monitoring across broader spatial scales – CSIRO used acoustics to examine presence of gas bubbles in the water column along 500 m spaced transects in a 5 km x 5km area encompassing Legendre Hub, Legendre South-1 and Legendre South-3. Beyond 20 m from Legendre Hub gas bubbles were not detected. There is no evidence to suggest that impacts from the gas releases are manifest beyond the immediate area of the release.
+ Naturally Occurring Radioactive Materials (NORMs, radium226, radium228 and thorium228) were analysed from sediment samples taken in 2021 and were at levels well below the guideline value of 35,000 Bq/kg (RPS, 2021a) so are not proposed to be included as the gas seepage does not present a source of NORM.

Locations

Measurements and observations described in the scope will be taken at the Legendre Hub, Legendre South-1 and Legendre South-3 well locations within WA-20-L.

Methods

Methods are based on those used previously to ensure consistency with previous monitoring efforts and the unambiguous identification of changes through time. Noting that relevant and applicable improvements in sampling equipment and methodology will be considered at the time of future monitoring as long as consistent data interpretation can be maintained.

Gas flux rates will be measured at single points in time at representative seeps at each location using an ROV fitted with a high-resolution camera. The ROV will also be fitted with a methane sensor providing a live feed of point estimates of methane concentration in the surrounding water.

Gas samples will be taken at Legendre Hub and analysed for gas composition (C1-C6, O_2, Ar, N_2, CO_2) by gas chromatography by a NATA-accredited laboratory.

Sediment samples will be taken using a grab sampler at the well locations and at reference sites (greater than 100 m from the well sites).

Water samples will be taken using a niskin sampler or similar at the well locations at approximately 1 m above the seabed and at the sea surface.

The following chemical geophysical parameters will be analysed in a NATA accredited laboratory as appropriate:

+ Particle size distribution - sediment.
+ Metals/metalloids (Al, As, Ba, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Zn) - sediment and water.
+ Total recoverable hydrocarbons (TRH) (C6 – C40), BTEXN, PAHs and oil and grease (if TRH detected) - sediment and water.
+ Nutrients (total Kjeldahl nitrogen and total phosphorous) - sediment and water.
+ Total organic carbon - sediment and dissolved inorganic carbon - water.

To assess potential impacts, metals/metalloids and total recoverable hydrocarbons will be compared to the Australian & New Zealand Guidelines (ANZG, 2018) default guideline values (DGV). Where no guideline values are available a trigger value will be calculated by doubling the average reference values for each site (ANZECC & ARMCANZ 2000).

Type of vessel

Typically, a single vessel will be used to undertake the surveillance, monitoring and inspection activities. The actual vessel will be determined according to the purpose of the support activity. However, for environmental assessment purposes, the Bhagwan Dryden has been considered a representative vessel, noting that the actual vessel to be used is likely to be smaller. The intent of using a proxy in the Bhagwan Dryden is to assess impacts and risks of the largest typical vessel so that the assessment is conservative and allows for flexibility in vessel selection at the time. The Bhagwan Dryden is a 57 m long, 1,475-tonne multi-purpose support vessel with accommodation for up to 42 people. Previous surveys in 2021 were conducted from a 24 m vessel. The vessel will typically use thruster propellors to maintain station and is not expected to need to anchor as part of the support activity. Due to the short duration of the activity refuelling at sea will not be required.

Schedule

The monitoring program is to be carried out once during the duration of the WA-20-L Environment Plan and within the fourth year after the EP is accepted.

Monitoring once during the duration of the EP is considered ALARP and acceptable based on the following:

+ There is no evidence to indicate that the composition of the gas will change over a 5 year period, as indicated by the:
  - consistency of gas sample composition collected in 2021 (RPS, 2021) and in 2022 (Talukder, 2024).
  - Legendre field subsurface study report by Santos subsurface team (Santos, 2024).
  - gas composition analysis and review by external SME (Murray Partners, 2021).
  - conclusions of the risk assessment of Legendre gas release by internal and external SMEs in a workshop held by Santos on 14 November 2024.
  - SME technical input following the workshop.
+ There is no evidence to indicate that the rate of gas releases will change over a 5 year period, as indicated by the:
  - ROV surveys since 2011 at Legendre Hub provide qualitative evidence that gas release rates have not materially changed over 14 years. Note this video footage and estimates of gas release rates before the RPS survey in 2021 are not referenced in EP, however, Santos holds video records and release rate estimates that support this statement.
  - quantitative measurements taken 1.5 years apart (RPS, 2021 and Talukder, 2024) showing no material change in gas release rate.
  - conclusions of the assessment of Legendre gas release by internal and external SMEs in a workshop held by Santos on 14 November 2024.
  - SME technical assessments following the workshop.
+ Studies have predicted that the migration pathway of gas from the reservoir is convoluted (Add Energy, 2023a,b), and the assessment of Legendre gas release by internal and external SMEs (**Section 6.1.1.7**) concluded that this pathway will not escalate through time.

Monitoring Results

Once data and information is made available from the monitoring campaign, the findings will be compared to the previous monitoring campaign results. This comparison will be conducted by an external SME. Based on the monitoring results and assessment, the Santos Management of Change process shall be applied where relevant. **Figure 6-1** provides an overview of the seepage assessment process.

This monitoring campaign is considered by Santos and external SMEs to be adequate to inform the evaluation of environmental impacts and risks associated with the seepage.

6.1.1.10 Seepage summary

- The Legendre production wells were plugged and abandoned in 2011 as a part of a decommissioning campaign under an EP which was accepted by the Western Australia Department of Mines and Petroleum in 2011. The production wellheads were removed during P&A activities, and some concrete stabilising structures and sections of pipeline were left in situ, as approved under the EP.
- After the abandonment of the production wells and subsequent removal of the platform and associated infrastructure, small gas bubbles were observed in the vicinity of the plugged and abandoned wells during a post-decommissioning ROV survey in 2013.
- Several additional ROV surveys were conducted at WA-20-L between 2011 and 2021, however these surveys could not determine whether the seeps were emanating from inside or outside of the casing, and the gas seepage flux rates could not be accurately quantified.
- Two targeted field surveys have since been conducted to inspect and analyse any gas seeps: Legendre field environmental survey (referred to as the ‘RPS 2021 survey’, RPS 2021a/b) and NWS offshore gas seeps and leakage characterisation project survey (referred to as the ‘CSIRO 2022 survey’, Talukder et al. 2024).
- During the RPS 2021 survey it was confirmed that gas seepage at WA-20-L was occurring at three well locations: Legendre Hub, Legendre South-1, Legendre South-3. The majority of seepage was at Legendre Hub, with smaller amounts emanating from Legendre South-1 and Legendre South-3.
- The CSIRO 2022 survey confirmed seabed gas seepage at Legendre Hub. There was no confirmation of gas seeps emerging from the seafloor for the Legendre South-1 and Legendre South-3 sites.
- The gas bubbles are estimated to be 1-11mm in diameter in size.
- Flux rates are provided in **Table 2-2** and **Table 2-3**. The CSIRO estimated flux rate at Legendre Hub are the same order of magnitude as the flux estimation made during the RPS survey 2021 (Talukder et al., 2024).
- External SME technical assessments have indicated there is no credible risk of the bubble rates to increase at any of the wells.
- External SME technical assessments have indicated there are no credible risks of reservoir bubbles at Legendre-1. Santos ranked the likelihood of bubbles occurring at Legendre-1 as remote, using the Santos risk matrix. If the wellhead was removed or once it has degraded, there may be a remote likelihood of bubbles, which would be similar to the other bubbles, and would have a negligible potential impact to the environment.
- An additional monitoring campaign will be performed to gather another round of data on the seepage.

Table 6-6: Seepage Summary

Wells	Gas bubbles	Evidence	Risk of escalation
Legendre Hub	Present	Confirmed during the RPS and CSIRO monitoring surveys.	No
Legendre South-1	Present	Confirmed during the RPS survey.	No
Legendre South-3	Present	Confirmed during the RPS survey.	No
Legendre-1	Not present	Seeps/Bubbles have not been detected in Legendre-1. Santos has investigated whether bubbles may be a risk at Legendre-1 if the wellhead was removed or degrades over time. The risk of hydrocarbon gas seepage from the well is assessed as extremely low (remote). Refer to **Section 6.1.1.8**.	No

6.1.2 Nature and scale of environmental impacts

As detailed in **Section 2.1**, gas seepage has been observed at three locations on the seabed of WA-20-L: Legendre Hub, Legendre South-1 and Legendre South-3 (**Figure 2-1**). The risk of hydrocarbon gas seepage from the Legendre-1 well is assessed as extremely low (remote). See **Section 2.1** for characterisation of the gas seeps compiled from field sampling and analysis in 2021 (RPS 2021a) and in 2022 (CSIRO; Talukder et al. 2024).

Methane was by far the dominant component at approximately 85% of the total gas, followed by ethane (~7%), propane (~3.8%), n-butane (1.3%) and nitrogen (~1%). A review of the major toxicological databases (US National Institutes of Health, US Environmental Protection Agency, European Chemicals Agency) and the peer reviewed literature by CSIRO (Talukder et al., 2022) found that all of these compounds are considered non-toxic in the aquatic environment, or not to be a chemical hazard.

Compounds that contributed less than 1% included i-Butane, Neo-Pentane, i-Pentane, n-Pentane, Hexanes, M-C-Pentane, Cyclohexane, Heptanes and M-C-Hexane. The petroleum gases are generally classified in Annex I of Directive 67/548/EEC under REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) legislation as physical hazards but not environmental hazards. (European Chemicals Agency 2022). A thorough Web of Science search did not identify any relevant ecotoxicological literature (Talukder et al., 2022).

Gas bubbles released at the seabed will initially be supersaturated relative to the seawater and dissolution of gas will be subject to time-varying rates of dissolution across the gas/water interface as a product of the dissolution rates of the component gases, the surface area of the bubbles, the temperature of the water, and the background concentration of the component gases (Olsen et. al., 2017). All component gas released as natural gas mixtures may dissolve into the water column on rising from releases in deeper water (>200 m) (Olsen et al., 2017, 2019, Gentz et al., 2014). Typically for bubbles released in shallow water (<100m), a significant proportion of the gas within bubbles will remain within the bubbles and be released into the atmosphere on reaching the sea surface (Olsen *et al.*, 2017, 2019, Gentz *et al.*, 2014).

While the WA-20-L seeps are in 50-60m water depth, the Talukder et al. (2024) study reached the following conclusion: At the Legendre Hub acoustic data, bubble size distribution and rise velocity suggest that some seeps are reaching the sea surface. However, due to the gas exchange between the rising gas bubbles and the water column, it is anticipated that only a small portion of the methane in the original expelled bubble will reach the surface.

During the RPS 2021 survey, dissolved methane at the Legendre Hub site was detected at a maximum of 391 parts per million by volume (ppmv) up to 5 m horizontally away from the approximately 20 seeps and was detectable, but below the reliable detection limit of 20 ppmv, 20 m away from the gas seeps (RPS 2021a) (**Section 2.1)**. The total estimated flux rate from the 20 gas seeps at Legendre Hub was estimated as 338 mL/min and the bubble size ranged from 1 to 10 mm near the seabed (RPS 2021a) (see **Section 2.1**). At the Legendre South-1 site four gas seeps were present with a lower estimated flux rate compared to the Legendre Hub site (total 12 mL/min, 1 mm bubble size) (see **Section 2.1**). At the Legendre South-3 site there were two gas seeps present with a lower estimated flux rate of 6 mL/min and bubble size range between 5 to 10 mm near the seabed. No other gas seeps were identified at the remainder of the well surface locations in WA-20-L (RPS 2021a).

The CSIRO 2022 survey confirmed seabed gas seepage at Legendre Hub, and while small gas bubbles were observed in the water column of Legendre South-1 and Legendre South-3, there was no confirmation of gas seeps emerging from the seafloor for these sites. The estimated total flux rate at Legendre Hub was 435 ml/min to 931.32 ml/min. In this work, the estimated flux rate was estimated only when the seep is active. While the RPS estimation is an average during the time span when seep is active and inactive. As a result, the estimated flux rates estimated in the CSIRO work are higher than the RPS estimation. This is not considered an actual increase in rate as the CSIRO estimates were based on a constant release of bubbles from the seeps, whereas, the RPS estimates considered the intermittent (on/off) nature of the releases. The results correlate well with flux estimation based on acoustic backscatter strength measurements and are the same order of magnitude as the flux estimation made during the RPS survey (Talukder et al., 2024).

In conjunction with a literature review of methane behaviour in the water column, site-specific methane release volumes immediately above the seabed, were calculated for the Legendre Hub seeps (RPS, 2021b). The following parameters from the field survey were used in the calculations:

+ spatial locations of the gas seeps;
+ water depth of individual gas seeps at the point of origin from the seabed;

+ water temperature;
+ rates of discharge of gas per seep; and
+ diameter of the gas bubbles generated immediately above the seep.

Assuming methane represents 85% of the gas bubble volume at depth, the volume and mass of methane in each gas bubble was derived. The mass transfer rates of methane into the water column and the potential accumulation of methane in the water column immediately above the seep, assuming static water conditions was then calculated.

Calculations indicate the mass transfer rate of methane into the water column is small across a range of bubble sizes due to the shallow (50 m) water depth, indicating that a relatively long period of time (up to 16 minutes) is required before all the methane within a bubble may dissolve into the water column in static water conditions (RPS, 2021b). **Figure 6-4** shows the predicted concentration of methane (above background) over the time period the water above the seep is static. Given that the environmental conditions in the seep locations are not static, a significant proportion of the methane gas remains within the bubbles and may be released into the atmosphere on reaching the surface, totalling an estimated 0.628 tonnes of methane per year over WA-20-L. The 2021 field studies where dissolved methane was not detected above ambient at 10 m from the seep location and bubbles were observed at the sea surface on a few occasions (RPS 2021b, **Section 2.1**).

Talukder et al. (2022) reported that across the NWS, direct and indirect evidence suggests that active natural gas seepage has been occurring in three basins: the Browse Basin (in the Vulcan Sub-basin and on the Yampi Shelf, Jones et al., 2005; Rollet et al., 2006), the Canning Basin and the northern Carnarvon Basin. The natural seepage in these basins was first interpreted during the 1990s and has been re-interpreted since as new techniques allow further investigation including Logan et al. (2010) concluding that despite extensive evidence of palaeo-seepage, very limited occurrence of active seepage existed on the NWS. Since 2010, CSIRO has conducted two seep surveys in the Browse Basin; one in the vicinity of the Ashmore Platform and the other in the vicinity of the Ichthys and Prelude fields. During both surveys, active expulsion of gas bubbles from the seabed into the water column was detected using a multibeam water column scanning echosounder (Stalvies et al., 2017). The findings of these seep surveys demonstrated that there is geochemical evidence of thermogenic hydrocarbon seepage and led to the conclusion that the gas bubbling by natural seepage in the NWS is highly ephemeral and seems to be controlled by tidal variation.

At end of Legendre field life (EOFL), the field had produced over 47 MMstb of oil along with over 92 Bscf of associated gas with 75 Bscf reinjected, and the remainder either used for fuel, flared, or vented. At EOFL, modelling indicates over 77 MMstb of oil remain in place along with 95 Bscf of associated gas with 43 and 52 Bscf in the vapour and liquid phases, respectively (Santos, 2024). A study was undertaken by Santos subsurface engineers to explore future scenarios of gas release from the Legendre field using production data, estimated flux rates at the sites measured by RPS (2021a) and Talukder et al. (2024), a history- matched numerical model of the reservoir and other reservoir modelling tools (Santos, 2024).

Focus was placed on matching current measured estimated flux rates with a simplistic single well model using parameters from a history-matched numerical model to predict the reservoir properties at the start of the seepage into the distant future. This involved placing a ‘Legendre Hub’ well at a crestal location (maximising contact with gas vapour in the reservoir) and then controlling the well over an extended period at a gas control rate set at the measured rate of 18 scf/d. Following this, the reservoir parameters were used to generate a range of Inflow Performance Relationship (IPR)/Vertical Lift Profiles (VLP) at a range of water to gas ratios (WGR), which predicted that a WGR of 0.01 stb/Mscf and a 0.5 mm diameter tubular leak path direct from reservoir to seabed is representative of the current estimated flux rate, i.e. matching the range of measured rates. Note that this is an oversimplification of the leak paths which cannot be accurately determined and are not a simple straight conduit as modelled. This seepage pathway is miniscule and according to simple erosion modelling, will not be further exacerbated over time given the low rates across the Legendre Hub area. At current estimated flux rates of 18 to 37 scf/d with an estimated 95 Bscf of gas in place in the reservoir, these rates are likely to be sustained over geological time. Seepage will not increase over time as reservoir pressure is almost constant within ~5 years after EOFL.

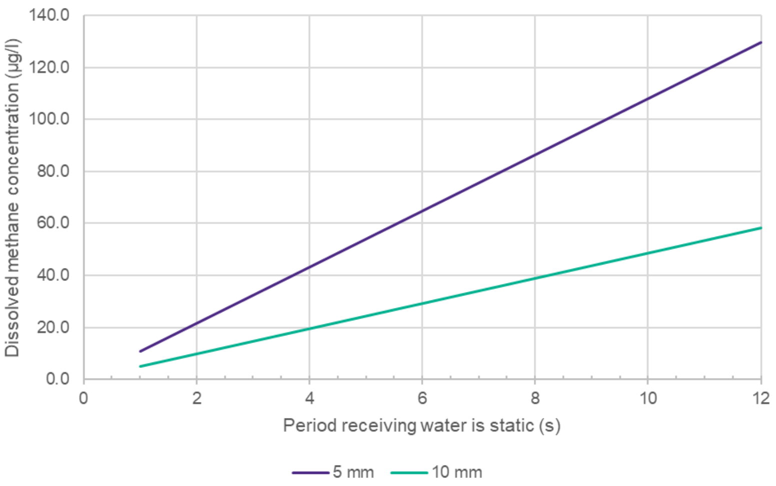


Figure 6-4: Comparison of potential accumulation of methane over time at Legendre Hub[1]

[1] For bubble sizes at 5 mm and 10 mm assuming no exchange of water or methane in the 1 m above the seep source.

6.1.2.1 Physical environment or habitat

Water quality

As described above, methane gas is soluble, but dissolution will not occur instantaneously. Due to the shallow water depth at the seepage locations (50 m, 54 m and 53 m respectively) and the low mass transfer rate of methane into the water column, a significant proportion of the methane gas is expected to remain within the bubbles and be released into the atmosphere on reaching the surface (RPS, 2021b, Olsen *et al.*, 2017, 2019, Gentz *et al.*, 2014). Considering this, localised concentrations of methane in the water (above background) are expected to be limited to within tens of meters of the seepage locations (RPS, 2021b) which was confirmed during in-field surveys (see **Section 2.1**). In-field measured concentrations of entrained methane were highest in close proximity to the gas seepages (within 1 m of the source) and rapidly decreased with distance from the seepage location and were not detected above ambient 10 m away (RPS 2021b).

Dissolution of methane into the water column may result in local oxygen depletion within a highly localised area (tens of metres) surrounding a gas seep location (Yanamoto *et al.* 2014). The large tides and ocean currents experienced in the region (**Section 3.3.3**) are expected to rapidly disperse any hydrocarbons dissolved in the water and to counteract any localised oxygen depletion effects.

Talukder et al. (2024), from analysis of water samples taken in 2022, for a suite of hydrocarbons **Section 2.1)**, concluded that, very low concentrations of hydrocarbons were detected in a few samples and were not detected repeatably and consistently in samples, as such there was no conclusive evidence of significant dissolved hydrocarbons in the water column at Legendre Hub. Given the Legendre Hub site has the greater release of gas bubbles, it is highly unlikely that dissolved hydrocarbons would be detected at Legendre South-1 and Legendre South-3.

Sediment quality

Sediment TRH concentrations within 20 m of the plugged and abandoned wells at the Legendre Hub site were observed to be 155-490 mg/kg which is higher than concentrations at the reference sites (40-70 mg/kg), located 100 m away. Sediment TRH concentrations at the Legendre South-1 and Legendre South-3 gas seepage sites were 85-95 mg/kg and 55-70 mg/kg respectively (RPS 2021a). All but 2 samples at Legendre Hub were below the default guideline values for TRH. There were no detections above reporting limits for BETXN compounds. The patterns of sediment contamination (e.g. of aluminium, barium, iron and TRH) are consistent with contamination from drilling muds and fluids and possibly decommissioning activities (**Section 3.3.5**; RPS 2021b). Results indicate that any contamination from the gas seepage is likely to be highly localised to where gas bubbles leave the sediment (i.e., it is not spreading through the sediment) (RPS 2021a).

Benthic habitats

Benthic habitats in the vicinity of the gas seepages support more complex epibiotic communities than found on the surrounding flat, featureless sand habitat due to the hard substrate provided by remnant concrete at well locations and the concrete mattresses at Legendre Hub (see **Section 3.6.3**). These structures probably support more mature epibiotic communities than the surrounding soft benthos, because they are less affected by sediment scour and burial than the natural pavement reef and small boulder substrates of the surrounding seabed. The hard substrates and associated marine growth also support abundant fish assemblages because they create complex physical shelters (RPS 2021a).

Although seeps and vents are known to provide a unique environment for chemosynthetic organisms, these have not been recorded around the vents and seeps examined within the Browse Basin (CSIRO, 2005) nor around seeps in WA-20-L (RPS 2021a). Rather, these vent and seep habitats seem to provide a novel hard substrate that supports a range of filter-feeding organisms—such as sponges and corals—that are commonly found on other hard substrates (e.g., shoals and reefs) within the region (Geoscience Australia, 2021).

The Glomar Shoals KEF is a littoral shelf that is present within WA-20-L. The values of this KEF (high productivity and aggregations of marine life) have been observed at a small scale near some of the gas seepages (visual observations in RPS 2021a and Talukder et al., 2024).

Air quality

As described above, a significant proportion of the gas released in shallow water (<100 m) can remain in a gaseous state and escape into the atmosphere on reaching the surface (Olsen et al., 2017, 2019, Gentz et al., 2014), resulting in a temporary, localised reduction of air quality in the environment immediately surrounding the location of a surface release of gas. This release of methane and other gases will make a negligible contribution to Santos, state and national GHG emissions.

A quantification study was undertaken to inform the assessment of the potential impacts from the GHG emissions associated with the gas seeps within WA-20-L (RPS, 2021b). Emissions from the gas seeps were conservatively estimated by assuming 100% release of the gas into the atmosphere (although there will be dissolution into the water column).

Annual greenhouse gas emissions were estimated for WA-20-L using Method 1 of the API Compendium (American Petroleum Institute 2009) that addresses non-routine emissions involving venting events that result in CH4 emissions. Equation 5-24 was selected to estimate the fugitive emissions as gas seepage from plugged and abandoned wells is not an activity directly addressed in the Determination. For calculation purposes, the activity has been equated with fugitive emissions from system upsets, accidents and deliberate releases from process vents, production-related but non-routine emissions, and well blowouts (Section 3.85L of the Determination). Of the gas composition, the C1 to C5 molar percentage values (see **Table 2-4**) have been normalised to the total C1-C5 gases, not to the whole sample composition which includes inorganic gases and minor liquid (C6+) components (RPS 2021a); therefore, the C1 molar percentage values are considered to only represent methane. The other one-carbon molecules (carbon dioxide and carbon monoxide) are inorganic gases.

The molecular composition of gas seep at Legendre South-3 has been assumed to be similar to the gas seep at Legendre South-1 due to its close proximity. As such, the C1 molar percentage value from Legendre South-1 has been applied to Legendre South-3 in the calculation below. The tonnes of carbon dioxide equivalence per year for WA-20-L is shown in **Table 6-7**, based on the RPS 2021 data.

Table 6-7: Annual greenhouse gas emissions for WA-20-L

Location	Estimated quantity of emission	
Units	**tonnes of methane / year**	**tonnes of carbon dioxide equivalence / year**
Legendre Hub	0.596	16.675
Legendre South-1	0.022	0.607
Legendre South-3	0.011	0.303
Total	**0.628**	**17.585**
Notes: + The estimated flux rates were measured at seabed pressure (~6 atmospheric pressure (ATM) at ~50 m for the Legendre field locations). + Calculation of methane density and variation in net volume due to pressure and field water temperature value is sourced from the RPS report (RPS 2021b). + The gas volume released (at 50 m water depth and 25°C) assumes that the daily rate of gas seep is constant		

over an annual period.

- The gas volume released (at 0 m water depth and 25°C) assumes that the net volume of gas would be larger if released to the water surface (1 ATM) as it is sourced from greater depths and pressure (RPS 2021b).
- The gas volume released (at 0 m water depth and 25°C) conservatively assumes that the total volume of gas is released at the water surface and does not account for methane dissolution into the water column.
- The molecular volume conversion of methane at 25°C is sourced from Table 3-3 of the API Compendium (American Petroleum Institute 2009).
- The quantity of emissions in tonnes of carbon dioxide equivalence per year was calculated by multiplying the tonnes of methane per year by methane's Global Warming Potential (GWP) of 28 (sourced from Section 2.02 of the Regulations).
- As per **Section 6.1.1.8**, gas bubbles are not predicted at Legendre-1, however there is a remote risk that bubbles could occur if the wellhead was removed, or once the wellhead has degraded in hundreds of years. The bubbles are predicted to be similar rates and characteristics to the other seeps. The emissions calculation in this table would therefore potentially increase to account for Legendre-1, in the event that bubbles did occur.

To quantify potential GHG impact, the emissions of carbon dioxide equivalent (CO_2-e) are used as a metric to compare the emissions of GHG on the basis of their global-warming potential by converting amounts of GHG emitted to the equivalent amount of carbon dioxide with the same global-warming potential.

The estimated annual average CO2-e emissions associated with WA-20-L gas seeps is 17.585 tonnes of carbon dioxide equivalence per year. The Australian household average is approximately 15-20 tonnes of carbon dioxide equivalence per year (CPA, 2024).

The total Australian fugitive emissions was estimated by the Department of Industry, Science, Energy and Resources (DISER) as 48.6 Mt CO2-e during the 2020/21 period (DCCEEW 2022). The WA-20-L gas seep emissions over an annual period would equate to 0.00004% of the 2020/21 national fugitive emissions.

As the gas seepage occurs in open offshore waters, the discharge in such a remote location will not impact on air quality for any human receptors. The quantities of gas emissions are relatively small and will quickly dissipate to the atmosphere as methane is lighter than air. There would be no credible impact and no flow on impacts to fauna as a result of gas seepage in WA-20-L, hence the impact to air quality is not discussed further.

6.1.2.2 Threatened, migratory, or local fauna

Large mobile marine fauna including turtles, fishes, sharks and rays are expected to occur only occasionally within the vicinity of the gas seepage locations due to the lack of high, complex structures. However, smaller mobile marine fauna (e.g., squirrelfishes) generally occur in places where hard substrates stand above the seabed and create physical shelter (RPS 2021a). This is to be expected in areas where hard substrates are rare, as even a small increase in structural complexity of the benthic habitats is likely to be sufficient to attract a rich resident fish assemblage. Marine fauna that did occur at the gas seepage locations were not observed to be either attracted to or repelled by the gas seeps (RPS 2021a).

The NWMR contains commercial fisheries that target a variety of demersal and pelagic fish species. The indicator species for commercial fisheries that are historically active within WA-20-L (see **Section 3.6.1**) include red emperor, rankin cod, bluespotted emperor and Spanish mackerel. Due to movement of water and the mobile nature of the fauna species present and the relatively small area that contains dissolved methane above background levels (methane levels back to ambient within 10 m of seeps at the Legendre Hub site (RPS 2021b) any exposure to marine fauna is expected to be minimal and temporary in nature. Methane and the other gases are not toxic in the marine environment and are not considered environmental hazards (Talukder et al., 2022). No adverse outcome pathways were identified by Talukder et al. (2022) and as a consequence, no specific biomarkers would be meaningful to assess the health and condition of fish and other species exposed to the gas seepage.

6.1.2.3 Socio-economic receptors

Commercial fisheries

Exposure of commercial fish species to methane may impact on the marketability of potentially tainted fishes. Impacts potentially include restrictions on sales (e.g., catches are unsafe for human consumption) or effects to market value (e.g. perceived and real tainting). Impacts may be triggered by measurable effects to fishes. WAFIC stated during consultation that Western Australia had an international reputation for clean oceans and this reputation supports the WA fishing industry to export product all over the world. WAFIC further stated that gas leaks would have a direct impact on the commercial fishing industry's reputation and markets. Santos subsequently met with WAFIC on 16 May 2022 and presented the findings of the CSIRO study (Talukder et al., 2022). WAFIC had no additional comments on proposed activities and potential impacts. WAFIC suggested Santos produce a fact sheet for WAFIC to distribute to its members and relevant stakeholders if asked about impacts of the gas seepage on the marine environment and commercial fish species. Santos issued the activity update fact sheet to stakeholders who requested to be kept informed about the monitoring and research programme (refer to **Appendix H**).

As discussed above, biological level impacts to fish are not expected, as exposure to dissolved or gaseous methane would not result in ecotoxicological impacts. Larger mobile marine fauna, such as commercially valued fish species are not expected to aggregate near to the gas seepage locations due to the lack of large complex structures and therefore any exposure to dissolved or gaseous methane is expected to be minimal and temporary in nature.

6.1.3 Environmental performance outcomes and control measures

The EPO relating to this risk is:

+ EPO-01: No significant effect on marine fauna or benthic habitats caused by sediment and water quality changes due to gas seepage.

The control measures considered for this activity are shown in **Table 6-8** and described in more detail below the table. EPS and measurement criteria for the adopted controls are presented in **Section 8.4.1**.

Table 6-8: Control Measures Evaluation for gas seepage

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
No standard controls have been identified.				
Additional Control Measures				
N/A	Intervene to reduce or stop gas seepage by drilling an intercept well	Reduce or prevent the release of gas into the water column.	Re-entry of wells or drilling intercept wells has never been applied to wells with small, intermittent gas seepage. Re-entry of Legendre wells is not considered credible due to casing strings having already been removed and the plugs that have already been set. Intercept wells are not considered credible for effectively remediating annular cement. Estimated costs: AUD 50-100 million.	**Reject** – Option carries significant risk and costs with a very low likelihood of success. Given the negligible impact of the gas releases on the marine environment, drilling relief wells is rejected.
N/A	Concrete mattress removal	May provide a clearer indication of the wells with seepage.	The mattress has been on the seabed for a long time (±12 years) and its conditions is unknown, but it is likely it will not have much integrity to be easily and safely removed. Estimated costs: AUD 10 million	**Reject** – Option carries technical challenges and costs. Given the negligible impact of the gas releases on the marine environment, additional work to remove the mattress is rejected.
N/A	Well re-entry	Reduce or prevent the release of gas	During the 2011 Legendre plug and abandonment campaign, multiple permanent cement plugs were installed into the development well bores, and	**Reject** – Option carries significant technical challenges and is not feasible.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		into the water column.	surface casing strings, conductors and wellheads were cut and removed from below the mudline. The exploration wells were also plugged and abandoned at the completion of drilling activities, with multiple cement plugs installed into the wellbore and surface casing strings, conductors and wellheads cut and removed. It is not considered feasible to re-enter the abandoned wellbores due to: An inability to tie-back and re-establish a structural connection and a pressure envelope with the well because the production casing, surface casing, conductor and wellhead have been cut and removed; and There is no safe conduit to re-enter the well because the multiple permanent cement plugs (across cut casing stumps and in the wellbore below) means the original wellbore no longer exists – any attempt to "drill through" existing permanent cement plugs will be uncontrolled and is likely to result in inadvertent side-tracking. There are no documented cases where wells with seeps/bubbles have been repaired by re-entering with or without a wellhead. There is no direct access to the 9-5/8" casing or 13-/8", all the Legendre wells have cement plugs in place, which will need to be removed in order to install the casing reconnect system. An independent study (**Section 6.1.1.3**) did not identify a feasible re-entry option.	
N/A	In-field investigations at Legendre-1 to check wellhead pressures through available valve access or hot-tapping	May provide a greater understanding of the Legendre-1 pressures.	Legendre-1 has a subsea wellhead with no valves available to check for gas and pressure below the wellhead. Hot tapping is feasible for the wellhead TA cap only which will provide access to 9-5/8" casing only, however there is no value in doing this as the internal cement plug set in 9-5/8" casing means gas accumulation below the tree cap is not credible.	**Reject** – Significant technical challenges and cost, outweigh the potential environmental benefits.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			The 9-5/8" is on a profile inside the high-pressure wellhead using a casing hanger. That profile is typically located below the top of low-pressure housing which means to get access to that annulus you would need to hot tap through the side, which means going through the low pressure and high-pressure wellhead. And in the case of Legendre-1 the PGB presents a barrier, so it is not physically possible to drill a hole through the side.	
N/A	Remove the Legendre-1 wellhead to determine if there are bubbles	May provide an understanding of seepage risks at Legendre-1	Significant financial costs and technical risks. The likelihood of bubbles is assessed as remote likelihood, and the potential consequence to the environment is negligible.	**Reject** - Significant financial costs and technical risks are grossly disproportionate to any environmental gains.
CM-01	Gas seepage monitoring campaign	Allows comparison of seep characteristics over time to inform next revision of the WA-20-L EP.	Monitoring campaign would cost approximately AUD 750,000-1,000,000.	**Adopt** – Results provide data and information to assess the seepage risks. **Section 6.1.1.9** provides additional information.
CM-02	Results of the monitoring campaign are to be analysed and compared to the previous campaigns	Allows comparison of seep characteristics over time.	Negligible costs.	**Adopt** – Assessing the data and comparing the results to previous surveys will provide assurance that seepage has not changed.
N/A	Increase monitoring frequency	May provide further seepage information to inform risk	It is more useful to allow several years in between surveys, so a survey around year 4 of the EP (once accepted) would put approx. 6 years between surveys to see if any acute change. Having a fourth dataset within close proximity to the second and third surveys would not improve the overall validity of the data comparisons. An extra survey would cost approximately AUD 1,000,000. The monitoring program is to be conducted once during the duration of the EP and within 1 or 2 years of the expiry date. **Section 6.1.1.9** includes further details of the assessment.	**Reject** – The proposed single survey is sufficient to assess the seepage. This has been confirmed during the SME workshop and supported by the SME technical input. Existing survey data have shown that seepage rates have not changed, between the last two surveys. The cost of an extra survey is significant and is unlikely to provide any additional

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				data that will not already be acquired by the proposed single survey. **Section 6.1.1.9** includes further details of the assessment.

6.1.4 Environmental impact assessment

Receptor	Consequence Level
Threatened, migratory, or local fauna	Given the mobile nature of threatened fauna that may be present and that the dissolved methane and PAHs were not detected at reportable limits in any sample or blanks throughout both CSIRO voyages any exposure to marine fauna is expected to be negligible. This would preclude chronic effects to marine megafauna. Impacts to threatened or migratory fauna are assessed as I - Negligible.
Physical environment or habitat	Dissolution of methane and other gas constituents into surficial sediments and the water column may result in local oxygen depletion. This may result in a shallow anoxic zone within a highly localised area (<tens of metres) surrounding the gas seep location. The gas seeps overlap the Glomar Shoals KEF but the scale of the seepage is too small to impact values of the KEF. Impacts to the physical environment/ habitat are assessed as I - Negligible.
Threatened ecological communities	Not applicable – No threatened ecological communities occur at or near the gas seepages.
Protected areas	Not applicable – No threatened protected areas occur at or near the gas seepages.
Socio-economic receptors	Impacts to individual fish in close proximity to the gas seepage are not expected due to the lack of toxicity of the methane and other gas constituents. No reported impact to commercial fisheries. WAFIC received no feedback from fishers on the gas seepage.
Overall worst-case consequence	I – Negligible

6.1.5 Demonstration of ALARP

The assessed residual consequence for this impact is I – Negligible. This assessment considers the present and future potential impacts to the environment.

Re-entry of the abandoned well bore to reduce or stop gas seepage is technically challenging due to limited and untested tie-back mechanisms that may be able to re-establish a structural connection and a pressure envelope with the well. Further, there is no safe conduit to re-enter the well because multiple permanent cement plugs mean the original wellbore no longer exists and any attempt to drill through existing permanent cement plugs will be uncontrolled and is likely to result in inadvertent side-tracking into the surrounding shallow formation. An independent study (**Section 6.1.1.3**) did not identify a feasible re-entry option.

Natural dry gas and oil seepages have been detected previously (Geoscience Australia, 2021) and low concentrations of methane in waters of the Browse Basin were detected by Ross et al. (2017) demonstrating that methane within the water column is not unheard of within the region. Further, the areas where seeps were supported diverse biotic communities (Geoscience Australia, 2021).

The WA-20-L gas seep emissions over an annual period would equate to approximately 0.00004% of the 2020/21 national fugitive emissions. It can be concluded that the gas seeps in WA-20-L are not expected to be a significant GHG emissions contributor on a national scale.

Stakeholder concerns regarding the ‘clean and green’ image of Western Australia’s commercial fishery were raised during consultation. An independent SME assessment (CSIRO) of the potential environmental impacts of the gas seepage concluded that methane and the other gas constituents would not pose a risk to fish due to the lack of toxicity and small spatial scale of the release (Talukder et al., 2022).

Given the environmental consequence of the gas seeps is ranked as I – Negligible and the control measures in place, it is therefore considered that the impact of the gas seepage is reduced to ALARP.

6.1.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence of introducing gas (predominantly methane) into the water column is rated I - Negligible.
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes - Activity evaluated in accordance with the Environmental Hazard Identification and Assessment Procedure which considers the principles of ESD. The consequence against this aspect is I - Negligible, and therefore does not affect the outcomes of the principles of ecologically sustainable development as per **Table 5-5**.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with the OPGGS Act and the OPGGS(E)R. Santos has considered the values and sensitivities of the receiving environment including relevant Species Recovery Plans, Conservation Management Plans and management actions including but not limited to: Recovery Plan for Marine Turtles in Australia (2017) Conservation Advice *Rhincodon typus* whale shark (2015) Conservation Management Plan for the Blue Whale, 2015–2025 (DoE, 2015). Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – Aligns with the Santos Environmental Management Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – stakeholders’ concerns were addressed through the provision of additional information.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

6.2 Interaction with other marine users – vessel and monitoring equipment presence

6.2.1 Description of event

Event	Sources of impact to other marine users may occur as a result of the vessels moving through WA-20-L posing collision risk and potential inconvenience. The presence of the vessels performing survey activities could potentially inhibit commercial fishing and other oil and gas activities.
Extent	**Localised** around the support vessel and monitoring equipment.
Duration	**Temporary and intermittent** interaction with vessels when transiting WA-20-L. **Short term** presence of seabed equipment – approximately one month.

6.2.2 Nature and scale of impacts

6.2.2.1 Socio-economic receptors

There are four commercial fisheries that overlap WA-20-L and are actively fished (**Section 3.6.1**). Significant disruption to commercial fishers due to the presence of the seabed equipment and vessel is not expected. This is due to the small size of the monitoring equipment, short deployment (approximately one month) and the fishers will be notified of their presence through notice to mariners.

No shipping routes overlap WA-20-L. No concerns have been raised by the shipping industry through consultation or in the past five years relating to disturbance to shipping routes as a result of activities within the region.

Tourism and recreational activity is expected to occur very infrequently throughout WA-20-L. Recreational fishing activity is most likely to occur on the Glomar Shoals. Interaction with tourism and the vessels could occur, potentially resulting in minor deviations from their planned route, which may slightly increase transit times and fuel consumption.

AMSA requires a high level of communication during the activities and inclusion of the activity on a notice to mariners, therefore reducing the likelihood of interaction with other sea users. Other users will still be able to access the operational areas during the activity as no exclusions are in place, but usual maritime safe distance for concurrent operations will apply.

6.2.3 Environmental performance outcomes and control measures

The EPO relating to this risk is:

+ **EPO-02**: Reduce impacts on other marine users through the provision of information to relevant stakeholders such that they are able to plan for their activities and avoid unexpected interference.

The CMs for this activity are shown in **Table 6-9**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-9: Control measures evaluation for interaction with other marine users

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-04	Automatic Identification System (AIS) identification system on vessel	Vessel has AIS to aid in its detection at sea. Reduces risk of environmental impact from vessel collisions.	Negligible costs of operating navigational equipment.	**Adopt** – Benefits considered to outweigh negligible costs to Santos.
CM-05	Maritime notices	Ensures other marine users are aware of the presence of the vessel, and static data collection (including monitoring equipment).	Costs associated with the personnel time in issuing notifications and closing out queries and responses.	**Adopt** – Benefits considered to outweigh negligible costs. Maritime requirement to issue marine notices.

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-06	Lighting will be used as required for safe work conditions and navigational purposes.	Ensures vessels are seen by other marine users. Reduces risk of third-party vessel collisions. Marine Order Part 30: Prevention of Collisions, and with Marine Order Part 21: Safety of Navigation and Emergency Procedures requires vessels to have navigational equipment to avoid collisions.	Negligible costs of operating navigational equipment. Costs associated with vessel fit-out with navigational equipment.	**Adopt** – The safety benefits (and thus environmental benefits) outweigh the cost. Compliance with Marine Orders are a legislated requirement.
CM-07	Watchkeeping maintained on bridge	Reduce impacts to commercial fisheries by actively avoiding their activities and schooling fish in their vicinity.	Negligible costs.	**Adopt** – Benefits considered to outweigh costs.
CM-08	Stakeholder consultation	Santos will update relevant stakeholders on a quarterly basis, prior to the activity commencing and upon activity cessation.	Costs associated with personnel time in preparing and distributing information and collating/addressing any feedback provided.	**Adopt** – Benefits considered to outweigh negligible costs to Santos.
CM-09	No recreational fishing from vessel	Reduce potential impacts to fisheries in the vicinity of the activity.	Negligible costs.	**Adopt** – Benefits considered to outweigh negligible costs to Santos.
Additional controls				
N/A	Eliminate the use of vessels	Would eliminate potential impacts to other marine users.	Not considered feasible as a vessel is the only form of transport that can undertake the survey activities.	**Reject** – Not feasible.
N/A	Manage the timing of the operational activities to avoid peak marine user periods (e.g., fishing).	Would eliminate potential impacts to other marine users.	High cost in moving schedule due to OSV vessel availability. Not considered feasible as marine users could potentially be in the area all year round.	**Reject** – Stakeholders and shipping in the area all year round. Cost grossly disproportionate to low socio-economic benefit given the location of the activity has low-usage by commercial fishers or areas of tourism. The area that stakeholders are displaced from is small (500 m) when compared to the area available to other marine users and there is low marine user activity in the area as

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				evidenced through consultation.
N/A	Avoidance of other active marine users, where safe to do so	Reduced potential disturbance to other marine users. Note primary controls around Automatic Identification System (AIS) transponders, stakeholder engagement and navigational lighting will suffice this control to not be implemented.	The vessel, when operating (e.g. ROV deployed) needs to be stationary and is not able to move from its position. If it has to move from it position this will delay the activity.	**Reject** – Not feasible as the vessel needs to be stationary. Primary controls to avoid other marine users are considered sufficient to reduce the risk to ALARP.
N/A	Use of Support vessel(s) during the activity. This includes having competent crew on maintaining a constant bridge-watch.	Support vessel would monitor area around the support vessel to identify approaching third-party vessels and communicate with the vessels to mitigate disturbance, including safety risk, to other maritime users.	Additional vessels used in the activity would increase impacts to the environment for example from anthropogenic light and routine vessel discharges.	**Reject** – Primary controls to avoid other marine users are considered sufficient to reduce the risk to ALARP for the short duration (approximately 7 days) of the activity. The area that stakeholders are displaced from is small (500 m) when compared to the area available to other marine users and there is low marine user activity in the area as evidenced through consultation.

6.2.4 Environmental impact assessment

The impacts and consequence ranking for interaction with other marine users are outlined in **Table 6-10**.

Table 6-10: Impacts and consequence ranking – interaction with other marine users

Key receptors	Consequence Level
Threatened, migratory, or local fauna	Not applicable – related to socio-economic receptors only.
Physical environment or habitat	
Threatened ecological communities	
Protected areas	
Socio-economic receptors	Given the controls in place and limited interaction expected with other marine users the impact of the support vessel activity is expected to be low. Other marine users currently plan their activities in consideration of other petroleum activities and other marine users (shipping) in the region. AMSA requires a high level of communication during the activity, therefore reducing the likelihood of interaction with other sea users. The presence of monitoring equipment and vessel for approximately one month at the Legendre Hub, Legendre South-1 and Legendre South-3 with the provision of notice to mariners is considered a I – Negligible impact to commercial fisheries. Therefore the expected consequence is (I - Negligible).

Key receptors	Consequence Level
Overall worst-case consequence	I - Negligible

6.2.5 Demonstration of ALARP

No alternative options to the use of support vessels to undertake a marine based survey are possible.

In consultation, stakeholders are made aware of the proposed area from which other marine users may be displaced for the duration of vessel-based activity and no concerns have been raised regarding the potential impact.

The potential impact of displacing other users from vessel-based activities and monitoring equipment a have been assessed as I - Negligible. Given the impact is well understood, the negligible consequence and the proposed controls, impacts to marine users are considered ALARP.

6.2.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum interaction with other marine users consequence is I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with the International Convention for the *SOLAS 1974* and *Navigation Act 2012.*
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	No concerns raised regarding support vessel or monitoring equipment presence.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Industry good practice controls will be applied by the support vessels. The vessels will have a collision radar to allow communication between vessels, watch keeping maintained on bridge and notifications are issued through Australia Hydrographic Office (AHO) and AMSA In addition, no concerns have been raised by other marine users regarding the support vessel activities (**Section 4**).

The presence of a support vessel and monitoring equipment is not expected to significantly affect commercial fishing operations or shipping traffic given the various routes that can be taken. The activity is considered acceptable.

6.3 Acoustic emissions

6.3.1 Description of event

Event	Underwater noise emissions will be generated by vessel, SBES and ROV activities which could potentially have the following effects on marine fauna: + Masking of vocalisations/signals from predators/prey. + Modification of fauna behaviour (avoidance/attraction/disruption of normal behaviour). + Physical injury to fauna from exposure to excessive noise (barotrauma, hearing loss).
Extent	**Localised**: A vessel using main engines and bow thrusters to maintain position will become inaudible above background noise within thousands of metres. **Localised:** A conservative estimate for the use of monitoring equipment (such as SBES) is within a 400m radius **Localised**: Noise from ROV operations will extend to the area immediately adjacent to vessels.
Duration	**Intermittent**: Approximately seven days for each survey.

Noise associated with vessel activity that could impact marine fauna includes noise generated by vessel thrusters, engines and propellers. The main source of vessel noise will be from propellers or DP thrusters.

Sound levels from the R/V Ocean Pioneer, a 62 m long 5600 HP (4,175 kW) vessel were measured during transit at ten knots and found to have a monopole source level of 166.3 dB re 1 µPa @ 1 m (Chorney et al., 2011). In this study, in the Arctic in 46 m of water, the maximum distance to 120 dB re 1 µPa was found to be 1,600 m. A monopole source level is a source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point-like (monopole) sound source. To place this in context with other studies, McCauley (1998) measured underwater sound levels from the Pacific Ariki, a 64 m long support vessel with 8,000 HP (6,000 kW) main engines during calm conditions in the Timor Sea in 110 m of water while transiting at 11 knots, and found the distance to 120 dB re 1 µPa to be approximately 1 km.

Noise generated by a vessel used to perform environmental survey (e.g. the Bhagwan Dryden) is expected to be less than those from R/V Ocean Pioneer, or the Pacific Ariki, due to the higher speeds and more powerful engines of the larger vessels, although the work-rate of the engines, and thus output power and noise, will depend upon speed and sea-state, and the propagation will depend upon the location. Practical spreading loss, 15log10 (Range) (Urick, 1983), is a reasonably conservative approach to take in waters on the continental shelf, representing a balance between spherical and cylindrical spreading. If practical spreading loss is applied with the monopole source level of the Ocean Pioneer under transit, 166.3 dB re 1 µPa @ 1 m, the distance to 120 dB re 1 µPa (sound pressure level [SPL]) will be less than 1,200 m.

The thrusters on the Bhagwan Dryden are similar to the main engines of the Ocean Pioneer (2,700 kW total installed thruster power, compared to 2,386 kW) therefore the use of the monopole source level derived from the main engines to represent the vessel during position holding is appropriate. To place this in context with available information, McCauley (1998) calculated the Pacific Ariki to have a monopole source level equivalent to approximately 182 dB re 1 µPa @ 1 m while holding position using both main engines and an unspecified bow thruster.

The distance of 1 km for vessel noise to reduce to 120 dB re 1 µPa (SPL) estimated using practical spreading loss for the Ocean Pioneer under transit is considered a conservative estimate for the representative vessel, the Bhagwan Dryden, under DP.

Considering the vessel to have a monopole source level of 166.3 dB re 1 µPa, and operating in a single location for 24 hours, allows the accumulated sound levels to be estimated through the addition of 10*log10 (Time in seconds) to sound levels. This approach can be used to calculate the unweighted sound exposure level (SEL), which can be used in a conservative comparison against relevant SEL impact assessment thresholds.

Sound pressure levels for SBES typically range from 210 to 245 dB re 1 µPa @ 1 m (DECC, 2011). A modelling study indicated the maximum distances at which sound pressure levels were reduced to just above background level (120 dB re 1 µPa) for SBES was approximately 350 m from the sound source (JASCO, 2016).

6.3.2 Nature and scale of environmental impacts

6.3.2.1 Threatened, migratory or local fauna

WA-20-L overlaps BIAs for the whale shark (foraging), wedge-tailed shearwater (reproduction, foraging), and flatback turtle (internesting). No impacts are predicted to the wedge-tailed shearwater from vessel noise and hence this receptor is not discussed further.

The use of sound in the underwater environment is important for marine animals, particularly cetaceans, to navigate, communicate and forage effectively, along with reptiles, sharks/rays and other fish, for a range of functions such as social interaction, foraging and orientation. Underwater noise may impact on marine fauna through:

+ attraction;
+ increased stress levels;
+ disruption to underwater acoustic cues;
+ localised avoidance;
+ disturbance, leading to behavioural changes or displacement from areas;
+ masking or interference with other biologically important sounds such as communication or echolocation (used by certain cetaceans for location of prey and other objects);
+ physical injury to hearing or other organs; or
+ indirectly by inducing behavioural and physiological changes in predator or prey species.

The nature and scale of impacts must be considered in the context of the ambient noise environment. Ambient underwater noise levels are dependent on location, and are often dominated by local wind noise, waves, biological noise and ship traffic. Wind speed and seabed conditions have a clear influence on the ambient noise level. Fish choruses are capable of raising background noise levels to 120 to 130 dB re 1 µPa (McCauley, 2011). Anthropogenic underwater noise sources in the region comprise shipping and small vessel traffic, petroleum-production and exploration-drilling activities and sporadic petroleum seismic surveys.

The surveys will involve a vessel similar to that described in in **Section 2.3**. This sound source is non-impulsive.

Marine fauna respond variably when exposed to underwater noise from anthropogenic sources, with effects dependent on a number of factors, including distance from the sound source, water depth and bathymetry, the animal's hearing sensitivity, type and duration of sound exposure and the animal's activity at time of exposure. Broadly, the effects of sound on marine fauna can be categorised as:

+ Acoustic masking – anthropogenic sounds may interfere with, or mask, biological signals, therefore reducing the communication and perceptual space of an individual. Auditory masking impacts may occur when there is a reduction in audibility for one sound (signal) caused by the presence of another sound (noise). For this to occur the noise must be loud enough and have a similar frequency to the signal and both signal and noise must occur at the same time.
+ Behavioural response – behavioural impacts will depend on the audible frequency range of each potential receptor in relation to the frequency of the noise, as marine animals will only respond to acoustic signals they can detect, as well as the intensity of the noise. The intensity of behavioural responses of marine mammals to sound exposure ranges from subtle responses, which may be difficult to observe and have little implications for the affected animal, to obvious responses, such as avoidance or panic reactions. The context in which the sound is received by an animal affects the nature and extent of responses to a stimulus. The threshold for elicitation of behavioural responses depends on received sound level, as well as multiple contextual factors such as the activity state of animals exposed to different sounds, the nature and novelty of a sound, spatial relations between a sound source and receiving animals, and the gender, age, and reproductive status of the receiving animal.
+ Physiological impacts – auditory threshold shift (temporary and permanent hearing loss) – marine fauna exposed to intense sound may experience a loss of hearing sensitivity, or even potentially mortal injury. Hearing loss may be in the form of a temporary threshold shift (TTS) from which an animal recovers within minutes or hours, or a permanent threshold shift (PTS) from which the animal does not recover.

Available threshold criteria associated with behavioural and physiological impacts for sensitive receptors have been derived from a number of sources (NMFS, 2018; NMFS, 2014; Popper et al., 2014). These criteria have been compared with measured and predicted sound levels for different sound sources to assess potential impacts.

Marine mammals

No known aggregation, resting, reproduction or feeding areas for mammals lie in close proximity to WA-20-L. **Table 6-11** details receptor noise impact and behavioural thresholds for continuous noise for:

+ mid-frequency cetaceans: which consists of toothed whales except porpoises and river dolphins.

Table 6-11: Continuous noise: acoustic effects on mammals: unweighted thresholds

Hearing Group	NMFS (2014)	NMFS (2018)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL [1] (Lp ; dB re 1 μPa)	Weighted SEL_{24h} [2] ($L_{E,24h}$ [2]; dB re 1 $\mu Pa^2 \cdot s$)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 $\mu Pa^2 \cdot s$)
	SPL [1] (Lp ; dB re 1 μPa)	Weighted SEL_{24h} [2] ($L_{E,24h}$ [2]; dB re 1 $\mu Pa^2 \cdot s$)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 $\mu Pa^2 \cdot s$)
Low-frequency	120	199	179
Mid-frequency		198	178

1. Sound pressure level. 2. Sound pressure level weighted over 24 hours.

Auditory masking impacts may occur when there is a reduction in audibility for one sound (signal) caused by the presence of another sound (noise). For this to occur the noise must be loud enough and have a similar frequency to the signal and both signal and noise must occur at the same time. Therefore, the closer the whale is to the vessel, and the more overlap there is with their vocalisation frequencies, the higher the probability of masking. The potential for masking and communication impacts is therefore classified as high near the vessel (within tens of metres), moderate within hundreds to low thousands of metres (Clark et al., 2009).

There is a potential for auditory masking impacts to whales due to vessel noise however impacts are considered temporary and localised because the individual and the vessels will be almost constantly moving and therefore no single area will be impacted for any length of time.

The estimated distances to behavioural and physiological thresholds (as listed in **Table 6-11**) for marine mammals from vessels are provided in **Table 6-12**.

Potential PTS to low-frequency whales (for example, blue whales) could occur within 12 m of the centre of the vessel (considering a representative vessel that is 57 m long) and within 266 m for TTS if the vessel and the cetacean remained in the same place for 24 hours. However, the vessel will never remain in the one position for this long, and as whales are also always moving, the potential for this impact is extremely low. Behavioural impacts may be expected for marine mammals, from the vessels but these will not result in injury to the marine mammals as the behaviours move them further away from the noise source.

The Conservation Management Plan for the Blue Whale identifies threats from anthropogenic noise and stipulates that "anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilize the area without injury and is not displaced from a foraging area" to address the threat. The assessment of noise emissions has determined that the activity may have a behavioural impact from anthropogenic noise during the activity, however this is not likely to occur within the foraging BIA.

Table 6-12: Estimated distances to thresholds for mammals from vessels

Potential Receptor	Estimated Distance	Justification
PTS		
Low-Frequency cetaceans	12 m	Based upon accumulation of unweighted SEL over 24h for a vessel with a source level of 166.3 dB re 1 μPa (SPL), and applying practical spreading loss, see **Section 6.3.1**.
Mid-Frequency cetaceans	Not predicted to occur	Not predicted to occur for vessels with a significantly greater power output (McPherson et al., 2019)
TTS		

Potential Receptor	Estimated Distance	Justification
Low-Frequency cetaceans	266 m	Based upon accumulation of unweighted SEL over 24h for a vessel with a source level of 166.3 dB re 1 µPa (SPL), and applying practical spreading loss, see **Section 6.3.1**.
Mid-Frequency cetaceans	Not predicted to occur	Not predicted to occur for vessels with a significantly greater power output (McPherson et al., 2019)
Behaviour		
Low-Frequency cetaceans	Within 1,200 m	Considering a vessel with a source level of 166.3 dB re 1 µPa (SPL), and applying practical spreading loss, see (McPherson et al., 2019)
Mid-Frequency cetaceans		

Marine reptiles

Marine turtles

Turtles utilise shallow waters for feeding, nesting, reproduction and internesting. The internesting BIA for the flatback turtle intersects WA-20-L.

Marine turtles use sounds for navigation, to avoid predators and to find prey (Piniak, 2012). No numerical thresholds have been developed for impacts of continuous sources (for example, vessel noise) on marine turtles. However, Popper et al. (2014) have developed risk-based criteria, and these are presented in **Table 6-13**.

The Recovery Plan for Marine Turtles (Commonwealth of Australia, 2017) notes there is limited information available on the impact of noise on marine turtles and that the impact of noise on turtle stocks may vary depending on whether exposure is short (acute) or long term (chronic). Turtles have been shown to respond to low frequency sound, with indications that they have the highest hearing sensitivity in the frequency range 100 to 700 Hz (Bartol and Musick, 2003).

Although WA-20-L overlaps with the flatback turtle internesting BIA, (as per **Table 3-2**), impacts are not expected on a population level or on turtle habitat. Individuals may be encountered within WA-20-L but are likely to be internesting adults due to the distance from the closest nesting beaches. Behavioural impacts could occur within the immediate vicinity of the vessel and monitoring equipment for a short duration and will likely result in the turtles moving away from the area. As the area within which foraging and distribution of all turtles species is widespread, the minimal disturbance is not expected to significantly impact the critical habitat for turtles, or impact at a population level due to the nature and scale of the activity (temporary, short duration, vessel-based activity).

Based on the criteria detailed within **Table 6-13** there is a low risk of any injury to marine turtles from vessel noise. Behavioural changes, for example, avoidance and diving, are only predicted for individuals in close proximity to the activity vessels (high risk of behavioural impacts within tens of metres of a vessel and moderate risk of behavioural impacts within hundreds of metres of a vessel). There is a high risk of masking within hundreds of metres of the vessel, and a moderate risk of masking within thousands of metres from the vessel. Turtles have not been shown to have a reliance on sound for finding food or avoiding predators. Sounds potentially could be used by turtles in a social manner to synchronise activities during the nesting season (Ferrara et al., 2014); however, this has not been demonstrated for sea turtles. The noises are relatively quiet (Ferrara et al., 2014), and thus would only have a limited range of detection by turtles even in ideal conditions, with masking from natural sounds likely. The impacts from masking are expected to be low.

Sea snakes

There is limited information about the effects of noise on sea snakes. A current research project investigating the impacts of seismic surveys found that hearing sensitivity of sea snakes is similar to species of fish without a swim bladder (discussed below). Therefore, it is considered that there is a moderate risk in the near and intermediate distances (which extends hundreds of metres) of behavioural impacts to sea snakes, with the impacts being limited to temporary avoidance of the area.

Table 6-13: Continuous noise: criteria for vessel noise exposure for turtles

Potential Receptor	Masking	Behaviour	TTS	Recoverable injury	Mortality and Potential mortal injury
Marine Turtle	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low

Notes: adapted from Popper et al. (2014)

Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of metres, intermediate (I) - hundreds of metres, and far (F) – thousands of metres.

Sharks, fish and rays

The whale shark foraging BIA overlaps WA-20-L and therefore whale sharks are considered likely to occur in WA-20-L.

All fish species can detect noise sources, although hearing ranges and sensitivities vary substantially between species (Dale et al., 2015). Sensitivity to sound pressure seems to be functionally correlated in fishes to the presence and absence of gas-filled chambers in the sound transduction system. These enable fishes to detect sound pressure and extend their hearing abilities to lower sound levels and higher frequencies (Ladich and Popper, 2004; Braun and Grande, 2008). Based on their morphology, Popper et al. (2014) classified fishes into three animal groups comprising:

+ fishes with swim bladders whose hearing does not involve the swim bladder or other gas volumes;
+ fishes whose hearing does involve a swim bladder or other gas volume; and
+ fishes without a swim bladder that can sink and settle on the substrate when inactive.

Thresholds for PTS and recoverable injury are between 207 dB PK and 213 dB PK (depending on the presence or absence of a swim bladder), and the threshold for TTS is 186 dB SELcum (Popper et al., 2014). Given there is no exposure criteria for sharks and rays, the same criteria are adopted, though typically sharks and rays do not possess a swim bladder.

Individual demersal fish may be impacted in the vicinity of the activity and mobile pelagic species may transverse WA-20-L. However, WA-20-L is not known to be an important spawning or aggregation habitat for commercially caught targeted species. Therefore, no impacts to fish stocks are expected.

The criteria defined in Popper et al. (2014) for continuous (**Table 6-14**) noise sources have been adopted.

Table 6-14: Continuous noise: criteria for noise exposure for fish

Potential Marine Fauna Receptor	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Notes: Adapted from Popper et al. (2014)

Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N) – tens of metres, intermediate (I) – hundreds of metres, and far (F) – thousands of metres.

Based on criteria developed by Popper et al. (2014) for noise impacts on fish, vessel noise has a low risk of resulting in mortality and a moderate risk of TTS impacts when fish are within tens of metres of a vessel. The most likely impacts to fish from noise will be behavioural responses. Popper et al. (2014) identified a moderate risk of behavioural impacts to fish in near (tens of metres) and intermediate distances (hundreds of metres) from the noise source. Masking could occur within thousands of metres under a worst-case scenario of vessel operations, however typically any effect will be limited to within hundreds of metres.

It is possible that whale sharks could pass through the survey area, as the whale shark foraging BIA overlaps WA-20-L. Whale sharks would be expected to show a behavioural response only, as it is unlikely that this species would swim within close range (within metres) of high energy sound sources (for example, bow thrusters). The slow working speed of vessels within the area further reduces the risk of any negative impacts attributable to vessel noise as well as the additional controls to manage interaction with marine fauna described in **Section 7.4**.

The Conservation Advice Rhincodon typus Whale Shark (Threatened Species Scientific Committee, 2015a) identifies habitat disturbance as a risk. The expected noise levels and behavioural response are not considered to result in habitat disturbance, which is consistent with this advice.

Invertebrates

Underwater noise emissions from the activity are not expected to cause a change in behaviour to benthic invertebrates. Benthic invertebrates are unlikely to be negatively impacted from noise generated from vessel operations due to the fact that the activity is intermittent and of short duration with the vessel not sitting in one location for a long period of time. Additionally, there is no convincing scientific evidence for any significant effects induced by non-impulsive noise in benthic invertebrates.

Plankton, including fish eggs and larvae, and pelagic invertebrates could drift into close proximity to high energy noise sources (for example, bow thrusters). However, any negative impacts that could occur would be restricted to within metres of the sound source. At such a localised extent, impacts would be negligible at an ecosystem or population level.

Some behavioural response to vessel noise could occur to benthic fish communities within WA-20-L. The sand and silt seabed of WA-20-L suggests there are unlikely to be any areas of particularly high abundance or diversity of fishes within this area, although it is likely that there will be some attraction of fishes to the remaining subsea infrastructure.

6.3.2.2 Socio-economic receptors

Impacts to fish may result in indirect impacts to commercial fisheries active in WA-20-L (**Section 3.6**), with impacts restricted to moderate within hundreds of metres of the vessel as detailed above. With the majority of the noise emissions being of short duration and of limited extent, any impact on commercial fishing is expected to be minimal. There are expected to be no impacts to other marine users (petroleum industry, or shipping) from the noise emissions associated with the activity.

6.3.3 Environmental performance outcomes and control measures

The EPO relating to this risk is:

- **EPO-03**: No injury or mortality to EPBC Act 1999 and WA Biodiversity Conservation Act 2016 listed fauna during activities.

The CMs considered for this activity are shown in **Table 6-15** with EPSs and measurement criteria for the EPOs described in **Section 8**.

Table 6-15: Control measures evaluation for noise emissions

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-10	Procedure for interacting with marine fauna	Reduces risk of physical and behavioural impacts to marine fauna from vessel, because if they are sighted, then the vessel can slow down or move away.	Operational costs to adhere to marine fauna interaction restrictions, such as vessel speed and direction, are based on legislated requirements and must be adopted.	**Adopt** – Benefits in reducing impacts to marine fauna outweigh the costs incurred by Santos. Control drives compliance with EPBC Regulations (Part 8).
CM-11	Vessel planned maintenance system to vessel engines and machinery	Ensures equipment which generates noise is operating optimally and sound sources levels are appropriately verified and within desired operating range.	Costs are standard for routine PMS	**Adopt** – benefits in reducing noise impacts.
CM-07	Watchkeeping maintained on bridge	Monitoring of surrounding marine environment to identify potential collision risks (and reducing harm) to cetaceans and other marine fauna.	No additional cost – industry practice.	**Adopt** – industry practice, benefits outweigh cost. Control drives compliance with the EPBC Regulations.
Additional controls				
N/A	Dedicated Marine Mammal Observer (MMO) (as per EPBC Policy Statement 2.1 – Part B.1)	Improved ability to spot and identify marine fauna at risk of impact from vessel noise.	Additional cost of contracting specialist MMO per survey.	**Reject** – Potential impacts are low and of short duration for the surveys and therefore the potential for interaction is considered low. Cost of MMOs is disproportionate to environmental benefit.
N/A	Operational activities to avoid coinciding with sensitive marine fauna	Reduce risk of impacts from noise emissions during environmentally sensitive periods for listed marine fauna	The risk to all listed marine fauna cannot be reduced due to variability in timing of environmentally sensitive periods and unpredictable presence of some species.	**Reject** – Given the minimal risk of impacts to threatened species occurring, the financial and environmental costs of amending the activity schedule to suit multiple sensitivity windows is deemed grossly disproportionate to low environmental benefits.
N/A	Use of Passive Acoustic Monitoring (PAM)	Improve detection of some sensitive receptors	Costs of PAM operators, operational costs of increased shutdowns and	**Reject** – Cost disproportionate to increase in environmental benefit given the

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
			potentially prolonging the activity therefore increased impacts to the environment for example from anthropogenic light and routine vessel discharges.	low-level behavioural response expected. As PAM can only detect vocalising cetaceans, the limited ability of PAM to detect cetaceans would provide little benefit.

6.3.4 Environmental impact assessment

The impacts and consequence ranking for acoustic disturbance to marine fauna are outlined in **Table 6-16**.

Table 6-16: Impacts and Consequence Ranking – Acoustic disturbance to marine fauna

Receptor	Consequence level
Threatened, migratory, or local fauna	Noise emitted by vessels and the survey activity will be short in duration for each survey and is likely to be reduced to background levels within a few kilometres. As such, any potential related marine fauna behavioural impacts are expected to be temporary and short ranged and are not expected to lead to long-term changes in individual behaviour (for example, migration) or lead to changes at the population level.
Physical environment or habitat	Not applicable – noise will not impact the physical environment itself, only the species mentioned above utilising it.
Threatened ecological communities	Not applicable – no threatened ecological communities identified in the area over which noise emissions are expected.
Protected areas	Not applicable – no protected areas identified in the area over which noise emissions are expected.
Socio-economic	Noise levels are not expected to impact on socio-economic receptors due to their low activity level within the vicinity of WA-20-L. Impacts to fish may result in indirect impacts to fisheries in the area; however, considering the noise emissions are localised, the available catch area for commercial fishermen and the area over which commercial species spawn, impacts to fisheries are considered acceptable.
Overall worst-case consequence	I - Negligible

6.3.5 Demonstration of ALARP

The use of the vessels and survey equipment is unavoidable if the planned activity is to proceed. Equipment maintenance will keep the noise levels to within normal operating limits, which will also aid in reducing the likelihood of impacts to sensitive receptors.

Note that marine fauna affected in varying degrees by acoustic noise (in other words, marine mammals, turtles, sharks and fish) are all expected to avoid the source of noise. This avoidance is likely to be from a small area (due to the small spatial extent of required activities) and to be temporary; in other words, activities are planned for approximately two to seven days at a time, up to 14 days.

The vessel is also expected to produce similar noise emissions to other marine vessels that frequent or transit through the vicinity of WA-20-L. The vessel will adhere to the EPBC Regulations (Part 8) to ensure that actions are undertaken to avoid marine mammals, turtles and whale sharks within 500 m of a vessel, and all crews will be inducted into these requirements.

Any behavioural impact caused by vessel and survey activity noise is likely to be localised and temporary, with marine species expected to resume normal behavioural patterns in the open oceanic waters surrounding WA-20-L in a short timeframe with no significant impact on their normal behaviour, including during sensitive periods such as migration, nesting or foraging.

Santos have considered the actions prescribed in various recovery plans and conservation advices such as Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017), and the Blue Whale Conservation Management Plan 2015–2025 (DoE, 2015) when developing the controls relevant to potential surveys to minimise noise impacts on marine cetaceans, sharks, fish and marine turtles. Management controls are in place to reduce operating noise including vessel operational protocols, and to adhere to the fauna interaction management stated in Part 8 of the EPBC Regulations 2000. As such, noise emitted during the activities is not expected to significantly impact on marine fauna within the receiving environment.

Avoiding periods of higher sensitivity such as migration or nesting periods for whales and turtles (for example) is not considered feasible. Given the low potential impacts to individual fauna, there is not expected to be an impact at population level or significant impacts on migratory or nesting behaviours.

Additional controls were identified and considered but rejected, as detailed in **Table 6-15**. Therefore, the risks to marine fauna from noise associated with the project activities are considered to be ALARP.

6.3.6 Acceptability demonstration

Is the consequence ranked as I or II?	Yes – maximum consequence from underwater noise emissions is I - Negligible
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – IUCN principles and strategic objectives of protected species conservation management plans are met. Controls implemented will minimise the potential impacts from the activity to species identified in Recovery Plans as having the potential to be impacted by noise emissions. Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: Recovery Plan for Marine Turtles in Australia (2017) Conservation Advice Rhincodon typus whale shark (2015) Conservation Management Plan for the Blue Whale, 2015–2025 (DoE, 2015) Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

No significant impacts are expected from noise for sensitive receptors in WA-20-L given the localised and temporary and intermittent nature of the underwater emissions associated with planned activities and the proposed controls.

Minimal behavioural changes are expected from all marine fauna in WA-20-L, and therefore the I - Negligible impacts expected from these noise sources are considered environmentally acceptable. No long term harm is expected to result to EPBC listed marine fauna during vessel activities. Through adherence to Santos' Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003), which drives compliance with EPBC Policy Statement Part 8, and consideration of EPBC Policy Statement 2.1, the activity is considered acceptable to undertake in the area.

6.4 Vessel light emissions

6.4.1 Description of event

Event	Potential impacts from light emissions may occur in WA-20-L from: + safety and navigational lighting on the support vessels; and + spot lighting that may also be used as needed, such as equipment deployment and retrieval. Lighting will typically consist of bright white (in other words, metal halide, halogen, fluorescent) lights typical of lighting used in the offshore petroleum industry and not dissimilar to lighting used for other offshore activities in the region, including shipping and fishing.
Extent	**Localised**: Limited light 'spill' or 'glow' on surface waters surrounding the vessels. Impacts expected to remain within WA-20-L.
Duration	**Intermittent**: Vessel in WA-20-L for approximately seven days for each survey. Navigational and task lighting is required 24 hours a day for the duration of the activity.

6.4.2 Nature and scale of environmental impacts

6.4.2.1 Threatened, migratory, or local fauna

Continuous light emanating from the same location for an extended period of time may result in alterations to fauna behaviour. The combination of colour, intensity, closeness, direction and persistence of a light source are key factors in determining the magnitude of environmental impact (EPA, 2010). Disturbance may include:

+ seabirds may either be attracted by the light source itself or indirectly due to marine fauna prey (such as fish and invertebrates) attracted to light;
+ marine turtles may be misoriented and disoriented by lights; and
+ fish and zooplankton may be directly or indirectly attracted to lights.

According to the National Light Pollution Guidelines for Wildlife (DCCEEW 2023), a 20 km threshold provides a precautionary buffer between artificial lighting and important habitat, based on observed effects of sky glow on marine turtle hatchlings, demonstrated to occur at 15 to 18 km from the light source and fledgling seabirds grounded in response to artificial light 15 km away. The intensity and extent of light glow, and the potential to result in biological impact, will depend on the light source itself, including the number, intensity, spectral output and position of individual lights at the source. The effect of light glow may occur at distances greater than 20 km for some species and under certain environmental conditions. The 20 km threshold provides a nominal distance at which artificial light impacts should be considered, not necessarily the distance at which mitigation will be necessary (DCCEEW 2023).).

Fish and plankton

The response of fish to light emissions varies according to species and habitat. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al., 2001), with traps drawing catches from up to 90 m away (Milicich et al., 1992). Lindquist et al. (2005) concluded from a study that artificial lighting associated with offshore oil and gas activities resulted in an increased abundance of clupeids (herring and sardines) and engraulids (anchovies). These species are known to be highly photopositive: the artificial light serves to focus their marine plankton prey and consequently leads to enhanced foraging success.

Marine mammals

There is no evidence to suggest artificial light sources adversely affect the migratory, feeding or breeding behaviours of marine mammals. Cetaceans predominantly use acoustic senses to monitor their environment rather than visual sources (Simmonds et al., 2004). Therefore, light from the vessel night-time activity is not expected to have an impact on marine mammal behaviour.

Marine reptiles

WA-20-L intersects the internesting BIA for the flatback turtle (**Figure 3-1**) and therefore individuals may occur within WA-20-L.

Marine turtles are particularly sensitive to artificial lighting, which is known to disrupt breeding adult turtles, post-emergent hatchlings and hatchlings dispersing in nearshore waters (Limpus, 1971; Salmon & Wyneken, 1992; Limpus, 2007, 2008a, 2008b, 2009a, 2009b; Wilson et al. 2018). However, marine turtles do not feed during the breeding season (Limpus et al., 2013), and light is not a cue to internesting behaviours. Therefore, potential impacts of artificial light to internesting turtles are not considered likely, and not discussed further.

Sharks, fish and rays

The response of fish to light emissions varies according to species and habitat. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al., 2001), with traps drawing catches from up to 90 m (Milicich et al., 1992). Lindquist et al. (2005) concluded from a study that artificial lighting associated with offshore oil and gas activities resulted in an increased abundance of clupeids (herring and sardines) and engraulids (anchovies); these species are known to be highly photopositive. Lighting impacts may increase the risk of predation to these fish species. Shaw et al. (2002), in a similar light trap study, noted that juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, may have been preying upon concentrations of zooplankton attracted to the light field of the platforms. This could potentially lead to increased predation rates compared to unlit areas.

However, the low level of light emitted from a vessel is unlikely to lead to large scale changes in species abundance or distribution. Impacts to transient fish will therefore be limited to short-term behavioural effects with no decrease in local population size or area of occupancy of species, nor loss or disruption of critical habitat or disruption to the breeding cycle.

A localised increase in fish activity as a result of vessel lighting is expected to occur as a result of the activity.

Birds (seabirds/shorebirds)

Lighting from the vessel may result in behavioural impacts to seabirds including terns and shearwaters. However, as they will be for a short duration, the consequence is considered I - Negligible.

Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquenie et al., 2008) and that lighting can attract birds from large catchment areas (Wiese et al., 2001). Birds may either be attracted by the light source itself or indirectly as structures in deep water environments tend to attract marine life at all trophic levels, creating food sources and shelter for seabirds (Surman, 2002). The light from a vessel may also provide enhanced capability for seabirds to forage at night.

A study into light impacts upon nocturnally migrating birds on the North Sea found that birds were disoriented and attracted by red and white light (containing visible long-wavelength radiation), whereas they were clearly less disoriented by blue and green light (containing less or no visible long wavelength radiation) (Poot et al., 2008). In addition, disoriented adult birds may not be able to return to their burrows to relieve their mates or feed their young. Fledglings are particularly vulnerable to light through misorientation and disorientation when departing the colony for the first time.

WA-20-L overlaps the reproduction BIA for the wedge-tailed shearwater. The location of WA-20-Ls should not significantly impact breeding behaviour, given the large distances typically covered by breeding individuals.

6.4.3 Environmental performance outcomes and control measures

The EPO relating to this risk is:

- **EPO-04**: Reduce impacts to marine fauna from lighting on vessels through limiting lighting to that required by safety and navigational lighting requirements.

The CMs for this activity are shown in **Table 6-17** with EPS and measurement criteria for the EPOs described in **Section 8.4**.

Table 6-17: Control measures evaluation for vessel light emissions

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-06	Lighting will be used as required for safe work conditions and navigational purposes.	Light spill from unnecessary lighting reduced, even further lowering likelihood of impacts to the fauna from vessel lighting.	Additional costs associated with implementing control.	**Accepted** – Cost is considered acceptable for the benefit that may be realised from this control.

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
		Lighting is assessed to only provide necessary lighting for safety and navigation during the activity including orientation of lighting to reduce light spill on the water wherever feasible without compromising navigation and safety requirements. Reducing the potential for additional light pollution to the environment, thus reducing the potential impacts to fauna.		
Additional controls				
N/A	Limit or exclude night-time operations.	Would eliminate potential impacts of artificial light during hours of darkness when light sources are more apparent and potential impacts are greatest.	Would double duration of activity; increase impacts or potential impacts in other areas, including increase in waste, air emissions, risk of vessel collision etc. A minimal level of artificial lighting will still be required on-board the vessel(s) on a 24-hour basis for safety reasons.	**Rejected** – Given the minimal risk of impacts to turtles occurring, the financial and environmental costs by requiring all works to be undertaken during daylight hours only are not considered appropriate given the extended duration of the activity that would occur.
N/A	Review lighting on vessels to replace with a type (colour) that has less potential to impact	Reduce potential for impacts on certain sensitive receptors from light emissions.	High cost to complete lighting change out vessels. Navigational lighting colours are stipulated by law. Other non-navigational lighting on the vessels could be considered for change-out, but a pre-mobilisation review of lighting will ensure that only essential lighting is used as required.	**Rejected** – Cost considered disproportionate compared to the incremental environmental benefit and is a legislative requirement.
N/A	Manage the timing of the activity to avoid sensitive periods at the location (e.g. shearwater breeding).	Impacts are predicted to be I - Negligible therefore a planning the activity would have little or no benefit in terms of outcomes i.e. reducing impacts further.	The risk to all listed marine fauna would not be reduced due to variability in timing of environmentally sensitive periods and unpredictable presence of some species.	**Rejected** – Given the minimal risk of impacts to threatened species (e.g. whales, whale sharks and turtles) occurring, the financial and environmental costs of amending the activity

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
				schedule to suit multiple sensitivity windows is deemed grossly disproportionate to low environmental benefits.
N/A	Use of dark, matt surfaces to reduce sky glow across all activities	Reduce potential for impacts on turtles from light emissions during hours of darkness when light sources are more apparent and potential impacts are greatest.	Additional cost to repaint vessel surfaces	**Rejected** – Given the short duration of the activity and controls in place to limit lighting, the cost is considered disproportionate to the benefit received.

6.4.4 Environmental impact assessment

The impacts and consequence ranking for vessel light emissions are outlined in **Table 6-18**.

Table 6-18: Impacts and Consequence Ranking –vessel light emissions

Receptor	Consequence level
Threatened, migratory, or local fauna	Due to management controls in place, the artificial lighting associated with the vessel surveys is considered to have a negligible impact on fauna, including the breeding success of seabird populations.
Physical environment or habitat	Not applicable – no impacts to physical environments and/or habitats from light emissions are expected.
Threatened ecological communities	Not applicable – no threatened ecological communities identified in the area over which light emissions are expected.
Protected areas	Not applicable – no protected areas identified in the area over which light emissions are expected.
Socio-economic receptors	Not applicable – lighting is not expected to cause an impact to socio economic receptors other than as a visual cue for avoidance of the area.
Overall worst-case consequence level	I - Negligible

6.4.5 Demonstration of ALARP

With the described controls, the consequence of artificial light on marine fauna and seabirds is considered to be I - Negligible with insignificant impacts to ecological function. No population level impacts are expected, and the consequence is considered environmentally acceptable. WA-20-L overlaps the flatback turtle internesting BIA, however this is a very small area in which flatback turtles may be affected from October to March (during nesting). This is not expected to impact the population or impact individuals over an extended period.

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) specifies the following priority actions for the Pilbara genetic stock of flatback turtles in relation to light pollution: Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats. Although WA-20-L overlaps the flatback internesting BIA, lighting from the transient planned activity is not expected to impact aggregating adults or internesting and nesting behaviour and therefore displacement will not occur and the adjacent habitat critical to survival of the species will only be affected for a short-term duration and not at levels that could result in impacts at a population level. Avoiding periods of higher sensitivity nesting periods for turtles is not considered required given the low potential impacts to individual fauna.

The increased risks/impacts with potentially larger scale consequences associated with reduced light levels are considered to present a cost that is grossly disproportionate to any environmental benefit. Given that lighting on the vessels will be consistent with industry standards and will result in I - Negligible/ II - Minor consequences, and that no reasonably practicable additional controls or alternatives were identified, it is considered that the environmental impacts of using 24-hour artificial lighting at an intensity to allow work to proceed safely are ALARP. The assessed residual consequence for this impact is I - Negligible and cannot be reduced further. Additional CMs were considered but rejected since the associated cost or effort was grossly disproportionate to any benefit, as detailed in **Table 6-17**. It is considered therefore that the impact of the activities conducted are acceptable and ALARP.

6.4.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum consequence from light emissions is I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with International Convention of the *Safety of Life at Sea (SOLAS) 1974 and the Navigation Act 2012*. Consistent with relevant species recovery plans, conservation management plans and management actions including but not limited to: National Light Pollution Guidelines for Wildlife (DCCEEW 2023 Recovery Plan for Marine Turtles in Australia (2017).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no stakeholder concerns have been raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Lighting of the vessels is industry standard and required to meet relevant maritime and safety regulations. The potential consequences of the anthropogenic light sources in WA-20-L are considered to be insignificant in nature and restricted to short-term behavioural impacts on individual fauna that may be present in WA-20-L during the activity.

The potential consequence of light emissions on receptors is assessed as I - Negligible. Therefore, the impacts of light emissions to the receiving environment are ALARP and considered environmentally acceptable.

6.5 Vessel atmospheric emissions

6.5.1 Description of event

Event	Potential atmospheric emissions from support vessels include greenhouse gases (GHG), such as carbon dioxide (CO_2) and nitrous oxide (N_2O), non-GHGs such as sulphur oxides (SO_X), oxides of nitrogen (NO_X) and ozone depleting substances (ODS) resulting from: use of fuel to power vessel engines, generators and equipment; incineration generating point source emissions including CO_2, carbon monoxide (CO), NO_X, sulphur dioxide (SO_2) and particulates; and ODS should leaks occur from refrigeration and chiller systems on vessels.

Extent	**Localised**: The quantities of gaseous emissions are relatively small and will, under normal circumstances, quickly dissipate into the surrounding atmosphere.
Duration	**Intermittent**: Approximately seven days for each survey.

6.5.2 Nature and scale of environmental impacts

6.5.2.1 Threatened, migratory, or local fauna

Emissions are relatively small and will, under normal circumstances, quickly dissipate into the surrounding atmosphere. Short-term behavioural impacts to seabirds could be expected if they overfly the location; they may avoid the area. No decrease in local population size or area of occupancy of species, loss or disruption of critical habitat, disruption to the breeding cycle or introduction of disease is expected.

6.5.2.2 Physical environment or habitat

Hydrocarbon combustion may result in a temporary, localised reduction of air quality in the environment immediately surrounding the discharge point during the activity, which could affect seabirds and humans in the immediate vicinity. The combustion emission of GHGs can lead to a reduction in local air quality and add to the national GHG loading, which could in turn contribute to climate change. Non-GHGs may be toxic, odoriferous or aesthetically unpleasing.

Ozone-depleting substances are used in closed refrigeration systems on board vessels. Ozone-depleting substances have the potential to contribute to ozone-layer depletion if accidentally released to the atmosphere. Ozone-depleting substances are not used, generated or discharged by vessel activity other than what is incidentally located and used in closed systems on board vessels. ODS will not be deliberately released during the course the activity. ODS air emissions would only occur in the event of damaged or faulty refrigeration equipment.

Based on the information available, the atmospheric emissions that are a key focus in terms of potential environmental impacts are GHG (principally CO2) and oxides of nitrogen.

As the activity occurs in offshore waters, the combustion of fuels in such remote locations will not impact on air quality in coastal towns or large human settlements. The emissions will, under normal circumstances, quickly dissipate into the surrounding atmosphere. The highly dispersive nature of local winds (in other words, strong and consistent) is expected to reduce potentially harmful or ‘noticeable’ gaseous concentrations within a short distance from the vessel and therefore will not impact on other marine users in the vicinity. Atmospheric emissions will add to the global inventory of GHGs; however, they and non-GHGs are not expected to have any local environmental consequences.

6.5.3 Environmental performance outcomes and control measures

The EPOs relating to this risk are:

+ **EPO-05**: Reduce impacts to air and water quality from planned discharges and emissions from the activities.
+ **EPO-06**: No unplanned objects, emissions or discharges to sea or air.

The CMs for this activity are shown in **Table 6-19** with EPS and measurement criteria for the EPOs described in **Section 8**.

Table 6-19: Control measures evaluation for atmospheric emissions

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-11	Vessel planned maintenance system to vessel engines and machinery	Reduces emissions from vessels because equipment operating within its parameters.	Operational costs and labour/access requirements of undertaking vessels maintenance.	**Adopt** – benefits of operating equipment within operational parameters will help maintain vessel fuel efficiency.

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
CM-12	Fuel oil quality in accordance with MARPOL	Reduces emissions through use of low sulphur fuel in accordance with Marine Order 97.	Operational costs of refuelling.	**Adopt** – environmental benefit outweighs the costs.
CM-13	International Air Pollution Prevention (IAPP) Certificate	Reduces probability of potential impacts to air quality due to ODS emissions, high NOx, SOx and incineration emissions.	Vessel has current IAPP Certificate as per vessel class, during vessel contracting procedure and in pre-mobilisation audits/inspections.	**Adopt** – under Marine Orders, the vessel must be compliant to operate in Australian waters.
CM-14	Ozone-depleting substance (ODS) handling procedures	Reduces probability of potential impacts to air quality due to ozone-depleting substance emissions.	Personnel cost of maintaining ozone-depleting substance record book or recording system.	**Adopt** – Benefit of ensuring no ozone- depleting substance release outweighs the minimal costs.
CM-15	Waste incineration	Reduce potential impacts to air quality due to waste incineration.	Increase in health risk from storage of wastes. Increase in risk due to transfers (increased fuel usage, potential increase in collision risk, disposal on land).	**Adopt** – environmental benefit outweighs the costs associated with transporting waste to shore for landfill.
Additional Controls				
N/A	No incineration during vessel-based operations activities	Removes all emissions associated with incineration activities during the Project	Increase in health risk from storage of wastes. Limited space available to store additional waste, additional trips to shore would be required to transport waste. Increase in risk due to transfers (increased fuel usage, potential increase in collision risk, disposal on land).	**Reject** – Health and safety risks outweigh the benefit given the offshore location. Cost associated with transporting waste to shore for landfill or incineration outweighs onboard incineration. Incineration on the vessels is a permitted maritime operation.
N/A	Removal of all ozone-depleting substance–containing equipment.	Eliminates potential of ozone-depleting substance emissions occurring, impacting on air quality.	Lack of refrigeration systems on board the vessels would lead to unacceptable workplace conditions (i.e., air conditioning) and poor food hygiene standards, limiting the vessel's ability to undertake the activity; therefore, there is no practical solution to	**Reject** – Based on cost to replace all equipment and there is only a low potential for ozone-depleting substance releases.

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
			the use of refrigeration. It is noted that ozone-depleting substances are rarely found on vessels.	
N/A	Alternative fuel type (non-hydrocarbon based) selected for the vessel	Could reduce level of pollutants released to the environment during fuel combustion.	Practical and reliable alternative fuel types and power sources for the vessel have not been identified. If an alternative was available, vessels have fuel specification for equipment. Change of fuel may require further modifications to equipment.	**Reject** – not feasible.
N/A	Use incinerators and engines with higher environmental efficiency	Improves air quality by more efficient burning or fuel combustion.	Significant cost in changing unknown vessel equipment.	**Reject** – cost grossly disproportionate to low environmental benefit (impact rated I - Negligible).

6.5.4 Environmental impact assessment

The impacts and consequence ranking for vessel light emissions are outlined in **Table 6-20**.

Table 6-20: Impacts and Consequence Ranking – atmospheric emissions

Receptor	Consequence level
Threatened, migratory, or local fauna	Any potential impacts are not expected to result in a decrease in local population size or disruption to the breeding cycle, I - Negligible.
Physical environment or habitat	The activity may result in the deterioration of local and regional air quality. Gaseous and particulate emissions will, under normal circumstances, quickly dissipate into the surrounding atmosphere.
Threatened ecological communities	Not applicable – no threatened ecological communities identified in the area over which air emissions are expected.
Protected areas	Not applicable – protected areas identified in the area over which air emissions are expected.
Socio-economic receptors	Not applicable – atmospheric emissions are not expected to cause an impact to socio economic receptors.
Overall worst-case consequence level	I - Negligible

6.5.5 Demonstration of ALARP

Power generation through combustion of fossil fuels is essential to undertaking the vessel surveys either by vessel or power generation. Given the routine maintenance of these systems by suitably qualified personnel, all practicable management measures are considered to have been implemented, and the likelihood of significant impacts occurring have been reduced to ALARP.

Implementation of a zero-incineration policy on the vessels would result in significant costs associated with the transport of waste to shore for disposal. Further transportation of the waste to shore would increase the environmental impacts and risks associated with the surveys through increased vessel movements and generate greater volumes of emissions associated with the vessel movements. Since incineration is a permitted maritime operation in accordance with Marine Order 97 (reflecting MARPOL Annex VI requirements) it is considered ALARP.

Lack of refrigeration systems (in other words, air conditioning) would lead to unacceptable workplace conditions and poor food hygiene standards, limiting the ability to undertake the activities. Therefore, there is no practical alternative to using refrigeration.

The MARPOL standards and AMSA Marine Orders are considered to be the most appropriate standards for vessels to adhere to in this environment, given the nature and scale of the activities, and they are widely used by the industry. These include regulations controlling the level of NOx and SOx from vessel engines. Compliance with these requirements together with implementation of the controls listed above reduces the environmental impacts associated with air emissions to ALARP.

The assessed residual consequence for this impact is I - Negligible and cannot be reduced further. Additional CMs were considered but rejected since the associated cost/effort was grossly disproportionate to any benefit. It is considered therefore that the impact of the activities conducted is ALARP.

6.5.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum consequence from atmospheric emissions is I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with Convention of the SOLAS 1974, *Navigation Act 2012*. No plans identified atmospheric emissions like those described above as being a threat to marine fauna or habitats. The activity is compliant with requirements of the North-west Marine Parks Network Management Plan (2018).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no stakeholder concerns have been raised regarding this aspect.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Atmospheric emissions from vessels are permissible under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, which is enacted in Australian waters by Marine Order 97 (Marine pollution prevention – air pollution) (which also reflects MARPOL Annex VI requirements). This is an internationally accepted standard that is utilised industry wide, and compliance with MARPOL standards is considered to be an appropriate management measure in this case.

The overall impacts to the atmosphere and sensitive receptors are expected to be I - Negligible if the emission management is adhered to and impacts from emissions that are generated by the activity are considered environmentally acceptable.

6.6 Seabed and benthic habitat disturbance

6.6.1 Description of event

Event	Disturbance to the seabed and benthic habitats could potentially occur as a result of the following activities undertaken at survey locations within WA-20-L: + Collection of grab sediment samples which is expected to disturb an area approximately 1.5 m deep and 1 m^2 area per sample; + ROV surveys: Turbidity and increased sedimentation due to the use of ROVs (thrusters); or + Other surveys: Deployment of monitoring equipment (for example, plankton nets, towed equipment, landers) will result in some additional water turbidity. + The Legendre-1 wellhead remaining in situ permanently.
Extent	**Localised**: within WA-20-L.
Duration	**Intermittent**: Approximately seven days for each survey.

6.6.2 Nature and scale of environmental impacts

6.6.2.1 Threatened, migratory or local fauna

Habitat modification is identified as a potential threat to a number of marine fauna species in relevant Recovery Plans and Conservation Advice. Disturbance of the seabed is not anticipated to significantly affect mobile marine fauna, such as marine mammals, marine reptiles, fish, sharks and rays. The area of seabed to be disturbed within WA-20-L also represents a negligible portion of the habitat available for these species. No decrease in local population size, area of occupancy of species, loss or disruption of critical habitat or disruption to the breeding cycle of any of these protected matters is expected.

An internesting BIA for flatback turtles overlaps WA-20-L. However, internesting activities typically occur within shallower waters. The habitat present within WA-20-L is representative of habitats within the broader BIA and the region. Permanent displacement of habitat from seabed disturbance is not expected due to the small scale of the activity.

Fish, sharks and rays

Fish, sharks and rays may forage in the soft sediments for marine invertebrates. However, given the small scale of the activity (up to 1 m^3 for each activity) and the regional availability of habitat, seabed and benthic habitat disturbance is not expected to affect these species.

6.6.2.2 Physical environmental or habitat

The use of equipment for the survey will directly contact the seafloor and will inevitably result in very localised impact (direct and indirect) to water quality, seabed features and the benthic environment in WA-20-L at highly localised locations. The highest significance survey activity resulting in seabed disturbance is grab sampling activities. Environmental impacts would be directly associated with direct loss of benthic habitat in the sampling footprint, and secondary impacts due to localised turbidity. Given the diameter of a grab sample is expected to be up to 1 m in diameter, the impacts to seabed are expected to be highly localised and of short duration. The benthic biota around WA-20-L is very similar to that of the wider region, with a low species abundance and high species richness.

The scale of potential habitat loss and seabed disturbance from localised vessel survey activities is small in comparison to the vast size of soft substrata habitats spanning the NWS and limestone pavement habitats in the region of the activity. The relatively small disturbance area (up to 1 m^3 size for each activity) from these planned activities will therefore not have a significant impact on benthic biota or habitat.

Indirect impacts associated with a temporary (several hours) and localised (within tens of metres) decline in water quality due to increased suspended sediments or sedimentation of the seabed are not expected to affect any values and sensitivities of regional importance. It is not considered that localised impacts within WA-20-L will result in indirect impacts (in other words, turbidity) to nearby marine reserves, offshore reefs or islands given their distance from the activity.

WA-20-L overlaps the Glomar Shoals KEF. The conservation values of the KEF (**Appendix E**) are not considered to be impacted from seabed and benthic habitat disturbance and therefore are not discussed further.

The presence of the wellhead could interact with hydrodynamic conditions and result in localised seabed disturbance by scouring. The anti-scour mats have been designed to entrap sediments in order to minimise scour. The wellhead remaining in will have negligible scouring effects and not impact benthic habitats.

6.6.3 Environmental performance outcomes and control measures

EPOs relating to this risk include:

+ **EPO-06**: No unplanned objects, emissions or discharges to sea or air.
+ **EPO-07**: Seabed disturbance is limited to the extent required for sampling.

The CMs considered for this activity are shown in **Table 6-21**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-21: Control measure evaluation for seabed and benthic habitat disturbance

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				
CM-16	Dropped object recovery	Requires dropped objects to be recovered (where safe and practicable to do so unless the environmental consequences are I – Negligible).	Additional personnel and vessel costs to plan and undertake if safe and practicable to do so.	**Adopt** – Benefits of recovering dropped objects (e.g. ROV) where safe and practicable unless the environmental consequences are I - Negligible to do so outweigh the costs.
CM-17	Dropped object prevention procedure	Implementation of a dropped object prevention procedure for equipment deployment helps to minimise impacts and extent of seabed disturbance through standards for lifting equipment inspection and maintenance and procedures for lifting.	No additional costs to Santos other than negligible personnel costs of reviewing information.	**Adopt** – helps to minimise impacts and extent of seabed disturbance.
Additional controls				
N/A	Take fewer samples	Impacts to the seabed are reduced.	Substantial cost to the quality of survey data obtained.	**Reject** – cost outweighs the benefit.
N/A	Samples are not taken from the Glomar Shoals KEF	Ensures no impacts to the KEF.	The Glomar Shoals KEF overlaps the entire permit area; therefore no samples could be taken. There is no alternative.	**Reject** – Survey objectives are not met if sediment samples are not taken.

6.6.4 Environmental impact assessment

The impacts and consequence ranking for seabed and benthic habitat disturbance are outlined in **Table 6-22**.

Table 6-22: Impacts and Consequence ranking – seabed and benthic habitat disturbance

Key receptors	Consequence level
Threatened, migratory, or local fauna	Given the fact that the activity is proposed in small areas, the activity is short term and the nature of the existing environment is such that there is no benthic habitat providing significant environmental value to threatened or migratory species, the consequence level is considered to be I - Negligible.
Physical environment or habitat	Given the nature of the habitats within WA-20-L that are representative of those within the region, and the localised nature of disturbance, impacts to the physical environment/habitat are assessed as I - Negligible.
Threatened ecological communities	Not applicable – no threatened ecological communities are identified in the area where seabed disturbance could occur.
Protected areas	Not applicable – no protected areas are identified in the area where seabed disturbance could occur.
Socio-economic	Not applicable – disturbance of the seabed and benthic habitat within WA-20-L will not impact socio-economic receptors.
Worst case consequence level	I - Negligible

6.6.5 Demonstration of ALARP

There are no additional practicable alternatives in order to proceed in a successful and safe manner to reduce seabed disturbance associated with the survey activities.

The activities within WA-20-L occur in benthic habitats (in other words, primarily soft sediments with little epifauna) that are widely represented at a regional scale on the NWS. Impacts will be localised within the immediate vicinity of the sediment samples. The survey activities may cause a temporary increase in water column turbidity, but this will be limited to the top layer of sediment.

Given the localised nature of activities which may cause seabed and benthic habitat disturbance, and expected rapid recovery time, environmental impacts are expected to be I - Negligible.

The proposed management controls for seabed disturbance are considered appropriate to manage the risk to ALARP.

6.6.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum consequence to seabed and benthic habitats is I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – no plans identified seabed disturbance like those described above as being a threat to marine fauna or habitats. Section 270(3)(e) and (f) of the OPGGS Act, impacts to benthic habitats are of an acceptable level.
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.

Are performance standards consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The potential consequence of seabed disturbance on receptors is discussed above and is assessed as I - Negligible. With the control measures in place no significant impacts are expected. As such, the risk is considered acceptable.

6.7 Operational discharges

6.7.1 Description of event

Event	Planned discharges from vessels to the marine environment include: + deck drainage/run off; + sewage and grey water; + food wastes; + cooling water; + bilge water; or + brine (if a reverse osmosis unit is used for water treatment). Deck drainage/run off Deck drainage from rainfall or wash-down operations would discharge to the marine environment. The deck drainage would contain particulate matter and residual chemicals such as cleaning chemicals, oil and grease. Sewage and greywater The volume of sewage and food waste is directly proportional to the number of persons on-board the vessels. Depending on waste production rates and the specifications of sewage systems available, the total volume of this waste stream generated typically ranges between 0.04 and 0.45 m^3 per day per person. Treated sewage/greywater will be disposed in accordance with Marine Order 96. Food waste Putrescible waste is estimated to consist of approximately 1 L of food waste per person per day. The vessel will dispose food waste in accordance with AMSA and Marine Order 95, and MARPOL Annex V. Cooling water Seawater is used as a heat exchange medium for the cooling of machinery engines. Cooling water temperatures vary, dependent upon the vessel's engines' workload and activity. Bilge water While in WA-20-L, the vessel may discharge oily water after treatment at a concentration of up to 15 ppm through an approved oily water filter system required by Marine Order 91. Brine If a reverse osmosis unit is used for water treatment, waste brine generated will be discharged to the ocean at a salinity of approximately 10% higher than seawater. The volume of the discharge is dependent on the requirement for fresh (or potable) water and demand based on the number of people on-board.
Extent	Localised: The small volumes of non-hazardous discharges may cause localised nutrient enrichment, organic and particulate loading, toxic impacts to marine fauna, thermal impacts and increased salinity in waters around discharge points and in the direction of the prevailing current. The environment that may be affected by operational discharges will likely be contained within WA-20-L and are predicted to be restricted to within approximately 100 m of the discharge point in the upper 5 m of the water column.
Duration	Intermittent: Approximately seven days for each survey, and potentially one survey over the duration of this EP. Localised impacts to water quality will occur, however, water quality conditions will return to normal within minutes to hours of cessation of discharges.

6.7.2 Nature and scale of environmental impacts

6.7.2.1 Threatened, migratory, or local fauna

As discussed in the sections above, the discharge extent for planned discharges is localised, and rapid dilution is predicted to occur within the open ocean environment. Marine fauna within WA-20-L are likely to be transient. If contact does occur with any marine fauna, it will be for a short duration due to the rapid dispersion of the plume and the transient nature of fauna movement, such that exposure time may not be of sufficient duration to cause a toxic effect.

Discharges may cause changes to behaviour in marine fauna (in other words, avoidance or attraction). Fishes and oceanic seabirds may be attracted to the discharge of food scraps. However, such discharges would be isolated occurrences and not in any one location, so no prolonged influence on faunal behaviour is expected. Discharges of cooling water and brine may cause avoidance behaviour in marine fauna. Given the nature of the discharges (localised, rapid dilution, intermittent), any behavioural impacts are expected to be short term and minimal.

6.7.2.2 Physical environment or habitat

Planned non-hazardous discharges will be small in volume and continuous, with volumes dependent on a range of variables. The discharge of non-hazardous wastes to the marine environment will result in a localised reduction in water quality. This would be expected to be temporary (minutes to hours in any one location), localised and limited to surface waters (less than 5 m depth). The discharges are expected to be dispersed and diluted rapidly, with concentrations of wastes significantly dropping with distance from the discharge point. Changes to ambient water quality outside of WA-20-L are considered unlikely to occur.

Specifics of potential impacts to water quality from vessel discharges are described in the following sections.

Eutrophication impacts from sewage, greywater and putrescible food wastes

Sewage liquids and grey water discharges to the ocean from the vessel can cause water discolouration, localised nutrient enrichment, increase in water column productivity of phytoplankton and bacteria, or oxygen depletion from increased biological oxygen demand around the discharge. Liquid sewage generally contains more than 99% fresh water with trace contaminants and nutrients such as organic carbon, nitrogen and phosphorus, which could cause toxicity impacts to the marine environment, as well as suspended solids and bacterial organisms which could transmit disease to marine fauna and humans.

Dispersion and dilution of discharges is expected to be rapid in the open ocean environment as the discharges are of low volume and short duration, from a vessel that will be moving for the majority of the activity. The discharges will be subject to biodegradation of organics through bacterial action, oxidation and evaporation.

Salinity increases

A support vessel may have a desalination unit. The desalination of seawater results in a discharge of brine with a slightly elevated salinity (around 10% higher than seawater). On discharge to the sea, the desalination brine, being of greater density than seawater, will sink and disperse in the currents. On average, seawater has a salt concentration of 35,000 ppm. The volume of the discharge is dependent on the requirement for fresh (or potable) water and the number of people on board.

Changes to seawater salinity can play a significant role in the growth and size of aquatic life and the marine species disturbance, either in a beneficial way (for example, shellfish) or in an adverse way.

According to some studies about the effects of changes in the salinity of sea water on marine organisms, the primary and apparent changes might occur firstly in mobile species such as plankton and fish; the reaction will be highest in those organisms with a plankton stage in their life history (Hiscock et al., 2004). However, impacts differ between different sorts of organism. In some fish, juvenile stages are more vulnerable to salinity changes than the adult generation.

Most marine species are able to tolerate short-term fluctuations in salinity in the order of 20 to 30% (Walker and McComb, 1990), and it is expected that most pelagic species would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine.

Given the relatively low volume, temporary and intermittent nature of brine discharges from the vessels, the impact on water quality in WA-20-L is expected to be low. There is no relationship between the level of salinity and biological or chemical oxygen demand of the discharged concentrate – over 80% of the minerals that encompass concentrate salinity are sodium and chloride, and they are not food sources or nutrients for aquatic organisms.

Changes in water temperature

Cooling water will be discharged at a temperature above ambient seawater temperature. Upon discharge, it will be subjected to turbulent mixing and transfer of heat to the surrounding waters.

Temperature dispersion modelling shows that the water temperature of discharged water will decrease rapidly as it mixes with the receiving waters, with discharge waters being less than 1°C above background levels within less than 100 m (horizontally) of the discharge point. Vertically, the discharge will be within background levels within 10 m (Woodside, 2008).

Several studies have been performed in order to determine how the distribution and abundance of marine flora and fauna species react to a change in temperature. Temperature can have an influence on the growth and reproduction of marine species. Mobile species such as plankton and fish are the first and most likely sort of marine life to be influenced due to changes in the seawater temperature (Hiscock et al,). Temperature increase can have a positive effect on reproduction and growth rate but also lead to a shorter lifespan depending on the species affected and the extent of temperature change.

Cooling water discharge points vary between vessels. However, they all adopt the same discharge design that permits cooling water to be discharged above the water line, in order to facilitate cooling and oxygenation of this wastewater stream before mixing with the surrounding marine environment. Given the relatively low volume of cooling water, the temperature differential and the open ocean water surrounding the vessel, the impact on water quality is expected to be low and short-term.

Contamination from releases of bilge water and deck drainage

Discharges of oily bilge water could result in a localised reduction in water quality with impacts on protected marine fauna and plankton. However, oily water discharged from vessels will be treated to a concentration (<15 ppm) in accordance with Marine Order 91: Marine Pollution Prevention - Oil requirements therefore is unlikely lead to any impacts to the receiving environment. Given the concentration and dosage of exposed receptors within surface waters (for example, plankton, fish) is expected to be very low, impacts to organisms would be on a negligible scale.

Given that oil and grease residues in oily water drainage will be in low concentrations, the potential for impact is low and would be further reduced due to the strong tidal movements experienced in the region and the naturally turbid environment. Dispersion and biodegradation of potentially contaminated oily water drainage is expected to be rapid and highly localised resulting in no long-term or adverse effects on water quality or marine ecology. An initial dilution of 100:1 is expected to occur from within metres to tens of metres from the discharge location.

Toxicity

Discharges from vessel systems may include chemicals within sewage systems, greywater, desalination and residues of those used for cleaning decks.

On discharge to the marine environment, the low volumes of these types of chemicals are expected to rapidly disperse in the offshore marine environment. Hence, any potential impacts would be confined to a localised area immediately surrounding the discharge.

There may be a localised and temporary (hours) reduction in water quality in the immediate vicinity of the release. Toxicity impacts to marine fauna from the release of chemicals are unlikely to eventuate because:

+ Strong ocean currents result in the discharge being further diluted upon release to the marine environment, so the duration of exposure of chemicals to fauna will be minimal.
+ Deck cleaning products planned to be released to sea will meet the criteria for not being harmful to the marine environment according to MARPOL Annex V.
+ Potential discharges will be intermittent and temporary within WA-20-L.

6.7.3 Environmental performance outcomes and control measures

EPOs relating to this risk include:

+ **EPO-05**: Reduce impacts to air and water quality from planned discharges and emissions from the activities.
+ **EPO-06**: No unplanned objects, emissions or discharges to sea or air.

The CMs considered for this activity are shown in **Table 6-23**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-23: Control measures evaluation for operational discharges

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				
CM-18	Sewage treatment system	Reduces potential impacts of inappropriate discharge of sewage. Provides compliance with Marine Order 96, Marine Pollution Prevention – Sewage.	Personnel cost in ensuring vessel certificates are in place during vessel contracting and in premobilisation audits and inspections and in reporting discharge levels.	**Adopt** – Benefits of ensuring vessels are compliant with marine orders, outweigh minimal costs of personnel time, and it is a legislated requirement.
CM-19	Oily water treatment system	Reduces potential impacts of planned discharge of oily water to the environment. Provides compliance with Marine Order 91, Marine Pollution Prevention – Oil.	Time and personnel costs in maintaining oil record book.	**Adopt** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-20	Waste (garbage) management procedure	Reduces probability of garbage being discharged to sea, reducing potential impacts to marine fauna. Stipulates putrescible (food) waste disposal conditions and limitations and AMSA Placards displayed on vessels to provide a visual message to personnel about what wastes can be discharged where and improves waste awareness. Provides compliance with Marine Order 95, Marine Pollution Prevention – Garbage.	Personnel cost of premobilisation audits and inspections and of reporting discharge levels.	**Adopt** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-21	Deck cleaning product selection	Improves water quality discharge (reduces toxicity) to the marine environment. Those deck cleaning products planned to be released to sea meet the criteria for not being harmful to the marine environment according to MARPOL Annex V.	Personnel costs of implementing. Potential additional cost and delays of deck cleaning product substitution.	**Adopt** – Benefits of ensuring vessels are compliant and that those deck cleaning products planned to be released to sea meet MARPOL criteria outweigh the cost.
CM-22	Chemical management procedure	Potential impacts to the environmental are reduced through following correct	Personnel costs associated with ensuring procedures are in place and	**Adopt** – Benefits of ensuring procedures are followed and measure

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
		procedures for the safe handling and storage of chemicals.	implemented during handling and storage of chemicals.	implemented outweigh the costs.
Additional controls				
N/A	Mandatory closed drain system to prevent deck drainage discharged overboard.	Eliminates risk of oily water from deck being discharged overboard without treatment. Ensures wastewater is directed to OWTS for treatment prior to discharge.	Increased cost due to treatment system required, modifications to vessels, storage space required for containment of drained liquids, increase in transfers to vessels resulting in increased potential impacts and risks. Increased transfers results in increased fuel usage, increased safety risks to personnel during transfer (e.g. crushing between skips), increase in crane movements.	**Reject** – Cost outweighs the benefit given the low impact expected from planned discharges and high potential impacts from risk transfer.
N/A	Discharge point for cooling water discharges, restricted to above sea level to allow it to cool further before mixing at sea surface.	Reduce potential impacts associated with discharge of higher temperature water into the marine environment.	High costs associated with modifications to vessels. Reduction in temperature would be minimal compared to the cost of altering the discharge height.	**Reject** – Cost outweighs the benefit given the low impact expected from planned discharges and high potential impacts from risk transfer. Discharge of cooling water permitted maritime practice.
N/A	Storage of all wastes on-board (e.g. oily water and sewage) for disposal onshore.	Would eliminate any discharge to sea, reducing potential impacts to the marine environment	Storage space required for containment of waste, resulting in requirement for transfer of wastes to support vessels resulting in increased potential impacts and risks. Increased transfers can result in increased fuel usage, increased safety risks to personnel during transfer (e.g. crushing between skips), increase in crane movements.	**Reject** – Cost outweighs the benefit given the low impact expected from planned discharges.
N/A	Storage of cooling and brine water onboard, prior to discharge onshore	Eliminates risks to receiving environment associated with deteriorating water quality as a consequence of activity	Increased fuel consumption and increased atmospheric emissions, associated with vessel transit to port to unload the	**Reject** – Cost associated with fuel and emissions disproportionate to risk and costs of

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
		cooling water and brine by avoiding requirement to discharge.	wastes, and by land transport to the nearest disposal facility. Increased energy consumption and atmospheric emissions would also result from the disposal (e.g. incineration treatment on land).	discharging within approved conditions.

6.7.4 Environmental impact assessment

The impacts and consequence ranking for operational discharges are outlined in **Table 6-24**.

Table 6-24: Impacts and Consequence ranking – operational discharges

Key receptors	Consequence level
Threatened, migratory, or local fauna	Only short-term behavioural impacts are expected with no decrease in local population size or area of occupancy of species, nor loss or disruption of critical habitat, disruption to the breeding cycle or introduction of disease, I - Negligible.
Physical environment or habitat	As the activity is located in an open oceanic environment where tides and currents would quickly dilute and disperse the planned discharges, and the activity is short-term (days) and transient, it is not expected that impacts to the physical environment will occur, I - Negligible.
Threatened ecological communities	Not applicable – no threatened ecological communities are identified in the area where operational discharges are expected to disperse.
Protected areas	Not applicable – no protected areas are identified in the area where operational discharges are expected to disperse.
Socio-economic receptors	Not applicable – no planned operational discharges will occur within areas known to be utilised by third party operators or for tourism and recreation. No impacts to fish stocks are expected to occur. Therefore, there is no conceivable impact to commercial, traditional or recreational fisheries.
Overall worst case consequence	I - Negligible

6.7.5 Demonstration of ALARP

Vessels are required to undertake the in-field surveys. The alternative to discharging these small amounts of liquid wastes to the marine environment is to store and transport the wastes to land, where they would be disposed of in line with industry best practice. However, this would result in an increase in environmental impacts through increased fuel consumption and increased atmospheric emissions, both by the vessel (or transport vessel) having to return to port a number of times to unload the wastes and by land transport to the nearest disposal facility. Increased energy consumption and atmospheric emissions would also result from the disposal (for example, incineration, treatment, etc.) of the additional wastes. This method would also result in an increased risk of vessel to platform or vessel-to-vessel collision, which could lead to a marine diesel spill. Therefore, this option would be of no net environmental benefit and would increase the risk associated with the activity, so it has not been adopted.

Therefore, to reduce the impacts and risks associated with discharging liquid wastes, these wastes will be treated in line with industry best practice. Discharge of sewage and other liquid wastes from vessels in Australian waters is permissible under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, which reflects requirements of MARPOL 73/78 Annexes IV, V and I and AMSA Marine Orders 95 and 96.

On-board treatment of most wastes and their subsequent discharge to the marine environment is considered to be the most environmentally sound method of disposal, considering that the waste streams will either be treated to a level unlikely to cause significant environmental harm or will be of a nature not considered to pose significant risk to the receiving environment. The proposed management controls for planned operational discharges are considered appropriate to manage the risk to ALARP. Additional controls considered but rejected are in **Table 6-24**.

6.7.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum planned operational discharge consequence is rated I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes –Consistent with relevant species recovery plans, conservation management plans and management actions including but not limited to: Recovery Plan for Marine Turtles in Australia (2017).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Release of non-hazardous discharges into the sea from vessels in Australian waters is permissible under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, which reflects MARPOL Annex IV, V and I requirements respectively and is enacted by:

+ Marine Order 91: Marine Pollution Prevention – Oil;
+ Marine Order 96: Marine Pollution Prevention – Sewage; and
+ Marine Order 95: Marine Pollution Prevention – Garbage.

The operational discharges are not expected to significantly impact the receiving environment with management controls proposed, including compliance with all MARPOL requirements. The MARPOL standard is considered to be the most appropriate standard given the nature and scale of the activities. These standards are internationally accepted and utilised industry wide. Therefore, compliance with the relevant and appropriate MARPOL requirements and standards is expected to reduce the potential for environmental impacts to a level which is considered environmentally acceptable.

Deteriorating water quality is identified as a potential threat to turtles in the marine turtle recovery plan and some bird and shark species. However, the operational discharges are not expected to significantly impact the receiving environment with management controls proposed. Therefore, the activities will be conducted in a manner that is considered acceptable.

6.8 Spill response operations

The spill response strategies that may be adopted in the event of a hydrocarbon spill (identified in **Section 7.6**) are summarised below. Potential impacts arising from the implementation of the following spill response operations/actions have been assessed as planned events in this section.

6.8.1 Description of event

Event	In the event of a hydrocarbon spill, response strategies will be implemented to reduce environmental impacts to ALARP. The selection of strategies will be undertaken through the net environmental benefit analysis (NEBA) process, outlined in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01). Spill response will be under the direction of the relevant Control Agency, as defined within the OPEP, which may be Santos or another agency or both. In all instances, Santos will undertake a 'first-strike' spill response and will act as the Control Agency until the designated Control Agency assumes control. The response strategies selected as appropriate for the worst-case oil spill scenario identified for the event comprise: + source control; + monitoring and evaluation; + mechanical dispersion; + oiled wildlife response; + scientific monitoring; and + waste management. While response strategies are intended to reduce the environmental consequences of a hydrocarbon spill, poorly planned and coordinated response activities can result in a lack of or inadequate information being available, which can lead to poor decisions being made, thereby exacerbating or causing further environmental harm. An inadequate level of training and guidance during the implementation of spill response strategies can also result in environmental harm over and above that already caused by the spill. The greatest potential for impacts additional to those described for routine operations is from shoreline clean-up and oiled wildlife response operations where coastal and shoreline habitat damage and fauna disturbance may occur.
Extent	Extent of spill.
Duration	Until termination criteria are met.

6.8.2 Nature and scale of environmental impacts

Given spill response operations will be within offshore waters and shorelines, primarily using vessels, the types of impact are consistent with operations described elsewhere within this EP for routine operations. Details of these environmental impacts and risks for spill response operations are outlined in **Table 6-25**.

Table 6-25: Nature and scale of environmental impacts and risks – spill response operations

Light emissions:	
Spill response activities may involve the use of vessels which are required at a minimum, to display navigational lighting. Vessels may operate in close proximity to shoreline areas during spill response activities. Aircraft may also be involved in spill response.	
Potential receptors:	Threatened, Migratory or local Fauna Protected Areas Socio-Economic
Lighting may cause behavioural changes to fish, birds and marine turtles which can have a heightened consequence during key life-cycle activities, for example turtle nesting and hatching. Turtles and birds, which includes threatened and migratory fauna, have been identified as key fauna susceptible to lighting impacts; **Section 6.4** provides further detail on the nature of impacts to fish, birds and marine turtles. Spill response activities (scientific monitoring) that require lighting may take place in surrounds of the Montebello Islands which are seasonally important for turtles. During nesting and hatching season (primarily over summer months) lighting may cause behavioural impacts to turtles, including aborted nesting attempts and disorientation of newly hatched turtles, which may increase mortality rates. As a consequence of impacts to fauna, lighting has the potential to directly impact supported industries, such as tourism, and indirectly impact the values of protected areas.	
Acoustic emissions:	
Spill response activities may involve the use of aircraft and vessels which will generate noise both offshore and in proximity to sensitive receptors in coastal areas.	

Potential receptors:	Threatened, Migratory or local Fauna Protected Areas Socio-Economic
Underwater noise from the use of vessels may impact marine fauna, such as fish (including commercial species), marine reptiles and marine mammals in the worst instance causing physical injury to hearing organs, but more likely causing short term behavioural changes, for example, temporary avoidance of the area, which may impact key life-cycle process (for example, spawning, breeding, calving). Underwater noise can also mask communication or echolocation used by cetaceans. **Section 6.2.1** provides further detail on these impacts from vessels. Whales have been identified as the key concern for vessel noise within the EMBA. The humpback migration BIA and the pygmy blue whale distribution and migration BIA is within the EMBA. Spill response activities using vessels have the potential to impact fauna in protected areas, this includes the Montebello AMP. As a consequence of impacts to fauna (including marine mammals and fish), noise has the potential to impact supported industries such as tourism and commercial fishing. Noise from aircraft used for surveillance purposes is not expected to cause disturbance to fauna as the aircraft will remain airborne; however, there may be a resulting loss of amenity value through the presence of and noise from aircraft.	
Atmospheric emissions:	
The use of fuels to power vessel and aircraft engines, generators and mobile equipment used during spill response activities will result in emissions of GHG such as carbon dioxide (CO_2) and nitrous oxide (N_2O), along with non-GHG such as sulphur oxides (SO_x) and nitrous oxides (NO_x). Emissions will result in localised decrease in air quality.	
Potential receptors:	Threatened, migratory, or local fauna Physical environment or habitat Protected areas
Atmospheric emissions from spill response equipment will be localised (apart from aircraft emissions which will rapidly dissipate) and while there is potential for fauna and flora impacts, the use of mobile equipment, vessels and vehicles is not considered to create emissions on a scale where noticeable impacts would be predicted.	
Operational discharges and waste:	
Operational discharges include those routine discharges from vessels used during spill response which may include: + bilge water; + deck drainage; + putrescible waste and sewage; + cooling water from operation of engines; and + brine. In addition, there are specific spill response discharges and waste creation that may occur, including: + cleaning of oily equipment/vessels; or + creation, storage and transport of oily waste and contaminated organics.	
Potential receptors:	Threatened, migratory, or local fauna Physical environment or habitat Protected areas Socio-economic receptors
Operational discharges from vessels may create a localised and temporary reduction in marine water quality. Effects include nutrient enrichment, toxicity, turbidity, temperature and salinity increases, as detailed in **Section 6.7**. These may impact a different set of receptors than previously described in that section given vessel use may occur in shallower coastal waters during spill response activities. Discharge could potentially occur adjacent to marine habitats such as corals, seagrass, macroalgae, and in protected areas, which support a more diverse faunal community; however, discharges will be very localised and temporary. Cleaning of oil contaminated equipment and vessels has the potential to spread oil from contaminated areas to those areas not impacted by a spill, potentially spreading the impact area and moving oil into a more sensitive environment.	

Physical presence and disturbance:	
The movement and operation of vessels, aircraft, personnel and equipment and undertaking of clean-up activities (i.e., oiled wildlife response) during spill response activities has the potential to disturb the physical environment and marine fauna, which may include those habitats and fauna within protected areas of the Montebello AMP. Disturbance may also impact cultural and amenity values of an area. The movement of vessels could potentially introduce IMS attached as biofouling to nearshore areas. Oiled wildlife response activities may involve deliberate disturbance (hazing), capture, handling, cleaning, rehabilitation and release of wildlife which could lead to additional impacts to wildlife.	
Potential receptors:	Threatened/Migratory Fauna Physical Environment/habitat Protected Areas Socio-Economic
The use of vessels may disturb benthic habitats in coastal waters including corals, seagrass, macroalgae and. Impacts to habitats from vessels include damage through the deployment of anchor/chain and grounding. Vessel use in shallow coastal waters also increases the chance of contact or physical disturbance with marine megafauna such as turtles and dugongs. Oiled wildlife response may include the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling such as birds and marine turtles. While oiled wildlife response is aimed at having a net benefit, poor responses can potentially create additional stress and exacerbate impacts from oiling, interfering with life-cycle processes, hampering recovery and in the worst instance increasing levels of mortality. Impacts from IMS released from vessel biofouling include out-competition, predation and interference with other ecosystem processes. The ability for a non-native species to establish is generally mitigated in deeper offshore waters where the depth, temperature, light availability and habitat diversity is not generally conducive to supporting reproduction and persistence of the invasive species. However, in shallow coastal areas, such as areas where vessel-based spill response activities may take place, conditions are likely to be more favourable. The disturbance to marine natural habitat may have flow on impacts to socio-economic values and industry (for example, tourism, fisheries).	
Disruption to other users of marine and coastal areas and townships:	
Spill response activities may involve the use of vessels, aircraft and equipment	
Potential receptors:	Socio-Economic Receptors
The use of vessels in the nearshore and offshore environment may temporarily exclude the general public and industry use of the affected environment. As well as impacting leisure activities of the general public, this may impact on revenue with respect to industries such as tourism and commercial fishing.	

6.8.3 Environmental performance outcomes and control measures

EPOs, CMs, EPSs and measurement criteria for oil spill preparedness and response activities are outlined in the relevant strategy sections of the OPEP. CMs relevant to reducing the potential impacts from spill response operations are shown in **Table 6-26**.

Table 6-26: Control measures evaluation - spill response operations

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-23	Competent Incident Management Team (IMT) and oil spill responder personnel	Ensures that spill response strategy selection and operational activities consider the potential for additional environmental impacts.	Personnel and operational costs associated with maintaining competent IMT team and responder personnel.	**Adopt** – Considered a standard spill response control.

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-24	Use of competent vessel crew and personnel	Reduces potential for environmental impacts from vessel usage.	Personnel and operational costs associated with maintaining contracts with competent vessel crew and personnel.	**Adopt** – Considered a standard spill response control.
Acoustic Disturbance				
CM-10	Vessels and aircraft compliant with Santos' Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003)	Reduces potential for behavioural disturbance to cetaceans.	No cost/issue associated with this CM.	**Adopt** – Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).
Light Emissions				
CM-06	Lighting will be used as required for safe work conditions and navigational purposes.	Light spill from unnecessary lighting reduced, even further lowering likelihood of impacts to the fauna from vessel lighting. Lighting is assessed to only provide necessary lighting for safety and navigation during spill response activities.	Additional costs associated with implementing control.	**Accept** – Cost is considered acceptable for the benefit that may be realised from this control.
Atmospheric Emissions				
CM-13	Where required under MARPOL, vessels will maintain a current IAPP Certificate	Reduces level of air quality impacts.	Personnel and operational costs associated with maintaining Air Pollution Certificate.	**Adopt** – Considered a standard spill response control (regulatory requirement).
Disruption to Other Marine Users				
CM-08	Stakeholder consultation	Promotes awareness and reduces potential impacts from response to socio-economic activities.	Minimal cost in relation to overall effort/costs in managing incident.	**Adopt** – Considered a standard control for incident management.
Operational Discharges and waste				

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-18	Vessel sewage system	Reduces potential for water quality impacts.	No cost/issue associated with this CM.	**Adopt** – Considered a standard spill response control (regulatory requirement).
CM-19	Oily water treatment system	Reduces potential for water quality impacts.	No cost/issue associated with this CM.	**Adopt** – Considered a standard spill response control (regulatory requirement).
CM-25	Compliance with controlled waste, unauthorised discharge and landfill regulations	Ensures correct handling and disposal of oily wastes.	No cost/issue associated with this CM.	**Adopt** – Considered a standard spill response control (regulatory requirement).
Physical presence and disturbance				
CM-26	Spill response activities selected on basis of a NEBA	Provides a systematic and repeatable process for evaluating strategies with net least environmental impact.	No cost/issue associated with this CM.	**Adopt** – Considered a standard spill response control.
CM-10	Vessels and aircraft compliant with Santos' Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003)	Reduces potential for behavioural disturbance to cetaceans.	No cost/issue associated with this CM.	**Adopt** – Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).
CM-27	Use of shallow draft vessels for nearshore operations	Reduce seabed disturbance.	Operational costs associated with operating shallow draft vessels for nearshore operations.	**Adopt** – Considered a standard control.

6.8.4 Environmental impact assessment

Key receptors	Consequence Level
Spill Response Operations – Light Emissions	
Threatened, migratory, or local fauna	The receptors considered most sensitive to lighting from vessel operations are seabirds and marine turtles, particularly over summer months with respect to marine turtles where emerging hatchlings are sensitive to light spill onto beaches. These species are likely to be values of the protected area they occur in (for example, the Montebello AMP and the impact to the protected area from light is considered II - Minor (II).
Physical environment or habitat	
Protected areas	

Key receptors	Consequence Level
Socio-economic receptors	As a consequence of impacts to fauna, lighting has the potential to impact supported industries, such as tourism; however, as impacts to fauna are considered I - Negligible, any indirect impacts on tourism will also be I - Negligible.
Overall worst-case consequence level	II - Minor
Spill Response Operations – Acoustic Disturbance	
Threatened, migratory, or local fauna	The receptors considered most sensitive to vessel noise disturbance is the humpback whale during migration season and the pygmy blue whale, when these whales come close to the Montebello Islands during their peak migration (July to October), as well as populations of marine turtles and whale sharks. However, following the adoption of CMs to limit close interaction with protected fauna (in other words, Protected Marine Fauna Interaction and Sighting Procedure (EA-91-II-00003)), a temporary behavioural disturbance is expected only with a consequence of I - Negligible.
Physical environment or habitat	
Protected areas	
Socio-economic receptors	
Overall worst-case consequence level	I - Negligible
Spill Response Operations – Atmospheric Emissions	
Threatened, migratory, or local fauna	Atmospheric emissions from spill response equipment will be localised; and impacts to even the most sensitive fauna, such as birds, are expected to be *I - Negligible*. Because of the emissions will be localised and low level, impacts to protected area values, physical environment and socio-economic receptors are predicted to be *I - Negligible*.
Physical environment or habitat	
Protected areas	
Socio-economic receptors	
Overall worst-case consequence level	I - Negligible
Spill Response Operations – Operational Discharges and Waste	
Threatened, migratory, or local fauna	Operational discharges from vessels may create a localised and temporary reduction in marine water quality, which has the potential to impact shallow coastal habitats in particular; however, following the adoption of regulatory requirements for vessel discharges, which prevent discharges close to shorelines, discharges will have a I - Negligible impact to habitats, fauna or protected area values. Furthermore, washing of vessels and equipment will take place only in defined offshore hot zones preventing impacts to shallow coastal habitats. As a consequence of impacts to fauna, operational discharge from vessels has the potential to impact supported industries, such as tourism and commercial fishing; however, as impacts to fauna are considered I - Negligible, any indirect impacts on socio-economic receptors will also be I - Negligible. The storage, transport and disposal of hydrocarbon-contaminated waste arising from spill response actions, such as oiled wildlife response, will be managed by Santos' appointed waste management contractor; and dedicated waste containment receptacles will prevent further hydrocarbon contamination. The consequence of oiled waste generation is therefore ranked as I - Negligible in terms of impacts to habitats, fauna or protected area values.
Physical environment or habitat	
Protected areas	
Socio-economic receptors	
Overall worst-case consequence level	I - Negligible
Spill Response Operations – Physical Presence and Disturbance	
Threatened, migratory, or local fauna	The use of vessels has the potential to disturb benthic habitats, including sensitive habitats in coastal waters of the Montebello AMP. A review of shallow water habitats

Key receptors	Consequence Level
Physical environment or habitat	and of bathymetry and the establishment of demarcated areas for access and anchoring will reduce the level of impact to I - Negligible.
Protected areas	The main direct disturbance to fauna would be the hazing, capture, handling, transportation, cleaning and release of wildlife susceptible to oiling impacts, such as birds and marine turtles. This would only be done if this intervention were to deliver a net benefit to the species, but it may result in a II - Minor consequence.
Socio-economic receptors	These habitats or environments are likely to be values of the protected area they occur in, and the impact to the protected areas from physical disturbance is therefore also considered II - Minor. The disturbance to marine habitat, as well as the potential for disruption to culturally sensitive areas, which may occur in specially protected areas, may have flow-on impacts to socio-economic values and industry (for example, tourism, fisheries). This impact is considered II - Minor.
Overall worst-case consequence level	I - Negligible
Spill Response Operations – Disruption to Other Users of Marine and Coastal Areas and Townships	
Threatened, migratory, or local fauna	The use of vessels in the nearshore and offshore environment may exclude general public and industry use. Note that this is distinct from the socio-economic impact of a spill itself, which would have a far greater detrimental impact to industry and recreation. Following the application of CMs, it is considered that the additional impact of spill response activities on affected industries would be II - Minor.
Physical environment or habitat	
Protected areas	
Socio-economic receptors	
Overall worst-case consequence level	II - Minor

6.8.5 Demonstration of ALARP

A NEBA is the primary tool used during spill response to evaluate response strategies with the goal of selecting strategies that results in the least net impact to key environmental sensitivities. The NEBA process will identify and compare net environmental benefits of alternative spill response options. The NEBA will effectively determine whether an environmental benefit will be achieved through implementing a response strategy compared to undertaking no response. NEBA will be undertaken by the relevant Controlling Agency for the activity.

Spill response activities may be conducted in offshore and coastal waters using vessels and aircraft. The greatest potential for additional impacts from implementing spill response is considered to be to wildlife in offshore waters from oiled wildlife response activities.

Given the types of activities considered appropriate to responding to a worse-case spill and the scale of operations, standard CMs adopted by Santos for spill response to reduce the level of additional impacts are considered to reduce these impacts to ALARP. This includes working with the relevant Controlling Agency for spill response and applying the process and standards, for example, for oiled wildlife response as included within the WA Oiled Wildlife Response Plan (WAOWRP) and Pilbara Regional Oiled Wildlife Response Plan.

Santos considers the actions prescribed in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) and Approved Conservation Advice for other threatened fauna (**Table 3-4**) relevant to spill responses for the activities to minimise noise and light impacts on marine mammals, fish and marine turtles. The proposed activity will not result in significant impacts on these species and implementation of identified CMs is in line with the relevant Conservation Advice and Recovery Plans. Pollution events (such as hydrocarbon spills) could impact on marine fauna (as described in **Section 7.6**), and the use of vessels and equipment during the spill response could result in potential impacts as described within this EP. CMs in place for vessel and helicopter use a will reduce potential impacts to marine fauna and these are consistent with current conservation advice. The assessed residual consequence for this impact is Minor (II) and cannot be reduced further without disproportionate costs. It is considered therefore that the impact of the activities conducted are acceptable and ALARP.

The North-west Marine Parks Network Management Plan states that actions required to respond to oil pollution incidents, including environmental monitoring and remediation, in connection with mining operations authorised under the OPGGS Act may be conducted in all zones of the Montebello AMP (DNP, 2018) without an authorisation issued by the Director, provided that the actions are taken in accordance with an EP that has been accepted by NOPSEMA, and the Director is notified in the event of oil pollution within a marine park, or where an oil spill response action must be taken within a marine park, so far as reasonably practicable, prior to response action being taken.

6.8.6 Acceptability evaluation

Is the consequence ranked as I or II? Is the risk ranked between Low to Medium?	Yes – maximum consequence is II (Minor).
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Offshore Division Environmental Hazard Identification and Assessment Guideline which considers principles of ESD. The consequence against this aspect is II (Minor) and therefore does not affect the outcomes of the principles of ecologically sustainable development.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – IUCN principles and strategic objectives of nearby reserves (Montebello AMP) are met. CMs implemented will minimise the potential impacts from spill response activities to protected areas and their values and to species identified in recovery plans and conservation advice as having the potential to be impacted. Consistent with relevant species recovery plans, conservation management plans and management actions. Management consistent with EPBC Act Regulations (Part 8), Marine Orders (91, 96 and 97) and Australian Ballast Water Requirements.
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised. During any spill response, a close working relationship with relevant regulatory bodies (for example, the Department of Transport (DoT), department of Biodiversity, Conservation and Attractions (DBCA) and AMSA) will occur and thus there will be ongoing consultation with relevant stakeholders on the acceptability of response operations. Wildlife response will be conducted in accordance with the WA Oiled Wildlife Response Plan and Pilbara Regional Oiled Wildlife Response Plan.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The implementation of response activities to reduce the potential impacts from a spill are required by legislation. The spill response options selected have been demonstrated to show a net environmental benefit, are standard industry practice, and are consistent with relevant standards and guidelines, including the National Plan for Maritime Environmental Emergencies (AMSA, 2019). No concerns from stakeholders have been raised regarding response activities, and the controls proposed reduce the consequences of the potential impacts to Minor (II) and ALARP. The controls used during spill response activities are therefore considered to reduce additional impacts and risks to an acceptable level.

6.9 Legendre-1 wellhead: degradation

6.9.1 Description of event

Event	Degradation of the wellhead introduces contaminants (predominantly iron oxides) to the water column and sediment surrounding the wellhead as it degrades over time.
Extent	**Localised**: Immediate area surrounding the wellhead.
Duration	**Long term:** The wellhead is expected to persist long term (i.e., it will take hundreds of years to degrade completely).

Note that wellhead degradation in relation to potential gas seepage is considered in **Section 6.1**.

6.9.2 Nature and Scale of Environmental Impacts

6.9.2.1 Threatened, migratory, or local fauna

Since 1968, the wellhead has provided a stable hard substrate, which has been colonised by marine growth and the structurally complex habitat supports a greater abundance and diversity (notably fish) of marine biota than the surrounding flat, sandy sediments (RPS 2021a). This 'reef effect' of anthropogenic structures has been well documented (Claisse *et al.* 2014) and has been described for wellheads at various depths on the North West Shelf (McLean et al., 2018). The value of the wellhead as artificial benthic habitat will continue until the wellhead has completely degraded (i.e., potentially many decades).

The release of breakdown compounds into the water column and accumulation in sediments may affect marine fauna, particularly infauna species immediately surrounding the wellhead. Notwithstanding this, iron oxide is naturally occurring and generally has low toxicity to marine biota.

Of the metals and metalloids in the sediments sampled from the Legendre field permit, none were recorded at concentrations above the relevant Australian & New Zealand Guidelines (ANZG) (2018) default guideline value (RPS 2021a, see **Section 3.3.5**). Metal components will degrade slowly with very small amounts released at any one point in time and are expected to disperse rapidly in currents. Particulate contaminants are expected to become entrained in the sediment matrix and be diluted through mixing with natural sediments and broken down through bio-chemical processes.

6.9.2.2 Physical environment or habitat

Studies of erosion/accretion around subsea structures (e.g., shipwrecks, artificial reefs) indicate indirect impacts may be limited to within 20 m of the structure (Smiley 2006; Lewis and Pagano 2016). Surveys undertaken in the field in 2021 did not indicate a significant change in the existing seabed profile between the wellhead and the surrounding reference areas apart from localised erosion under the edges of the steel temporary guide base (RPS 2021).

As the wellhead degrades over time, breakdown products (predominantly iron oxides) will be released into the surrounding water column and accumulate in the surrounding sediments. Iron, the main constituent (~98%) of the wellheads and casing material, is not considered a significant contaminant in the marine environment and is only toxic to marine organisms at extremely high concentrations (Grimwood and Dixon, 1997) and is an abundant element in marine sedimentary systems (Taylor et al, 2011). Wellhead material compositions are detailed in **Section 2.2**. Given the slow breakdown process, toxic levels are not expected to occur any time in the future.

Ocean currents are expected to rapidly disperse the breakdown products and limited deposition of breakdown compounds are expected to occur in surficial sediments surrounding the wellhead. This has been supported by field studies conducted by RPS in 2021 which did not indicate a change in the existing seabed chemistry surrounding the wellhead, apart from sediment contamination which is consistent with contamination from drilling muds and fluids and possibly decommissioning activities (RPS 2021b, see **Section 3.3.6**).

As the wellhead integrity reduces in time, sections of the wellhead may break off and fall onto the surrounding seabed. This would affect habitat (i.e., unconsolidated sediments) within 5 m of the wellhead.

The wellhead is comprised predominantly of iron which is not considered to be a contaminant in the marine environment. Corrosion is likely to be a relatively slow process about 0.2 mm/year (Melchers, 2005). Based on the composition of the wellhead and the low corrosion rate of the wellhead materials, environmental impacts associated with leaving the wellhead in situ are considered to be of an acceptable level.

6.9.3 Environmental performance outcomes and control measures

The control measures considered for this activity are shown in **Table 6-27**.

Table 6-27: Control Measures evaluation for presence of the wellhead: degradation

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
No standard controls have been identified.				
Additional Control Measures - Removal				
N/A	Removal of the wellhead by external cutting above the mudline using an Inline 155" crane-deployed DWS cutting tool	Removing the wellhead would avoid degradation of material in the environment.	Bulky equipment to deploy from vessel involving the safety risks associated with deployment and retrieval of equipment. Tool is designed for cutting subsea structures, not wellheads and PGBs. Due to uncertainty in PGB size it is unknown whether PGB dimensions are within tool capability. It is unknown whether the tool is capable of clamping onto the PGB. Tool is new design and has never been used in this application.	**Reject** –There is significant uncertainty whether this option is technically feasible (Section 2.2.1). Costs are high and due to significant technical challenges the likelihood of success is low. The costs, and health and safety risks to remove the wellhead are considered disproportionately high to the low environmental impacts of leaving the wellhead in-situ. The small size (3-5 m wide by 3.6 m tall) and properties of the wellhead (inert material) the environmental benefits of removal are Negligible.
N/A	Removal of the wellhead by internal cutting below the mudline using a Sea Axe (.e.g. Internal Abrasive Water Jet Cutting Tool)		Requires removal of the TA cap to regain access to the wellbore. Shallow cement plug in 9-5/8" casing may prevent access to effect cut below mudline. Requires circa 125m2 of deck space for AWJC equipment and equipment spread is circa 37T. The removal operations would, amongst other	**Reject** – As described in Section 2.2.1, this option may be technically feasible however significant technical challenges exist which may prevent safe and effective removal. Costs of removal are high. The

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			environmental impacts cause localised seabed disturbance, generate metal cuttings, vessel emissions, and remove artificial habitat.	costs and health and safety risks to remove the wellhead are considered disproportionately high to the low environmental impacts of leaving the wellhead in-situ. The small size (3-5 m wide by 3.6 m tall) and properties of the wellhead (inert material) the environmental benefits of removal are Negligible.
N/A	Removal of the wellhead by external cutting above the mudline using an Inline ROV deployed Diamond Wire Saw (DWS) cutting tool	Removing the wellhead would avoid degradation material in the environment.	PGB prevents access to the conductor to mount the DWS using an ROV. Dredging below the PGB to gain access to the conductor is considered high risk and remote chance of success as presence of cement or hard sediments will prevent effective dredging and PGB is likely to slump as it is not physically locked to the wellhead and conductor.	**Reject** – This option is assessed as not credible.
	Removal of the wellhead by internal cutting below the mudline using a Terminator Mechanical cutting and wellhead retrieval tool	Removing the wellhead would avoid degradation material in the environment.	Not proven to be technically feasible for this application. Requires removal of the TA cap and access to the wellbore. Shallow cement plug in 9-5/8” casing may prevent tool access to effect cut below mudline. To effect wellhead removal four casing strings would need to be cut through and the tool is designed for three. Requires vessel with heave compensated crane (or possibly use an inline compensator).	**Reject** - Not proven to be technically feasible.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
N/A	Removal of the wellhead by internal cutting below the mudline using an Internal Multi-String Cutting Tool (IMCT)	Removing the wellhead would avoid degradation material in the environment.	Not proven to be technically feasible. Requires removal of the TA cap and access to the wellbore. Shallow cement plug in 9-5/8" casing may prevent access to effect cut below mudline. Requires circa 100m2 of deck space for AWJC equipment. Equipment spread is circa 45T.	**Reject** - Not proven to be technically feasible.
N/A	Marine growth removal to inform wellhead condition	No environmental benefit. Marine growth cleaning of the wellhead may allow positive visual identification of the interfaces and may allow more accurate information to be gathered on the wellhead corrosion status and configuration.	Wellhead cleaning would require an ROV fitted with cleaning equipment to be deployed from a vessel, which would be a separate campaign to a wellhead removal campaign. Even with cleaning, it may still not be possible to identify the components due to their age, having been installed in 1968. Mobilising a vessel to conduct an activity that may not be informative and will cost approximately US1-3 million. Blasting the marine growth from the wellhead will destroy the biota living on the structure. By combining the cleaning campaign with another scope, the vessel mobilisation costs would be reduced.	**Reject** – The environmental impacts of leaving the wellhead in situ are negligible. While marine growth cleaning may provide some additional information to inform wellhead severance options, the cost is disproportionate to the negligible environmental gains.
Additional Controls – Monitoring and Maintenance				
N/A	Wellhead monitoring	Wellhead monitoring will not provide material environmental benefit. The wellhead has remained in place since 1968 and considering the properties of the wellhead seabed contaminant levels are not	It is estimated that a monitoring campaign would cost between AUD 500,000 to 1,000,000. Each monitoring campaign would result in environmental impact including vessel emissions and displacement of other marine users.	**Reject** - There is no compelling reason for wellhead monitoring given seabed contaminant levels are not expected to change for the remaining presence of the structure. No

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		expected to change for the remaining presence of the structure. Monitoring would not reduce the I - Negligible environmental impact of wellhead degradation		metals or metalloids were recorded in sediment samples at the wellhead site above the ANZG DGV. Monitoring would not reduce the environmental impact of the wellhead degradation.
N/A	Wellhead maintenance	No environmental benefit is expected from any wellhead maintenance.	In addition to the above monitoring assessment, the task would involve more time in the field, with HSE risks, for no environmental gain.	**Rejected –** There is no justification for maintaining the wellhead. The well has been permanently plugged and abandoned. The wellhead will slowly degrade, lose its structure integrity and break apart. This is inevitable, and an ALARP and acceptable outcome.

6.9.4 Environmental Impact Assessment

The impact and consequences ranking for wellhead degradation are outlined in **Table 6-28**.

Table 6-28: Impacts and consequence ranking – degradation

Receptor	Consequence Level
Threatened, migratory, or local fauna	Given the low toxicity of iron, the slow rate of release, and rapid dilution in the open ocean environment, no impacts are expected to protected species that may occur at the depth of the wellhead. Impacts to threatened or migratory fauna or local fauna are assessed as I - Negligible.
Physical environment or habitat	No metals or metalloids were recorded in sediment samples at the wellhead site above the ANZG DGV (RPS 2021a). The wellhead location overlaps the Glomar Shoals KEF, valued for its high productivity and aggregations of marine life (**Section 3.4.2**). Several studies undertaken on wellheads on the NWS have observed a diverse range of reef dependent and transient pelagic species associating with structures (Pradella et al. 2014, McLean et al., 2018) and numerous marina fauna species were observed aggregating at the Legendre-1 wellhead in 2021 (RPS 2021a). Impacts to the physical environment or habitat are assessed as I - Negligible.
Threatened ecological communities	Not applicable – No threatened ecological communities occur at or near the wellhead.
Protected areas	Not applicable – No Protected areas occur at or near the wellhead.
Socio-economic receptors	Adverse impacts to commercial fisheries' target species are not predicted given the small size and inherent properties of the wellhead. The wellhead has provided a hard substrate habitat on a seabed predominantly comprising soft sediment, since 1968.

Receptor	Consequence Level
	The physical presence of the wellhead is likely to increase the diversity and abundance of some commercially valuable fish species; thereby providing a potential benefit to commercial fishers. Impacts to socio-economic receptors are assessed as I - Negligible.
Overall worst-case consequence	**I - Negligible**

6.9.5 Demonstration of ALARP

As described in **Section 2.2**, leaving the wellhead in situ is proposed by Santos as providing an equal or better environmental outcome. The environmental impacts of this option have been assessed as I - Negligible and cannot be reduced further. Additional control measures were considered (as detailed in **Section 6.9.3)** but rejected given they provided no material environmental benefit. It is considered therefore that the impact is ALARP.

6.9.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum environmental consequence is I - Negligible.
Is further information required in the consequence assessment?	No – potential impacts and risks are sufficiently understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes – activity evaluated in accordance with Santos's Environmental Hazard Identification and Assessment Procedure which considers principles of environmentally sustainable development. The consequence against this aspect is I - Negligible and therefore does not affect the outcomes of the principles of ecologically sustainable development as per **Table 5-5**.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes Consistent with relevant species recovery plans, conservation management plans and management actions set out in **Table 3-4**, including but not limited to: + Recovery Plan for Marine Turtles in Australia (2017) + Conservation Advice *Rhincodon typus* whale shark (2015) + Conservation Management Plan for the Blue Whale, 2015–2025 (DoE, 2015). + Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021) Principles and strategic objectives of the 1989 International Maritime Organisation (IMO) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and the Exclusive Economic Zone, the OPGGS Act and OPGGSE(R) are met. As described in **Section 1.7.3.1**, Section 572(3) of the OPGGSA requires titleholders to remove all equipment and property that is neither used nor to be used in connection with the operations unless alternative arrangement can be agreed via NOPSEMA's acceptance of the EP. This EP demonstrates that all impacts and risks of leaving the wellhead in-situ are of an ALARP and acceptable level. As per 3.15 of the DISER Guideline Offshore Petroleum Decommissioning, options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws. **Section 2.2.2** shows that leaving the wellhead in situ delivers an equal or better environmental outcome to removing the wellhead.

	The wellhead removal study (**Section 2.2.1.1**) concluded that whilst both internal and external cutting options are feasible, there is a low chance that they will be successful. There is significant uncertainty in the feasibility of an internal cutting method and the external cutting tool most likely to succeed is unproven for wellheads and is large and bulky which introduces additional safety risks. It is estimated that wellhead removal costs would be in the range of AUD 10 to 15 M for a single dedicated campaign. This cost would be reduced if the campaign can be combined with an additional Santos offshore campaign, with the Legendre-1 costs of a combined campaign estimated to be AUD 5 M to 10 M. The complexities and challenges associated with the old wellhead removal could likely result in the activity duration and cost escalating through failed removal attempts. This would extend the duration of environmental impact for no gain in terms of environmental outcomes. In addition, removal of the wellhead carries technical, safety and environmental risks that are not introduced should the wellhead remain in situ. Therefore, the costs and risks to the environment to remove the wellhead are considered disproportionately high to the negligible environmental impact of leaving the wellhead in-situ. Santos considers that there is technical uncertainty in the feasibility of removal and would involve extreme cost and therefore it is acceptable that the wellhead remains in situ. The presence of the wellhead is not expected to significantly affect commercial fishing operations. The activity is considered acceptable. The 1989 IMO Resolution A6.72 (16), Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (IMO 1989) paragraph 3.1 states that “All abandoned or disused installations or structures standing in less than 75 m of water and weighing less than 4,000 tonnes in air, excluding the deck and superstructure, should be entirely removed.” However, it goes on to state that “Notwithstanding the requirements of paragraphs 3.1 and 3.2, where entire removal is not technically feasible or would involve extreme cost, or an unacceptable risk to personnel or the marine environment, the coastal State may determine that it need not be entirely removed.” As demonstrated in **Section 2.2**, removal of the Legendre-1 wellhead would result in localised and direct environmental impacts, and extreme cost for negligible environmental benefit, which would be avoided by leaving the wellhead in situ.
Are risks and impacts consistent with the Santos’s Environmental Management Policy?	Yes – Aligns with the Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – WAFIC asked what long-term plans Santos had in place to monitor the degradation of infrastructure to be left in situ, which Santos responded to and considered in this section. WAFIC also advised it was opposed to materials left in situ that result in toxic substances or contaminants presenting an unacceptable risk to aquatic resources or the marine environment. Leaving the wellhead in situ is acceptable as toxic levels are not expected to occur at present or anytime in the future as detailed in this section.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

7 Environmental assessment – unplanned events

OPGGS(E)R 2023 Requirements
Section 21(5)
The environment plan must include: + details of the environmental impacts and risks for the activity; + an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and + details of the control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level.
Section 21(6)
To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: + all operations of the activity; and + potential emergency conditions, whether resulting from accident or any other reason.
Section 21(7)
The environment plan must: + set environmental performance standards for the control measures identified under paragraph (5)(c); + set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and + include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

Santos' environmental assessment identified six potential sources of environmental risk from an unplanned event associated with the activities in this EP. The results of the environmental assessment are summarised in **Table 7-1** and **Table 7-2**. A comprehensive risk and impact assessment for this unplanned event, and subsequent CMs proposed by Santos to reduce the risk and impacts to ALARP, are detailed in the following sub-sections.

The Legendre-1 wellhead was permanently plugged and abandoned in 1968; hence, a well-related hydrocarbon release has not been considered. There is no Well Operations Management Plan (WOMP) for the Legendre-1 wellhead. There are no planned activities associated with leaving the wellhead in situ and the only unplanned event regarding the wellhead considered credible is a snag risk.

Table 7-1: Summary of the environmental risks associated with the wellhead remaining in situ

EP Section	Unplanned event	Likelihood	Consequence	Residual risk level
7.1	Legendre-1 wellhead: interaction with marine users	a – Remote	Negligible	Very Low

Table 7-2: Summary of the environmental risks associated with environmental monitoring

EP Section	Unplanned event	Likelihood	Consequence	Residual risk level
7.2	Release of solid objects	d - Occasional	I - Negligible	Low
7.3	Introduction of invasive marine species	a - Remote	III - Moderate	Very Low
7.4	Marine fauna interaction	b - Unlikely	III - Moderate	Low
7.5	Hazardous liquid releases	b - Unlikely	I - Negligible	Very Low
7.7	Release of hydrocarbons	b - Unlikely	II - Minor	Very Low

7.1 Presence of the Legendre-1 wellhead - interaction with marine users

7.1.1 Description of Event

Event	Presence of wellhead (3.6 m high x 3-5 m wide) resulting in snag of trawl fishing nets until the wellhead has completely degraded (i.e., over hundreds of years) or untrawlable ground. Current and future displacement of commercial fishers
Extent	**Localised**: Approximately 1 km area around the wellhead.
Duration	**Long term:** The potential effects may occur until equipment degrades (i.e., many decades).

7.1.2 Nature and scale of environmental impacts

7.1.2.1 Socio-economic receptors

As described in **Section 3.6.1**, Santos assessed historical commercial fishing catch records to determine commercial fisheries that may be displaced by the ongoing presence of the wellhead. No fishing effort by a Commonwealth-managed commercial fishery was recorded within WA-20-L from 2009 to 2019.

Analysis of Fish Cube data indicates fisheries which may be active within the vicinity of the wellhead include the Mackerel Managed Fishery, Pilbara Fish Trawl (Interim) Managed Fishery, Pilbara Line Fishery, and the Pilbara Trap Managed Fishery (**Section 3.6.1**). The Pilbara Fish Trawl is a trawl fishery; hence, the wellhead represents a snag hazard for trawl nets.

Review of at least five years of historical fishing effort within WA-20-L is considered appropriate to describe the relative importance of the waters to commercial fisheries as this aligns with the five-year review cycle of Commonwealth fisheries harvest strategies. Five years of data is analysed to manage performance of the fishery through time and the scale of inter-annual variability of environmental parameters that affect fisheries resources (DAWR 2018), both indicating the suitability of this time scale to fishing decision of individual fishers.

Snagging risk study

Santos engaged the Australian Maritime College (AMC) to undertake an independent assessment of the potential impacts of the Legendre-1 wellhead on trawl fishers potentially operating in the area (**Appendix I**). The study examined the historical trawl fishing effort near the wellhead and found that the majority of fishing activity is associated with the Pilbara Demersal Scalefish Fisheries which is consistent with the data presented in Fishery Status Reports (Newman et al. 2019, 2020) and WA Department of Primary Industry and Regional Development (DPIRD) catch and effort data (see **Section 3.6.1**). This includes the Pilbara Fish (Interim) Trawl Managed Fishery (PFITMF) which targets cod and emperor via the demersal trawl method. Fishing activity in the PFITMF has increased overall in the last five years (Newman et al. 2020).

To determine the likelihood of a snag occurring if a fisher were to operate in the area, the study examined the equipment and experience on the four vessels used by the PFITMF. Some of the key findings included of the study included the following:

+ All four vessels have equipment and systems that are upgraded frequently in response to safety concerns, changes in regulations, and opportunity.
+ All four vessels have passed AMSA stability examinations and a trawl operator in this area, using the available technologies of trawl monitoring systems, sonar obstacle detection, single-beam echo sounders, integrated GPS platters and seabed mapping software, is likely to be aware of the fixed location of the wellhead and therefore will avoid the obstacle in a timely manner and therefore avoid snagging.
+ Evidence provided by fishers to AMC indicated that trawlers currently pass the wellhead at a distance of at least 0.5 nm.
+ Further, the wellhead is within the Glomar Shoal, which is ‘for the best part untrawlable ground’.
+ The size of the wellhead is small when compared to the total amount of trawlable ground in the fishery (less than 0.002 % of the total trawlable area). Therefore, given the position is known (marked on charts), the advanced level of equipment and experience on the vessels and that the wellhead is actively avoided due to the ground type, the study concluded it is unlikely that trawlers would interact with the wellhead into the future.

+ In the unlikely event of a snag occurring, the study determined that a demersal trawler coming into contact with the wellhead would likely snag and that some net and wires (bridle gear) would have to be left behind, with recovery of this gear unlikely.
+ In the event of unfavourable weather the severity of a snag event would increase, however the study concluded that due to the technology employed on the four vessels and experience of the vessel operators a snag event is unlikely to result in capsize, as demonstrated by nil capsize events due to snagging in the last three decades in the fishery.

The review found that commercial vessels are equipped with one or more echosounders and GPS plotters. Echo sounders detect strong target strength seabed obstacles such as the wellhead. Given the water depth of the wellhead location, the trawl gear in 50 m of water may reside some 200 m astern of the vessel, so there would be sufficient time and room to manoeuvre to avoid the obstacle. GPS plotters accurately show the vessel's position relative to marked seabed infrastructure such as the well-head and allow trawlers to plan their routes to safety avoid the obstacle (John Wakeford Pers Comm, 2021).

A review of the historical fishing vessel incident data from the AMSA Monthly Domestic Vessel Incident Reporting Database (two-year data set) and Australian Transport Safety Bureau (ATSB) Marine Safety Investigations Reports (1982-2020) shows that there are no reported fishing vessel incidents confirmed as related to offshore oil and gas infrastructure in Australia.

Outside of Australia, historically, wellheads are recorded to have caused fewer snag incidents in commercial fisheries, compared to pipelines and marine debris from oil and gas operations, which accounted for more than 50% of incidents in the UK between 1989 and 2016 (Rouse, 2020). In comparison, production infrastructure, which includes wellheads, were involved in 4% of incidents over the same period (Rouse, 2020). Overall, the likelihood of interactions between trawl equipment and oil and gas infrastructure is reducing over time, as a result of an increase in communication from the petroleum industry and improvement in fishery GPS equipment (Rouse, 2020).

In the unlikely event of snagging, potential consequences are financial loss to commercial fishers either through lost fishing time or damages to, and losses of, fishing gear (Rouse, 2020). Studies of historical snag incidents in the UK have found that vessel damage or loss occurred less than 0.5% of the time, with one capsize resulting in fatalities/injuries occurring in the UK between 1989 and 2016 (Rouse, 2020), equating to 0.06% of incidents.

The wellhead has been in situ since 1968 and charted by the AHO without any known impact to stakeholders. WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery (less than 0.002 % of the total trawlable area) the AMC concluded that the likelihood of interaction between a trawler and the wellhead is low. In the event of a snag, some net and wires (bridle gear) would have to be left behind, with recovery of this gear unlikely. In the event of unfavourable weather the severity of a snag event would increase, however the study concluded that due to the technology employed on the four vessels and experience of the vessel operators a snag event is unlikely to result in capsize, as demonstrated by nil capsize events due to snagging in the last three decades in the fishery. Therefore, significant disruption to this fishery is not expected, given the historical effort is focussed away from WA-20-L and the vast areas available to the fisheries. Even if commercial fishing activities were to increase in the future near WA-20-L, the reasoning explained above, such as the very small size of the wellhead and that the location is marked on charts, potential impacts to fisheries would be negligible.

Given the short deviation required to trawl around the wellhead, and given the historical effort is focussed away from WA-20-L and the vast areas available to the fisheries, significant disruption to this fishery is not expected.

The presence of the wellhead on the seabed may interfere with future petroleum activities (e.g. interfere with jack-up rig placement) if future users do not check nautical charts. However, due to the small footprint (approximately 5 m diameter) and known presence of the wellhead marked on nautical charts, any such interference would be unlikely. A debris clearance survey conducted as routine precursor to a future petroleum activity would identify the structure on the seabed. As such, this potential impact is not discussed further.

7.1.3 Environmental performance outcomes and control measures

The EPO relating to this event is:

+ **EPO-08:** Marine users are not adversely impacted by the presence of the wellhead.

The control measures considered for this activity are shown in **Table 7-3**. EPS and measurement criteria for the adopted controls are presented in **Section 8.3.**

Table 7-3: Control Measures Evaluation for presence of wellhead: disturbance to other users

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
CM-28	Navigational charting of wellhead	Wellhead is charted on AHO nautical charts so that marine users are aware of its location, they can therefore avoid the wellhead if required thus reducing snag risk. Note - marine users are not excluded from area.	No additional costs to Santos.	**Adopt** – The positive benefits of identifying the wellhead to other marine users by confirming it continues to be charted with the AHO is considered acceptable. Charting is considered an effective measure to reduce the snag risk to trawl fishers. Under the Navigation Act 2012, the AHO is responsible for maintaining and disseminating hydrographic and other nautical information and nautical publications. Specifically, subsea infrastructure is identified as a potential subsea hazard to commercial shipping activities (such as fisheries) and thus locations are included on appropriate marine charts.
CM-29	Stakeholder notification through industry representative body	Direct notification to relevant commercial fishers that operate in the vicinity of the wellhead increases the likelihood that the information is received and acted upon.	No potential costs are expected from this mitigation.	**Adopt** - The positive benefits of confirming the wellhead to other marine users is considered to be acceptable.
Additional Control Measures				
N/A	Install a wellhead cover or cap	Installing a wellhead cover or cap would reduce snagging risks to commercial trawl fishers.	Significant cost (in the range of AUD 1.4 M to 1.8 M.) associated with conducting installation program. Offshore campaign would introduce environmental impacts and risks, including air emissions and fuel oil spill risks, associated with vessel operations. Disturbance to seabed while placing the cover or cap on the seabed.	**Reject** – Previous consultation with trawl fisheries for other wellheads of similar size indicated that wellhead caps or cover does not remove the snag risk. The costs associated with installing a wellhead cover or cap would be comparable to removing the wellhead. I The height of the wellhead may need to be reduced to allow for the

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			Consultation with trawl fisheries indicated that wellhead caps or cover does not remove the snag risk (Santos Tern-1 Wellhead Abandonment Environment Plan).	placement of a 'low profile' cover or cap.
N/A	Rock dumping	Rock dumping over the wellhead may reduce the risk of snagging.	Negligible potential benefit as the rock-dumped area may still be a snag risk. Rock dumping would introduce additional technical and HSE risks.	**Reject** – Negligible environmental benefit is far outweighed by the technical and HSE risks and project costs.
Additional Control Measures - Removal				
N/A	Wellhead monitoring	Monitoring of snagging would assist in validating the impact assessment and enable further understanding of the ongoing nature and scale of impact of the wellhead presence to other users.	It is estimated that each monitoring campaign would cost between AUD hundreds of thousands. Each monitoring campaign would result in environmental impact including vessel emissions and displacement of other marine users.	**Reject** – There is no compelling reason for wellhead monitoring given monitoring would not reduce the I - Negligible impact of wellhead presence.
N/A	Wellhead maintenance	No environmental benefit is expected from any wellhead maintenance.	In addition to the above monitoring assessment, the task would involve more time in the field, with HSE risks, for no environmental gain.	**Rejected –** There is no justification for maintaining the wellhead. The well has been permanently plugged and abandoned, hence, the wellhead is of no use. The wellhead will slowly degrade, lose its structure integrity and break apart. This is inevitable and the desired outcome.
N/A	Removal of the wellhead	The option of internal cutting of the wellhead below the mudline would result in removal of the snag risk and markings on the navigational charts. However, due to the lack of known snags on the wellhead since it's placement in the 60's, the benefits of removal are expected to be minimal.	It is estimated that wellhead removal costs would be in the range of AUD 10 to 15 M for a single dedicated campaign. This cost would be reduced if the campaign can be combined with an additional Santos offshore campaign, with the Legendre-1 costs of a combined campaign estimated to be AUD 5	**Reject** – As detailed in Section 2.2, wellhead removal would pose more environmental impacts and risks than it mitigates. As such, the cost to remove the wellhead is considered disproportionately high to the minimal environmental benefit of removal.

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		The option of external cutting of the wellhead above the mud line would likely result in a snag risk as a smaller wellhead profile would reduce the ability for fishers to detect the presence of the wellhead on sonar. There is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground.	to 10 M. The complexities and challenges associated with the old wellhead removal could likely result in the activity duration and cost escalating through failed removal attempts. This would extend the duration of environmental impact for no gain in terms of environmental outcomes. The removal operations would, amongst other environmental affects, cause localised seabed disturbance, generate metal cuttings, and exclude other users from the area, and additional vessels could mean additional navigational risks to other users.	
N/A	As per **Table 6-27** 'additional control measures – removal'.	As per **Table 6-27** 'additional control measures – removal'.	As per **Table 6-27** 'additional control measures – removal'.	**Reject** – Multiple control measures relating to wellhead removal are provided in **Table 6-27**. The technical and cost justification for rejecting these controls also applies to this risk and is not duplicated in this table. The technical risks and financial costs and given the potential risks to other users is negligible, the cost of removing the wellhead is considered disproportionately high to the minimal potential risk reduction to other marine users if the wellhead was removed.

7.1.4 Environmental impact assessment

Description – Presence of wellhead: interaction with other marine users	
Receptors	Socio-economic receptors
Consequence	I - Negligible

Description – Presence of wellhead: interaction with other marine users	
Socio-economic receptors Given the wellhead has been in place since 1968, is charted on navigational charts, and represents a very small percentage of the overall fishery, the current and potential future impact to commercial fish trawlers is considered I – Negligible. The independent assessment of the snag risk of the wellhead concluded that in the Remote event of a demersal trawler coming into contact with the wellhead, the trawler would likely snag and that some net and wires (bridle gear) would have to be left behind, with recovery of this gear unlikely. It was also concluded that due to the technology employed on the four vessels and experience of the vessel operators a snag event is unlikely to result in capsize, as demonstrated by nil capsize events due to snagging in the last three decades in the fishery. It is expected the loss of some net or wire would be a I – Negligible consequence.	
Likelihood	a - Remote
It is remote that a snag incident will occur at the Legendre-1 wellhead given the small size of the wellhead when compared to the total amount of trawlable ground in the PTIMF (less than 0.002 % of the total trawlable area) and the vessels that operate in the fishery have the required experience, equipment and technology to avoid snagging. The control measures proposed, to ensure that all trawl fishers in the area are notified of the wellhead location, and to ensure the ongoing marking of the wellhead on official navigational charts reduced the likelihood of snagging risk resulting in a I – Negligible consequence is considered a - Remote.	
Residual Risk	The residual risk associated with this event is Very Low

7.1.5 Demonstration of ALARP

The assessed residual risk ranking for this snagging is very low and cannot be reduced further. Additional control measures were considered (as detailed in **Section 7.1.3**) but rejected since the associated cost / effort was grossly disproportionate to any benefit.

Relevant stakeholders were consulted with during the development of the EP. The 'information for relevant persons' explained the details of the wellhead and that Santos is proposing to leave the wellhead in situ given the age of the structure and the considerable technical risks and challenges in executing its removal wellhead. WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ. WAFIC objects to infrastructure being left in situ that presents a snagging risk to current and future operations.

Given the small size of a deviation required around the wellhead, and given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery, a significant disruption to this fishery is not expected. A detailed feasibility and ALARP assessment of the option to remove the wellhead has been performed (**Section 2.2.1.1**).

It is concluded that the likelihood of interaction between a trawler and the wellhead is a - Remote. In the remote likelihood of a snag event the consequence to commercial trawl fishers would be the loss of some net or wires, with recovery unlikely, causing financial loss. Therefore, significant disruption to trawl fisheries at present or in the future is not expected. It is considered therefore that the impact is ALARP.

The potential impact of displacing other users by leaving the wellhead in-situ has been assessed as I - Negligible. Given the impact is well understood, the negligible consequence and the proposed controls, impacts to marine users are considered ALARP.

7.1.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – Maximum environmental consequence is rated I - Negligible.
Is further information required in the consequence assessment?	No – Potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ecologically sustainable development (ESD)?	Yes - Activity evaluated in accordance with the Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species	Yes – Santos has consulted with relevant decision-making government authorities and no concerns or objections have been raised.

recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Principles and strategic objectives of the 1989 International Maritime Organisation (IMO) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and the Exclusive Economic Zone, the OPGGS Act and OPGGSE(R) are met. As described in **Section 1.7.3.1**, Section 572(3) of the OPGGSA requires titleholders to remove all equipment and property that is neither used nor to be used in connection with the operations unless alternative arrangement can be agreed via NOPSEMA's acceptance of the EP. This EP demonstrates that all impacts and risks of leaving the wellhead in-situ are of an acceptable level. As per 3.15 of the DISER Guideline Offshore petroleum decommissioning, options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the OPGGS Act and regulations, including well integrity and safety-related matters, and other applicable laws. **Section 2.2.1.1** shows that leaving the wellhead in situ delivers an equal or better environmental outcome to removing the wellhead. The 1989 IMO Resolution A6.72 (16), Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (IMO 1989) paragraph 3.1 states that "All abandoned or disused installations or structures standing in less than 75 m of water and weighing less than 4,000 tonnes in air, excluding the deck and superstructure, should be entirely removed." However, it goes on to state that "Notwithstanding the requirements of paragraphs 3.1 and 3.2, where entire removal is not technically feasible or would involve extreme cost, or an unacceptable risk to personnel or the marine environment, the coastal State may determine that it need not be entirely removed." As demonstrated in **Section 2.2**, removal of the Legendre-1 wellhead would result results in localised and direct environmental impacts, which would be avoided by leaving the wellhead in situ. The wellhead removal study (**Section 2.2.1.1**) concluded that whilst both internal and external cutting options are feasible, there is a low chance that they will be successful. There is significant uncertainty in the feasibility of an internal cutting method and the external cutting tool most likely to succeed is a prototype unused for wellheads and is large and bulky which introduces additional safety risks. It is estimated that wellhead removal costs would be in the range of AUD 10 to 15 M for a single dedicated campaign. This cost would be reduced if the campaign can be combined with an additional Santos offshore campaign, with the Legendre-1 costs of a combined campaign estimated to be 5 to 10 M. The complexities and challenges associated with the old wellhead removal could likely result in the activity duration and cost escalating through failed removal attempts. This would extend the duration of environmental impact for no gain in terms of environmental outcomes. In addition, removal of the wellhead carries technical, safety and environmental risks that are not introduced should the wellhead remain in situ. Therefore, the costs and risks to the environment to remove the wellhead are considered disproportionately high to the negligible environmental impact (**Section 2.2**) of leaving the wellhead in-situ. Santos considers that there is technical uncertainty in the feasibility of removal and would involve extreme cost and therefore it is acceptable that the wellhead remains in situ.

Are risks and impacts consistent with the Santos's Environmental Management Policy?	Yes – Aligns with the Santos Environmental Management Policy.
Are risks and impacts consistent with stakeholder expectations?	During the stakeholder consultation process, WAFIC objected to the wellhead being left in situ. Santos has assessed the potential impacts to existing and future fisheries in the area. No fishing effort by a Commonwealth-managed commercial fishery was recorded within WA-20-L from 2009 to 2019. Three state-managed commercial fisheries recorded commercial fishing effort within WA-20-L from 2009 to 2019, being the Mackerel Managed Fishery (MMF), Pilbara Demersal Trap Managed Fishery (PDTMF) and the Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF). Given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery it is concluded that the likelihood of interaction between a trawler and the wellhead is low. In the unlikely event of a snag occurring some damage or loss of equipment may occur. Given the small size of deviation required to move around the known position of the wellhead (marked on charts), and that it has been in place for nearly six decades, negligible disruption to fisheries is predicted.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The removal of the wellhead carries technical, safety and environmental risks (see **Section 2.2**) that are not introduced should the wellhead remain in situ. Vessel operations carry medium ranked risks of hydrocarbon spill, hydraulic fluid spill, and introduction of invasive marine species. Loss of complex habitat will reduce the biodiversity and productivity of the area. Therefore, the costs and risks to the environment to remove the wellhead are considered disproportionately high to the negligible environmental impact of leaving the wellhead in-situ.

The potential socio-economic consequence of leaving the wellhead in-situ has been assessed as I - Negligible. WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of the wellhead when compared to the total amount of trawlable ground in the fishery it is concluded that the likelihood of interaction between a trawler and the wellhead is low. The wellhead is located within largely untrawlable ground and there is low historical fishing effort in the region.

As outlined in **Section 2.2.2.2**, all four vessels active in the PFITMF have passed AMSA stability examinations. In addition, a trawl operator in this area, using the available technologies of trawl monitoring systems, sonar obstacle detection, single-beam echo sounders, integrated GPS platters and seabed mapping software, is likely to be aware of the fixed location of the wellhead and therefore will avoid the obstacle in a timely manner and therefore avoid snagging. In the recent ROV surveys of the wellhead there has been no evidence of snagged gear.

7.2 Release of solid objects

7.2.1 Description of events

Event	Solid objects such as those listed below can be accidentally released to the marine environment: + non-hazardous solid wastes, such as paper, plastics and packaging + hazardous solid wastes, such as batteries, fluorescent tubes, medical wastes, and aerosol cans + equipment and materials, such as hard hats, tools or infrastructure parts.
Extent	The event will only occur within WA-20-L, and all non-buoyant waste material or dropped objects are expected to remain within WA-20-L. Buoyant objects could potentially move beyond WA-20-L.
Duration	An unplanned release of solids may occur during any survey.

7.2.2 Nature and scale of environmental impact

Solids such as plastics have the potential to affect benthic environments and to harm marine fauna through entanglement or ingestion. Release of hazardous solids (for example, wastes such as batteries) may result in the pollution of the immediate receiving environment, leading to detrimental health impacts to marine flora and fauna. Physiological damage can occur through ingestion; or absorption may occur in individual fish and sharks, marine mammals, marine reptiles or seabirds.

7.2.2.1 Threatened, migratory, or local fauna

Marine turtles and seabirds are particularly at risk from entanglement. Marine turtles may mistake plastics for food; once ingested, plastics can damage internal tissues and inhibit physiological processes, which can both potentially result in fauna fatality. Floating, non-biodegradable marine debris has been highlighted as a threat to marine turtles, whales, and whale sharks in the relevant recovery plans and approved conservation advices. The recovery plans and approved conservation advice, as well as the Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans (DoEE, 2018), have specified a number of recovery actions to help combat this threat. Of relevance to this event is the legislation for the prevention of garbage disposal from vessels. As the surveys are of short duration, the risk of unplanned release of plastics is low.

The Recovery Plans and Approved Conservation Advices have specified a number of recovery actions to help combat this threat. Of relevance to this activity is the legislation for the prevention of garbage disposal from vessels, which Santos implements through adherence to MARPOL.

7.2.2.2 Physical environment or habitat

The use of ROVs is not expected to result in any dropped objects and the ROVs will be tethered to the vessel. Non-buoyant equipment dropped over the side of the vessel could impact on the seabed.

While soft sediment benthic habits will not be destroyed, disturbance of the communities on and within them (in other words, the epifauna and infauna) will occur in the event of a dropped object; and depressions may remain on the seabed for some time after removal of the dropped object as they gradually infill over time. The seafloor of this bioregion is strongly affected by cyclonic storms, long-period swells and large internal tides, which can resuspend sediments within the water column and move sediment across the seafloor. In this context, any potential sediment movement caused by a dropped object is likely to have minimal impacts, including to the Glomar Shoal KEF.

The area of potential seabed disturbance due to release of a heavier non-hydrocarbon solid would be restricted to WA-20-L (for example, equipment). The habitat type in WA-20-L is widely distributed and well represented in the NWS region.

7.2.2.3 Socio-economic receptors

Impacts to socioeconomic receptors could occur should debris interfere with other marine users or their equipment (for example, fishing nets). The area of potential disturbance due to a non-buoyant dropped object would be restricted to WA-20-L. The seabed within WA-20-L varies, but is generally made up of silts, sands and some low relief hard substrates and limited benthic faunal communities. Damage to hard substrates within WA-20-L or the KEF, and associated fauna may occur, however such impact is expected to be restricted to the size of the dropped object, and since the vessels will operate over a very short period of time, overall impacts will be I - Negligible.

7.2.3 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

EPO-06: No unplanned objects, emissions or discharges to sea or air.

The CMs for this activity are shown in **Table 7-4**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 7-4: Control measures evaluation for release of solid objects

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control Measures				
CM-20	Waste (garbage) management plan	Reduces probability of garbage (waste) being accidentally discharged to sea, reducing potential impacts to marine fauna. Complies with Marine Order 95, Marine Pollution Prevention – Garbage.	Personnel cost of vessel audits and inspections, and in reporting discharge levels.	**Adopt** – Benefits of ensuring vessel is compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-16	Dropped object recovery	Requires dropped objects to be recovered (where safe and practicable to do so unless the environmental consequences are I - Negligible).	Additional personnel and vessel costs to plan and undertake if safe and practicable to do so.	**Adopt** – Benefits of recovering dropped objects where safe and practicable to do so (unless the environmental consequences are I - Negligible) outweigh the costs.
CM-17	Dropped object prevention procedure	Impacts to environment are reduced by preventing dropped objects.	Personnel costs involved in implementing procedures and in incident reporting.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.
CM-11	Vessel planned maintenance system	Requires that lifting equipment is maintained and certified, and that lifting procedures are followed, reducing probability of dropped objects occurring.	Additional personnel costs of ensuring equipment is maintained and certified as appropriate and that procedures are in place and followed.	**Adopt** – Benefits of ensuring procedures are followed and equipment is compliant outweigh the minimal costs of personnel time.
Additional Control Measures				
N/A	Eliminate lifting in field	Reduces the risk of releasing solid objects to the marine environment due to dropped object.	Eliminating lifting would require support vessels storing more equipment and supplies on board, and/or additional trips	**Reject** – Not feasible to eliminate lifting in the field.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
			to shore. Support vessels will not have enough deck space to store all required equipment, materials, and supplies needed for the duration of the activity, without incurring safety risks.	

7.2.4 Environmental impact assessment

Description – Release of solid objects	
Receptors	Physical environment or habitats Threatened, migratory, or local fauna.
Consequence	I - Negligible
Marine fauna – Cetaceans, marine turtles, seabirds, fish and sharks In the event of loss of a solid object, the quantities would be limited by type of activities planned. If the solid object can be ingested by marine fauna, impacts would be restricted to a small number of individuals, if any. Relevant recovery plans and conservation advice have identified marine debris as a potential threat. There is a Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans (DoEE, 2018). The limited quantities associated with this event indicate that, even in a worst-case release of solid waste, impacts to fauna would be limited to individuals and are not expected to result in a decrease of the local population size. The consequence level is therefore I - Negligible.	
Physical environment – Seabed disturbance In the event of a dropped object, there will be localised and short-term damage to the seabed. The extent of the impact is limited to the size of the dropped object; given the size of the equipment used, any impact is expected to be very small. Any impact to the seabed through dropped objects would result in a I - Negligible reduction in habitat area or function impacted.	
Likelihood	d – Occasional
A set of control measures and checks have been proposed to ensure that the risks of dropped objects, lost equipment or release of hazardous/ non-hazardous solid waste to the environment has been minimised. The likelihood of dropped objects in the operational area is limited and given the controls in place, the likelihood of releasing hazardous and non-hazardous solids to the environment resulting in a I - Negligible consequence is considered to be occasional given the company experience	
Residual Risk	The residual risk associated with this event is Low

7.2.5 Demonstration of ALARP

Wastes generated and equipment used during the activity and managed through the proposed CMs. The CMs proposed are considered sufficient to reduce the risk of dropped objects to a level that is ALARP. No further feasible CMs were identified. If an object is dropped, the incident will be responded to in accordance with the implementation strategy for incident response. With the above controls in place, Santos considers the residual risk arising from a dropped object is ALARP.

7.2.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – residual risk is ranked Low.

Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Santos' Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with MARPOL Annex III. CMs implemented will minimise the potential impacts from the activity to species identified in recovery plans and approved conservation advice as well as the Threat Abatement Plan for the Impacts of Marine Debris on the Vertebrate Wildlife of Australia's Coasts and Oceans (DoEE, 2018) as having the potential to be impacted by non-hydrocarbon surface releases of solid objects. Consistent with relevant species recovery plans, conservation management plans and management actions. Relevant species Recovery Plans, Conservation Management Plans and management actions including but not limited to: Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018) Recovery Plan for Marine Turtles in Australia (2017) Approved Conservation Advice for *Rhincodon typus* (whale shark) (2015a).
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

With the controls in place to prevent accidental release of hazardous/non-hazardous solid waste or a dropped object, and the I - Negligible impacts predicted, the risk to the marine environment is considered low and reduced to a level that is considered acceptable. The activity, undertaken with the controls, will be conducted in a manner that is acceptable under the relevant Recovery Plans and Approved Conservation Advice to prevent accidental release of hazardous/non-hazardous solid (marine debris).

7.3 Introduction of invasive marine species

7.3.1 Description of events

Event	Introduction of IMS may occur due to: + biofouling on vessels and external/internal niches (such as sea chests, seawater systems, etc); + biofouling on equipment that is routinely submerged in water (such as survey equipment); + discharge of high-risk ballast water; or + cross-contamination between vessels. Once established, IMS have the potential to out-compete indigenous species and affect overall native ecosystem function.
Extent	**Localised** (seabed and water column within WA-20-L) to widespread if successfully translocated to new areas via ocean currents or project equipment transit.
Duration	**Temporary** to long-term (in the event of successful translocation).

7.3.2 Nature and scale of environmental impact

IMS are marine flora and fauna that have been introduced into a region that is beyond their natural range but have the ability to survive, and possibly thrive (DAFF, 2011). The majority of climatically compatible IMS to the NWS are found in south-east Asian countries.

Some IMS pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports and tourism (DAFF, 2011; Wells *et al.*, 2009). When IMS achieve pest status, they are commonly referred to as introduced marine pests or IMPs. IMPs can cause a variety of adverse effects in a receiving environment, including:

+ over-predation of native flora and fauna;
+ out-competing of native flora and fauna for food;
+ human illness through released toxins;
+ depletion of viable fishing areas and aquaculture stock;
+ reduction of coastal aesthetics; and
+ damage to marine and industrial equipment and infrastructure.

The above impacts can result in flow on detrimental effects to marine parks, tourism and recreation.

Species of concern are those that are not native to the region, are likely to survive and establish in the region, and are able to spread by human-mediated or natural means. Species of concern vary from one region to another depending on various environmental factors, such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities.

It is recognised that artificial, disturbed and polluted habitats in tropical regions are susceptible to introductions, which is why ports are often areas of higher IMS risk (Neil *et al.*, 2005). However, in Australia there are limited records of detrimental impact from IMS compared to other tropical regions (such as the Caribbean).

Following their establishment, eradication of IMS populations is difficult, limiting management options to ongoing control or impact minimisation. However, this depends on the environmental conditions and species. For this reason, increased management requirements have been implemented in recent years by Commonwealth and State regulatory agencies.

Potential sources for the introduction of marine species into WA-20-L includes biofouling on the vessels, including external niches (such as propulsion units, steering gear and thruster tunnels) and internal niches (such as sea chests, strainers, seawater pipe work, anchor cable lockers and bilge spaces).

Equipment that is submerged in water for periods of time (such as ROVs) may acquire marine pest species, which can be spread if the equipment is not cleaned prior to use in pest-free areas.

Vessels based in local ports, such as Dampier or Onslow, do not carry the same quarantine risks as international vessels or out of State vessels, as they supply the same waters as those WA-20-L resides in. Given the depths at WA-20-L, establishment is considered unlikely to occur on the seabed.

7.3.3 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

+ **EPO-09**: No introduction of marine pest species.

The CMs for this activity are shown in **Table 7-5**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 7-5: Control measures evaluation for introduction of IMS

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard control measures				
CM-30	Implementation of the management controls in the	The risk of introducing IMS is reduced due to assessment	Personnel costs involved in risk assessing vessels in accordance with the Invasive Marine Species Management	**Adopt** – Minimal personnel costs and potential delays or costs to project are

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
	Santos Invasive Marine Species Management Plan (IMSMP)	procedure and management of ballast water.	Plan. Costs associating with reducing the vessel risk to 'low' (for example, dry docking, hull cleaning or additional costs due to inspections). Could lead to potential delays and therefore costs in vessel contracting process due to unavailability of vessels.	considered outweighed by the benefits of reducing the risk of IMS.
CM-31	Anti-foulant system	The risk of introducing IMS is reduced due to anti-foulant systems.	Could lead to potential delays and therefore costs, in vessel contracting process due to availability of vessels with appropriate anti-foulant systems.	**Adopt** – minimal potential delays or costs to project are considered outweighed by the benefits of reducing the risk of IMS.
Additional Control measures				
N/A	Heat or chemical treatment of ballast water to eliminate IMS.	Would reduce potential for IMS to establish by eliminating individuals present in ballast water.	High cost compared to existing risk; introduction of chemicals or water at much higher temperature than surrounding marine environment would likely be toxic or result in death of native marine species.	**Reject** – Based on increased risk to marine environment compared to base case risk.
N/A	Contract vessels only operating in local, State or Commonwealth waters to reduce potential for IMS.	Reduce potential for IMS to be transported into area since vessels would not have originated elsewhere.	Vessels and equipment suitable for the activity may not be available in State/National waters therefore work could not be completed.	**Reject** – not feasible.
N/A	Mandatory dry docking of vessels prior to entering field to clean vessel and/or equipment and remove biofouling.	Ensure that no IMS are present on vessel or associated equipment.	Significant cost (grossly disproportionate to the risk) would lead to scheduling delays.	**Reject** – Costs disproportionately high compared to environmental benefit given other controls in place already reduce the risk.
N/A	Utilise an alternative ballast system to avoid uptake and discharge of water in vessels.	Eliminate need for ballast water exchange, therefore decreasing risk	Vessels suitable for the activity may not have options for alternative ballast, therefore would require modification at significant cost.	**Reject** – Cost disproportionately high compared to env benefit
N/A	Zero discharge of ballast water.	Would reduce the potential for IMS by implementation of no ballast water exchange	Ballast water exchange required on the vessel for stability.	**Reject** – On the basis that ballast water exchange is a safety-critical activity for marine operations.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
		policy on vessels.		

7.3.4 Environmental impact assessment

Description – Invasive Marine Species	
Receptors	Physical Environment and Habitats Threatened, migratory and local fauna Socio-economic receptors Protected areas
Consequence	III - Moderate
Ballast water is responsible for 20 to 30% of all marine pest incursions into Australian waters; however, research indicates biofouling (the accumulation of aquatic micro-organisms, algae, plants and animals on vessel hulls and submerged surfaces) has been responsible for more foreign marine introductions than ballast water (DAFF, 2011). IMS, if successfully established, can outcompete native species for food or space, prey on native species or change the nature of the environment and can subsequently impact on fisheries or aquaculture. If an IMS is introduced, the species has been known to colonise areas outside of the areas to which it is introduced. In the event that an invasive marine species is introduced into WA-20-L, given the lack of diversity and extensiveness of similar benthic habitat in the region, there would only be a minor reduction in the physical environment. No threatened ecological communities are present in the area that could be affected. The overall consequence level was assessed as *III - Moderate*.	
Likelihood	a - Remote
The pathways for IMS introduction are well known; consequently, standard preventive measures are proposed. The ability for invasive marine species to colonise a habitat depends on a number of environmental conditions. It has been found that highly disturbed environments (such as marinas) are more susceptible to colonisation than are open water environments where the number of dilutions and the degree of dispersal are high (Paulay *et al.*, 2002). IMS are more likely to populate shallower areas with favourable substrates. Given that the depth of WA-20-L is greater than 30 m, this creates an unfavourable habitat for colonisation (in other words, light limiting and low habitat biodiversity with sparse epibiota) and it is distant from shallow coastal habitats, there is a very low likelihood that v would be able to survive translocation and subsequently establish and colonise. With CMs in place to reduce the risk of introduction of IMS, the likelihood of introducing an IMS is considered a - Remote.	
Residual Risk	The residual risk associated with this event is Very Low.

7.3.5 Demonstration of ALARP

Vessels and submersible equipment are required for the activity and no alternatives to vessels are feasible.

Ballast water exchange will be managed through Ballast Water Management actions consistent with the Australian Ballast Water Management Requirements (DAWR), and a vessel biosecurity risk assessment in accordance with the IMSMP (EA-00-RI-10172) will be undertaken to demonstrate vessels are low risk so IMS are not introduced.

Santos has adopted a risk-based approach to managing biofouling given it is not practicable or reasonable to inspect and/or clean every vessel before each voyage. Such an approach is consistent with other petroleum operators on the NWS and is beyond that enforced on the majority of commercial and recreation vessels that regularly transit the same bioregion. International vessels are given the highest priority to prevent the introduction of IMS into Australian waters. However, domestic vessels (interstate and locally sourced) are also risk-assessed to reduce the likelihood of spreading marine pest species already established in Australian waters. The biofouling risk assessment approach adopted by Santos will ensure the *Aquatic Resources Management Act 2016* (as amended) and associated regulations prohibiting the introduction of non-endemic fish species will be met.

Typically, domestic vessels will be sourced for the proposed surveys. With the controls in place, vessel risk will be managed to ALARP regardless of the vessel source location.

No other controls were identified to reduce the risk of introducing IMS. Therefore, with the above CMs in place, the risk of introducing IMS has been reduced to ALARP.

7.3.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – introduction of IMS residual risk ranking is Very Low.
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Santos' Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with Biosecurity Act 2015 and National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018). Also consistent with the Aquatic Resources Management Act 2016.
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

The mobilisation of vessels and equipment to undertake offshore petroleum activities is industry standard practice, and the IMS risks are well understood and subject to regulation. The vessels and equipment that are internationally mobilised will meet Australian biosecurity requirements, and proposed management is consistent with National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018).

Application of the proposed CMs and adherence to legislation and regulations reduce the likelihood of introducing IMS into WA-20-L, and the dispersive offshore location in WA-20-L reduces the probability of successful establishment in the unlikely event of introduction.

No stakeholder concerns have been raised regarding this aspect, and the proposed controls will reduce the residual level of risk to Very Low and ALARP. Therefore, the residual risk associated with IMS is considered by Santos to be environmentally acceptable.

7.4 Marine fauna interaction

7.4.1 Description of events

Event	There is the potential for vessels or equipment (for example, ROV) involved in surveys to interact with marine fauna, including potential strike or collision, potentially resulting in severe injury or mortality.
Extent	Within WA-20-L, in the immediate vicinity of the vessels or subsea equipment.
Duration	Vessel usage for approximately 7 days, potentially once during the course of this EP.

7.4.2 Nature and scale of environmental impact

7.4.2.1 Threatened, migratory, or local fauna

Cetaceans are naturally inquisitive marine mammals that are often attracted to vessels underway; for example, dolphins commonly 'bow ride' with vessels.

Marine fauna in surface waters that are most at risk from vessel collision include marine mammals, marine turtles and whale sharks. As summarised in **Section 3**, WA-20-L overlaps with a number of BIAs. Approved Conservation Advice for Megaptera novaeangliae (humpback whale) indicates that humpback whales are one of the most frequently reported whale species involved in vessel strikes worldwide (Laist et al., 2001; Jensen & Silber, 2003). The increase in vessel numbers (Silber & Bettridge, 2012) is not only a threat to humpback whales in relation to vessel strikes but also in disturbance and displacement from key habitats. Similarly, boat strike is also recognised by the Approved Conservation Advice for Rhincodon typus (whale shark) as one of the threats to the recovery of whale sharks and the Conservation Management Plan for the Blue Whale.

The worst potential impact from vessel collision would be mortality or serious injury of an individual. Collisions between vessels and cetaceans are most frequent on continental shelf areas where high vessel traffic and cetacean habitat occur simultaneously (WDCS, 2004). There have been recorded instances of cetacean deaths as a result of vessel collisions in Australian waters (for example, a Bryde's whale in Bass Strait in 1992) (WDCS, 2004), though the data indicate this is likely to be associated with container ships and fast ferries. Whale and Dolphin Conservation Society (WDCS,2004) also indicates some cetacean species can detect and change course to avoid a vessel.

The reaction of whales to the approach of a ship is quite variable. Some species remain motionless when in the vicinity of a ship while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving ships (Richardson et al., 1995).

Turtle/vessel interactions arising from increased vessel traffic is also recognised as one of a number of key impacts to marine turtles in the Recovery Plan for Marine Turtles in Australia (DoEE, 2017). In the recovery plan, vessel disturbance is identified as a risk to flatback turtles. Marine turtles are highly mobile and, given the low speeds of vessels used for operations, are likely to be able to move from an area where there is vessel activity. Marine turtles make extensive migrations through the region; and it is possible that individual turtles of any of the species known from the region may be encountered in WA-20-L.

Marine turtle mortality due to boat strike has been identified as an issue in Queensland waters in the Marine Turtle Recovery Plan (Commonwealth of Australia, 2017). However, turtles appear to be more vulnerable to boat strike in areas of high urban population where incidents of pleasure crafts are higher. WA turtle populations have not been highlighted as those most affected by boat strike, possibly due to the relatively low human population density of the NWS coastline.

Whale sharks, other pelagic fish and demersal fish are likely to exhibit a short-term avoidance to vessels. This is likely to be initiated through the vibrations and underwater noise emitted from these activities (**Section 6.**3) rather than the physical presence. Such avoidance is likely to be temporary.

7.4.3 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

+ **EPO-03:** No injury or mortality to EPBC Act 1999 and *WA Biodiversity Conservation Act 2016* listed marine fauna during activities.

The CMs for this activity are shown in **Table 7-6**. EPSs and measurement criteria for the EPOs are described in **Section 8.**

Table 7-6: Control measures evaluation for marine fauna interaction

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control measures				
CM-10	Procedure for interacting with marine fauna	Reduces risk of physical and behavioural impacts to marine fauna from vessels because if they are sighted, then vessels can slow down, or move away.	Potential delay in vessel movement, increasing activity duration and costs to Santos. Personnel costs involved in reporting sightings to authorities.	**Adopt** – Benefits of reducing risk of impacts to marine fauna outweigh the costs. Implementing relevant EPBC Act procedures for interacting with EPBC Act-listed marine fauna

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
				complies with the EPBC Regulations 2000.
CM-07	Watchkeeping maintained on bridge	Monitoring of surrounding marine environment to identify potential collision risks (and reducing harm) to cetaceans and other marine fauna.	No additional cost; industry practice and regulated by AMSA.	**Adopt** – Industry practice, benefits outweigh cost.
Additional Control Measures				
N/A	Adopt further measures to those outlined in 'EPBC Regulations 2000 — Part 8 Division 8.1 during peak periods of ecological sensitivity, for example, additional management considerations for vessels outlined in the Australian National Guidelines for Whale and Dolphin Watching (2017)	Potentially provide an additional level of protection of marine fauna.	Administrative costs to update existing procedure. Operational costs through interruption to activities through implementation of controls developed for an industry trying to get close to marine fauna, when Santos activities aim to avoid fauna.	**Reject** – The existing control '*procedure for interacting with marine fauna*' has been written in accordance with the EPBC Act and other relevant guidelines. A review of this procedure against the Australian National Guidelines for Whale and Dolphin watching found that there are no additional relevant controls in the Australian National Guidelines for Whale and Dolphin watching and therefore adopting this control is not ALARP.
N/A	Restrict the timing of activities to operate outside of sensitive periods only	Reduce risk of collisions (causing harm) during environmentally sensitive periods for listed marine fauna.	Protected Marine Fauna species are present year-round, meaning there are no non-sensitive periods to operate in.	**Reject** – Grossly disproportionate to the environmental benefit and would severely limit operations which are required to occur 24 hours a day, 7 days a week.
N/A	Dedicated MMO on vessels (EPBC Policy Statement 2.1 Part B)	Improved ability to spot and identify marine fauna at risk of collision (that may cause harm).	Additional cost of contracting MMO.	**Reject** – Risk of animals being encountered is too low to justify additional cost of MMO; in other words, cost is disproportionate to environmental benefit.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
N/A	Limit or exclude night-time operations.	Would eliminate potential impacts to marine fauna during times when watch is limited.	Would double duration of activity; increase impacts or potential impacts in other areas, including increase in waste, air emissions, risk of vessel collision etc.	**Reject** – Given the minimal risk of impacts, the financial and environmental costs by requiring all works to be undertaken during daylight hours only are not considered appropriate given the extended duration of the activity that would occur.

7.4.4 Environmental impact assessment

Key Receptors	Threatened/migratory fauna (marine mammals, marine reptiles, sharks and seabirds).
Consequence	III - Moderate
Threatened, migratory and local fauna There is the potential for death or injury of EPBC listed or local individual species, however, as they would represent a small proportion of the local population it is not expected that it would result in a decreased population size over what would usually occur due to natural variation, at a local or regional scale. It is expected that the loss of an individual would be a III - Moderate consequence.	
Likelihood	b - Unlikely
No known aggregation areas occur within WA-20-L and therefore concentrations of milling individuals are unlikely. Vessels will be moving very slowly while inside WA-20-L, posing a low risk of collision with marine fauna. In addition, the noise generated from vessel operations may locally deter marine fauna from coming in close proximity to vessels. Consequently, the likelihood of a collision with marine fauna resulting in a minor consequence is considered to be b - Unlikely.	
Residual Risk	The residual risk associated with this hazard is Low

7.4.5 Demonstration of ALARP

No alternative options to the use of vessels are possible in order to undertake the activity. Any impact caused by the physical presence of vessels is likely to be localised and temporary, with marine species expected to resume normal behavioural patterns in the open oceanic waters surrounding WA-20-L in a short time frame following completion of the survey.

In the event that vessels come in close proximity to EPBC Act listed marine fauna, such as whales and whale sharks, controls (**Table 7-6**) have been implemented for limiting vessel operations, as well as for ensuring that the crew are aware through inductions of the risk posed by conducting the activity, in order to reduce the likelihood of a marine fauna collision to ALARP.

The inherent likelihood of encountering fauna in WA-20-L is limited by the short duration of the activities and the separation from areas of high surface-fauna density. With low vessel speeds and compliance with fauna interaction procedures, including Regulation 8 of the EPBC Regulations 2000, which aim to prevent adverse interactions of vessels with marine megafauna, a fauna collision is considered very unlikely. With the controls adopted, the assessed residual risk for this impact is ALARP.

7.4.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – maximum marine fauna interaction residual risk ranking is Low.

Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Santos' Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with Part 8 of the EPBC Regulations. CMs implemented will minimise the potential risks and impacts from vessel strike from the activity to relevant species identified in recovery plans and conservation advice, including but not limited to: + Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for Rhincodon typus (whale shark) (2015b) + Conservation Management Plan for the Blue Whale, 2015–2025 (DoE, 2015). + Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021)
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Application of the proposed management and adherence to applicable regulations in line with relevant actions prescribed in the Recovery Plans and Approved Conservation Advices, reduces the likelihood of vessel interactions with marine fauna. While the potential exists for a collision to occur, it is considered a rare scenario. Vessels will be travelling at low speeds within WA-20-L, also reducing the likelihood of fauna strike. In the unlikely event an impact did occur, it would be highly probable that only a single individual would be contacted. It is thought that owing to the rare likelihood of a collision occurring, coupled with the potential impact being limited to a single individual, the risk is deemed acceptable.

7.5 Hazardous liquid releases

7.5.1 Description of event

Event	Causes for accidental liquid releases (other than diesel which is assessed in **Section 7.6**) include: + hydraulic fluids, lubricant oils and stored waste oils from: + stern tube oil (non-hydrocarbon-based lube oil) from the vessel thruster/propeller stern tube (approximately <1 m^3) + loss of primary containment (drums, tanks, IBCs, etc.) due to handling, storage and dropped objects (such as swinging load during lifting activities) + vessel pipework failure or rupture, hydraulic hose failure and inadequate bunding. + chemicals, including corrosion inhibitor, cleaning and cooling agents, recovered solvents, stored or spent chemicals, leftover paint materials and used greases, through: + spills or leaking machinery accidentally discharged overboard in deck drainage water + overflow of the open and closed drainage systems + loss of primary containment (drums, tanks, IBCs, etc.) due to handling, storage and dropped objects (such as swinging load during lifting activities). + oily water from vessels includes bilge water and deck drainage water. The vessel main engines and equipment, such as pumps, cranes, winches, power packs and generators, require diesel for fuel and a variety of hydraulic fluids and lubricating oils for efficient operation and maintenance of moving parts. These products are present within the equipment and also held in storage containers and tanks on vessels. Small hydrocarbon leaks could occur from loss of primary containment due to handling, storage and dropped objects (during lifting activities). Impacts associated with hydrocarbons are provided in **Section 7.6**.
Extent	Volumes are likely to be small and limited to the volume of individual containers (such as intermediate bulk container (IBCs), 44-gallon drums) stored on the deck of supply vessels. The credible spill for this scenario is considered to be the loss of an IBC (1 m^3). The relative low volumes are expected to rapidly disperse into the marine environment. Concentrations below toxic or harmful thresholds are expected to occur at short distances from the release point. Should a spill occur, potential impacts beyond WA-20-L are not expected in the event of a worst-case spill.
Duration	Potentially toxic or harmful threshold concentrations limited to a very short period immediately following an instantaneous release.

7.5.2 Nature and scale of environmental impacts

Hydraulic fluids and lubricating fluids behave similarly to marine diesel when spilt in the marine environment. Hydraulic fluids are oils of light to moderate viscosity and have a relatively rapid spreading rate. Like diesel, they will dissipate quickly, particularly in high sea states, although lubricating oils are more viscous and so the spreading rate of a spill of these oils would be slightly slower.

Impacts associated with the unplanned discharge of hazardous liquids to the marine environment depend on the nature of the liquid released, the volume and its behaviour in the marine environment (i.e. whether it sinks, floats, disperses). In the event of a spill to the marine environment, these liquids would be subjected to rapid dispersion and dilution by the open ocean water conditions and prevailing currents and would remain within the surface waters.

7.5.2.1 Physical environment or habitat

Potential impacts include a temporary and highly localised decline in water quality. This would have limited potential for toxicity to marine fauna, due to the likely short duration of exposure and rapid dilution of the released hazardous liquids in the marine environment.

7.5.2.2 Threatened, migratory or local fauna

Impacts are likely to be limited to the immediate vicinity of the spill and would not affect population viability of contacted species or ecosystem function. The greatest potential for impact would likely be for passive or low mobility fauna such as plankton, pelagic invertebrates and small pelagic fishes which may be exposed for the greatest periods of time and likely have a permanent presence within WA-20-L. Large, more mobile fauna are likely to be transient within WA-20-L and toxic impacts are unlikely to occur to these species in the event of a small liquid hazardous release.

Toxic impacts are not expected to the benthic community due to the water depths.

For marine mammals that may be exposed to the more toxic aromatic components of minor chemical spills, toxic effects are considered unlikely since these species are mobile and therefore will not be constantly exposed for extended durations that would be required to cause any major toxic effects.

It is possible that individual turtles may come into contact with the release, however considering the water depth of WA-20-L compared to observed water depths of internesting turtles, large numbers of the species are not expected and significant impacts to population will not occur. Impacts may occur small proportion (individuals) of a local population with no consequences for conservation status or reproductive success. Deteriorating water quality is identified as a potential threat to turtles in the marine turtle recovery plan and to some bird species. However, the potential minor chemical releases are not expected to significantly impact the receiving environment.

7.5.3 Environmental performance outcomes and control measures

The EPO relating to this event is

EPO-06: No unplanned objects, emissions or discharges to sea or air.

The CMs considered for this activity are shown in **Table 7-7**, with EPSs and measurement criteria for the EPOs described in **Section 8**.

Table 7-7: Control measures evaluation for hazardous liquid releases

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
CM-11	Vessel planned maintenance system	Requires that equipment is maintained and certified, reducing probability of leaks of hydraulic fluid from the equipment.	Additional personnel costs of ensuring equipment is maintained and certified as appropriate and that procedures are in place and followed.	**Adopt** – Benefits of ensuring procedures are followed and equipment is compliant outweigh the minimal costs of personnel time.
CM-19	Oily water treatment system	Reduces potential impacts of discharge of oily water to the environment. Provides compliance with Marine Order 91, Marine Pollution Prevention – Oil.	Time and personnel costs in maintaining oil record book.	**Adopt** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-21	Deck cleaning product selection procedure	Improves water quality discharge (reduces toxicity) to the marine environment. Those deck cleaning products planned to be released to sea meet the criteria for not being harmful to the marine	Personnel costs of implementing. Potential additional cost and delays of deck cleaning product substitution.	**Adopt** – Benefits of ensuring vessels are compliant and that those deck cleaning products planned to be released to sea meet MARPOL criteria outweigh the cost.

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
		environment according to MARPOL Annex V.		
CM-32	Vessel spill response plans (SOPEP/SMPEP)	Implements response plans to deal with an unplanned release quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents and large costs of implementing response strategies.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented and that the vessel is compliant outweighs the costs.
CM-33	Remotely operated vehicle inspection and maintenance procedures	Maintenance and pre-deployment inspection on ROV completed as scheduled to reduce the risk of hydraulic fluid releases to the marine environment.	Additional personnel costs of ensuring procedures in place and followed.	**Adopt** – Benefits of ensuring procedures are followed outweigh costs.
CM-22	Chemical Management Procedure	Potential impacts to the environment are reduced through following correct procedures for the safe handling and storage of chemicals.	Personnel costs associated with ensuring procedures are in place and implemented during handling and storage of chemicals.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented outweigh the costs.
CM-34	Hazardous Chemical Management Procedure	Reduces the risk of spills and leaks (discharges) to sea by controlling the storage, handling and clean-up.	Personnel cost associated with implementation of procedures and permanent or temporary storage areas.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented outweigh costs.
Additional Controls				
N/A	Use of subsea hydraulic fluid in a closed loop system.	Would eliminate the loss of hydraulic fluid from a subsea source.	Closed-loop systems would require an additional return line in the control umbilical and oil cleaning equipment, leading to increased complexity and cost. Commercially available closed-loop systems typically use mineral-based fluids, which if released to the environment have a greater impact than water-based fluids.	**Reject** – Cost disproportionately high compared to env benefit.

7.5.4 Environmental impact assessment

Description – Hazardous Liquid Releases	
Receptors	Physical environment or habitats Threatened, migratory, or local fauna. Protected areas
Consequence	I - Negligible
Physical Environment and Habitats The small volumes and dilution and dispersion from natural weathering processes such as ocean currents are such that spills will be limited in area and duration. Releases of hazardous liquids to the marine environment will impact local water quality for a short period of time whilst the release disperses. Impact to water quality will be I - Negligible. WA-20-L lies within the Glomar Shoals KEF. While the features associated with the KEF are benthic and will not be directly contacted by a surface slick, they may support increased productivity or abundance of marine fauna that use surface waters above the features (including plankton, pelagic invertebrates and fish, marine mammals, marine reptiles and seabirds) which may be impacted by floating oil. Impacts to these marine faunae are described above and in **Table 7-13** and **Table 7-14**.	
Threatened, migratory or local fauna In the event of a minor hazardous liquid release, the quantities would be very small (worst case identified to be limited to approximately 1 m^3 for the loss of the contents of an IBC). The small volume and dilution and dispersion from natural weathering processes such as ocean currents are such that spills will be limited in area and duration. The number of receptors present at the activity location are expected to be limited to a small number of transient individuals. Given that a small hazardous liquid spill would not result in a decreased population size of marine fauna at a local or regional scale, it is expected that a spill of this nature would result in a I - Negligible consequence.	
Likelihood	b - Unlikely
The CMs proposed ensure that the risk of or release hazardous materials to the environment has been minimised. The likelihood of transient marine fauna occurring in WA-20-L coincident with a release is limited and given the CMs in place, the likelihood of releasing hazardous liquids to the environment resulting in a I - Negligible consequence is considered b - Unlikely.	
Residual Risk	The residual risk associated with this event is Very Low

7.5.5 Demonstration of ALARP

Storage and use of hydraulic and lubricating oils or fluids for equipment and machinery are required to undertake the activity, so their removal from the activity is not viable.

Only volumes of hazardous materials as required for maintaining vessel capabilities will be stored or handled on-board the vessels. The vessels will implement safeguards, as per relevant AMSA Marine Orders/MARPOL requirements. Such safeguards may include (but not limited to) designated storage and handling areas, correct stowage, accurate labelling and marking, Safety Data Sheet (SDS) information, spill clean-up equipment and containment.

In addition, administrative controls, such as all vessels being required to have a Garbage Management Plan that describes the on-board controls for preventing unplanned discharges, will minimise the risk of the hazardous liquid being accidentally discharged through mishandling or poor storage.

Other management controls that have been implemented include vessel maintenance systems, chemical management procedures, spill clean-up equipment and SMPEP/OPEPs not only to minimise the risk of an accidental release, but also to reduce the impact in the event that a release does occur.

Containment of small spills from bunding, inherent in the design of vessels and from spill containment kits onboard these vessels (detailed in the SMPEP) provides a barrier to any spills reaching the marine environment. The inspection and maintenance of bunding and drainage systems and of spill response kits provides assurance that these are available to contain spills in the event of a small leak. It is considered that barriers in place to contain spills would prevent spills from reaching the marine environment and thus it is considered that there are no further controls that would offer a further benefit to the environment.

A thorough set of CMs has been proposed to ensure the risks of minor hazardous liquid spills and leaks occurring and subsequent impacts are minimised. The resulting impacts to marine fauna that could potentially result from a spill of this size would be minor, with impacts restricted to a small number of individuals within a localised area.

The CMs proposed are in line with applicable actions described in relevant recovery plans and conservation advice to reduce the risk of habitat degradation and deteriorating water quality (for example, from pollution) to a level considered to be ALARP by Santos. The assessed residual risk for this impact is low and cannot be reduced further. It is considered therefore that the impact of the activities conducted is ALARP.

7.5.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – maximum minor hazard liquid release residual risk is ranked Very Low.
Is further information required in the consequence assessment?	No – potential impacts and risks well understood through the information available.
Are risks and impacts consistent with the principles of ESD?	Yes – activity evaluated in accordance with Santos' Environmental Hazard Identification and Assessment Procedure which considers principles of ESD.
Are risks and impacts consistent with relevant legislation, international agreements and conventions, guidelines and codes of practice (including species recovery plans, threat abatement plans, conservation advice and AMP zoning objectives)?	Yes – management consistent with International Convention of the SOLAS 1974 and *Navigation Act 2012*, MARPOL Annex I – Oil. Consistent with relevant species recovery plans, conservation management plans and management actions including but not limited to: + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for Rhincodon typus (whale shark) (2015b) + Conservation Management Plan for the Blue Whale, 2015–2025 (DoE, 2015). + Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021)
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes (see ALARP above).

With the CMs in place to prevent an accidental release of hazardous liquids and the I - Negligible impacts predicted from unplanned spills, the risk to the marine environment is considered Very Low. Potential risks are unlikely to be greater than those caused by other commercial marine vessels or offshore petroleum activities in deep water.

Hazardous liquids will be managed in accordance with relevant legislation and industry standards and Santos procedures. The small volume negates the need for any further contingencies to be in place that are included for some of the larger spill scenarios associated with the activity.

With the CMs in place to prevent accidental spills and the I - Negligible impacts predicted from a spill of this size, the environmental risk of using and handling the required chemicals is considered acceptable.

7.6 Overview of unplanned release of hydrocarbons

There is the potential for loss of containment of marine diesel as a result of a vessel collision event or refuelling occurring during the activity. Diesel spill trajectory modelling was utilised to predict the potential extent of a worst-case spill event. Hydrocarbon spill modelling was commissioned for the activity (RPS, 2021c).

7.6.1 Spill scenario selection

7.6.1.1 Vessel collision

It is considered credible that a release of diesel to the marine environment could occur from a collision between the activity vessel and a third-party vessel. Such events could have sufficient impact to result in the rupture of a diesel tank (loss of integrity). This is considered credible given the diesel tanks may not be protected or double-hulled, and fuel tank ruptures resulting in a hydrocarbon release have occurred before.

The AMSA (2015) Technical Guidelines for Preparing Contingency Plans for Marine and Coastal Facilities recommend that the spill scenario for modelling and impact assessment should be based on the largest single fuel tank volume. The specific vessel to undertake each survey is yet to be confirmed; a review of available vessels applicable to undertake the activity indicated that the largest single fuel tank is likely to be up to 32.5 m^3 in capacity. Although the likely vessel's largest fuel tank will be smaller, a conservative modelled spill volume of 35 m^3 has been used for this EP.

7.6.2 Spill modelling overview

To determine the spatial extent of impacts from a potential hydrocarbon spill during the proposed survey within WA-20-L, modelling was completed for the vessel collision scenario (RPS, 2021c).

The spill modelling was carried out using a purpose-developed oil spill trajectory and fates model, SIMAP (Spill Impact Mapping and Assessment Program). This numerical model is designed to simulate the transport and weathering processes that affect the outcomes of hydrocarbon spills to the sea, accounting for the specific oil mixture, spill scenario, water temperature and prevailing wind and current patterns.

To account for variable outcomes of the hypothetical spill scenario, depending upon the wind, current and water temperatures over the period of a spill event, a stochastic modelling process was applied.

One hundred simulations of the spill scenario were completed, with each simulation using a unique sequence of current and wind data. The start time for each sequence was selected, at random from within the period of the decade-long set of wind and current data.

The set of 100 replicates was statistically analysed to calculate the frequency at which oil concentrations were calculated by the model to exceed defined thresholds at all locations within the model domain. If, for example, a location was calculated to receive oil concentrations exceeding a given threshold during 50 of the 100 replicate simulations, a probability of 50% was assigned to that location for the probability of exposure to concentrations at or greater than that threshold. Locations that were not calculated to receive exposure at the lower threshold in any of the 100 simulations are designated a probability of < 1% (not 0%). Separate analysis was applied to each of the following:

+ Oil floating at the water surface
+ Oil entrained in the water column as droplets
+ Soluble aromatic hydrocarbons dissolved in the water column
+ Oil contacting shorelines.

A hypothetical spill location at Legendre-1 was used in the model, which was chosen at the well within WA-20-L which is closest to the nearest shallow water feature.

Results of the analysis are presented as spatial maps that define (i) the EMBA (see **Figure 3-1**, and (ii) the area exposed to concentrations above the moderate threshold levels, for each of the oil components (floating, entrained, dissolved (**Figure 7-1**)) resulting from the defined spill scenario occurring at the hypothetical spill site. In addition, results are presented for the maximum concentration of entrained oil (parts per billion) at depths along a transect drawn through the hypothetical spill site and intersecting with the shallowest point along Glomar Shoals, as well as for a transect drawn along the shallowest section of the Glomar Shoals (**Section 7.6.5**).

7.6.3 Hydrocarbon characteristics

Either Marine Diesel Oil or Marine Gas Oil (MGO) could also be used by support vessels. Modelling has performed based on the characteristics of MGO, with MGO and MDO having very similar properties.

MGO is a term applied to fuel oils formulated for use in marine diesel engines that are entirely composed of distillates that are separated from crude oil through the process of heat-fractionation. They contain none of the long carbon chain, high boiling point, residues that are a component of heavier grade fuel oils. MGO formulations vary with grades defined under ISO 8217 2017 Fuel Standard for marine distillate fuels. The more commonly used grade, referred to as DMA grade, was assumed for this study.

DMA grade MGO contains a relatively low proportion (~ 5%) of highly volatile components that might evaporate rapidly (within 3-6 hours) if the oil is afloat and a larger component (~ 43% that would take 1-2 days to evaporate completely if afloat. A further component (~ 50 %) may require a week to weather at temperatures on the North West Shelf, leaving a small residual component. However, the low viscosity of the mixture (4 cP @ 25 C) can be expected to result in a large proportion of the mixture breaking up into small droplets (a few 10s of microns in diameter) and entraining into the upper water column if sea conditions are energetic. Higher rates of entrainment can be expected with increased surface waves, which will occur with increasing wind speeds over open water.

The entrainment process would markedly alter the fate of the mixture by reducing atmospheric weathering, altering the transport of the oil (entrained oil would drift with the prevailing current and not due to the combined effect of current and wind), and increasing the proportion of the soluble components that dissolve (as opposed to evaporating). Reduction of the concentration of entrained droplets would be dependent upon dispersal and biological degradation.

A summary of the representative characteristics of diesel, as assessed in this EP, is provided in **Table 7-8**.

Table 7-8: Summary of diesel characteristics

Oil Name	Initial density (g/cm^3) (25°C)	Viscosity (cP) (25°C)	Component	Volatiles (%)	Semi-volatiles (%)	Low Volatility (%)	Residual (%)	Aromatics (%)
			Boiling Points (°C)	<180 C4 to C10	180 to 264 C11 to C15	264 to 380 C16 to C20	>380 > C20	Of whole oil < 380 °C BP
				NON-PERSISTENT			PERSISTENT	
MGO	0.856 @25°C	4 @25°C	% of total	4.9	42.6	51.5	<1	6.9

7.6.4 Hydrocarbon exposure values

To inform the impact assessment it is important to understand the profile of the concentrations of hydrocarbons after a spill. To do this NOPSEMA recommends identifying hydrocarbon exposure values that broadly reflect the range of consequences that could occur at certain concentrations (NOPSEMA, 2019). The exposure values that have been applied to this EP are described below.

The EMBA shown in **Section 3.1** was identified using low exposure values. These low exposure values are not considered to be representative of a biological impact, but they are adequate for identifying the full range of environmental receptors that might be contacted by surface and/or subsurface hydrocarbons (NOPSEMA, 2019) and a visible sheen.

To inform impact assessment, exposure values that may be representative of biological impact have also been identified. These are called ‘moderate exposure values’ and ‘high exposure values’. Moderate and high exposure values are modelled for each fate of hydrocarbon to identify what contact is predicted for surface (floating oil), subsurface (entrained oil and dissolved aromatic hydrocarbons), and shoreline accumulation of hydrocarbon at sensitivities.

Determining exposure values that may be representative of biological impact is complex since the degree of impact will depend on the sensitivity of the receptors contacted, the duration of the exposure and the toxicity of the hydrocarbon type making the contact. The toxicity of a hydrocarbon will also change over time, due to weathering processes altering the composition of the hydrocarbon. To identify appropriate exposure values Santos has considered the advice provided by NOPSEMA Bulletin #1 Oil Spill Modelling (April 2019) and scientific literature. The selected hydrocarbon exposure values are discussed in **Table 7-9, Table 7-10, Table 7-11** and **Table 7-12**; these tables explain how the exposure value is relevant to the risk evaluation and provides context on how that exposure value is used to inform response planning (which is addressed further in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).

Table 7-9: Floating hydrocarbon exposure values

Surface Oil Concentration (g/m²)	Exposure Value	Description
1	Low	Risk Evaluation It is recognised that a lower floating oil concentration of 1 g/m² (equivalent to a thickness of 0.001 mm or 1 ml of oil per m^2) is visible as a rainbow sheen on the sea surface. Although this is lower than the exposure value for ecological impacts, it may be relevant to socio-economic receptors and has been used as the exposure value to define the spatial extent of the environment that might be contacted (EMBA) from floating oil. Response Planning Contact at 1 g/m² (as predicted by oil spill trajectory modelling) is used as a conservative trigger for activating scientific monitoring plans as detailed in the OPEP.
10	Moderate	Risk Evaluation There is a paucity of data on floating oil concentrations with respect to impacts to marine organisms. Hydrocarbon concentrations for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at about 10 to 25 g/m² (French et al., 1999; Koops et al., 2004; NOAA, 1996). The impact of floating oil on birds is better understood than on other receptors. A conservative exposure value of 10 g/m² has been applied to impacts from surface hydrocarbons (floating oil) in this EP. Although based on birds, this hydrocarbon exposure value is also considered appropriate for turtles, sea snakes and marine mammals (NRDAMCME, 1997). Response Planning Contact at 10 g/m² is not specifically used for spill response planning.
50	High	Risk Evaluation At greater thicknesses the potential for impact of surface oil to wildlife increases. All other things being equal, contact to wildlife by surface oil at 50 g/m² is expected to result in a greater impact. Response Planning Containment and recovery effectiveness drops significantly with reduced oil thickness (McKinney et al., 2017; NOAA, 2014). McKinney et al. (2017) tested the effectiveness of various oil skimmers at various oil thicknesses. Their results showed that the oil recovery rate of skimmers dropped significantly when oil thickness was less than 50 g/m² (less than Bonn Agreement Code 4). Hence, 50 g/m² has been set as a guide for planning effective containment and recovery operations. Similarly, surface oil >50 g/m² (Bonn Agreement Code 4/5 and equivalent to oil observed as discontinuous or continuous true colour) is considered to be a lower limit for effective dispersant operations and is therefore considered for planning.

Table 7-10: Shoreline hydrocarbon accumulation exposure values

Shoreline Accumulation (g/m²)	Exposure Value	Description
10	Low	Risk Evaluation An accumulated concentration of oil above 10 g/m² on shorelines is considered to represent a level of socio-economic effect (NOPSEMA, 2019). For example, reduction in visual amenity of shorelines. This value has been used in previous studies to represent a low contact value for interpreting shoreline accumulation modelling results (French-McCay, 2005, 2006). Response Planning Not specifically used for response planning because below the limit that can be effectively cleaned.

100	Moderate	Risk Evaluation The impact exposure value for exposure to hydrocarbons stranded on shorelines is derived from levels likely to cause adverse impacts to marine or coastal fauna and habitats. These habitats and marine fauna known to use shorelines are most at risk of exposure to shoreline accumulations of oil, due to smothering of intertidal habitats (such as mangroves and emergent coral reefs) and coating of marine fauna. Environmental risk assessment studies (French-McCay, 2009) report that an oil thickness of 0.1 mm (100 g/m²) on shorelines is assumed as the lethal exposure value for invertebrates on hard substrates (rocky, artificial or man-made) and sediments (mud, silt, sand or gravel) in intertidal habitats. Therefore, a conservative exposure value for impacts of 100 g/m² has been applied to impacts from shoreline accumulation of hydrocarbons. Response Planning A shoreline concentration of 100 g/m², or above, is likely to be representative of the minimum limit that the oil can be effectively cleaned according (AMSA, 2015; NOPSEMA, 2019) and is therefore used as a guide for shoreline clean-up planning. This exposure value equates to approximately ½ a cup of oil per square metre of shoreline contacted.
1,000	High	Risk Evaluation At greater thicknesses, the potential for impact of accumulated oil to shoreline receptors increases. All other things being equal, accumulation of oil above 1000 g/m² is expected to result in a greater impact. Response Planning As oil increases in thickness the effectiveness of oil recovery techniques increases. This value can therefore be used to prioritise oil recovery efforts, assuming oil recovery is deemed to have an environmental benefit.

Table 7-11: Dissolved aromatic hydrocarbon exposure values

Dissolved hydrocarbons (ppb)	Exposure Value	Description
10	Low	Risk Evaluation Dissolved Aromatic Hydrocarbons (DAH) include the monoaromatic hydrocarbons (MAHs) (compounds with a single benzene ring such as BTEX [benzene, toluene, ethyl benzene, and xylenes]) and polycyclic aromatic hydrocarbons [PAHs] (compounds with multiple benzene rings such as naphthalenes and phenanthrenes). These compounds have a greater bioavailability that other components of oil and are considered to be main contributors to oil toxicity. The toxicity of DAHs is a function of the concentration and the duration of exposure by sensitive receptors with greater concentration and exposure time causing more sever impacts. Typically tests of toxicity done under laboratory conditions measure toxicity as proportion of test organisms affected (for example, 50% mortality or LC50) at the end of a set time period, often 48 or 96 hours. French-McCay (2002) in a review of literature, reported LC50 for dissolved PAHs with 96 h exposure, range between 30 ppb for sensitive species (2.5th-percentile species) and 2,260 ppb for insensitive species (97.5th-percentile species), with an average of about 250 ppb. The range of LC50s for PAHs obtained under turbulent conditions (this includes fine oil droplets) was 6 ppb to 410 ppb with an average of 50 ppb (French-McCay, 2002). The dissolved hydrocarbon 10 ppb exposure value has been used to inform the EMBA within **Section 7.6**. An exposure value of 10 ppb is appropriate as it is concentration that could have some potential negative effect. Response Planning Contact at 10 ppb (as predicted by oil spill trajectory modelling) is used as a trigger for activating scientific monitoring plans as detailed in the OPEP.

		Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers (NOPSEMA, 2019).
50	Moderate	Risk Evaluation Approximates potential toxic effects, particularly sublethal effects to sensitive species (refer to above text). Consistent with NOPSEMA (2019). Response Planning Encompassed by response to 10 ppb. There is nothing different for higher exposure values.
400	High	Risk Evaluation Approximates toxic effects including lethal effects to sensitive species (NOPSEMA, 2019). Response Planning Encompassed by response to 10 ppb. There is nothing different for higher exposure values.

Table 7-12: Entrained hydrocarbon exposure values

Entrained hydrocarbons (ppb)	Exposure Value	Description
10	Low	Risk Evaluation Entrained hydrocarbons, as opposed to DAHs, are oil droplets suspended in the water column and insoluble. Entrained hydrocarbons are not as bioavailable to marine organisms compared to DAHs and on that basis are considered to be a less toxic, especially over shorter exposure time frames. Entrained hydrocarbons still have potential effects on marine organisms through direct contact with exposed tissues and ingestion (NRC, 2005); however, the level of exposure causing effects is considered to be considerably higher than for DAHs. Much of the published scientific literature does not provide sufficient information to determine if toxicity is caused by entrained hydrocarbons, but rather the toxicity of total oils which includes both dissolved and entrained components. Variations in the methodology of the total water accommodated fraction (TWAF [entrained and dissolved]) may account for much of the observed wide variation in reported exposure values, which also depend on the test organism types, duration of exposure, oil type and the initial oil concentration. Total oil toxicity acute effects of total oil as LC50 for molluscs range from 500 to 2000 ppb (Clark et al., 2001; Long and Holdway, 2002). A wider range of LC50 values have been reported for species of crustacea and fish from 100 to 258,000,000 ppb (Gulec et al., 1997; Gulec and Holdway, 2000; Clark et al., 2001) and 45 to 465,000,000 ppb (Gulec and Holdway, 2000; Barron et al., 2004), respectively. The 10 ppb exposure value represents the very lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC (2019) water quality guidelines. This is consistent with NOPSEMA (2019) guidance. Response Planning Contact at 10 ppb (as predicted by oil spill trajectory modelling) is used as a trigger for activating scientific monitoring plans as detailed in the OPEP. Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers (NOPSEMA, 2019).
100	Moderate	Risk Evaluation The 100 ppb exposure value is considered to be more representative of sub-lethal impacts to most species and lethal impacts to sensitive species based on toxicity testing as described above. This is considered conservative as toxicity to marine organisms from oil is likely to be driven by the more bioavailable dissolved aromatic fraction, which is typically not differentiated from entrained oil in toxicity tests using water accommodated fractions (WAFs). Given

Entrained hydrocarbons (ppb)	Exposure Value	Description
		entrained oil is expected to have lower toxicity than dissolved aromatics, especially over time periods where these soluble fractions have dissolved from entrained oil, the higher Moderate exposure value for entrained oil over DAH (100 versus 50 ppb) is considered appropriate. Response Planning Encompassed by response to 10 ppb. There is nothing different for higher exposure values.

7.6.5 Spill risk assessment approach

A consistent risk assessment approach is applied to the unplanned hydrocarbon release scenario. The spill risk assessment approach is based on Santos' Oil Spill Risk Assessment and Response Planning Procedure (QE-91-II-20003). The procedure describes the spill risk assessment process as follows:

+ Identify the spatial extent of the EMBA. This has been completed for this EP as part of the assessment of the existing environment and receptors that are known to occur or may occur within the EMBA are described **in Section 3**.
+ Identify areas of high environmental value (HEV) within the EMBA.
+ Identify and then risk assess hotspots. Hotspots are effectively a subset of HEVs, and their determination.
+ Identify priorities for protection (for consideration of spill response strategies in the OPEP).

7.6.5.1 Spill environment that may be affected

Defining the EMBA by an oil spill is the first step in oil spill risk assessment. For activities where there is the potential for multiple spill scenarios, the spill scenario, or combination of spill scenarios, resulting in the greatest spatial extent of impacts is used to define the overall EMBA for the activity. The EMBA is further described in **Section 3.1**.

7.6.5.2 Areas of high environmental value

Santos has predetermined areas of high environmental value (HEV) along the Western Australian coastline by ranking these areas based on:

+ Protected area status – This is used as an indicator of the biodiversity values contained within that area, where a World Heritage Area, Ramsar Wetland and Marine Protected Area will score higher than areas with no protection assigned.
+ BIAs of LTS – These are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour, such as reproduction, feeding, resting or migration. Each one of these within the predefined areas contributes to the score.

Further input to determine areas of HEV included:

+ sensitivity of habitats to impact from hydrocarbons in accordance with the guidance document Sensitivity Mapping for Oil Spill Response produced by IPIECA, the International Maritime Organisation and International Association of Oil and Gas Producers;
+ sensitivities of receptors with respect to hydrocarbon-impact pathways;
+ status of zones within protected areas (in other words, IUCN (1a) and sanctuary zones compared to IUCN (VI) and multiple use zones);
+ listed species status and predominant habitat (surface versus subsurface); and
+ social values; in other words, socio-economic and heritage features (such as commercial fishing, recreational fishing, amenities, aquaculture).

Tallied scores for each predefined area along the Western Australian coastline were then ranked from 1 to 5, with an assignment of 1 representing areas of the highest environmental value and those with 5 representing the areas of the lowest environmental value.

7.6.5.3 Priorities for protection

For the purposes of a spill response preparedness strategy, it is not necessary for all HEVs to have detailed planning. For example, wholly submerged HEVs may only be contacted by entrained oil, and the response would be largely to implement scientific monitoring to determine impact and recovery. Features that are not wholly submerged (in other words, emergent features) should have specific spill response planning conducted. This final determination of 'Priority for Protection' sites, for the oil spill response strategy, is based on the worst-case estimate of floating oil concentration, shoreline loading and minimum contact time at exposure value concentrations. An assessment of each protection priority will be undertaken to determine the most appropriate spill response strategies based on the type of oil and the values of the protection priority area. This can be done through a strategic NEBA approach.

7.6.5.4 Potential hydrocarbon impact pathways

To help inform the hydrocarbon spill risk assessment receptors within the EMBA (see **Figure 3-1**) and potential impact pathways have been defined (**Table 7-13**). The potential impact pathways consider physical and chemical pathways. Physical pathways include contact from floating oil and entrained oil droplets. Chemical pathways include ingestion, inhalation or contact from any hydrocarbon phase. The pathways to potential receptors in the EMBA (as relevant to an MGO spill) are summarised in **Table 7-13** and the information is drawn upon within the hydrocarbon risk assessment. **Table 7-14** further describes the nature and scale of the hydrocarbon spills for this activity on marine fauna and socio-economic receptors found within the EMBA.

Table 7-13: Physical and chemical pathways for hydrocarbon exposure and potential impacts

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
Sharks, rays and fish	Coating of adults but primarily eggs and larvae – reduced mobility and capacity for oxygen exchange.	Mortality. Oxygen debt. Starvation. Dehydration. Increased predation. Behavioural disruption.	Ingestion. External contact and adsorption across exposed skin and cellular membranes. Uptake of DAH across cellular membranes (for example, gills).	Mortality. Cell damage. Flesh taint. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Reduced egg/larval success. Growth abnormalities. Behavioural disruption.
Birds (seabirds and shorebirds)	Degree of coating is dependent upon the type of the receptor and continual weathering of the oil.	Feather and skin irritation and damage.	Ingestion (during feeding or preening). External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Growth abnormalities. Behavioural disruption.
Marine reptiles	Degree of coating is dependent upon the type of the receptor and continual	Behavioural disruption particularly during turtle nesting periods.	Inhalation. Ingestion. External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
	weathering of the oil.			Reduced growth. Reduced hatchling success. Reduced reproductive output. Growth abnormalities. Behavioural disruption.
Marine mammals	Fur damage and matting, reduced mobility and buoyancy (for applicable species). Coating of feeding apparatus in some species (in other words, baleen whales).	Behavioural disruption such as deviation from migration pathways and commonly frequented feeding grounds. Smooth skinned marine mammals are more susceptible to chemical pathways than physical pathways.	Inhalation. Ingestion. External contact and adsorption across exposed skin and membranes.	Mortality. Cell damage, lesions. Secondary infections. Reduced metabolic capacity. Reduced immune response. Disease. Reduced growth. Reduced reproductive output. Growth abnormalities. Behavioural disruption.
Plankton	Coating of feeding apparatus. Reduced mobility and capacity for oxygen exchange.	Mortality. Behavioural disruption (for example, reduced mobility).	Inhalation. Ingestion. External contact.	Mortality. Impairment of biological activities (for example, feeding, respiration). Reduced mobility.
Water quality	Presence of hydrocarbon residue in the water. Degree of loading in the water column is dependent upon the influence of wave energy and tidal range.	Impacts to fauna, as discussed in rows above.	Adsorption via cellular membranes and soft tissue, ingestion, irritation/burning on contact and inhalation. Impacts to fauna, as discussed in rows above.	Impacts to fauna, as discussed in rows above.
Protected areas	Note that while the Montebello AMP is within the EMBA, it does not experience surface oil concentrations above the	N/A	N/A	N/A

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
	moderate threshold value.			
Socio-economic environment (fisheries, tourism, shipping, defence, Indigenous users, oil and gas)	Coating of marine fauna/flora within protected areas as discussed in rows above.	Degradation of cultural or maritime heritage sites. Disruption to tourism, recreation or shipping activities. Reduction in resource available for commercial and recreational fisheries.	Impacts to flora, fauna and the physical environment as discussed in rows above. Commercial/recreational fish species – refer to 'fish' as discussed above.	Degradation of cultural or maritime heritage sites. Disruption to tourism, recreation or shipping activities. Reduction in resource available for commercial and recreational fisheries.

Table 7-14: Nature and scale of hydrocarbon spills on receptors within the EMBA

<table>
<tr><th rowspan="2">Receptor</th><th colspan="2">Impacts of hydrocarbon spills</th></tr>
<tr><th>Entrained and dissolved aromatic hydrocarbons in the water column</th><th>Surface hydrocarbons</th></tr>
<tr><td colspan="3">Threatened, Migratory or local fauna</td></tr>
<tr><td rowspan="2">Plankton (including zooplankton; fish and coral larvae)</td><td>There is potential for localised mortality of plankton due to reduced water quality and toxicity. Also, through physical contact of small oil droplets, plankton mobility, feeding and/or respiration may be impaired. Plankton could include the eggs and larvae of marine invertebrates and fish and therefore entrained oil could impact on recruitment of invertebrate/fish species and commercial fisheries. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest.</td><td>Plankton utilising the sea surface layer could be impacted by floating oil.</td></tr>
<tr><td colspan="2">Plankton could include the eggs and larvae of marine invertebrates and fish and therefore impact on recruitment of invertebrate/fish species. WA-20-L has the potential to overlap with spawning of some fish species given the year round spawning of some species. In the unlikely event of a spill occurring, fish larvae may be impacted by hydrocarbons entrained in the water column. Following a hydrocarbon release a portion of the slick will rapidly evaporate and disperse in the offshore environment, reducing the concentration and toxicity of the spill. Plankton utilising the sea surface layer, as well as pelagic invertebrates, could be impacted from floating oil. Exposure to entrained oils and DAHs may result in lethal or sub-lethal impacts to plankton or pelagic invertebrates through a direct contact pathway. Such contact could impair the mobility, feeding and respiration of these fauna and exchange of chemicals could occur.
Entrained oil concentrations above the moderate exposure threshold (see Section 7.6.4) are predicted within 80 km of a spill.
Floating oil concentrations above the moderate exposure threshold are predicted within 20 km of the spill.</td></tr>
<tr><td rowspan="2">Marine mammals</td><td>Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness.</td><td>At risk of direct contact with surface hydrocarbons due to chance of surfacing within slick. Effects include irritation of eyes/mouth and potential illness. Surface respiration could lead to accidental ingestion of hydrocarbons or result in the coating of sensitive epidermal surfaces. Potential impact to feeding apparatus of some species; in other words, baleen whales.</td></tr>
<tr><td colspan="2">Fifteen migratory marine mammal species were identified by the PMST as occurring within the EMBA. Of these, one is listed as endangered (blue whale) and three as vulnerable (humpback whale, fin whale and sei whale). WA-20-L and the EMBA overlap with pygmy blue whale (distribution) and humpback whale (migration) BIAs. For further information about environmental impacts to marine mammals from hydrocarbon exposure and increased toxicity, refer to Table 7-13.
Other migratory marine mammals may encounter either surface or water column hydrocarbons in the EMBA. Dugongs may be particularly susceptible to surface slicks. Aerial surveys of dugong distribution have found that the animals occur around the Montebello Islands (Prince, 2001).</td></tr>
</table>

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
Marine reptiles	Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness. The Recovery Plan for Marine Turtles in Australia: 2017–2027 (Commonwealth of Australia, 2017) highlights acute chemical discharge as one of several threats to marine turtles.	At risk of direct contact with surface hydrocarbons due to chance of surfacing within slick. Effects include irritation of eyes/mouth and potential illness. Surface respiration could lead to accidental ingestion of hydrocarbons or result in the coating of sensitive epidermal surfaces.
	Seven species of Threatened Marine reptile were identified by the PMST as occurring within the EMBA. Short-nosed and leaf-scaled seasnakes, flatback, hawksbill, leatherback, green and loggerhead turtles are widely dispersed across the NWS and in the unlikely event of a hydrocarbon spill occurring, individuals traversing open water may come into contact with water column or surface hydrocarbons. The EMBA overlaps with BIAs for four turtle species (flatback, green, hawksbill and loggerhead) as shown in **Figure 3-1**. WA-20-L overlaps only the BIAs for the flatback turtle. For further detailed environmental impacts to marine reptiles from hydrocarbon exposure and increased toxicity, refer to **Table 7-13**.	
Birds (seabirds and shorebirds)	Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness. May encounter entrained hydrocarbons while diving and foraging.	Particularly vulnerable to surface slicks. As most fish survive beneath floating slicks, they will continue to attract foraging seabirds, which typically do not exhibit avoidance behaviour. Smothering can lead to reduced water proofing of feathers and ingestion while preening. In addition, direct contact with hydrocarbons can erode feathers causing chemical damage to the feather structure that subsequently affects ability to thermoregulate and maintain buoyancy on water. Shorebirds may be impacted by the presence of hydrocarbons accumulated on shorelines which may result in exposure to eggs and ingestion by foraging individuals. Shoreline hydrocarbons are expected to be less toxic than fresh oils due to weathering processes such as photo oxidation and biodegradation reducing the levels of lighter chain hydrocarbons which are generally more toxic.
	Eleven threatened or migratory species of seabirds and shorebirds were identified by the PMST as occurring within the EMBA. The Roseate tern (Vulnerable status) has BIA for breeding intersecting the EMBA. The Wedge-tailed shearwater has BIAs for breeding and foraging intersection WA-20-L and EMBA, as shown in **Figure 3-1**. These species may be impacted by surface and entrained hydrocarbons while foraging (dive and skim feeding) with higher numbers expected during the breeding periods. Birds (seabirds and shorebirds) are highly susceptible to hydrocarbon spills, with impacts primarily attributed to oiling of birds at the sea surface from slicks and oil on shorelines. Impacts to birds may include coating by oil when floating in open water or when diving into open waters to feed on fish. Other impacts could include behavioural impacts whereby birds avoid important nesting and migratory stop-over areas or reduced food availability if important foraging areas are impacted. For further information about environmental impacts to seabirds/shorebirds through hydrocarbon exposure and toxicity effects, refer to **Table 7-13**.	

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
Sharks, Rays and Fish	Hydrocarbon droplets can physically affect fish, sharks and rays exposed for an extended duration (weeks to months). Smothering through coating of gills can lead to the lethal and sub-lethal effects of reduced oxygen exchange, and coating of body surfaces may lead to increased incidence of irritation and infection. Fish may also ingest hydrocarbon droplets or contaminated food leading to reduced growth. There is potential for localised mortality of fish eggs and larva due to reduced water quality and toxicity. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest. For further information about environmental impacts to fish/sharks/rays from hydrocarbon exposure and toxicity effects, refer to **Table 7-13**.	While fish, sharks and rays do not generally break the sea surface, individuals may feed at the surface. For condensate/diesel spills where a slick is expected to quickly disperse and evaporate, prolonged exposure to surface hydrocarbons by fish, shark and ray species is unlikely. However, for diesel the surface slick may extend 150 to 400 km from the release location at the 1 g/m² exposure value and will weather at the sea surface over time with little entrainment into the water column. Due to the filter-feeding nature of whale sharks they may be susceptible to ingesting surface hydrocarbons, both fresh and weathered (tar balls) if feeding at the sea surface particularly from diesel spills.
	The NWS supports a diverse assemblage of fish, including 456 species of finfish, particularly in shallower water near the mainland and islands. Threatened species identified by the PMST of the EMBA are the white shark, whale shark, grey nurse shark, oceanic whitetip shark, shortfin mako shark, longfin mako shark, sawfishes (dwarf, green, narrow), giant manta ray and reef manta ray A whale shark foraging BIA overlaps the EMBA. The EPBC Act-listed whale shark may occur in EMBA between March and June and is known to feed in surface waters. There is, therefore, the potential for this species to ingest oil from surface slicks with resultant damage to gills, other tissues and organs. Given the absence of BIA's and habitat critical for the survival of the species for most of the protected species which have been identified in the PMST, significant numbers are not expected to be exposed to hydrocarbons in the event of a spill. These threatened and migratory fish and sharks could be present at low densities all year round within WA-20-L and the EMBA. For further information about environmental impacts to fish/sharks/rays from hydrocarbon exposure and toxicity effects, refer to **Table 7-13**.	
Socio-economic		
Commercial, Recreational and Traditional Fisheries	Hydrocarbons in the water column can have toxic effects on fish (as outlined above) potentially reducing catch rates and rendering fish unsafe for human consumption.	In addition to the effects of entrained and DAHs, exclusion zones surrounding a spill can directly impact fisheries by restricting access for fishermen. Weathered diesel slicks may form tar balls which may result in oiling of nets and fishing infrastructure.
	A number of commercial fisheries operate within the EMBA (**Section 3.6.1**). Impacts to these fisheries from a spill are expected to be limited to temporary disruption of fishing activities caused by the physical presence of the slick and contact of surface and entrained hydrocarbons with the eggs and larvae of commercially important species. Exposure to entrained and DAHs could result in the accumulation of oil in fish tissues to the extent that could result in hydrocarbon taint of fish flesh. Connell and Miller (1981) compiled a summary of studies listing the exposure value concentrations at which tainting occurred for hydrocarbons. The results contained in their review indicate that tainting of fish occurs when fish are exposed to ambient	

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	**Surface hydrocarbons**
	concentrations of 4–300 ppm (4,000-300,000 ppb) of hydrocarbons in the water, for durations of 24 hours or more, with response to phenols and naphthenic acids being the strongest. Given that entrained hydrocarbons are predicted to exceed the moderate threshold at some locations in the EMBA, hydrocarbon taint is possible in fish flesh although it is difficult to assess how long fish might be exposed for; small, less mobile fishes would be more susceptible. Due to the small size of the potential worst-case spill and there being no known aggregations of key species in the EMBA, it is not considered credible that impacts would be detected to fisheries on a stock level. The same impacts could also occur to important recreational fish species and the recreational fisheries they support.	
Recreation and Tourism	Recreation such as boating, diving and fishing activities are generally concentrated in the vicinity of the population centres such as Dampier, Onslow, Point Samson and Port Hedland. The open waters of WA-20-L do not support significant recreational or tourist activity. The south western extent of the EMBA reaches within 20 km of the Montebello Islands, which offer recreational fishing, surfing, snorkelling and SCUBA diving. Fishing and SCUBA charter companies operate at the islands from April to November. However, the modelling indicates that the EMBA in proximity to the Montebello Islands is defined by entrained oil and the surface oil at levels above the low exposure value would not reach this area. No impact to the values of these tourism areas is expected.	
Shipping	Shipping fairways intersect the EMBA but do not pass through WA-20-L (**Section 3.6.4)**. Hydrocarbons in the water column will have no effect on shipping.	Temporary exclusion zones surrounding a spill would reduce access for shipping vessels for the duration of the response (if applicable); vessel may have to take detours leading to potential delays and increased costs.
Defence	There are no Defence restricted areas within WA-20-L or EMBA. Interference with Defence activities due to a hydrocarbon spill is not expected.	
Shipwrecks	A search of the department of Agriculture, Water and the Environment Australasian Underwater Cultural Heritage Database was undertaken and indicated there are no registered shipwrecks within WA-20-L or the EMBA.	
Cultural Heritage	Marine resource use by First Nations people is generally restricted to coastal waters. Fishing, hunting and the maintenance of maritime cultures and heritage through ritual, stories and traditional knowledge continue as important uses of the nearshore region and adjacent areas. The level of activities undertaken by First Nations people is expected to be low given that no native title claims, or registered cultural heritage sites within the EMBA.	
Existing oil and gas activity	A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. As the surface slick will be at levels above the moderate threshold only within approximately 20 km of the release site, there is limited potential to disrupt activity. Temporary exclusion zones surrounding spills (if applicable) are also unlikely to reduce access to existing operations.	
Protected Areas		
Marine Parks and	The EMBA extends into the Montebello AMP (Multi Use zone) as described in **Section 3.4**. The AMP is managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park values.	

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
Commonwealth Heritage Areas	Modelling predicts that the Montebello AMP will not receive hydrocarbons at levels above the moderate thresholds.	
KEFs	The EMBA overlaps the Glomar shoals KEF, the Ancient Coastline at 125 m KEF and a small portion of the Continental Slope Demersal Fish Communities. WA-20-L sits within the Glomar shoals KEF.	
	While the values associated with the KEFs are benthic habitat and will not be directly contacted by a surface slick or entrained oil, they may support increased productivity or abundance of marine fauna that use surface waters above the features (including plankton, pelagic invertebrates and fish, marine mammals, marine reptiles and seabirds) which may be impacted by floating oil. Impacts to these marine faunae are described above. In the case of Continental Slope Demersal Fish Communities, impacts are not expected as hydrocarbon concentrations are below the moderate thresholds at this location.	

7.7 Release of hydrocarbons

7.7.1 Description of event

Event	It is considered credible that a release of diesel to the marine environment could occur from a collision between the activity vessel and a third-party vessel. The specific vessel to undertake the survey is yet to be confirmed; a review of available vessels indicated that the largest single fuel tank is likely to be up to 35 m³ in capacity. Although the likely vessel's largest fuel tank will be smaller, a conservative modelled spill volume of 35 m³ has been used for this EP. No vessel refuelling will occur during the survey activity.
Extent	Diesel spill trajectory modelling (RPS, 2021) of a 35 m³ MGO* spill predicted the following (using the moderate exposure thresholds): No shoreline contact. Surface oil to occur within approximately 20 km. Entrained hydrocarbons to occur up to 80 km from the spill, though will occur mostly within 60 km. No quantifiable areas of dissolved hydrocarbons.
Duration	An instantaneous release of 35 m³ of diesel was modelled.

*Marine Gas Oil (MGO) is a term applied to fuel oils formulated for use in marine diesel engines that are entirely composed of distillates

7.7.2 Nature and scale of environmental impact

Hydrocarbon spills can cause a decline in water quality and may cause chemical (for example, toxic) and physical (for example, coating of emergent habitats, oiling of wildlife at sea surface) impacts to marine species. The severity of the impact of a hydrocarbon spill depends on the magnitude of the spill (in other words, extent, duration) and sensitivity of the receptor. The nature and scale of a hydrocarbon spill is described throughout this chapter for a vessel collision scenario, given smaller hydrocarbon spills (from refuelling) will impact a smaller area than a vessel collision.

A surface release of MGO to the marine environment would result in temporary and localised reduction in water quality in the upper surface waters of the water column near the location of the spill. Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-13** and potential impacts to receptors found within the EMBA are further described in **Table 7-14**.

7.7.3 Spill modelling results

Spill trajectory modelling (RPS, 2021c) of a 35 m³ MGO spill predicted the following (using the moderate exposure value):

+ No shoreline contact.
+ Surface oil present within approximately 20 km of the spill site.
+ Entrained hydrocarbons present within approximately 80 km of the spill site.
+ No quantifiable areas of dissolved hydrocarbons.

The areas exposed to hydrocarbon levels in exceedance of the moderate exposure values defined in **Section 7.6.4** are presented in **Figure 7-1**.

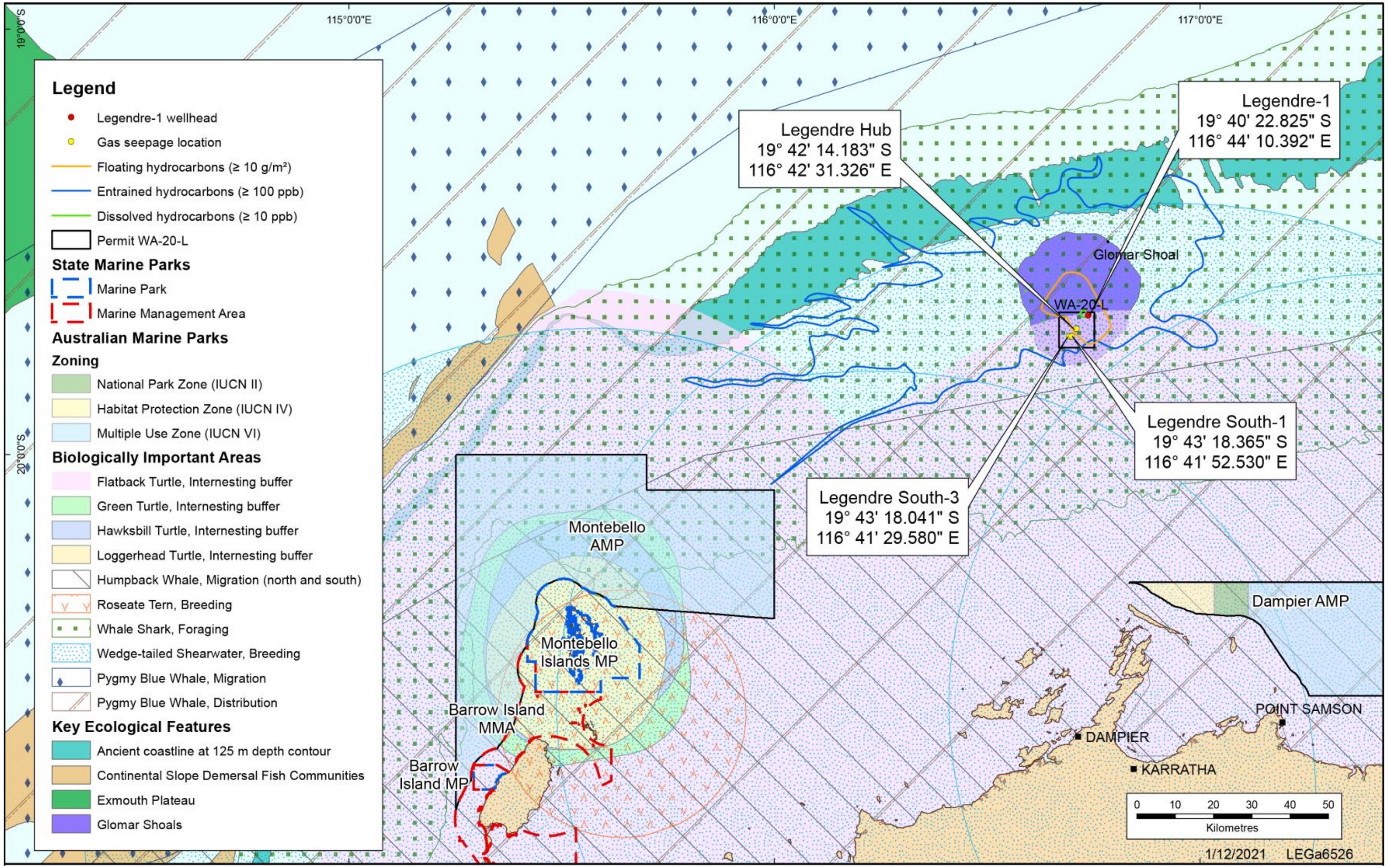


Figure 7-1: Areas contacted above moderate exposure values for a 35 m^3 MGO spill

Figure 7-2 presents the predicted maximum concentration of entrained oil (parts per billion) at depths along a transect drawn through the hypothetical spill site and intersecting with the shallowest point along Glomar Shoals and **Figure 7-3** presents this information for a transect drawn along the shallowest section of the Glomar Shoals.

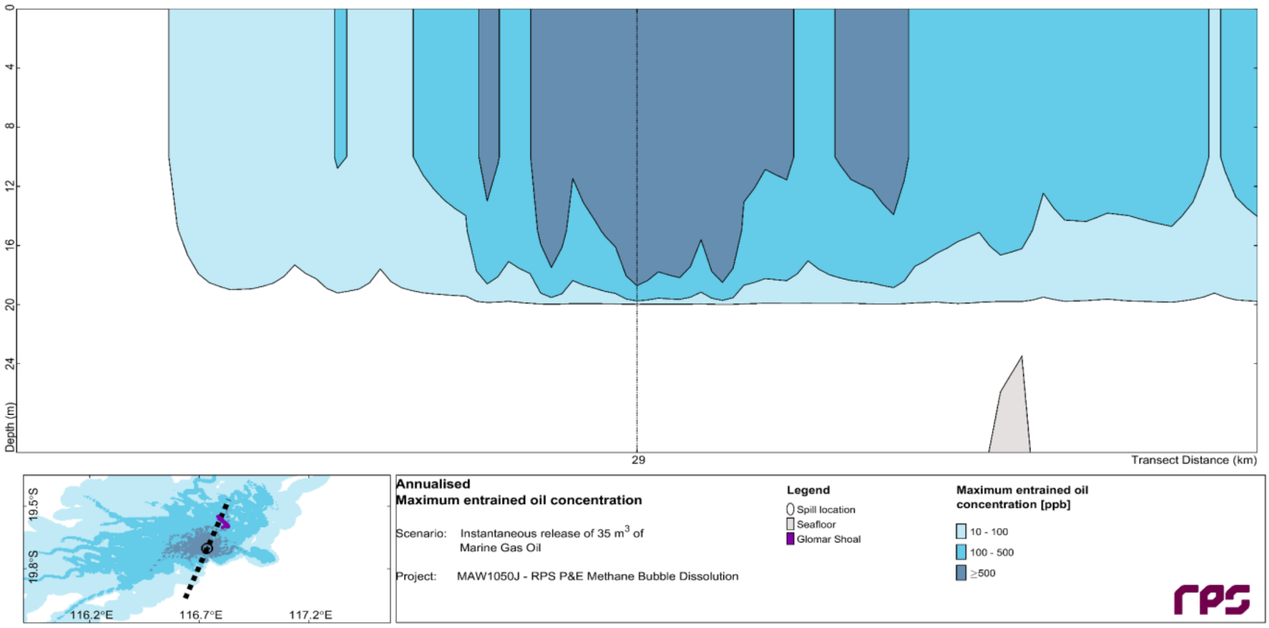


Figure 7-2: Maximum concentration of entrained oil (parts per billion) at depths along a transect drawn through the hypothetical spill site and intersecting with the shallowest point along Glomar Shoals (35 m3 MGO spill)

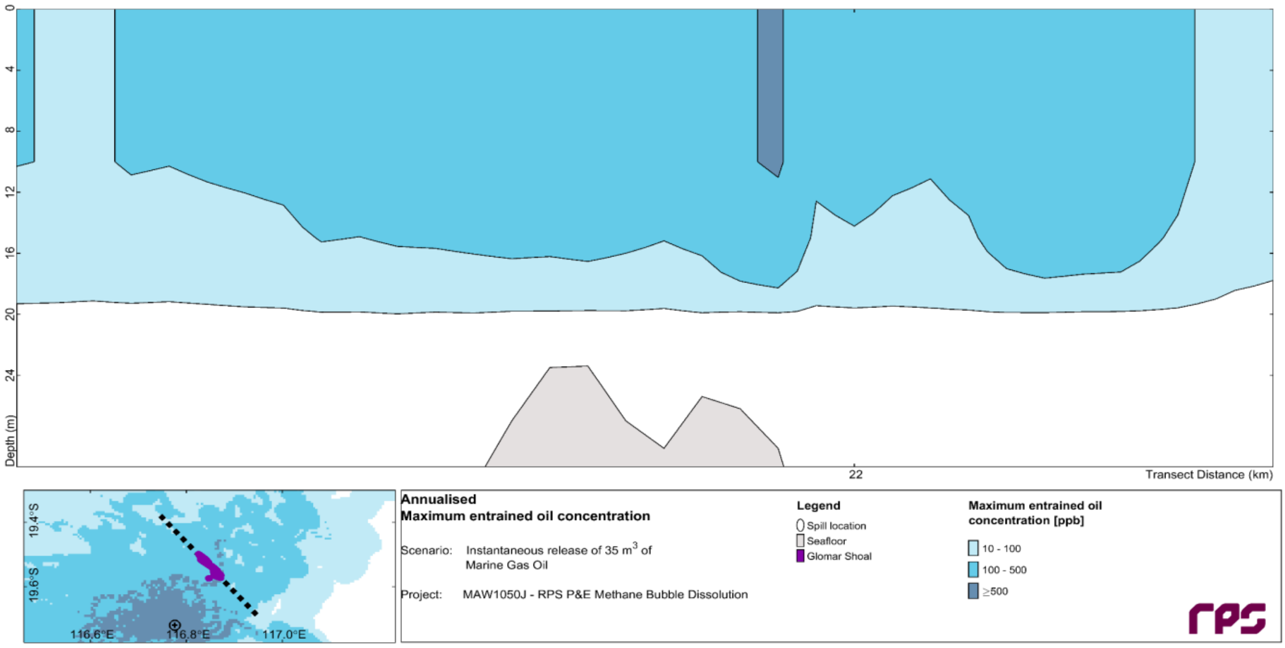


Figure 7-3: Maximum concentration of entrained oil (parts per billion) at depths along a transect drawn along the shallowest point along Glomar Shoals (35 m3 MGO spill)

Figure 7-2 and **Figure 7-3** demonstrate that although the area that might potentially receive entrained oil concentrations > 100 ppb extends over the shallow ridge of Glomar Shoals, concentrations > 10 ppb are not expected to extend to the depth of the shallowest ridge.

7.7.4 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

+ EPO-10: No loss of containment of hydrocarbon to the marine environment.

CMs applied to prevent a hydrocarbon spill from refuelling and vessel collision are shown in **Table 7-15** and corresponding EPSs and measurement criteria are described in **Section 8**.

Selection of oil spill response strategies and associated performance outcomes, CMs and performance standards, including those required to maintain preparedness and for response, are detailed within the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01). The OPEP contains an evaluation of oil spill preparedness arrangements to demonstrate that oil spills will be mitigated to ALARP.

Table 7-15: Control measures evaluation for release of hydrocarbons

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control measures				
CM-06	Lighting will be used as required for safe work conditions and navigational purposes	Ensures vessels meet minimum safety standards therefore reducing potential for vessel collision events with associated diesel spill to the environment. Marine Order Part 30: Prevention of Collisions, and with Marine Order Part 21: Safety of Navigation and Emergency Procedures requires vessels to have navigational equipment to avoid collisions. Requirement of the *Navigation Act 2012*.	Costs associated with personnel time in checking vessel certifications are in place. Negligible costs of operating navigational equipment.	**Adopt** – Benefits considered to outweigh costs.
CM-07	Watchkeeping maintained on bridge	Minimises risk of collision through visual identification and avoidance of other vessels.	Negligible costs	**Adopt** – Benefits considered to outweigh costs.
CM-32	Vessel spill response plans (SOPEP/ SMPEP)	Implements response plans on board vessels to deal with unplanned hydrocarbon releases and spills quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents. Generally undertaken by vessel contractor so time for Santos personal to confirm and check SOPEP/SMPEP in place.	**Adopt** – Benefits considered to outweigh costs.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-35	Accepted oil pollution emergency plan (OPEP)	Implements response plans to deal with an unplanned hydrocarbon release quickly and efficiently in order to reduce impacts to the marine environment.	Administrative costs of preparing documents and large costs of preparing for and implementing response strategies.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented and that the vessels are compliant, outweighs the costs. Regulatory requirement must be adopted.
CM-36	Marine assurance standard	Ensures vessels meet Marine assurance standards to reduce the likelihood of unplanned discharges.	Costs associated with personnel time in checking vessel.	**Adopt** – Benefits of ensuring procedures are followed and measures implemented and that the vessels are compliant, outweighs the costs. Regulatory requirement must be adopted.
CM-37	Pre-Activity commencement assurance check	Ensures consideration of worst-case hydrocarbon spill scenario for the proposed activity based on actual vessel and activity details	Administrative costs to undertake assurance check and risk assessments for each survey undertaken.	**Adopt** – Benefits considered to outweigh costs.
Additional control measures				
N/A	Schedule activities to avoid coinciding with sensitive periods for marine fauna present in WA-20-L	Potential reduction in risk of a hydrocarbon spill to some sensitive receptors.	Impractical to schedule activities to avoid all listed marine fauna due to variability in timing of environmentally sensitive periods and the constant or unpredictable presence of some species. Short duration activity (in other words, a few days) that is low risk to marine fauna.	**Reject** – Cost is disproportionate to increase in environmental benefit.
N/A	Require all vessels involved in the activity to be double hulled	Reduces the likelihood of a loss of hydrocarbon inventory in the highly unlikely event of a vessel collision, minimising potential environmental impact.	Vessels are subject to availability and are required to meet Santos' standards during activities; requirement of a double hull on vessels would limit the number available to Santos; requiring vessels to be refitted to ensure double hulls would also be of high cost.	**Reject** – Large costs associated with vessel selection and by having an activity schedule determined by vessel availability considered grossly disproportionate compared to low risk of a vessel collision and low risk of a large diesel spill.

7.7.5 Environmental impact assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.6.5**.

Two areas of high environmental value have been identified within the EMBA, the Montebello AMP and Glomar Shoals KEF. The Glomar Shoals KEF is the only high environmental value area contacted by hydrocarbons greater than the moderate exposure values.

Table 7-16: Summary of high environmental values areas

Receptor	Exposure Value	
	Low	Moderate
Glomar shoals KEF	✓	✓
Montebello AMP	✓	✗

Priority protection areas are emergent features (i.e., coastal areas and islands) that would be targeted by nearshore spill response operations such as protection and deflection and shoreline clean-up. No priority protection areas for spill response have been identified.

The closest shallow feature within the EMBA is a ridge within the Glomar Shoals which rises to a minimum water depth of approximately 22 m. Oil spill modelling indicates that neither entrained nor dissolved oil at levels greater than 10 ppb will reach this depth.

Therefore, in the event of a 35 m^3 MGO spill at WA-20-L, mobile fauna in the area where floating and entrained oil concentration are above the moderate exposure values, would constitute the highest priority for response.

Key sensitivities in WA-20-L are the:

+ Pygmy blue whale (Distribution BIA);
+ Whale sharks (Foraging BIA);
+ Flatback turtles (Internesting BIA); and
+ Wedge-tailed shearwater (Reproduction BIA).

Description	
Key Receptors	Physical environment and habitats Threatened, migratory fauna and local fauna Protected Areas Socio-economic
Consequence	II - Minor
A summary of the consequence assessment for each receptor category is presented below. Potential impact pathways (physical and chemical) of hydrocarbon exposure for receptors are summarised in **Table 7-13**, and potential impacts to receptors found within the EMBA are further described in **Table 7-14**.	
<u>Physical environment and habitats</u> Hydrocarbons are not predicted to reach any shorelines or impact benthic habitats. A surface release of MGO to the marine environment would result in a localised reduction in water quality in the upper surface waters of the water column. As a light hydrocarbon, MGO undergoes rapid spreading and evaporative loss in warm waters, indicating that a surface slick will be temporary. DMA grade MGO contains a relatively low proportion (~ 5%) of highly volatile components that might evaporate rapidly (within 3-6 hours) if the oil is afloat and a larger component (~ 43% that would take 1-2 days to evaporate completely if afloat. A further component (~ 50 %) may require a week to weather at temperatures on the North West Shelf, leaving a small residual component. Impacts to water quality are predicted by modelling to be: + Surface oil above the moderate exposure value within approximately 20 km. + Entrained hydrocarbons above the moderate exposure value within approximately 80 km. + No quantifiable areas of dissolved hydrocarbons. The worst-case consequence to the physical environment and habitats from a vessel collision resulting in a worst-case unplanned hydrocarbon release is ranked as II - Minor.	

Description
Threatened, migratory and local fauna Surface oil, and entrained hydrocarbon in the sea surface layer, could have the physical effect of coating fauna interacting within and under the surface, including plankton, pelagic invertebrates and fishes, marine reptiles, marine mammals and seabirds, and may also affect some species through ingestion of oiled fish (as described in **Table 7-13** and **Table 7-14**). The pygmy blue whale distribution BIA overlaps the area exposed to hydrocarbon levels greater than the moderate exposure levels. There is the potential for behavioural disruption to individuals as they traverse the area affected, with potential for coating of and ingestion of oiled prey (plankton/fish) as described in **Table 7-13** and **Table 7-14**. Waters exposed to hydrocarbon levels greater than the moderate exposure levels overlap a reproduction BIA for the Wedge-tailed shearwater. An unplanned release of MGO is not expected to interfere with their breeding activity, but could cause slight secondary effects through ingestion after preening or ingestion of oiled fish (as described in **Table 7-13** and **Table 7-14**). The whale shark foraging BIA overlaps the area exposed to hydrocarbon levels greater than the moderate exposure levels. There is the potential for behavioural disruption to the local population as individuals traverse the area affected, with potential for coating of and ingestion of oiled prey (plankton/fish) as described in **Table 7-13** and **Table 7-14.** The humpback whale (migration, north and south) BIA overlaps a very small portion of the area predicted to receive entrained oil at levels above the moderate exposure value (**Figure 7-1**), with minor impact to individuals possible. The area exposed to hydrocarbon levels greater than the moderate exposure levels overlaps the outer limits of an internesting buffer BIA for flatback turtle. Behaviour could be temporarily disrupted for a small number of individuals, however due to the temporary duration and small area of exposure, this disruption is not expected to threaten turtle populations. Deteriorating water quality is identified as a potential threat to turtles in the marine turtle recovery plan and to some bird species (**Table 3-3**). The worst-case consequence to the physical environment and habitats from a vessel collision resulting in a worst-case unplanned hydrocarbon release is ranked as II - Minor.
Protected areas Modelling predicts that the Montebello AMP will not receive hydrocarbons at levels above the moderate exposure levels (**Figure 7-1**). Modelling indicates that the EMBA in proximity to the Montebello AMP is defined by entrained oil and the surface oil at levels above the low exposure value would not reach this area. WA-20-L is situated within the Glomar Shoals KEF. While the features associated with the KEF are related to benthic habitat and will not be directly contacted by a surface or entrained oil, they may support increased productivity or abundance of marine fauna that use surface waters above the features (including plankton, pelagic invertebrates and fish, marine mammals, marine reptiles and seabirds) which may be impacted by floating oil. Impacts to these marine faunae are described above and in **Table 7-13** and **Table 7-14**.
Socio-economic receptors Impacts to fisheries from a hydrocarbon spill are expected to be limited to temporary disruption of fishing activities caused by the physical presence of the slick and contact of surface and entrained hydrocarbons with the eggs and larvae of commercially important species. Given that entrained hydrocarbons are predicted to exceed the moderate threshold at some locations in the EMBA, hydrocarbon taint is possible in fish flesh although it is difficult to assess how long fish might be exposed for; small, less mobile fishes would be more susceptible. Due to the small size of the potential worst-case spill and there being no known aggregations of key species in the EMBA, it is not considered credible that impacts would be detected to fisheries on a stock level. The same impacts could also occur to important recreational fish species and the recreational fisheries they support. A number of oil and gas operators operate within the EMBA with existing projects and infrastructure in place as well as continuing drilling and exploration programs. As the surface slick will be at levels above the moderate threshold only within approximately 20 km of the release site, there is limited potential to disrupt activity. Temporary exclusion zones surrounding spills (if applicable) are also unlikely to reduce access to existing operations. Temporary exclusion zones surrounding a spill would reduce access for shipping vessels for the duration of the response (if applicable); vessel may have to take detours leading to potential minor delays and increased costs.

Description	
The worst-case consequence to socio-economic receptors from a vessel collision resulting in a worst-case unplanned hydrocarbon release, is ranked as a II - Minor.	
Likelihood	b - Unlikely
The likelihood of a hydrocarbon release occurring due to a vessel collision is limited given the set of mitigation and management controls in place. Subsequently the likelihood of a vessel collision releasing hydrocarbons to the environment resulting in a major consequence is considered to be b – Unlikely.	
Residual Risk	Very Low

7.7.6 Demonstration of ALARP

The use of vessels is integral to activity and therefore vessels and associated risks of unplanned hydrocarbon releases, cannot be completely eliminated.

Hydrocarbon types such as heavy fuel oil and intermediate fuel oil will not be used for this activity (only diesel will be used in WA-20-L).

The combination of the standard prevention CMs (**Section 7.7.4**) (which reduce the likelihood of the event happening), and the spill response strategies together reduce the overall hydrocarbon spill risk.

No additional controls have been identified and given the controls in place detailed above, the assessed residual risk for this impact is Low and cannot be reduced further. It is considered therefore that the impact of the activities conducted is reduced to ALARP.

In terms of spill response activities, Santos will implement oil spill response as specified within the OPEP. A detailed ALARP assessment on the adequacy of arrangements available to support spill response strategies and CMs is presented in the OPEP.

7.7.7 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – residual risk is ranked as Very Low.
Is further information required in the consequence assessment?	No – potential impacts and risks are well understood through the information available.
Are the activities and their risks and impacts consistent with the principles of ESD?	Yes – aligns with the principles of ESD where these natural resources are used in a sustainable manner with environmental and economic considerations factored into decision making.
Are performance standards consistent with industry standards, legal and regulatory requirements, including protected matters?	Yes – management consistent with the OPGGS(E)R and with International Convention of the SOLAS) 1974 and Navigation Act 2012, MARPOL Annex I – Prevention of Pollution from Ships, and relevant recovery plans. Santos has considered the values and sensitivities of the receiving environment including, but not limited to: IUCN principles and strategic objectives of nearby reserves (Montebello AMP) are met Relevant Species Recovery Plans, Conservation Management Plans and management actions, including but not limited to: + Threat Abatement Plan for Impacts of Marine Debris on Vertebrate wildlife of Australia's coasts and oceans (DoEE, 2018) + Recovery Plan for Marine Turtles in Australia (2017) + Approved Conservation Advice for *Rhincodon typus* (whale shark) (2015b) + Approved Conservation Advice for *Balaenoptera physalus* (fin whale) (2015c) + Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015d) + Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*)

	(2014b) + Recovery Plan for the White Shark (*Carcharodon carcharias*) (2013a) + Sawfish and River Sharks Multispecies Recovery Plan (2015a) + Commonwealth Conservation Advice on *Pristis zijsron* (green sawfish) (2008) + Blue Whale Conservation Management Plan 2015–2025 (DoE, 2015) + Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE, 2021) + Wildlife Conservation Plan for Migratory Shorebirds (2015) + Conservation advice for various seabird species.
Are risks and impacts consistent with Santos Environment, Health and Safety Policy?	Yes – aligns with Santos Environment, Health and Safety Policy.
Are risks and impacts consistent with stakeholder expectations?	Yes – no concerns raised.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP assessment above.

Given the CMs in place to prevent a vessel collision and the low frequency of significant volume diesel spills that occur in the industry, a loss of containment event during the activity is unlikely. The risks from diesel spills are well understood and the activities will be managed in accordance with relevant legislation and standards. The CMs proposed are consistent with applicable actions described in the relevant Recovery Plans and Approved Conservation Advice and no stakeholder concerns have been raised regarding this aspect.

With the implementation of industry standard and activity-specific CMs to reduce the chance of a diesel spill event (and minimise impacts), the residual risk is assessed to be Very Low and ALARP. CMs will reduce the risk of impact from MDO spill to a level that is acceptable.

8 Implementation strategy

OPGGS(E)R 2023 Requirements
Section 22(1)
The environment plan must contain an implementation strategy for the activity in accordance with this regulation.
Section 22(16)
The implementation strategy must comply with the Act, this instrument, any other regulations made under the Act, and any other environmental legislation applying to the activity.

The specific measures and arrangements that will be implemented in the event of an oil pollution emergency are detailed within the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).

Stakeholder engagement is assessed separately for the requirements of the activity. Ongoing stakeholder management strategies are discussed in **Section 4**.

8.1 Environmental management system

OPGGS(E)R 2023 Requirements
Section 22(2)
The implementation strategy must contain a description of the environmental management system for the activity, including specific measures to be used to ensure that, for the duration of the activity: + the environmental impacts and risks of the activity continue to be identified and reduced to a level that is ALARP; and + CMs detailed in the environment plan are effective in reducing the environmental impacts and risks of the activity to ALARP and an acceptable level; and + environmental performance outcomes and standards set out in the environment plan are being met.

Santos' Management System exists to support its moral, professional and legal obligations to undertake work in a manner that does not cause harm to people or the environment. The framework of policies, standards, processes, procedures, tools and CMs that, when used together by a properly resourced and competent organisation, result in:

+ a common HSE approach is followed across the organisation.
+ HSE is proactively managed and maintained.
+ the mandatory requirements of HSE management are implemented and are auditable.
+ HSE management performance is measured and corrective actions are taken.
+ opportunities for improvement are recognised and implemented.
+ workforce commitments are understood and demonstrated.

The structure of this implementation strategy aligns with the HSE Management System structure and is designed to require that:

+ environmental impacts and risks continue to be identified for the duration of the activity and reduced to ALARP.
+ CMs are effective in reducing environmental impacts and risks to ALARP and acceptable levels.
+ environmental performance outcomes and standards set out in this EP are met.
+ Relevant person consultation is maintained throughout the activity as appropriate.

8.2 Environment, Health and Safety policy

Santos' Environment, Health and Safety Policy (**Appendix A**) clearly sets out Santos' strategic environmental objectives and the commitment of the management team to continuous environmental performance improvement. This EP has been prepared in accordance with the fundamentals of this policy. By accepting employment with Santos, each employee and contractor is made aware during the recruitment process that he or she is responsible for the application of this policy.

8.3 Hazard identification, risk and impact assessment and controls

Hazards and associated environmental risks and impacts for the proposed activity have been systematically identified and assessed in this EP (refer to **Sections 6** and **7**). The CMs and EPSs that will be implemented to manage the identified risks and impacts, and the EPOs that will be achieved, are detailed in **Section 8.4**.

To ensure that environmental risks and impacts remain acceptable and ALARP during the activity and for the duration of this EP, hazards will continue to be identified, assessed and controlled as described in **Section 8.10** (Document Management) and **Section 8.11** (Audits and Inspections).

Any new, or proposed amendment to a CM, EPS or EPO will be managed in accordance with the MoC procedure (**Section 8.10.2**).

Oil spill response CMs and EPSs and EPOs are listed in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).

8.4 Environmental performance

To ensure environmental risks and impacts will be of an acceptable level, EPOs have been defined and are listed in **Table 8-1**. Those relating to oil spill response are listed in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).

Table 8-1: Environmental performance outcomes

Reference	Environmental Performance Outcomes
EPO-01	No significant effect on marine fauna or benthic habitats caused by sediment and water quality changes due to gas seepage.
EPO-02	Reduce impacts on other marine users through the provision of information to relevant stakeholders such that they are able to plan for their activities and avoid unexpected interference.
EPO-03	No injury or mortality to EPBC Act 1999 and *WA Biodiversity Conservation Act 2016* listed fauna during activities.
EPO-04	Reduce impacts to marine fauna from lighting on vessels through limiting lighting to that required by safety and navigational lighting requirements.
EPO-05	Reduce impacts to air and water quality from planned discharges and emissions from the activities.
EPO-06	No unplanned objects, emissions or discharges to sea or air.
EPO-07	Seabed disturbance is limited to the extent required for sampling.
EPO-08	Marine users are not adversely impacted by the presence of the wellhead.
EPO-09	No introduction of marine pest species.
EPO-10	No loss of containment of hydrocarbon to the marine environment.

8.4.1 Control measures and environmental performance

OPGGS(E)R 2023 Requirements
Section 22(7)
The environment plan must: + set environmental performance standards for the CMs identified under paragraph (5)(c); and + set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and + include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

The CMs that will be used to manage identified environmental impacts and risks and the associated statements of performance required of the CM (in other words, EPSs) are listed in **Table 8-2**. Measurement criteria outlining how compliance with the CM and the expected environmental performance could be evidenced are also listed. CMs relating to oil spill response are listed in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).

Table 8-2: Control measures and environmental performance standards for the proposed activities

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference	Measurement Criteria	EPO Reference	Section
Gas seepage monitoring campaign	CM-01	Monitoring and recording of gas flow rates and constituents is undertaken, in the fourth year after the EP is accepted. Sampling of water quality and sediment quality at Legendre Hub, Legendre South-1 and Legendre South-3.	CM-01-EPS-01	Written report completed after the field monitoring campaign.	EPO-01	6.1
Monitoring results comparison	CM-02	Results of the monitoring campaign are assessed compared to previous surveys and findings, within 3 months of the monitoring report being available. SME assessments / technical input (as required). The Santos Management of Change process is applied where relevant.	CM-02-EPS-01	Written technical report. Written memo or technical report. The Santos Management of Change form.	EPO-01	6.1
Automatic Identification System (AIS) identification system on vessel	CM-04	Vessel has an Automatic Identification System (AIS) to aid in its detection at sea.	CM-04-EPS-01	Completed inspection report or statement of conformance supplied by vessel contractor	EPO-02	6.2
Maritime notices	CM-05	Information provided to either the AMSA, DoD, Australian Hydrographic Office (AHO) and/or nearest port authority on vessel arrival and departure so that the maritime industry is aware of petroleum activities.	CM-05-EPS-01	Transmittal records demonstrate notification of activity prior to the activity commencing.	EPO-02	6.2
Lighting will be used as required for safe work conditions and navigational purposes	CM-06	Vessel navigation lighting and equipment is compliant with COLREGS / Marine Orders 30: Prevention of Collisions, and with Marine Orders 21: Safety of Navigation and Emergency Procedures.	CM-06-EPS-01	Vessel certification confirms compliance with applicable regulations	EPO-02 EPO-04 EPO-10	6.2, 6.4, 7.7
Watchkeeping maintained on bridge	CM-07	Competent crew on the support vessel(s) shall maintain a constant bridge-watch.	CM-07-EPS-01	Completed operational report	EPO-02 EPO-03 EPO-10	6.2, 6.3, 6.8, 7.4, 7.7
Stakeholder consultation strategy	CM-08	Relevant persons consulted on the planned activity covered by this EP.	CM-08-EPS-01	Saved consultation records demonstrate consultation and notifications were undertaken in line with the accepted EP implementation and consultation strategies.	EPO-02	6.2, 6.8
		All correspondence with external stakeholders is recorded.	CM-08-EPS-02	Saved consultation records.	EPO-02	6.2, 6.8
		Santos' Consultation Coordinator is contactable before, during and after completion of the planned activity to ensure stakeholder feedback is evaluated and considered during the operational activity phases.	CM-08-EPS-03	Records show Santos' Consultation Coordinator is contactable before, during and after completion of the planned activity.	EPO-02	6.2, 6.8
No recreational fishing from vessel	CM-09	Personnel are prohibited from recreational fishing activities on the vessel	CM-09-EPS-01	Induction records confirm no fishing prohibition is communicated to all personnel.	EPO-02	6.2, 6.8
Procedure for interacting with marine fauna	CM-10	Vessel(s) and aircraft comply with Santos' Protected Marine Fauna Interaction and Sighting Procedure (EA-91-11-00003) which ensures compliance with Part 8 of Environment Protection and Biodiversity Regulations 2000.	CM-10-EPS-01	Log kept of marine fauna sightings when in WA-20-L.	EPO-03	6.3, 6.8 7.4
Vessel planned maintenance system to vessel engines and machinery	CM-11	Engines, machinery and equipment are maintained in accordance with PMS.	CM-11-EPS-01	Condition and suitability survey of the vessel demonstrates compliance with PMS.	EPO-03 EPO-05 EPO-06	6.3, 6.5 7.2, 7.5
Fuel oil quality in accordance with MARPOL	CM-12	MARPOL-compliant fuel oil will be used during the activity.	CM-12-EPS-01	Fuel bunkering records.	EPO-05 EPO-06	6.5
International Air Pollution Prevention (IAPP) Certificate	CM-13	Pursuant to MARPOL Annex VI, vessel(s) will maintain a current International Air Pollution Prevention (IAPP) Certificate which certifies that measures to prevent ozone-depleting substance (ODS) emissions, and reduce NOx, SOx and incineration emissions during the activity are in place.	CM-13-EPS-01	Current IAPP certificate.	EPO-05 EPO-06	6.5, 6.8
Ozone-depleting substance (ODS) handling procedures	CM-14	ODS managed in accordance with Australian Marine Order 97 to reduce the risk of an accidental release of ODS to air.	CM-14-EPS-01	Completed ODS record book or recording system.	EPO-05 EPO-06	6.5
Waste incineration	CM-15	Waste incineration managed in accordance with MARPOL Annex VI, except incineration within the 500-m exclusion zone shall not occur.	CM-15-EPS-01	Completed waste record book or recording system.	EPO-05 EPO-06	6.5
Dropped object recovery	CM-16	Objects dropped overboard are recovered to mitigate the environmental consequences from objects remaining in the marine environment, unless the environmental consequences are I - Negligible, or safety risks are disproportionate to the environmental consequences.	CM-16-EPS-01	Fate of dropped objects detailed in incident documents.	EPO-06 EPO-07	6.6, 7.2
Dropped object prevention procedures	CM-17	Vessel lifting procedures include the following CMs to reduce the risk of objects entering the marine environment:	CM-17-EPS-01	Lifting equipment register. Permit to work records. Training records.	EPO-06 EPO-07	6.6, 7.2

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference	Measurement Criteria	EPO Reference	Section
		+ lifting equipment certification and inspection + lifting crew competencies + heavy lift procedures + preventative maintenance on cranes.				
Sewage treatment system	CM-18	Pursuant to MARPOL Annex VI, vessel(s) have a current International Sewage Pollution Prevention (ISPP) Certificate which certifies that required measures to reduce impacts from sewage disposal are in place (as applicable to vessel class). Sewage discharged in accordance with MARPOL Annex IV. Preventive maintenance on sewage treatment equipment is completed in accordance with the PMS as scheduled.	CM-18-EPS-01	Current ISPP certificate. Completed inspection checklist. Maintenance records.	EPO-05 EPO-06	6.7, 6.8
Oily water treatment system	CM-19	Oily mixtures (bilge water) only discharged to sea in accordance with MARPOL Annex I. Preventative maintenance on oil filtering equipment completed in accordance with the PMS. Pursuant to MARPOL Annex 1a vessel(s) will have an International Oil Pollution Prevention (IOPP) Certificate (applicable to vessel class) which certifies that required measures to reduce impacts of planned oil discharges are in place.	CM-19-EPS-01	Completed inspection checklist. Oil record book or log. Maintenance records. Current IOPP certificate.	EPO-05 EPO-06	6.7, 6.8, 7.5
Waste (garbage) management procedure	CM-20	Waste management procedure implemented to reduce the risk of unplanned release of waste to sea. The procedure includes standards for: + Bin types; + Lids and covers; + Waste segregation; and + Bin storage. + No waste (garbage) discharged to sea, unless the waste is food waste disposed in accordance with MARPOL Annex V. + Pursuant to MARPOL Annex V, placards displayed to notify personnel of waste disposal restrictions.	CM-20-EPS-01	Completed inspection checklist. Completed garbage disposal record book or recording system.	EPO-05 EPO-06	6.7, 7.2
Deck cleaning product selection	CM-21	Deck cleaning products planned to be released to sea meet the criteria for not being harmful to the marine environment according to MARPOL Annex V.	CM-21-EPS-01	Safety data sheet (SDS) and product supplier supplementary data as required. Completed inspection checklist.	EPO-05 EPO-06	6.7, 7.5
Chemical management procedure	CM-22	Safety data sheet (SDS5) available for all chemicals to aid in the process of hazard identification and chemical management. Chemicals managed in accordance with SDS in relation to safe handling and storage, spill-response and emergency procedures, and disposal considerations	CM-22-EPS-01	Completed inspection checklist	EPO-05 EPO-06	6.7, 7.5
Competent Incident Management Team (IMT) and oil spill responder personnel	CM-23	Vessel crew are trained and competent, in accordance with Flag State regulations, to navigate vessels and reduce interaction with other marine users.	CM-23-EPS-01	Training records.	OPEP	6.8
Use of competent vessel crew and personnel	CM-24	Vessel crew are trained and competent, in accordance with Flag State regulations, to navigate vessels and reduce interaction with other marine users.	CM-24-EPS-01	Training records.	OPEP	6.8
Compliance with controlled waste, unauthorised discharge and landfill regulations	CM-25	Ensure operational NEBA considers waste management, to ensure environmental benefit outweighs the environmental impact of strategy implementation which may include secondary contamination	CM-25-EPS-01	NEBA Template.	OPEP	6.8
Spill response activities selected on basis of a NEBA	CM-26	A NEBA is undertaken for every operational period.	CM-26-EPS-01	Incident Log contains NEBA	OPEP	6.8
Use of shallow draft vessels for nearshore operations	CM-27	Shallow draft vessels are used for shoreline and nearshore operations unless directed otherwise by the designated Control Agency.	CM-27-EPS-01	Vessel specification documentation contained in IAP.	OPEP	6.8
Navigational charting of wellhead	CM-28	Santos' Consultation Coordinator is contactable before, during and after completion of the planned activity to ensure stakeholder feedback is evaluated and considered during the operational activity phases.	CM-28-EPS-01	Records show Santos' Consultation Coordinator is contactable before, during and after completion of the planned activity.	EPO-08	7.1
Stakeholder notification through industry representative body	CM-29	Direct notification to relevant commercial trawl fishers that operate in the vicinity of the Legendre-1 wellhead will be made providing the position of the wellhead as per the 2021 survey.	CM-29-EPS-01	Australian Hydrographic Service nautical charts show that the wellhead is charted.	EPO-08	7.1
Implementation of the management	CM-30	Vessels are managed to low risk in accordance with the Santos IMSMP (EA-00-RI-10172) prior to movement or	CM-30-EPS-01	Completed risk assessment demonstrating vessel and equipment is low risk.	EPO-09	7.3

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference	Measurement Criteria	EPO Reference	Section
controls in the Santos Invasive Marine Species Management Plan (IMSMP)		transit into or within the invasive marine species management zone, which requires: + assessment of applicable vessels using the IMSMP risk assessment + the management of immersible equipment to low risk.				
		Pursuant to the Biosecurity Act 2015 and Australian Ballast Water Management Requirements 2017, support vessels carrying ballast water and engaged in international voyages shall manage ballast water so that marine pest species are not introduced.	CM-30-EPS-02	Records show Ballast Water Management is implemented. Completed ballast water record book or log is maintained.	EPO-09	7.3
Anti-foulant system	CM-31	Vessel anti-foulant system maintained in compliance with International Convention on the Control of Harmful Anti-fouling Systems on Ships	CM-31-EPS-01	Current International Anti-Fouling System Certificate.	EPO-09	7.3
Vessel spill response plans (SOPEP/SMPEP)	CM-32	Support vessels have a shipboard oil pollution emergency plan (SOPEP) or shipboard marine pollution emergency plan (SMPEP), which outlines steps taken to combat spills.	CM-32-EPS-01	Audit records. Inspection records.	EPO-06 EPO-10	7.5 7.7
Remotely operated vehicle inspection and maintenance procedures	CM-33	Preventive maintenance on ROV completed as scheduled to reduce the risk of hydraulic fluid releases to sea.	CM-33-EPS-01	Maintenance records.	EPO-06	7.5
		ROV pre-deployment inspection completed to reduce the risk of hydraulic fluid releases to sea.	CM-33-EPS-02	Completed pre-deployment inspection of hose integrity.	EPO-06	7.5
Hazardous chemical management procedures	CM-34	For hazardous chemicals, including hydrocarbons, the following standards apply to reduce the risk of an accidental release to sea: + Storage containers closed when the product is not being used. + Storage containers managed in a manner that provides for secondary containment in the event of a spill or leak. + Storage containers labelled with the technical product name as per the safety data sheet. + Spills and leaks to deck, excluding storage bunds and drip trays, immediately cleaned up. + Storage bunds and drip trays do not contain free-flowing volumes of liquid. + Spill response equipment readily available.	CM-34-EPS-01	Audit Records. Inspection Records.	EPO-06	7.5
Accepted oil pollution emergency plan (OPEP)	CM-35	In the event of a hydrocarbon spill to sea, the Santos OPEP requirements are implemented to mitigate environmental impacts.	CM-35-EPS-01	Completed incident documentation.	EPO-10	7.7
Marine assurance standard	CM-36	Vessels selected and on-boarded in accordance with the Offshore Marine Assurance Procedure (SO 91 ZH 10001) to ensure contracted vessels are operated, maintained and manned in accordance with industry standards (for example, Marine Orders) and regulatory requirements (this EP) and the relevant Santos procedures mentioned in this EP	CM-36-EPS-01	Completed inspection checklist and premobilisation documentation.	EPO-10	7.7
Pre-Activity commencement assurance check	CM-37	Prior to activity commencement, an assurance check will be undertaken in accordance with Santos Environment Management of Change Procedure (EA-91-IQ-10001). This involves a documented review of the EP to ensure: + the activity details are current + changes in legislation are identified + stakeholder consultation has been completed and stakeholder concerns addressed + potential impacts and risks are still relevant + oil spill scenario is appropriate + EPOs and EPSs are appropriate + activity is acceptable and ALARP in accordance with the EP.	CM-37-EPS-01	Completed Assurance Check form.	EPO-10	7.7

8.5 Leadership, accountability and responsibility

OPGGS(E)R 2023 Requirements
Section 22(3)
The implementation strategy must establish a clear chain of command, setting out the roles and responsibilities of personnel in relation to the implementation, management and review of the environment plan, including during emergencies or potential emergencies.

While Santos' Chief Executive Officer (CEO) has the overall accountability for the implementation of the Santos Management System and Environment, Health and Safety Policy, the General Manager Subsurface WA, NA & TL is accountable for ensuring implementation, management and review of this EP.

The chain of command and accountabilities of personnel in relation to the implementation, management and review of the EP is outlined in **Table 8-3**. It is also outlined in the OPEP for oil spill response.

Table 8-3: Chain of command, key leadership roles and responsibilities

Role	Responsibilities
General Manager Subsurface WA, NA & TL	+ Ensure compliance with Santos' Environment, Health and Safety Policy. + Ensure relevant Santos Management System Standards and procedures are implemented as necessary. + Ensure adequate resources are in place to meet the requirements within the EP. + Ensure overall compliance with the EP with advice and guidance from the Santos Environmental Coordinator. + Ensure incidents and non-conformances are managed as per this EP.
Senior Stakeholder Adviser	+ Ensure relevant stakeholders are identified throughout the life of the EP. + Maintain records of all stakeholder correspondence specific to the EP. + Be available before, during and after the activities to ensure opportunities for stakeholders to provide feedback are available. + Prepare and distribute quarterly consultation updates to relevant stakeholders.
Environment Manager WA, NT & TL	+ Ensure environmental audits are conducted as required to ensure compliance. + Ensure environmental monitoring is conducted in accordance with the Santos Management System and this EP. + Liaise with the Santos Production Manager – Asset Retirement and Offshore Field Representative to ensure compliance with all aspects of this EP. + Perform environmental education and inductions for operational personnel. + Ensure incident investigations are conducted as per Santos Management System. + Ensure EP compliance report that covers environmental performance of the activity in this EP is prepared and submitted to NOPSEMA.
Company Site Representative	+ Implementing EP commitments. + Ensuring personnel competency. + Ensuring compliance with procedures and work instructions. + Being site focal point for onshore/offshore communications. + Reporting all incidents and potential hazards. + Leading site-based incident response. + Implementing corrective actions from environmental incidents and audits.
Vessel Master	+ Implementation and compliance with relevant environmental legislative requirements, EP commitments and operational procedures on the vessel. + Maintaining clear communication with personnel on board. + Communicating hazards and risks to the workforce. + Monitoring daily activities on the vessel to ensure that the relevant environmental legislative requirements, EP commitments and operational procedures are being followed.

Role	Responsibilities
	+ Maintaining vessels to all regulatory and class requirements. + Maintaining their vessel in a state of preparedness for emergency response. + Reporting environmental incidents to PIC and ensuring follow-up actions are performed.
Senior Crisis Security & Emergency Response Adviser	+ Overarching incident and crisis management responsibility. + Managing the Crisis Management Team and IMT personnel training program. + Reviewing and assessing competencies for Crisis Management Team, IMT, and field-based Incident Response Team members. + Managing the Duty roster system for Crisis Management Team and IMT personnel. + Managing the maintenance and readiness of incident response resources and equipment.
Senior Spill Response Advisor	+ Providing upfront and ongoing guidance, framework, and direction on preparation of this OPEP. + Developing and maintaining arrangements and contracts for incident response support from third parties. + Developing and defining objectives, strategies and tactical plans for response preparedness defined in this OPEP and IRP. + Undertaking assurance activities on arrangements outlined within the OPEP.

8.6 Workforce training and competency

OPGGS(E)R 2023 Requirements
Section 22(4)
The implementation strategy must include measures to ensure that each employee or contractor working on, or in connection with, the activity is aware of his or her responsibilities in relation to the environment plan, including during emergencies or potential emergencies, and has the appropriate competencies and training.

This section describes the mechanisms that will be in place so each employee and contractor is aware of his or her responsibilities in relation to the EP.

8.6.1 Inductions

All personnel on vessels will complete an induction which will include a component addressing their EP responsibilities. Induction attendance records for all personnel will be maintained. Inductions will include information about:

+ Environment, Health and Safety Policy;
+ regulatory regime (NOPSEMA regulations);
+ EPBC Act Policy Statement 2.1 and how it applies to the activity;
+ operating environment (for example, nearby protected marine areas);
+ activities with highest risk;
+ EP commitments;
+ incident reporting and notifications;
+ regulatory compliance reporting;
+ importance of marine communications regarding any potential interactions with active commercial fishing;
+ MoC process for changes to EP activities;
+ oil pollution emergency response (for example, OPEP requirements).

8.6.2 Training and competency

All members of the workforce on the vessels will complete relevant training and/or hold relevant qualifications and certificates for their roles.

Santos and its contractors are individually responsible for ensuring that their personnel are qualified and trained. The systems, procedures and responsible persons will vary and will be managed through the use of online databases, staff on-boarding process and training departments, etc.

Personnel qualification and training records will be sampled before and/or during an activity. Such checks will be performed during the procurement process, facility acceptance testing, inductions, crew change, and operational inspections and audits.

8.6.3 Workforce involvement and communication

For vessel activities, daily operational meetings will be held at which HSE will be a standing agenda item. It is a requirement that supervisors attend daily operational meetings and that all personnel attend daily toolbox or pre-shift meetings. Toolbox or pre-shift meetings will be held to plan jobs and discuss work tasks, including HSE risks and their controls.

HSE performance will be monitored and reported during the activity, and performance metrics (such as the number of environmental incidents) will be regularly communicated to the workforce. Workforce involvement and environmental awareness will also be promoted by encouraging offshore personnel to report marine fauna sightings and marine pollution (for example, oil on water, dropped objects).

8.7 Emergency preparedness and response

OPGGS(E)R 2023 Requirements
Section 22(8)
The implementation strategy must contain an oil pollution emergency plan and provide for the updating of the plan.

Vessels are required to have and implement incident response plans, such as an emergency response plan and SMPEP or SOPEP. Regular incident response drills and exercises (for example, as defined in an emergency response plan, SMPEP or SOPEP) are performed to refresh the crew in using equipment and implementing incident response procedures.

Santos will implement the activity WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01) in the event of a hydrocarbon spill. The OPEP details how Santos will prepare and respond to a spill event and meets the requirement of the OPGGS(E)R 2023.

8.8 Incident reporting, investigation and follow-up

OPGGS(E)R 2023 Requirements
Section 22(7)
The implementation strategy must state when the titleholder will report to NOPSEMA in relation to the titleholder’s environmental performance for the activity. The interval between reports will not be more than 12 months. Note: Section 51 requires a titleholder to report on environmental performance in accordance with the times or intervals set out in the environment plan.
Section 22(6)
The implementation strategy must provide for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

All vessel personnel will be informed through inductions and daily operational meetings of their duty to report HSE incidents and hazards. Reported HSE incidents and hazards will be shared during daily operational meetings and will be documented in the incident management systems as appropriate. HSE incidents will be investigated in accordance with the the Santos Incident Reporting, Investigation and Learning Procedure SMS-HSS-OS07-PD01 which uses root cause analysis or vessel contractor procedures.

Environmental recordable and reportable incidents will be reported to NOPSEMA as required, in accordance with **Section 8.9**. The incident reporting requirements will be provided to all crew on board the facilities and support vessels with special attention to the reporting time frames to provide for accurate and timely reporting. For the purposes of this activity, in accordance with OPGGS(E)R:

+ a recordable incident, for an activity, means a breach of an EPO or EPS, in the EP that applies to the activity, that is not a reportable incident
+ a reportable incident, for an activity, means an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage.

For the purposes of this EP, a reportable incident is an incident that is assessed to have an environmental consequence of moderate or higher in accordance with the Santos environmental impact and risk assessment process outlined in **Section 5**.

8.9 Reporting and notifications

OPGGSR 2023 Requirements
Section 22(7)
The implementation strategy must state when the titleholder will report to NOPSEMA in relation to the titleholder's environmental performance for the activity. The interval between reports will not be more than 12 months.
Section 22(6)
The implementation strategy must provide for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

8.9.1 Notifications and compliance reporting

Regulatory, other notification and compliance reporting requirements are summarised in **Table 8-4**.

Table 8-4: Activity notification and reporting requirements

Initiation	Required Information	Timing	Type	Recipient
On acceptance of this EP				
NOPSEMA must be notified that the activity is to commence	Complete Start or End of Activity Notification form prior to each environmental survey.	At least ten days before the activity commences.	Written	NOPSEMA
Before each survey				
WAFIC	Monitoring and research programme outcomes.	Upon request or at the completion of the monitoring and research programme.	Written	WAFIC
	Prior to commencement of each environmental survey, Santos will liaise with WAFIC on the required notifications to relevant commercial fishers.	At least one week prior.	Written	WAFIC
Recfishwest	Monitoring and research programme outcomes.	Upon request or at the completion of the monitoring and research programme.	Written	Recfishwest
	Prior to commencement of each environmental survey, Santos will inform Recfishwest.	At least one week prior.	Written	
DPIRD	Monitoring and research programme outcomes.	Upon request or at the completion of the monitoring and research programme.	Written	DPIRD
Consultation with AMSA	Notification of proposed start and end dates and any other relevant information for the Notice to Mariners to be issued. AMSA's JRCC requires the: + vessel details (including name, callsign and Maritime Mobile Service Identity) + satellite communications details (including INMARSAT-C and satellite telephone numbers) + area of operation + requested clearance from other vessels + any other information that may contribute to safety at sea + when operations start and end.	At least 24 to 48 hours before operations commence.	Written	AMSA's JRCC
		No less than four working weeks before operations.	Written	AHO
Consultation	Each environmental survey will be included in the Quarterly Consultation Update until the activity has ended.	Quarterly	Written	The Quarterly Consultation Update is

Initiation	Required Information	Timing	Type	Recipient
				circulated to a broad group of Santos stakeholders
Department of Agriculture, Fisheries and Forestry (DAFF) – Biosecurity (vessels, aircraft and personnel)	In addition to completing an IMS Risk Assessment in accordance with CM- 33, Santos will: + pursuant to the *Biosecurity Act 2015* and the *Biosecurity (Exposed Conveyances – Exceptions from Biosecurity Control) Determination 2016*, undertake a vessel biosecurity risk and be assessed as 'low' by the Commonwealth Department of Agriculture prior to interacting with domestic support vessels and aircraft + undertake pre-arrival approval for the vessels (where applicable) using the Maritime Arrivals Reporting System (MARS) to meet the DAFF biosecurity reporting obligations.	At least one month prior to each environmental survey commencement. MARS reporting at least 12 hours prior to arrival.	Written	DAFF Biosecurity (vessels, aircraft and personnel)
During the activity				
OPGGS(E)R 50 – Reporting recordable Incidents NOPSEMA must be notified of a breach of an EPO or EPS, in the environment plan that applies to the activity that is not a reportable incident	Complete NOPSEMA's Recordable Environmental Incident Monthly Report form.	The report must be submitted as soon as practicable after the end of the calendar month, and in any case, not later than 15 days after the end of the calendar month.	Written	NOPSEMA
OPGGS(E)R 51 – Reporting Environmental Performance NOPSEMA must be notified of the environmental performance at the intervals provided for in the EP	Report must contain sufficient information to determine whether or not EPO and EPS in the EP have been met.	An environmental performance report will be submitted annually, within three months of each anniversary of the acceptance of this EP.	Written	NOPSEMA
OPGGS(E)R 24(c), 47, 48 – Reportable Incident NOPSEMA must be notified of any reportable incidents	The oral notification must contain: + all material facts and circumstances concerning the reportable incident known or by reasonable search or enquiry could be found out	As soon as practicable, and in any case not later than two hours after the first occurrence of a reportable incident, <u>or</u> if the incident was not detected at the time of the first occurrence, at the time of	Oral	NOPSEMA

Initiation	Required Information	Timing	Type	Recipient
For the purposes of Section 24(c), a reportable incident is defined as: an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage	+ any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident + the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident.	becoming aware of the reportable incident.		
	A written record of the oral notification must be submitted. The written record is not required to include anything that was not included in the oral notification.	As soon as practicable after the oral notification.	Written	NOPSEMA NOPTA
	A written report must contain: + all material facts and circumstances concerning the reportable incident known or by reasonable search or enquiry could be found out + any action taken to avoid or mitigate any adverse environmental impacts of the reportable incident + the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident + the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future. Consider reporting using NOPSEMA's Report of an Accident, Dangerous Occurrence or Environmental Incident form.	Must be submitted as soon as practicable, and in any case not later than three days after the first occurrence of the reportable incident unless NOPSEMA specifies otherwise. Same report to be submitted to NOPTA and DMIRS within seven days after giving the written report to NOPSEMA.	Written	NOPSEMA NOPTA
AMSA Reporting Under the Memorandum of Understanding (MoU) between Santos and AMSA	Titleholder agrees to notify AMSA of any marine pollution incident[2].	Within 2 hours of incident.	Oral	AMSA
	POLREP and SITREP available online (refer OPEP).	POLREP as requested by AMSA following verbal notification. SITREP as requested by AMSA within 24 hours of request.	Written	AMSA

[2] For clarity and consistency across Santos regulatory reporting requirements Santos will meet the requirement of reporting marine oil pollution by reporting oil spills assessed to have an environmental consequence of moderate or higher in accordance with Santos's environmental impact and risk assessment process outlined in **Section 5**.

Initiation	Required Information	Timing	Type	Recipient
Director of National Parks Reporting Notification of the event of oil pollution within a marine park or where an oil spill response action must be taken within a marine park (requested through consultation)	The DNP should be made aware of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park as soon as possible. Notification should be provided to the 24-hour Marine Compliance Duty Officer on 0419 293 465. The notification should include: + titleholder details + time and location of the incident (including name of marine park likely to be affected) + proposed response arrangements as per the OPEP (such as dispersant, containment, etc.) + confirmation of providing access to relevant monitoring and evaluation reports when available + contact details for the response coordinator. Note that the DNP may request daily or weekly Situation Reports, depending on the scale and severity of the pollution incident.	So far as reasonably practicable prior to response action being written.	Oral and written	Director of National Parks
DPIRD Reporting If marine pests or disease are suspected this must be reported to DPIRD	Notification of any suspected marine pests or diseases including any organism listed in the Western Australian Prevention List for Introduced Marine Pests and any other non-endemic organism that demonstrates invasive characteristics.	Within 24 hours.	Oral	DPIRD FishWatch
DCCEEW Reporting Any harm or mortality to EPBC Act- listed threatened marine fauna	Notification of any harm or mortality to an EPBC listed species of marine fauna whether attributable to the activity or not.	Within seven days to EPBC.permits@environment.gov.au.	Written	DCCEEW
Marine Fauna Sighting Data	Marine fauna sighting data recorded in the marine fauna sighting database.	As soon as practicable, in any case no later than three months after the end of each campaign.	Written	DCCEEW
Any harm or mortality to fauna listed as threatened under the *WA Biodiversity Conservation Act 2016*	Notification of any harm or mortality to fauna listed as a threatened species under the *WA Biodiversity Conservation Act 2016* as a result of Santos activities.	A fauna report will be submitted to DBCA Within seven days to fauna@dbca.wa.gov.au.	Written	DBCA
Australian Marine Mammal Centre Reporting	Ship strike report provided to the Australian Marine Mammal Centre: https://data.marinemammals.gov.au/report/shipstrike.	As soon as practicable.	Written	DCCEEW

Initiation	Required Information	Timing	Type	Recipient
Any ship strike incident with cetaceans will also be reported to the National Ship Strike database				
DBCA Reporting Impacts to marine mammals or turtles in reserves	Notification of any incidence of entanglement, boat collisions and stranding of marine mammals in the reserves and any incident of turtle mortality and incidents of entanglement in the reserves as detailed in the Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves.	Within 48 hours.	Written	DBCA
Department of Transport Reporting All actual or impending MOP incidents that are in, or may impact, State waters resulting from an offshore petroleum activity	Notification of actual or impending spillage, release or escape of oil or an oily mixture that is capable of causing loss of life, injury to a person or damage to the health of a person, property or the environment.	Within two hours.	Oral	DoT
	WA DoT POLREP and SITREP available online (refer OPEP).	As requested by DoT following verbal notification.	Written	DoT
AHO	Notification of updates on progress and, importantly, any changes to the intended operations.	As soon as possible.	Written	AHO
Consultation with AMSA	Notification of updates to both the AMSA and the JRCC on progress and, importantly, any changes to the intended operations.	As soon as possible.	Written	AMSA's JRCC
AMSA (JRCC) Consultation	Notification that each environmental survey has been completed.	Within ten days of cessation of each environmental survey.	Written	JRCC
AHO	Notification that each environmental survey has completed	Within ten days of cessation of each environmental survey.	Written	AHO
WAFIC	Upon completion of each environmental survey, Santos will liaise with WAFIC on the required notifications to commercial fishers.	Within ten days of cessation of each environmental survey.	Written	WAFIC
Consultation requirement	Upon completion of each environmental survey, Santos will provide a cessation notification to the relevant stakeholders listed, or as revised, in **Table 8-4**.	Within ten days of cessation of each environmental survey.	Written	Relevant stakeholders listed, or as revised, in **Table 8-4**

Initiation	Required Information	Timing	Type	Recipient
Consultation requirements	Santos will include the activity in Quarterly Consultation Update until activity ends.	Quarterly	Written	The Quarterly Consultation Update is circulated to a broad group of Santos stakeholders
End of EP validity				
OPGGS(E)R 54 – Notifications NOPSEMA must be notified that the activity is completed	Complete NOPSEMA's Section 54 Start or End of Activity Notification form.	Within ten days after end of the EP validity.	Written	NOPSEMA
OPGGS(E)R 46 EP ends when titleholder notifies completion and NOPSEMA accepts the notification NOPSEMA must be notified that the activity has ended and all EP obligations have been completed	Notification advising NOPSEMA of end of all activities to which the EP relates and that all obligations have been completed.	Within six months of the final Section 54 (2) notification.	Written	NOPSEMA

8.9.2 Monitoring and recording emissions and discharges

OPGGS(E)R 2009 Requirements
Regulation 10A(e)
Includes an appropriate implementation strategy and monitoring, recording and reporting arrangements;
Regulation 14 (7)
The implementation strategy must provide for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges (whether occurring during normal operations or otherwise), such that the record can be used to assess whether the environmental performance outcomes and standards in the environment plan are being met.

Estimated emissions associated with the gas seepage will be included in annual performance reports (where relevant).

Gas seepage data from the monitoring campaign (**Section 6.1.1.9)** will be included in the annual performance report.

Vessel-based discharges to the marine environment associated with this activity will be recorded and controlled in accordance with requirements under relevant marine orders.

Santos and support vessel contractors will maintain records so that emissions and discharges can be determined or estimated. Such records will be maintained for a period of five years. Contractors are required to make these records available upon request. Santos records discharges or emissions (where practicable), to the environment as described in **Table 8-5**.

Table 8-5: Monitoring methods for emissions and discharges

Discharge/emission	Parameter	Quantitative Record	Recording frequency
Gas from gas seepage	Volume, constituents, rate, location	Estimated from measurements taken during surveys	For every survey
Chemicals (discharged to marine environment as per Section 6.7)	Volume	Chemical Risk Assessment. Volumes used will be estimated based on known inventories	For every chemical use with a fate to the marine environment
Oily water	Volume and location	Oil Record Book* or equivalent report	For every discharge
Garbage (including food scraps)	Volume and location	Garbage Record Book*	For every discharge
Sewage	Volume and location	Sewage Record Book*	For every discharge
Ballast Water	Volume and location	Ballast water record book or log**	For every discharge
Unplanned discharge of solid objects	Volume	Incident report	For every discharge
Unplanned discharge of hazardous liquids	Volume	Incident report	For every discharge
Unplanned hydrocarbon release	Volume	Incident report	For every discharge

*Maintained as per vessel class in accordance with relevant Marine Orders

** Maintained as per Australian Ballast Water Management Requirements 2017

8.10 Document management

8.10.1 Information management and document control

This EP and any approved MoC documents, are controlled documents and current versions will be available on the Santos intranet. Vessel contractors are also required to maintain current versions of these documents.

EPOs and EPSs will be measured based on the measurement criteria listed in **Table 8-3**. Such records will be maintained for a period of five years. Contractors are required to make these records available upon request.

8.10.2 Management of change

Proposed changes to this EP will be managed in accordance with the Santos Environment Management of Change Procedure (EA-91-IQ-10001). The MoC process provides a systematic approach to initiate, assess, document, approve, communicate and implement changes to EPs.

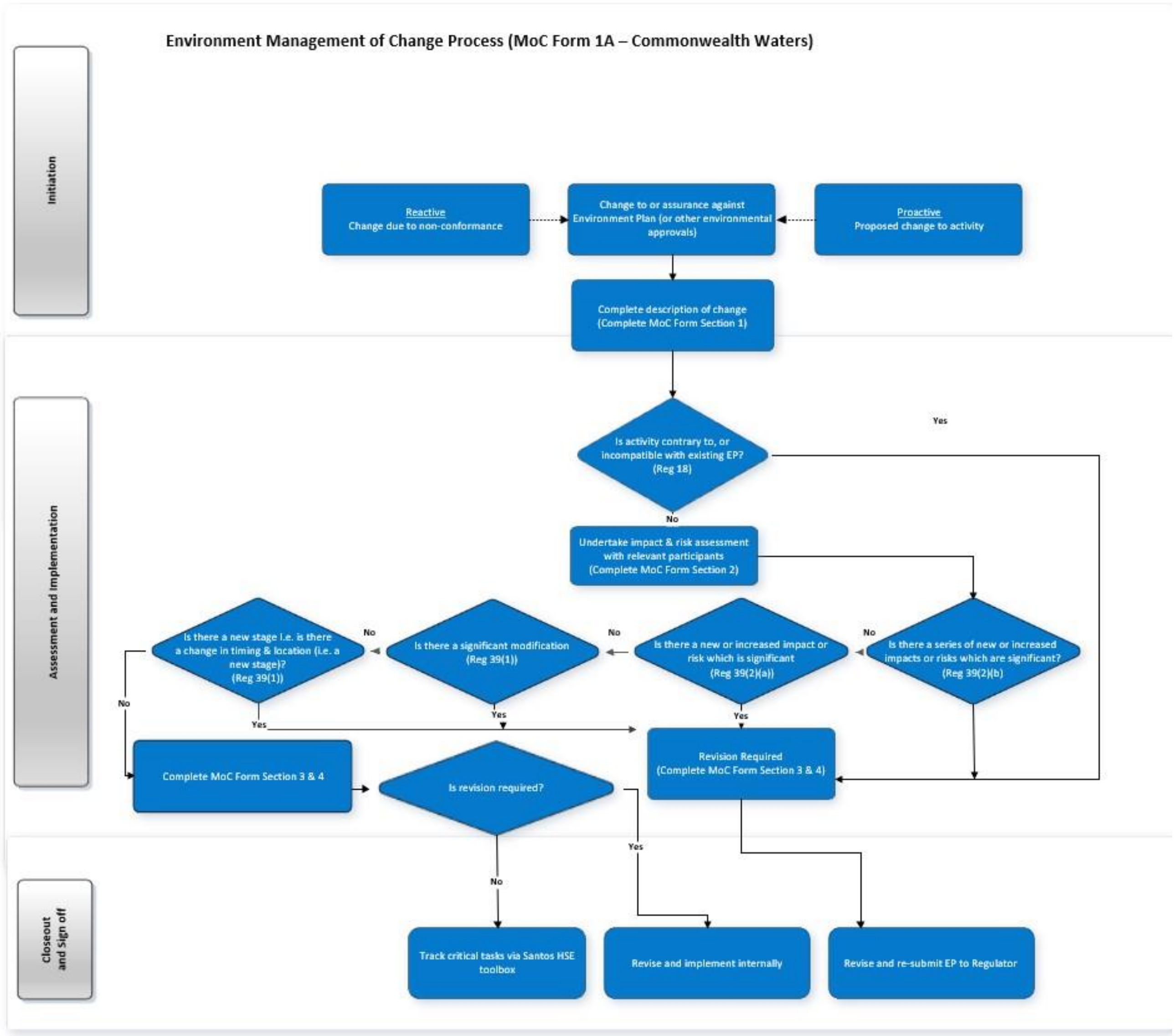
The MoC process considers Sections 18, 19 and Division 5 of the OPGGS(E)R 2023 and determines if a proposed change can proceed and the manner in which it can proceed. The MoC procedure will determine whether a revision of the EP is required and whether that revision is to be submitted to NOPSEMA. For a change to proceed, the associated environmental impacts and risks must be demonstrated to be acceptable and ALARP. Additional stakeholder consultation may be required, depending on the nature and scale of the change. Additional information about the MoC process is provided in **Figure 8-1**.

The MoC procedure also allows for the assessment of new information that may become available after EP acceptance, such as new management plans for AMPs, new recovery plans or conservation advice for species, and changes to the EPBC Protected Matters Search results. If a review identifies new information, this is treated as a “Change that has an impact on EP”, and the MoC process is followed accordingly.

The MoC procedure also includes an assurance check process which applies the MoC process to long term (usually five year multi-activity EPs) EPs that may have lengthy periods of time between use or acceptance and activity commencement. Applying this Assurance Check to this EP helps Santos determine whether the activity will still comply with the EP and is still acceptable, or, if there are any changes to what is covered by the relevant EP. Where there is an identified change from the accepted EP content, a check is done to test the ‘significance’ of the change, to determine whether it can be accommodated which may then result in an MoC as described above.

Accepted MoCs become part of the in force EP or OPEP, are tracked on a register and are made available on Santos’ intranet. Where appropriate, the EP compliance register will be updated so that CM or EPS changes are communicated to the workforce and implemented.

Any MoC will be distributed to the management people identified in **Table 8-3** (excluding the CEO and Directors); and the most relevant management position will ensure the MoC is communicated and implemented, which may include crew meetings, briefings or communications as appropriate for the change.



Notes: The regulation requirements in this chart are summarised. For exact wording, refer to the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023.
Regulation 39(3) in relation to a change in titleholder and a new activity resulting in a change of the levy category as per Regulation 38 a revised or new EP is required to be submitted to the Regulator.

Figure 8-1: Environment management of change process (Commonwealth Waters)

8.10.3 Reviews

This EP includes an assessment of impacts and risks across the entire permit area, during any time of the year for planned and unplanned events.

It is recognised that the following may change over the validity of the EP:

- legislation;
- businesses conditions, activities, systems, processes and people;
- industry practices;
- science and technology; and
- societal and stakeholder expectations.

To ensure Santos maintains up to date knowledge of the industry, legislation and conservation advice, the following tasks are undertaken:

- maintaining membership of AEP (Australian Energy Producers, formerly the Australian Petroleum Production & Exploration Association), which provides a mechanism for communicating potential changes in legislation, industry practice and other issues that may affect EP implementation to relevant personnel in Santos;

+ undertaking annual spill response exercises to check spill response arrangements and capability are adequate;
+ identifying stakeholders prior to the activity commencing under this EP via the mechanisms outlined in **Section 4**;
+ reviewing the Values and Sensitivities within the permit area which includes completing a new EPBC Protected Matters Search, reviewing against relevant legislation to capture and review any relevant updates and incorporate as required, and reviewing any recently known published relevant scientific papers;
+ subscribing to various regulator updates; and
+ having regular liaison meetings with Regulators.

Through maintenance of up to date knowledge, these changes are identified. If the changes have an impact on the activity or risks described and assessed in this EP, the EP will be reviewed and any changes required documented in accordance with Santos' MoC procedure (**Section 8.10.2**).

8.11 Audits and inspections

OPGGS(E)R 2023 Requirements
Section 2(5)
The implementation strategy must provide for sufficient monitoring, recording, audit, management of nonconformance and review of the titleholder's environmental performance and the implementation strategy to ensure that the environmental performance outcomes and standards in the environment plan are being met.

8.11.1 Audits

Santos audit plans and schedules are reviewed and updated at the beginning of each calendar year and cover all Santos facilities and activities. Santos' audit schedule may be amended to accommodate operational priorities, activity risk, personnel availability or high audit demand during certain periods (for example, regulatory audits, contractor audits). Santos will determine if a vessel audit is required following contract award and vessel confirmation.

Audits will be undertaken in a manner consistent with Santos' Assurance Operating Standard (SMS-LRG-OS03).

Audit scope typically includes a selection of CMs and EPSs and EPOs. However, audits may also include other parts of the EP.

Audits findings may include opportunities for improvement and non-conformances. Audit non-conformances are managed as described in **Section 8.11.3**.

8.11.2 Inspections

During an activity, HSE inspections (desktop) will be conducted at least once during the activity to identify hazards, incidents and EP non-conformances. These inspections will also check compliance against all the EPOs and EPSs of this EP (**Table 8-3**) and inform end of activity reporting (**Table** 8-4). Any in-field opportunities for improvement or corrective actions will be discussed during the inspection with the Vessel Master.

8.11.3 Non-conformance management

EP non-conformances will be addressed and resolved by a systematic corrective action process as outlined in Santos' Assurance Standard (QE-91-ZF-10007). Non-conformances arising from audits and inspections will be entered into Santos' incident and action tracking management system (in other words, 'Enablon'). Once entered, corrective actions, time frames and responsible persons (including action owners and event validators) will be assigned. Corrective action 'close out' will be monitored using a management escalation process.

8.11.4 Continuous improvement

For this EP, continuous improvement will be driven by the list below and may result in a review of the EP, with changes applied in accordance with **Section 8.10.2**:

+ improvements identified from the review of business-level HSE key performance indicators;
+ actions arising from Santos and departmental HSE improvement plans;
+ corrective actions and feedback from HSE audits and inspections, incident investigations and after action reviews;
+ opportunities for improvement and changes identified during pre-activity reviews and MoC documents; and
+ actions taken to address concerns and issues raised during the ongoing stakeholder management process (**Section 4)**.

Identified continuous improvement opportunities will be assessed in accordance with the MoC process (**Section 8.10.2**) to ensure any potential changes to this EP are managed in accordance with the OPGGS(E)R and in a controlled manner.

8.12 Post-acceptance consultation implementation strategy

8.12.1 First Nations people and groups, and local governments, communities and industry

Santos is committed to appropriate post-acceptance consultation implementation for this Activity with relevant government authorities and other relevant interested persons and organisations.

Post acceptance consultation activities for this EP will be principally supported by Santos' existing regional relationships with those organisations with functions, interests and activities at the activity location.

This regional approach is being taken given the relatively short duration of inspection, monitoring, maintenance and repair activities and limited geographical extent of activity impacts.

Santos recognises and respects the preference of relevant government authorities and other relevant interested persons and organisations to determine the frequency and method of updates, in addition to the written quarterly updates outlined in this strategy below.

First Nations people and groups

Santos will undertake consultation over the life of the activity with First Nations representative organisations. Santos will provide quarterly written activity updates via land councils and Aboriginal Corporations.

Having regard to Santos' experience consulting with First Nations groups, and feedback from First Nations relevant persons, Santos considers that consultation through representative bodies provides an appropriate mechanism for ongoing consultation with First Nations relevant interested persons.

Representative bodies provide for regular, culturally appropriate engagement, including processes for dissemination of information to First Nations Elders, cultural leaders and communities in a manner that is readily accessible and culturally appropriate.

Local governments, communities and industry

Santos will provide quarterly written activity updates to regional local government and associated communities.

Santos will also provide quarterly written activity updates to the commercial fishing industry, which is the industry most likely to be affected by proposed activities. Santos will provide quarterly written activity updates to those representative organisations whose membership are most likely to be affected, specifically to:

8.12.2 Post-acceptance consultation implementation strategy approach

Formal acceptance of the EP will be communicated via the NOPSEMA website. Santos will also provide access to the EP via the NOPSEMA website and will provide details on the Santos website on how to provide ongoing feedback in relation to the activity.

Santos will provide to those organisations identified in this implementation strategy quarterly written updates on the Activity. The updates will also be posted on Santos' website, with notifications to registered / subscribed interested parties.

Activity notifications and reports will also be made in accordance with **Section 8.9.1**. The notifications and reports are based on legislative requirements, standing arrangements with particular Relevant Persons, Relevant Persons' requests for notification made during Regulation 25 consultation, or as otherwise deemed appropriate by Santos.

Santos will apply the regional engagement model to consider the preference of with relevant government authorities and other relevant interested persons and organisations when determining the frequency and method of additional updates.

Santos will continue to accept, assess and respond to post-acceptance consultation feedback during the life of the Activity. Records of any post-acceptance consultation will be maintained in an appropriate Santos consultation database.

During the EP validity period, Santos will:

+ Review information sources that may give rise to additional or new Relevant Persons, as part of planned consultation activities to support future approvals.
+ Request recipients of Santos' Quarterly Update to advise Santos of other organisations who may be relevant interested persons or organisations or who may be relevant Commonwealth, State or Territory authorities with respect to particular regional activities. The Quarterly Update is sent to a diverse range of organisations and provides information about Santos' proposed, existing and completed activities.

Additional new potentially Relevant Persons that may be affected by activities will be engaged and provided information about the accepted activity, as well as information about the consultation process and opportunities to provide input or receive activity updates.

Additional new Relevant Persons will also be added to the distribution list for its Quarterly Update, unless they request that they not be added.

If, during the course of post-acceptance consultation, Santos receives information demonstrating a new or increased environmental impact or risk that is not provided for in this EP, as in force at the time, Santos will apply its Management of Change process outlined in **Section 8.10.2**.

Santos will maintain a database of relevant authorities, and other relevant interested persons and organisations for this Activity. This includes updating its database in light of post acceptance consultation, including identification of new Relevant Persons.

References

Add Energy (2022a) Part B – Global Offset Review – Gas migration post P&A. Document No. AEA-RPT-22-061001. 26 July 2022.

Add Energy (2022b) Part C – Remedial Feasibility Assessment Legendre P&A. Document No. AEA-RPT-22-111501. 6 December 2022.

Add Energy (2023a) File Note: P&A Integrity Assessment Legendre Development Wells. Document No. AEA-RPT-23-061601. 20 June 2023.

Add Energy (2023b) Part A – Independent Integrity Assessment Legendre P&A. Document No. AEA-RPT-22-111701 (Rev 0). 5 June 2023.

Add Energy. (2021). Legacy Subsea Wellhead Removal Options Study. Subsea Wellhead Removal Options Study. Document No. AEA-RPT-21-0209. 13 July 2021.

AMCS. (2021). Risk Investigation – Potential impact of Santos Legendre Wellhead on commercial fishing operations in the Pilbara Demersal Scalefish Fisheries. Training and Consultancy division of the Australian Maritime College.

American Petroleum Institute. 2009. Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. https://www.api.org/~/media/files/ehs/climate-change/2009_ghg_compendium.ashx. Accessed 5 July 2022

AMSA (2015). Technical guidelines for preparing contingency plans for Marine and Coastal Facilities. Available online at: https://www.amsa.gov.au/sites/default/files/2015-04-np-gui012-contingency-planning.pdf

AMSA (2019). National Plan for Maritime Environmental Emergencies. Available online at: https://www.amsa.gov.au/sites/default/files/amsa-496-national-plan.pdf

AMSA (2020). Shipping fairways network. Data provided through consultation.

ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Apache (2011). Legendre field Decommissioning Environmental Plan. Apache Energy.

Australian Museum. (2019). Ruby Snapper, Etelis carbunculus (Cuvier, 1828). Available online at: https://australianmuseum.net.au/learn/animals/fishes/ruby-snapper-etelis-carbunculus-cuvier-1828/. Accessed on 20 March 2021.

Australian Ocean Data Network 2022, Australian Phytoplankton Database, Integrated Marine Observing System. Available from: https://portal.aodn.org.au/

Azmi Abdul Wahab, M., Radford, B., and Colquhoun, J. (2018). Biodiversity and spatial patterns of benthic habitat and associated demersal fish communities at two tropical submerged reef ecosystems. Coral Reefs 37(2). DOI:10.1007/s00338-017-1655-9.

Barron, M.G., Carls, M.G., Heintz, R., and Rice, S.D. (2004). Evaluation of fish early life-stage toxicity models of chronic embryonic exposures to complex polycyclic aromatic hydrocarbon mixtures. Toxicological Sciences, 78(1), 60-67.

Bartol, M.S. and Musick, J.A. (2003). Sensory biology of sea turtles. In: Lutz, P.L., Musick, J.A., Wyneken, J. (eds) Biology of sea turtles, Vol II. CRC Press, Boca Raton, FL, p. 79-102

Begg, G.A., Chen, C.C.-M., O'Neill, M.F. and Rose, D.B. (2006). Stock assessment of the Torres Strait Spanish mackerel fishery. CRC Reef Research Centre Technical Report No. 66. CRC Reef Research Centre, Townsville, Queensland.

BoM (2021a). Climate Statistics of Australian Locations. Summary statistics DAMPIER PORT. Available online at: http://www.bom.gov.au/climate/averages/tables/cw_004097.shtml. Accessed 2 July 2021.

BoM (2021b). Tropical Cyclones Affecting Port Hedland. Available online at: http://www.bom.gov.au/cyclone/history/wa/pthed.shtml. Accessed 25 May 2021.

BOM (2021c). Tide Tables for Western Australia. Available online at: http://www.bom.gov.au/oceanography/projects/ntc/wa_tide_tables.shtml. Accessed 19 July 2021.

BoM (2021d). Climatology of Tropical Cyclones in Western Australia. Available online at: http://www.bom.gov.au/cyclone/history/wa/pthed.shtml. Accessed 2 July 2021.

Braun, C. B. and Grande, T. (2008). Evolution of peripheral mechanisms for the enhancement of sound reception. In: Springer Handbook of Auditory Research. Fish Bioacoustics, Vol. 32 (ed. Popper, A. N., Fay, R. R. and Webb, J. F.), pp.99-144. New York: Springer-Verlag.

Bray, D.J. (2020). Etelis carbunculus in Fishes of Australia. Available online at: http://136.154.202.208/home/species/1238. Accessed 14 May 2020.

Burns, K.A., Greenwood P.F., Summons R.E. and Brunskill G.J. (2001). Vertical fluxes of hydrocarbons on the North West Shelf of Australia as estimated by a sediment trap experiment. Organic Geochemistry (32):1241-1255.

Carbon Positive Australia (CPA) 2024. Calculate your footprint. https://carbonpositiveaustralia.org.au/calculate/#:~:text=How%20does%20my%20footprint%20compare,2%20tonnes%20CO2e%20per%20year.

Chorney, N.E., G.A. Warner, J.T. MacDonnell, A. McCrodan, T.J. Deveau, C.R. McPherson, C. O'Neill, D.E. Hannay, and B. Riddout (2011). Underwater Sound Measurements. In: Reiser, C.M., D.W. Funk, R. Rodrigues, and D.E. Hannay (eds.). Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore Inc. in the Alaskan Chukchi and Beaufort Seas, July-October 2010: 90-day report. LGL Report P1171E–1. Report from LGL Alaska Research Associates Inc. and JASCO Applied Sciences for Shell Offshore Inc., National Marine Fisheries Service (US), and US Fish and Wildlife Service. 240 pp plus appendices. http://www.nmfs.noaa.gov/pr/pdfs/permits/shell_90day_report2010.pdf.

Claisse, J. T., Pondella, D. J., Love, M., Zahn, L. A., Williams, C. M., Williams, J. P., & Bull, A. S. (2014). Oil platforms off California are among the most productive marine fish habitats globally. Proceedings of the National Academy of Sciences, 111(43), 15462-15467.

Clark, C.W., W.T. Ellison, B.L. Southall, L.T. Hatch, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis (2009). Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395: 201-222. https://doi.org/10.3354/meps08402.

Clark, J.R., Bragin, G.E., Febbo, R.J. and Letinski, D.J. (2001). Toxicity of physically and chemically dispersed oils under continuous and environmentally realistic exposure conditions: Applicability to dispersant use decisions in spill response planning. Pp. 1249– 1255 in Proceedings of the 2001 International Oil Spill Conference, Tampa, Florida. American Petroleum Institute, Washington, D.C.

Commonwealth of Australia (2017). ‘Recovery Plan for Marine Turtles in Australia 2017-2027 Available at https://www.environment.gov.au/system/files/resources/46eedcfc-204b-43de-99c5-4d6f6e72704f/files/recovery-plan-marine-turtles-2017.pdf

Commonwealth of Australia (2017). Australian National Guidelines for Whale and Dolphin Watching 2017. Available at https://www.environment.gov.au/system/files/resources/7f15bfc1-ed3d-40b6-a177-c81349028ef6/files/aust-national-guidelines-whale-dolphin-watching-2017.pdf

Commonwealth of Australia (2020). National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds, Commonwealth of Australia 2020.

Commonwealth of Australia (2021). National Inventory Report 2019. The Australian Government Submission to the United Nations Framework Convention on Climate Change

Connell, D.W. and Miller, G.J. (1981). Petroleum hydrocarbons in aquatic ecosystems – behaviour and effects of sub lethal concentrations. CRC report Critical reviews in environmental controls.

CoreLab (2021) Compositional Analysis Report for Santos WA Energy Ltd. Seabed gas samples RFL 202006681.

CSIRO (2005). RV Southern Surveyor. Voyage Summary SS 06/2005. CSIRO Division of Marine Research, Hobart. 19pp.

Currey-Randall, M, Galaiduk, R, Stowar, M, Vaughan, B.I and K. J. Miller (2021) Mesophotic fish communities of the ancient coastline in Western Australia. PLoS ONE 16(4): e0250427. https://doi.org/10.1371/journal.pone.0250427Dambacher, JM, Rochester, W & Dutra, L, (2009). Addendum to ecological indicators for the exclusive economic zone waters of the South-west Marine Region., report for the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

D'Anastasi, B., Simpfendorfer, C. & van Herwerden, L. (2013). Anoxypristis cuspidata (errata version published in 2019). The IUCN Red List of Threatened Species 2013: e.T39389A141789456. https://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39389A141789456.en.

DAFF (2011). Australian Ballast Water Management Requirements – Version 5. Viewed 26 March 2012, http://www.daff.gov.au/aqis/avm/vessels/quarantine_concerns/ballast/australian-ballast-water-management-requirements.l.

Dale, J., Gray, M., Popper, A., Rogers, P., and Block, B. (2015). Hearing thresholds of swimming Pacific bluefin tuna Thunnus orientalis. Journal of Comparative Physiology A, 1-14.

DAWE (2021) Guidance on key terms within the Blue Whale Conservation Management Plan, September 2021.

DAWE (2021a). Species profile and Threats database. Glomar Shoals. Available online at: https://www.environment.gov.au/sprat-public/action/kef/view/10;jsessionid=01AD87551D0DE1B0248C8722BE137004. Accessed on 2 July 2021.

DAWE (2021b). Biologically important areas of regionally significant marine species. Available online at: https://www.environment.gov.au/marine/marine-species/bias. Accessed on 2 July 2021.

DAWE (2021c). National heritage. Available online at: https://www.environment.gov.au/heritage/about/national. Accessed on 21 July 2021

DAWE (2021d). Underwater Cultural Heritage Act 2018. Available online at https://www.environment.gov.au/heritage/underwater-heritage/underwater-cultural-heritage-act. Accessed on 21 July 2021.

DAWE (2021e). Species Profile and Threats Database. Ardenna pacifica — Wedge-tailed Shearwater. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=84292. Accessed on 2 July 2021.

DAWE (2021f). Species Profile and Threats Database. Carcharias taurus (west coast population) — Grey Nurse Shark (west coast population). Available online at: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68752. Accessed on 2 July 2021.

DAWE (2021g). Species Profile and Threats Database. Pristis zijsron — Green Sawfish, Dindagubba, Narrowsnout Sawfish. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68442. Accessed on 2 July 2021.

DAWE (2021h). Species Profile and Threats Database. Carcharodon carcharias — White Shark, Great White Shark. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64470. Accessed on 2 July 2021.

DAWE (2021i). Species Profile and Threats Database. Caretta caretta – Loggerhead turtle. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763. Accessed on 2 July 2021.

DAWE (2021j). Species Profile and Threats Database. Chelonia mydas — Green Turtle. Available online at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765. Accessed on 2 July 2021.

DAWE (2021k). Species Profile and Threats Database. Dermochelys coriacea — Leatherback Turtle, Leathery Turtle. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768. Accessed on 2 July 2021.

DAWE (2021l). Species Profile and Threats Database. Eretmochelys imbricata — Hawksbill Turtle. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1766. Accessed on 2 July 2021.

DAWE (2021m). Species Profile and Threats Database. Natator depressus — Flatback Turtle. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257. Accessed on 2 July 2021.

DAWE (2021n). Species Profile and Threats Database. Balaenoptera borealis — Sei Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=34. Accessed on 12 July 2021.

DAWE (2021o). Species Profile and Threats Database. Balaenoptera edeni — Bryde's Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=35. Accessed on 12 July 2021.

DAWE (2021p). Species Profile and Threats Database. Balaenoptera musculus — Blue Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=36. Accessed on 12 July 2021.

DAWE (2021q). Species Profile and Threats Database. Balaenoptera physalus — Fin Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=37. Accessed on 12 July 2021.

DAWE (2021r). Species Profile and Threats Database. Megaptera novaeangliae — Humpback Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=38. Accessed on 12 July 2021.

DAWE (2021s). Species Profile and Threats Database. Stenella attenuata — Spotted Dolphin, Pantropical Spotted Dolphin. Avaiable online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=51. Accessed on 12 July 2021.

DAWE (2021t). Species Profile and Threats Database. Delphinus delphis — Common Dolphin. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=60. Accessed on 12 July 2021.

DAWE (2021u). Species Profile and Threats Database. Grampus griseus — Risso's Dolphin, Grampus. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64. Accessed on 12 July 2021.

DAWE (2021v). Species Profile and Threats Database. Tursiops aduncus — Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68418. Accessed on 12 July 2021.

DAWE (2021w). Species Profile and Threats Database. Tursiops aduncus (Arafura/Timor Sea populations) — Spotted Bottlenose Dolphin (Arafura/Timor Sea populations). Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=78900. Accessed on 12 July 2021.

DAWE (2021x). Species Profile and Threats Database. Tursiops truncatus s. str. — Bottlenose Dolphin. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68417. Accessed on 12 July 2021.

DAWE (2021y). Species Profile and Threats Database. Orcinus orca — Killer Whale, Orca. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=46. Accessed on 12 July 2021.

DAWE (2021z). Species Profile and Threats Database. Pseudorca crassidens — False Killer Whale. Available online at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=48. Accessed on 12 July 2021.

DAWR (2018). Fishery status reports 2018. ABARES. Fishery status reports 2018 is available at agriculture.gov.au/abares/publications.

DAWR (2020). Fishery status reports 2020. ABARES. Fishery status reports 2020 is available at https://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status

DCCEEW (2022). National Greenhouse Gas Inventory Quarterly Update: December 2021. Available online: https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-gas-inventory-quarterly-update-december-2021.

DCCEEW 2023, National Light Pollution Guidelines for Wildlife, Department of Climate Change, Energy, the Environment and Water, Canberra.

DCCEEW (2023a). Conservation Advice for Calidris ferruginea (curlew sandpiper). Canberra: Department of Climate Change, Energy, the Environment and Water. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice-18122023.pdf. In effect under the EPBC Act from 18-Dec-2023.

DCCEEW (2023b). Conservation Advice for Phaethon rubricauda westralis (Indian Ocean red-tailed tropicbird). Canberra: Department of Climate Change, Energy, the Environment and Water. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/91824-conservation-advice-21122023.pdf. In effect under the EPBC Act from 21-Dec-2023.

DCCEEW (2024). Conservation Advice for Calidris acuminata (sharp-tailed sandpiper). Canberra: Department of Climate Change, Energy, the Environment and Water. Available from:

http://www.environment.gov.au/biodiversity/threatened/species/pubs/874-conservation-advice-05012024.pdf. In effect under the EPBC Act from 05-Jan-2024.

DCCEEW. (2024a). Listing Advice for Sphyrna lewini (scalloped hammerhead). https://www.environment.gov.au/biodiversity/threatened/species/pubs/85267-listing-advice-27022024.pdf

DEWHA (2008a). The North-west Marine Bioregional Plan. Bioregional Profile. The South-West Marine Bioregional Plan, 208.

DEWHA (2008b). Approved Conservation Advice for Green Sawfish. Canberra: Department of the Environment, Water, Heritage and the Arts. Available online from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/68442-conservation-advice.pdf. Accessed on 12 July 2021.

DEWHA (2008c). Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1768-conservation-advice.pdf

Di, P., Feng, D., & Chen, D. (2019). The distribution of dissolved methane and its air-sea flux in the plume of a seep field, Lingtou Promontory, South China Sea. Geofluids, 2019.

Director of National Parks (DNP) (2018). North-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra. Available online: https://parksaustralia.gov.au/marine/pub/plans/north-west-management-plan-2018.pdf.

DISER (2018). Offshore Petroleum Decommissioning Guideline. Available online from: https://www.nopta.gov.au/_documents/guidelines/decommissioning-guideline.pdf

DoE (2014). Recovery Plan for the Grey Nurse Shark (Carcharias taurus). Canberra, ACT: Department of the Environment. Available online at: http://www.environment.gov.au/resource/recovery-plan-grey-nurse-shark-carcharias-taurus. Accessed on 12 July 2021.

DoE (2014a). Conservation Advice Phaethon lepturus fulvus white-tailed tropicbird (Christmas Island). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/26021-conservation-advice.pdf. In effect under the EPBC Act from 06-Nov-2014.

DoE (2014b). Approved Conservation Advice for Pristis pristis (largetooth sawfish). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf. In effect under the EPBC Act from 11-Apr-2014.

DoE (2015). Conservation Management Plan for the Blue Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999. Canberra, ACT: Commonwealth of Australia. Available online at: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/blue-whale-conservation-management-plan. Accessed on 12 July 2021.

DoE (2015a). Conservation Advice Numenius madagascariensis eastern curlew. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf. Accessed on 12 July 2021.

DoE (2015b). Sawfish and River Sharks Multispecies Recovery Plan. Canberra, ACT: Commonwealth of Australia. Available online at: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/sawfish-river-sharks-multispecies-recovery-plan. Accessed on 12 July 2021.

DoE (2015c). Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Commonwealth of Australia. Available online at: https://www.environment.gov.au/system/files/resources/9995c620-45c9-4574-af8e-a7cfb9571deb/files/widlife-conservation-plan-migratory-shorebirds.pdf

DoEE (2017). Recovery Plan for Marine Turtles in Australia. Australian Government, Canberra. Available online at: http://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017. Accessed om 12 July 2021.

DOEE (2018) Threat Abatement Plan for Marine Debris (2018). Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018). Available online at: http://www.environment.gov.au/system/files/resources/e3318495-2389-4ffc-b734-164cdd67fe19/files/tap-marine-debris-2018.pdf

DoEE (2021). The Ramsar Convention on Wetlands. Available online at: https://www.environment.gov.au/water/wetlands/ramsar. Accessed on 12 July 2021.

DPIRD (2019a). Finfish Spawning Table for some Key Species – Updated 5 June 2019. Perth, Western Australia.

DSEWPaC (2012a). Species Group Report Card – Sharks; Supporting the Marine Bioregional Plan for the North Marine Region. Department of Sustainability, Environment, Water, Population and Communities. Commonwealth of Australia.

DSEWPC (2011a). Approved Conservation Advice for Sternula nereis nereis (Fairy Tern). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/82950-conservation-advice.pdf. Accessed on 12 July 2021.

DSEWPC (2011b). Approved Conservation Advice for Aipysurus apraefrontalis (Short-nosed Sea Snake). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1115-conservation-advice.pdf

DSEWPC (2011c). Approved Conservation Advice for Aipysurus foliosquama (Leaf-scaled Sea Snake). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities

DSEWPC (2012). Species Group Report Card – Marine Reptiles; Supporting the Marine Bioregional Plan for the North Marine Region. Department of Sustainability, Environment, Water, Population and Communities. Commonwealth of Australia.

DSEWPC. (2013). Recovery Plan for the White Shark (Carcharodon carcharias). Department of Sustainability, Environment, Water, Population and Communities. Available online at: http://www.environment.gov.au/biodiversity/threatened/publications/recovery. Accessed on 12 July 2021.

EPA (2010). Environmental Assessment Guidelines No. 5. Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts. Environmental Protection Authority, Western Australia, November 2010.

European Chemicals Agency (2022). https://echa.europa.eu/information-on-chemicals/ Accessed 4 April 2022.

Ferrara, C.R., R.C. Vogt, R.S. Sousa-Lima, B.M.R. Tardio, and V.C.D. Bernardes. (2014). Sound communication and social behaviour in an Amazonian river turtle (Podocnemis expansa). Herpetologica 70(2): 149-156. https://doi.org/10.1655/HERPETOLOGICA-D-13-00050R2

FRDC (2019). Status of Australian Fish Stocks Reports. Available online at: https://www.fish.gov.au/. Accessed on 12 July 2021

French, D. P., Schuttenberg, H. Z., & Isaji, T. (1999). Probabilities of oil exceeding thresholds of concern: examples from an evaluation for Florida Power and Light. In ARCTIC AND MARINE OILSPILL PROGRAM TECHNICAL SEMINAR (Vol. 1, pp. 243-270). MINISTRY OF SUPPLY AND SERVICES, CANADA.

French-McCay, D. (2009). State-of-the-art and research needs for oil spill impact assessment modelling, in: Proceedings of the 32nd AMOP Technical Seminar on Environmental Contamination and Response. Presented at the 32nd AMOP Technical Seminar on Environmental Contamination and Response, Environment Canada, Ottawa, pp. 601–653

French-McCay, D.P. (2002). Development and Application of an Oil Spill Toxicity and Exposure Model, OilToxEx. Environmental Toxicology and Chemistry 21(10): 2080-2094.

Gaughan, D.J. and Santoro, K. (eds). (2021). Status Reports of the Fisheries and Aquatic Resources of Western Australia 2019/20: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Gaughan, D.J., Newman, S.J., and Wakefield, C.B. (2018). Western Australian Marine Stewardship Council Report Series No. 11: Summary of the stock structure information used for determining spatial management of the index species for the scalefish resources of northern Western Australia. Department of Primary Industries and Regional Development, Western Australia. 32pp.

GBRMPA. (2011). A Vulnerability Assessment for the Great Barrier Reef – Sea Snakes. Great Barrier Reef Marine Park Authority. Commonwealth of Australia.

Gentz, T., Damm, E., Schneider von Deimling, J., Mau, S., McGinnis, D. F., & Schluter, M. (2014). A water column study of methane around gas flares located at the West Spitsbergen continental margin. Continental Shelf Research, 72, 107-118.

Geoscience Australia (2021) Browse Basin Regional Geology. Published by Geoscience Australia.

GHD (2020). Dancer-1 and Bedout Basin Diesel Spill Modelling Report. Report prepared for Santos Energy Limited. November 2020.

Grimwood, M.J. & Dixon, E. 1997. Assessment of risks posed by List II metals to Sensitive Marine Areas (SMAs) and adequacy of existing environmental quality standards (EQSs) for SMA protection. Report to English Nature

Grosjean, E., Logan, G. A., Rollet, N., Ryan, G. J., & Glenn, K. (2007). Geochemistry of shallow tropical marine sediments from the Arafura Sea, Australia. Organic geochemistry, 38(11), 1953-1971.

Gulec, I. and Holdway, D.A. (2000). Toxicity of crude oil and dispersed crude oil to ghost shrimp Palaemon serenus and larvae of Australian bass Macquaria novemaculeata, ENVIRON TOX, 15(2), 2000, pp. 91-98

Gulec, I., Leonard, B. and Holdway, D.A. (1997). Oil and dispersed oil toxicity to amphipods and snails. Spill Science & Technology Bulletin, 4(1), 1-6.

Higgins PJ & Davies SJJF eds (1996) Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

Hiscock, K., Southward, A.J., Tittley, I. & Hawkins, S.J. (2004). Effect of changing temperature on benthic marine life in Britain and Ireland. Aquatic Conservation 14, 333-362.

Howey-Jordan, L. A., Brooks, E. J., Abercrombie, D.L., Jordan, L. K. B., Brooks, A. (2013). Complex Movements, Philopatry and Expanded Depth Range of a Severely Threatened Pelagic Shark, the Oceanic Whitetip (Carcharhinus longimanus) in the Western North Atlantic. PLoS ONE 8(2): e56588. doi:10.1371/ journal.pone.0056588

James, N.P., Bone, Y., Kyser, T.K., Dix, G.R. and Collins, L.B. (2004). The importance of changing oceanography in controlling late Quaternary carbonate sedimentation on a high-energy, tropical, oceanic ramp, North-western Australia, Sedimentology 51: 1179–1205.

JASCO Applied Science (JASCO). 2016b. Potential Impacts of Underwater Noise from Operation of the Barossa FPSO Facility on Marine Fauna. Report prepared for Jacobs, Perth, Western Australia.

Jensen, A.S. Sibler, K. (2003). Large whale ship strike database. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Technical Memorandum NMFS-OPR-. 37 pp.

Jones, A.T, Kennard, J.M. Ryan, G.J., Bernardel, G., Earl, K.L., Rollet, N., Grosjean, and Logan, G.A. (2007). Geoscience Australia Marine Survey SS06/2006 Post-Survey Report: Natural hydrocarbon seepage on the Central North West Shelf. Record 2007/21. Geoscience Australia, Canberra.

Jones, A.T., Logan, G.A., Kennard, J.M. and Rollet, N. (2005) Testing natural hydrocarbon seepage detection tools on the Yampi Shelf, Northwestern Australia. Geoscience Australia Survey S267, Post-survey report. Record 2005/15 Geoscience Australia, Canberra.

Kearney, A., O'Leary, M., & Platten, S. (2023). Sea Country: Plurality and knowledge of saltwater territories in Indigenous Australian contexts. The Geographical Journal, 189(1), 104-116.

Koops, W., Jak, R.G. and van der Veen, D.P. (2004). Use of dispersants in oil spill response to minimise environmental damage to birds and aquatic organisms. Trondheim, Norway: Interspill 2004.

Ladich, F., and Popper, A. N. (2004). Parallel evolution in fish hearing organs. In: Evolution of the Vertebrate Auditory System, eds G. Manley, R. R. Fay, and A. N. Popper. New York, NY: Springer-Verlag. pp 95–127.

Laikre, L., Palm, S., Rymna, N. (2005). Genetic Population Structure of Fishes: Implications for Coastal Zone Management. Sustainable Coastal Zone Management. 31 (2): 111-119.

Laist, D., Knowlton, A., Mead, J.G., Collet, A.S. & Podestà, M. (2001) Collisions between ships and whales. Marine Mammal Science. 17. 35-75.

Langstreth, J., Williams, A., Stewart, J., Marton, N., Lewis, P. and Saunders, T. (2018). Spanish Mackerel. Available online at: https://www.fish.gov.au/report/253-Spanish-Mackerel-2018. Accessed on 20 March 2021.

Lewis, P. and Jones, R., (2018). Statewide Large Pelagic Finfish Resource Status Report 2017, in Gaughan, D.J. and Santoro, K. (Ed.) Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Limpus, C.J. (2007). A biological review of Australian marine turtle species. 5. Flatback turtle, Natator depressus (Garman). The State of Queensland. Environmental Protection Agency.

Limpus, C.J. (2008a). A biological review of Australian marine turtle species. 1. Loggerhead turtle, Caretta caretta (Linneaus). The State of Queensland. Environmental Protection Agency, Australia.

Limpus, C.J. (2008b). A biological review of Australian marine Turtles 2. Green Turtle Chelonia mydas (Linnaeus). The State of Queensland, Environmental Protection Agency, Australia.

Limpus, C.J. (2009a). A biological review of Australian marine turtle species. 3. Hawksbill turtle, Eretmochelys imbricata. The State of Queensland. Environmental Protection Agency, Australia.

Limpus, C.J. (2009b). A biological review of Australian marine turtle species. 6. Leatherback turtle, Dermochelys coriacea (Vandelli). The State of Queensland. Environmental Protection Agency, Australia.

Limpus, C.J., Parmenter, C.J. & Chaloupka, M. (2013) Monitoring of coastal sea turtles: Gap analysis 5. Flatback turtles, Natator depressus, in the Port Curtis and Port Alma region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation’s Ecosystem Research and Monitoring Program.

Limpus, CJ (1971). Sea turtle ocean finding behaviour. Search, vol. 2, pp. 385–387.

Lindquist, D.C., Shaw, R.F. and Hernandez Jr, F.J. (2005). Distribution patterns of larval and juvenile fishes at offshore petroleum platforms in the north central Gulf of Mexico. Estuarine, Coastal and Shelf Science 62: 655-665.

Lisk, M., Brincat, M.P., Eadington, P.J. and O’Brien, G.W. (1998) Hydrocarbon charge in the Vulcan Sub-basin. In Purcell, P.G. & R.R. (Eds), The Sedimentary Basins of Western Australia 2. Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, 1998, 287-303.

Lisk, M., O’Brien, G.W. and Brincat, M.P. (1997). Gas displacement; an important control on oil and gas distribution in the Timor Sea? The APPEA Journal. 37: 259-271.

Logan, G.A, Jones, A.T, Ryan, G.J, Wettle, M, Thankappan, M, Grosjean, E, Rollet, N and Kennard J.M. (2008). Review of Australian Offshore Natural Hydrocarbon Seepage Studies. Geoscience Australia record 2008/17.

Logan, G.A., Jones, A.T., Kennard, J.M. Ryan, D and Rollet, N. (2010) Australian offshore natural hydrocarbon seepage studies, a review. Marine and Petroleum Geology, 27, 26-45.

Long, S.M. and Holdway, D.A. (2002). Acute toxicity of crude and dispersed oil to Octopus pallidus (Hoyle, 1885) hatchlings. Water Res 36: 2769-2776

Mackie M.C., Lewis P.D., Kennedy J., Saville K., Crowe F., Newman, S.J. and Smith, K.A. (2010). Western Australian Mackerel Fishery. Ecologically Sustainable Development Series No. 7. Western Australian Department of Fisheries, Perth, Western Australia.

Marine Pest Sectoral Committee 2018, National biofouling management guidelines for the petroleum production and exploration industry, Department of Agriculture and Water Resources, Canberra, December. CC BY 4.0. Document modified in 2018 to meet accessibility requirements

Marquenie, J., Donners, M., Poot, H., Steckel, W. and de Wit, B. (2008). Adapting the spectral composition of artificial lighting to safeguard the environment. pp 1-6.

Marshall, A., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Liu, K.M., Pacoureau, N., Rigby, C.L., Romanov, E. & Sherley, R.B. (2019). Mobula alfredi. The IUCN Red List of Threatened Species 2019. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T195459A68632178.en.

McCauley, R. (1998). Radiated underwater noise measured from the drilling rig Ocean General, rig tenders Pacific Ariki and Pacific Frontier, fishing vessel Reef Venture and natural sources in the Timor Sea, Northern Australia. (Report No. C98-20). Centre for Marine Science and Technology, Curtin University of Technology, Perth, Western Australia.

McCauley, R.D. (2011). Woodside Kimberley sea noise logger program, Sept-2006 to June-2009: Whales, fish and man-made noise. Report produced for Woodside Energy Ltd, 86 pp.

McKinney, K., Caplis, J., DeVitis, D., & Van Dyke, K. (2017). Evaluation of oleophilic skimmer performance in diminishing oil slick thicknesses. In International Oil Spill Conference Proceedings (Vol. 2017, No. 1, pp. 1366-1381). International Oil Spill Conference.

McLean, D.L., Taylor, M.D., Partridge, J.C., Gibbons, B., Langlois, T.J., Malseed, B.E., Smith, L.D., Bond, T (2018) Fish and habitats on wellhead infrastructure on the north west shelf of Western Australia. Continental Shelf Research 164: 10-27.

McPherson, C.R., J.E. Quijano, M.J. Weirathmueller, K.R. Hiltz, and K. Lucke (2019). Browse to North-West-Shelf Noise Modelling Study: Assessing Marine Fauna Sound Exposures. Document Number 01824, Version 2.0. Technical report by JASCO Applied Sciences for Jacobs. https://www.epa.wa.gov.au/sites/default/files/PER_documentation2/Appendix%20D%203.pdf

McPherson, G. R. (1993). Reproductive biology of the narrow barred Spanish Mackerel (Scomberomorus commerson) in Queensland waters. Asian Fish. Sci. 6, 169–182.

Medwin, H., & Clay, C. S. (1998). Fundamentals of acoustical oceanography. Academic Press.

Meekan, M.G., Wilson, S.G., Halford, A. and Retzel, A. (2001). A comparison of catches of fishes and invertebrates by two light trap designs, in tropical NW Australia. Marine Biology 139: 373–381.

Melchers, R.E., 2005. Effect of Immersion Depth on Marine Corrosion of Mild Steele. Corrosion Science Section NACE International.

Milicich, M.J., Meekan, M.G. and Doherty, P.J. (1992). Larval supply: a good predictor of recruitment in three species of reef fish (Pomacentridae). Mar Ecol Prog Ser. 86: 153-166.

Murray Partners PPSA (2021) Molecular and isotope composition of seabed gas samples from the Dampier Sub Basin. Report to Santos.

Neil, km, Hilliard, RW, Clark, P, Russell, B, Clark, R and Polglaze, J (2005) Situation and Gaps Analysis of Introduced Marine Species, Vectors, Nodes and Management Arrangements for the Northern Planning Area, Report published by the National Oceans Office (Marine Division, Department of Environment and Heritage), Canberra.

Newman, D.J., Smith, K.A., Skepper, C.L. and Stephenson, P.C. (2008). Northern Demersal Scalefish Managed Fishery, ESD Report, Series No. 6, June 2008. Department of Fisheries, Western Australia.

Newman, S. Trinnie, F., Saunders, T. and Wakefield, C. (2018a). Rankin Cod. Available online at: http://fish.gov.au/report/206-Rankin-Cod-2018. Accessed on 24 May 2020.

Newman, S., Wakefield, C., Saunders, T. and Trinnie, F. (2018b). Bluespotted Emperor. Available online at: http://fish.gov.au/report/227-Bluespotted-Emperor-2018. Accessed on 24 May 2020

Newman, S., Wakefield, C., Skepper, C., Boddington D. and Smith, E. (2019). North Coast Demersal Resource Status Report 2018. In: Status Reports of the Fisheries and Aquatic Resources of Western Australia 2017–2018: The State of the Fisheries eds. D.J. Gaughan and K. Santoro. Department of Primary Industries and Regional Development, Western Australia. pp. 125-133.

Newman, S., Wakefield, C., Skepper, C., Boddington D. and Steele, A. (2020). North Coast Demersal Resource Status Report 2020. In: Reports of the Fisheries and Aquatic Resources of Western Australia 2019–2020: The State of the Fisheries eds. D.J. Gaughan and K. Santoro. Department of Primary Industries and Regional Development, Western Australia.

NMFS (National Marine Fisheries Service) (2014). Marine Mammals: Interim Sound Threshold Guidance (webpage). National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html.

NMFS (National Marine Fisheries Service) (2018). 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59.

NOO (National Oceans Office) (2002). Sea country: An Indigenous Perspective. The South-East Regional Marine Plan.

NOPSEMA (2019). Environment Bulletin A652993. April 2019. Available online at https://www.nopsema.gov.au/assets/Bulletins/A652993.pdf

NRC (2005). Oil Spill Dispersants: Efficacy and effects. National Research Council of the National Academies. The National Academies Press. Washington, D.C.

NRDAMCME (1997). The CERCLA Type A Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAMCME) Technical Documentation Vol 4, 14 -42. http://www/doi.gov/oepc/oepcbb.html.

O'Brien G.W. and Woods E.P. (1995). Hydrocarbon-related diagenetic zones (HRDZs) in the Vulcan Sub-basin, Timor Sea: Recognition and exploration implications. APEA Journal. 220-251.

O'Brien G.W., Lawrence G.M., Williams A.K. Glenn K., Barrett A.G., Lech M., Edwards D.S., Cowley R., Boreham C.J. and Summons R.E. (2005). Yampi Shelf, Browse Basin, North-West Shelf, Australia: a test-bed for constraining hydrocarbon migration and seepage rates using combinations of 2D and 3D seismic data and multiple, independent remote sensing technologies. Marine and Petroleum Geology. 22: 517-549.

O'Brien, G. W., Bickford, G. P., Bishop, J., & Marshall, J. F. (1992). Light Hydrocarbon Geochemistry of the WA-28-P Area, Dampier Sub-Basin, Western Australia: Rig Seismic Survey 97 (BMR Record 1992/61).

O'Brien, G.W., Lisk, M., Duddy, I., Eadington, P.J., Cadman, S. and Fellows, M. (1996). Late Tertiary fluid migration in the Timor sea: A key control on thermal and diagenetic histories. The APPEA Journal. 36: 399-426.

O'Brien, G.W., Lisk, M., Duddy, I.R., Hamilton, J., Woods, P. and Cowley, R. (1999). Plate convergence, foreland development and fault reactivation; Primary controls on brine migration, thermal histories and trap breach in the Timor Sea, Australia. Marine and Petroleum Geology. 16:533-560.

O'Hara, TD. 2023. An assessment of the offshore marine natural values of Australia's Indian Ocean Territories. Museums Victoria.

Olsen, J. E., Dunnebier, D., Davies, E. J. Skjetne, P. & Morud, J. (2017). Mass transfer between bubbles and seawater. Chemical Engineering Science, 161, 308-315.

Olsen, J. E., Krause, D. F., Davies, E. J., & Ekjetne, P. (2019). Observations of rising methane bubbles in Trndheimsfjord and its implications to gas dissolution, Journal of Geophysical Research: Oceans, 124, 1399-1409.

Paganoni, M., King, J. J., Foschi, F., Mellor-Jones, K., and Cartwright, J. A. (2019). natural gas hydrate system on the Exmouth Plateau (NW shelf of Australia) sourced by thermogenic hydrocarbon leakage. Marine and Petroleum Geology. 99: 370-392. https://doi.org/10.1016/j.marpetgeo.2018.10.029

Paulay, G. Kirkendale, L. Lambert, G. and Meyer, C. 2002. Anthropogenic biotic interchange in a coral reef ecosystem: A case study from Guam. Pacific Science 56(4): 403–422

Pearce, A., Buchan, S., Chiffings, T., D'Adamo, N., Fandry, C., Fearns, P., Mills, D., Phillips, R. and Simpson, C. (2003). A review of the oceanography of the Dampier Archipelago, Western Australia, Museum of Western Australia, Perth, Western Australia.

Pengfei, D.I, Qinghua, C and Duofu, C (2017). Quantification of Methane Fluxes form Hydrocarbon Seeps to the Ocean and Atmosphere: Development of an in-situ and Online Gas Flux Measuring System. Ocean University of China. 16 (3): 447-454.

Piniak W.E. (2012). Acoustic Ecology of Sea Turtles: Implications for Conservation. PhD thesis, Marine Science and Conservation Duke University. pp 136. Accessed online on 07/06/2019 at: https://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/6159/Piniak_duke_0066D_11691.pdf?sequence=1.

Poot, H., Ens, B. J., de Vries, H., Donners, M. A. H., Wernand, M. R. and Marquenie, J. M. (2008). Green light for nocturnally migrating birds. Ecology and Society 13(2): 47.

Popper, A.N., Hawkins, A.D., Fay, R.R., Mann, D., Bartol, S., Carlson, Th., Coombs, S., Ellison, W.T., Gentry, R. Halvorsen, M.B., Lokkeborg, S., Rogers, P., Southall, B.L., Zeddies, D.G., Tavolga, W.N., (2014). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report. ISBN 978-3-319-06659-2

Pradella, N., Fowler, A.M., Booth, D.J. & Macreadie, P.I. (2014). Fish assemblages associated with oil industry structures on the continental shelf of north-western Australia. Journal of Fish Biology, 84: 247-255.

Prince, R.I.T. (2001). Aerial survey of the distribution and abundance of dugongs and associated macroinvertebrate fauna- Pilbara Coastal and Offshore Region, W.A. Report to Environment Australia.

Quadrant Energy. (2018). Legendre Field Seismic Shallow Hazards Review Rev 0.

Reeburgh, W. S. (2007). Oceanic methane biogeochemistry. Chemical reviews, 107(2), 486-513.

Reeves, D. B., Chesney, E. J., Munnelly, R. T., Baltz, D. M., & Marx, B. D. (2018). Abundance and distribution of reef-associated fishes around small oil and gas platforms in the northern Gulf of Mexico's hypoxic zone. Estuaries and coasts, 41(7), 1835-1847.

Reynolds, S. D., Norman, B. M., Beger, M., Franklin, C. E., Dwyer, R. G. (2017). Movement, distribution and marine reserve use by an endangered migratory giant. Diversity and Distributions.23 (11): 1268-1279.

Richardson, W.J., Greene, C.R., Malme, C.I. and Thomson, D.H. (1995). Marine Mammals and Noise Academic Press, San Diego, California.

Rigby, C.L., Barreto, R., Carlson, J., Fernando, D., Fordham, S., Francis, M.P., Herman, K., Jabado, R.W., Liu, K.M., Marshall, A., Pacoureau, N., Romanov, E., Sherley, R.B. & Winker, H. (2019). Carcharhinus longimanus. The IUCN Red List of Threatened Species 2019: e.T39374A2911619. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T39374A2911619.en.

Rollet N., Logan G.A., Kennard J.M., O'Brien P., Jones A.T. and Sexton M. (2006). Characterisation and correlation of active hydrocarbon seepage using geophysical data sets: an example from the tropical, carbonate Yampi Shelf, Northwest Australia. Marine and Petroleum Geology. 23: 145-164.

Rollet, N., Logan, G. A., Ryan, G., Judd, A. G., Totterdell, J. M., Glenn, K., & Earl, K. L. (2009). Shallow gas and fluid migration in the northern Arafura Sea (offshore Northern Australia). Marine and Petroleum Geology, 26(1), 129-147.

Ross, A., Stalvies, C., Talukder, A., Trefry, C., Mainson, M., Cooper, L., Yuen, M., Palmer, J. (2017). Hydrocarbon abundance and distribution in the vicinity of the Prelude/Ichthys fields of the Browse Basin. Applied Research Program Project 2 Task 5a Report. CSIRO confidential report EP177989. Pp 118.

Rouse, S., Hayes, P., & Wilding, T. A. (2020). Commercial fisheries losses arising from interactions with offshore pipelines and other oil and gas infrastructure and activities. ICES Journal of Marine Science, 77(3), 1148-1156.

RPS (2021a). Legendre Field Environmental Survey Report. Well site survey, gas and sediment sampling, March 2021.

RPS (2021b). Assessment for methane dissolution from subsea release of gas bubbles.

RPS (2021c). Oil Spill Risk Assessment For Fuel Spill In The Legendre Field. Technical memo. MAW1050J.001. October 2021.

Salerno, J., Little, B., Lee, J., Ray, R., and Hamdan, L.J. (2016). Conserving archaeological sites as biological and historical resources in the Gulf of Mexico: the effects of crude oil and dispersant on the biodiversity and corrosion potential of shipwreck bacterial biofilms. American Geophysical Union's Ocean Sciences Meeting. New Orleans, February 22, 2016

Salmon, M., Wyneken, J., Fritz, E., Lucas, M. (1992). Seafinding by hatchling sea turtles: role of brightness, silhouette and beach slope as orientation cues. Behaviour 122:56–77

Sanseverino, A. M., Bastviken, D., Sundh, I., Pickova, J., & Enrich-Prast, A. (2012). Methane carbon supports aquatic food webs to the fish level.

Santos (2020). Legendre (WA-20-L) P&A review. Document number DR-00-RW-20035.

Santos (2024). Legendre Field Seabed Gas Seepage – Subsurface Study (Revision 1). Document number 7715-375-REP-0001.

Santos (2024a). Legendre-1 Petrophysical Analysis.

Schramm, K. D., Marnane, M. J., Elsdon, T. S., Jones, C. M., Saunders, B. J., Newman, S. J., & Harvey, E. S. (2021). Fish associations with shallow water subsea pipelines compared to surrounding reef and soft sediment habitats. Scientific reports, 11(1), 1-15.

Scoulding, B., Kloser, R., Gastauer, S. (2020) Evaluation of unmanned surface vehicle acoustics for gas seep detection in shallow coastal waters, International Journal of Greenhouse Gas Control, Volume 102, 103158.

Shaw, R.F., Lindquist, D.C., Benfield, M.C., Farooqi, T. and Plunket, J.T. (2002). Offshore petroleum platforms: functional significance for larval fish across longitudinal and latitudinal gradients. Prepared by the Coastal Fisheries Institute, Louisiana State University. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2002-077, p. 107.

Silber, K,G., & S. Bettridge (2012). An assessment of the final rule to implement vessel speed restrictions to reduce the threat of vessel collisions with North Atlantic Right Whales. NOAA Technical Memorandum NMFS OPR-48. February 2012.

Simmonds, M.P., Dolman, S.J. and Weilgart, L. (eds). (2004). Oceans of Noise [Online]. http://www.wdcs.org/submissions_bin/OceansofNoise.pdf. AWDCS Science Report Published by the Whale and Dolphin Conservation Society.

Smyth, D. (2007). Sea countries of the North-west. Literature review of Indigenous connection to and uses for the North West Marine Region. For the National Oceans Office Branch, Marine Division, Australian Government Department of the Environment and Water Resources.

Sommer, B., Fowler, A. M., Macreadie, P. I., Palandro, D. A., Aziz, A. C., & Booth, D. J. (2019). Decommissioning of offshore oil and gas structures–Environmental opportunities and challenges. Science of the total environment, 658, 973-981.

Stalvies, C, Talukder, A, Ross, A, Grosjean, E, Carr, A, Williams, A, Gresham, M, Binning, M and Jablonski, D. (2017). Establishing hydrocarbon charge to the Ashmore Platform, Bonaparte Basin, Australia: A natural seeps study. Marine and Petroleum Geology 82, pp. 56-68.

Stalvies, C., Talukder, A., Ross, A., Grosjean, E., Carr, A., Williams, A., Gresham, M., Binning, M., Jablonski, D., (2017). Establishing hydrocarbon charge to the Ashmore Platform, Bonaparte Basin, Australia: A natural seeps study, Marine and Petroleum Geology, doi: 10.1016/j.marpetgeo.2016.12.018.

Surman, C. (2002). Survey of the marine avifauna at the Laverda-2 appraisal well (WA-271-P) Enfield Area Development and surrounding waters. Report prepared for Woodside Energy Ltd., Perth

Talukder, A., Hook, S., Ross, A. and Myers, J. (2022) NWS Offshore Gas Seeps and Leakage Characterisation Project – Stage 1, Milestone 1 report: Literature review of offshore wells leakage and natural gas seepage. EP2022-2532, pp 19.

Talukder, A., Ryan, T., Crooke, E., Squiers, I., Hasan, R., Green, M. and Ross, A. (2024) NWS Offshore Gas Seeps and Leakage Characterisation Project – Stage 3: Data Interpretation. EP2024-2213, pp 105.

Taylor, K. Macquaker, J. 2011. Iron Minerals in Marine Sediments Record Chemical Environments. Elements, Vol. 7, pp. 113–118.

Thompson, P. A., Bonham, P., Thomson, P., Rochester, W., Doblin, M. A., Waite, A., Richardson, A., & Rousseaux, C. S. (2015). Climate variability drives plankton community composition changes: the 2010-2011 El Niño to la Niña transition around Australia. Journal of Plankton Research, 37(5), 966-984. https://doi.org/10.1093/plankt/fbv069

Threatened Species Scientific Committee, 2015b. Conservation advice Rhincodon typus whale shark. Department of the Environment, Canberra.

Trebilco R, Fischer M, Hunter C, Hobday AJ, Thomas L, Evans K (2021). Marine: Marine ecosystem processes. In: Australia State of the environment 2021, Australian Government Department of Agriculture, Water and the Environment, Canberra, https://soe.dcceew.gov.au/marine/environment/marine-ecosystem-processes, DOI: 10.26194/nvaa-rf92

TSSC (2001). Commonwealth Listing Advice on Rhincodon typus (Whale shark). Available online at: http://www.environment.gov.au/biodiversity/threatened/species/r-typus.html. Accessed on 9 July 2021.

TSSC (2008). Listing Advice for Pristis zijsron (Green Sawfish). Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/68442-listing-advice.pdf. Accessed on 9 July 2021

TSSC (2010). Commonwealth Listing Advice on Thunnus maccoyii (Southern Bluefin Tuna). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/69402-listing-advice.pdf. In effect under the EPBC Act from 15-Dec-2010.

TSSC (2014). Listing Advice Isurus oxyrinchus shortfin mako shark. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/79073-listing-advice.pdf. Accessed on 9 July 2021

TSSC (2015a). Conservation Advice Rhincodon typus whale shark. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66680-conservation-advice-01102015.pdf. Accessed on 9 July 2021

TSSC (2015b). Conservation Advice Balaenoptera borealis sei whale. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/34-conservation-advice-01102015.pdf. Accessed on 9 July 2021

TSSC (2015c). Conservation Advice Balaenoptera physalus fin whale. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/37-conservation-advice-01102015.pdf. Accessed on 9 July 2021

TSSC (2015d). Conservation Advice Megaptera novaeangliae humpback whale. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf. Accessed on 9 July 2021.

TSSC (2016a). Conservation Advice Calidris canutus Red knot. Canberra: Department of the Environment. Available online at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/855-conservation-advice-05052016.pdf. Accessed on 9 July 2021

TSSC (2024). Listing Advice for Sphyrna lewini (scalloped hammerhead). Canberra: Department of Climate Change, Energy, the Environment and Water. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/85267-listing-advice-27022024.pdf. In effect under the EPBC Act from 27-Feb-2024.

Urick, R.J. (1983). Principles of Underwater Sound. 3rd edition. McGraw-Hill, New York, London. 423 p.

VAHC (Victorian Aboriginal Heritage Council) (2021).

Wakeford M, Puotinen M, Nicholas W, Colquhoun J, Vaughan BI, Whalan S, et al. (2023) Mesophotic benthic communities associated with a submerged palaeoshoreline in Western Australia. PLoS ONE 18(8): e0289805. https://doi.org/10.1371/journal.pone.0289805

Walker, D.I and McComb, A.J. (1990). Salinity response of the seagrass Amphibolus antarctica: an experimental validation of field results. Aquatic Botany 36: 359-366.

WDCS (2004). Oceans of Noise. Whale and Dolphin Conservation Society (Online). Available from: http:www.wdcs.org/stop/pollution/index.php.

Wells, F.E., McDonald, J.I. and Huisman, J.M. (2009). Introduced marine species in Western Australia. Published by the Department of Fisheries, Perth, WA.

Wiese, F.K., Montevecchi, W.A., Davoren G.K., Huettmann F., Diamond A.W. and Linke, J. (2001). Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic. Marine Pollution Bulletin Vol. 42, No. 12, pp. 1285-1290.

Wilson, P., Thums, M., Pattiaratchi, C., Meekan, M., Pendoley, K., Fisher, R. & Whiting, S. (2018) Artificial light disrupts the nearshore dispersal of neonate flatback turtles Natator depressus. Marine Ecology Progress Series, 600, 179-192. doi:https://doi.org/10.3354/meps12649

Wilson, S.G., Polovina, J.J., Stewart, B.S. and Meekan, M.G. (2006). Movements of whale sharks (Rhincodon typus) tagged at Ningaloo Reef, Western Australia, Marine Biology, vol. 148, no. 55, pp. 1157-1166.

Wolgemuth, K. S., Cudahy, E. A., & Schwaller, D. W. (2008). Underwater and dive station work-site noise surveys. Naval Submarine Medical Research Lab Groton CT.

Woodside (2008). Torosa South-1 Pilot Appraisal Well Environment Plan. Woodside Energy, Perth.

Yamamoto, A., Yamanaka, Y., Oka, A., & Abe-Ouchi, A. (2014). Ocean oxygen depletion due to decomposition of submarine methane hydrate. Geophysical Research Letters, 41(14), 5075-5083.

Young, C.N., Carlson, J.K. (2020). The biology and conservation status of the oceanic whitetip shark (Carcharhinus longimanus) and future directions for recovery. Rev Fish Biol Fisheries 30, 293–312 (2020). https://doi.org/10.1007/s11160-020-09601-3

Appendices

Appendix A: Santos Environment, Health and Safety Policy

Environment, Health & Safety

Santos

Policy

Our Commitment

Santos is committed to being the safest gas company wherever we have a presence and preventing harm to people and the environment

Our Actions

We will:

1. Integrate environment, health and safety management requirements into the way we work
2. Comply with all relevant environmental, health and safety laws and continuously improve our management systems
3. Include environmental, health and safety considerations in business planning, decision making and asset management processes
4. Identify, control and monitor risks that have the potential for harm to people and the environment, so far as is reasonably practicable
5. Report, investigate and learn from our incidents
6. Consult and communicate with, and promote the participation of all workers to maintain a strong environment, health and safety culture
7. Empower our people, regardless of position, to "Stop the Job" when they feel it necessary to prevent harm to themselves, others or the environment
8. Work proactively and collaboratively with our stakeholders and the communities in which we operate
9. Set, measure, review and monitor objectives and targets to demonstrate proactive processes are in place to reduce the risk of harm to people and the environment
10. Report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety and Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	David Banks, Chief Operating Officer		
Approved by:	The Board	Version:	3

15 August 2022 Page 1 of 1

Appendix B: Legislation

Key Agreements and Conventions

International Agreements and Conventions	Summary	Relevant aspects of the activity	EP Section
London Convention and Protocol (2006)	The objective of the London Convention and Protocol is to promote the effective control of all sources of marine pollution. Contracting Parties shall take effective measures to prevent pollution of the marine environment caused by dumping at sea. The Protocol is more restrictive than the convention as application of a "precautionary approach" is included as a general obligation; a "reverse list" approach is adopted, which implies that all dumping is prohibited unless explicitly permitted.	Not applicable - See Sea Installations Act 1981	N/A
United Nations Convention on the Law of the Sea (UNCLOS)	Article 60 prescribes that "prescribes that any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation" and that "and that such removal shall also have due regard to fishing, protection of the marine environment and the rights and duties of other States".	UNCLOS is enacted in Australia by Section 572 of the OPGGS Act. The activity involves the permanent abandonment of the Legendre-1 wellhead in-situ, which is a petroleum activity regulated by NOPSEMA under the OPGGS Act.	**Section 2.2.2** demonstrates that leaving the wellhead in situ has considered the protection of the marine environment.
1989 International Maritime Organisation (IMO) Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and the Exclusive Economic Zone (IMO Resolution A.672(16))	This guideline requires that abandoned or disused offshore installations or structures on any continental shelf or in any exclusive economic zone are required to be removed, except where non-removal or partial removal is consistent with the guidelines and standards. It also states that the decision to allow and offshore installation, structure, or parts thereof, to remain on the seabed should be based on a case-by-case evaluation including consideration of: Any potential effect on the safety of surface or subsurface navigation, or of other uses of the sea; The rate of deterioration of the material and its present and possible future effect on the marine environment, The potential effect on the marine environment, including living resources, The risk that the material will shift from its position at some future time The costs, technical feasibility, and risks of injury to personnel associated with removal of the installation or structure, and	This guideline is enacted in Australia by Section 572 of the OPGGS Act. The activity involves the permanent abandonment of the Legendre-1 wellhead in-situ, which is a petroleum activity regulated by NOPSEMA under the OPGGS Act.	**Section 2.2.2** demonstrates that leaving the wellhead in situ has considered not causing a significant adverse effect upon the environment.

International Agreements and Conventions	Summary	Relevant aspects of the activity	EP Section
	the determination of a new use of other reasonable justification for allowing the installation to remain on the seabed. The guideline includes standards that the governing body should consider regarding the removal of a structure, including that removal should be performed in such a way as to not cause significant adverse effect upon navigation or the marine environment.		
The International Convention for the Prevention of Pollution from Ships (MARPOL)	The International Convention for the Prevention of Pollution from Ships (MARPOL) includes "regulations aimed at preventing both accidental pollution and pollution from routine vessel operations."	This convention is enacted in Australia through the *Navigation Act 2012* which regulates international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters, and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*	**Section 6.2**
International Regulations for Preventing Collisions at Sea, 1972 (COLREGS)	The COLREGS outline internationally agreed rules for safe navigation, including 'give way' rules between vessels and other requirements for safe conduct including the requirement to keep a look out, travel at a safe speed, and how to operate vessels in narrow channels.	This convention is enacted in Australia through the Navigation Act 2012 which regulates international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters.	**Section 6.2**

Key Commonwealth Legislation and Regulations

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
Corporations Act 2001	This Act is the principal legislation regulating matters of Australian companies, such as the formation and operation of companies, duties of officers, takeovers and fundraising.	Australian Securities and Investments Commission	The titleholder has provided ACN details within the meaning of the Act.	**Section 1**
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	This Act provides for the preservation and protection from injury or desecration areas and objects that are of significance to Aboriginal people, under which the Minister may make a declaration to protect such areas and objects. The Act also	DCCEEW	There are no known sites of Aboriginal Heritage Significance within WA-20-L. This Act would only apply to the activity if there was a discovery of Aboriginal remains, which is	**Section 3.6**

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
	requires the discovery of Aboriginal remains to be reported to the Minister.		not considered likely to occur, given the offshore location of the activity.	
Australian Heritage Council Act 2003	This Act identifies areas of heritage value listed on the Register of the National Estate and sets up the Australian Heritage Council and its functions.	Australian Heritage Council (AHC)	There are no known sites of Aboriginal Heritage Significance within WA-20-L.	**Section 3.6**
Underwater Cultural Heritage Act 2018 Draft Underwater Cultural Heritage guidelines 2023	This Act protects its shipwrecks, sunken aircraft and other types of underwater heritage and their associated artefacts. These guidelines outline the requirements of the UWH Act so proponents can plan for and implement the necessary risk assessment and management strategies to protect UCH from any direct or indirect impacts and to manage any residual impacts to acceptable levels. Any adverse impact to protected UCH is unacceptable, unless these impacts are mitigated and managed in accordance with the UCH Act, the UNESCO 2001 Convention and the Annex Rules. Activities of any kind that have the potential to impact protected UCH must comply with the requirements of the UCH Act and, if applicable, any relevant state or the Northern Territory legislation. To satisfy their obligations under the UCH Act, proponents must be able to demonstrate: that they are aware of the relevant UCH legislation; that their actions will be compliant with the legislation; and that they will implement appropriate and effective risk mitigation strategies to prevent or reduce the likelihood or severity of accidental impacts to protected UCH.	DCCEEW	There are no known sites of shipwrecks, aircraft or other underwater heritage within WA-20-L. This Act would only apply to the activity if there was a discovery of underwater heritage, which is not considered likely to occur, given the offshore location of the activity.	This is not relevant to the activity as there are no known sites within WA-20-L.

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
Biosecurity Act 2015 Biosecurity Regulations 2016	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.	DAFF	Potential internationally sourced vessels operating in Australian Waters which could have the potential for introduction of IMS through potential ballast water exchange.	**Section 7.3**
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	Regulates ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc.	AMSA	Provides for discharges and emissions from ships as per MARPOL Annex I, II, III, IV, V and VI. Several Marine Orders are enacted under this Act relevant to the activity, including: Marine Order 91: Marine pollution prevention – oil Marine Order 93: Marine pollution prevention – noxious liquid substances Marine Order 94: Marine pollution prevention – packaged harmful substances Marine Order 95: Marine pollution prevention – garbage Marine Order 96: Marine pollution prevention – sewage Marine Order 97: Marine pollution prevention – air pollution Marine Order 98: Marine pollution prevention – anti-fouling systems.	**Section 6.7**

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
			Provides exemptions for the discharge of materials in response to marine pollution incidents. Requires ships ≥400 gross tonnes to have pollution emergency plans.	
Environment Protection and Biodiversity Conservation Act 1999 Environment Protection and Biodiversity Conservation Amendment Regulations 2006	The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is the sole assessor for offshore petroleum activities in Commonwealth water (as of 28 February 2014). Under the new arrangements, environmental protection will be met through NOPSEMA's decision-making processes. This Act is the Australian Government's key piece of environmental legislation. The Act focuses on the protection of matters of national environmental significance (MNES). Australian Marine Park Management Plans were also developed under this Act.	DCCEEW	This Act applies to all aspects of the petroleum activity that have the potential to impact MNES. Appropriate environmental approvals will be sought from NOPSEMA for all operations (this EP) which outlines compliance with the relevant regulations and plans under the Act. Where activities have existing approvals under the Act, these will continue to apply.	**Section 6** **Section 7**
Environment Protection (Sea Dumping) Act 1981	Regulates the loading and dumping of waste at sea and fulfils Australia's international obligations under the London protocol to prevent marine pollution by controlling dumping of wastes and other matter. The Sea Dumping Act applies to all vessels, aircraft and platforms in Australian waters and to all Australian vessels and aircrafts in any part of the sea. This Act does not apply in relation to the disposal or storage of controlled material (other than a vessel, aircraft or platform) directly arising from, or related to, the exploration, exploitation and associated off-shore processing, of seabed mineral resources.	DCCEEW	Generally, where a titleholder proposes to dispose of or abandon in-situ infrastructure at sea, the titleholder will be required to apply for a permit under the Act. However, since the abandonment took place before the Sea Dumping Act came into force, a permit is not required. Santos has provided written notification to DAWE and NOPSEMA confirming that the Legendre-1 wellhead was plugged and abandoned before 1983 when the Sea Dumping Act 1981 was enacted.	NA
Navigation Act 2012	Regulates international ship and seafarer safety, shipping aspects of protecting the marine	AMSA	Several Marine Orders are enacted under this Act relating to offshore petroleum activities, including:	**Section 7** and **Section 8**

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
	environment and the actions of seafarers in Australian waters. It gives effect to the relevant international conventions (MARPOL, COLREGS 1972) relating to maritime issues to which Australia is a signatory. The Act also has subordinate legislation contained in Regulations and Marine Orders		Marine Order 21: Safety and emergency arrangements Marine Order 27: Safety of navigation and radio equipment Marine Order 30: Prevention of collisions Marine Order 31: Vessel surveys and certification Marine Order 58: Safe management of vessels.	
Offshore Petroleum and Greenhouse Gas Storage Act 2006 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023	Petroleum exploration and development activities in Australia's offshore areas are subject to the environmental requirements specified in the OPGGS Act and associated Regulations. The OPGGS Act contains a broad requirement for titleholders to operate in accordance with "good oil-field practice". Specific environmental provisions relating to work practices essentially require operators to control and prevent the escape of wastes and petroleum. The Act also requires that activities are carried out in a manner that does not unduly interfere with other rights or interests, including the conservation of the resources of the sea and seabed, such as fishing or shipping. In some cases, where there are particular environmental sensitivities or multiple use issues it may be necessary to apply special conditions to an exploration permit area. The holder of a petroleum title must maintain adequate insurance against expenses or liabilities arising from activities in the title, including expenses relating to clean-up or other remedying of the effects of the escape of petroleum. The OPGGS Environment Regulations provide an objective based regime for the management of environmental performance for Australian offshore petroleum exploration and production activities in	NOPSEMA	The activity involves the permanent abandonment of the Legendre-1 wellhead in-situ and the ongoing gas seepage, which are petroleum activities regulated by NOPSEMA under this Act.	**Section 6**

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
	areas of Commonwealth jurisdiction. Key objectives of the Environment Regulations include: to ensure operations are carried out in a way that is consistent with the principles of ecologically sustainable development; to adopt best practice to achieve agreed environment protection standards in industry operations; and to encourage industry to continuously improve its environmental performance.			
Sea Installations Act 1987	The Sea Installations Act regulates the placement, use and maintenance of seabed installations in Australian waters. A sea installation refers to any man-made structure that is in contact with the seabed and used for an environment-related activity: tourism or recreation carrying on of a business exploring, exploiting or using the living resources of the sea, seabed or sub-soil of the seabed whether by way of fishing, pearling, oyster farming, fish farming or otherwise marine archaeology other activities including a scientific activity or transport activity. Section 55 of the Act allows The Minister to serve in writing a notice to the owner of an installation for that installation to be removed, and/or to make good any damage to the seabed cause by that installation.	DCCEEW	The London Protocol is implemented through Section 5 of the Sea Installations Act; Article 1.4.1.4 of the London Protocol covers the abandonment of man-made structures. The Minster has not directed the removal of structures under this Act for the purposes of this EP.	NA

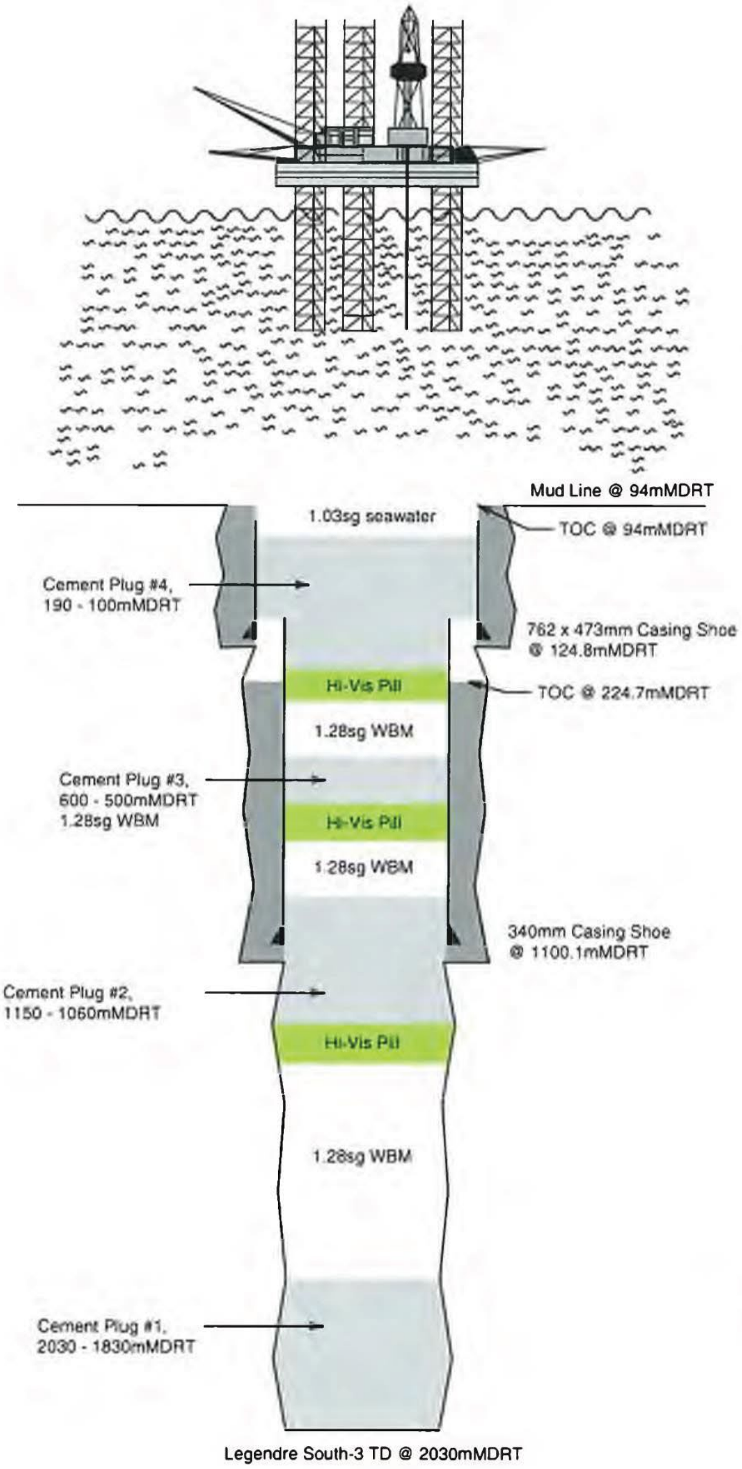
Key WA State Legislation and Regulations

State Legislation	Summary	Administering Authority	Relevant to activity?	EP Section
Biodiversity Conservation Act 2016	The Biodiversity Conservation Act 2016 came into effect on 3 December 2016 and replaced the Wildlife Conservation Act 1950. Relating to potential impacts to listed species: this Act provides for the conservation and protection of Western Australian wildlife.	Department of Biodiversity, Conservation and Attractions (DBCA)	Yes, hydrocarbon spill scenarios impacts relating to potential impacts to listed species	**Section 6** **Section 7**
Aboriginal Cultural Heritage Act 2021	This Act provides a modern framework for the recognition, protection, conservation and preservation of Aboriginal cultural heritage while recognising the fundamental importance of Aboriginal cultural heritage to Aboriginal people. This Act is replacing the Aboriginal Heritage Act 1972 in stages from December 2021.	Department of Planning, Lands and Heritage (DPLH)	No, there are no known sites of Aboriginal Heritage Significance within WA-20-L.	**Section 3.6**
Aboriginal Heritage Act 1972	This Act provides for the protection of objects and places which are sacred or have significance to Aboriginal people.	DPLH	No, there are no known sites of Aboriginal Heritage Significance within WA-20-L.	**Section 3.6**
Dangerous Goods Safety Act 2004	Act relating to the safe storage, handling and transport of dangerous goods and for related purposes	Department of Mines, Industrial Safety and Regulation (DMIRS)	Yes, however WA waters are outside of WA-20-L. May be relevant during operations in response to an unplanned hydrocarbon spill that enters WA waters.	**Section 6** **Section 7**
Environmental Protection Act 1986	Relating to non-routine operations (potential oil spills) in areas under State jurisdiction: this Act provides for the prevention, control and abatement of pollution and environmental harm and for the conservation, preservation, protection, enhancement and management of the environment.	Environmental Protection Authority (EPA)	Yes, environment may receive exposure from a hydrocarbon spill	**Section 6** **Section 7**
Fish Resources Management Act 1994	This Act establishes a framework for management of fishery resources and is the nominated lead agency responsible for implementing Western Australian marine biosecurity management requirements through implementation of the Fish	DPIRD	Yes. Vessels required to comply with the Act.	**Section 6** **Section 7**

State Legislation	Summary	Administering Authority	Relevant to activity?	EP Section
Fish Resources Management Regulations 1995.	Resources Management Act 1994 (FRMA 1994) and associated regulations. Under regulation 176 of the Fish Resources Management Regulations 1995 (FRMR), it is an offence to translocate live non-endemic fish to WA without permission. Under section 105 of the Fish Resources Management Act 1994 (FRMA), it is an offence to bring noxious fish into WA. Also, under Part 16A of the FRMA, the Department has emergency powers to deal with incursions of IMS, which include directing a person to carry out necessary activities to prevent or control the spread of IMS, or to eradicate them in WA waters. If these activities are not undertaken, department may carry out the activities and recover any costs incurred from the person initially directed			
West Australian Maritime Archaeology Act 1973	Protects maritime archaeological sites on state land and in State waters, such as bays, harbours and rivers. Other than shipwrecks, it includes single relics, such as an anchor, and land sites associated with exploration, early settlements, whaling and pearling camps and shipwreck survivor camps	West Australian Museum	Yes. maritime archaeological site in WA-20-L. Sites may receive exposure from a hydrocarbon spill.	**Section 6** **Section 7**
Western Australia Marine Act 1982	Relating to vessel movements: an Act to regulate navigation and shipping.	Department of Transport	May be relevant during operations in response to an unplanned hydrocarbon spill that enters WA waters.	**Section 6** **Section 7**

Appendix C: Well schematics

WA-20L
LEGENDRE SOUTH-3
ABANDONMENT SCHEMATIC (FINAL)



LOCATION

Lat:	19° 43'18.042"S
Long:	116° 41'29.580"E

ELEVATIONS - OCEAN SHIELD

RT to AHD Elevation:	38.4 m
Water Depth (AHD):	55.6 m
Mud Line:	94.0 m

WELL TRACK DETAILS

610mm Hole to:	127.0 mMDRT
762 x 473mm Casing at:	124.8 mMDRT
406mm Hole to:	1105.0 mMDRT
340mm Casing at:	1100.1 mMDRT
311mm Hole to:	2030.0 mMDRT

ABANDONMENT PLUGS

Cement Plug 1	2030 - 1830 mMDRT
Cement Plug 2	1150 - 1060 mMDRT
Cement Plug 3	600 - 500 mMDRT
Cement Plug 4	190 - 100 mMDRT

ADDITIONAL INFORMATION

340mm Casing cut @ 123 mMDRT

473mm Casing cut @ 97 mMDRT

Approval- Name & Signature

Engineer: Werner Janisch

Signature: [signature]

Drill Manager: Mitch Elkins

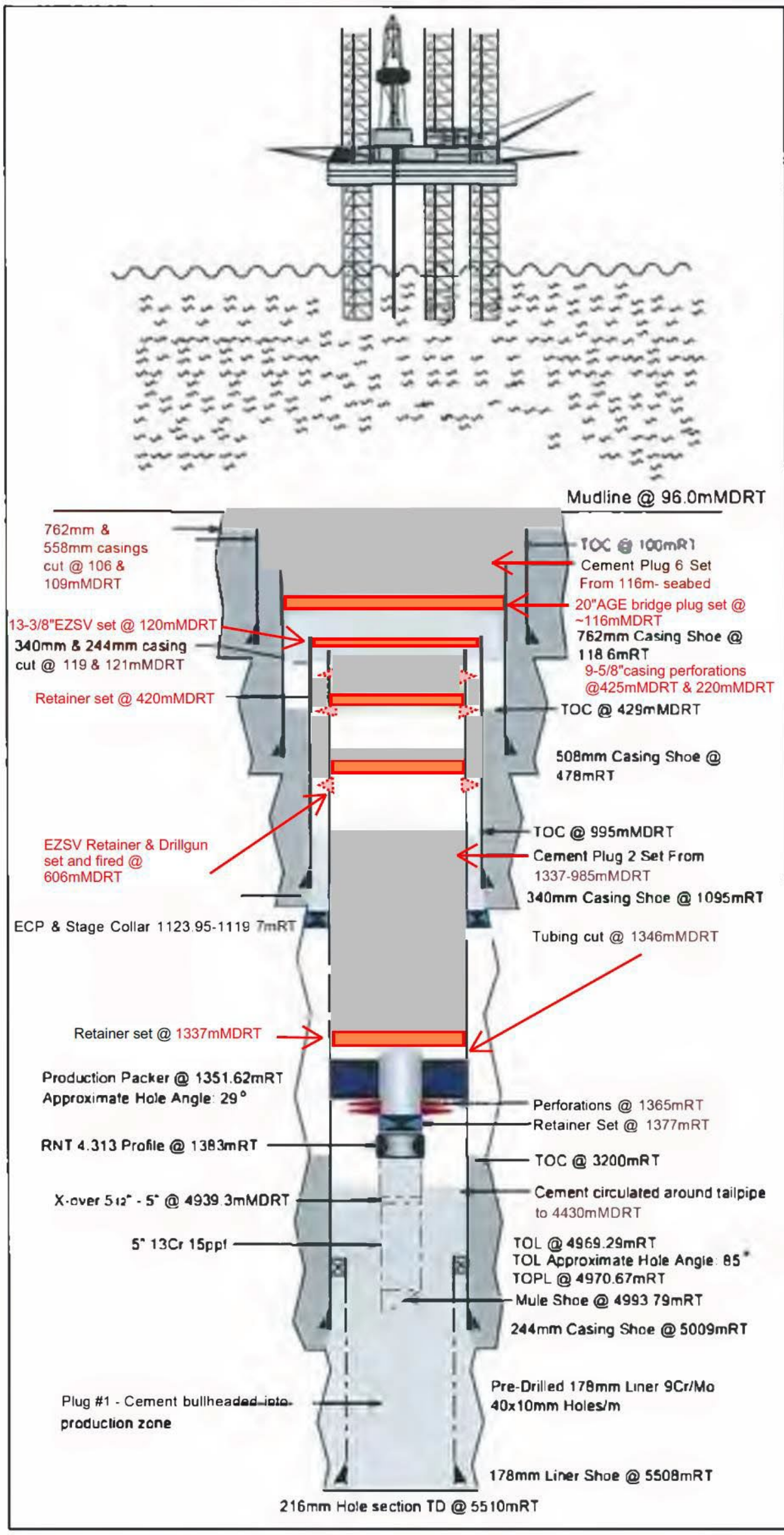
Signature: [signature]

All depths MDRT/TVD	Scale: NOT TO SCALE
Drawn by: S.HARES	Date: SEPTEMBER 2010
File Name: LEGENDRE SOUTH-3 ABAND.dgn	

WA-20-L

LEGENDRE NORTH-1H, 1H ST1 & 1H ST2

AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,255.22mN
Easting:	469,470.99mE

ELEVATIONS

RT to AHD Elevation:	44.4mMDRT
Water Depth (AHD):	51.47mMDRT
Mud Line:	96.0mMDRT

WELL TRACK DETAILS

914mm (36") Hole to:	122.0mMDRT
762mm (30") Casing at:	118.6mMDRT
660mm (26") Hole to:	498.0mMDRT
508mm (20") Casing at:	478.0mMDRT
406mm (16") Hole to:	1101.0mMDRT
340 mm (13 3/8") Casing at:	1095.0mMDRT
311mm (12 1/4") Hole to:	5009.0mMDRT
244mm (9 5/8") Liner at:	5018.0mMDRT
216mm (8 1/2") Hole to:	5510.0mMDRT
178 mm (7") Liner at:	5508.0mMDRT

ADDITIONAL INFO.

LN-1H Hole TD @ 5310 mRT

LN-1H ST1 KOP - 5050m & TD - 5464mRT

LN-1H ST2 KOP - 5281m & TD - 5510mRT

Plug #1
-Cement bullheaded into production Zone
-TOC @4430mMDRT (Theoretical based on returns)
- Pressure test failed

Plug #2
-1337-985mMDRT
-Tagged and P/Tested to 1000psi

Plug #3 (& annulus squeeze)
-606-586mMDRT
-36bbls Cement pumped into annulus
-TTOC in 9-5/8"x 13-3/8"annulus @ 456mMDRT

Plug# 4 (& annulus squeeze)
- Circulated cement through 9-5/8"x 13-3/8"annulus 425 to 220mMDRT
- Set balanced plug 400m to 194mMDRT (tagged)

Plug #5
- 194-150mMDRT
- not tagged

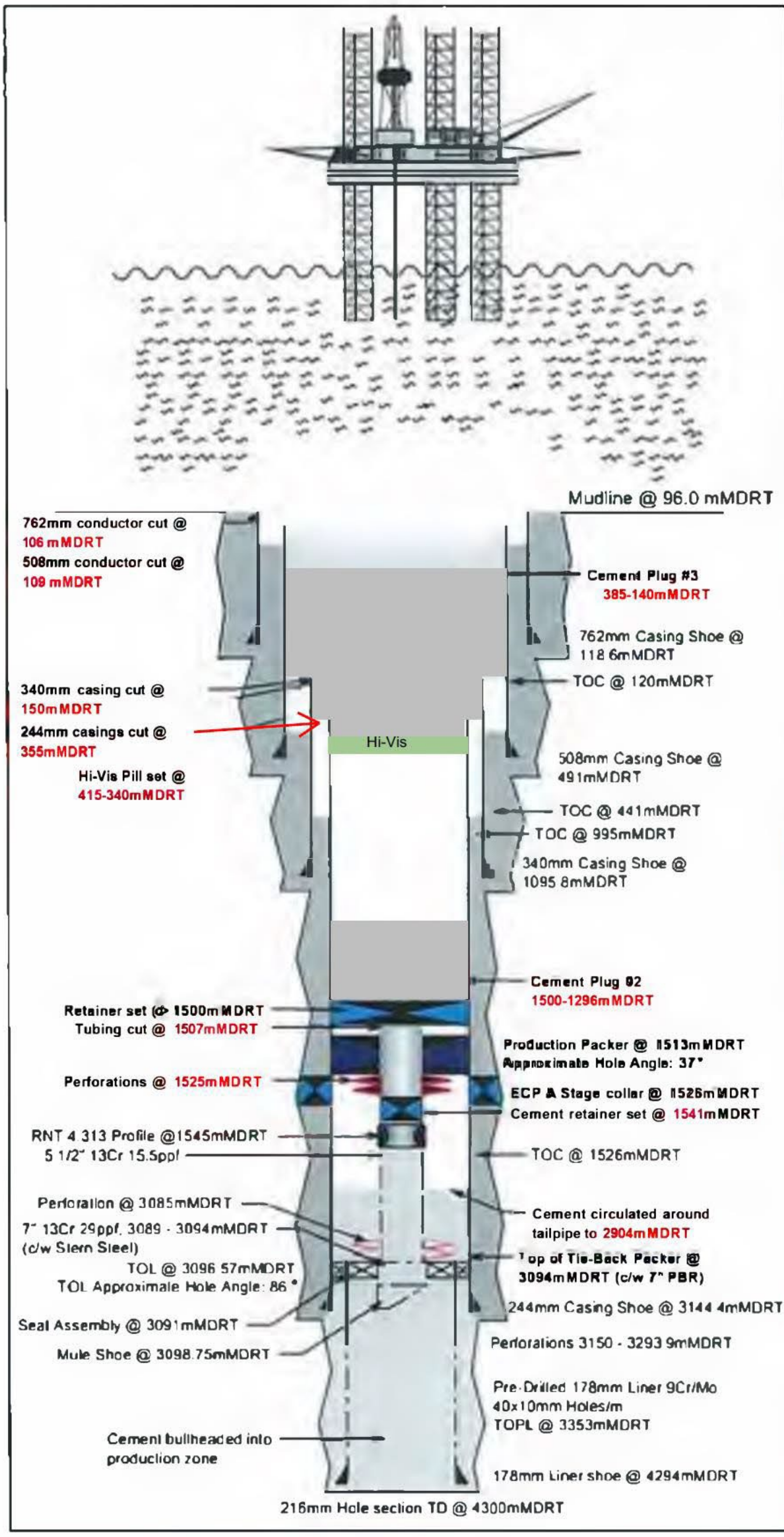
Plug #6
- 116mMDRT to seabed

All depths MDRT	Scale: NOT TO SCALE
Drawn by: S.HARES	
File Name: Legendre North-1_Pro Abandonment.dgn	

WA-20-L

LEGENDRE N0RTH-2H

AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,256 55mN
Easting:	469,472.48mE

ELEVATIONS

RT to AHD Elevation:	44 4 mMDRT
Water Depth (AHD):	51 47 mMDRT
Mud Line:	96.0 mMDRT

WELL TRACK DETAILS

914mm (36") Hole to:	122.0 mMDRT
762mm (30") Casing at:	118 6 mMDRT
660mm (26") Hole to:	499.0 mMDRT
508mm (20") Casing at:	491.0 mMDRT
406mm (16") Hole to:	1101.0 mMDRT
340 mm (13 3/8") Casing at:	1095 8 mMDRT
311mm (12 1/4") Hole to:	3150.0 mMDRT
244mm (9 5/8") Liner at:	3144 4 mMDRT
216mm (8 1/2") Liner at:	4300 0 mMDRT
178 mm (7") Liner at:	4294.0 mMDRT

ADDITIONAL INFO.

The EOW is confusing Mention is made of Liner Wiper Plugs and 1 9m cmt slurry was pumped - possibly an ECP & Stage Diverter in 7" Liner

Pre-Drill joints at 3305 66mMDRT

7" Stem seal stabbed into 7"PBR on top of Tie-Back Packer

Packer is HRS THT (9 5/8"x5 1/2") Mill to release

Spot Hi-Vis weighted pill from 385-415mMDRT

Cement Plug Details

Plug #1
- Cement Bullheaded into production zone then circulated around tailpipe.
- TOC @ 2904m (based on 26bbls returns)
- Failed pressure test

Plug #2
- 1500-1296mMDRT
- TOC tagged
- 6 bbl cement squeezed below retainer

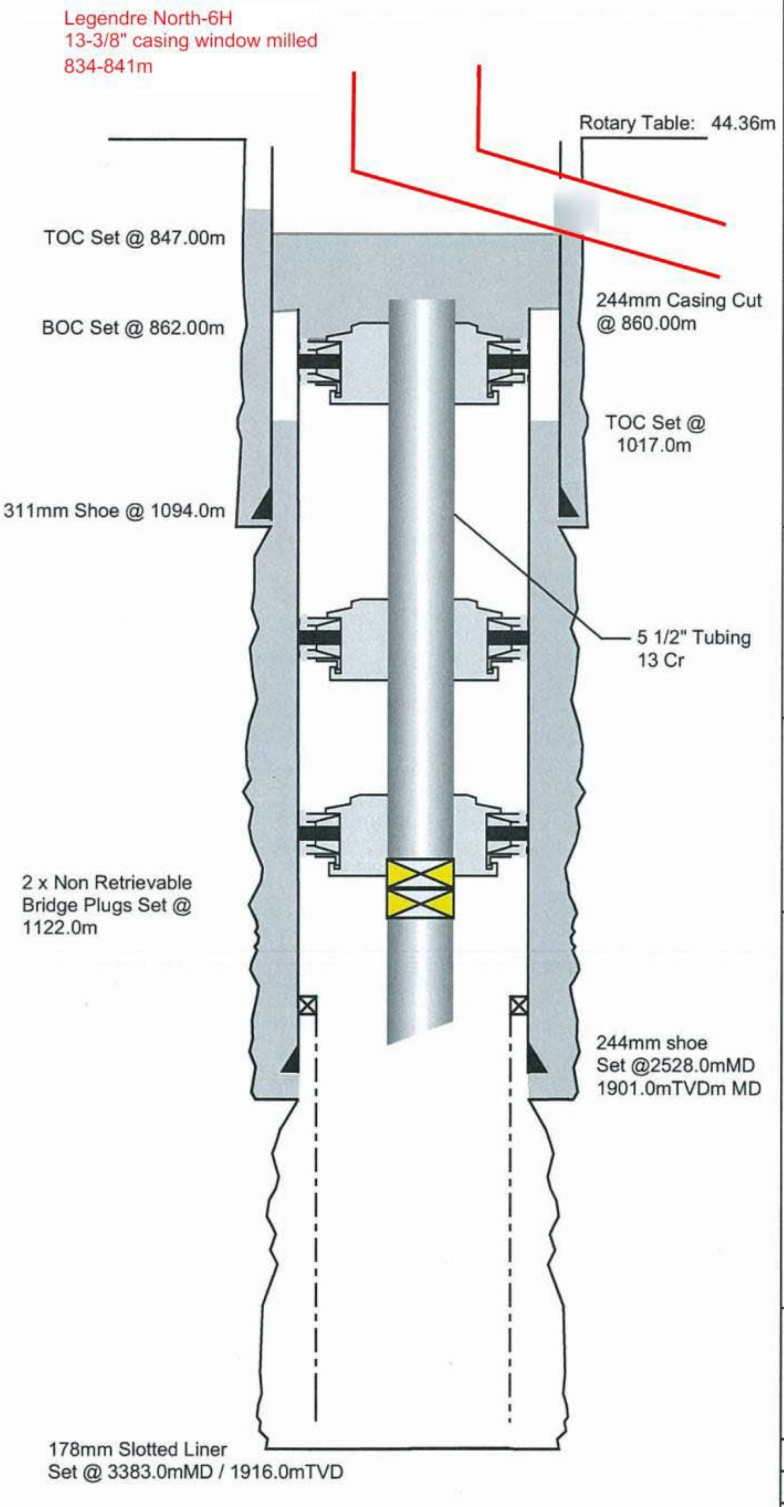
Plug #3
- 385-140mMDRT
- TOC not tagged

All depths MDRT	Scale: NOT TO SCALE
Drawn by. S.HARES	
File Name. Legendre North-2H_Pro Abandonment.dgn	

WA-20-L

LEGENDRE NORTH-3H

PLUG AND ABANDONMENT



LOCATION

Lat:	20° 33' 43.468" S
Long:	115° 02' 31.124" E

ELEVATIONS

Rotary Table	44.36 m

WELL TRACK DETAILS

311mm Shoe Set @:	1094.0 mRT
244mm Shoe Set @:	2528.0 mRT
Slotted Liner Set @:	3383.0 mRT

ABANDONMENT PLUGS

TOC Set @:	847.00 mRT
BOC Set @:	862.00 mRT

ADDITIONAL EQUIPMENT

Packer #1:	863.00 mMD
Packer #2:	1092.91 mMD
Packer #3:	1113.13 mMD

Approval Signature

Drill Engineer:

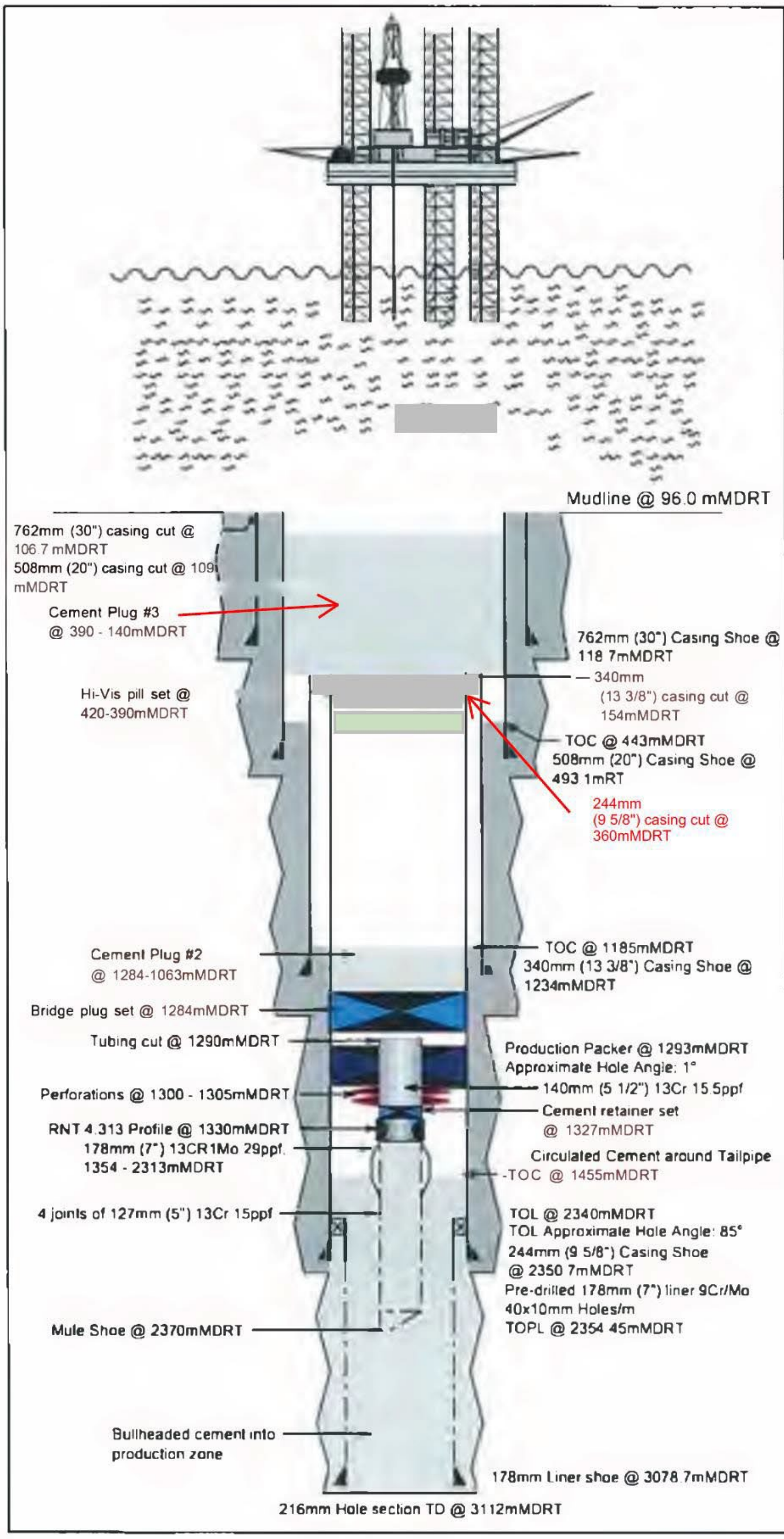
Drill Supervisor:

All depths MDRT	Scale: NOT TO SCALE
Drawn by: G.COOKS	Date: JUNE 2008
File Name: Abandonment Legendre North-3H.DGN	

WA-20-L

LEGENDRE NORTH-4H, ST1, ST2 & ST2 BHC1

AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,253.57mN
Easting:	469,475.14mE

ELEVATIONS

RT to AHD Elevation:	44.4 mMDRT
Water Depth (AHD):	51.47 mMDRT
Mud Line:	96.0 mMDRT

WELL TRACK DETAILS

914mm (36") Hole to:	122.0 mMDRT
762mm (30") Casing at	118.7 mMDRT
660mm (26") Hole to:	515.0 mMDRT
508mm (20") Casing at:	493.1 mMDRT
406mm (16") Hole to:	1243.0 mMDRT
340 mm (13 3/8") Casing at:	1234.0 mMDRT
311mm (12 1/4") Hole to:	2370.0 mMDRT
244mm (9 5/8") Casing at:	2350.7 mMDRT
216mm (8 1/2") Hole to:	3112.0 mMDRT
178 mm (7") Liner at:	3078.7 mMDRT

ADDITIONAL INFO.

1) 5" 13Cr 15ppf tubing inside TOL
2) OH drilled - 2533mMDRT. DP Stuck. BO @ 2003.5mMDRT. Set cement plug.
3) KOP, 2005-1900mMDRT. KO @ 1922mMDRT 9 5/8" casing @ 2350.7mMDRT (LN-4H ST1)
4) Due to excess build, KO 2486mMDRT. ~~Section TD 2766mMDRT (LN-4H ST2).~~
5) KO @ 2709mMDRT. Section TD @ 3112mMDRT (LN-4H ST2 BHC1).

Cement Plug Details

Plug #1
- Cement Bullheaded into production zone then circulated around tailpipe.
- TOC @ 1455m (based on returns)
- Pressure tested

Plug #2
- 1284-1063mMDRT
- TOC tagged

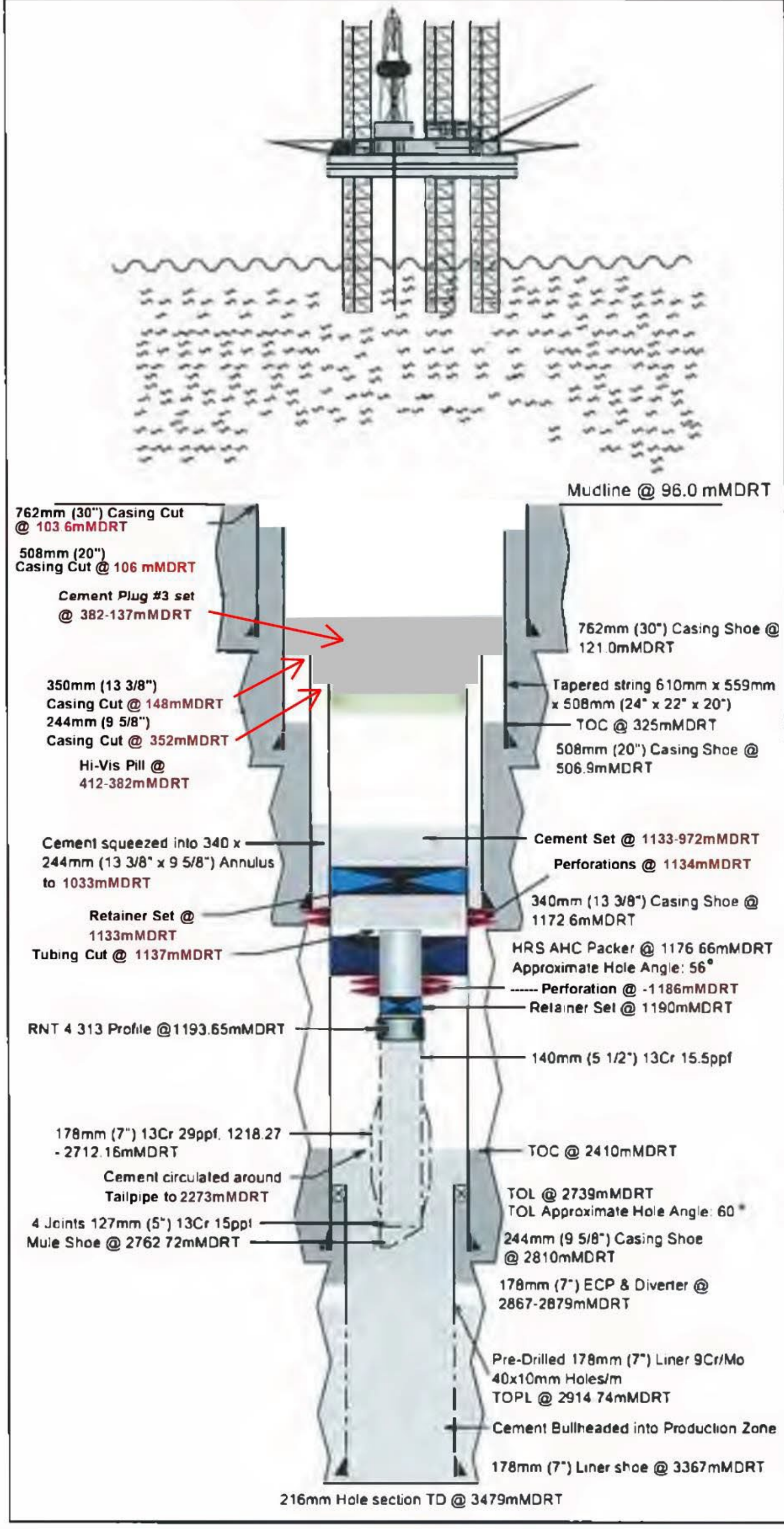
Plug #3
- 390-140mMDRT
- TOC not tagged

All depths MDRT	Scale: NOT TO SCALE
Drawn by: S.HARES	
File Name: Legendre North-4H,ST1,ST2 & ST2 BHC1_Pro.dgn	

WA-20-L

LEGENDRE NORTH-5H

AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,252.24mN
Easting:	469,473.65mE

ELEVATIONS

RT to AHD Elevation:	44.4 mMDRT
Water Depth (AHD):	51.47 mMDRT
Mud Line:	96.0 mMDRT

WELL TRACK DETAILS

914mm (36") Hole to:	125.5 mMDRT
762mm (30") Casing at:	121.0 mMDRT
660mm (26") Hole to:	516.0 mMDRT
508mm (20") Casing at:	506.9 mMDRT
406mm (16") Hole to:	1180.0 mMDRT
340 mm (13 3/8") Casing at:	1172.6 mMDRT
311mm (12 1/4") Hole to:	2953.0 mMDRT
244mm (9 5/8") Casing at:	2810.0 mMDRT
216mm (8 1/2") Hole to:	3479.0 mMDRT
178 mm (7") Liner at:	3367.0 mMDRT

Cement Plug Details

Plug #1
- Cement Bullheaded into production zone then circulated around tailpipe.
- TOC @ 2273m (based on returns)
- Pressure tested

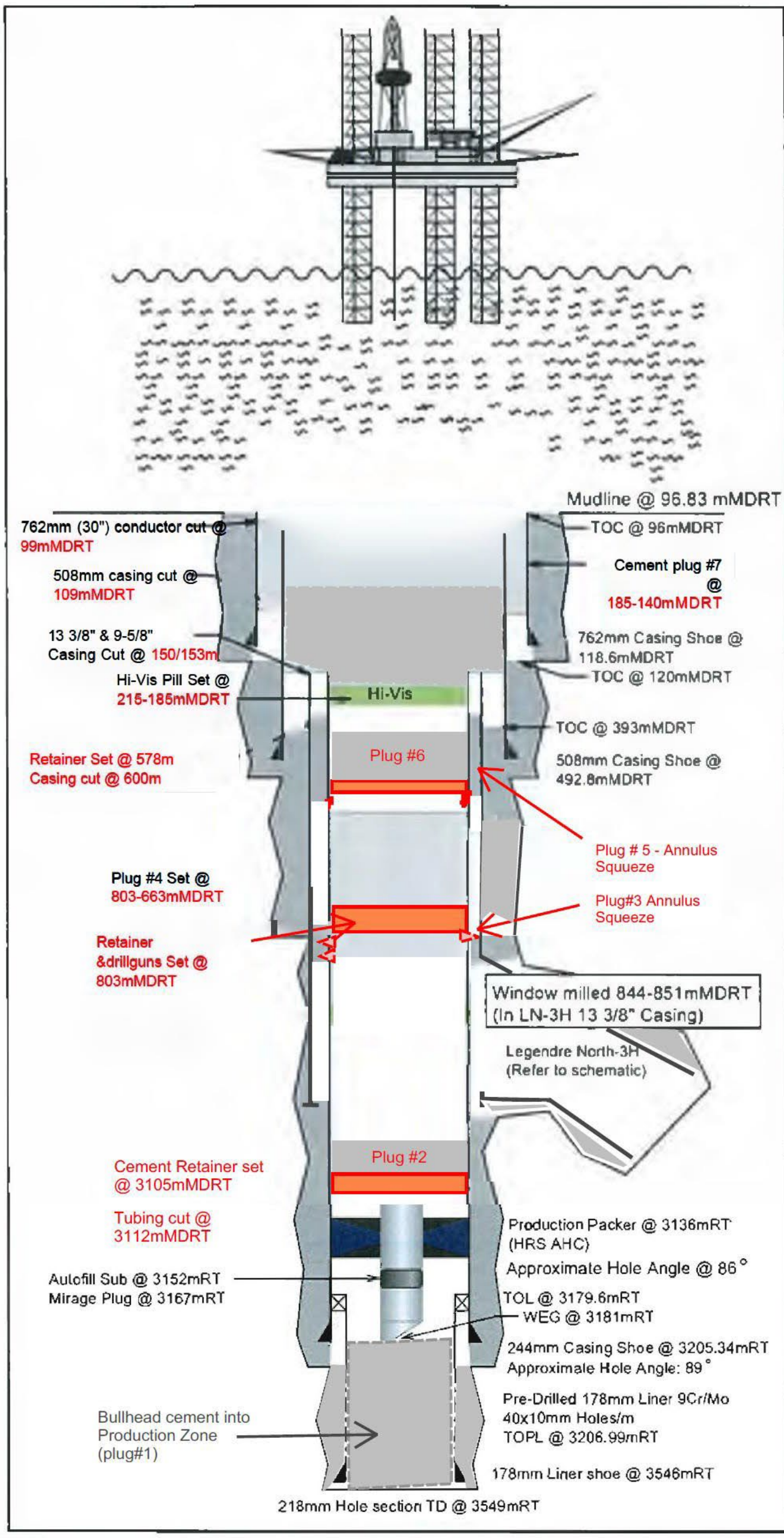
Plug #2
- 1133-972mMDRT
- TOC tagged & Pressure Tested

Plug #3
- 382 -137mMDRT
- TOC not tagged

All depths MDRT	Scale: NOT TO SCALE
Drawn by: S.HARES	
File Name: Legendre North-5H_Pro Abandonment.dgn	

WA-20L

LEGENDRE NORTH-6H (E-106)
AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,255.06mN
Easting:	469,473.81mE

ELEVATIONS - Ensco 106

RT to AHD Elevation:	53.8 m
Water Depth (AHD):	52.0 m
Mud Line:	96.83 m

WELL TRACK DETAILS

Legendre North-3H

914mm (36") Hole to:	121.0mMDRT
762mm (30") Casing at:	118.6mMDRT
660mm (26") Hole to:	502.0mMDRT
508mm (20") Casing at:	492.8mMDRT
Window Milled (340mm) at:	844 - 851mMDRT

Legendre North-6H

311mm (12 1/4") Hole to:	3211.0mMDRT
244mm (9 5/8") Casing at:	3205.34mMDRT
216mm (8 1/2") Hole to:	3549.0mMDRT
178 mm (7") Liner at:	3546.0mMDRT

CEMENT PLUGS

Plug #1
- Cement Bullheaded into production zone then circulated around tailpipe.
- 3549m -3105mMDRT

Plug #2
- 3105-2670mMDRT
- TOC tagged & P/Test to 1000psi

Plug #3
- 9-5/8"x 13-3/8"Annulus Squeeze
- 25bbl @ 803mMDRT
- TTOC unknown & P/T Failed

Plug #4
- 803-663 mMDRT
- TOC Tagged

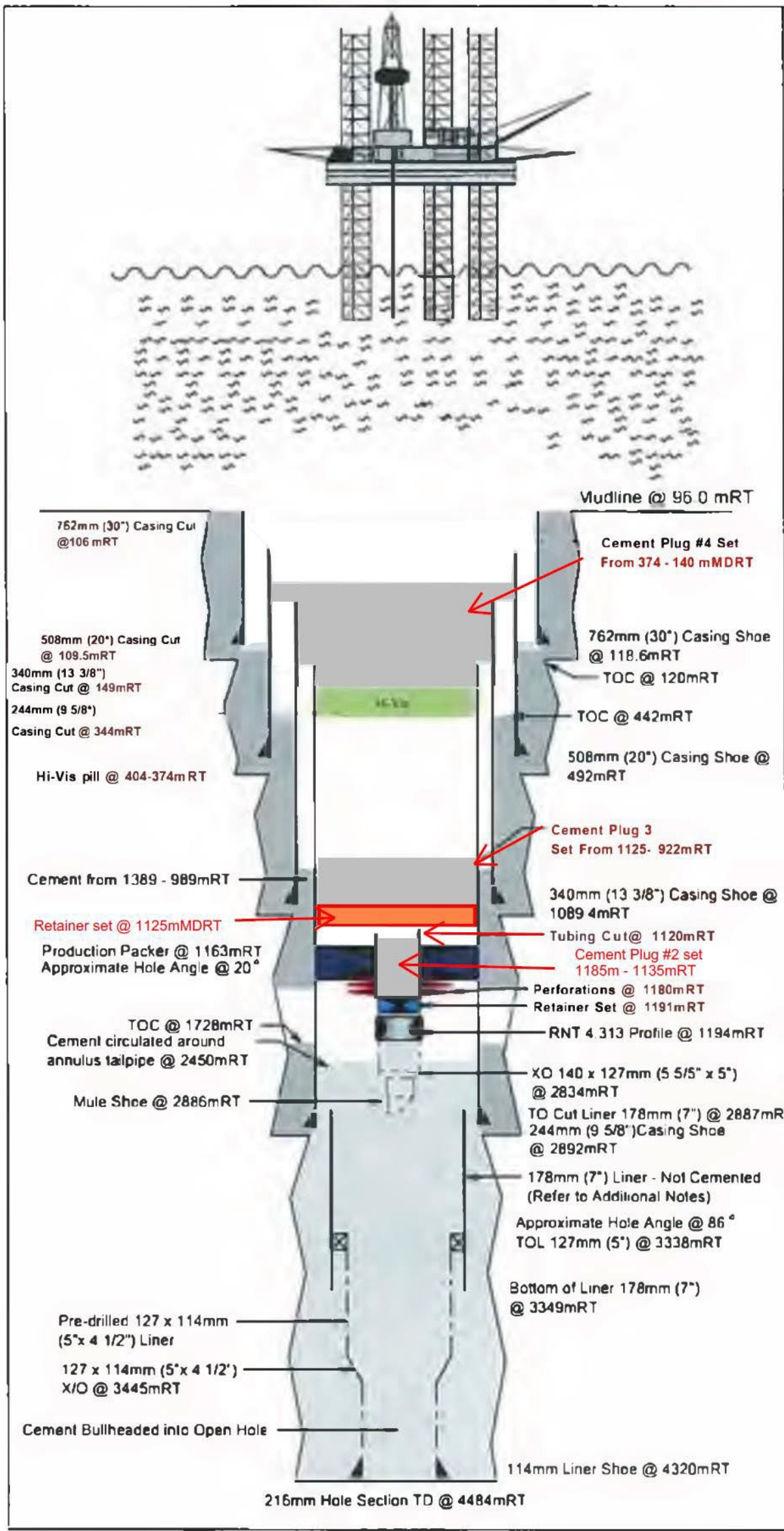
Plug #5
- 9-5/8"x 13-3/8"Annulus Squeeze
- 35bbl @600mMDRT
- TTOC unknown & P/T to 1650psi

Plug #6
- 578-482 mMDRT
- TOC Tagged & P/T to 1000psi

Plug #7
- 185-140 mMDRT
- Not tagged

All depths MDRT	Scale: NOT TO SCALE
Drawn by: M MORRISON	
File Name: Legendre Dev_Pro Aband Schematics.dgn	

WA-20-L
LEGENDRE SOUTH-2H
AS-BUILT ABANDONMENT SCHEMATIC



LOCATION

SURFACE

Northing:	7,821,253.89mN
Easting:	469,469.5mE

ELEVATIONS

RT to AHD Elevation:	44 65 m
Water Depth (AHD):	51.47 m
Mud Line:	96.0 m

WELL TRACK DETAILS

914mm (36") Hole to:	122 0 mRT
762mm (30") Casing at:	118.6 mRT
660mm (26") Hole to:	502.0 mRT
508mm (20") Casing at:	492.0 mRT
406mm (16") Hole to:	1096.0 mRT
340 mm (13 3/8") Casing at:	1089.4 mRT
311mm (12 1/4") Hole to	2898.0 mRT
244mm (9 5/8") Liner at:	2892.0 mRT
216mm (8 1/2") Hole to:	4484.0 mRT
178mm (7") Liner at:	3349.0 mRT
114mm (4 1/2") Liner at:	4320.0 mRT

Cement Plugs

Plug #1
-Cement bullheaded into production zone, then circulated around tailpipe
- Well flowed during placement and WOC
- Failed Pressure test

Plug #2
-Set inside Tailpipe 1135 -1185mRT
- Tagged and P/Tested to 2500psi

Plug #3
-1125-922mMDRT
-Tagged and P/Tested to 1000psi

Plug #4
- 374-140mMDRT
-Not tagged

178mm (7") Liner became stuck while running in hole. After failed attempts to release, top of liner was cut below the liner hanger and retrieved.
The Liner was NOT cemented
127 x 114mm (5" x 4 1/2") Pre-drilled liner was run to TD.

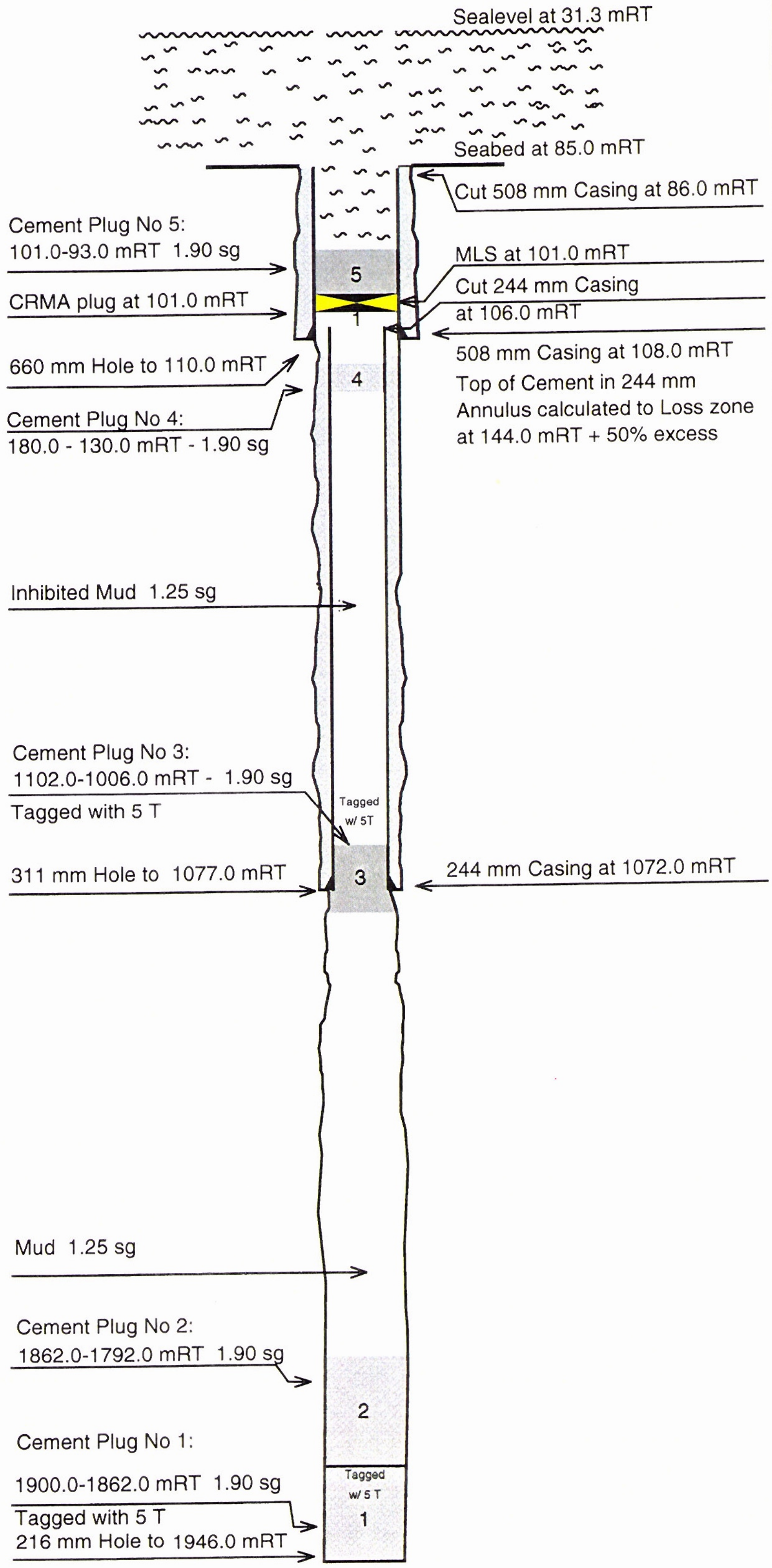
All depths MDRT	Scale: NOT TO SCALE
Drawn by: S.HARES	
File Name:Legendre South-2H_Pro Abandonment.dgn	

Apache ENERGY

WA-1-P

LEGENDRE SOUTH-1

ABANDONMENT SCHEMATIC



LOCATION

Lat:	19°43' 23.174" S
Long:	116°41' 47.761" E

ELEVATIONS

RT Elevation:	31.3 m AHD
Water Depth:	53.7 m

WELL TRACK DETAILS

660 mm Hole to:	110.0 mRT
508 mm Casing at:	108.0 mRT
311 mm Hole to:	1077.0 mRT
244 mm Casing at:	1072.0 mRT
216 mm Hole to:	1946.0 mRT

ABANDONMENT PLUGS

P&A Plug No1:	1900.0-1862.0 mRT
P&A Plug No2:	1862.0-1792.0 mRT
P&A Plug No3:	1102.0-1006.0 mRT
P&A Plug No4:	180.0-130.0 mRT
P&A Plug No5:	101.0-93.0 mRT
CRMA Plug at:	101.0mRT

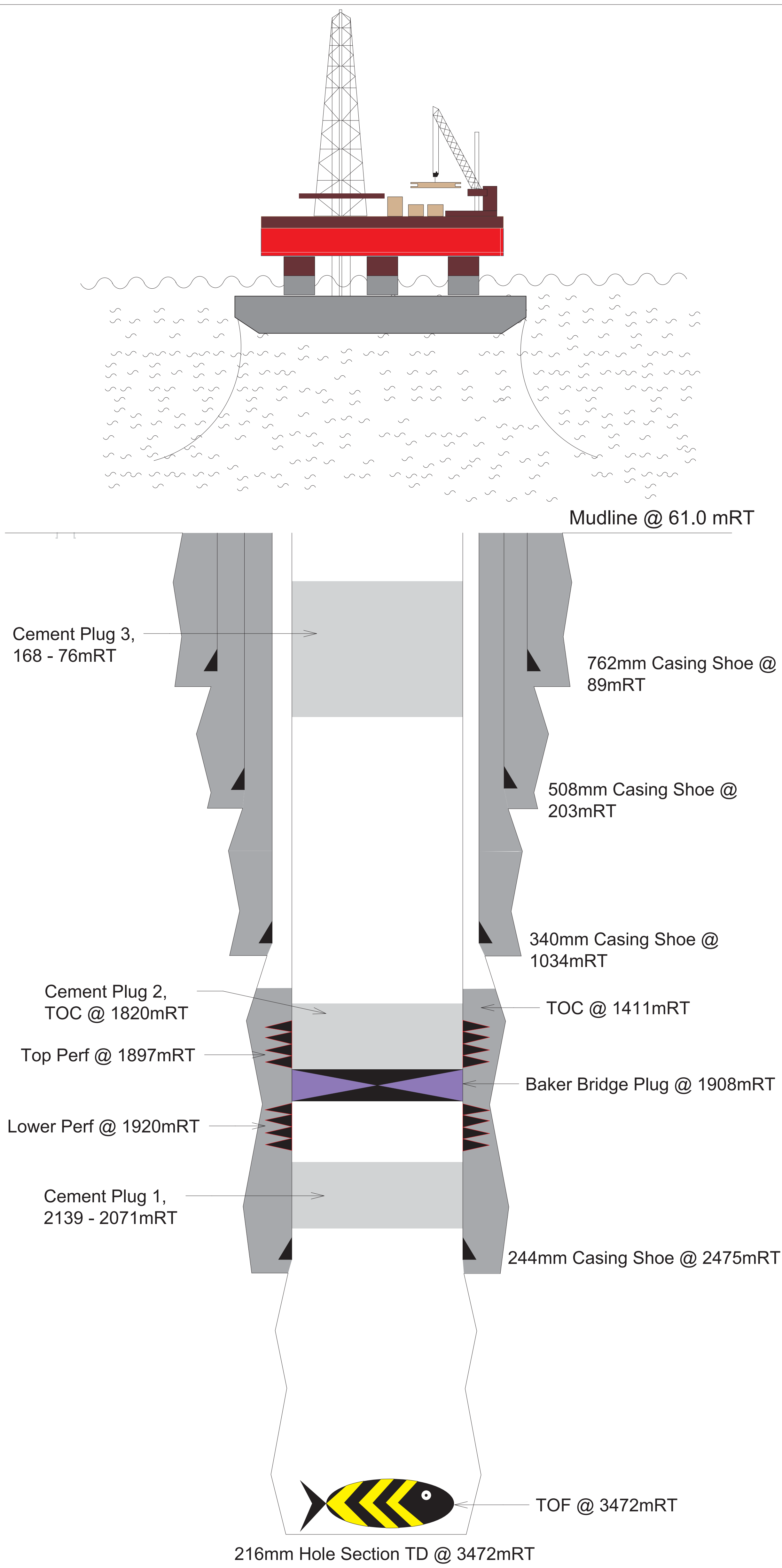
Figure 3

All depths mMDRT	Scale: NOT TO SCALE
Drawn by: J.MELING	Date: JUNE 1998
Fale Name: ABANDLS1.DGN	

WA-20-L

LEGENDRE-1

WELL SCHEMATIC (SPUDDED - JUNE 1968)



LOCATION

SURFACE

Northing:	7825032.00N
Easting:	472,046.60E

BOTTOM HOLE

Northing:
Easting:

ELEVATIONS

RT to AHD Elevation:	9.20 m
Water Depth (AHD):	51.80 m
Mud Line:	61.0 m

WELL TRACK DETAILS

914mm (36") Hole to:	89.0 mRT
762mm (30") Casing at:	89.0 mRT
660mm (26") Hole to:	259.0 mRT
508mm (20") Casing at:	203.0 mRT
406mm (16") Hole to:	1047.0 mRT
340 mm (13 3/8") Casing at:	1034.0 mRT
311mm (12 1/4") Hole to:	2489.0 mRT
244mm (9 5/8") Casing at:	2475.0 mRT
216mm (8 1/2") Hole to:	3472.0 mRT

ADDITIONAL INFO.

Well Status: Well has been plugged, capped and abandoned - 16/11/1968

762mm Conductor - Grade B 316ppf

508mm Ccasing - H40 94ppf

340mm Casing - J55 68ppf

244mm Casing - N-80 & P110 47ppf

Approval- Name & Signature

Contractor: Gareth Cooks

Signature:

Drill Manager: Jamie Ressler

Signature:

All depths MDRT	Scale: NOT TO SCALE
Drawn by: G.COOKS	Date: NOV 2011
File Name: Legendre Schematics - As Build.dgn	

Appendix D: Field surveys

- Legendre field environmental survey (referred to as the 'RPS 2021 survey', RPS 2021a/b)
- NWS offshore gas seeps and leakage characterisation project survey (referred to as the 'CSIRO 2022 survey', Talukder et al. 2024).

RPS 2021 survey

Santos commissioned RPS to conduct a visual and sampling survey at Legendre, which included inspection and analysis of any gas seeps at all eight well locations. The marine survey program was designed to characterise the benthic habitats and sea floor infrastructure, search for gas seeps and sample sediment quality. The data informed the characterisation of gas seeps and associated benthic habitats in the Legendre field.

One of the main objectives of the survey was to describe, quantify and analyse gas seeps emanating from well sites and elsewhere if encountered during the survey. The survey was led by marine scientists who ensured that the ROV transects were flown according to the survey plan and to oversee the ROV gas sampling and sediment grab sampling.

The Legendre field survey was undertaken during 7–13 March 2021. The ROV surveys were undertaken during 8–9 March 2021, with gas sampling conducted on 10 March 2021. At each well location, the visual survey comprised a sampling radius of 20 m from the abandoned well locations. The ROV, fitted with USBL and video systems flew a visual survey across the well locations as well as the surrounding benthic seabed.

Gas detection

Gas bubbles were detected by visual observation when locating and identifying infrastructure, and by detection of dissolved methane with the methane sensor (sniffer). The sniffer was secured to the ROV and the live data feed monitored onboard at the control station. Point estimates of methane concentration were taken when the sniffer was stationary. The location of the gas seeps were recorded using the vessel GPS position corrected by ROV offset from the vessel as indicated by the USBL system and verified using the video recordings and multibeam data.

Gas measurement

Where gas seeps were detected, sampling was undertaken.

- The rate of release (flow rate) of gas bubbles at each seep site was measured to estimate the total rate of gas being emitted from each well location. RPS and Intervention Engineering designed, tested, and developed a suitable gas collection apparatus that was operable from the ROV at depth.
- A transparent funnel was fitted to the ROV to collect the gas bubbles as they arose in a stream from the seep site. The gas collection funnel was marked with 100 ml, 200 ml, 300 ml, 400 ml, 500 ml, and 1000 ml volumes such that the volume of collected gas could be accurately determined.
- While the gas was being collected, the bubble sizes were also assessed. Due to the rapid movement of the bubbles, high variation in their shape and site conditions, this is considered a less accurate but still useful measure of this characteristic of the seeps.
- The approximate rate of release of gas was determined by recording how long it took to fill the transparent funnel to a known volume. The ROV filmed the filling of the funnel and the video time-code was used to calculate flow rates. Several measurements of gas flow rate were taken when the release varied markedly at any release site, or if there were multiple release sites at a well location.
- At several gas seeps, no flow rate was able to be collected and calculated using the funnel due to several factors including weak flow, soft sediment, and site constraints. The flow rates of these seeps were estimated using the calculated flow rates of similar-strength seeps, adjusted for intermittency in the gas seeps where present.

Gas sampling

The ROV was fitted with an evacuated and pre-cleaned 500 ml stainless steel cylinder, which was filled with the gas collected in the funnel positioned over the rising stream of gas bubbles. The inverted funnel was filled with gas and allowed to settle briefly away from the stream of bubbles before the inlet valve of the sample cylinder was opened. The gas from the funnel rose under natural buoyancy to fill the sample cylinder. The cylinder valve was closed by the ROV actuator when the gas stopped flowing into it.

Gas samples were collected from two well locations, Legendre Hub and Legendre South-1. A very intermittent gas seep was found at Legendre South-3, during the post-survey ROV video analysis. No gas samples were collected at this site. No gas seeps were found at the other well locations.

CSIRO 2022 survey

Santos commissioned CSIRO to conduct leakage surveillance and monitoring at the Legendre sites in the WA-20-L permit. The project comprised three stages:

+ Stage 1 - Literature review of the natural seepage in the north-west shelf (NWS) (Talukder et al., 2022) and seep monitoring technologies to develop an effective surveillance and monitoring plan for the leakage sites. Three seep sites (Legendre Hub, Legendre South 1 and 3) were selected for the field experiment and data collection.
+ Stage 2 - Field equipment testing, deployment and recovery, and data collection to test the surveillance and monitoring plan developed in Stage 1. CSIRO conducted two voyages, instrument deployment voyage between 10 – 15 October 2022 and instrument recovery voyage between 18 – 24 November 2022. Data collection objectives included: 1. Fine scale (10 m apart transects) acoustic survey of well head location and vicinity to locate bubble seeps and provide synoptic mapping of their backscatter strength and distribution. 2. Conduct atmospheric methane survey and wide area acoustic survey over target areas. 3. Collect and analyse water and gas samples at the identified seepage locations to validate sensor responses. 4. Monitor temporal occurrence of gas seepage from the P&A wells associated with the Legendre field using acoustic, optical, and chemical methods.
  - Data was collected using various methods: Single-Beam Acoustic System (SBES), Underwater Video Systems (UVS), ROV mounted video equipment, gas sampling equipment and methane sensors, conductivity-temperature-depth profiler (CTD) with water sampling equipment and an atmospheric methane monitoring system.
+ Stage 3 - Provides an interpretation of collected data from Stage 2. The interpretation enabled a more detailed understanding of the spatial-temporal occurrence of the gas seeps associated with the Legendre field and inform further adaptive environmental monitoring plans.

One of the main objectives was to establish if there were any spatial and temporal changes of the characteristics of the seep sites over the period of CSIRO 2022 survey and the RPS 2021 survey and sampling activities at the Legendre site.

The focus of the CSIRO survey was on the Legendre Hub site, with limited data acquisition at Legendre South-1 and Legendre South-3 due to the gas bubbles at these sites being highly intermittent (Talukder et al. 2024).

Acoustic gas detection and data collection

The vessel was fitted with a pole mounted dual frequency (38 kHz and 120 kHz) single beam echosounder (SBES). The SBES recorded data to provide continuous observation of the water column and seafloor. Multiple fine-scale acoustic surveys with 10 m or less survey transects spacing were conducted at the Legendre Hub, South-1 and South-3 sites. Additionally, wide scale transects surveys with 500 m survey transects spacing were conducted for both acoustic sampling and to sample atmospheric CH4. This provided an opportunity to record concurrent acoustic-based observations over the greater area.

The primary objective of the vessel-based acoustic program was to conduct fine-scale synoptic recording of the acoustic backscatter to locate bubble seeps and provide synoptic mapping. The focus was on the well head locations but with coverage of the surrounding areas. Repeat surveys were carried out to detect temporal and spatial variation of the seep fluxes.

Acoustic gas measurement

Gas bubbles in water are excellent acoustic energy scatterers because of the large differences in sound speed and density between water and gas and the resonance effects controlled by bubble size, frequency and water depths (Medwin and Clay, 1998; Scheider von Deimling and Papenberg, 2012).

An estimate of gas released was made following a modified method and assumptions described in Scoulding (Scoulding et al., 2020), where acoustic observations of controlled gas release were compared with model estimates to calibrate measured volume backscatter (Maclennan et al., 2002) to kilograms of gas released.

ROV data collection

An ROV was used to carry out following tasks: 1) Visual inspection of gas seep bubble streams, 2) Close quarters seabed gas bubble sampling and collection, 3) Dissolved hydrocarbon plume reconnaissance using a methane sensor, and 4) Visual inspection of deployed lander and/ or UVS frames. Eight deployments were conducted during the two voyages. The ROV was only able to collect one gas sample from an active seep.

ROV gas sampling

The aim of gas sampling was to understand if there have been composition changes in the gas sampled from the site since the 2021 RPS survey.

A custom funnel and sampling cylinder assembly was fabricated for the ROV to sample gas and estimate the volumetric flux from the seeps. To collect a gas sample, the cylinder was filled with water to exclude atmospheric air, with the ROV actuated valve opened once the assembly was submerged. This was done to ensure the whole assembly was exposed to the same pressure on descent without any differential that could have weakened the burst disc. When positioned over a bubble plume, the ROV actuated valve was shut, to allow the gas to accumulate in the funnel.

ROV flux observations and sampling

To make estimates of the gas flux from individual seeps, video footages were collected as the funnel assembly was positioned over an active seep, and gas was allowed to displace the water in the funnel. This was timed and the footage analysed later to give an estimate of volumetric flow rate of the gas at these points. The bubble size distribution and rise velocity are analysed from the selected ROV videos.

Gas seepage

RPS 2021 survey

The RPS 2021 survey revealed that three well locations at the Legendre field had ongoing gas seepage in close proximity to the plugged wells. Most of the gas seeps were located at or around the infrastructure at the well locations.

At most locations, the gas bubbles were seeping from the concrete itself or from around the edges of grouting concrete and sediment on the seabed around the wells. The bubbles tended to be in the range of 1–10 mm diameter with some fine seeps comprising smaller bubbles and others where gas accumulated under a hard structure and then released intermittently as larger bubbles.

+ Legendre Hub - The cluster of seeps around the well locations and the confirmation of the gas' thermogenic origin in laboratory analysis, suggests the gas was percolating up through the sediment matrix from sub-seabed pockets, and finding different pathways to the surface under natural buoyancy. None of the seeps appeared to be highly pressurised releases.
+ Legendre South-1 - Four gas seeps were observed at the Legendre South-1 location. These seeps were in close together and were very intermittent, with long breaks (~10–20 minutes) between streams of bubbles. The gas seeps emerged from the sediment and rock/concrete. The bubble sizes at this location were consistently small.
+ Legendre South-1 - These seeps were in close together and were very intermittent, with long breaks (~10–20 minutes) between streams of bubbles. The gas seeps emerged from the sediment and rock/concrete. The bubble sizes at this location were consistently small.

CSIRO 2022 survey

The interpretation of the acoustic data from the fine scale surveys over Legendre Hub, revealed active seepage of gas bubbles emerging from the seabed during those surveys. Rising gas bubbles were also imaged in the water column.

All individual seeps were observed to be highly intermittent. Sometimes a seep would release gas bubbles for a few minutes, and when that seep stops an adjacent seep commences releasing bubbles. At other times several seeps may release bubbles simultaneously.

Within 100 m of the concrete mattress, multiple bubbles were observed in the water column along a NW-SE line, moving with the prevailing current. No further gas releases were observed during an acoustic survey of the wider area (approximately 5 km x 5 km) covering the Legendre Hub and Legendre South-1 and Legendre South-3 sites. Most of the seeps were approximately same locations found in the RPS surveys.

Gas seepage summary

Table 2-1 summarises the detected gas seepage at the various locations across the two surveys. At the Legendre Hub, the CSIRO 2022 survey observed 13 seeps, which was less than the 20 seeps observed by RPS in 2021 (Talukder et al. 2024).

The overall mean bubble sizes were similar between the RPS 2021 survey and CSIRO 2022 survey (Talukder et al. 2024).

Gas seepage rates

The CSIRO estimated flux rate at Legendre Hub are the same order of magnitude as the flux estimation made during the RPS survey 2021 (Talukder et al., 2024). The CSIRO estimated flux rate is based on the seep being active for the entire time span. While the RPS estimation is an average during the time span to take into account that the seep is active and inactive. As a result, the flux rates estimated in the CSIRO are higher than the RPS estimation. Both acoustic and ROV observations have shown that the seeps are highly intermittent (Talukder et al. 2024). The CSIRO 2022 survey results are the same order of magnitude as the flux estimation made during the RPS 2021 survey (Talukder et al., 2024).

Gas seepage composition

RPS 2021 Survey

Gas samples were collected during the 2021 survey from the seabed at Legendre Hub and Legendre South-1 (RPS 2021a). Samples were not collected at Legendre South-3 as the seepage rate was too slow for effective gas collection at sea (RPS 2021a). Samples were analysed for composition by gas chromatography (CoreLab, 2021).

The compounds that contributed greater than 1% to the gas composition are listed in **Table 2-4**. Methane was by far the dominant gas at approximately 85% of the total gas. Compounds that contributed less than 1% included i-Butane, Neo-Pentane, i-Pentane, n-Pentane, Hexanes, M-C-Pentane, Cyclohexane, Heptanes and M-C-Hexane.

CSIRO 2022 Survey

CSIRO collected a single gas sample in 2022 from the Legendre Hub site. The composition of the analysed gas sample was consistent with that collected in 2021.

While only a single sample, the level of consistency in the composition indicates a high likelihood that, between the 2021 and 2022 surveys the gas composition has not changed significantly, and the source of the gas has remained the same (Talukder et al 2024).

Gas seepage source

RPS Survey 2021

Gas chromatography (GC) and compound specific isotopic analyses (CSIA) of the gas from the two locations (Legendre Hub and Legendre South-1) concluded that the two gases were very similar in molecular and isotopic composition (Murray Partners PPSA, 2021). The CSIA indicated that the samples were also very similar to solution gases from oils collected from both the Legendre North and Legendre South pools of the Legendre Field during the production life of the field, with the closest match being to solution gas from the Legendre North pool (RPS 2021a). The lack of biodegradation in the gas samples indicated that it is not migrating to the seabed over geological periods of time.

The possibility that the gas originated from a shallow source was investigated by examining reprocessed seismic data over the Legendre field. Whilst geological faults extend from the level of the Legendre Field reservoir to very close to the present-day seabed within the WA-20-L permit, the shallow, near seabed, part of these faults is not at or near the surface location of the gas seepages. This suggests the sampled gas has not migrated up fault lines. Further, if gas was migrating up the faults, the slow rate of migration would result in higher biodegradation of the gas than was measured in the samples taken in 2021.

CSIRO 2022 Survey

While only a single sample, the level of consistency in the composition indicates a high likelihood that, between the 2021 and 2022 surveys the gas composition has not changed significantly, and the source of the gas has remained the same (Talukder et al 2024).

Appendix E: Values and sensitivities of the marine and coastal environment

EA-00-RI-10062

Santos

Values and Sensitivities of the Marine and Coastal Environment

PROJECT / FACILITY	All
REVIEW INTERVAL (MONTHS)	12 Months
SAFETY CRITICAL DOCUMENT	NO

Rev	Owner	Reviewer/s Managerial/Technical/Site	Approver
	Senior Environmental Approvals Adviser	Senior Environmental Approvals Adviser	Team Leader-Regulatory Approvals
10			

Any hard copy of this document, other than those identified above, are uncontrolled. Please refer to the Santos Business Document Management System for the latest revision.

Rev	Rev Date	Author / Editor	Amendment
A	13/05/2014	Oceanica	Technical review
B	13/05/2014	Oceanica	Editorial review
0	30/07/2014	EG/GG	Final
1	30/12/2014	GG	Updated
2	28/07/2016	Jacobs	Updated
3	28/11/2017	Jacobs	Updated
3.1	11/12/2018	Jacobs	Issued for technical review
4	17/12/2018	Jacobs	Issued for use
4.1	09/01/2019	Jacobs	Issued for technical review
5	14/02/2019	Santos	Issued for use
5.1	15/01/2020	CDM Smith	Issued for technical review
6	19/03/2020	CDM Smith	Issued for use
6A	15/11/2020	Astron	Issued Technical review
7	30/11/2020	Astron	Issued for use
7A	25/02/2021	Advisian	Issued for Technical review
8	31/03/2021	Advisian	Issued for use
8A	02/07/2021	Advisian	Issued for technical review
9	09/07/2021	Advisian	Issued for use
9A	5/10/2022	Advisian	Draft for review
9B	14/11/2022	Advisian	Annual update. Issued for use. Will be issued as Rev 10 once additional information to support stakeholder consultation requirements is included.
10	25/01/2023	Santos	Issued for use

Contents

Santos

Figures

Tables

Appendices

1. Introduction

Santos Energy Limited (Santos) is the titleholder of multiple petroleum titles for exploration, development. operational and title decommissioning activities located in marine waters off north-western Western Australia. With the exception of Bayu-Undan, this document describes the combined existing environment that may be affected (EMBA) by these petroleum activities and includes details of the relevant values and sensitivities of that environment as required by the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* and State Western Australian *Petroleum and Geothermal Energy Resources (Environment) Regulations 2012*, *Petroleum (Submerged Lands) (Environment) Regulations 2012 and Petroleum Pipelines (Environment) Regulations 2012.*

Worst-case hydrocarbon spills, particularly during drilling activities, generally have the largest EMBA of all the environmental impacts and risks managed by Santos. Santos routinely commissions hydrocarbon spill modelling studies to assist in assessing the environmental risk of a hydrocarbon spill. The low hydrocarbon exposure values as defined in NOPSEMA's '*Environmental Bulletin – Oil Spill Modelling*' (April 2019), are used as a predictive tool to set the outer boundaries of the EMBA for a given hydrocarbon spill.

To create the EMBA which defines the spatial extent of the values and sensitivities described herein, all of Santos' available hydrocarbon spill modelling results were merged to create a combined EMBA. The combined EMBA represents the largest possible spatial extent that could be contacted by combining the worst-case spill event modelled for Santos activities to date.

The combined EMBA encompasses the full range of environmental receptors that might be contacted by surface and subsurface hydrocarbons in the highly unlikely event of any worst case oil spill from Santos's activities.

The combined EMBA does not represent the worst case loss of well control event of any one activity.

This document is informed by searches of:

- the protected matters search tool (PMST) published by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW). PMST searches were undertaken in September 2022 and are provided in **Appendix A**;
- published scientific literature and studies, and
- other State and Territory protected species databases where applicable.

Descriptions of all marine and coastal fauna within the EMBA that may credibly be impacted by Santos' activities are provided, with a focus on protected species that are threatened and migratory. The PMST is performed annually and any changes from this updated search are detailed in a change register (**Appendix B**). This document is then reviewed annually and updated accordingly.

The PMST searches were made using the combined EMBA. The combined EMBA includes the same spatial data used to produce the figures in Santos' environment plans (EPs), ensuring that the combined EMBA encompasses the full range of environmental receptors that might be contacted by surface and subsurface hydrocarbons at the low exposure level in the highly unlikely event of a worst case oil spill.

Limitations on the PMST required the combined EMBA be subset into a series of small grids. Each grid cell derived from the combined EMBA was then used to perform a PMST search. The results from these PMST searches were then collated and presented in Appendix A.

Figures provided throughout this document are zoomed to the relevant data represented to allow detail to be shown at a readable scale.

1.1 Geographical Extent

The combined EMBA, includes the coastal waters and shoreline habitats of Western Australia (WA) and part of the Northern Territory (NT), encompassing the south of WA to the most northern coastlines of the NT in the north (**Appendix A**). This area largely approximates the Commonwealth North-West Marine Region (NWMR), the South-West Marine Region (SWMR) and the North Marine Region (NMR). Based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Version 4.0, there are 18 provincial-scale bioregions that occur within the combined EMBA. These bioregions are based on fish, benthic habitat and oceanographic data (IMCRA v. 4.0). Where relevant, the physical, biological and social environments within the combined EMBA are discussed with reference to the IMCRA Provincial Bioregions. The provinces of most relevance (**Figure 1-1**) are:

North-west Marine Region

+ Northwest Shelf Transition;
+ Timor Province;
+ Northwest Transition;
+ Northwest Province;
+ Northwest Shelf Province;
+ Central Western Transition;
+ Central Western Shelf Transition; and
+ Central Western Shelf Province.

South-west Marine Region

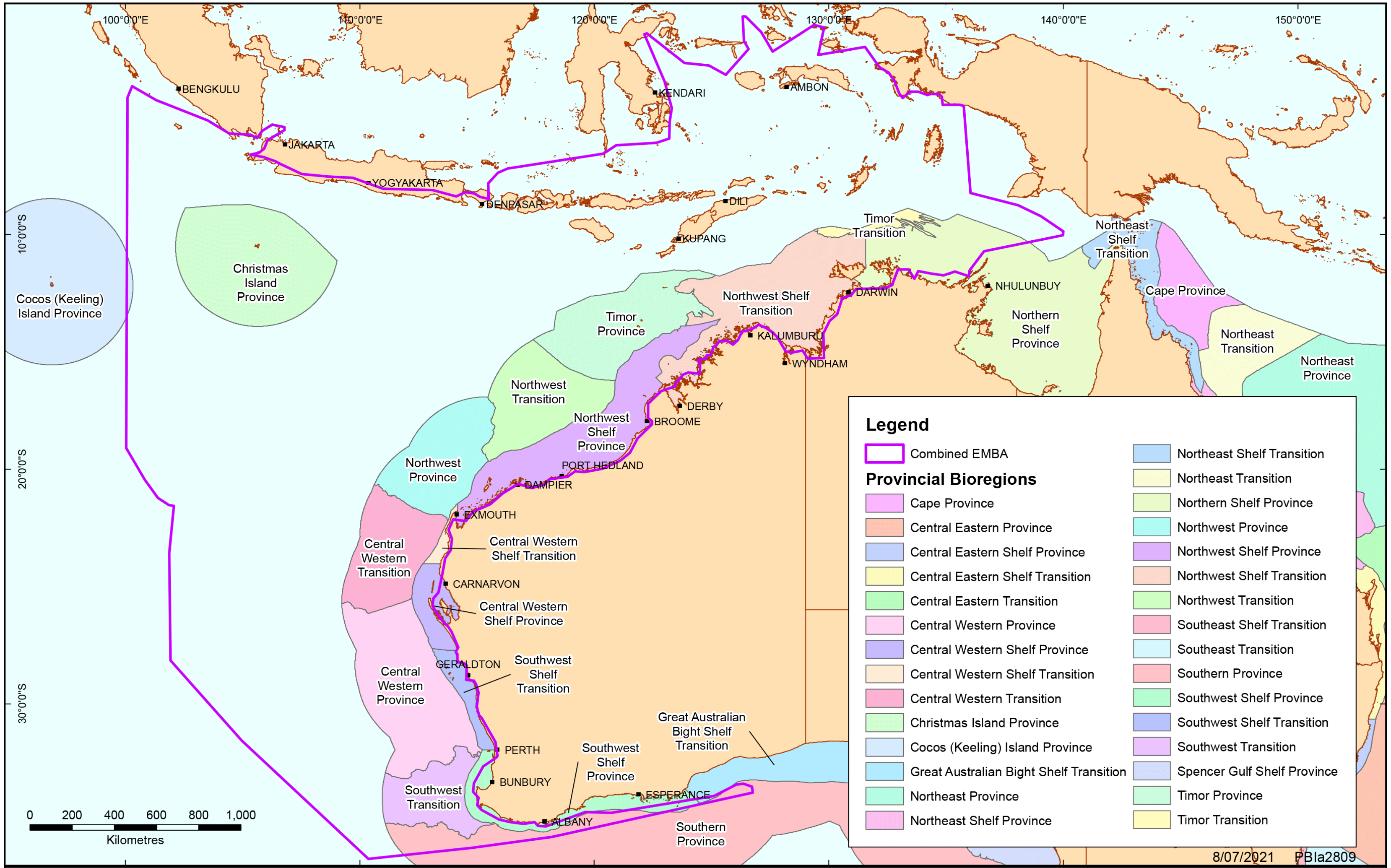
+ Central Western Province;
+ Southwest Shelf Transition;
+ Southwest Transition;
+ Southwest Shelf Province;
+ Southern Province; and
+ Great Australian Bight Shelf Transition.

North Marine Region

+ Northwest Shelf Transition (as above);
+ Timor Transition; and
+ Northern Shelf Province.

Other IMCRA 4.0 bioregions of interest include: Christmas Island Province and Cocos (Keeling) Island Province.

The international waters of south west Indonesia and Timor-Leste (in part) are also included in the combined EMBA and described where relevant throughout this document.



Santos

PROVINCIAL BIOREGIONS

Figure 1-1: EMBA within IMCRA 4.0 Provincial Bioregion

2. Physical Environment

2.1 Geomorphology

2.1.1 Formation History

Approximately 550–160 million years ago, northern and western parts of Australia formed part of the northern margin of Gondwana. About 300 million years ago, crustal stretching, rifting and breakup initiated development of an extensive basin that became the site for deposition of sediments (Baker *et al*. 2008 in Department of the Environment, Heritage, Water and the Arts (DEWHA) 2008a). Approximately 135 million years ago the continent broke up resulting in the separation of greater India and Australia. Ocean spreading associated with the continental break-up resulted in the creation of the Argo and Cuvier abyssal plains. Subsidence of the rifted margin resulted in the formation of the Exmouth and Scott plateaux and the Rowley Terrace. The narrow shelf south of North West Cape was formed approximately 130 million years ago as a result of the separation of India and seafloor spreading (Baker *et al*. 2008 in DEWHA 2008a).

The South-west region has been relatively stable throughout its recent geological past. This has shaped a continental shelf that has high wave exposure and is punctuated with coastal features such as island groups and fringing coastal reefs providing sheltered habitats for marine communities (2008a).

2.1.2 Present Day Geological Features

The EMBA consists of five major landform features: continental shelf, continental slope, continental rise, Exmouth plateau and abyssal plain. The majority of the area consists of either continental shelf or continental slope (DEWHA 2008a).

Limited surveys have shown that the continental slope in the combined EMBA comprises diverse geological features such as canyons, plateaux, terraces, ridges, reefs, banks and shoals (DEWHA (2008) (**Figure 2-1** and **Figure 2-2**). These features are significant in that over half of the total area of banks and shoals across Australia's entire marine jurisdiction occurs in the Commonwealth waters from the South Australian border to the Northern Territory border, as well as 39% of terraces and 56% of deeps, holes and valleys (DEWHA 2008a).

An important characteristic of the combined EMBA is the significant narrowing of the continental shelf around North West Cape from the broad continental shelf in the north (**Figure 2-3**). For example, in the Joseph Bonaparte Gulf (at the NT boundary), the continental shelf is around 400 km wide, whereas at North West Cape the shelf is only 7 km wide – the narrowest of anywhere on the Australian continental margin (DEWHA 2008a). Shelf width affects oceanography with flow on effects to productivity and ecosystem functioning.

The continental shelf north of Cape Leveque is characterised by a rimmed ramp where the waters over the outer margins of the shelf (approximately 50 to 100 m waters depth) are shallower than the middle portions (up to 150 m water depth). The rim at its outer edge is the site of a number of coral reefs including Ashmore, Cartier, Scott and Seringapatam (DEWHA 2008a).

The Indonesian archipelago lies between the Pacific and Indian oceans, and bridges the continents of Asia and Australia. The archipelago is divided into several shallow shelves and deep-sea basins.

Several geomorphic formations within the combined EMBA have been associated with Key Ecological Features (DEWHA 2008a) and these are discussed in **Section 10**.

2.1.3 Southwest Transition

The Southwest Transition is an offshore deep-water bioregion with a submerged continental fragment as its dominant seafloor feature – the Naturaliste Plateau. The Plateau extends across an area of 90,000 km^2 of which only 29,825 km^2 is within Commonwealth waters. It is located west of Cape Leeuwin and Cape Naturaliste in water depths ranging from 2,000–5,000 m. It is relatively flat with a slight northward dip, and has steep southern and western sides and a more gently sloping northern side. The Plateau is separated from the Australian continent by the Naturaliste Trough and two offshore terraces on the continental slope (average depth 780 m). Submarine canyons incise the northern parts of the slope and parts of the Naturaliste Plateau.

2.1.4 Southwest Shelf Province

The Southwest Shelf Province consists of an area of narrow continental shelf from Rottnest to Point Dempster. For the purposes of this document (EMBA), the northern and western limits of the bioregion are the main focus because it is this portion that falls within the combined EMBA, which are an extension of the seafloor described in the Southwest Shelf Transition (below). It includes features such as limestone ridges, depressions defining an inshore lagoon and a relatively smooth inner shelf plain that meets the South Bank Ridge on the outer shelf, and islands providing important habitat, such as Rottnest Island. The shelf progressively broadens to form the relatively sheltered waters of Geographe Bay before narrowing once again at Cape Mentelle. Within this region lies the Albany canyon system, which contains Bremer Canyon on the south-west coast of Australia. Together with the adjacent shelf break, these canyon systems have been labelled as a 'key ecological feature' in the South-west Marine Region (DoNP 2017) due to high productivity and aggregations of cetaceans, including humpback whales (Megaptera novaeangliae), southern right whales (Eubalaena australis), and killer whales (Jones *et al.,* 2019). In particular, Bremer Canyon is known to support periodic sub-surface upwelling, which increases nutrients and sustains higher phytoplankton abundance and primary productivity (Baumgartner 1997). This in turn supports higher abundances of zooplankton, fish, seabirds and cetaceans (Moors-Murphy 2014).

2.1.5 Southwest Shelf Transition

This bioregion consists of a narrow continental shelf, ranging from approximately 40-80 km wide that is noted for its physical complexity. It includes a series of nearshore ridges and depressions that form inshore lagoons, a smooth inner shelf plain, a series of offshore ridges and a steep, narrow outer shelf. The near-shore ridges are formed by eroded limestone reefs and pinnacles that stand 10-20 m above the seafloor. The edge of the inner shelf plain is marked by a series of broken offshore ridges that extend north to the northern limits of the bioregion, where they emerge to support the tropical carbonate reef growth of the Houtman Abrolhos Islands (DEWHA, 2008b).

2.1.6 Southern Province

The Southern Province is the largest bioregion within Australia's waters stretching from the shelf break south of Kangaroo Island to the southern edge of the Naturaliste Plateau. The bioregion includes the deepest ocean areas within the Australian Exclusive Economic Zone (approximately 5,900 m maximum water depth) and consists of a long continental slope incised by numerous well-developed submarine canyons. Several key ecological features are present within the combined EMBA and include the Albany Canyons Group, the Ceduna and Eyre Terraces (covering approximately 147,150 km^2) and the Diamantina Fracture Zone.

2.1.6.1 Great Australian Bight

The Great Australian Bight Shelf Transition is characterised by the largest seafloor feature of the Region – an extensive flat continental shelf covering 177,130 km^2. The centre of the shelf reaches widths of 260 km narrowing to 80 km at its margins. Geomorphology, sedimentology and hydrodynamics interact to create ideal conditions for carbonate organisms such as molluscs and bryozoans to flourish without being smothered or buried. As a result, carbonate sediments derived from invertebrate skeletons and shells make up over 80 per cent of shelf sediments, making the Bight part of the world's largest modern cool-water carbonate bioregion that extends along Australia's southern margin. Within the wave abrasion zone (0-120 m) sediments are typically rippled and coarse grained, forming a 'shaved shelf' where carbonate accumulation is less than the amount of active erosion and therefore there is a net loss of sediment from the shelf (DEWHA, 2008b).

2.1.7 Central Western Province

This bioregion is characterised by a narrow continental slope that is heavily incised by many submarine canyons as far north as Kalbarri. The Perth Canyon, located at the southern margin of the bioregion, is an order of magnitude larger than any other canyon in the Region (**Figure 2-2** and **Figure 2-3**). The Perth Canyon, formed by erosive processes associated with the ancient Swan River, cuts into the continental shelf at approximately the 150 m depth contour, north-east of Rottnest Island. Other relatively large canyons, such as the Murchison Canyon, occur in the bioregion but little is known about them as they have not yet been studied (DEWHA, 2008b).

The bioregion contains the most extensive area (52,185 km^2) of continental rise on the Australian margin. The continental rise is located on the edge of the Perth Abyssal Plain (103,911 km^2). There is a large terrace known as the Carnarvon Terrace on the continental slope, extending north from the Houtman Abrolhos Islands at an average of 780 m water depth (DEWHA 2008b).

2.1.8 Central Western Shelf Province

This bioregion is located on the Dirk Hartog Shelf and is generally very flat. It varies in width from less than 20 km in the north to around 125 km in the vicinity of Shark Bay. A small area of reef and tidal sandwaves or sandbanks occur at the entrance to Shark Bay and within its vicinity. Other topographic features of the bioregion include a deep hole and associated area of banks and shoals offshore of Kalbarri. The banks and shoals in this bioregion are of note because they occur at latitudes significantly south of banks and shoals elsewhere in the North-west Marine Region (DEWHA, 2008a).

2.1.9 Central Western Transition

The Central Western Transition is characterised by large areas of continental slope, with sediments dominated by muds and sands that decrease in grain size with increasing depth. The slope is incised by numerous topographic features such as terraces (i.e. the Carnarvon Terrace), canyons (i.e. Cloates Canyon and Carnarvon Canyon) and rises. A large part of the bioregion consists of the Cuvier Abyssal Plain. The Wallaby Saddle is another important feature of this bioregion and it is the most extensive area of this type of topographic feature in the North-west Marine Region (DEWHA, 2008a).

2.1.10 Central Western Shelf Transition

The Central Western Shelf Transition is located entirely on the continental shelf and is comprised mainly of sandy sediments. The close proximity of the coast to the shelf break is a significant feature of this bioregion and is an important factor in determining its biodiversity (DEWHA, 2008a).

Ningaloo Reef is the most significant geomorphic feature in the bioregion. It extends south of North West Cape along the Cape Range Peninsula, and stretches for over 260 km. It is the only example in the world of an extensive fringing coral reef on the west coast of a continent (DEWHA, 2008a).

2.1.11 Northwest Province

The bioregion occurs entirely on the continental slope and is comprised of muddy sediments. It is distinguished by a number of topographic features, such as the Exmouth Plateau, terraces and canyons (including the Swan and Cape Range canyons), as well as deep holes and valleys on the inner slope. The Montebello Trough occurs on the eastern side of the Exmouth Plateau and represents more than 90 per cent of the area of troughs in the North-west Marine Region. Significantly, this bioregion contains the steepest shelf break of the North-west Marine Region, along the Cape Range Peninsula near Ningaloo Reef (DEWHA, 2008a).

2.1.12 Northwest Transition

The majority (52 per cent) of the Northwest Transition bioregion occurs on the continental slope, with smaller areas in the north-west of the bioregion located on the Argo Abyssal Plain and continental rise. The sediments of the slope are dominated by sands, whereas the sediments of the abyssal plain/deep ocean floor are dominated by muds. More than 60 per cent of the Argo Abyssal Plain occurs within this bioregion and much of the Northwest transition occurs in water over 4,000 m deep (DEWHA, 2008a).

Other topographic features within the bioregion include areas of rise, ridges, canyons and apron/fans. The bioregion also has reefs such as Mermaid, Clerke and Imperieuse reefs, which are collectively known as the Rowley Shoals (DEWHA, 2008a).

2.1.12.1 Northwest Shelf Province

The Northwest Shelf Province is located almost entirely on the continental shelf, except for a small area to the north of Cape Leveque that extends onto the continental slope. This bioregion includes more than 60% of the continental shelf in the North-west Marine Region (DEWHA, 2008a). The shelf gradually slopes from the coast to the shelf break, but displays a number of seafloor features such as banks/shoals and holes/valleys. These are thought to be morphologically distinct from other features of these types found elsewhere in the North-west Marine Region, and have a different sedimentology (DEWHA, 2008a). For example, the Glomar Shoals occur approximately 30–40 km offshore of Dampier in water depths of between 26–70 m and are distinguished by highly fractured molluscan debris, coralline rubble and coarse carbonate sand. The province also includes the Leveque Rise, a large plateau, and one of only two shelf plateaux within the North-west Marine Region (DEWHA, 2008a).

2.1.12.2 Northwest Shelf Transition

The Northwest Shelf Transition is predominantly located on the continental shelf with a small portion extending onto the continental slope causing waters in the area to be relatively shallow, only up to 330 m. It also consists of geomorphic features that are unique to the Northwest Shelf Transition and not found elsewhere in the North-west Marine Region (DEWHA, 2008a). An example of this is that 90% of the Region’s carbonate banks are located within the Northwest Shelf Transition (DEWHA, 2008a).

The Bonaparte Depression lies within the Northwest Shelf Transition, which is a 45 000 km^2 geomorphic basin that is the only occurrence of its type in the North-west Marine Region (DEWHA, 2008a). The Bonaparte Depression is a relatively flat feature with a higher content of mud and gravel than what is found elsewhere in the Northwest Shelf Transition and it has a number of pinnacles of which form the key ecological feature ‘pinnacles of the Bonaparte Basin’ (see **Section 10.1.23**).

2.1.12.3 Timor Province

The Timor Province is located on the continental slope. The notable topographical features include the Scott Plateau, the Ashmore Terrace and part of the Rowley Terrace and Argo Abyssal Plain (DEWHA, 2008a). Of these, the Scott Plateau is particularly significant with water depths of up to 3,000 m and being fringed by spurs and valleys (DEWHA, 2008a). The Scott Plateau is also separated from Rowley Terrace by canyons that are up to 50 million years old (DEWHA, 2008a).

The Timor Province encompasses almost half of the reefs in the North-west Marine Region, including Scott Reef, Seringapatam Reef and Ashmore Reef which are all within the combined EMBA (DEWHA 2008a).

2.1.12.4 Timor Transition

The Timor Transition is predominantly shelf terrace and slope, which extend into waters that are 200-300 m deep. The deepest point (300 m) is the Arafura Depression. The Timor Transition is also dominated by a series of canyons that represent a drowned river system from the Pleistocene era (DEWHA, 2008c). The canyons are approximately 80-100 m deep and up to 20 km wide (DEWHA, 2008c).

2.1.12.5 Northern Shelf Province

The Northern Shelf Province consists of large areas of relatively featureless sandy and muddy sediments (DWEHA, 2008c). A significant feature of the Northern Shelf Province is the Gulf of Carpentaria, which is outside the combined EMBA, the majority of the reefs in the Northern Shelf Province are also outside the combined EMBA and form a broken margin around the Gulf of Carpentaria. However, within the combined EMBA is the Arafura Shelf which is characterised by continental shelf, canyons, terraces, the Arafura Sill and the Arafura Depression (DEWHA, 2008c).

2.1.12.6 Christmas Island Province

This bioregion contains the 4th largest abyssal plain/deep ocean floor area and smallest area of slope of all the National Benthic Marine Bioregionalisation (NBMB) bioregions (DEH, 2005a). Due to the similar geomorphology and location adjacent to Indonesia in the tropical Indian Ocean, the fauna contained in this bioregion is probably similar or related to the fauna associated with the Cocos (Keeling) Island bioregion.

2.1.12.7 Cocos (Keeling) Island Province

This bioregion contains the largest abyssal plain/deep ocean floor area of all the NBMB bioregions and is the deepest NBMB bioregion on average due to the relatively large areas of abyssal plain/deep ocean floor (DEH, 2005b). Due to the similar geomorphology and location adjacent to Indonesia in the tropical Indian Ocean, the fauna contained in this bioregion is probably similar or related to the fauna associated with the Christmas Island bioregion. The Cocos basin comprises dominantly flat abyssal plain occurring at water depths around 5,500 km.

2.1.13 Sediments

Terrestrial environments are not a major source of sediment in the area and terrigenous sediments tend to be confined to the inner shelf (generally less than 100 m water depth), particularly in areas adjacent to rivers. Sediments in the area generally become finer with increasing water depth, ranging from sand and gravels on the shelf to mud on the slope and abyssal plain. Joseph Bonaparte Gulf is an exception to this pattern, as sediments with high mud content extend across the inner and mid shelf within the Gulf, graduating to sands and gravels in the Bonaparte Depression.

The distribution and resuspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic events such as cyclones. Further offshore, on the mid to outer shelf and on the slope itself, sediment movement is primarily influenced by ocean currents and internal tides. Internal tides describe the tidal movement across a slope of water stratified by marked differences in density. Internal tides cause resuspension and net down-slope deposition of sediments on the North West Shelf (DEWHA 2008a).

Surveys conducted over the North West Shelf indicate that similar sediments occur extensively over this geographic region, but with spatial variation in the grain size and origin of the surface sediments.

The ecology of the southwest is also greatly influenced by the lack of river discharge into the Region. The few significant rivers adjacent to the Region flow intermittently and their overall discharge is low. The low discharge of rivers and the generally low rate of biological productivity also results in low turbidity (suspended sediments), making the waters of the Region relatively clear (McLoughlin & Young 1985). Surface sediments in the area are predominantly composed of skeletal remains of marine fauna, with lenses of weathered sands (McLoughlin & Young 1985).

Several geomorphic formations have been associated with Key Ecological Features (DEWHA 2008a) and these are discussed in **Section 10**.

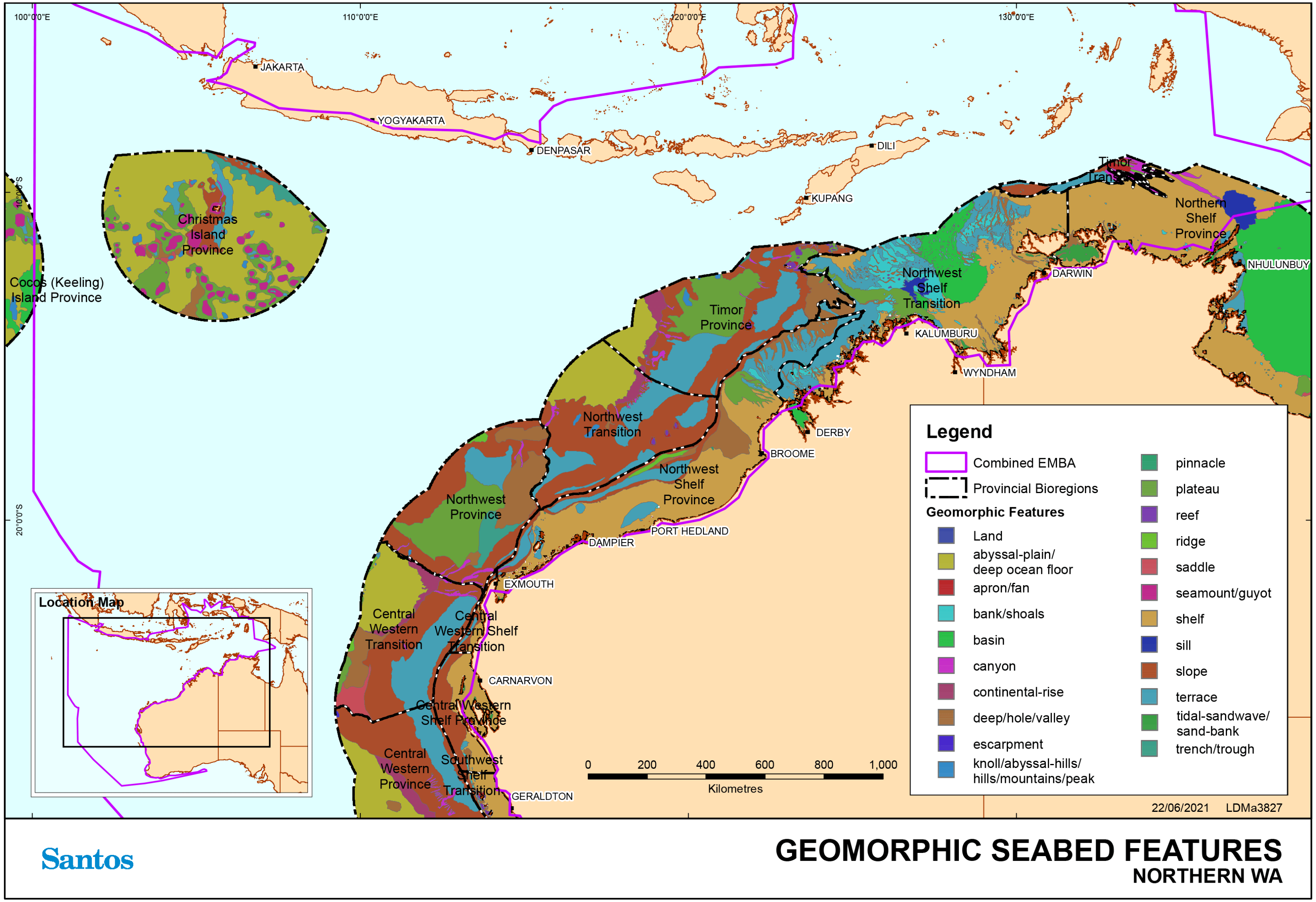


Figure 2-1: Geomorphic/seafloor features of Northern WA

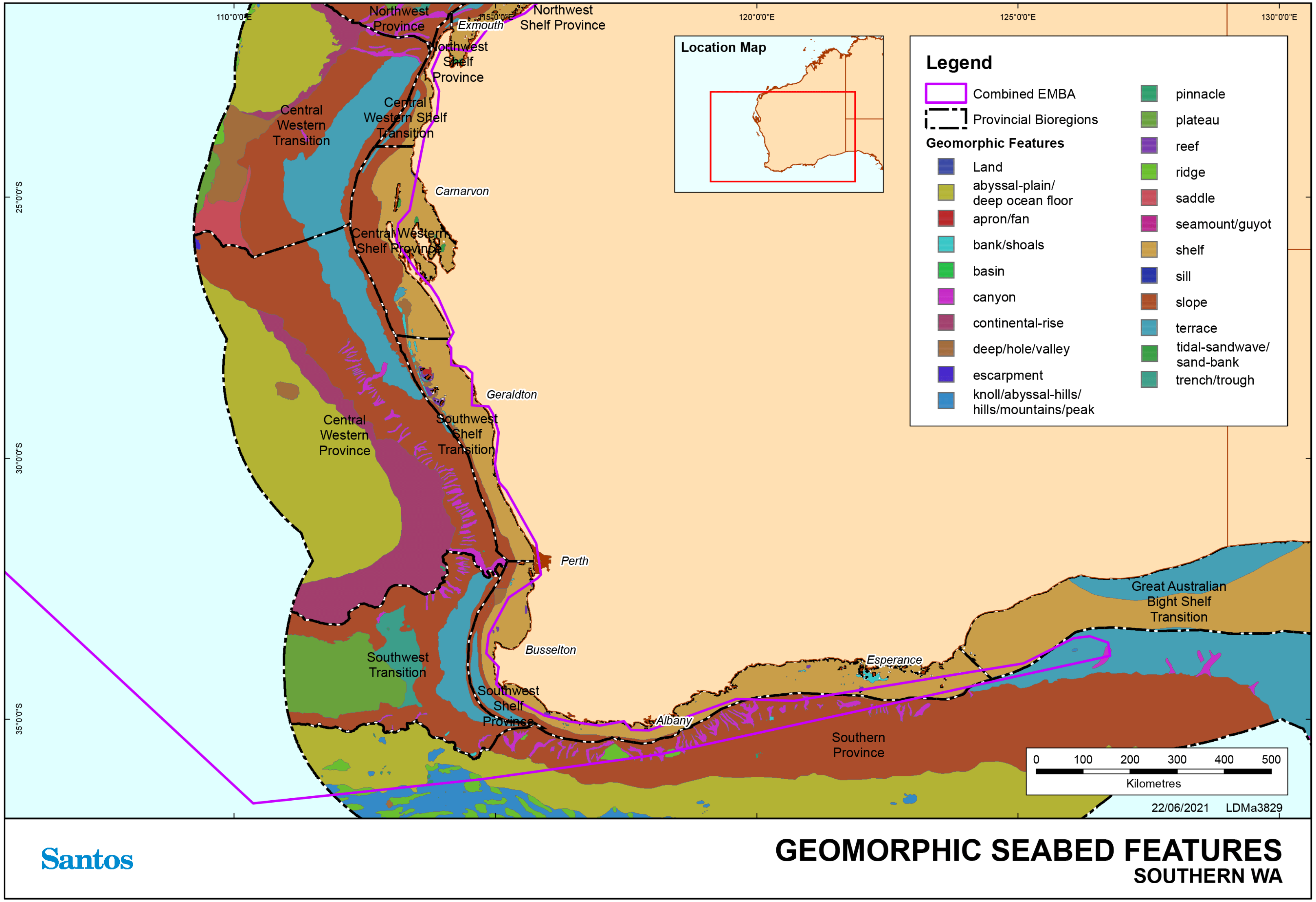


Figure 2-2: Geomorphic/seafloor features of Southern WA

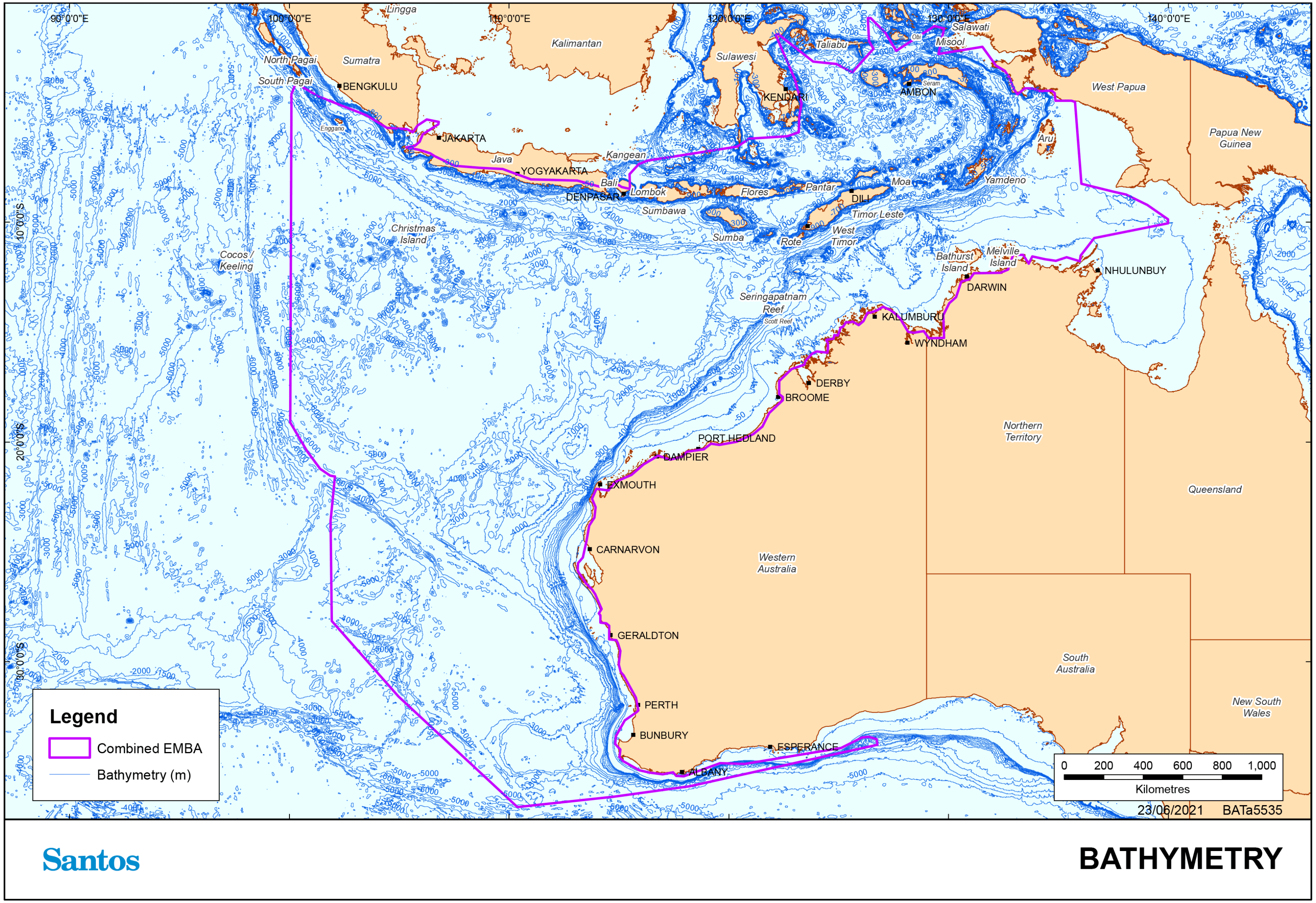


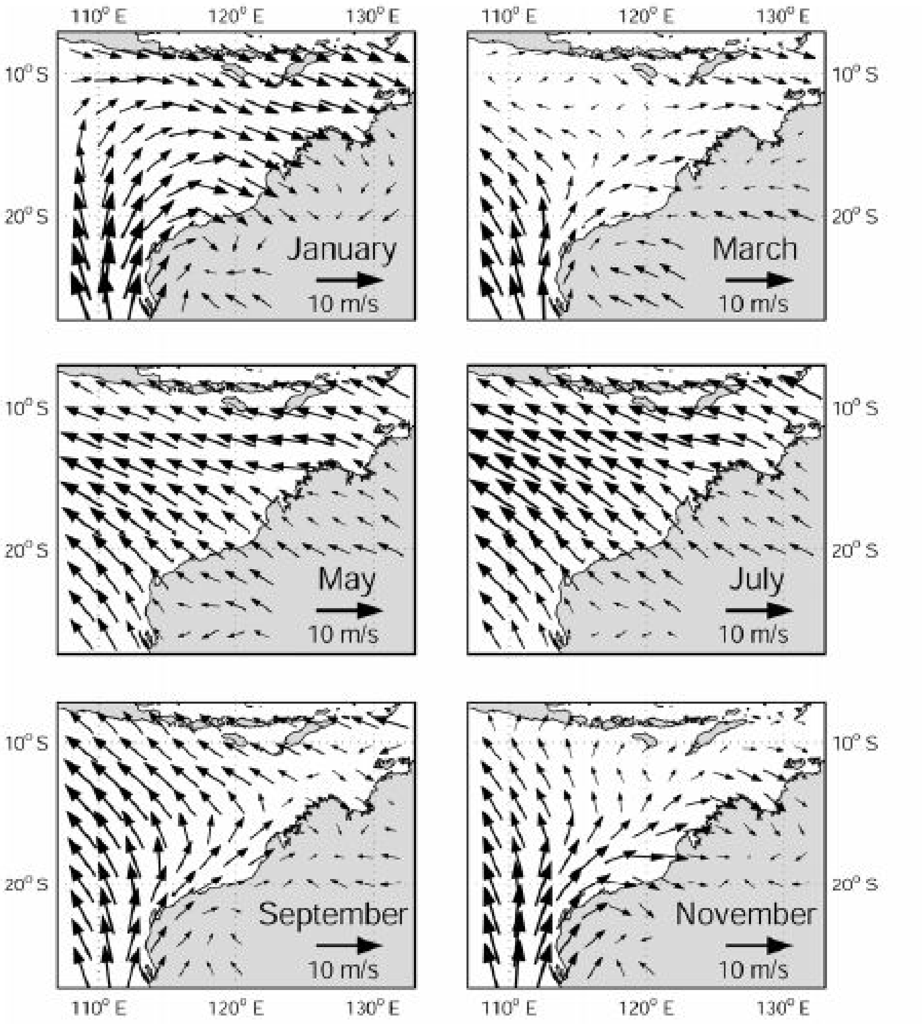
Figure 2-3: Bathymetry of the combined EMBA

2.2 Climate

Waters in northern Western Australia predominantly lie in the arid tropics, experiencing high summer temperatures and periodic tropical cyclones in summer. Rainfall in the region is low, although intense rainfall may occur during the passage of summer tropical cyclones and thunderstorms (Condie *et al.* 2006). Mean air temperatures range from a minimum of 11°C in winter to a maximum of 36°C in summer (Condie *et al.* 2006). Due to the arid climate, daytime visibility in the area is generally greater than 5 nautical miles (SSE 1991).

The summer and winter seasons fall into the periods September–March and May–July, respectively. Winters are characterised by clear skies, fine weather, predominantly strong east to southeast winds and infrequent rain (calculated from NCEP-NCAR dataset measured from 1982 to1999; Condie *et al.* 2006; **Figure 2-4**).

Summer winds are more variable, with strong south-westerlies dominating. Transitional wind periods, during which either pattern may predominate, can be experienced in April–May and September of each year.



Calculated from NCEP-NCAR dataset measured from 1982 to 1999. Source: Condie *et al*. (2006)

Figure 2-4: Seasonally averaged winds at 10 m above mean sea level

Tropical cyclones generate the most significant storm conditions in the area (SSE 1993). These clockwise-spiralling storms have generated wind speeds 50–120 knots (SSE 1991). Tropical cyclones develop in the eastern Indian Ocean, and the Timor and Arafura Seas during the summer months. Three to four cyclones per year are typical, with the official cyclone season being November through to April (Bureau of Meteorology (BoM) 2013). In Indonesia, the main variable in climate is not temperature or pressure, but rainfall, which varies greatly by month and place, ranging from 997 millimetres (mm) to 4,927 mm.

Waters in the southwest and southern Western Australia experience a Mediterranean style climate that is characterised by cool, wet winters and hot, dry summers. In winter, wind patterns are characterised by a prevailing westerly wind stream. This enables winter cold fronts and strong westerly winds to regularly penetrate the south-west, with cold fronts crossing the coast every week or so. Apart from the passage of storms, typically lasting one day or less, the weather is otherwise mild in winter with winds variable and relatively weak. In summer, cold fronts rarely penetrate into the south of the state with any strength and hot easterly winds prevail.

The Bonaparte Basin and Timor Sea region in the north has a tropical climate. These areas experience a distinct 'wet' season with summer monsoonal conditions from October to March and a distinct 'dry' season with cooler and drier conditions from April to September. The wet season usually comprises south-westerly winds capable of generating thunderstorm activity, high rainfall and cyclones. The dry season usually comprises dry and warm conditions with little rainfall (Fugro, 2015).

2.3 Oceanography

Major drivers of marine ecosystems include ocean currents, tides, waves, temperature and salinity. The dominant offshore sea surface current is the Leeuwin Current (**Figure 2-5**), which carries warm tropical water south along the edge of Western Australia's continental shelf, reaching its peak strength in winter and becoming weaker and more variable in summer (Condie *et al.* 2006). The current is typically located seaward of the shelf break (200 m isobath) and is a narrow, surface current, extending to a depth of 150 m (BHPB 2005, Woodside 2005) and a width of 50–100 km (DEWHA 2008a). The formation of meanders and eddies are also a feature of the Leeuwin Current and a number of eddies occur south of Shark Bay (DEWHA 2008a). The strength of the Leeuwin Current is influenced by seasonal variability in the pressure gradient (DEWHA 2008a). The Holloway Current is the prevailing seasonal current, travelling south-west along the north West Australian coast in winter and north-east in summer (Brewer et al. 2007). It is a relatively narrow boundary current that flows along the north-west shelf at between 100 m and 200 m depth, flowing towards the north-east in summer and the south-west in winter (Fugro, 2015).

The Indonesian Throughflow is the other important current influencing the upper 200 m of the outer North West Shelf (Woodside 2005). This current brings warm and relatively fresh water to the region from the western Pacific via the Indonesian Archipelago (**Figure 2-5**). Modelling undertaken by Woodside and Commonwealth Scientific and Industrial Research Organisation (CSIRO) Marine and Atmospheric Research indicates that significant east–west flows occur across the North West Shelf to the north of the North West Cape, possibly linking water masses in the area (Woodside 2005, Condie *et al.* 2006).

Currents in the coastal zone and over the inner to mid-shelf are largely driven by tides and winds, whereas offshore, over the continental shelf, slope and rise are influenced by large scale regional circulation (DEWHA 2008a). Large-scale currents of the Timor and Arafura seas in the north are dominated by the Indonesian Throughflow. Christmas and Cocos (Keeling) Islands territories are located in the eastern Indian Ocean, in the path of the South Equatorial Current that carries the Indonesian Throughflow waters into the Indian Ocean.

The nearshore Ningaloo Current flows northwards opposite to the Leeuwin Current, along the outside of the Ningaloo Reef and across the inner shelf from September to mid-April (BHPB 2005, Woodside 2005). The nearshore Capes Current, which is to the south of the Ningaloo Current, is a seasonal current that appears strongest between Cape Leeuwin and Cape Naturaliste, in the southwest of Western Australia (Pearce and Pattiaratchi 1999). Strong northwards winds between November and March slow the Leeuwin Current and increase the strength of the Capes Current. Localised upwelling is also known to occur in the area (Pearce and Pattiaratchi 1999).

Tides increase in amplitude from south to north, corresponding with the increasing width of the shelf (Holloway 1983). Tides in the area are generally semi-diurnal (i.e. two high tides and two low tides per day) with a spring/neap cycle. The northern area experiences some of the largest tides in the world. In the Kimberley, the daily tidal range is up to 10 m during spring tides and less than 3 m during some neap tides. Mid-shelf tidal currents are predicted to have average speeds of approximately 0.25 knots during neap tides and up to 0.5 knots during spring tides (NSR 1995, WNI 1995).

The wave climate in the northwest is composed of locally-generated wind waves (seas) and swells that are propagated from distant areas (WNI 1995). In summer the seas typically approach from the west and southwest, while in winter the seas typically approach from the south and east. Mean sea wave heights are typically less than 1 m and peak heights of less than 2 m are experienced in all months of the year (WNI 1995). Cyclones and tropical storms can greatly increase wave heights by up to 8 m in the outer Timor Sea during the cyclone season (Przeslawski et al. 2011).

Indonesian waters, especially the eastern part of the archipelago, play an important role in the global water mass transport system, in which warm water at the surface conveys heat to the deeper cold water in what is known as the great ocean conveyor belt (refer **Figure 2-5**). The eastern archipelago is the only place in the Pacific Ocean that connects with the Indian Ocean at lower latitudes. The water mass transport from the Pacific to the Indian Ocean through various channels in Indonesia is called Arlindo (Arus Lintas Indonesia), also known as the Indonesian Throughflow (ADB 2014). Surface currents in Indonesian waters are more strongly influenced by circulation from the Pacific Ocean than from the Indian Ocean. The currents are also greatly influenced by the winds of the prevailing monsoon.

Average swell heights are low, around 0.4–0.6 m in all months. The greatest exposure to swells is from the west (SSE 1993). Tropical cyclones have generated significant swell heights of up to 5 m in this area, although the predicted frequency of swells exceeding 2 m is less than 5% (WNI 1996). In the open ocean, sustained winds result in wind-forced currents of approximately 3% of the wind speed (Holloway & Nye 1985).

Tides in the South West Capes area are mixed (i.e. diurnal and semi-diurnal) and generally less than one metre, with a typical daily range of about 0.7 m during spring tides and about 0.5 m during neap tides. Tides of this magnitude produce weak currents compared to wind and wave driven flows (Hill & Ryan 2002 cited in Department of Environment and Conservation (DEC) 2013).

Waters on the continental shelf are usually thermally-stratified, with a marked change in water density at approximately 20 m (SSE 1993). Surface temperatures vary annually, being warmest in March (32°C) and coolest in August (19°C). Vertical gradients are related to the seasonality of sea surface temperatures, and are greatest during the warm-water season (SSE 1991). Near-bottom water temperature on the North West Shelf is approximately 23°C, with no discernible seasonal variation.

Salinity is relatively uniform at 34–35 ppt throughout the water column and across the North West Shelf. Due to the low rainfall there is little freshwater run-off from the adjacent mainland (Blaber *et al*. 1985).

Pronounced shifts in water column characteristics can occur following the passage of tropical cyclones (McKinnon *et al*. 2003). Changes in water temperature and salinity characteristics can result from changes in local heating and evaporation following the southward movement of warmer water due to southward-moving cyclones, and can have flow-on effects to primary and secondary productivity (McKinnon *et al*. 2003).

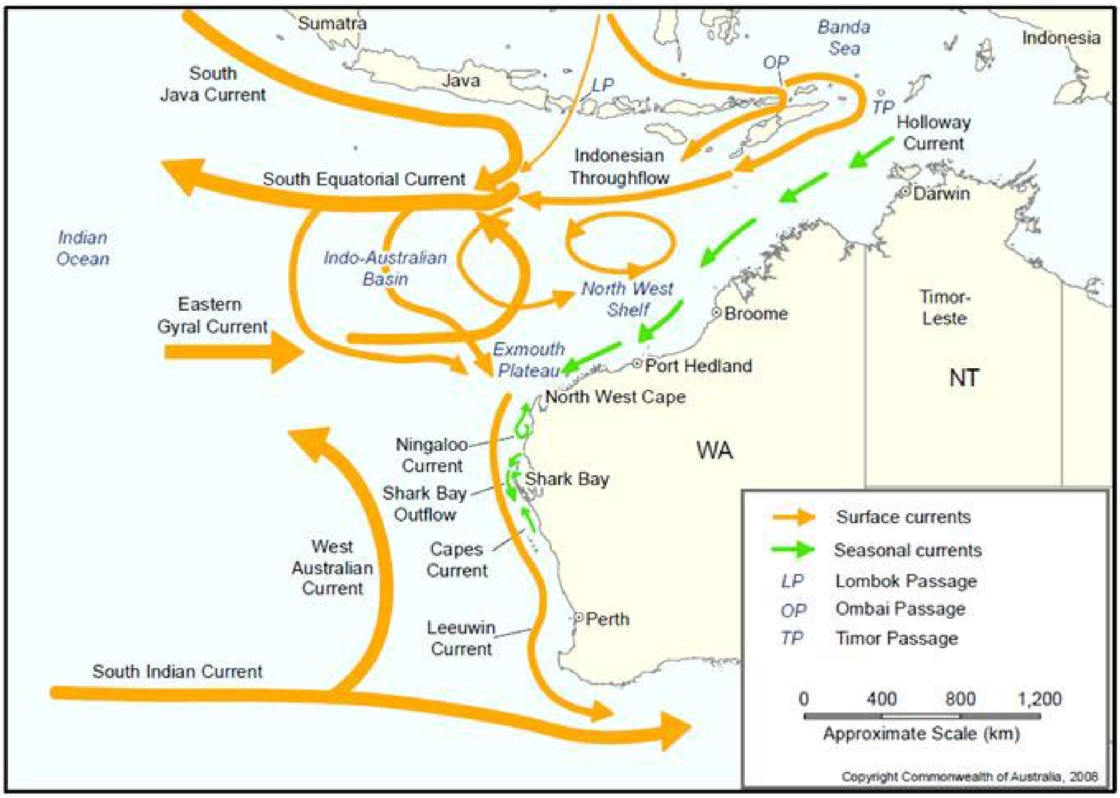


Figure 2-5: Surface currents in the Northern Territory and Western Australia

Source: DEWHA (2008b)

3. Benthic and Pelagic Habitats

Benthic habitats are defined as those subtidal habitats lying below the lowest astronomical tide (LAT). The benthic habitats within waters in the combined EMBA lie at depths ranging from LAT down to more than 6,000 m at Argo and Cuvier abyssal plains (DEWHA 2008a, 2008b, 2008c).

Benthic habitats are partially driven by light availability. Primary producers (photosynthetic corals, seagrasses and macroalgae) are limited to the photic zone, whereas benthic invertebrates including filter feeding communities may be found in deeper waters. The depth of the photic zone varies spatially and temporally and is predominantly dependent on the volumes of suspended material in the water column. The photic zone in the offshore Pilbara is approximately 70 m whereas in oceanic waters in the northwest and coastal waters of the southwest the photic zone may extend to 120 m (DEWHA 2008b). The photic zone in the offshore north extends to 100 m (DEWHA 2008c).

The following section broadly categorises benthic habitats as four biological communities; coral, seagrasses, macroalgae and non-coral benthic invertebrates. These communities are discussed in terms of the 18 IMCRA v. 4.0 bioregions. Some broad scale benthic habitat mapping exists for the Northwest and Central Western Shelf Provinces and this is shown in **Figure 3-1**.

3.1 Coral Reefs

Corals are both primary producers and filter feeders and thus play a role in the provision of food to marine fauna and in nutrient recycling to support ecosystem functioning (Conservation and Land Management (CALM) & Marine Parks and Reserves Authority (MPRA) 2005a).

Corals create settlement substrate and shelter for marine flora and fauna. Studies have shown that declines in the abundance, or even marked changes in species composition of corals, has a marked impact on the biodiversity and productivity of coral reef habitats (Pratchett *et al*. 2008). As part of the reef building process, scleractinian corals are also important for protection of coastlines through accumulation and cementation of sediments and dissipation of wave energy (CALM & MPRA 2005a).

The waters in the combined EMBA contain extensive coral communities. Coral reefs in the area fall into two general groups: the fringing reefs around coastal islands and the mainland shore; and large platform reefs, banks and shelf-edge atolls offshore (Woodside 2011). The distribution of corals in area is governed by the availability of hard substrate for attachment and light availability.

Coral reefs are dynamic environments that regularly undergo cycles of disturbance and recovery. Depending on how frequent and severe the disturbances are, recovery can take a few years or more than a decade. Disturbances can include bleaching, cyclones and disease outbreaks (Australian Institute of Marine Science (AIMS) 2011).

Corals in the northwest and central provinces have experienced bleaching events and subsequent recovery. Bleaching is the process where symbiotic algae are expelled from the coral tissue, often leading to the death of the colony. Causes of bleaching include high temperatures (Ningaloo; 2011 and Scott Reef; 1998 and 2016) (information available at AIMS.gov.au), anoxic conditions (Bill's Bay; 2008) or smothering (Waples & Hollander 2008, Gilmour et al. 2013). Coral susceptibility to bleaching and their ability to recover is an important consideration in the context of potential anthropogenic impacts.

Three bioregions (Northwest Province, Central Western Province and Central Western Transition) lie in deep waters below the photic zone. Two bioregions (Southwest Transition and Southern Province) occur in waters that are too cold to support tropical coral reefs species. Photosynthetic corals are not present in either of these locations and hence these bioregions are not discussed further. The EMBA overlaps the deeper waters of the Cocos (Keeling) Island Province, (not those close to shore) which are greater than 4000m deep and therefore photosynthetic corals are not present.

3.1.1 Southwest Shelf Transition

The coral reefs of the Houtman Abrolhos Islands are the most southern extensive coral community along the west coast. Smaller localised pockets do occur as far south as Rottnest Island and even extend to Cape Naturaliste in the Southwest Shelf Province. The reefs around the Abrolhos Islands comprise 211 known species of corals and all but two of the coral species are tropical (Department of Fisheries (DoF) 2012). The greatest diversity and density of corals is found on the reef slopes, shallow reef perimeters and lagoon patch reefs in the more sheltered northern and eastern sides of each of the three limestone platforms that support the island groups (DoF 2012).

3.1.2 Southwest Shelf Province

The Southwest Shelf Province is a nearshore bioregion that extends from Rottnest Island to Point Dempster, approximately 185 km east of Esperance. Adjacent to Commonwealth waters, the extensive area of granite reef (35 203 km2 of reef habitat) and seagrass habitat of the Recherche Archipelago is noted for its high diversity of warm temperate species including 263 known species of fish, 347 known species of molluscs, 300 known species of sponges, and 242 known species of macro-algae (DEWHA, 2008a).

3.1.3 Great Australian Bight Shelf Transition

Few species of scleractinian and soft coral (Orders Stolinifera, Telestacea and Alcyonacea) occur in southern Australia. Three reef-building species occur in shallow waters and >50 species of non-reef-building (ahermatypic) species occur in waters up to 900 m deep. The distribution patterns of corals in the GAB are largely unknown (McLeay et.al, 2003).

3.1.4 Central Western Shelf Province

The Central Western Shelf Province occurs on the continental shelf between Coral Bay and Busselton and is generally flat with depths ranging from 0–100 m. The province includes Shark Bay and Bernier, Dorre and Dirk Hartog Islands.

Studies at Shark Bay recorded 80 species of coral (Marsh 1990). The study determined that salinity and seasonal temperature gradients restrict the distribution of corals to areas that have normal salinity in the western half of the Bay, a few species occur in the metahaline waters but none in the hyper saline areas (Marsh 1990). The eastern shores of Bernier, Dorre and Dirk Hartog Islands provide the most favourable habitats for coral growth due to shelter, and water with relatively small salinity and temperature fluctuations. Some sections of these islands support prolific coral growth (up to 100% cover) both in the sheltered leeward and exposed areas. This bioregion is a transitional zone between the predominantly tropical flora and fauna of the north and temperate flora and fauna further south (CALM & NPNCA 1996).

3.1.5 Central Western Shelf Transition

A significant proportion of this bioregion is covered by the Ningaloo Reef. The Ningaloo Reef is unique in that it is the largest fringing reef in Australia and is the only large reef found on the western side of a continent in the southern hemisphere.

A 300 km section of the coast, from Red Bluff to North West Cape and extending to Bundegi in Exmouth Gulf, is included in the Ningaloo Marine Park. Ningaloo Reef supports variable lagoonal, intertidal and subtidal coral communities along its length. Ningaloo Reef is characterised by a high diversity of hard corals with at least 217 species representing 54 genera of hermatypic (reef building) corals recorded to date (Veron &

Marsh 1988). The most diverse coral communities are found in the shallow relatively clear water, high energy environment of the fringing barrier reef and low energy lagoonal areas to the west of North West Cape (CALM & MPRA 2005a).

Coral diversity reduces with increasing depth, and corals are uncommon at depths greater than 40 m (Waples & Hollander 2008). At depths between 20 and 30 m hard corals have been found to be more dominant in the northern areas of the Ningaloo Marine Park, whereas in southern areas other sessile invertebrates such as sponges, are more prevalent (Waples & Hollander 2008).

3.1.6 Northwest Transition

This bioregion lies mostly over the continental slope and the abyssal plain in deep waters that preclude photosynthetic coral growth (DEWHA 2008a). However, in contrast with the surrounding area, the Rowley Shoals are three distinct reef systems (Mermaid, Clerke and Imperieuse Reefs) approximately 30–40 km apart that rise vertically to the surface from depths of between 500 and 700 m. The marine reef fauna of the Rowley Shoals is considered to be exceptionally rich and diverse, including species typical of the oceanic coral reef communities of the Indo-West Pacific. As many of these species are not found in the inshore tropical waters of northern Australia, such populations are of regional significance (DEWHA 2008a).

A 1993 survey at Mermaid Reef recorded 214 species of scleractinian corals (Done *et al*. 1994) which is comparable to a more recent survey recording 211 species, including 22 new distribution records (McKinney 2009). The Rowley Shoals system has maintained high coral cover and has not been impacted by mass bleaching, despite neighbouring bleaching events reported at Scott reef during 1998 and 2016 (Gilmour *et al., 2021*). Since 1997, mean coral cover has increased through periods of impact and recovery from cyclones, reaching the highest (71%) on record in 2017 (Gilmour *et al.* 2019). The survey found that coral assemblages of the Rowley Shoals are broadly comparable to those found on the reefs of the outer Great Barrier Reef and in the Coral Sea. While the coral fauna is similar to Scott Reef, it differs considerably from that of north-western Australia (Veron 1986). Veron (1986) notes that the clear water of the Rowley Shoals allows coral communities to exist over a great range of depths, while the strong wave action on the outer coral slopes and the wide tidal range result in distinct patterns of zonation.

Recent genetic studies have also shown distinct genetic differences between offshore reef systems, the inshore macrotidal Kimberley region and Ningaloo Coast World Heritage Area reefs (Adam et al. 2022, Gilmour et al. 2016, Underwood 2009, Underwood et al. 2020). This is likely a result of their isolation, with negligible supply of larva from other reefs (Adam et al. 2022, Thomas et al. 2017). These studies highlight the importance of local recruitment in offshore reef systems in order to maintain healthy coral populations, which may reduce their capacity to adapt to rapid environmental change.

3.1.7 Northwest Shelf Province

This province contains numerous small coastal islands in addition to larger archipelago and offshore island groups. Many of these features are surrounded by shallow waters with small barrier and fringing reefs that support coral communities. Key areas recognised for coral communities in this bioregion are discussed below.

The Dampier Archipelago supports coral reefs in shallow waters near islands and submerged pinnacles. The most significant coral reefs have formed along the seaward slopes of Delambre Island, Hamersley Shoal, Sailfish Reef, Kendrew Island and north-west Enderby Island (CALM & MPRA 2005). Field trips in the Dampier Archipelago between 1972 and 1998 recorded 229 species of corals from 57 genera (Griffith 2004). Surveys of the Dampier Port and inner Mermaid Sound recorded approximately 120 coral species from 43 genera (Blakeway & Radford 2005) with coral reefs dominated by acroporids and pocilloporids. The greatest coral cover (up to 70%) was recorded in the eastern half of the archipelago (Wells *et al*. 2003).

The Montebello, Lowendal and Barrow Islands include 315 islands associated with extensive coral reefs, the most significant of which occur in the sheltered waters on the eastern side of the islands. Examples of these significant reefs include Dugong Reef, Batman Reef and reefs along the Lowendal Shelf (DEC & MPRA 2007a). Dominant corals include acroporids and poritids, with greater than 70% cover recorded for some areas (Chevron 2010). Subtidal coral reef communities around the islands are highly diverse, with at least 150 species of hard corals recorded from fringing and patch coral reef areas (DEC & MPRA 2007a).

Coral distribution near the mainland is restricted by lack of light due to natural turbidity. Corals may exist as sparse coral colonies in some locations, rather than extensive coral communities. Within Exmouth Gulf, coral communities are less common but are present on fringing reefs surrounding islands, as solitary corals distributed across areas of hard substrate, or on larger isolated patch reefs.

An epibenthic dredge survey of nearshore areas north of Broome identified 14 species of hard corals from six families (Keesing *et al*. 2011). Limited coral surveys conducted at Broome (15 species) and the Lacepede Islands (ten species) (Veron & Marsh 1988) suggest the species diversity in this locality may be low. However, low species diversity observed during the dredge survey may reflect the limited sampling frequency, limited depth range (11–23 m) or inadequate sampling in habitats considered favourable for the proliferation of hard corals (hard substrate). In contrast, other surveys of nearshore locations in the region have recorded much higher levels of species diversity. Veron and Marsh (1988) stated that 102 species of hard corals have been recorded from the Kimberley coast and nearshore reefs and Cairns (1998) recorded 87 species of azooxanthellate hard coral species from north-western Australian waters.

3.1.8 Northwest Shelf Transition

Coral communities of the Northwest Shelf Transition have historically not been well studied. However, based on the scale of reef development and the diversity of coral species recorded through limited surveys, it is highly likely that further surveys will demonstrate that the Kimberley contains a coral reef province of global significance (Masini *et al*. 2009).

Coral reefs in the province include fringing reefs around coastal islands and some mainland shores. Development of coral communities in inshore areas is limited due to persistent high turbidity. Known examples of coral reefs in the bioregion are given below, however further mapping is required.

Benthic habitat surveys at Adele and Long Islands in 2009 and 2010 revealed extensive development of hard and soft coral communities (Richards *et al*. 2013). Scleractinian coral communities at Adele Island were diverse, supporting 176 species in intertidal and subtidal areas up to 14 m depth. At Long Island approximately 200 species of scleractinian corals were recorded in intertidal and subtidal areas. These surveys also identified two significant and unique habitats; a zone of mixed corallith and rhodolith habitat at Adele Island and an Organ Pipe Coral habitat zone with unusually high benthic cover at Long Island (Richards *et al*. 2013).

Studies by DBCA and the LNG industry indicate that fringing and emergent coral reefs are well developed in the Heyward island group, around islands in the Bonaparte Archipelago, and off mainland shores of Cape Voltaire and Cape Bougainville. Surveys by INPEX of Maret, Bethier and Montalivet islands, which were largely restricted to the intertidal zone, have recorded 280 species of coral from at least 55 genera, making the Kimberley Bioregion the most coral-diverse area in WA (INPEX 2008).

Montgomery Reef has been identified as a key feature in the area. Montgomery Reef is a huge, submerged rock platform covering approximately 400 km^2. Corals occur in the subtidal area around Montgomery Reef, and in the many rock pools on the platform where there is shaded from the sun by algae or rock ledges

(DEWHA 2008a). A survey of benthic habitats at Montgomery Reef was conducted in 2009 by AIMS but a literature search found no published results from this survey (AIMS 2014).

Browse Island is surrounded by a minor fringing coral reef. Assemblages at Browse Island are characteristic of coral platform reefs throughout the Indo-West Pacific region, particularly Cartier Island. Coral diversity was greatest on the reef faces and shallow lagoons, but these areas were of very limited extent (URS 2010a).

Hard corals have been recorded at Echuca Shoals, but the community was low in both species richness and abundance (URS 2010a). The presence of occasional large outcrops suggests that larger coral structures have occurred previously and may still occur elsewhere on the shoal (RPS Environmental 2008).

3.1.9 Timor Province

Although water depths in this province are generally deep (200 m to almost 6,000 m) there are several reefs and islands that are regarded as biodiversity hotspots (DEWHA 2008a).

Ashmore Reef, Cartier Island, Hibernia, Scott and Seringapatam Reefs are areas of enhanced local biological productivity, within an area of relatively unproductive waters. Ashmore Reef National Nature Reserve supports one of the greatest number of coral species of any reef off the West Australian coast, with 255 species of reef-building corals in 56 genera (Veron 1993). Taxonomic revisions and additional surveys have resulted in a net increase in species numbers to 275 (Griffith 1997, Ceccarelli *et al*. 2011). Species are typical of the Indo-pacific region and none are unique or considered endemic. However, 41 species (15% of the total hard coral species at the site) are listed as vulnerable on the IUCN Red List (IUCN 2019). In 1998, hard coral covered an area of around 717 ha at Ashmore Reef. The majority of hard corals occur in the deep lagoon (265 ha) and shallow reef top (315 ha) with small areas in the shallow lagoons, and reef edge/slope habitats (Skewes *et al*. 1999a). The soft, non-reef building corals are less well studied at Ashmore Reef than the hard corals (Hale & Butcher 2013). In 1986, 39 soft coral taxa were recorded within the Ashmore Reef, including the vulnerable blue coral (*Heliopora coerulea*) which was moderately common on the reef flats (Marsh 1993). In 1998, the total cover of soft coral at Ashmore Reef was 323 ha and *Sarcophyton* spp. was the dominant taxa covering around 19 ha in total (Skewes *et al*. 1999b, Hale & Butcher 2013).

The species composition of all the hard coral reefs in the bioregion is very similar and reflects strong links with Indo-West Pacific fauna, largely as a result of the dispersal of coral spawn via regional currents. The reefs and islands in this bioregion are thought to be important biological stepping-stones between centres of biodiversity in the Indo–Pacific and reef ecosystems further south (DEWHA 2008a).

Seringapatam Reef is a regionally important scleractinian coral reef as it has a high biodiversity, which is comparable to Ningaloo Reef. Results from the Western Australian Museum (WAM) survey in 2006 noted 159 species of scleractinian corals with a hard coral cover of approximately 16% (WAM 2009). The dominant benthic habitats of the reef were observed to include hard and soft corals (Heyward et al. 2013 cited in ConocoPhillips 2018).

Scott Reef consists of two reefs, North Scott Reef and South Scott Reef, which are separated by a deep (400–700 m) channel. North Scott Reef is an annular reef which encloses a lagoon that is connected to the ocean. South Scott Reef is a crescent-shaped reef which forms an arc and partially encloses another lagoon. Light penetration at Scott reef is high due to low turbidity. Light penetration depths to the deeper part of South Reef Lagoon are in excess of 50m with corals able to survive at depths of up to 70 m (Woodside Energy Limited *et al.* 2010). Studies at Scott reef have identified over 300 scleractinian coral species in the shallow water habitats alone, from almost 60 genera and 14 different families (Gilmour et al. 2013). The Scott reef system has experienced two mass bleaching events in 1998 and 2016, with the latter showing > 90% decreases in cover of branching corals (Porites, Acropora, Millepora, Isopora and Pocillopoiridae) (Gilmour *et al.,* 2021). Regular monitoring following the 1998 mass bleaching event showed increasing cover of branching corals 5 years post bleaching event, with most coral groups recovering approximately 12 years later (Gilmour *et al.,* 2021).

Hibernia Reef consists of an approximately oval-shaped reef, with large areas of the reef becoming exposed at low tide. Hibernia Reef is also characterised by a deep central lagoon and drying sand flats.

There are a number of shoals and banks in the NMR and NWMR. Relatively few studies have been undertaken of these features with the majority of the understanding derived from the Big Bank Shoals study (Heyward *et al*. 1997), PTTEP surveys initiated in response to the Montara incident (Heyward *et al*. 2010; Heyward *et al.* 2011) and ConocoPhillips baseline surveys undertaken to support the Barossa Area Development (Heyward *et al.* 2017). The PTTEP surveys completed at Ashmore, Cartier and Seringapatam Reefs were undertaken during a coral bleaching disturbance likely to be attributed to regional thermal stress indicated by both *in situ* and satellite-based data for the region. The condition of the reefs communities was consistent with previous surveys within the area and did not indicate any disturbance from the Montara incident (Heyward *et al*. 2010; Heyward *et al.* 2012).

In general, the submerged features are characterised by abrupt bathymetry, rising steeply from the surrounding outer continental shelf at depths of 100 m–200 m. The shoals and banks tend to flatten at depths of 40-50 m, with horizontal plateau areas of several square kilometres generally present at 20-30 m depths (Heyward *et al*. 2010). The shoals and banks support a diverse and varied range of benthic communities, including algae, reef-building soft corals, hard corals and filter-feeders (Heyward *et al.* 1997, Heyward *et al.* 2012). The plateau areas were dominated by benthic primary producer habitat, with interspersed areas of sand and rubble patches (Heyward *et al*. 2012).

3.1.10 Timor Transition

Due to the deep, offshore nature of the Timor Transition (up to 300 m with no coastal areas), there are no corals expected within this area (DEWHA 2008c). However, there is evidence of relic reef next to drainage channels of the outer slope of the Timor Transition. This is thought to be associated with local upwellings of cooler nutrient rich water from the Timor Sea (DEWHA 2008c).

3.1.11 Northern Shelf Province

The Northern Shelf Province contains submerged patch or barrier reefs in areas with approximately 30-50 m depth of water, these mainly occur around the margin of the Gulf of Carpentaria (which lies outside the combined EMBA) (DEWHA 2008c). The majority of the province is relatively featureless with sandy and muddy sediments and this is expected to be the case for the portion of the combined EMBA that overlaps the Northern Shelf Province.

3.1.12 Christmas Island Province

The subsurface marine habitat immediately surrounding Christmas Island consists of a relatively narrow and shallow coral reef shelf about 20 to 100 metres wide in approximately six to 20 metres of water depth. There are caves in some of the island’s rocky sea cliffs that adjoin the coral reef shelves. Coral reef shelves also contain areas of sand and rubble.

The shallow coral reef shelves drop off steeply to the island’s mid and deep-water marine habitats which include outer reef seaward slopes, vertical walls and oceanic waters. The marine boundary of the Christmas Island National Park extends 50 metres seaward from the low water mark, which means that the park has no true deep-water habitats, but some outer reef slopes and vertical walls fall within the park’s waters (DNP, 2012).

3.1.13 International Waters

Important areas outside of the IMCRA bioregions include:

Indonesia (west)

Indonesia has an estimated 75,000 km^2 coral reef ecosystem distributed throughout the archipelago (Tomascik et al. 1997 cited in Hutumo & Moosa 2005). Fringing reefs are the most common reef types with scleractinian corals as being the most dominant and important group. 452 species of hermatypic scleractinian coral were collected from Indonesian waters by Tomascik et al. (1997 cited in Hutumo & Moosa 2005), a study presented by Suharsono (2004 cited in Hutumo & Moosa 2005), indicated that 590 species of scleractinian corals exist in Indonesian waters. *Acropora, Montipora* and *Porites* are the most important reef building corals in Indonesia.

The Lesser Sunda Ecoregion encompasses the chain of islands and surrounding waters from Bali, Indonesia to Timor-Leste. This region contains suitable habitat for corals on shallow water substrates formed by limestone and lava flows and is thought to contain more than 500 species of scleractinian reef-building corals (DeVantier *et al.* 2008). Coral species composition is influenced by regional and local scale seasonal upwellings that typically occur from April to May each year on the southern side of the islands. The ecoregion is considered important for coral endemism, particularly the areas of Bali-Lombok, Komodo, and East Flores. Fringing coral reefs tend to be less developed on the southern, more exposed shorelines (Wilson *et al.* 2011).

The world heritage sites of Siberut and Ujung Kulon are also recognised for their extensive coral ecosystems, as well as marine national parks in the waters and islands surrounding Indonesia, such as Laut Sawu, Teluk Cenderawasih, Bunaken, Kapulauan Wakatobi, Togian Islands, Karimunjawa, the islands of Kepulauan Seribu, the table reefs of Taka Bonerate and the Savu Sea National Marine Conservation Area (refer to **Section 9.8**).

Majority of these sites form parts of the marine area known as the Coral Triangle, named for its staggering number of corals and associated marine life, situated in the waters of Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and Solomon Islands (ADB, 2014).

Timor-Leste

See **Section 3.1.8** for a description of habitat typical of shoals and banks in the Timor Sea.

3.2 Seagrasses

Seagrasses are biologically important for four reasons:

1. As sources of primary production;
2. As habitat for juvenile and adult fauna such as invertebrates and fish;
3. As a food resource; and
4. For their ability to attenuate water movement and trap sediment (Masini *et al*. 2009).

Twenty-five species of seagrass have been recorded in WA, the highest diversity in the world, and over 30 species of seagrasses have been recorded as occurring within Australian waters (Masini *et al*. 2009). Waters extending from Busselton to the NT border support predominantly tropical species although temperate species are also found, particularly between Busselton and Exmouth (Walker 1987). One species, *Cymodocea angustata*, is endemic to WA (Department of Parks and Wildlife (DPAW) 2013). Other seagrass meadows of note include those around Tiwi Islands which provide significant habitat to a number of species. Seagrass habitats also occur within shallower waters near islands and have potential to occur closer to the Indonesian and Timor-Leste coastlines.

The main seagrasses of the region are small, ephemeral species that grow on soft sediments and have a seed bank in the surficial sediments that allows them to recover quickly from disturbance (Walker 1989). Small, ephemeral species of seagrass tend to form mixed associations with macroalgae (CALM & MPRA 2005, DEC & MPRA 2007a, BHPBIO 2011) and usually covers less than 5% of the substrate (BHPBIO 2011, van Keulen & Langdon 2011).

Areas occupied by seagrass vary markedly both seasonally and interannually and it is not clear why some areas of suitable substrate will support seagrass in one year but not the next. It appears that recruitment to what may otherwise be suitable substrate is haphazard, lending weight to the descriptions of these seagrass communities as ephemeral (CALM & MPRA 2005, DEC & MPRA 2007a).

Four bioregions (Northwest Province, Central Western Province, Central Western Transition and Timor Transition) lie entirely in deep waters below the photic zone. Two bioregions (Southwest Transition and Southern Province) occur in waters that are too cold to support seagrasses. The EMBA overlaps the deeper waters of the Cocos (Keeling) Island Province, (not those close to shore) which are greater than 4000m deep and therefore seagrasses are not present.

Seagrasses are not present hence these bioregions are not discussed further.

3.2.1 Southwest Shelf Province

Geographe Bay is a large relatively sheltered area with that supports extensive beds of tropical and temperate seagrass that have a high diversity of species and endemism (DEWHA 2008a). They are thought to account for about 80% of benthic primary production in the area. These seagrass beds provide important nursery habitat for many shelf species that use the shallow seagrass habitat as nursery grounds for several years before moving out over the shelf to their adult feeding grounds along the shelf break.

The Geographe Bay seagrass meadows are among the most extensive temperate seagrass communities on the west coast (MPRSWG 1994 cited in DEC 2013), and include 10 species from five genera (*Amphibolis, Posidonia, Halophila, Heterozostera* and *Thalassodendron*). Geographe Bay is dominated by stands of the narrowleaf tape-weed (*Posidonia sinuosa*) that covers approximately 70% of Geographe Bay. It has smaller areas of *Posidonia angustifolia*, *Amphibolis griffithii*, *A. antarctica* and minor species, which have irregular distributions both spatially and temporally (Lord 1995 cited in DEC 2013). *Thalassodendron pachyrhizum*, *Posidonia* spp. and *Amphibolis* spp. are also found in depths of between 27 and 45 m (Walker *et al*. 1994 cited in DEC 2013).

3.2.2 Southwest Shelf Transition

Species diversity of seagrasses in this bioregion is the highest in the world, with 14 species occurring (DEWHA 2008a). In total, 10 seagrass species have been recorded at the Abrolhos ranging from small, delicate species to larger, more robust types that grow in large meadows (DoF 2012). Small paddle-weeds grow in protected lagoon areas or deep waters between the islands, such as Goss Passage and the larger species may be found growing on reef as well as in sandy areas (DoF 2012). *Thalassodendron pachyrhizum*, which is encountered growing on the exposed reef crest area, has been recorded at a number of the island groups. There are also two species of wire-weed (*Amphibolis* species), endemic to southern Australia, found at the Abrolhos (DoF 2012). The most abundant seagrass is *Amphibolis antarctica*, while *Amphibolis griffithii* appears to be restricted to bays such as Turtle Bay in the Wallabi Group.

The larger ribbon-weeds (*Posidonia* species) grow in sheltered bays and lagoons where the sand cover is deeper and more stable (e.g. Turtle Bay, the Gap, East Wallabi Island, the lagoon on the west side of West Wallabi Islands and around North Island) (DoF 2012).

Nine species of seagrass are found in the Perth region, including at Rottnest Island where *Amphibolis* thrives in clear waters overlying limestone rock (Amalfi 2006). Seagrasses are a major component of the ecosystem on the Rottnest Shelf, thriving in waters ranging in depth from intertidal to 45m (Amalfi 2006). All of the seagrass species identified with the exception of *Syringodium isoetifolium* and *H. ovalis* are endemic to temperate areas of southern Australia (Amalfi 2006). At Rocky Bay, on the north side of the island where it is protected from big swells and strong south to south-westerly winds, a mix of dense seagrass meadow consisting of *Amphibolis* and *Posidonia* thrive. The meadows around Rottnest Island serve as nurseries for juveniles of many fish species and are home to species such as the cobbler and long-headed flathead (Amalfi 2006).

3.2.3 Great Australian Bight Shelf Transition

The Australian coastline has the highest number of seagrass species of any continent. There are approximately 30 species of seagrasses in Australia belonging to 11 genera. Approximately one third (18 species) of all species known worldwide are endemic in Australia. Of these, 16 species are restricted to temperate waters.

Southern temperate waters have two endemic genera, *Heterozostera* and *Amphibolis*. Many endemic species belong to the genera *Posidonia*. The distribution and abundance of seagrasses is a function of topography and environment. A distinction exists between subtropical and warm temperate types. In southern Australia, species with warm water affinities (*Posidonia, Amphibolis*) decline in number from west to east as water temperatures decrease.

In South Australia, seagrasses cover approximately 9620 km2 and represent one of the largest seagrass ecosystems in the world. Seagrass distribution in the GAB is patchy and limited by exposure to swell. Most seagrass is found in sheltered bays or in the lee of reefs and islands in the eastern GAB. These areas contain nearly 10% of the seagrass meadows found in South Australia. Posidonia species dominate, especially *P. angustifolia, P. coriacea* at the base of cliffs and *P. australis* and *P. angustifolia* in the sheltered lee of fringing reefs. *Amphibolis antarctica* and *Heterozostera tasmanica* are present but less common in sheltered bays of the region (McLeay et al., 2003).

3.2.4 Central Western Shelf Province

Shark Bay contains the largest reported seagrass meadows in the world (approximately 4,000 km^2), as well as some of the most species-rich seagrass assemblages (Walker *et al.* 1989). Twelve species of seagrass are found in the Bay with the dominant species being *Amphibolis antarctica*. Seagrass is a fundamental component of biological processes in Shark Bay; it has modified the physical, chemical and biological characteristics of the Bay and provides food, habitat and nursery grounds for many species (CALM & National Parks and Nature Conservation Authority (NPNCA) 1996).

An inshore survey of benthic habitats near Busselton recorded dense coverage of *Amphibolis* spp. on limestone pavement. *Halophila* spp., *Heterozostera* spp. and *Syringodium isoetifolium* were recorded on sandy substrates (DoF 2007).

3.2.5 Central Western Shelf Transition

Nine species of seagrasses have been found throughout Ningaloo Reef (van Keulen & Langdon 2011). Some delineation of temperate and tropical species exists; however, several species were found throughout the Ningaloo Reef. Halophila ovalis was the most commonly found seagrass at Ningaloo and was generally found growing in sandy patches between coral bomboras. *Amphibolis antarctica* is a large meadow forming species that has been found growing in large clumps in Bateman Bay, north of Coral Bay (van Keulen & Langdon 2011).

3.2.6 Northwest Transition

The Rowley Shoals provide the only suitable shallow substrate for seagrasses in this predominantly deep bioregion. Sparse seagrass is found within subtidal coral reef communities of the Rowley Shoals but is not a major habitat type. Two species of seagrass, *Thalassia hemprichii* and *Halophila ovalis*, have been recorded at Mermaid Reef (Huisman *et al*. 2009). Earlier studies at Mermaid and Imperieuse Reef recorded the above two species and a third species; *Thalassodendron ciliatum* (Walker & Prince 1987).

3.2.7 Northwest Shelf Province

In the Northwest Shelf Province, seagrasses are present but sparsely distributed to depths of approximately 30 m (LEC & Astron 1993, URS 2009, CALM 2005a). The abundance and distribution of tropical (and subtropical) seagrass species can vary greatly due to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature), with biomass tending to peak in summer (Lanyon & March 1995).

Studies between Quondong and Coulomb Points north of Broome identified seagrass communities of *Halophila* spp. patchily distributed across large areas, from the lower intertidal and out to a depth of approximately 20 m (DEC 2008, Fry *et al*. 2008). Similarly, *Halophila decipiens* was the only seagrass collected from epibenthic dredge studies at five localities near Broome from Gourdon Bay to Packer Island (Keesing *et al.* 2011).

Roebuck Bay is located south of Broome and includes large areas of intertidal mudflats. Extensive seagrass meadows occur in the northern regions of Roebuck Bay and are dominated by *Halophila ovalis* and *Halodule uninervis*. *Halophila minor* and *Halodule pinifolia* have also been reported at this location (Prince 1986, Walker & Prince 1987, Seagrass-Watch 2019).

In the Dampier Archipelago seagrass occurs in the larger bays and sheltered flats of the area (CALM & MPRA 2005). Six species of seagrass, including three Halophila species, have been recorded on the subtidal soft sediment habitats (CALM & MPRA 2005). Seagrasses do not form extensive meadows within the proposed reserves, but rather form interspersed seagrass/macroalgal beds. The largest areas of seagrass are found between Keast and Legendre islands, and between West Intercourse Island and Cape Preston (CALM & MPRA 2005).

Surveys near Onslow found that *Halophila* spp. were the most widespread of the seagrasses in that region. Seagrasses were found to be generally sparsely distributed (<10% cover), occurring in small patches within larger areas of suitable substrate. Small areas of higher (>50%) seagrass cover occurred in shallow clear water areas but were not common (URS 2009, URS 2010b, Chevron 2010).

Similarly, in the Montebello/Barrow Islands Marine Conservation Reserves, seagrasses appear not to form extensive meadows but are sparsely interspersed between macroalgae. Seven seagrass species have been recorded in the Reserves (DEC & MPRA 2007a) with *Halophila* spp. the most common seagrass species on shallow soft substrates and sand veneers. Distributions of these species extend from the intertidal zone to approximately 15m water depth (DEC & MPRA 2007a). Surveys to the northwest and southeast of Barrow Island from 2002 to 2004 did not identify any significant seagrass meadows but confirmed the presence of sparse coverage of *Halophila* and *Halodule* spp. in shallow areas east of Barrow Island (RPS BBG 2005).

A significant meadow of large seagrasses at Mary Anne Reef east of Onslow was identified almost 30 years ago and its presence today is unconfirmed. The meadow was several hundred hectares of *Cymodocea angustata* at 30–50% cover, occurring primarily at a depth of 2–3 m (Walker & Prince 1987).

3.2.8 Northwest Shelf Transition

Extensive and diverse intertidal seagrass meadows are known from islands in the southern Kimberley, particularly in the Sunday Island One Arm Point area (Walker 1995, Walker & Prince 1987). Ten species of seagrasses have been recorded at One Arm Point, with the majority of meadows low to moderate in abundance and dominated by *Thalassia hemprichii* with *Halophila ovalis*, *Halodule uninervis* and *Enhalus acoroides* (Seagrass-Watch 2019).

While some seagrasses have been collected from intertidal sites in the central and north Kimberley (Walker *et al*. 1996, Walker 1997), these areas were not found to be species rich and did not support extensive seagrass meadows like those found in the southern Kimberley.

Subtidal seagrass meadows in the Northwest Shelf Transition are not well mapped, although dugongs are known to feed on seagrass communities in coastal waters of the Joseph Bonaparte Gulf (DEWHA 2008a).

3.2.9 Timor Province

Seagrass has been reported on the reef flats of offshore reefs of this bioregion (Whiting 1999, Hale & Butcher 2013). Five species of seagrass were reported at Ashmore Reef with *Thalassia hemprichii* being the dominant species (Pike & Leach 1997, Skewes *et al*. 1999b, Brown & Skewes 2005). The total area of seagrass at Ashmore Reef in 1999 was estimated to be 470 ha (Skewes *et al*. 1999b). However, much of this was very sparse cover and there were only 220 ha of seagrass with a greater than 10% cover (Brown & Skewes 2005). Seagrass grew in a sparse, patchy distribution across the sand flats, but had a higher coverage on the reef flat area, where it extended to within 100 m of the reef crest. The area of greatest cover and diversity was in the west and south-west areas of the reef on the inner reef flat (Brown & Skewes 2005). These seagrass meadows support a small but significant population of dugongs estimated at around 100 individuals comprising all age classes from calves to adults (Hale & Butcher 2005).

Similarly, Scott Reef supports five species of seagrass (URS 2006), with *Thalassia hemprichii* most abundant (Skewes *et al*. 1999a, URS 2006). The area of seagrass at Scott Reef is significantly less than that recorded for Ashmore Reef (approximately 100 ha) (Woodside 2011). The highly energetic environment and significant tidal exposure of Scott Reef restricts the area of habitats potentially suitable for seagrass establishment to a small proportion of the total area, resulting in low abundance (Skewes *et al*. 1999a, URS 2006).

Seringapatam Reef was found to have a seagrass cover of 2 ha out of 5,519 ha (0.04%) composed of *Thalassia hemprichii* and *Halophila ovalis* in approximately equal quantities (Skewes *et al*. 1999a). This finding contrasts with a more recent survey where only one species of seagrass (*Halophila decipiens*) was recorded at Seringapatam (Huisman *et al*. 2009).

Skewes *et al*. (1999a) did not observe any seagrass communities at Hibernia Reef.

3.2.10 Northern Shelf Province

Coastlines adjacent to the Northern Shelf Province contain seagrasses providing habitat to a number of marine species, particularly juvenile tiger prawns, which make up approximately 50% of the total prawn catch in the province. However, majority of these seagrass habitats exist within the Gulf of Carpentaria, which lies outside the combined EMBA.

3.2.11 Christmas Island Province

The subsurface marine habitat immediately surrounding Christmas Island consists of a relatively narrow and shallow coral reef shelf about 20 to 100 metres wide in approximately six to 20 metres of water depth. The sandy areas and some lagoons are also known to support seagrass habitat (DNP 2012).

3.2.12 International Waters

Important areas outside of the IMCRA bioregions include:

Indonesia (west)

Within Indonesian waters, the lower intertidal and upper subtidal zones are considered important areas for the growth of seagrass (Hutumo and Moosa 2005). Pioneering vegetation in the intertidal zone is dominated by *Halophila ovalis* and *Halodule pinifolia* while *Thalassodendron ciliatum* dominate the lower subtidal zones. Wide areas of the Indonesian coastal waters are covered by dense beds of seagrass.

Seagrass habitats are widely distributed across the Lesser Sunda Ecoregion. Preliminary data from the United Nations Environment Program's (UNEP) World Conservation Monitoring Centre (WCMC) has identified the following areas as potential areas of importance for seagrass, many of which are outside the combined EMBA (DeVantier *et al.* 2008):

+ North-west Bali;
+ South-west and west Lombok;
+ North-east Sumbawa;
+ Komodo Islands;
+ Savu; and
+ South coast of Timor-Leste.

The Kepulauan Seribu National Park, Laut Sawu Marine National Park, Bunaken National Park, Karimunjawa Marine National Park and Savu Sea National Marine Conservation Area are also known for their rich diversity of seagrasses (refer to **Section 9.8**).

3.3 Macroalgae

Macroalgae are important contributors to primary production and nutrient cycling in the region, providing food and habitat for vertebrate and invertebrate fauna. Macroalgae are also recognised for their role in spatial subsidies; the movement of nutrients or energy between neighbouring habitats. Spatial subsidies involving macroalgae include the movement of wrack from macroalgal beds to bare substrates and shorelines (Orr 2004).

Macroalgae are primarily associated with hard substrates. They occur in moderate to high cover on exposed hard substrates, but typically have lower cover on hard substrates that are covered with a veneer of sediment (SKM 2009, BHPBIO 2011). Macroalgae exhibit very high seasonal and interannual variation in biomass (Heyward *et al*. 2006) and distribution, abundance and biodiversity (Rio Tinto 2009, BHPBIO 2011). The distribution of hard substrates therefore indicates areas that may support macroalgal communities, although abundance and diversity may fluctuate annually.

Macroalgae are susceptible to disturbance from factors such as sedimentation, scouring and turbidity but the marked seasonality in biomass, abundance, diversity and distribution suggests macroalgae are likely to be resilient to acute, short-term disturbance acting at local scales. Macroalgae may be more susceptible to impacts acting over longer time scales (years) and at certain times of the year, where recruitment at a regional scale could be affected. Indirect impacts affecting the numbers, distribution and community structure of herbivorous fish can also be expected to have impacts (either positive or negative) on macroalgal habitats (Vergès *et al*. 2011).

Three bioregions (Northwest Province, Central Western Province and Central Western Transition) lie entirely in deep waters below the photic zone. Two bioregions (Southwest Transition and Southern Province) occur in colder waters. The EMBA overlaps the deeper waters of the Cocos (Keeling) Island Province, (not those close to shore) which are greater than 4000m deep and therefore macroalgae are not present.

Macroalgae are not present hence these bioregions are not discussed.

3.3.1 Southwest Shelf Province

Species diversity of macroalgae is very high. The south coast of the bioregion is characterised by a relatively higher diversity of temperate macro-algal species compared with the Southwest Shelf Transition. These colonise the exposed rocky shorelines and rocky reefs (DEWHA 2008a).

3.3.2 Southwest Shelf Transition

The Houtman Abrolhos have known species of benthic algae with macroalgae communities considered important in supporting a diversity of marine life.

More than 340 species of macroalgae (including 54 species of green algae, 71 species of brown algae, and 222 species of red algae) have been recorded from rock platforms around Rottnest Island (Amalfi 2006).

3.3.3 Great Australian Bight Shelf Transition

Seaweed diversity and endemism in temperate waters of Australia is among the highest in the world, perhaps due to the length of the southerly-facing rocky coastline and the long period of geological isolation. The number of species found in southern Australia is 50-80% greater than other temperate regions of the world. A small number of tropical species and isolated species from tropical genera also occur in the GAB.

Oceanic waters of South Australia support one of the world's most diverse seaweed assemblages, with >1200 species recorded. Many species of macroalgae found in South Australian waters extend into the cool temperate waters of Victoria and Tasmania and warmer waters of Western Australia. However, South Australia has the highest concentration of species. The waters of the GAB are clear and allow chlorophyllus plants to live at depths of up to 70 m.

Among the green algae (Chlorophyta), few microscopic forms have been studied; however, a few southern Australian species are recognised in the genera *Ulva* (2) and *Bryopsis* (6). Coenocytic green algae are well represented, including *Codium* (15 species) and *Caulerpa* (19 species). Brown algae (*Phaeophyta*) and red algae (*Rhodophyta*) are particularly diverse. Approximately 43% of the genera (658) and 20% of the species (~4000) of red algae that occur worldwide are found in southern Australia. Over 75% of red algae, 57% of brown algae, and 30% of green algae are endemic to southern Australia (Womersley 1990). Womersley (1984, 1987, 1994, 1996, 1998 and 2003) documents the macroalgae of southern Australia. (McLeay et al., 2003).

3.3.4 Central Western Shelf Province

Although seagrasses are the most visually dominant organisms found in Shark Bay (Walker *et al*. 1989) macroalgae are also a significant component within the system, with 161 taxa of benthic macroalgae reported from the location (Kendrick *et al*. 1990). The seagrass meadows host a large number of epiphytic algal species (Harlin *et al*. 1985, Kendrick *et al*. 1990), which numerically dominate the algal flora of the area. Eighty algal species were epiphytic on the seagrass *Amphibolis antarctica*, and of these, over half have been reported both as epiphytes and benthic algae. Benthic macroalgae can be found growing on occasional subtidal rock (limestone–sandstone) platforms and extensive sand flats that occur throughout Shark Bay, and as drift within seagrass meadows (Kendrick *et al*. 1990).

The benthic algae of Shark Bay are not predominantly temperate as is the case with the seagrasses (Walker *et al*. 1989) and seagrass epiphytes (Kendrick *et al*. 1990). The majority of taxa are either of tropical or cosmopolitan distribution. Their local distribution within Shark Bay is correlated with salinity, with benthic algal species richness lower in areas of high salinity (Kendrick *et al*. 1990).

Limestone platforms occur along the bioregion's coastline and high energy environments are likely to be dominated by large brown algae including *Ecklonia radiata* and *Sargassum* spp. with articulated coralline algae making up the understorey. More diverse algae assemblages may be observed in sheltered locations such as potholes and ledges (DoF 2007).

3.3.5 Central Western Shelf Transition

Macroalgal beds along the Ningaloo coastline are generally found on the shallow limestone lagoonal platforms and occupy about 2,200 ha of the Ningaloo Marine Park and Muiron Islands Marine Management Area (CALM & MPRA 2005a). Macroalgal communities within the area have been broadly described (Bancroft & Davidson 2000). The dominant genera are the brown algae *Sargassum*, *Padina*, *Dictyota* and *Hydroclathrus* spp. (McCook et al. 1995).

3.3.6 Northwest Transition

Although macroalgae is present at the Rowley Shoals, it is not recognised as a key habitat component in the Mermaid Reef Marine National Nature Reserve Plan of Management (EA 2000) or the Rowley Shoals Marine Park Management Plan (DEC & MPRA 2007b).

There is nothing to suggest that the algal flora of the Rowley Shoals is unique within the Indo-Pacific (Huisman *et al*. 2009). A study of macroalgae at 16 locations at Mermaid Reef recorded over 100 species (Huisman *et al*. 2009). The algal flora recorded at the Rowley Shoals represents a small portion of the highly diverse Indo-Pacific flora. The majority of species that were recorded at Mermaid Reef had been previously recorded from mainland north-western Australia or from Indonesia (Huisman *et al*. 2009).

3.3.7 Northwest Shelf Province

Macroalgae are diverse and widespread throughout the Northwest Shelf Province. They are restricted to depths where sufficient light penetrates to the substrate and therefore tend to be most common in shallow subtidal waters down to approximately 20 m depth.

In the nearshore regions of the Pilbara, macroalgae are often a dominant component of the mosaic of benthic organisms found on hard substrates in shallow water. In these shallow waters, regular disturbance to reef habitats from seasonal changes in sedimentation/ erosion patterns and the less frequent impacts of cyclones and storms through sedimentation and scouring may substantially alter the distribution and composition of the benthic communities associated with reefs, including macroalgal habitats (BHPBIO 2011).

Macroalgae dominate shallow (<10 m) submerged limestone reefs and also grow on stable rubble and boulder surfaces in the Dampier Archipelago (CALM & MPRA 2005). Huisman and Borowitzka (2003) reported approximately 200 species of macroalgae from the Dampier Archipelago. Low relief limestone reefs that are dominated by macroalgae, account for 17% (approximately 35,460 ha) of the marine habitats within the proposed Marine Management Area (CALM 2005a).

Epibenthic dredge surveys along the coastline north of Broome identified 43 species of algae from 22 families (Keesing *et al*. 2011). The lower species diversity collected by this study is attributed to the method of collection and limited depth range (11–23 m) (Keesing *et al*. 2011).

Macroalgae occur around the numerous small offshore islands within this bioregion (including Thevenard Island, Airlie Island and Serrurier Island) associated with limestone pavement and protected areas of soft sediments. Dominant species are consistent with those described for the Dampier Archipelago (Woodside 2011).

In the shallow offshore waters of the Pilbara region, macroalgae are the dominant benthic habitat on hard substrates in both the Montebello and Barrow Islands Marine Parks and are the main primary producers (DEC & MPRA 2007a, Chevron 2010). Shallow water habitats outside these marine parks are also likely to support substantial areas of macroalgal habitat wherever conditions are suitable.

Macroalgae occupy approximately 40% of the benthic habitat area in the Montebello/ Lowendal/ Barrow Island region (CALM 2005b). At least 132 macroalgal taxa occur around Barrow Island, with most thought to be widely distributed in the tropical Indo-Pacific region (Chevron 2005).

Macroalgae monitoring around the Lowendal and Montebello Islands since 1996 (The Ecology Lab 1997, IRCE 2002 2003 2004 2006 2007, URS 2009) has found macroalgal cover and biomass to be naturally spatially and temporally variable. *Sargassum* spp. represented 70% of the macroalgal assemblage in 2009, compared to 96% in 2002 (URS 2009). Sargassum spp. cover as a percentage of total macroalgae cover was significantly lower in 2009 than in previous years, primarily due to an increase in filamentous algae at a number of sites (URS 2009).

3.3.8 Northwest Shelf Transition

There is a lack of information regarding the marine benthic flora of north-west Western Australia and no comprehensive marine flora list exists for the region (Huisman 2004). However, about 70 algae species were collected during a survey of intertidal reefs on the central Kimberley coast in 1997 (Walker 1997).

Tropical macroalgae species are typically associated with areas of hard substrate and various types of macroalgae occur on rock platforms intermingled with coral and sponge. Abundance and biomass typically exhibit strong seasonal trends (Heyward *et al*. 2006).

The diversity and abundance of algae in the Kimberley is probably linked to the region’s extreme tidal exposure and highly turbid waters, reducing light penetration and resulting in deposition of fine sediments (Walker 1997). However, the role of algae appears crucial to the growth of reefs in the highly turbid waters of the Kimberley coast and islands (Brooke 1997). *Sargassum* spp. and coralline algae may be dominant (DPAW 2013).

It is also considered that in offshore parts of the Northwest Shelf Transition, there are high levels of primary production, including macroalgae. This is due to light penetration through relatively clear, shallow waters (DEWHA, 2008a). In particular, carbonate banks and reefs in the Northwest Shelf Transition are considered to support macroalgae, therefore macroalgae would be expected to be present within the Carbonate Bank and Terrace System of the Van Diemen Rise key ecological feature, located within the Northwest Shelf Transition.

3.3.9 Timor Province

Macroalgae at Ashmore Reef are estimated to cover over 2,000 ha, mostly on the reef slope and crest areas (Hale & Butcher 2013). The algal community is dominated by turf and coralline algae, with fleshy macroalgae comprising typically less than 10% of total algal cover (Skewes *et al*. 1999b).

Surveys at Scott and Seringapatam Reefs recorded over 100 species of marine algae (Huisman *et al*. 2009). The marine algal community was similar between reefs and also similar to the Rowley Shoals. Algae found at these offshore atolls forms a small subset of the Indo-Pacific algal flora, with virtually all of the species identified thus far having been previously collected from north-western Australia or from localities further north. Although further research is necessary, at present there is nothing to suggest that the macroalgae communities of these offshore atolls are unique within the Indo-Pacific (Huisman *et al*. 2009).

3.3.10 Timor Transition

There is a lack of published information regarding macroalage within the Timor Transition. However, the presence of the Shelf Break and Slope of the Arafura Shelf key ecological feature indicates that macroalgae may be present in association with this seabed feature. Upwelling associated with the topography of the shelf break lifts nutrient rich deep ocean water onto the edge of the shelf and into the euphotic zone, leading to enhanced biological productivity (DSEWPAC, 2012).

3.3.11 Northern Shelf Province

Macroalgae is sparse in the Northern Shelf Province (DEWHA, 2008c). However, around reef areas, there have been observations of phytoplankton blooms, thought to occur at localised micro-upwellings of nutrients potentially driven by wind and tidal eddies (DEWHA, 2008c).

3.3.12 Christmas Island Province

Coral reefs are 'turfed' with fine hair-like algae which are grazed by many animals. Some red algae form hard pink crusts which cement sand and dead coral together (DNP, 2012).

3.3.13 International Waters

No information on macroalgae in international waters has been identified other than for Timor-Leste waters.

See **Section 3.1.8** for a description of habitat typical of shoals and banks in the Timor Sea.

3.4 Non-Coral Benthic Invertebrates

The offshore marine environment from Busselton to the Northern Territory is overwhelmingly dominated by soft sediment seabeds; sandy and muddy substrates, occasionally interspersed with hard substrates covered with sand veneers, and rarely, exposed hard substrate. In shallow waters, non-coral benthic invertebrates may form part of the mosaic of benthic organisms found on hard substrates, alongside macrophytes and coral colonies. As light reduces with water depth, non-coral benthic invertebrates are the dominant community, albeit at low densities.

Non coral benthic invertebrates feed by filtering small particles from seawater, typically by passing the water over a specialised filtering structure. Examples of filter feeders are sponges, soft and whip corals and sea squirts.

3.4.1 Southwest Transition

There is little available information on benthic biological communities of this bioregion however deep sea crabs, such as the champagne crab and crystal crab are known to inhabit the seafloor of the slope (DEWHA 2008b).

3.4.2 Southwest Shelf Province

East of Albany, the dominant lobster species changes from the western rock lobster to the southern rock lobster. In this bioregion there is a notable increase in the ratio of benthic fish to crustaceans. Crustaceans appear to be less important in structuring shallow benthic communities here than in bioregions to the north and to the south-east of the Murray River mouth, around the Bonney Upwelling and Tasmania (DEWHA 2008b).

3.4.3 Southwest Shelf Transition

The inner shelf of the bioregion, extending between 0-50 m deep, includes distinct ridges of limestone reef with extensive beds of macro-algae (principally *Ecklonia* spp.). These inshore lagoons are inhabited by a diverse range of coralline algae, sponges, molluscs and crustaceans. On the outer shelf and shelf break filter feeding sponges and bryozoans dominate the hard bottom. The reefs around the Houtman Abrolhos islands support 492 known species of molluscs, 110 known species of sponges, 172 known species of echinoderms and 234 known species of benthic algae (DEWHA 2008b). Western rock lobster, the dominant large benthic invertebrate in this bioregion, is considered to be an important part of the food web of the inner shelf.

3.4.4 Southern Province

There is little information available on the benthic biological communities within the bioregion, however it is described as a unique region of deep-sea habitats that includes the Diamantina Fracture Zone Key Ecological Feature. The Diamantina Fracture Zone is described as structurally complex deep water environment of seamounts and numerous closely spaced troughs and ridges, which represents a unique region of deep-sea habitats including 26 endemic species of demersal fish (DSEWPaC) 2012b).

3.4.5 Great Australian Bight Shelf Transition

The invertebrate fauna of the GAB also displays a high degree of endemism (85-95%, Shepherd 1991). South Australia's benthic invertebrate assemblages also include tropical species. Fossils of benthic foraminiferans, nektonic nautiloids and planktonic protists suggest that tropical species have been transported into South Australia by the Leeuwin Current since the Eocene.

Early research in the GAB included an expedition on Australia's first fisheries research vessel, the Southern Endeavour that reported the presence of hydroids, molluscs and sponges. Many of South Australia's invertebrate species are included in the South Australian Handbook Series Marine Invertebrates of Southern Australia. Part I, includes the Porifera, Cnidaria, Platyhelminths, Annelida, Sipuncula, Echiura, Bryozoa and Echinodermata (Shepherd and Thomas 1982); Part II deals solely with the Mollusca (Shepherd and Thomas 1989); and Part III includes the Nemertea, Entoprocta, Phoronida, Brachiopoda, Hemichordata, Pycnogonids and Tunicates (Shepherd and Davies 1997). The most notable group not covered by these books is the Crustacea. Edgar (2000) describes 1200 species of invertebrates, fish, algae and sea grasses that occur in the intertidal zone to 30 m depth between Sydney and Perth (McLeay et al., 2003).

3.4.6 Central Western Province

The understanding of marine life in this bioregion is mostly confined to the demersal fish on the continental slope. The exception to this is the Perth Canyon which, although poorly understood, is known to have unique seafloor features with ecological properties of regional significance.

3.4.7 Central Western Shelf Province

The Central Western Shelf Province occurs on the continental shelf in water depths from 0 to 100 m. Biological communities of the shelf are likely to include a sparse invertebrate assemblage of sea cucumbers, urchins, crabs and polychaetes on sand substrates. Hard substrates are likely to contain sessile invertebrates such as sponges and gorgonians. The biological communities of this bioregion share many similarities with the adjoining temperate region (DEWHA 2008a).

Stromatolites occur in Shark Bay. Although they are a microbial colony (prokaryote), and not an invertebrate (eukaryote), they are described here as a unique benthic biological community. Stromatolites are rock-like structures built by cyanobacteria. Shark Bay's stromatolites are 2,000 to 3,000 years old and are similar to life forms found on Earth up to 3.5 billion years ago. Until about 500 million years ago, stromatolites were the only macroscopic evidence of life on the planet; hence they provide a unique insight into early life forms and evolution. The stromatolites are located in the hypersaline environment of Hamelin Pool and are one of the reasons for the area's World Heritage Listing (DPAW 2009).

3.4.8 Central Western Transition

The Central Western Transition extends from the shelf break to the continental slope with some parts of the bioregion occurring on the abyssal plain. Water depths range from 80 m to almost 6,000 m. Sediments are dominated by muds and sands that decrease in grain size with increasing depth. The present level of understanding of the marine environment in this bioregion is generally poor. The harder substrate of the slope in waters of 200–2,000 m deep is likely to support populations of epibenthic fauna including bryozoans and sponges. These support larger infauna and benthic animals such as crabs, cephalopods, echinoderms and other filter feeding epibenthic organisms. In the deeper waters of the abyss, the benthic communities are likely to be sparse (DEWHA 2008a).

3.4.9 Central Western Shelf Transition

The Central Western Shelf Transition is located entirely on the continental shelf and is comprised mainly of sandy sediments in depths between 0 and 80 m (DEWHA 2008a).

Some sponge species and filter-feeding communities found in deeper waters offshore from the Ningaloo Reef appear to be significantly different to those of the Dampier Archipelago and Abrolhos Islands, indicating that the Commonwealth waters have some areas of potentially high and unique sponge biodiversity (Rees *et al*. 2004).

3.4.10 Northwest Province

The Northwest Province is located entirely on the continental slope in water depths of predominantly between 1,000–3,000 m and is comprised of muddy sediments. Despite the present poor knowledge of the benthic communities on the Exmouth Plateau, information on sediments in the bioregion indicates that benthic communities are likely to include filter feeders and epifauna. Soft-bottom environments are likely to support patchy distributions of mobile epibenthos, such as sea cucumbers, ophiuroids, echinoderms, polychaetes and sea pens.

3.4.11 Northwest Transition

The Northwest Transition is located from the shelf break (200 m water depth) over the continental slope to depths of more than 1,000 m at the Argo Abyssal Plain. Benthic habitat mapping surveys and epibenthic sampling conducted by CSIRO at the continental slope (approximately 400 m water depth) showed that all survey sites predominantly comprised soft, muddy sediment, which was often riffled. Gravel, boulders and small outcrops were occasionally recorded. Epifaunal abundance was similar all sites, with epifauna limited to sparsely distributed isolated individuals. Epifauna included isolated scattered sessile crinoids, anemones, glass sponges and seapens. Occasional non-sessile fauna included urchins, prawns and other decapods, holothurians and sea stars. Modelling indicated a 1 km long beam trawl across the continental shelf (approximately 400 m water depth) would be expected to yield sparse (<20 individuals) and low diversity (<10 species) of epibenthic fauna (≥1 cm body size) (Williams *et al*. 2010). Deeper on the continental slope at approximately 700 m and approximately 1,000 m, habitats were similar to those observed at 400 m (Williams *et al*. 2010).

Although soft sediment habitat may appear monotonous and featureless, there is likely to be some marked differences in terms of ecological functioning and faunal composition between shelf and deep-sea areas, with the 200 m isobath widely believed to represent a key boundary (Wilson 2013, Brewer *et al*. 2007, Gage &

Tyler 1992). Beyond the 200 m isobath, deep-sea benthic communities rely exclusively on the settling of organic detritus from the overlying water column as a food source. The spatial and temporal distribution of benthic fauna depends on factors such as sediment characteristics, depth and season (Wilson 2013).

Due to contrasting depths, the Rowley Shoals supports a diverse marine invertebrate community including a number of endemic species. Invertebrate species (excluding corals) at the Rowley Shoals include sponges, cnidarians (jellyfish, anemones), worms, bryozoans (sea mosses), crustaceans (crabs, lobsters, etc.), molluscs (cuttlefish, baler shells, giant clams, etc.), echinoderms (starfish, sea urchins) and sea squirts (DEC & MPRA 2007b).

3.4.12 Northwest Shelf Province

This bioregion is located primarily on the continental shelf in water depths from 0 to 200 m (DEWHA 2008a). The sandy substrates on the shelf within this bioregion are thought to support low density benthic communities of bryozoans, molluscs and echinoids (DEWHA 2008a). Sponge communities are also sparsely distributed on the shelf, but are found only in areas of hard substrate. The region between Dampier and Port Hedland has been described as a hotspot for sponge biodiversity (Hooper & Ekins 2004).

Epibenthic dredge surveys in nearshore areas around Broome covered 1,350 m^2 of seabed in depths between 11 and 23 m. The survey recorded 357 taxa comprising 52 sponges, 30 ascidians, 10 hydroids, 52 cnidarians (not including scleractinian corals), 69 crustaceans, 73 molluscs and 71 echinoderms. The most important species on soft bottom habitats in terms of biomass was the heart urchin *(Breynia desorii)*, whilst sponges were the dominant fauna by biomass on hard bottom habitats. The biomass of other filter feeders, especially ascidians, soft corals, gorgonians was also high, indicating the importance of these groups in characterising hard bottom habitats.

In 2007, CSIRO conducted extensive benthic habitat mapping surveys and epibenthic fauna (living on the surface and ≥1 cm body size) sampling in deep waters (100–1,000 m) spanning thirteen sites between Barrow Island and Ashmore Reef running along the continental shelf and across the continental slope of the North West Shelf (Williams *et al*. 2010). At the continental shelf margin (approximately 100 m water depth) Williams *et al*. (2010) reported that similar benthic habitats occurred at each survey site across the breadth of the North West Shelf. Benthic habitats at this depth comprised a mix of riffled muddy sand (sometimes as a veneer over rocky subcrops) together with gravel to pebble-sized rubble, cobbles, boulders and some rock outcrops. Typical epifauna found at these depths included scattered isolated hydroids, sea fans and soft corals and often small sponges. Other fauna observed at some of the sites included scattered isolated sea whips, crinoids, sea pens, urchins and anemones. Epibenthic fauna along the continental shelf margin were quantified as sparse and low diversity (Williams *et al*. 2010). Modelling indicated that a trawl sample of 1 km length would generally be expected to yield approximately 80 individuals represented by 15 species (Williams *et al*. 2010) in 100 m depth waters.

At the shelf edge (approximately 200 m water depth), two sites were surveyed. Both sites were similar to the continental shelf margin, except the northern site mainly comprised coarse material. Epifauna observed at the northern site was similar at 200 m as at 100 m. At the southern site, epifauna included sparse and scattered individual soft corals, anemones, glass sponges and stalked crinoids (Williams *et al.* 2010). Modelling indicated epibenthic fauna were sparse and had low diversity, numbering approximately 20–40 individuals in a 1 km long trawl sample represented by approximately 5–10 species (Williams *et al*. 2010).

Baseline studies undertaken in nearshore areas of the Pilbara (SKM 2009, Rio Tinto 2009, BHPBIO 2011) and offshore areas around Barrow Island (Chevron 2010) have shown that filter feeder communities are a dominant component of benthic habitats in depths >10 m where reduced light appears to inhibit extensive development of hard corals and macroalgae. The pavement habitats between Barrow Island and the mainland are covered by a sediment veneer that appears to periodically move, exposing areas of pavement reef. Sessile benthic organisms that require hard substrates for attachment, such as gorgonians, are frequently seen emerging through a shallow veneer of sand. This type of substrate (sediment veneer) with sparse filter feeder communities is common throughout this area (SKM 2009, Rio Tinto 2009, BHPBIO 2011).

3.4.13 Northwest Shelf Transition

The Northwest Shelf Transition is located on the continental shelf with a small area extending onto the continental slope, with water depths ranging from 0–330 m. Nearshore areas may support significant filter feeding communities but these have not yet been described (Masini *et al*. 2009).

Pipeline route surveys north of the Kimberley in water depths from 10–250 m recorded a seabed largely devoid of hard substrate, with only sparse epibenthic fauna noted on the predominantly sandy substrate. Occasional epibenthic fauna (featherstars, gorgonians, bryozoans, sea urchins, hydroids and sponges) were recorded in areas where rocky substrate or outcrops were present (URS 2010a).

In contrast, benthic surveys at Echuca Shoals identified broad areas of hard substrate with substantial epibenthic fauna. The shallow shoal areas were dominated by a flat ‘reef’ platform with crinoids, sea whips, soft corals and low densities of hard corals. With increasing depth (25–80 m) soft corals and sponges became increasingly dominant. At greater depths (80–100 m) the density of epibenthic fauna decreased substantially with sea whips and sea fans became dominant (URS 2010a).

3.4.14 Timor Province

The Timor Province is located on the continental slope and abyssal plain and water depths range from 200 m to almost 6,000 m. Benthic studies in this bioregion are scarce, however data from the North West Slope Trawl Fishery suggests that muddy sediments in the Timor Province support significant populations of crustaceans (Brewer *et al*. 2007). Additionally, research into the demersal fish communities of the continental slope has identified the Timor Province as an important bioregion. This is due to the presence of a number of endemic fish species, and two distinct demersal community types associated with the upper slope (water depths of 225–500 m) and mid-slope (water depths of 750–1,000 m) (Last *et al*. 2005). The current understanding of the relationship between demersal fish communities and benthic environments on the continental slope is rudimentary (DEWHA 2008a).

Over 130 species of sponges have been recorded at the Ashmore Reef National Nature Reserve (Russell & Hanley 1993).

Studies of Seringapatam Reef have observed the dominant benthic habitats to include filter feeders, such as sponges, gorgonians, hydroids and seapens (Heyward et al. 2013 cited in ConocoPhillips 2018).

3.4.15 Timor Transition

Carbonate banks and reefs of the Timor Transition have been found to support non-coral communities and benthic invertebrate communities associated with hard substrates (DEWHA, 2008c). Of particular note is the Shelf Break and Slope of the Arafura Shelf key ecological feature which is located within the Timor Transition. This key ecological feature has been recognised for the invertebrates that is hosts, which are thought to be the basis for the offshore food webs in the area (DEWHA, 2008c). Furthermore, the Tributary Canyons of the Arafura Depression key ecological feature is also in the Timor Transition and surveys of this key ecological feature identified around 245 macroscopic species of invertebrates (Wilson, 2005).

3.4.16 Northern Shelf Province

Studies of taxa within the Northern Shelf Province found 684 taxa of infaunal benthic invertebrates in waters deeper than 20 m. However, the Gulf of Carpentaria Basin contains the most significant non-coral benthic habitats within the Northern Shelf Province, which is outside the boundary of the combined EMBA (DEWHA, 2008c).

3.4.17 Christmas Island Province

Three major molluscs grow on Christmas Island's reefs: bivalves, gastropods and cephalopods. Echinoderms include sea stars, brittle stars, feather stars, sea urchins and sea cucumbers (DNP, 2012). The deeper waters connecting Christmas Island to the Cocos (Keeling) Island Province are described below (**Section 3.4.18**).

3.4.18 Cocos (Keeling) Island Province

The hard substrates that occur on seamounts within the province are likely to provide surfaces and topographical structure for recruitment and growth of passive,sessile, epi-benthic suspension feeders (Genin et al., 1986) such as deep-sea corals, sponges,crinoids, ascidians and bryozoans. Most of the seamounts within the subregion are relatively deep (>2000 m) and the deeper seamounts (>3000 m) are a unique feature of this subregion. Little is known about the communities that live on the tops and slopes of these seamounts. However, it seems likely that their unique position in the water column, and geographically, will support unique benthic and demersal communities (Brewer *et al*., 2009).

3.4.19 International Waters

No information on non-coral benthic invertebrates in international waters has been identified other than for Timor-Leste waters.

See **Section 3.1.8** for a description of habitat typical of shoals and banks in the Timor Sea.

3.5 Plankton

Plankton abundance and distribution is patchy, dynamic and strongly linked to localised and seasonal productivity (Evans *et al.* 2016). Fluctuations in abundance and distribution occur both vertically and horizontally in response to tidal cycles, seasonal variation (light, water temperature and chemistry, currents and nutrients) and cyclonic events. As a key indicator for ecosystem health and change, Plankton distribution and abundance has been measured for over a century in Australia (Richardson *et al.* 2015). The compilation of this data has been made publicly available through the Australian Ocean Data Network (Australian Ocean Data Network 2017) and has been used in the Australia State of the Environment 2016 report (Jackson *et al.* 2017) to nationally assess marine ecosystem health. According to their findings, warming ocean temperatures has extended the distribution of tropical phytoplankton species (which have a lower productivity), further south resulting in a decline in primary productivity in oceanic waters north of 35°C, especially the North West Shelf (Evans *et al.* 2016). Trends of primary productivity across Australia are however variable with the South West of Australia experiencing an increase in productivity and northern Australia experiencing no change between 2002-2016 (Evans *et al.* 2016).

Within the combined EMBA, peak primary productivity varies on a local and regional scale. For example, peak phytoplankton biomass in waters surrounding Broome has been observed in May with a high variability recorded in August, whereas recorded phytoplankton biomass in waters surrounding Geographe Bay has been found to peak during winter and is localised close to the coast (Bloundeau-Patissier *et al.* 2011). In general, these peaks are linked to mass coral spawning events, peaks in zooplankton and fish larvae abundance and periodic upwelling. Regional upwelling is most common close to the coast and where surface waters diverge. Despite the suppression of major upwelling along the WA coast by the Leeuwin Current, known key upwelling regions include the Ningaloo region (Hanson & McKinnon 2009) and Cape Mentelle (Pattiaratchi 2007). It is also expected that a high abundance of plankton will occur within areas of localised upwelling in the combined EMBA where the seabed disrupts the current flow.

In waters surrounding Indonesia, seasonal peaks in phytoplankton biomass is linked to monsoon related changes in wind. When the winds reverse direction (offshore vs. onshore), nutrient concentrations decrease/increase because of the suppression/enhancement of upwelling (National Aeronautics and Space Administration (NASA) 2017). Annual variability of phytoplankton productivity in waters surrounding Indonesia is heavily influenced by the El Niño-Southern Oscillation climate pattern (NASA 2017). For example, phytoplankton productivity around Indonesia increases during El Niño events.

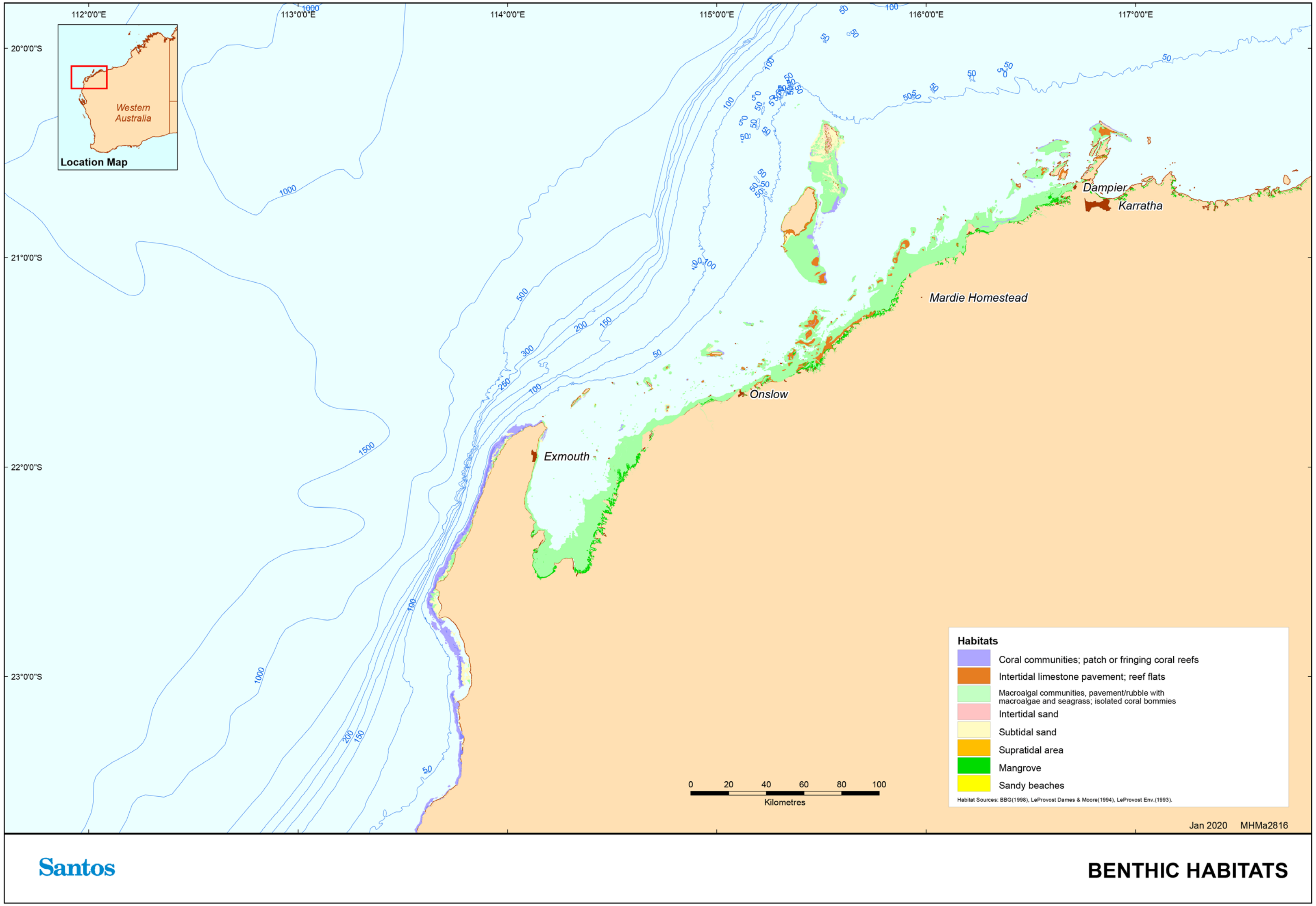


Figure 3-1: Benthic habitats from Coral Bay to Dampier

4. Shoreline Habitats

Shoreline habitats are defined as those habitats that are adjacent to the water along the mainland and of islands that occur above the LAT and most often in the intertidal zone.

The following section broadly categorises shoreline habitats as the following biological communities; mangroves, intertidal mud/sand banks, beaches, and rocky shores. These communities are discussed in **Sections 4.1- 4.5**, in terms of the 18 IMCRA v. 4.0 bioregions where relevant and where information is available.

Figure 3-1 broadly illustrate these habitats within the Northwest Shelf Province and Central Western Shelf Transition. Noting that shoreline habitats of the Cocos (Keeling) Islands are not described as the combined EMBA is restricted to the outermost deep waters of the bioregion.

4.1 Mangroves

Mangroves commonly occur in sheltered coastal areas in tropical and sub-tropical latitudes (Kathiresan and Bingham 2001). Up to eight species of mangroves are found further north in the Central Western Shelf Transition region, but at most locations the dominant mangrove (in terms of area of intertidal zone occupied) is *Avicennia marina*, with the stilt rooted mangrove *Rhizophora stylosa* often occurring as thin zones of dense thickets within the broad zone of *A. marina*. Mangroves are found wherever suitable conditions are present including wave dominated settings of deltas, beach/dune coasts, limestone barrier islands and ria/archipelago shores (Semeniuk 1993). Mangrove plants have evolved to adapt to fluctuating salinity, tidal inundation and fine, anaerobic, hydrogen sulfide rich sediment (Duke *et al.* 1998).

Mangroves are important primary producers and have a number of ecological and economic values. For example, they play a key role in reducing coastal erosion by stabilising sediment with their complex root systems (Kathiresan and Bingham 2001). They are also recognised for their capacity to help protect coastal areas from the damaging effects of erosion during storms and storm surge. Mangroves are also important in the filtration of run-off from the land which helps maintain water clarity for coral reefs which are often found offshore in tropical locations (National Oceanic and Atmospheric Administration (NOAA) 2010). The intricate matrix of fine roots within the soil also binds sediments together.

Mangroves play an important role in connecting the terrestrial and marine environments (Alongi 2009). Numerous studies (e.g. Nagelkerken *et al.* 2000, Alongi 2002, Alongi 2009, Kathiresan and Bingham 2001) have shown mangroves to be highly productive and an important breeding and nursery areas for juvenile fish and crustaceans, including commercially important species (Kenyon *et al*. 2004). They also provide habitat for many juvenile reef fish species.

Mangroves also play an important ecosystem role in nutrient cycling and carbon fixing (NOAA 2010). The trees absorb carbon dioxide from the atmosphere and the organic matter such as fallen leaves forms nutrient rich sediments creating a peat layer that stores organic carbon (Alongi 2009, Ayukai 1998).

The muddy sediments that occur in mangrove forests are home to a variety of epibenthic, infaunal and meiofaunal invertebrates (Kathiresan and Bingham 2001). Crustaceans known to inhabit the mud in mangrove systems include fiddler crabs, mud crabs, shrimps and barnacles. Within the water channels of the estuary, various finfish are found from the smaller fish such as gobies and mudskippers (which are restricted to life in the mangroves) through to larger fish such as barramundi (*Lates calcarifer*) and the mangrove jack (*Lutjanus argentimaculatus).* Mangroves and their associated invertebrate-rich mudflats are also an important habitat for migratory shorebirds from the northern hemisphere, as well as some avifauna that are restricted to mangroves as their sole habitat (Garnet and Crowley 2000).

The two key State regulatory documents relevant to the protection and management of mangroves in WA are:

- EPA (2001) Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline. Guidance Statement No. 1; and
- EPA (2016) Technical Guidance – Protection of Benthic Communities and Habitats.

4.1.1 Great Australian Bight Shelf Transition

Mangrove forests occur at sheltered sites on the South Australian coast and cover an area of approximately 230 km^2. Mangroves are poorly represented in the Great Australian Bight as they show preference for low energy, muddy shorelines, particularly in the tropics. Of the 69 species in the world only one occurs in the eastern part of the GAB, the grey mangrove, Av*icennia marina*. It forms coastal woodlands up to 5 m tall with the most significant stands in the GAB occurring near Ceduna in the east (McLeay, 2003).

4.1.2 Central Western Shelf Province

Shark Bay (in the Central Western Shelf Province) supports the southern-most area of substantial mangrove habitat in Western Australia (Rule *et al*. 2012). The mangroves of Shark Bay comprise only one species, the white mangrove *Avicennia marina*, and these trees occur around the coastline in widely dispersed and often isolated stands of varying size.

4.1.3 Central Western Shelf Transition

The regional mangroves from Exmouth to Broome (within the Central Western Shelf Transition and southern part of the Northwest Shelf Province) represent Australia's only 'tropical-arid' mangroves. The most significant stand of mangroves in the Central Western Shelf Transition is Mangrove Bay on the western side of the Cape Range Peninsula in the Ningaloo Marine Park. This small area of mangrove (37 ha) represents the largest area of mangrove habitat within the Ningaloo Marine Park and is considered extremely important from a biodiversity conservation perspective (CALM 2005).

4.1.4 Northwest Shelf Province

In the Pilbara region, the coast is a complex of deltas, limestone barrier islands and lagoons, with a variable suite of substrates. As a result, mangroves in this region form relatively diverse fringing stands, albeit often stunted in stature but at times quite extensive in area. The mangroves along the Pilbara coastline are the largest single unit of relatively undisturbed tropical arid zone habitats in the world. The area has nine mangrove taxa and a total of 632 km^2 mangroves (MangroveWatch 2014). As with most arid zone mangroves, Pilbara mangroves are characterised by open woodlands and shrublands that are of relatively lower productivity than the mangrove communities of the wet tropics because of the extreme water and salinity stresses that affect the intertidal zone in the Pilbara (EPA 2001). Significant stands of mangroves in the Pilbara include:

- Exmouth Gulf: mangrove assemblages within the Bay of Rest on the western shore of the Gulf and the extensive mangrove system on the eastern shore of the Gulf that extends as a series of tidal flats and creek channels from Giralia Bay to Yanrey Flats (Astron 2014). These areas of mangrove are also designated as 'regionally significant' by the EPA (2001). The importance of these mangroves to the Exmouth Prawn Fishery is discussed in Kangas et al. (2006);

- Mainland coast and nearshore islands: mangrove assemblages at Ashburton River Delta, Coolgra Point, Robe River Delta, Yardie Landing, Yammadery Island and the Mangrove Islands are all designated as ‘regionally significant’ by the WA EPA (2001) and the EPA will give these mangrove formations the highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function; and
- Montebello, Barrow and Lowendal Islands: mangrove assemblages all lay within designated reserves. The mangrove communities of the Montebello Islands are considered globally unique as they occur in lagoons of offshore islands (DEC 2007). Mangrove stands identified on Varanus Island occur on the west coast in discrete patches within the tidal and supratidal zones, at South Mangrove Beach and a small embayment (Astron 2016). Mangrove stands on Varanus Island have been identified as healthy, with similar stands also identified as present on Bridled Island to the north of Varanus Island (Astron 2016).

The mangroves of the Kimberley are particularly diverse and relatively untouched. They occupy a variety of coastal settings including rocky shores, beaches and tidal flats (Cresswell and Semeniuk 2011). They belong to the Indo-Malaysian group of Old World Mangroves centred in the Indian-Pacific area (Cresswell and Semeniuk 2011). Of the eighteen species of mangrove plants known to Australia all are represented in the Kimberley including *Avicennia marina, Aegialitis annulata, Aegiceras corniculatum, Rhizophora stylosa, Ceriops tagal, Osbornia octodonta, Bruguiera exaristata, Camptostemon schultzii, Excoecaria agallocha, Sonneratia alba,* and *Xylocarpus australasicus* (Pendretti and Paling, 2001; Waples, 2007). Of these, ten occur only in the Kimberley (Waples 2007). *Rhizophora stylosa* and *Avicennia marina* are the most common mangrove species along the WA Coast.

Mangroves line much of the coastal area within the western Kimberley (and within the proposed Horizontal Falls Marine Park area). They are known to line the shore in the upper reaches of Talbot Bay and to fringe many of the islands of the Buccaneer Archipelago. There are large stands in the southern section of Dugong Bay. Kingfisher Islands has been noted to exhibit extensive mangroves where 10 species of mangrove have been recorded (Wilson 2013). Mangroves line the shores of the southern coast of Collier Bay and large tracts are found in Walcott Inlet and Secure Bay (Duke *et al.* 2010). The mangroves on the eastern side of the inlet extend about 30 km inland (Gueho 2007, Pendretti and Paling 2001, Zell 2007). Further along the coast mangroves have been identified lining much of the shores of Doubtful Bay. Mangroves are also known to line the shores of the Sale River and have been identified in George Water. For detailed maps of mangrove distribution refer to Pedretti and Paling (2001).

4.1.5 Northwest Shelf Transition

Mangroves are also a prominent feature of the North Kimberley. Fringing mangroves have developed around the edge of Prince Frederick Harbour and to the east of Cape Voltaire extending along the shores of Walmesly Bay and Port Warrender (Zell 2007). This region is humid and *Xylocarpus granatum* is localised here (Cresswell and Semeniuk 2011). The rocky coastline between Cape Pond and Cape Voltaire does not lend itself to mangrove development; instead coastal woodland grows on the shores above high water mark. Mangroves are interspersed with rocky outcrops and beaches around much of the Admiralty Gulf, Vansittart Bay and Napier Broome Bay (with extensive stands around the Drysdale estuary). Cape Londonderry marks the westerly limit of *Scyphiphora hydrophylacea* (Duke *et al.* 2010).

Between Cape Londonderry and Cape Dussejour mangrove communities are sparse, and limited to a few small stands in the bays as this part of the coastline is dominated by high relief rocky shores which are exposed to the prevailing easterly winds (Wilson 1994). Extensive mangroves do however line the shores of the islands and rivers in the Cambridge Gulf, where 12 mangrove species have been recorded (Wilson 2013).

The mangroves of the Ord River are notable in terms of their structural complexity and diversity. Fourteen species of mangrove have been recorded in the boundaries (Pedretti and Paling 2001). The mangroves of the Cambridge Gulf are important for saltwater crocodiles and mangrove bird communities. A unique type of flycatcher which is an intermediate between *Microcea flavigater* and *Microeca tormenti* has been identified in the mangroves of the Cambridge Gulf (Johnstone 1984). Additionally, the area is important for maintaining stocks of the commercially exploited species of the Red-Legged Banana Prawns (*Penaeus indicus)* (Kenyon *et al.* 2004).

Further north, mangroves also occur at the Tiwi Islands. Mangrove communities in the Tiwi Islands are predominantly within tidal creeks and are not expected along the shoreline. The Northern Territory mainland coastline, however, has a number of estuaries and rivers that drain into the surrounding hinterland during the wet season, this includes Darwin Harbour that contains approximately 260 km^2 of mangroves (INPEX, 2010).

4.1.6 Timor Province

Details on habitats in the Timor Province is provided in **Section 12.3.12**.

4.1.7 Northern Shelf Province

Coastlines within the Northern Shelf Province are described as being dominated by mangroves, which provide significant habitat for commercial and non-commercial fish species. In particular, banana prawns tend to favour mangrove areas with the highest catch of banana prawns being recorded in areas with the highest concentration of mangroves (DEWHA, 2008).

4.1.8 Christmas Island Province

There are no coastal mangroves, but a stand of normally estuarine *Bruguiera gymnorhiza* and *B. sexangula* occurs at Hosnie's Spring (registered as a Ramsar Wetlands site of international importance) about 50 metres above sea level. Two other mangrove species occur on the east coast. *Heritiera littoralis* occurs on the inland terrace above Greta Beach (outside the park) and further south towards Dolly Beach, as well as a discrete stand on the terrace above Dean's Point. *Cynometra ramiflora* occurs in two small stands south of Ross Hill (DNP, 2012).

4.1.9 International Waters

Subawa's south coast in Indonesia is thought to contain the most significant stand of mangroves in the Lesser Sunda Ecoregion (DeVantier 2008). Other significant stands have been mapped at the following locations (DeVantier 2008):

+ North-west and south east Bali;
+ North coast of Nusa Lembongan;
+ North-east and east Sumba;
+ South-west, north-west, north and east Flores and Maumere;
+ Komodo Island, and nearby islands; and
+ South west, south, central and north Timor-Leste.

Several Indonesian National Parks, including Laut Sawu Marine National Park, Karimunjawa National Park, Kepulauan Seribu National Park, Teluk Cenderawasih National Park, Kapulauan Wakatobi National Park, Meru Betiri National Park, Togian Islands National Park, Bali Barat National Park, Savu Sea National Marine

Conservation Area and the World Heritage sites of Komodo National Park, Siberut and Ujung Kulon contain mangrove forest (refer to **Section 9.8**).

4.2 Intertidal Mud/Sand Flats

Intertidal mudflats form when fine sediment carried by rivers and the ocean is deposited in a low energy environment. Tidal mudflats are highly productive components of shelf ecosystems responsible for recycling organic matter and nutrients through microbial activity. This microbial activity helps stabilise organic fluxes by reducing seasonal variation in primary productivity which ensures a more constant food supply (Robertson 1988). Intertidal sand and mudflats support a wide range of benthic infauna and epifauna which graze on microscopic algae and microbenthos, such as bivalves, molluscs, polycheate worms and crustaceans (Zell 2007).

The high abundance of invertebrates found in intertidal sand and mudflats provides an important food source for finfish and shellfish which swim over the area at high tide. Mudflats have also been shown to be significant nursery areas for flatfish. During low tide, these intertidal areas are also important foraging areas for indigenous and migratory shorebirds. Mudflats also play a vital role in protecting shorelines from erosion (Wade and Hickey 2008).

4.2.1 Central Western Shelf Province

Shark Bay in the Central Western Shelf Province has a protected intertidal ecological community 'Subtropical and Temperate Coastal Saltmarsh', as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is the northerly limit for this community and there is a transition zone for many saltmarsh species (CALM 1996). The EPBC 'Listed Advice' (DSEWPaC 2013a) reports that sediments associated with these communities generally consist of poorly-sorted anoxic sandy silts and clays, and may have salinity levels that are much higher than seawater due to evaporation. The drainage characteristics of coastal soils, along with tidal patterns and elevation, can strongly influence the distribution of flora and fauna within the Coastal Saltmarsh ecological community (DSEWPaC 2013a).

4.2.2 Northwest Shelf Province

Within Northwest Shelf Province both Roebuck Bay and Eighty Mile beach are areas with significant intertidal mudflats that are used by birds in spring and summer including species listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) or EPBC Act, or listed on the IUCN Red List of Threatened Species (IUCN 2019). Intertidal mudflats are also an important feature of the Kimberley coast forming in many bays and inlets of the region (Waples 2007). The sediments that dominate these flats are generally of terrigenous origin (Wilson 2013).

The mudflats of the Kimberley coast have been shown to be important for migratory birds of the East Asian-Australasian Flyway, which is estimated to support more than five million migratory shorebirds (Barter 2002, Bennelongia Pty Ltd 2010, Wade and Hickey 2008). The migratory birds visit the mudflats of the Kimberley coast to feed on benthic organisms prior to embarking on a 10,000–15,000 km migration to their breeding grounds in the Artic (Wade and Hickey 2008).

4.2.3 Northwest Shelf Transition

Extensive mud flats are located in Collier Bay, where the highest tidal range in Australia is found. (Wilson 2013, Zell 2007). A study by (Duke *et al*. 2010, Masini *et al*. 2009) also identified fringing mudflats around Walcott Inlet, and Doubtful Bay. The tidal mudflats of Walcott Inlet are up to 5 km wide and support a rich intertidal invertebrate community (Gibson and Wellbelove 2010). These invertebrate communities in turn also support large numbers of waterbirds (Wilson 1994).

Extensive intertidal mudflats occur in Prince Frederick Harbour and are generally backed by mangroves. The mudskipper is known to feed on these mudflats at low tide. Intertidal flats are also a feature of the estuary of the Mitchell River. The mudflats of Port Warrender are known to support 20 shorebird species and tern species and it is likely the other mudflats in the region also support high numbers of birds. The ecological significance of the wetlands of the Mitchell River has been recognised in *A Directory of Important Wetlands in Australia*. Mud and sand flats are also known to surround much of Deep Bay and Napier Broome Bay.

Intertidal sand and mudflats are a common feature of the East Kimberley. Large sand bars are present on the river mouths of the King George River, Berkeley River and Lyne River and intertidal mudflats are extensive along the edges of the Cambridge Gulf. The estuary is wide and very shallow in some sections, and the silt and clay is continually picked up and redeposited by strong tidal currents (Robson *et al.* 2008). The tidal flats of the Ord River in the Cambridge Gulf have been listed as a wetland of international importance for the conservation of waterbirds under the Ramsar convention. The area supports a variety of fauna including shorebirds and mudskippers. Tidal mudflats are also extensive along the coast between the Cambridge Gulf and the WA-NT Border.

Further north, the Tiwi islands have also been identified as containing tidal flats, whilst the extent of these are not well documented they are thought to be closely related to the mangrove habitats at the Tiwi Islands (ConocoPhillips, 2020).

4.2.4 Timor Province

Details on habitats in the Timor Province is provided in **Section 12.3.12**.

4.2.5 Northern Shelf Province

The subtidal and intertidal communities in Darwin Harbour and around the NT coastline, within the Northern Shelf Province are characterised as including a variety of shoreline habitats, including intertidal mud flats (URS 2010). The Tiwi Islands are also partially located within the Northern Shelf Province and are identified as supporting a number of shoreline habitats including sand and mud flats.

4.2.6 International Waters

Although no specific areas of intertidal mud or sand flats have been identified for international waters, the southern coasts of the islands that make up the Lesser Sunda Ecoregion of Indonesia and Timor-Leste do contain numerous estuarine habitats. These estuaries are likely to contain intertidal and tidal sand and mud flats that support a range of benthic invertebrate species that in turn attract other species such as birds and fish. Such estuaries in the Lesser Sunda Ecoregion are typically mangrove lined. Within the Lesser Sunda Ecoregion, the following areas are recognised as containing estuarine habitat (Wilson et al. 2011):

+ Lombok;
+ Sumba;
+ Central south and central north coasts of Sumbawa;
+ North-east coast of Flores; and
+ South-west coast of Timor-Leste.

The Irebere Estuary, located on the south-eastern coast, Tilomar located on the southern coast and Nino Konis Santana located on the eastern coast of Timor-Leste has been recognised as an Important Bird Area (Birdlife International 2018).

Several National Parks in the Ecoregion also contain estuarine habitats (likely to include intertidal sand and mud flats), including Karimunjawa National Park (refer to **Section 9.8**).

4.3 Intertidal Platforms

Intertidal platforms are areas of hard bedrock and/or limestone with or without a sediment veneer of varying thickness. These platforms can vary from low to high relief and provide a habitat for a diverse range of intertidal organisms (Morton and Britton in Jones 2004, SKM 2009, 2011, Hanley and Morrison 2012) and some species of shore birds (Garnet and Crowley 2000). They are common within each of the coastal bioregions within the combined EMBA.

4.3.1 Southwest Shelf Province and Southwest Shelf Transition

Intertidal platforms within the Northwest and Southwest bioregions support a mosaic of fauna and flora that typically exhibits strong variability in percent cover, community composition, abundance and diversity both between and within reefs at varying spatial and temporal scales (SKM 2009, 2011). Reef platforms typically exhibit zonation of fauna and flora from upper to lower levels on the intertidal zone, with increasing diversity, abundance and biomass lower in the intertidal (Morton and Britton in Jones 2004, SKM 2009, 2010, 2011, Hanley and Morrison 2012).

On the south coast of the Southwest Shelf Province, the coastal geomorphology changes from the predominant limestone reefs to eroded Precambrian rocks. Intertidal platforms are also common along the Southwest Shelf Transition. Shark Bay in the Central Western Shelf Province has a high diversity of intertidal marine habitats as a result of the diversity of benthic substrate, salinity and the broad geographical features which influence depth, water movement and turbidity (CALM 1996, DSEWPaC 2013b). This includes extensive, limestone platforms (as well as sand flats, mud flats, salt marsh and mangroves and beaches (CALM 1996).

4.3.2 Great Australian Bight Transition

The coastline is subject to moderate to high wave energy and high swells (2-4 m). This region features limestone cliffs interspersed by rocky headlands, narrow intertidal rock platforms, reefs and beaches backed by dune barriers.

The Eyre Region is subject to moderate to high wave energy and features a rocky coast with numerous headlands, sheltered bays, cliffs, shore platforms, beaches backed by dune barriers, offshore islands, seamounts and lagoon deposits in sheltered areas (McLeay, 2003).

4.3.3 Central Western Shelf Province and Transition

Limestone pavements extend out from the beach into subtidal zones, e.g. along the Ningaloo Coast and North West Cape; and higher relief platforms (>0.5 m off high water mark) are also present at a number of headlands along the North West Cape.

4.3.4 Northwest Shelf Province and Northwest Shelf Transition

Large tidal regimes are likely to be the defining environmental factor influencing the distribution of intertidal flora and fauna in the Northwest Shelf Province and Northwest Shelf Transition. The intertidal area of the Kimberley has an extreme tidal range (hypertidal) which creates unique environmental conditions and habitats not seen else anywhere else in the world. As a remote area many of the habitats are untouched and they are recognised as having significant conservation value (DPaW 2013). DPaW (2013) reports that as a result of the monsoonal influxes of freshwater and land-derived nutrients distinctive tropical marine ecosystems have occurred.

4.3.5 Christmas Island Province

Rocky shore platforms occur at many locations around the island, more extensively on the western coastline between North West Point and Egeria Point. There are also tidal rock pools which are maintained by wave splash and tidal surge (DNP, 2012).

4.3.6 International Waters

While no significant areas of intertidal platforms have been identified in international waters, the high energy southern coastlines of the islands of the Lesser Sunda Ecoregion of Indonesia (and also including Timor-Leste) are likely to have areas of exposed pavements consisting of limestone and remnant lava flows (Wilson *et al*. 2011).

4.4 Sandy Beaches

Sandy beaches are those areas within the intertidal zone where unconsolidated sediment has been deposited (and eroded) by wave and tidal action. Sandy beaches can vary from low to high energy zones; the energy experienced influences the beach profile due to varying rates of erosion and accretion. Sandy beaches are found across the combined EMBA and vary in length, width and gradient. They are interspersed among areas of hard substrate (e.g. sandstone) that form intertidal platforms and rocky outcrops. There is a wide range of variation in sediment type, composition, and grain size along the combined EMBA.

Sandy beaches provide habitat to a variety of burrowing invertebrates and subsequently provide foraging grounds for shorebirds (Garnet and Crowley 2000). The number of species and densities of benthic macroinvertebrates that occur in the sand are typically inversely correlated with sediment grain-size and exposure to wave action, and positively correlated with sedimentary organic content and the amount of detached and attached macrophytes (Wildsmith *et al.* 2005). However, the distributions of these faunas among habitats will also reflect differences in the suite of environmental variables that characterize those habitats (Wildsmith *et al.* 2005).

Sandy habitats are important for both resident and migratory seabirds and shorebirds (refer **Section 8**). While sand flats and beaches generally support fewer species and numbers of birds than mudflats of similar size; some species such as the beach thick knee (*Esacus giganteus*) a crab eater, are commonly associated with sandy beaches (Garnet and Crowley 2000). Sandy beaches can also provide an important habitat for turtle nesting and breeding (see marine turtles **Section 6.1**).

4.4.1 Southwest Shelf Province

The hooded plover (*Thinornis rubricollis*) is a shorebird found on several beaches within the South West capes. Hooded plovers live on sandy surf beaches and prefer beaches backed by dunes rather than cliffs (DEC 2013). In addition to this, beaches in the South West province provide a variety of socio-economic values including tourism, commercial and recreational fishing, and support other recreational activities.

4.4.2 Southwest Shelf Transition

Sandy beaches throughout the Abrolhos host breeding populations of the Australian sea lion. The Abrolhos represent the northernmost breeding population of Australian sea lions. The current population at the Abrolhos is estimated to be approximately 90 individuals (DoF 2012).

In addition to this, beaches in the South West province provide a variety of socio-economic values including tourism, commercial and recreational fishing, and support of other recreational activities.

4.4.3 Central Western Shelf Province

Sandy beaches are found along the coastline at Shark bay within the marine park which is further described in **Section 12.3.2**.

4.4.4 Northwest Shelf Province

Eighty Mile Beach Marine Park is one of the Australia's largest uninterrupted sandy beaches (stretching 220 km) and is an important feeding grounds for small wading birds that migrate to the area each summer, travelling from countries thousands of kilometres away (DEC 2012a). It is also a listed Ramsar wetland (see **Section 9** on Protected Areas).

4.4.5 Northwest Shelf Transition

Sand habitat within the Camden Marine Park is mainly associated with shorelines and inlets on both mainland and island shores. Some beach deposits on islands in the Kimberley are composed of skeletal carbonate sand, while they may also consist of sediments from inland areas carried to the sea by rivers and gullies (DPaW 2013). The sediment coarseness of the sand may vary, and may also be littered with dead shell, rock and/or coral material. Sea cucumbers that ingest sand and filter out microscopic food are often common in this habitat DPaW 2013).

Significant sandy beaches occur on the Tiwi Islands, specifically the west coast of Bathurst Island and the north coast of Melville Island. These beaches are important areas for marine turtles with nesting dominated by flatback and olive ridley turtles (peak nesting in March to May) (Chatto and Baker, 2008).

Generally, in this region, sand habitat is adjacent to either dense mangrove stands or rocky cliffs (DPaW 2013). Beaches can be highly influenced by tide and weather conditions. Those that overlie rock are likely to shift and be ephemeral in nature.

4.4.6 Timor Province

Details on habitats in the Timor Province is provided in **Section 12.3.12**.

4.4.7 Christmas Island Province

These are formed of sand and of coral and shell rubble, often with limestone outcrops. Dolly and West White Beaches are the two largest beaches in the island, while Dolly and Greta Beaches hold sufficient sand to provide habitat for hermit and ghost crabs and to enable green turtles to dig nests (DNP, 2012).

4.4.8 International Waters

The southern coastlines of the islands of the Lesser Sunda Ecoregion of Indonesia and Timor-Leste are known to contain sandy beaches consisting of soft black sand, formed by volcanic activity. Within this region, a number of National Parks are considered important sites for turtle nesting beaches, including the Meru Betiri National Park (refer to **Section 9.8**).

The World Heritage site of Ujung Kulon is also a known site of sandy beaches, as well as the marine national parks of Kepulauan Seribu and Taka Bonerate which are also known as important turtle nesting sites (See **Section 9.8**).

4.5 Rocky Shorelines

Rocky shorelines are found across the combined EMBA and are often indicative of high energy areas (wave action) where sand deposition is limited or restricted (perhaps seasonally or during a cyclone). They are formed from limestone pavement extending out from the beach into subtidal zones, for example along the

Ningaloo Coast and North West Cape; higher relief platforms (>0.5 m off high water mark) are also present at a number of headlands along the North West Cape. This habitat is also widespread heading south towards Perth.

Rocky shores can include pebble/ cobble, boulders, and rocky limestone cliffs (often at the landward edge of reef platforms). Rocky outcrops typically consist of hard bedrock, but some of the coastline has characteristic limestone karsted cliffs with an undercut notch. Rocky shorelines can vary from habitats where there is bedrock protruding from soft sediments to cliff like structures that form headlands. Rocky shorelines are an important foraging area for seabirds and habitat for invertebrates found in the intertidal splash zone (Morton and Britton cited in Jones 2004). For example, oyster catchers and ruddy turnstones feed along beaches and rocky shorelines (see seabirds in **Section 8.2.2**).

4.5.1 International Waters

The Lesser Sunda Ecoregion contains numerous rocky shores, particularly on the exposed southern coastlines of the islands that make up the ecoregion. Areas of rocky shores include the following (DeVantier 2008):

+ The Bukit Peninsula and Nusa Penida areas of Bali;
+ South Lombok;
+ South-east Sumbawa;
+ Nusa Tengara;
+ Sumba; and
+ Timor-Leste, including Roti Island, Fatu and Atapupu.

The World Heritage site of Ujung Kulon is also known for its coastline of rocky outcrops, among other ecosystems (see **Section 9.8**).

4.6 International Shorelines

The EMBA extends to the Indonesian, West-Timor and Timor-Leste coastline. The coastlines of these countries support a range of habitats and communities, including sand and gravel beaches, rocky shores and cliffs, intertidal mudflats, mangroves, seagrass and coral reefs (Tomascik et al. 1997; Asian Development Bank 2014). The coastal waters provide habitat for a number of protected species, including humphead wrasses, marine turtles, giant clams, some mollusc species, crustaceans, cetaceans (dolphins and whales) and dugongs, and commercially important species of fish, shrimps, and shellfish (Asian Development Bank, 2014). Nearshore waters also support significant capture fisheries (commercial and subsistence) that contribute to the nation’s economy and employment (Asian Development Bank 2014).

5. Fish and Sharks

Fish distributions in the combined EMBA are discussed with respect to the IMCRA Provincial Bioregions which were defined using CSIRO's 1996 regionalisation of demersal fish on the continental shelf to the shelf break, and their 2005 regionalisation of demersal fish on the continental slope to approximately 1,200 m depth (DEH 2006). The EPBC species listed as threatened and migratory found in the combined EMBA, according to the Protected Matters search (**Appendix A**), are shown in **Table 5-1** along with their WA and NT conservation listings (as applicable) and discussed in **Section 5.2** below.

The following WA conservation codes apply to WA conservation significant fauna:

+ Threatened species (listed under the *Biodiversity Conservation Act 2016* (WA) (BC Act)):
    - Critically endangered
    - Endangered
    - Vulnerable
+ Specially protected species (listed under BC Act):
    - Migratory
    - Species of special conservation interest (conservation dependant fauna)
    - Other specially protected species
+ Priority species (non-statutory state based administrative process):
    - Priority 1, 2 and 3: poorly-known species – possible threatened species that do not meet survey criteria or are otherwise data deficient. Ranked in order of priority. In urgent need of further survey.
    - Priority 4: species that are adequately known, are either: rare but not threatened; meet criteria for near threatened; or delisted as threatened species within last five years for reasons other than taxonomy. Requiring regular monitoring.

The following NT conservation codes apply to NT conservation significant fauna:

+ Threatened wildlife (listed under the Territory Parks and Wildlife Conservation Act 1976 (TPWC Act))
    - Extinct in the wild
    - Critically endangered
    - Endangered
    - Vulnerable
+ Protected wildlife (listed under the Territory Parks and Wildlife Conservation Act 1976)
    - Wildlife in a Territory park, reserve, sanctuary, wilderness zone or area of essential habitat
    - Any vertebrate that is indigenous to Australia

A detailed account of commercial and recreational fisheries that operate in the region is provided in in the Commercial Fisheries **Section 14.7** and detailed in *The State of the Fisheries Report* 2018/2019 (Gaughan *et al.*, 2020).

Table 5-1: EPBC listed fish and shark species in the combined EMBA

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	BC Act 2016[1]	Other WA Conservation Code	*TPWC Act 1976*		
Cape range cave gudgeon, Blind gudgeon (*Milyeringa veritas)*	Vulnerable	Vulnerable	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Balstons pygmy perch (*Nannatherina balstoni*)	Vulnerable	Vulnerable	-	-	Species or species habitat likely to occur within area.	None - No BIA defined
Blind cave eel (*Ophisternon candidum)*	Vulnerable	Vulnerable	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Blackstriped dwarf galaxias, Black-stripe minnow (*Galaxiella nigrostriatal*)	Endangered	Endangered	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Grey nurse shark (*Carcharias taurus*)	Vulnerable	Vulnerable	-	Listed nationally	Species or species habitat known to occur within area.	None - BIA not found in EMBA
White shark, Great white shark (*Carcharodon carcharias*)	Vulnerable & Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour known to occur within area.	Yes – Refer to **Table 5-3**
Whale shark (*Rhincodon typus*)	Vulnerable & Migratory	Migratory	-	Listed nationally	Foraging, feeding or related behaviour known to occur within area.	Yes – Refer to **Table 5-3**
Northern river shark, New guinea river shark (*Glyphis garricki)*	Endangered	-	Priority 1	Endangered	Breeding likely to occur within the area.	None - BIA not found in EMBA
Speartooth shark *(Glyphis glyphis)*	Critically Endangered	-	-	Vulnerable	Species or species habitat known to occur within area.	None - BIA not found in EMBA
Dwarf sawfish, Queensland sawfish (*Pristis clavata)*	Vulnerable & Migratory	Migratory	Priority 1	Vulnerable	Breeding known to occur within area.	Yes – Refer to **Table 5-3**

[1] The Wildlife Conservation (Specially Protected Fauna) Notice 2018 has been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of threatened, extinct and specially protected species under Part 2 of the BC Act.

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	BC Act 2016[1]	Other WA Conservation Code	*TPWC Act 1976*		
Freshwater sawfish, Largetooth sawfish, River sawfish, Leichhardt's sawfish, Northern sawfish (*Pristis pristis)*	Vulnerable & Migratory	Migratory	Priority 3	Vulnerable	Species or species habitat known to occur within area.	Yes – Refer to **Table 5-3**
Narrow sawfish, Knifetooth sawfish (*Anoxypristis cuspidate)*	Migratory	Migratory	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Green sawfish, Dindagubba, Narrowsnout sawfish (*Pristis zijsron)*	Vulnerable & Migratory	Vulnerable	-	Vulnerable	Breeding known to occur within area.	Yes – Refer to **Table 5-3**
Oceanic whitetip shark (*Carcharhinus longimanus*)	Migratory	-	-	-	Species or species habitat likely to occur within area.	None - BIA not found in EMBA
Shortfin mako, Mako shark *(Isurus oxyrinchus)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area .	None - No BIA defined
Longfin mako *(Isurus paucus)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area.	None - No BIA defined
Reef manta ray, Coastal manta ray *(Manta alfredi)*	Migratory	Migratory	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Giant manta ray *(Manta birostris)*	Migratory	Migratory	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Porbeagle, Mackerel shark *(Lamna nasus)*	Migratory	Migratory	-	-	Species or species habitat may occur within area.	None - No BIA defined
Orange Roughy, Deep-sea Perch, Red Roughy *(Hoplostethus atlanticus)*	Conservation Dependent	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Blue Warehou *(Seriolella brama)*	Conservation Dependent	-	-	-	Species or species habitat known to occur within area	None - No BIA defined
Scalloped Hammerhead (*Sphyrna lewini)*	Conservation Dependent	-	-	-	Species or species habitat known to occur within area	None - No BIA defined

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	BC Act 2016[1]	Other WA Conservation Code	*TPWC Act 1976*		
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark *(Galeorhinus galeus)*	Conservation Dependent	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Southern Bluefin Tuna *(Thunnus maccoyii)*	Conservation Dependent	-	-	-	Breeding known to occur within area	None - No BIA defined
Southern Dogfish, Endeavour Dogfish, Little Gulper Shark (Centrophorus zeehaani)	Conservation Dependent	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined

5.1 Regional Surveys

Within the combined EMBA a number of important geographical areas for fish exist, including Ningaloo Marine Park, Montebello/Barrow Island Marine Park, Abrolhos Marine Park and the Rowley Shoals.

5.1.1 Southwest Shelf Province

At least 150 species have been identified within the capes region as being reef-associated (Hutchins 1994 cited in DEC 2013). Of these, 77% are warm temperate species, 18% are subtropical species and 5% are tropical (DEC 2013).

The most abundant finfish species across the region identified during surveys were the Maori wrasse (*Opthalmolepis lineolatus*), red banded wrasse (*Pseudolabrus biserialis*), McCulloch scalyfin (*Parma mccullochi*), and western king wrasse (*Coris auricularis*). The yellow headed hulafish (*Trachinops noarlungae*), black headed puller (*Chromis klunzingeri*), rough bullseye and common bullseye (*Pempheris multiradiata* and *P. klunzingeri*) were also common at Eagle Bay and Geographe Bay (Westera *et al.* 2007 cited in DEC 2013).

5.1.2 Southwest Shelf Transition

A total of 389 finfish species have been recorded at the Abrolhos (DoF 2012). The Abrolhos and their surrounding coral and limestone reef systems consist of a combination of abundant temperate macroalgae with coral reefs, supporting substantial populations of large species such as baldchin groper and coral trout. Some of the species occurring in the Abrolhos are dependent on larvae carried southward by the Leeuwin Current from areas further north, such as Shark Bay or Ningaloo Reef. Similarly, populations of some of the species occurring at Rottnest Island are dependent on larvae generated from breeding populations at the Abrolhos (DoF 2012).

More than 20 species of sharks have been identified at the Abrolhos (DoF 2012). These sharks include:

+ Port Jackson sharks (*Heterodontus portusjacksoni*);
+ Tiger shark (*Galeocerdo cuvier*);
+ Whaler sharks (*Carcharhinus brachyurus*); and
+ Wobbegongs (*Orectolobus maculatus*).

Abrolhos waters are considered to be an important food source for sharks, due to the resident fish populations. Various species of rays have been recorded at the Abrolhos. These include the manta ray and the white spotted eagle ray (DoF 2012).

5.1.3 Southern Province

The demersal fish assemblages inhabiting the shelf break and slope resemble those found on the Southeast Marine Region's continental slope more than those of the Central Western Province. The canyons south of Kangaroo Island and adjacent shelf break appear to be important areas for biological productivity and for spawning and aggregation for a range of marine species, particularly during winter. The Albany Group of submarine canyons south of Albany and Esperance are also considered important for biological productivity that attracts feeding aggregations (DEWHA 2008b).

Scientists have described 463 species of fish on the slope of this bioregion, of which 26 are endemic. Only one extensive study of slope fish communities, undertaken during the late 1980s, has been conducted in this bioregion. There is a lower proportion of bottom-feeding demersal fish in this bioregion compared with the west coast, which appears to relate to greater availability of food such as meso-pelagic fish like myctophids (lantern fish) in the water column. Commercial fish landings taken from the shelf break and down the upper and mid-slope include orange roughy, blue grenadier, Bight redfish, school shark, gummy shark, angel shark, gemfish, deep water flatheads, leatherjackets, latchets, stingrays and stingarees (DEWHA 2008b).

Fisheries scientists and some fishers speculate that species such as blue grenadier and western gemfish may have spawning aggregations amongst the submarine canyons and other prominent geological features rising from the seafloor on the slope adjacent to Esperance and Hopetoun. The Diamantina Fracture Zone represents a unique but virtually unknown region of deep-sea habitat and experts speculate it is highly likely that marine communities in this area comprise unique species with high biodiversity. The physical complexity of numerous troughs and ridges and complex water circulation that occurs in this area support these assertions. A number of KEFs are defined which support enhanced productivity and aggregations of marine life (Section 10) (DEWHA 2008b).

5.1.4 Great Australian Bight Shelf Transition

Of the 600 species of fish occurring in southern Australia, 370 are recorded from South Australian waters (Scott et al. 1980). Species restricted to South Australia that occur in the GAB include the coastal stingaree (*Urolophus orarius*) and the crested threefin (*Norfolkia cristata*.

In South Australia, 77 species of fish are utilised commercially. The main fishes targeted by commercial fishers in the GAB are southern bluefin tuna (*Thunnus maccoyii)*, sardine (*Sardinops sagax*), school shark (*Galeorhinus galeus*), gummy shark (*Mustelus antarcticus*), bronzewhaler shark (*Carcharhinus brachyurus*), snapper *(Pagrus auratus*), King George whiting (*Sillaginodes punctata*) and deepwater species such as deepwater flathead (*Neoplatycephalus conatus*), bight redfish (*Centroberyx gerrardi*), deep sea trevalla (*Hyperoglyphe antarctica*) and orange roughy (*Hoplostethus atlanticus*). Surveys conducted by the CSIRO in the GAB between 1965 and 1989 collected information on species composition, sizes, and distribution patterns of fishes. Surveys were conducted by trolling (1979, 1981) and demersal (1978-81), pelagic (1979) and mid-water trawling (1978, 1980-81). CSIRO also have data from Russian surveys conducted in the GAB in 1965-1974.

Recreational fishers in the GAB target Australian salmon (*Arripis truttacea*), mulloway (*Argyrosomus japonicus*), snapper (*Pagrus auratus*), King George whiting (*Sillaginodes punctata*), Australian herring (*Arripis georgiana*) and yellowtail kingfish (*Seriola lalandi*) (Mcleay et al., 2003; DEWHA, 2008b).

5.1.5 Central Western Shelf Province

The Central Western Shelf Province is located near Shark Bay and is the northern limit of a transition region between temperate and tropical marine fauna. Of the 323 fish species recorded from Shark Bay, 83% are tropical species with 11% warm temperate and 6% cool temperate species (CALM 1996).

5.1.6 Central Western Shelf Transition

Ningaloo is the largest fringing coral reef in Australia, forming a discontinuous barrier that encloses a lagoon that provides habitat for many fish species. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). Ningaloo Reef is a well known biodiversity hotspot, supported by the direct link between the reef and the ancient reef systems found closer to the equator by the Leeuwin Current (Kemps 2010). Approximately 500 species of fish have been reported to inhabit the reef (Kemps 2010). The Piercam project from inception in 2005 to 2013, identified 165 fish species from 50 families at the Point Murat Navy Pier alone, located within the Ningaloo Marine Park (Whisson & Hoschke 2013).

Seasonal aggregations of whale sharks occur at Ningaloo each year (CALM 2005). There is limited data available on species diversity and distribution of sharks in the Ningaloo area as chondrichthyan biodiversity for the area has not been specifically recorded. Despite this, it is possible that the Ningaloo Reef Marine Park contains the largest and most diverse collection of sharks on the Australian coastline (Stevens *et al.* 2009). It was estimated in 2009 by Last and Stevens (cited in Stevens *et al.* 2009), that there are likely to be 118 species of chondrichthyan fishes occurring in the park. Of these species, 59 are shark species predicted to be found at depths of less than 200 m (Stevens *et al.* 2009).

The lagoon at Ningaloo Reef appears to provide a juvenile habitat and nursery area for shark species such as the grey nurse shark (*C. taurus*), black-tipped reef shark (*Carcharhinus melanopterus*) and other reef sharks (Carcharhinidiae) (Stevens *et al.* 2009). A study conducted on the distribution and abundance of elasmobranches in the Ningaloo Marine Park, in 2009, tracked the movements of six key shark species. Species such as *Galeocerdo cuvier* (tiger shark) and *Sphyrna mokarran* (great hammerhead) were found to remain for brief time periods in the park, in contrast to other species found to re-visit the Ningaloo area (Stevens *et al.* 2009). Several species of sharks within Ningaloo have been identified as key indicator species for the health of the system (Stevens *et al.* 2009).

Barrow Island includes Biggada Reef, an ecologically significant fringing reef, and the Montebello Islands comprise over 100 islands, the majority of which are rocky outcrops; providing fish habitat (DEC 2007a). Within the Barrow/Montebello region, at least 380 fish species have been recorded (de Lestang & Jankowski 2017). Most species exhibit wide distributions, with local species composition closely resembling that of the Dampier Archipelgao. Coral habitats support the most diverse fish community in this region, comprising, among others, many species of damselfish (Pomacentridae), parrotfish (Scaridae), snappers (Lutijanidae) and groupers (Serranidae) (de Lestang & Jankowski 2017). The region's macroalgal habitats are considered important nursery areas for a diverse range of fish species, such as emperor (Lethrinidae), threadfin bream (Nemipteridae), tuskfish (Labridae) and trevally (Carangidae) (de Lestang & Jankowski 2017).

Ramsar wetlands within the area (e.g. Eighty Mile Beach and Ashmore Reef National Nature Reserve) can also provide important habitat for fish (see **Section 9.1.3**).

5.1.7 Central Western Transition

The biological communities of the Central Western Transition are thought to be distinctive owing to the proximity of deep oceans areas to the continental slope and shelf, resulting in close interaction between pelagic species of the Cuvier Abyssal Plain and those of the slope and shelf (DEWHA 2008a).

The present level of understanding of the marine environment in this bioregion is generally poor. The diversity of fish and cephalopod species changes with depth, generally decreasing species numbers with increasing depth. The demersal slope fish bioregionalisation identified some endemism in communities in this bioregion (Last *et al*. 2005), however, it is lower than other areas of the North-west Marine Region (DEWHA 2008a).

Bentho-pelagic fish, such as deep-water snappers (e.g. *Paracaesio* spp, and *Eletis* spp.), hatchetfish (*Argyropelecus* spp.), dragonfish (*Melacosteus* spp.), viperfish (*Chauliodus* spp.) and a number of eels species migrate between the benthic and pelagic systems, forming an important link between these systems (DEWHA 2008a).

Transient fish species through the Central Western Transition bioregion include southern bluefin tuna (migrating to and from spawning grounds), broadbill swordfish (*Xiphius gladius*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and striped marlin (*Tetrapturus audax*). Pelagic sharks also range across the bioregion following schools of pelagic fish (DEWHA 2008a).

5.1.8 Central Western Province

The Perth Canyon appears to be an important ecological feature attracting krill and fish aggregations that in turn attract larger species such as predatory fish and pygmy blue whales (DSEWPaC 2012). Demersal slope fish assemblages in this bioregion are characterised by high species diversity. Scientists have described 480 species of demersal fish that inhabit the slope of this bioregion and 31 of these are considered endemic to the bioregion. Demersal fish on the slope in this bioregion in particular have high species diversity compared with other more intensively sampled oceanic regions of the world. Below 400 m water depth demersal fish communities are characterised by a diverse assemblage where relatively small, benthic species (grenadiers, dogfish and cucumber fish) dominate.

5.1.9 Northwest Transition

The Northwest Transition bioregion may support sparse populations of bentho-pelagic fish and cephalopods in low densities. Pelagic fish species likely to be present include grenadiers and hatchetfish (*Argyropelecus* spp.) as well as transient populations of highly mobile pelagic fish. Adult and juvenile southern bluefin tuna are through to migrate through this bioregion on their way to and from spawning grounds in the north-eastern Indian Ocean (DEWHA 2008a).

The slope habitat of this bioregion is associated with important populations of demersal fish species and supports the second richest demersal fish assemblage nationally (Last *et al*. 2005). Over 508 fish species have been identified on the slope in this area and 64 of these species are endemic. The high diversity and endemism of the demersal fish fauna indicates important interactions between physical processes and trophic structures in this bioregion. For more information on the slope habitat for fish and sharks, refer to **Section 10.1.19**.

The Rowley Shoals within the Northwest Transition comprise three oceanic reef systems approximately 30–40 km apart, namely Mermaid Reef, Clerke Reef and Imperieuse Reef. The Shoals are thought to provide a source of invertebrate and fish recruits for reefs further south and as such are regionally significant (DEC 2007b).

5.1.10 Northwest Shelf Province and Northwest Province

The demersal zone of the North West Shelf (which includes the Northwest Province and Northwest Shelf Province) hosts a diverse assemblage of fish of tropical Indo-west Pacific affinity, with up to 1,400 species known to occur, with a great proportion of these occurring in shallow coastal waters (Allen *et al*. 1988). Last *et al*. (2005) and Fox and Beckley (2005) described the North-west Province as being characterised by a high level of endemism and species diversity. Certain areas of increased biological activity (e.g. Glomar Shoals) attract demersal fish species such as Rankin cod, red emperor, crimson snapper and spangled emperor that are exploited by commercial trawl and trap fisheries (Sainsbury *et al*. 1992, Fletcher and Santoro 2013).

The shallow waters (<30 m) of the Dampier Archipelago, in the Northwest Shelf Province, support a characteristic and rich fish fauna of 650 species from a variety of habitats including coral and rocky reefs, mangroves, sand and silty bottoms and sponge gardens (Hutchins 2003 & 2004). The majority of these species are found over hard substrate, but significant numbers are also found from soft bottom and mangrove areas. The outer islands of the Archipelago are inhabited predominantly by coral reef fishes whereas inner areas close to the mainland are occupied by mangrove and silty-bottom dwellers. The inter-island passages have a relatively rich soft bottom fauna. EPBC Act protected fish species within the Dampier Archipelago include the dwarf sawfish (*Pristis clavata*), freshwater sawfish (*Pristis pristis*) and narrow sawfish (*Anoxypristis cuspidate*).

The fish fauna of the archipelago is less diverse than the islands of the West Pilbara to the south, but are closely related to the fauna at the offshore Montebello Islands (Hutchins 2004). The fish fauna of Barrow/ Lowendal/ Montebello Islands are widespread throughout the Indo-west Pacific region.

Within the southern portion of the Northwest and Northwest Shelf Province, small pelagic fish (e.g. lantern fishes) comprise a third of the total fish biomass (Bulman 2006) and inhabit a range of marine environments, including inshore and continental shelf waters. These small pelagic fish play an important ecological role, not only for this particular area but for the entire NWMR. They feed on pelagic phytoplankton and zooplankton and provide a food source for a wide variety of predators such as marine mammals, sharks, large pelagic fish and seabirds, thus providing a vital link between many of the region's trophic systems (Mackie *et al*. 2007).

Pelagic fish in the Northwest and Northwest Shelf Province include tuna, mackerel, herring, pilchard and sardine, and game fish such as marlin and sailfish (BBG 1994, Brewer *et al*. 2007), some of which are targeted by both commercial and recreational fishers. In particular, adult and juvenile southern bluefin tuna are thought to migrate through the North West Shelf on their way to and from spawning grounds in the north-eastern Indian Ocean. However, the timing of these migrations and the use of regional currents to assist their migration is still unclear. The oceanic waters of the North West Shelf are also believed to provide important spawning and nursery grounds for a number of large pelagic fish species. **Table 5-2** provides a summary of the key fish species and likely timing of their spawning in the region (DoF correspondence).

5.1.11 Northwest Shelf Transition

Creek systems, mangroves and rivers, and ocean beaches within this region provide habitat for a variety of species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin and cods (Fletcher and Santoro 2013). The offshore atolls and the continental shelf waters in the Northwest Shelf Transition are also geographically important for fish species. They support species of recreational and commercial interest, including saddle-tail snapper and red emperor, cods, coral and coronation trout, sharks, trevally, tuskfish, tunas, mackerels and billfish (Gaughan et al. 2019).

The Rowley Shoals within the Northwest Shelf Transition comprise three oceanic reef systems approximately 30–40 km apart, namely Mermaid Reef, Clerke Reef and Imperieuse Reef. The Shoals are thought to provide a source of invertebrate and fish recruits for reefs further south and as such are regionally significant (DEC 2007b). See **Section 11** on State Marine Parks and Nature Reserves for further details on important geographical areas for fish.

Table 5-2: Spawning and aggregation times of key commercially caught fish species within the North West Shelf

Species		Month											
Species Common Name	**Species Latin Name**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Blacktip shark	*Carcharhinus tilstoni* and *C. limbatus*												
Goldband snapper	*Pristipomoides multidens*												
Rankin cod	*Epinephelus multinotatus*												
Red emperor	*Lutjanus sebae*												
Sandbar shark	*Carcharhinus plumbeus*												
Spanish mackerel	*Scomberomorus commerson*												
Pink snapper	*Pagrus auratus*												
Baldchin groper	*Choerodon rubescens*												
Crystal (snow) crab	*Chaceon spp.*												
King George whiting	*Sillaginodes punctate*												
Spangled emperor	*Lethrinus nebulosus*												
Pearl oyster	*Pinctada maxima*												
Blue-spotted emperor	*Charaxes cithaeron*												
Dusky whaler	*Carcharhinus obscurus*	May occur throughout the year											
Whiskery shark	*Furgaleus macki*												
Gummy shark	*Mustelus antarcticus*	Peak pupping periods unknown											
Fish	other species	Timing of spawning activity varies between species											

5.1.12 Timor Province

The diversity of demersal fish assemblages on the continental slope in the Timor Province (as well as the Northwest Transition and the Northwest Province) is high compared to elsewhere along the Australian continental slope (DSEWPaC 2012). Elements of the Timor Province are not well known, due to limited survey data in the northern limits of the region. The province is geographically extensive and includes 418 fish species, 64 of which are endemic to the region (Last *et al.* 2009). Key indicator species include *Bembrops nelsoni*, *Bythaelurus* sp., *Halicmetus* sp., *Malthopsis* spp, *Neobythites australiensis*, *Nobythites bimaculatus*, *Neobythites macrops*, *Neobythites soelae*, *Parapterygotrigla* sp., *Physiculus roseus* (Last *et al.* 2005).

Scott and Seringapatam Reefs are regionally important for the diversity of their fauna, including 558 fish species (Department of the Environment (DoE) 2014). Scott Reef has enormous habitat diversity and is considered a hot spot for fish, with five endemic species (DoE 2014). Scott Reef has biogeographic significance due to the presence of species which are at or close to the limits of their geographic ranges, including fish known previously only from Indonesian waters such as cardinalfish, azure damselfish (*Chrysoptera hemicyanea*), comb-tooth blenny (*Escnius schroederi*) and several Gobiids (DoE 2014).

The diversity of fish at Ashmore Reef is also higher than other comparable reefs in the bioregion with over 760 species recorded (Russell *et al.* 2005, Kospartov *et al.* 2006. The majority of fish species are shallow water, benthic taxa that typically inhabit depths down to 100 m and are widely distributed throughout the

Indo-West Pacific (Russell *et al.* 2005). The most species rich groups are gobies (Gobiidae), damselfishes (Pomacentridae), wrasses (Labridae), cardinal fishes (Apogonidae), moray eels (Muraenidae), butterflyfishes (Chaetodontidae), and rockcods and groupers (Serranidae) (Allen 1989, Russell *et al*. 2005).

5.1.13 Timor Transition

Records show that the Timor Transition hosts at least 284 demersal fish species (DEWHA, 2008c). The Timor Transition is also known to have a number of pelagic species that are prominent in the open water environment, including some which also have pelagic larval stages in the area (DEWHA, 2008c). The North Marine Bioregional Plan Profile specifically describes pelagic species found within the trough of the Timor Transition including snaggle-teeth fish, hatchet fish and lantern fish (DEWHA, 2008c). The soft-edge/slope of the Timor Transition is also known to support whale sharks and threadfin fish species, with the canyons and channels having distance genetic stocks of red snapper (DEWHA, 2008c).

5.1.14 Northern Shelf Province

Records of the fish species in the Northern Shelf Province show that the majority of available information shows an abundance of fish species in the Gulf of Carpentaria, which is outside the combined EMBA. However, other fish species, including sharks and sawfish are known to occur within the estuarine waters and coastal waters of the Northern Shelf Province (DEWHA, 2008c).

Within the combined EMBA, the Arafura Shelf supports a number of submerged reefs that are used for breeding and aggregation of a number of fish species including mackerel, mangrove jack and snapper (DEWHA, 2008c). Sea snakes and shark species have also been observed in the reef areas (DEWHA, 2008c). Furthermore, the Canyons of the Arafura Depression key ecological feature, which is also within the combined EMBA, is specifically identified as attracting aggregations of predatory fish, whale sharks and sawfish (DEWHA, 2008c).

5.1.15 Christmas Island Province

The Christmas Island Province is in deep, offshore waters (2,200 m – 6,000 m depth range). The island's predominantly intact fringing reefs and adjacent waters support a number of marine and coastal ecosystems and species, including over 600 fish species, with most being typical of the Indian Ocean region. These waters provide habitat for pelagic finfish species including tuna (*Thunnus* sp.) and wahoo (*Acanthocybium solandri*), and some demersal species such as ruby snapper (*Etelis carbunculus)*. The island has more than 50 reef fish species that are not found anywhere else in Australia (although some species may also occur at the neighbouring Cocos Islands) (DNP, 2014).

5.1.16 Cocos (Keeling) Islands Province

The bulk of fish species are widespread or Indo-west Pacific in origin, which points to the significance of the Indonesian Throughflow current in delivering larval recruits to the island. About two thirds of fish species are shared with Christmas Island. A range of pipefish (syngnathidae) have been sighted in with eight identified at the Cocos (Keeling) Islands. This list is biased towards the shallow habitats where data has been collected by divers. There are likely to be more species occurring in these territories than recorded (e.g. in deeper water, on seamounts, slopes etc) (Brewer et al 2009).The province has an intermediate level of primary productivity due to the distance from upwelling events such as those associated with the Java coast. However, the shallower seamounts would be likely to have some significant upwelling or associated with them, which in turn will produce increased productivity and populations of pelagic fish such as bigeye (*Thunnus obesus*) and yellowfin tuna (*T. albacares*).

5.2 Fish Species

Four species of fish listed as Threatened under the EPBC Act (**Table 5-1**) were identified in the Protected Matters search (**Appendix A**):

- Balston's pygmy perch (*Nannatherina balstoni*);
- Black-stripe minnow (*Galaxiella nigrostriata*);
- Blind gudgeon (*Milyeringa veritas*); and
- Blind cave eel (Ophisternon candidum).

In addition the Barrow cave gudgeon *(Milyeringa justitia*) has been identified as relevant threatened species under the BC Act. This species is not listed under the EPBC Act.

5.2.1 Blind Gudgeon, Balston's Pygmy Perch and Blind Cave Eel

Both the blind gudgeon (*Milyeringa veritas*) and blind cave eel (*Ophisternon candidum*) are known to occur on the Cape Range Peninsula (in the Central Western Shelf Transition) (Humphreys and Feinberg 1995), and a related species of the genus Milyeringa, the Barrow cave gudgeon *(Milyeringa justitia*) has also been noted at Barrow Island (Humphreys 1999). The Barrow cave gudgeon is listed as Vulnerable under the WA BC Act. They have been recorded in waters ranging from fresh to seawater at depths of up to 33 m in caves and 50 m in wells and bores. Both species are restricted to either caves or groundwater (Humphreys and Blyth 1994) and are the only two vertebrate animals known from Australia for this (DoE 2014a).

The Balston's pygmy perch distribution ranges from Moore River (75 km north of Perth) at the northern extent to Two Peoples Bay near Albany. This freshwater species is typically associated with shallow waters near riparian vegetation and is considered to have low salinity tolerance, making it unlikely to occur in estuarine conditions (DoEE, 2016).

5.2.2 Syngnathids

The EPBC Protected Matters search also identified 72 'listed marine species of fish which are largely from the family Syngnathidae (**Appendix A**). Syngnathids are a group of bony fishes that include seahorses, pipefishes, pipehorses and sea dragons, although taxonomic uncertainty still surrounds a number of these (DEWHA 2012a). Knowledge about the distribution, abundance and ecology of syngnathids is limited, although no species is currently listed as threatened or migratory.

5.3 Sharks, Rays and Sawfishes

The diversity of marine environments in the waters within the NWMR has led to a rich fauna of cartilaginous fish (sharks and rays). Of the approximately 500 shark species found worldwide, 19% (94) are found in the region (DEWHA 2008a). The EPBC Act Protected Matters search (**Appendix A**) identified five species of shark and three species of sawfishes listed as threatened within the search area between southwest WA and northern NT (**Table 5-1**), including:

- Grey nurse shark (*Carcharias taurus*);
- Great white shark (*Carcharodon carcharias*);
- Northern river shark (*Glyphis garricki*);
- Whale shark (*Rhincodon typus*);
- Speartooth shark (Glyphis glyphis);

- Dwarf sawfish (*Pristis clavata*);
- Freshwater sawfish (*Pristis pristis*); and
- Green sawfish (*Pristis zijsron*).

In addition, the oceanic whitetip shark (*Carcharhinus longimanus*), the narrow sawfish (*Anoxypristis cuspidate*), two species of ray, the reef manta ray (*Manta alfredi*) and giant manta ray (*Manta birostris*), the porbeagle (*Lamna nasus*) and the longfin (*Isurus paucus*) and shortfin (*Isurus oxyrinchus*) mako sharks are listed as migratory within the search area (**Table 5-1**).

The Biologically Important Areas (BIAs) for relevant species detailed above are illustrated in **Figure 5-1**, **Figure 5-2** and **Figure 5-3**.

5.3.1 Grey Nurse Shark

The grey nurse shark (*Carcharias taurus*) is listed as vulnerable under the EPBC Act and the BC Act, and may be found within the combined EMBA. In Australia, the grey nurse shark is now restricted to two populations, one on the east coast from southern Queensland to southern NSW and the other is predominantly found around the southwest coast of WA, but has been recorded on the North West Shelf (DEWHA 2012b, Pogonoski *et al*. 2002). It is believed that the east and west coast populations do not interact, and ongoing research will probably confirm that the populations are genetically different (Last and Stevens 2009).

While it is thought that grey nurse sharks have a high degree of site fidelity, some studies (McCauley 2004) suggest that grey nurse sharks move between different habitats and localities, exhibiting some migratory characteristics. In certain areas grey nurse sharks are vulnerable to localised pressure due to high endemism. The status of the west coast population is poorly understood although they are reported to remain widely distributed along the WA coast and are still regularly encountered, albeit with low and indeterminate frequency (Chidlow *et al*. 2006).

Grey nurse sharks are often observed hovering motionless just above the seabed, in or near deep sandy-bottomed gutters or rocky caves, and in the vicinity of inshore rocky reefs and islands (Pollard *et al*. 1996). The species has been recorded at varying depths but is generally found between 15–40 m (Otway & Parker 2000). Grey nurse sharks have also been recorded in the surf zone, around coral reefs, and to depths of around 200 m on the continental shelf (Pollard *et al*. 1996). Grey nurse sharks feed primarily on a variety of teleost and elasmobranch fishes and some cephalopods (Gelsleichter *et al*. 1999, Smale 2005).

No grey nurse shark BIAs were identified in the combined EMBA.

5.3.2 Great White Shark

The great white shark (*Carcharodon carcharias*) is listed as vulnerable and migratory under the EPBC Act and is listed as vulnerable under the BC Act. In Australia, great white sharks have been recorded from central Queensland around the south coast to northwest WA but may occur further north on both coasts (Last and Stevens 2009). There are no known aggregation sites for white sharks in the North-west marine region, but the species has been recorded in North West Shelf waters during humpback migrations (DEWHA 2012b). They are widely but not evenly distributed in Australian waters and are considered uncommon to rare compared to most other large sharks (CITES 2004).

Study into great white shark populations is difficult (Cailliet 1996) given the uncertainty about their movements, emigration, immigration and difficulty in estimating the rates of natural or fishing mortality.

Great white sharks can be found from close inshore around rocky reefs, surf beaches and shallow coastal bays to outer continental shelf and slope areas (Pogonoski *et al*. 2002). They also make open ocean excursions and can cross ocean basins (for instance from South Africa to the western coast of Australia and from the eastern coast of Australia to New Zealand). Great white sharks are often found in regions with high prey density, such as pinniped colonies (DEWHA 2009). The relevant great white shark BIAs in the combined EMBA are detailed in **Table 5-3** and is shown on **Figure 5-1** (DoEE 2019b).

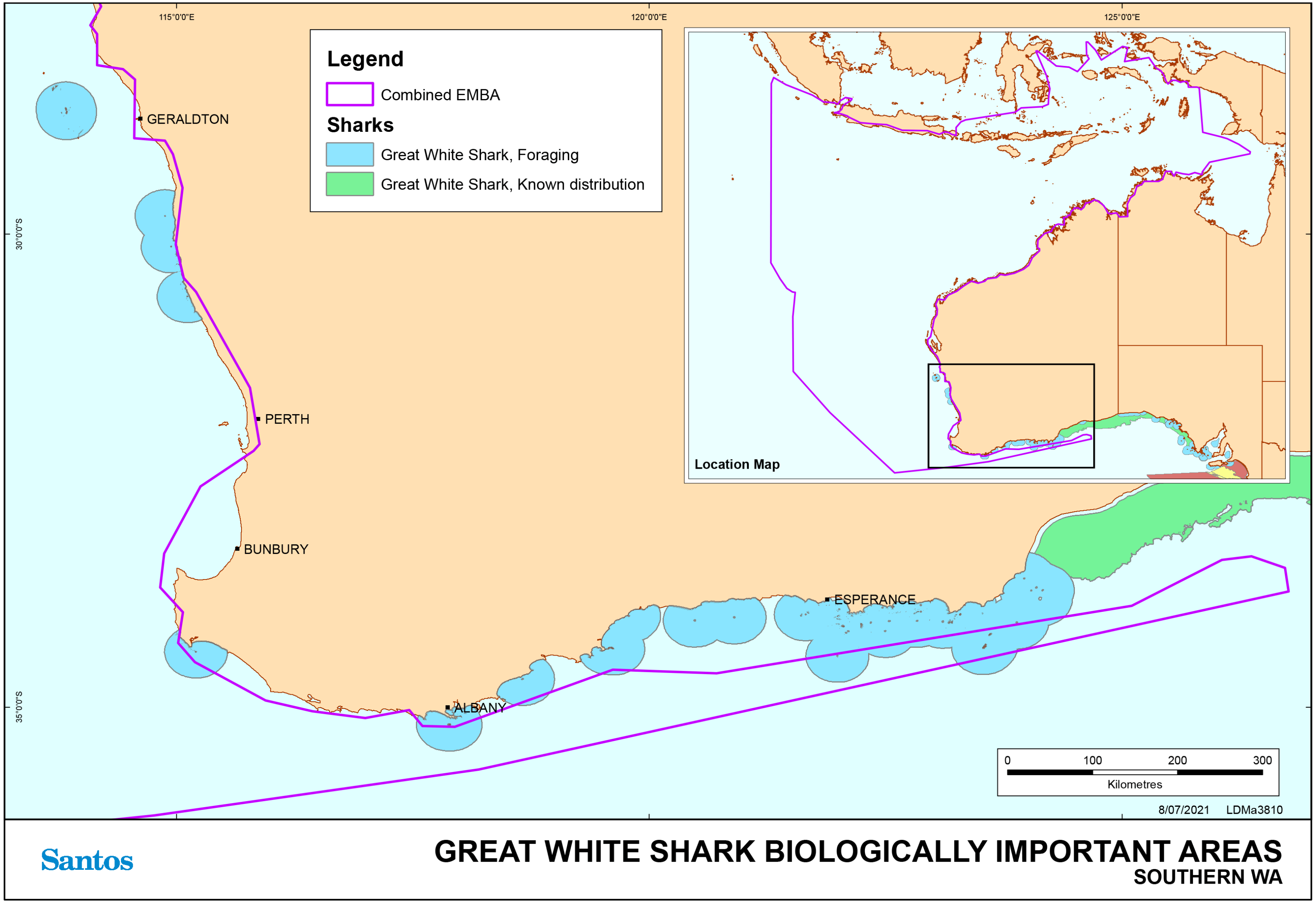


Figure 5-1: Biologically important area – great white shark

5.3.3 Northern River Shark

The northern river shark (*Glyphis garricki*) is listed as endangered under the EPBC Act and is one of the rarest species of shark in the world. Adults only recorded in marine habitats, whereas neonates, juveniles and subadults recorded in freshwater, estuarine and marine environments. It is also listed as a Priority 1 conservation species in WA and as Endangered under the NT *Territory Parks and Wildlife Conservation Act 1976*.

The associated recovery plan (Sawfish and River Sharks Multispecies Recovery Plan, Commonwealth of Australia 2015) identifies adults and juveniles are being known in WA marine waters north of Derby. Pupping and juvenile sharks are identified as known to occur in Cambridge Gulf and pupping is also identified as likely to occur in King Sound. Under the associated recovery plan all areas where aggregations of individuals have been recorded displaying biologically important behaviours such as breeding, foraging, resting or migrating are considered critical to the survival of the species unless population data suggests otherwise.

5.3.4 Whale Shark

The whale shark (*Rhincodon typus*) is listed as vulnerable and migratory under the EPBC Act and is also listed as a specially protected species under the BC Act as a species of special conservation interest (conservation dependent fauna). The species is also classified as vulnerable on the World Conservation Union’s Red List of Threatened Species (Norman 2005) and are protected under the WA *Conservation and Land Management Act 1984, NT Territory Parks and Wildlife Conservation Act 1976* and WA *Fish Resources Management Act 1994*.

The whale shark is the largest of all fish (>18 m; Borrell *et al*. 2011; Chen *et al*. 1997, Compagno 2001) and is a migratory species with worldwide geographical ranges between 30º N and 35º S (Last and Stevens 2009). Whale sharks are mostly epipelagic, whereby they spend a large amount of time in the top 200 m of the ocean (Tyminski *et al*. 2015), with a significant portion being spent at surface (<20 m) (Rowat & Brooks, 2012). This leads to an increased potential risk of vessel collision, which has been demonstrated from tracking data of 348 individuals (across all areas of distribution) showing a 92% horizontal and nearly 50% vertical space overlap with persistent large vessel (>300 gross tons) traffic (Womersley *et al.* 2022). There is a general lack of knowledge on many aspects of whale shark biology, however, the species is known to have a slow rate to sexual maturity, with field based studies from the Maldives estimating male sexual maturity to be approximately 25 years (Perry *et al.* 2018), with females potentially maturing even later (Pierce *et al.* 2021). This ‘slow’ life-history strategy places whale sharks at increased vulnerability to anthropogenic impacts (Pierce *et al.* 2021).

The species is oceanic but often forms aggregations in coastal waters at sites throughout the tropics. Typically, these aggregations are seasonal and often coincide with specific productivity events that are a focus of feeding for the animals. For example, whale sharks aggregate to feed on dense swarms of copepods in Baja California (Clark and Nelson 1997), fish spawn off Belize (Heyman *et al*. 2001) and red crab larvae at Christmas Island (Meekan *et al*. 2009). However, recent studies analysing fatty acids within whale shark tissue, suggest the species may also feed on benthic food sources, such as floating macroalgae (Meekan *et al.,* 2022; Courturier *et al.,* 2013*; Marcus* et al., 2016).

One of the best-known aggregation sites for whale sharks occurs along the central and NW coast of Western Australia from March to July and is focused at Ningaloo Reef, within the Exmouth region. The small size and general absence of female whale sharks from Ningaloo Reef suggests that the region may be important for feeding rather than breeding (Norman and Stevens 2007). The timing of this aggregation coincides with a pulse in seasonal productivity that results in large abundances of tropical krill on which these filter feeding sharks feed (Meekan *et al*. 2006, Jarman and Wilson 2004). At Ningaloo Reef, whale sharks are often found swimming close to the reef front, within a few kilometres of the shore and in water of less than 50 m deep. A tourist industry based on snorkelling with the sharks in this area has developed over the last 15 years and is now estimated to be worth over $4 million annually to the local economy of the Ningaloo region.

Estimates of the size of the population participating in the Ningaloo aggregation are between 300 and 500 individuals (Meekan *et al*. 2006), but research indicates that the Ningaloo population of whale sharks is declining (Bradshaw *et al*. 2007).

Whale sharks are known to be highly migratory with migrations of 13,000 km being recorded (Eckert and Stewart 2001). Research on the migration patterns of whale sharks in the western Indian Ocean, and isolated and infrequent observations of individuals, indicate that a small number of the Western Australian population migrate through the North West Shelf. Wilson *et al*. (2006) tagged 19 whale sharks in 2003 and 2004, with long term movements patterns successfully recorded from six individuals. All travelled northeast into the Indian Ocean after departing Ningaloo Reef, with one tracked to Ashmore Reef and another to Scott Reef. Whale sharks are occasionally observed from Santos'' offshore oil and gas facilities on the North West Shelf (Harriet Alpha and Stag platforms). In general, migration along the northern WA coastline broadly follows the 200 m isobath and typically occurs between July and November (DoE 2015). Whale sharks are well known to occur in the Christmas Island territory. There is evidence that the Christmas Island territory is on the migration route for many individuals, but they are rarely sighted within the Cocos (Keeling) Islands territory.

A common method for monitoring individual whale sharks is the use of variations in spot patterns, which has recently been tested to be 100% successful based on 154 photographic and genetic markers (Meenakshisundaram, 2021).

A biologically important area for whale sharks is located in northern WA, offshore of the Pilbara and Kimberley coastline, and broadly follows the 200 m isobath. The relevant whale shark BIAs in the combined EMBA are detailed in **Table 5-3** and is shown on **Figure 5-2**.

DBCA has a wildlife management program to manage whale shark interactions in reserves - *Whale shark management with particular reference to Ningaloo Marine Park, Wildlife Management Program no. 57 (2013).*

5.3.5 Speartooth Shark

The speartooth shark (*Glyphis glyphis)* is a medium sized shark found in tidal rivers and estuaries within the Northern Territory and Queensland (DAWE, n.d). It is listed as critically endangered under the EPBC Act and Vulnerable under the NT *Territory Parks and Wildlife Conservation Act 1976.*

There are three distinct geographical locations where the speartooth shark is known to occur with only one of these areas within the combined EMBA, the Van Diemen Gulf.

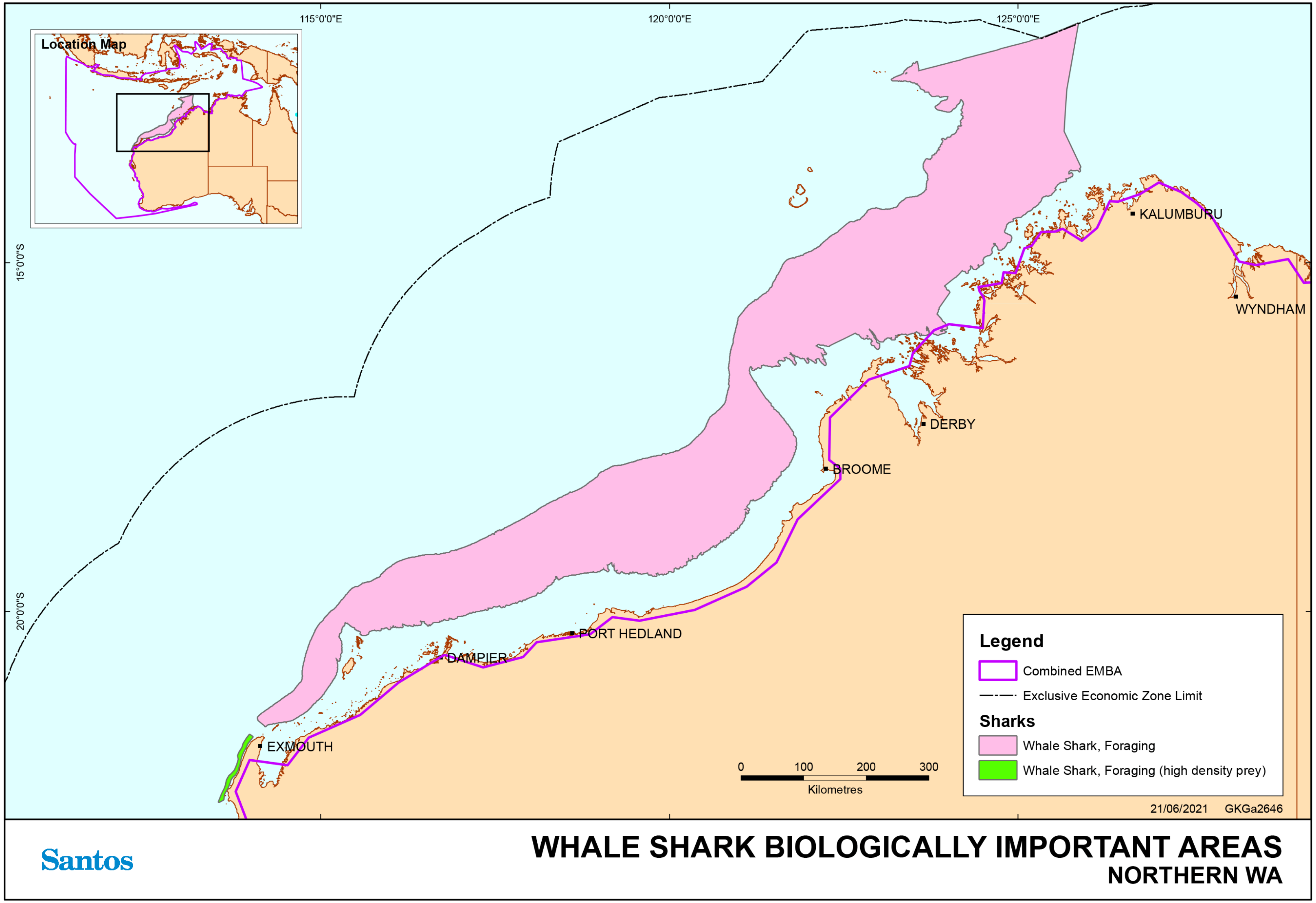


Figure 5-2: Biologically important area – whale shark

5.3.6 Dwarf Sawfish

The dwarf sawfish (*Pristis clavata*) is listed as vulnerable under the EPBC Act and thought to be restricted to Australia (DoE 2014b). It is also listed as a Priority 1 conservation species in WA and as Vulnerable in the NT. The Australian distribution of the dwarf sawfish is considered to extend across northern Australia and along the Kimberley and Pilbara coasts (Last and Stevens 2009, Stevens *et al*. 2005). However, the majority of records of dwarf sawfish in WA and the NT have come from shallow estuarine waters of the Kimberley region which are believed to be nursery (pupping) areas, with immature juveniles remaining in these areas up until three years of age (Thorburn *et al*. 2004). Adults are known to seasonally migrate back into inshore waters (Peverell 2007); although it is unclear how far offshore the adults travel as captures in offshore surveys are very uncommon. The species' range is restricted to brackish and salt water (Thorburn *et al*. 2007).

The recovery plan identifies pupping as known to occur in the King Sound, the Cambridge Gulf and 80 Mile Beach, with pupping likely to occur identified at a number of locations along the Pilbara and Kimberly Plan (Commonwealth of Australia, 2015). Under the associated recovery plan all areas where aggregations of individuals have been recorded displaying biologically important behaviours such as breeding, foraging, resting or migrating are considered critical to the survival of the species unless population data suggests otherwise.

The relevant sawfish BIAs in the combined EMBA are detailed in **Table 5-3** and are shown on **Figure 5-3**.

5.3.7 Freshwater and Green Sawfish

The freshwater sawfish (*Pristis pristis) (*also previously listed as the Largetooth sawfish*)* and green sawfish (*Pristis zijsron)* are listed as vulnerable under the EPBC Act. The freshwater sawfish is listed as a Priority 3 conservation species in WA, while the green sawfish is listed as Vulnerable under the BC Act and both species are listed as Vulnerable in the NT under the *Territory Parks and Wildlife Conservation Act 1976.*

The freshwater species are wider-ranging than the dwarf sawfish and are also found in the Indo-west Pacific (DoE 2014c, DoE 2014d). Important areas for sawfishes include King Sound, and the Fitzroy, Durack, Robinson and Ord rivers for the freshwater sawfish; and Cape Keraudren for the green sawfish (Stevens *et al*. 2008, Thorburn *et al*. 2007, 2008).

Sawfishes generally inhabit inshore coastal, estuarine and riverine environments. The freshwater sawfish has been recorded in north-west Australia from rivers (including isolated water holes), estuaries and marine environments (Stevens *et al*. 2005). Newborns and juveniles primarily occur in the freshwater reaches of rivers and in estuaries, while most adult freshwater sawfish have been recorded in marine and estuarine environments (Peverell 2005, Thorburn *et al*. 2007). It is believed that mature freshwater sawfish enter less saline waters during the wet season to give birth (Peverell 2005) and freshwater river reaches play an important role as nursery areas (DoE 2014c).

The green sawfish has predominantly been recorded in inshore coastal areas, including estuaries and river mouths with a soft substrate, although there have been records of sawfish offshore in depths up to 70 m (Stevens *et al*. 2005). This species does not occupy freshwater habitats (DoE 2014d).

Short-term tracking has shown that green sawfish appear to have limited movements that are tidally influenced, and they are likely to occupy a restricted range of only a few square kilometres within the coastal fringe, with a strong association with mangroves and adjacent mudflats (Stevens et al. 2008).

Sawfishes feed close to the benthos on a variety of teleost fishes and benthic invertebrates, including cephalopods, crustaceans and molluscs (Compagno & Last 1999, Last & Stevens 2009, Pogonoski *et al*. 2002, Thorburn *et al*. 2007, 2008).

Baseline surveys undertaken for Chevron's Wheatstone project identified green sawfish habitat and nursery area for juveniles within the north-eastern lagoon of the Ashburton Delta and in Hooley Creek near Onslow. Distribution of sawfish in these creeks is spatially and seasonally variable due to changing tidal and environmental conditions. However, they typically return to inshore waters to breed and pup during the wet season (i.e. January) (Chevron 2011).

The relevant sawfish BIAs in the combined EMBA are detailed in **Table 5-3** and are shown on **Figure 5-3**.

Santos

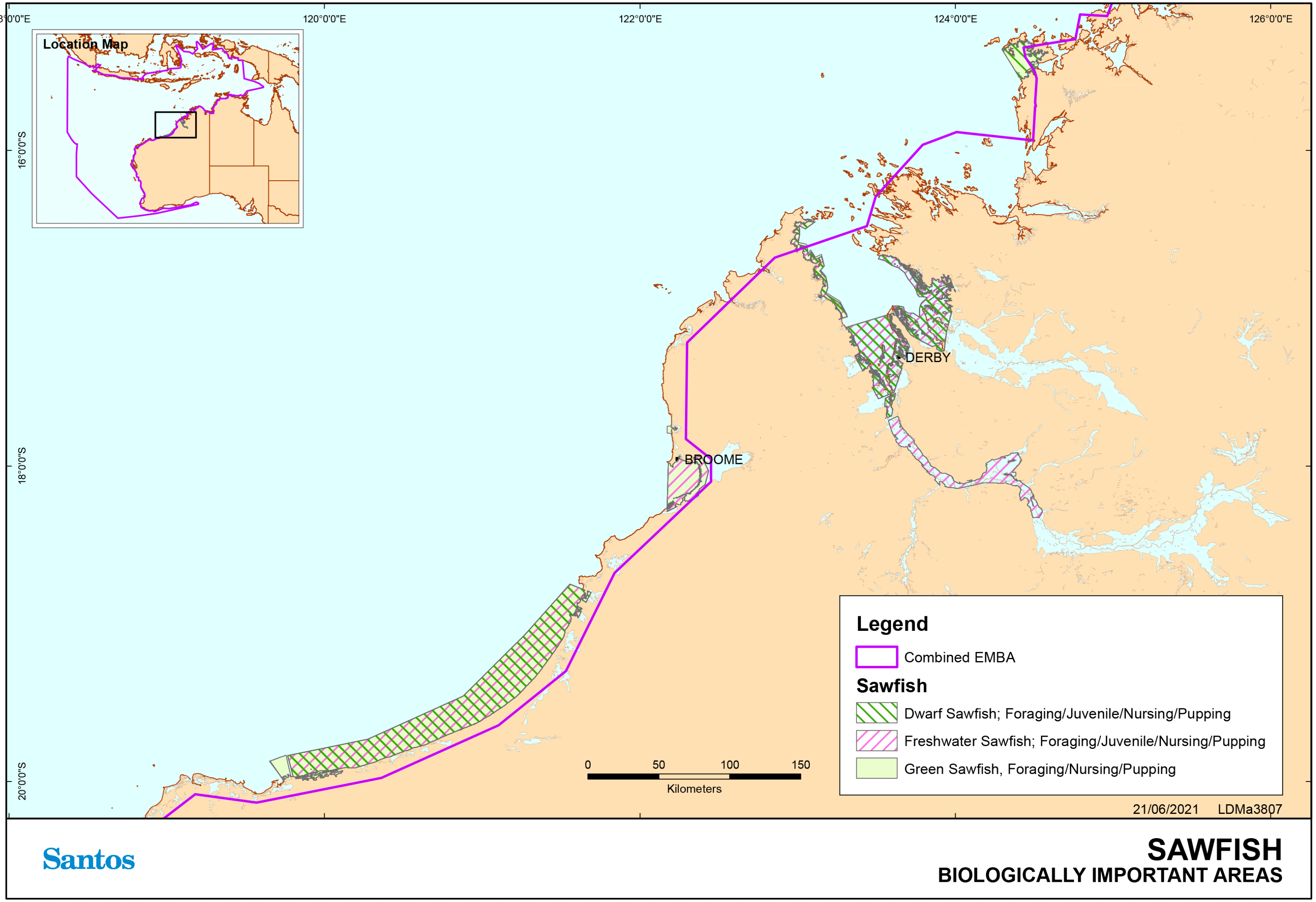


Figure 5-3: Biologically important areas – sawfish

5.3.8 Narrow Sawfish

The narrow sawfish (*Anoxypristis cuspidata*) is listed as migratory under the EPBC Act. It is a marine or marginal (brackish water) species found from inshore waters to a depth of 40 m (Compagno *et al.* 2006). Though details of its ecology are not precisely known, it probably spends most of its time on or near the bottom in shallow coastal waters and estuaries. A study showed the narrow sawfish to be the most abundant amongst the sawfish sampled in the Gulf of Carpentaria (Peverell, 2005) which holds some consistency with the offshore distribution of the species as shown by a study of Northern Prawn Fishery by-catch. Peverell (2005) also used catch data of offshore surface net fisheries to conclude that narrow sawfish also inhabit the mid-water column and can thus be described as a benthopelagic animal. The narrow sawfish is known to form aggregations of mature females during the months of October to November. Its Australian distribution is unclear though it is most common in the Gulf of Carpentaria with southward ranges extending to Broad Sound in Queensland and the Pilbara Coast (circa 116°E), Western Australia (Last & Stevens 2009).

5.3.9 Giant Manta Ray / Reef Manta Ray

The giant manta ray appears to be a seasonal visitor to coastal or offshore sites. Giant manta rays are often seen aggregating in large numbers to feed, mate, or clean. Sightings of these giant rays are often seasonal or sporadic but in a few locations their presence is a more common occurrence. This species is not regularly encountered in large numbers and, unlike some other rays do not often appear in large schools (>30 individuals) when feeding. Overall, they are encountered with far less frequency than the smaller manta species, despite having a larger distribution across the globe (IUCN 2019).

The giant manta ray (*Mobula birostris*) occurs in tropical, sub-tropical and temperate waters of the Atlantic, Pacific and Indian Oceans. They are commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts. The giant manta ray is commonly encountered on shallow reefs while being cleaned or is sighted feeding at the surface inshore and offshore. It is also occasionally observed in sandy bottom areas and seagrass beds (IUCN 2019).

The reef manta ray (*Mobula birostris*) has a circumtropical and sub-tropical distribution, existing in the Pacific, Atlantic and Indian Oceans. Within this broad range, however, actual populations appear to be sparsely distributed and highly fragmented. This is likely due to the specific resource and habitat needs of this species.

Overall population size is unknown, but subpopulations appear, in most cases, to be small (about 100–2,000 individuals). A proportion of the individuals in some populations undertake significant coastal migrations (IUCN 2019). Since the species is migratory it is possible that individuals may be encountered in the operational area, however, given that they generally do not aggregate in large groups, high numbers are not expected to be encountered during the activities.

5.3.10 Oceanic Whitetip Shark

The oceanic whitetip shark (*Carcharhinus longimanus*) is listed as migratory under the EPBC Act. The oceanic whitetip shark is widespread throughout tropical and subtropical waters of the world (30° N to 35° S) (IUCN 2020). They are an oceanic and pelagic species that regularly occurs in waters of 18 to 28°C, usually >20°C (IUCN 2020). Within Australian waters, they are found from Cape Leeuwin (Western Australia) through parts of the Northern Territory, down the east coast of Queensland and New South Wales to Sydney (Last and Stevens 2009). They are usually found in surface waters, though can reach depths of >180 m (Castro et al. 1999). They have occasionally been recorded inshore but are more typically found offshore or around oceanic islands and areas with narrow continental shelves (Fourmanoir 1961, Last and Stevens 1994).

5.3.11 Shortfin Mako and Longfin Mako Sharks

The shortfin mako and longfin mako sharks are listed as migratory under the EPBC Act. The longfin mako is widely distributed but rarely encountered oceanic shark that ranges from Geraldton around the north coast to at least Port Stephens in New South Wales (DSEWPaC 2012). The shortfin mako is an oceanic and pelagic species, although they are occasionally seen inshore. They are found throughout temperate seas but are rarely found in waters colder than 16°C.

5.3.12 Porbeagle (Mackerel Shark)

The porbeagle (mackerel shark) (*Lamna nasus*) is listed as migratory under the EPBC Act. The porbeagle is wide-ranging, typically occurring in oceanic waters off the continental shelf, although they occasionally enter coastal waters (Francis *et al*. 2002 cited in DoE 2014e). The porbeagle is known to undertake seasonal migrations, although the timing and details of these migratory movements are not well understood (Saunders *et al.* 2011 cited in DoE 2014e).

5.4 Biologically Important Areas / Critical Habitat – Fish

BIAs are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration**.** BIAs are identified by DAWE, however, they have no legal status, but are designed to assist decision making under the EPBC Act. They are not designed to identify protected areas, but may inform such processes. **Table 5-3** below provides an overview of BIAs in the combined EMBA for fish.

The DAWE may make recovery plans for threatened fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, and summary of relevant recovery plans is listed in **Section 13.2**. BIAs may overlap these sites, but may be identified for other purposes. DAWE state that the criteria used to identify 'habitat critical to the survival of the species' are more complex than those used to identify BIA. Specifically, the Sawfish and River Sharks Multispecies Recovery Plan (DoEE 2015) cites that *"all areas where aggregations of individuals have been recorded displaying biologically important behaviour such as breeding, foraging, resting or migrating, are considered critical to the survival of the species unless population survey data suggests otherwise"*.

In addition, both the EPBC Act and WA BC Act and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species'. To date no critical habitat in WA has been listed under either Act. No provision is made under the Territory Parks and Wildlife Conservation Act 1976 for listing critical habitat.

Table 5-3: Biologically important areas – fish

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Great white shark	*Carcharodon carcharias*	Foraging – associated with pinniped colonies in the mid-west and south west and waters off Bremer Bay	Waters off pinniped colonies throughout the South-west Marine Region Waters off Bremer Bay
Whale shark	*Rhincodon typus*	Foraging (high density prey) – Ningaloo Reef Foraging – Wider Ningaloo Region	Ningaloo Marine Park and adjacent Commonwealth waters Northward from Ningaloo along 200 m isobath
Dwarf sawfish	*Pristis clavata*	Foraging – Eighty Mile Beach, King Sound, Camden Sound Nursing - Eighty Mile Beach, King Sound, Fitzroy River and May Robinson River Pupping – Eighty Mile Beach, King Sound, Fitzroy River and May Robinson River Juvenile – King Sound, Fitzroy River and May Robinson River	Eighty Mile Beach Camden Sound - eastern shore Fitzroy River Mouth, May and Robinson River - tidal tributaries King Sound (inshore waters)
Freshwater sawfish	*Pristis pristis*	Nursing – King Sound Foraging – King Sound, Roebuck Bay, Eighty Mile Beach Pupping – Roebuck Bay, Eighty Mile Beach Juvenile – Roebuck Bay	Eighty Mile Beach King Sound - tidal tributaries Roebuck Bay
Green sawfish	*Pristis zijsron*	Pupping – Cape Keraudren, Eighty Mile Beach, Roebuck Bay, Willie Creek, Cape Leveque Foraging - Cape Keraudren, Roebuck Bay, Cape Leveque, Camden Sound Nursing - Cape Keraudren, Eighty Mile Beach, Ashburton River and Hooley Creek near Onslow	Eighty Mile Beach Camden Sound Cape Keraudren Cape Leveque Roebuck Bay Willie Creek Ashburton River Hooley Creek

6. Marine Reptiles

Thirty-four species of listed marine reptiles under the Commonwealth EPBC Act are known to occur in Australian waters in the combined EMBA, according to the Protected Matters search (**Appendix A**). An examination of the species profile and threats database (DoEE 2019) showed that some listed reptile species are not expected to occur in significant numbers in the marine and coastal environments in the combined EMBA due to their terrestrial distributions. Hence, these species are not discussed further.

Of the remaining reptile species identified in the Protected Matters search (**Appendix A**), eight are listed as threatened and seven are listed as migratory. These species are show in **Table 6-1** along with their WA and NT conservation listings (as applicable)[2]. BIAs within the combined EMBA area discussed in **Table 6-3**.

Table 6-1: EPBC listed marine reptile species in the combined EMBA

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
Green turtle (*Chelonia mydas*)	Vulnerable Migratory	Vulnerable	-	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Flatback turtle (*Natator depressus*)	Vulnerable Migratory	Vulnerable	-	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable Migratory	Vulnerable	-	Vulnerable	Breeding known to occur within area	Yes – refer to **Table 6-3**
Loggerhead turtle (*Caretta caretta*)	Endangered Migratory	Endangered	-	Vulnerable	Breeding known to occur within area	Yes – refer to **Table 6-3**
Olive ridley turtle (*Lepidochelys olivacea*)	Endangered Migratory	Endangered	-	-	Breeding known to occur within area	Yes – refer to **Table 6-3**
Leatherback turtle (*Dermochelys coriacea*)	Endangered Migratory	Vulnerable	-	Critically Endangered	Foraging feeding or related behaviour known to occur within area	Yes – refer to **Table 6-3**

[2] An overview of WA fauna conservation codes is provided in **Section 5** (fish and sharks).

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
Short-nosed seasnake (*Aipysurus apraefrontalis*)	Critically Endangered	Critically Endangered	-	-	Species or species habitat known to occur within area	None - No BIA defined
Leaf-scaled seasnake (*Aipysurus foliosquama*)	Critically Endangered	Critically Endangered	-	-	Species or species habitat known to occur within area	None - No BIA defined
Salt-water crocodile *(Crocodylus porosus)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined

6.1 Marine Turtles

Six species of marine turtle occur in, use the waters, and nest on sandy beaches, in and around the combined EMBA. These are the green turtle (*Chelonia mydas*), flatback turtle (*Natator depressus*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea)* and leatherback turtle (*Dermochelys coriacea*) (**Table 6-1**).

These six species are listed on the EPBC Act List of Threatened Species as either 'endangered' or 'vulnerable' and all six species are also listed as 'migratory'. They are also listed as threatened species under the BC Act and the hawksbill turtle, loggerhead turtle and leatherback turtle are also protected under the NT *Territory Parks and Wildlife Conservation Act 1976.*

A summary of the different habitat types used during the various life stages of marine turtle species identified in the combined EMBA is given in **Table 6-2.**

Table 6-2: Summary of habitat types for the life stages of the six marine turtle species in the combined EMBA (DSEWPaC, 2012b)

Life Stage		Green turtle	Flatback turtle	Hawksbill turtle	Loggerhead turtle	Olive ridley turtle	Leatherback turtle
Post-hatchling		Open ocean pelagic habitats (poorly studied for Australian populations)	Coastal waters (poorly studied for Australian populations)	Open ocean pelagic habitats (poorly studied for Australian populations)	Pelagic (poorly studied for Australian populations)	Pelagic (poorly studied for Australian populations)	Pelagic (no data for Australian populations)
Adult	Mating	Offshore from nesting beaches.	Currently unknown for North West Shelf region.	Offshore from nesting beaches.	Little is known for North West Shelf region but expected to occur either en-route or adjacent to nesting beaches.	Not recorded within North West Shelf region.	Not recorded within North West Shelf region.
	Nesting	Typically, high energy, steeply sloped beaches with deep sand and deep water approach.	Typically, low-energy beaches that are narrow with a low to moderate slope. Beach approach obstructed by broad intertidal mud or limestone platforms.	Typically beaches close to nearshore coral reefs and sediment comprised of coarse sand and coral rubble.	Poorly studied for North West Shelf region by generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches.	Not recorded within North West Shelf region.	Not recorded within North West Shelf region.
	Internesting	Shallow coastal waters within several kms of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats.	Shallow nearshore waters within 5-60 km of nesting beach. Inter-nesting buffers of 40-60 km identified around all nesting habitats.	Shallow coastal waters within several kilometres of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats.	Shallow coastal waters within several kilometres of nesting beach. Inter-nesting buffers of 20 km identified around all nesting habitats.	Not recorded within North West Shelf region. Inter-nesting buffers of 20 km identified around all nesting habitats.	Not recorded within North West Shelf region.
	Foraging	Neritic habitats associated with seagrass and algae, and mangrove habitats.	Turbid, shallow inshore waters, subtidal, soft-bottomed habitats of the continental shelf.	Subtidal and intertidal coral and rocky reef habitats of the continental shelf.	Subtidal and intertidal coral and rocky reefs, seagrass and deeper soft-bottomed habitats of the continental shelf.	Many feed within continental shelf waters, however it is not known if others are pelagic, as with the east Pacific population.	Mostly pelagic but will forage close to shore and over continental shelf in temperate waters.

6.1.1 Loggerhead Turtle

The loggerhead turtle (*Caretta caretta*) has a worldwide distribution, living and breeding in subtropical to tropical locations (Limpus 2008b). Breeding aggregations in Australia occur on both the east coast (Queensland and NSW) and the west. The annual nesting population in Western Australia is thought to be 3,000 females annually (Baldwin *et al*. 2003), and this is considered to support the third largest population in the world (Limpus 2008b). Loggerhead turtles have one genetic breeding stock within Western Australia (Commonwealth of Australia 2017a).

The WA distribution of sandy beach nesting areas extends from Shark Bay to the southern area of the North West Shelf, with occasional late summer nesting crawls recorded as far north as Barrow and Varanus Islands and the Lowendal and Rosemary Islands (DSEWPaC 2012d). Major nesting locations include the Muiron Islands, the Ningaloo Coast south to Carnarvon and the islands around Shark Bay, which includes Dirk Hartog Island, one of the principal nesting and internesting sites in WA (Limpus 2008). The Recovery Plan for Marine Turtles in Australia (2017) identifies the Muiron Islands (as a principal rookery), and all waters within a 20 km radius as habitat critical to the survival of loggerhead turtles (Commonwealth of Australia 2017a).

Estimates of up to 5,000 female loggerhead turtles have been predicted within the Ningaloo Marine Park and Muiron Islands Marine Management Area (Waayers 2010). Earlier surveys found higher proportions of nesting loggerheads in the southern areas of the reserves (CALM 2005a). Aerial surveys conducted in 2000 and 2001 in the Exmouth region recorded only 12 sightings in Commonwealth waters and these turtles were most likely loggerheads (BHP 2005). In a survey commissioned by Santos around the islands in the Exmouth Region, loggerhead turtles were recorded nesting on Flat Island north of the Exmouth Gulf which was the first time they had been recorded in that location (Astron 2014). Loggerhead nesting and breeding occurs from November to March, with a peak in late December/early January (Limpus 2008b).

Foraging areas are widespread for loggerhead turtle populations and migrations from nesting to feeding grounds can stretch thousands of kilometres, including feeding grounds as far north as the Java Sea of Indonesia for the WA population (Limpus 2008b). Loggerhead turtles have also been sighted in the Christmas and Cocos (Keeling) Islands. Shark Bay has been identified as an important foraging habitat for loggerhead turtles (Commonwealth of Australia 2017a). Loggerhead turtles are carnivorous and feed primarily on benthic invertebrates from depths of up to approximately 50 m to near shore tidal areas including areas of rocky and coral reef, muddy bays, sand flats, estuaries and seagrass meadows (Limpus 2008b).

Figure 6-1 illustrates the BIAs and habitat critical (draft) for loggerhead turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a).

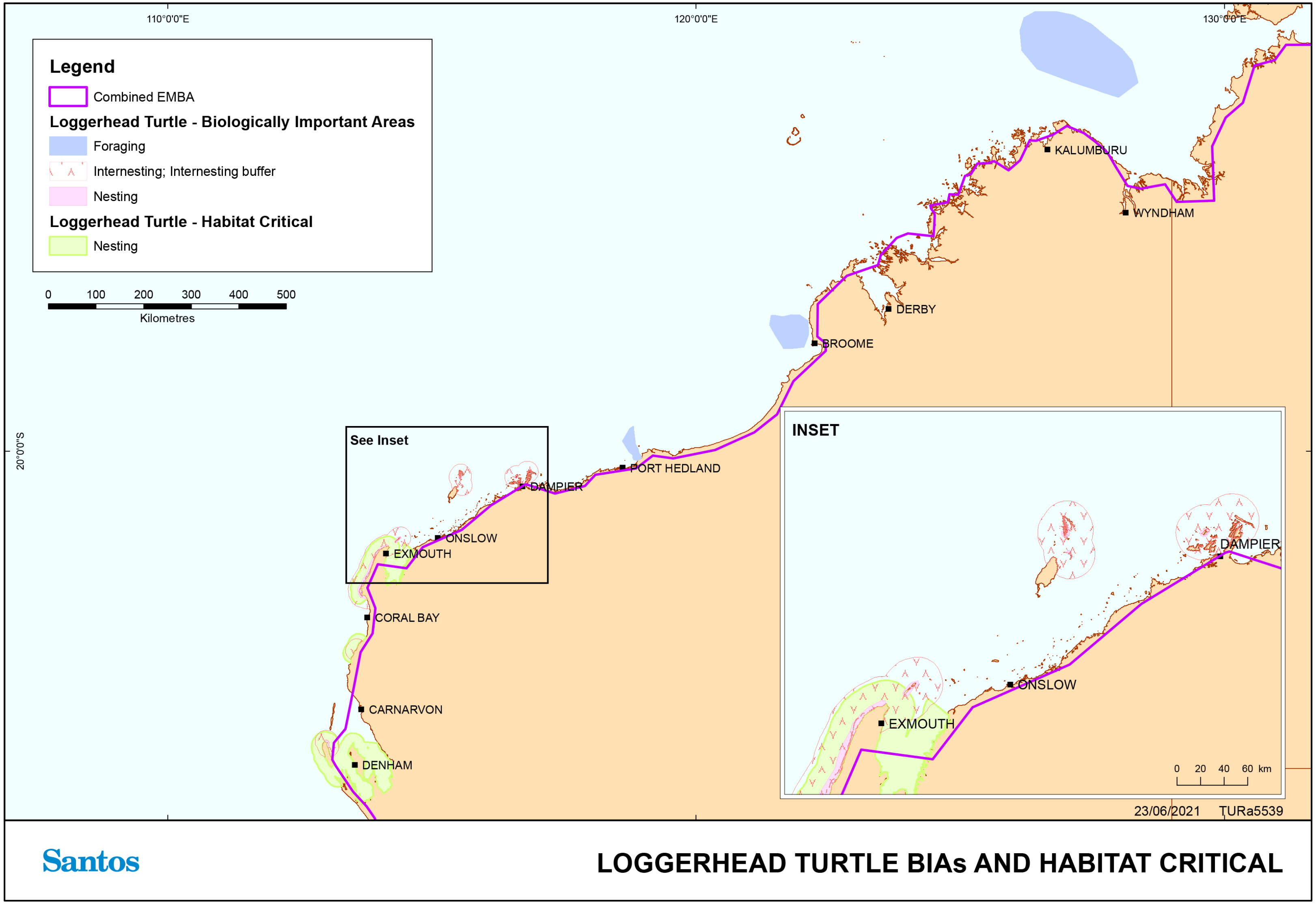


Figure 6-1: Biologically Important Areas and Habitat Critical – Loggerhead Turtle

6.1.2 Green Turtle

Australian population of green turtles is estimated to be approximately 70,000 and is divided into seven genetically distinct breeding aggregations. The species is widespread and abundant in WA and NT waters with an estimated 20,000 individuals occurring, arguably the largest population in the Indian Ocean (Limpus 2008a). There are three distinct breeding stocks in WA waters which include: the North west Shelf stock, the Scott-Browse stock and the Ashmore Stock (Commonwealth of Australia 2017a).

The North west Shelf population is one of the largest in the world and the most significant rookery is the western side of Barrow Island (Prince 1994, Limpus 2008a). Other principal rookeries include the Lacepede Islands, Montebello Islands, Dampier Archipelago, Browse Island and North West Cape (Prince 1994, Limpus 2008a, DSEWPaC 2012b). See **Table 6-3** for a complete list.

Surveys by Waayers (2010) within the Ningaloo Marine Park and Muiron Islands Marine Management Area estimated up to 7,500 female green turtles used these areas. In 2014, Santos commissioned a survey of the islands in the Exmouth Region which found that North and South Muiron Islands were significant nesting sites for green turtles with over 100 green turtles nesting overnight on one beach at North Muiron Island (Astron 2014). The green turtle is also known to breed in large numbers in the dunes above the extensive beaches found on Serrurier Island, with counts indicating the island supports the second largest rookery in the Pilbara (Oliver 1990).

Lower density green turtle nesting has also been recorded on Jurabi coast, Thevenard Island, Lowendal Islands and in Exmouth Gulf (Limpus 2008a). Only low numbers of green turtles have been observed nesting on Varanus Island, as well as Airlie Island (Pendoley Environmental 2011). From monitoring undertaken in 2016/17 by Santos on Varanus Island; three green turtles were observed to nest over a four week tagging effort (Astron 2017).

Green turtles have also been recorded nesting in the Bonaparte or Van Diemen Gulf bioregions and some nesting has been recorded on the west coast of Bathurst Island in the Tiwi Islands and Melville Island. BIAs for Green turtles occur on the north coast of the Tiwi Islands and an internesting buffer has been defined 20 km from the Tiwi Islands with internesting expected between October and April (DoEE, 2017).

Green turtle nesting abundance and timing fluctuates significantly from year to year depending on environmental variables, locality and food availability (Pendoley Environmental 2011). Nesting of green turtles has been recorded from August to March on Serrurier Island (Woodside 2002), from December to March along coast adjacent to Ningaloo (CALM 2005a) and from October to February on Varanus Island (Pendoley Environmental 2011). On Barrow Island, mating aggregations may commence from October with peak nesting from December to January, with hatchlings emerging through summer and early autumn. However, nesting on Barrow Island has been recorded all year round (Chevron 2005 and 2008, Pendoley 2005). Nesting on the Scott Reef-Sandy Islet and Browse Island has been observed all year round with peaks between December and January (Commonwealth of Australia 2017a).

In northern and eastern Australia, fluctuations in green nesting numbers have been linked the Southern Oscillation Index (Limpus & Nicholls, 1994, Limpus & Nicholls, 1988) and sea surface temperatures (Solow et al., 2002). In the NT nesting sites occur mostly from the western end of Melville Island to near the border with Queensland (Northern Territory Government, n.d). There are also four nationally significant nesting sites in the NT being the Cobourg Peninsula, the mainland from Gove to the northern edge of Blue Mud Bay, the southeast of Groote Eylandt and the northern beaches of islands in the Sir Edward Pellew group (Northern Territory Government, n.d). The Cobourg Peninsula genetic stock of Green turtles is the closest to those found within the combined EMBA on the Tiwi Islands. The nesting period for these are between October and April with the peak nesting period occurring between December and January.

Green turtles nest on both Christmas and Cocos (Keeling) Islands, though in low densities on Christmas Island. Up to 100 green turtles nest per year on Cocos (Keeling) Islands, mainly on the north atoll. Green turtles nesting on both Christmas and Cocos (Keeling) Islands are likely to be unique genetic stocks. They also use shallow reef habitats on both islands to forage (Brewer et al, 2009).

The re-nesting period for female green turtles is approximately five years (Hamann *et al*. 2002).

Green turtles spend the first five to ten years of their life drifting on ocean currents, before moving to reside in shallower benthic habitats, including tropical coral and rocky reefs and seagrass beds. Green turtles have been known to migrate more than 2,600 km between feeding and breeding grounds (Limpus 2008a).

Green turtles are omnivores, mainly feeding in shallow benthic habitats on seagrass and/ or algae, but are also known to feed on sponges, jellyfish and mangroves (Limpus 2008a). Green turtles are unlikely to forage or dwell within deeper offshore waters due to the water depths; however, they may occasionally migrate through it.

Figure 6-2 illustrates the BIAs and habitat critical (draft) for green turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a).

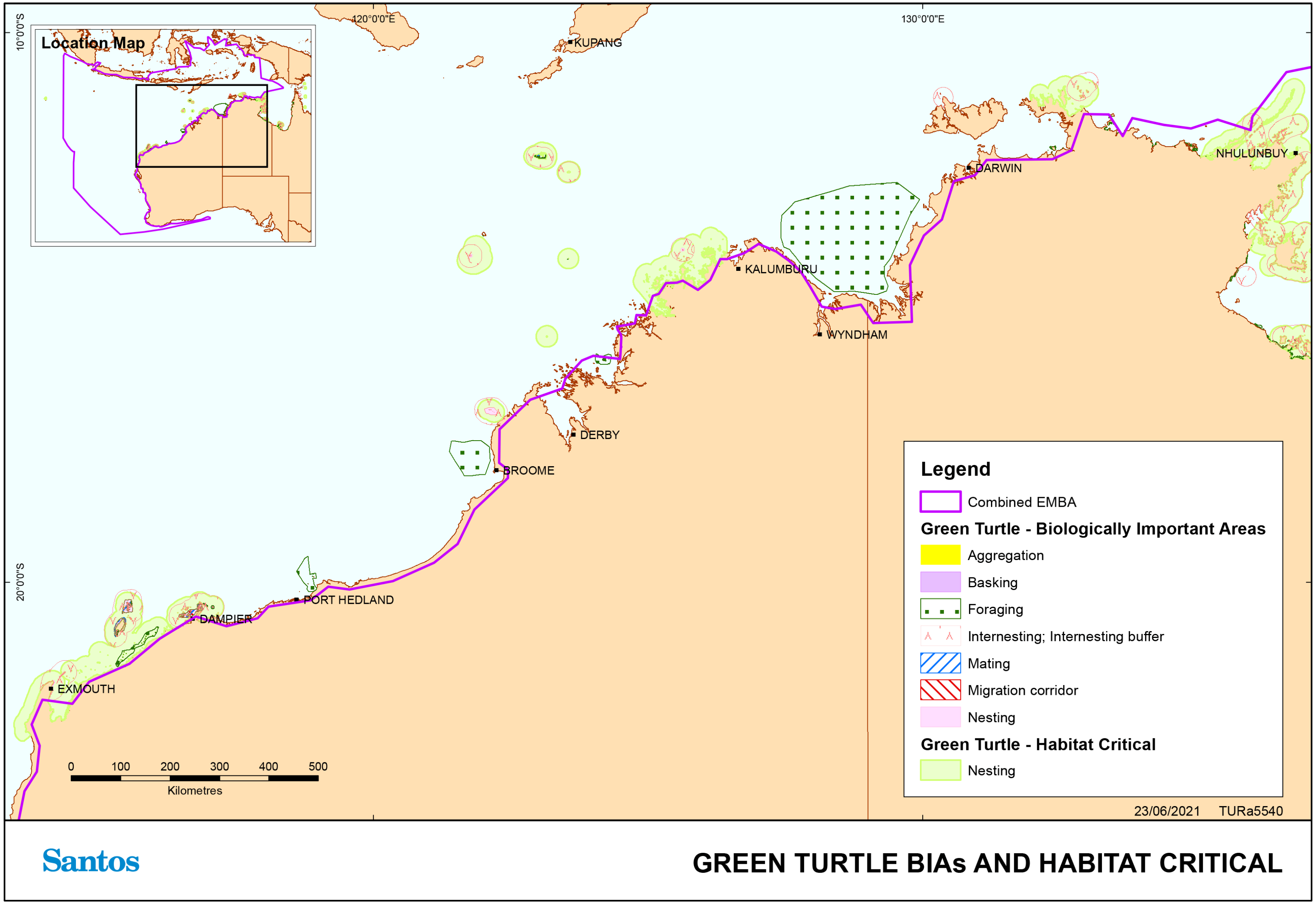


Figure 6-2: Biologically Important Areas and Habitat Critical – Green Turtle

6.1.3 Hawksbill Turtle

Hawksbill turtles (*Eretmochelys imbricata*) have a global distribution throughout tropical and sub-tropical marine waters. The Western Australian stock is concentrated on the North West Shelf (Dampier Archipelago) (Limpus 2009a),and is considered to be one of the largest hawksbill populations remaining in the world. The estimated number of nesting hawksbill turtles in WA waters is between 2,000 and 4,500 individuals (Morris 2004). There is a second major population of Hawksbill turtles in Australia, which is genetically isolated from the North West Shelf population located along the Northern Territory coast and north-eastern Queensland (Northern Territory Government, n.d).

In WA, their nesting range is relatively small and extends from the Muiron Islands to the Dampier Archipelago, a distance of approximately 400 km. The most significant breeding areas, that support hundreds of nesting females annually, are around sandy beaches within the Dampier Archipelago, Montebello Islands, Lowendal Islands and Barrow Island (Pendoley 2005, Limpus, 2009a).

The largest known nesting area for the North West Shelf population is the sandy shoreline of Rosemary Island, within the Dampier Archipelago, particularly on the north-western side of the Island. It is believed that the Rosemary Island rookery may support up to 1,000 nesting females annually (Limpus 2009). Low density nesting is also known from Barrow Island, Airlie Island, Muiron Islands and North West Cape/ Ningaloo coast (Cape Range) (Limpus 2009a). Nesting hawksbills have also been found on NE Regnard Island and SW Regnard Island, confirming the Regnard Islands as hawksbill rookeries (Pendoley Environmental 2009).

The hawksbill turtle nesting population within the Exmouth region is also considered important as the populations in Western Australia represent the largest remaining population in the Indian Ocean (CALM 2005). The best estimate of numbers within the Ningaloo Marine Park and Muiron Islands Marine Management Area is between 20–700 individuals (Waayers 2010).

A snapshot survey of Varanus Island and the Lowendal Islands conducted for Santos during October 2012 found the five most frequented beaches by hawksbills, based on the track counts, were Beacon Island *(n*=43), Parakeelya (*n*=41), Kaia (*n*=40), Rose (*n*=30) and Pipeline (*n*=28). Results of the October 2012 three-day track census program showed that Beacon Island also hosted the highest daily number of overnight emergences by hawksbills and is therefore an important nesting beach for hawksbill turtles (Pendoley Environmental 2013).

On Varanus Island, hawksbill turtle nesting activity is predominantly distributed on the island's east coast, including Pipeline, Harriet, and Andersons beaches (Pendoley Environmental 2019). Individual hawksbill turtles appear to show a strong fidelity to these beaches, often returning to the same beach to nest within the season (Pendoley Environmental 2019). Between 1986 and 2019, a total of 571 individual hawksbill turtles were tagged on Varanus Island. Recent baseline data was collected at the Montebello and Dampier AMPs by Keesing, 2019 showing that only one hawksbill turtle was identified during the survey at the Dampier AMP only. No marine turtle species were identified during the survey at Montebello AMP.

In the NT, nesting occurs on islands rather than on mainland beaches. In particular, NT nesting sites are concentrated around north-eastern Arnhem land and Groote Eylandt (Northern Territory Government, n.d). Within the combined EMBA, nesting is known to occur at Ashmore Reef. Although Scott Reef has been described as a nesting beach for hawksbill turtles, this is based on the tagging and recapture of a single hawksbill at this location (Guinea, 2009). Small numbers of Hawksbill turtles also nest on Cocos (Keeling) Islands (mainly the north island). However, thousands of individuals forage in the shallow reef environments feeding on encrusting algae and sessile invertebrates (Brewer et al , 2009).

Nesting is reported to occur between October and February in WA (Commonwealth of Australia 2017a). Hawksbill turtles have been observed breeding on the North West Shelf between July and March with peak nesting activity around the Lowendal Islands between October and December (Limpus 2009a). In the NT nesting is reported to occur from July – December (Chatto, 1997, 1998).

Female hawksbills skip annual breeding opportunities (Kendall & Bjorkland 2001), presumably due to high energy demands of breeding (Chaloupka & Prince 2012).

Individuals may migrate up to 2,400 km between their nesting and foraging grounds (DSWEPaC 2012a), however a recent tagging study showed that turtles migrating from WA rookeries remain on the continental shelf (< 200 m depth) and within Australian waters during their inter-nesting, migrating and foraging phases (Fossette *et al*. 2021). Satellite tracking of nesting turtles on Varanus Island (32 km) and Rosemary Island has shown adult turtles to feed between 50 and 450 km from their nesting beaches (DSWEPaC 2012a).

Adults tend to forage in tropical tidal and sub-tidal coral and rocky reef habitat where they feed on an omnivorous diet of sponges, algae, jelly fish and cephalopods (DSWEPaC 2012a). Hawksbill turtles are unlikely to spend significant time within offshore waters as it is too deep to act as a feeding ground. However, it is likely they may migrate through those areas.

In order to better quantify and map the important areas used by Hawksbill turtles, AIMS was engaged in 2020 to lead the North West Shoals to Shores Research Program. During this program, AIMS combined available existing satellite tracking data for 20 adult turtle with data from newly deployed satellite tags on 20 adults in the Lowendal Islands and Dampier Archipelago (AIMS, 2021). Results showed that critical habitat designated by the Australian Government for inter-nesting largely protects the nesting areas calculated (AIMS, 2021), however the existing foraging BIAs do not include the majority of foraging areas calculated (AIMS, 2021). While approximately 23% of the hawksbill turtles foraging distribution occurred within MPAs, the existing BIAs are largely underestimating the important foraging areas for the turtles (AIMS, 2021). This supports the results of a joint study conducted by Fossette *et al.* (Fossette *et al., 2021),* which found only 10% of foraging areas utilised by 42 nesting turtles (between 2000 and 2017) were encompassed by the designated foraging BIA. Fossette *et al* (2021) found that the highest overlap of individual turtles occurred within the Migratory BIA corridor.

Figure 6-3 illustrates the BIAs and habitat critical (draft) for hawksbill and olive ridley turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a).

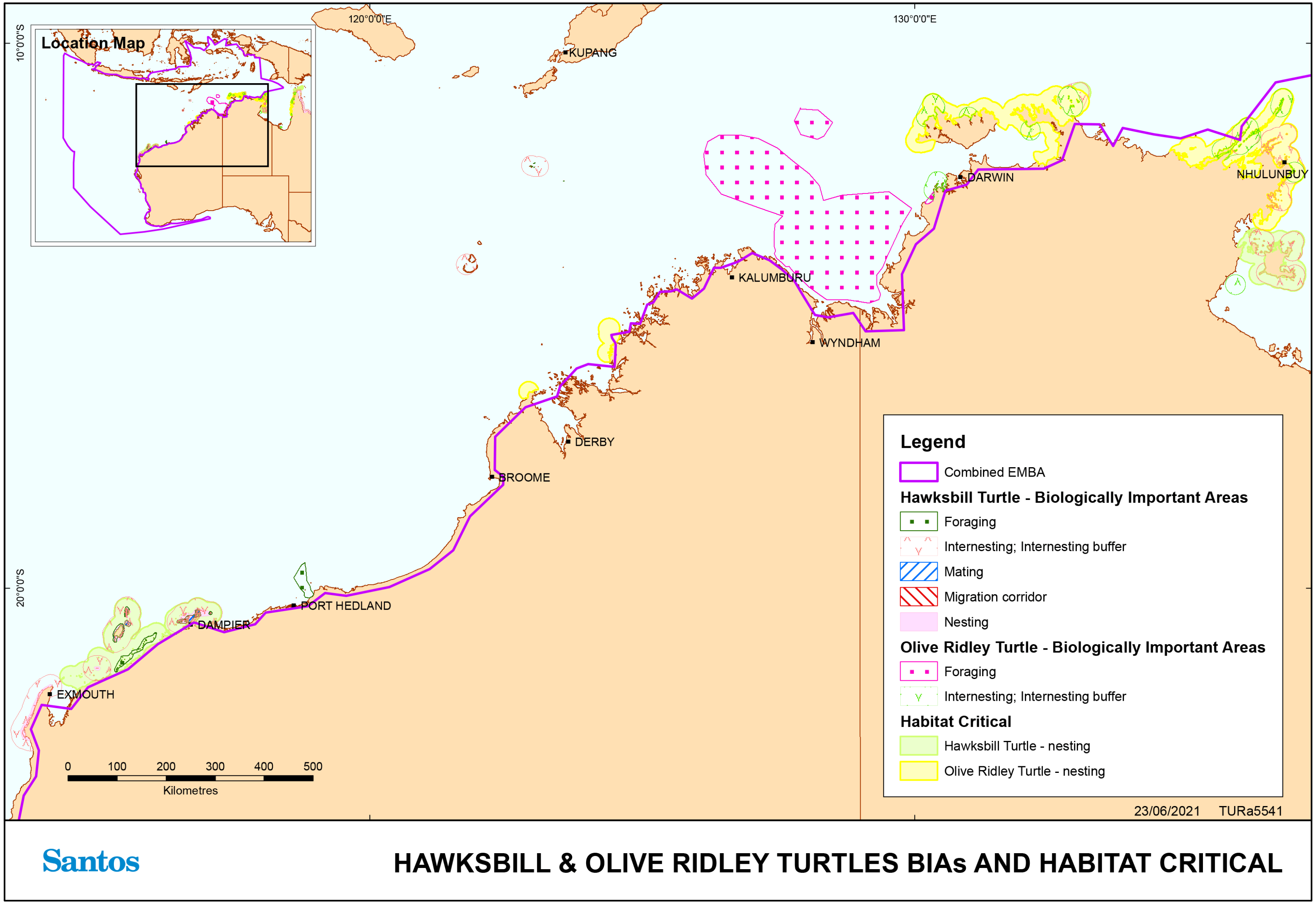


Figure 6-3: Biologically Important Areas and Habitat Critical – Hawksbill and Olive Ridley Turtle

6.1.4 Flatback Turtle

The flatback turtle (*Natator depressus*) has an Australasian distribution, with all recorded nesting beaches occurring within tropical to sub-tropical Australian waters. One third of the total breeding for the species occurs in Western Australia (WA) (Limpus, 2007). The management of the flatback turtle in Australia is broken up into five stocks currently described around Australia; eastern Queensland, Arafura Sea, Cape Domett, South-west Kimberley and Pilbara stocks (Commonwealth of Australia 2017). The Pilbara stock nests throughout the North West Shelf and is characterised by summer nesting (October to March), and the northern stock at Cape Domett breeds mainly in winter (July to September) (Commonwealth of Australia 2017a). The South-west Kimberley stock is also characterised by summer nesting. Populations in western NT are thought to nest all year round with nesting density reaching its peak in July. Populations in northern Australia also nest all year round, with nesting density reaching its peak between June and August (Limpus, 2007).

The southern WA nesting population of flatback turtles occurs from Exmouth to the Lacepede Islands off the Kimberley coast (DSEWPaC 2012c). On the North West Shelf, significant rookeries are centred on Barrow Island especially the east coast beaches (DSEWPaC 2012b). NT populations are typically found in the Gulf of Carpentaria, western Torres Strait, Wellesley Islands Group and Sand Islet.

Montebello Islands, Thevenard Island, Varanus Island, the Lowendal Islands, King Sound and Dampier Archipelago are also significant rookeries (Pendoley 2005, Limpus 2007, Pendoley Environmental 2011). Nesting is also widespread along the mainland beaches from Mundabullangana on the Pilbara coast north, including Cemetery Beach near Port Hedland, Eighty Mile Beach and to Broome (Limpus 2007, DSEWPaC 2012b).

Long term monitoring of flatback turtles nesting in the Port Hedland area, specifically at Cemetery Beach and Pretty Pool Beach, was undertaken between 2004 and 2014. Monitoring results indicated the main nesting season of flatback turtles in the area was between mid-October and January, which is consistent with other rookeries in the Pilbara region including Barrow Island, Mundabullangana, Karratha and Onslow (Waayers and Stubbs 2016). The onset of the nesting season appears to be relatively consistent each year and is thought to be associated with the southern movement of warmer sea surface temperatures along the northern WA coast.

There have been occasional records of nesting by flatback turtles on the Jurabi Coast and Muiron Islands (CALM 2005). During turtle surveys for Santos, WA flatback turtle nesting was recorded on Bessieres Islands (Astron 2014), Serrurier, Flat, Table and Round Island in previous surveys (Pendoley Environmental 2009). Flatback turtle tracks have been seen on Forty Mile beach and evidence of flatback nesting was recorded on the same beach the next day (Pendoley Environmental 2009). Previously the status of the flatback population(s) was undetermined and although not well quantified, it was estimated to be many thousands of females (Limpus 2007). However, Pendoley *et al*. (2014) reported both Barrow Island and Mundabullangana flatback turtles as substantial reproductive populations with 4,000 and 3,500 turtles tagged at each location between 2006/2006 and 2010/2011. Cemetery beach at Port Hedland had approximately 350 turtles were tagged over two seasons of monitoring (2009/2010 and 2011/12).

Satellite tracking of adult (female) flatback turtles shows they use a variety of inshore and offshore marine areas off the east and west coasts of Barrow Island. Females inter-nest close to their nesting beaches, typically in 0–10 m of water (Chevron 2008). However, flatback turtles also travel approximately 70 km and inter-nest in shallow nearshore water off the adjacent mainland coast, before returning to Barrow Island to lay another clutch of eggs. The average inter-nesting period is 13–16 days.

From long-term tagging studies on Varanus Island and Pendoley's observations, it appears that the nesting season for flatback turtles peaks in December and January with subsequent peak hatchling emergence in February and March. Flatbacks have been observed to nest on Varanus Island between November and February (Chevron 2008, Pendoley Environmental 2011 & 2013). Population monitoring of flatback turtles on Varanus Island, calculated from 16 seasons, indicates a mean population estimate of 226 (+/- 97). Modelled flatback turtle populations have shown a slight decline from 2008/09 to 2016/17, which is considered to be part of fluctuations in the natural cycle (Astron 2017). Flatback turtles tend to nest on all beaches on Varanus Island (Astron 2017). Flatback hatching and emergence success is noted as higher compared to that reported for other Western Australian rookeries (Pendoley et al. 2014; cited Astron 2017).

Unlike other sea turtles, the flatback turtle lacks a wide oceanic dispersal phase and adults tend to be found in soft sediment habitats within the continental shelf of northern Australia (DSEWPaC 2012b). Despite having geographically large foraging ranges (>1500 km), genetic differentiation suggests strong natal homing for both males and females (Turner Tomaszewicz *et al*, 2022). Little information is known on the diets of flatback turtles (DSEWPaC 2012b), however, they are believed to forage on primarily soft-bodied invertebrates (Commonwealth of Australia 2017a). Flatback turtles also differ from other species of sea turtles in maturing at a larger size and a likely younger age (<20 years) in comparison to other sea turtle species, indicating they may have a more rapid growth rate in their juvenile (similar to the leatherback turtle, a species with their own family) (Turner Tomaszewicz *et al*, 2022). This information from Turner Tomaszewicz *et al*, 2022 may provide valuable insight for ongoing population assessments and future recovery plans (Turner Tomaszewicz et al, 2022).

Figure 6-4 illustrates the BIAs and habitat critical (draft) for flatback turtles (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a).

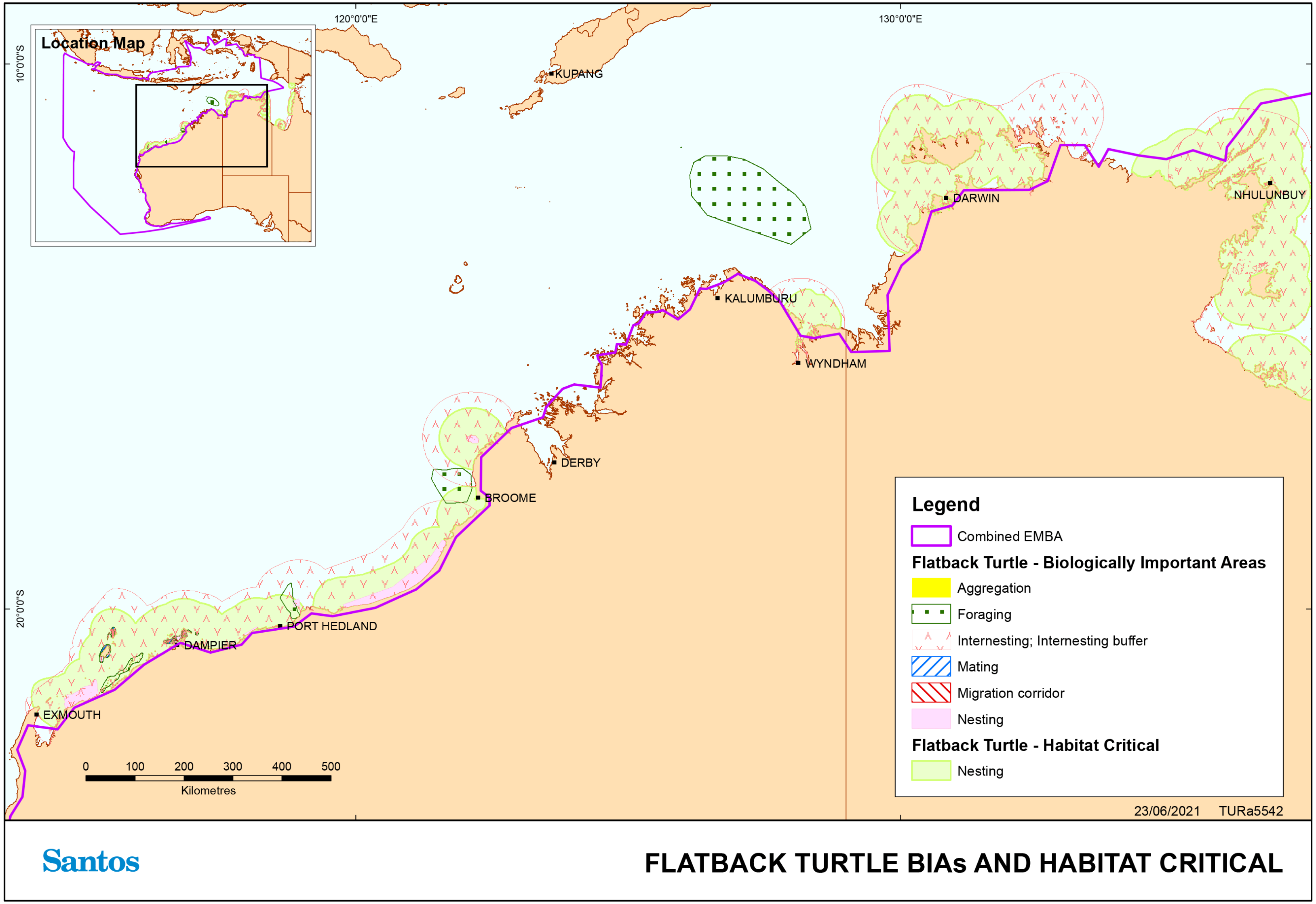


Figure 6-4: Biologically Important Areas and Habitat Critical – Flatback Turtle

6.1.5 Leatherback Turtle

The leatherback turtle *(Dermochelys coriacea*) has the widest distribution of any marine turtle, and can be found from tropical to temperate waters throughout the world (Márquez 1990). There are no major leatherback turtle centres of nesting activity that have been recorded in Australia, although scattered isolated nesting (one to three nests per annum) occurs in southern Queensland and the Northern Territory (Limpus and McLachlin 1994).

There have been several records of leatherback turtles off the coast of WA and NT, but no confirmed nesting sites (Limpus 2009c). Turtle observations have mainly occurred south of the North West Shelf area and in open waters (>200 m deep) (Limpus 2009c). Due to the lack of nesting sites around Australian coastal waters, it is presumed that leatherback turtles observed in Australian waters are migrating from neighbouring countries to utilise feeding grounds in Australia (Limpus 2009c).

The leatherback turtle will feed at all levels of the water column and is carnivorous feeding mainly on pelagic, soft-bodied marine organisms such as jellyfish, which occur in greatest concentrations in areas of upwelling or convergence (DSEWPaC 2012d). The leatherback turtle is a highly pelagic species with adults only going ashore to breed.

No leatherback turtle BIAs or habitat critical (draft) are found within the combined EMBA.

6.1.6 Olive Ridley Turtles

Olive ridley turtles (*Lepidochelys olivacea*) are the least common turtle species encountered with critical nesting habitat occurring near Vulcan Island, Darcy Island, Prior Point and Llanggi and Cape Leveque (Commonwealth of Australia 2017). They are also known to nest on Tiwi Islands, specifically on the west coast of Bathurst Island and the north coast of Melville Island. The turtles found nesting on the Tiwi Islands is the NT genetic stock whereby the long-term trends of this genetic stock are currently unknown (Commonwealth of Australia 2017). However, the number of females nesting on the Tiwi Islands are considered significant at the genetic stock, national and international level. Nesting of the NT genetic stock can occur year-round with a peak between April and June, and hatchling emergence peaking between June and August (Commonwealth of Australia, 2017).

Internesting habitat, critical to the survival of the olive ridley turtle, encompasses nearshore waters along the north, west and east coasts of the Tiwi Islands. Satellite tracking on a small sample of internesting olive ridley turtles in the region recorded that the individuals remained close to shore (waters depths typically less than 55 m deep) and within 37 km of the nesting beach during the internesting interval (Whiting et al. 2007, Whiting et al. 2005).

The species is known to forage within the shallow benthic habitats of northern WA, the NT and Timor Sea (Limpus 2009), however, it displays unusual behaviour patterns compared to other sea turtles, in being capable of deeper (up to 140 m), benthic and exceptionally long (>2 hour) dives (McMahon *et al.,* 2007). This trait, combined with their long-distance movement patterns (Polovina *et al*., 2004) is thought to be indicative of less specialist foraging (McMahon *et al.,* 2007). Olive Ridley turtles forage as far south as the Dampier Archipelago-Montebello Islands and have also been sighted in the Christmas and Cocos (Keeling) Islands in the north of the combined EMBA, and is thought to feed primarily on gastropods and small crabs within the benthic, soft-bottomed communities of the continental shelf (Limpus 2009). Their extensive movements and variability in migration patterns suggest this species may be susceptible to a wide range of human activities (McMahon *et al.,* 2007).

BIAs for this endangered species are known to occur in the vicinity of Joseph Bonaparte Depression (DSEWPaC 2012b, Commonwealth of Australia 2017a). See **Figure 6-3** for identified olive ridley turtle BIAs and critical habitats (draft) within the combined EMBA (as defined in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a).

6.2 Seasnakes

Storr *et al*. (1986) estimate nine genera and 22 species of sea snakes occur in WA waters, with 25 listed marine seasnake species being recorded in the search area of WA and NT waters (**Appendix A**). Little is known of the distribution of individual species, population sizes or aspects of their ecology. Seasnakes are essentially tropical in distribution, and habitats reflect influences of factors such as water depth, nature of seabed, turbidity and season (Heatwole and Cogger 1993). Seasnakes are widespread throughout waters of the North West Shelf in offshore and nearshore habitats. They can be highly mobile and cover large distances or they may be restricted to relatively shallow waters and some species must return to land to eat and rest. In the north-west region of Western Australia, no BIAs have been designated for seasnakes. However, both Ashmore Reef and Cartier Island are characterised for both a high density and high diversity of seasnakes (DSEWPaC 2012b). The limited evidence available suggests that there are no sea snakes in at least the coastal waters of Cocos (Keeling) Islands, and few sea snake sightings in the waters of the Christmas Island territory (Brewer *et al,* 2009).

Two species of seasnakes listed as threatened under the EPBC Act were identified in the Protected Matters search within the combined EMBA (**Appendix A**):

+ Short-nosed seasnake (*Aipysurus apraefrontalis*); and
+ Leaf-scaled seasnake (*Aipysurus foliosquama*).

6.2.1 Short-nosed Seasnake

The short-nosed seasnake (*Aipysurus apraefrontalis*) is listed as critically endangered under the EPBC Act and the BC Act. It is a fully aquatic, small snake and is endemic to WA. It has been recorded from Exmouth Gulf, WA to the reefs of the Sahul Shelf, in the eastern Indian Ocean. This species is believed to show strong site fidelity to shallow coral reef habitats in less than 10 m of water, with most specimens having been collected from Ashmore and Hibernia reefs (Minton & Heatwole 1975, Guinea and Whiting 2005).

The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (McCosker 1975, Cogger 2000). The species has been observed during daylight hours, resting beneath small coral overhangs or coral heads in 1–2 m of water (McCosker 1975). Guinea and Whiting (2005) reported that very few short-nosed seasnakes moved even as far as 50 m away from the reef flat and are therefore unlikely to be expected in high numbers in offshore, deeper waters.

6.2.2 Leaf-scaled Seasnake

The leaf-scaled seasnake *(Aipysurus foliosquama)* is listed as critically endangered under the EPBC Act and the BC Act. It occurs in shallow water (less than 10 m in depth), in the protected parts of the reef flat, adjacent to living coral and on coral substrates (DoE 2014). The species is found only on the reefs of the Sahul Shelf in WA, especially on Ashmore and Hibernia Reefs (Minton and Heatwole 1975). The leaf-scaled seasnake forages by searching in fish burrows on the reef flat (DoE 2014).

6.3 Crocodiles

The salt-water crocodile (*Crocodylus porosus*) is a migratory species under the EPBC Act and is also listed as a specially protected species (other specially protected fauna) under the BC Act. In WA, the species is found in most major river systems of the Kimberley, including the Ord, Patrick, Forrest, Durack, King, Pentecost, Prince Regent, Lawley, Mitchell, Hunter, Roe and Glenelg Rivers. The largest populations occur in the rivers draining into the Cambridge Gulf and the Prince Regent River and Roe River systems. There have also been isolated records in rivers of the Pilbara region, around Derby near Broome and as far south as Carnarvon on the mid-west coast (DEC 2009a).

In the NT salt-water crocodile has been found in the Mary, Adelaide, Daly, Moyle, Victoria, Finniss, Wildman, West Alligator, East Alligator, South Alligator, Liverpool, Blyth, Glyde, Habgood, Baralminar, Goromuru, Cator and Peter John Rivers with a total 79 individuals per km identified in these river systems (Fukuda, 2007).

6.4 Biologically Important Areas/Habitat Critical – Marine Reptiles

Table 6-3 provides an overview of BIAs in the combined EMBA for marine reptiles, as identified by the DAWE (Commonwealth) and critical habitats identified in associated recovery plans. The DAWE may make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[3].

In addition, both the EPBC Act and WA BC Act and associated regulations (2018) provide for the listing of habitat critical - habitat 'critical to the survival of the threatened species. To date no habitat critical in WA has been listed under either Act. No provision is made under the Territory Parks and Wildlife Conservation Act 1976 for listing critical habitat.

[3] Further background information on BIA and identification of critical habitat in recovery plans is provided in **Section 5.4**.

Table 6-3: Biologically important areas/critical habitats and geographic locations - reptiles

Species	Scientific name	Aggregation area and use	BIAs within EMBA	Habitat Critical within EMBA
Loggerhead turtle	*Caretta caretta*	Nesting, migration, foraging and internesting – Islands and coastline of the Kimberley region and islands of the North West Shelf, Ningaloo coast and Jurabi coast	Cohen Island De Grey River to Bedout Island Dirk Hartog Island Gnarloo Bay James Price Point Lowendal Island Montebello Island Muiron Island Ningaloo Coast and Jurabi coast Rosemary Island Western Joseph Bonaparte Depression	Exmouth and Ningaloo coast Gnaraloo Bay and beaches Shark bay, all coastal and island beaches out the to the northern tip of Dirk Hartog Island
Green turtle	*Chelonia mydas*	Nesting, migration foraging, aggregation, mating, basking and internesting – Offshore islands in the Browse Basin, North West Shelf and Kimberley/Pilbara coastlines Mating/nesting – Dampier Archipelago Basking – Middle Island	Ashmore Reef Barrow Island Browse Island Cartier Island Cassini Island Coral reef habitat west of the Montebello group. Extends the entire length of Montebellos Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Island Delambre Island Dixon Island Greens - inshore tidal and shallow subtidal areas around Barrow Island Hawksbills - shallow water coral reef and artificial reef (pipeline) habitat James Price Point Joseph Bonaparte Gulf Lacepede Island Legendre Island, Huay Island Middle Is. West Coast Barrow Island West Coast and North Coast Montebello Island - Hermite Island, NW Island, Trimouille Island Montebello Islands	Mainland east of Mary island to mainland adjacent to Murrara Island including all offshore islands Ashmore Reef and Cartier Reef Browse Island Scott Reef Adele Island Lacepede Island Dampier Archipelago Barrrow Island Montebello Islands Serrier Island and Thevenard Island Exmouth Gulf and Ningaloo Coast

Species	Scientific name	Aggregation area and use	BIAs within EMBA	Habitat Critical within EMBA
			Montgomery Reef North and South Muiron Island North Turtle Island North West Cape Scott Reef Scott Reef - Sandy Islet Seringapatam Reef String of islands between Cape Preston and Onslow, inshore of Barrow Is North-west of Melville Island	
Hawksbill turtle	*Eretmochelys imbricata*	Nesting, migration, mating, foraging and internesting – Offshore islands in the Browse Basin, North West Shelf and Kimberley/Pilbara coastlines Mating/ nesting/ internesting – Lowendal group, Montebello Islands	Ah Chong and South East Island Ashmore Reef Barrow Island Cartier Island Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Island Delambre Island Delambre Island (and other Dampier Archipelago Islands) Dixon Island Greens - inshore tidal and shallow subtidal areas around Barrow Island Hawksbills - shallow water coral reef and artificial reef (pipeline) habitat Lowendal Island Group Montebello Island - Hermite Island, NW Island, Trimouille Island Montebello Island, Trimoulle and NW islands Ningaloo coast and Jurabi coast Rosemary Island Scott Reef String of islands between Cape Preston and Onslow, inshore of Barrow Island Thevenard Island Varanus Island	Cape Preston to mouth of Exmouth Gulf (including Montebello Islands and Lowendal Islands) Dampier Archipelago (including Delambre Island and Rosemary Island) New Year Island 20 km internesting buffer

Species	Scientific name	Aggregation area and use	BIAs within EMBA	Habitat Critical within EMBA
Flatback turtle	*Natator depressus*	Nesting, migration, mating, aggregation, foraging, internesting – Islands of the North West Shelf and the Pilbara/Kimberley coastlines Mating, nesting – Barrow Island	Eighty Mile beach Barrow Island Cape Domett Cape Thouin/ Mundabullangana/ Cowrie Beach Coral reef habitat west of the Montebello group. Extends the entire length of Montebellos Dampier Archipelago (islands to the west of the Burrup Peninsula) De Grey River area to Bedout Island Delambre Island Dixon Island Holothuria Zone (Northern Kimberley, Holothuria Banks) Intercourse Island James Price Point Lacepede Island Legendre Island, Huay Is Montebello Island - Hermite Island, NW Island, Trimouille Island North Turtle Island Port Hedland, Cemetery Beach Port Hedland, Paradise Beach Port Hedland, Pretty Pool String of islands between Cape Preston and Onslow, inshore of Barrow Is The main nesting beach at Cape Domett is a 1.9-km-long north-west-facing sandy beach on the east of the Cambridge Gulf, East Kimberley, Western Australia (14 48.10S, 128 24.50E), located approximately 80 km north-north-east of the nearest town, Wyndham. Thevenard Island - South coast West of Cape Lambert	Cape Domett and Lacrosse Island Lacepede Islands Eighty Mile beach Cemetary beach Eco Beach Mundabullangana Beach Dampier Archipelago Barrow Island, Montebello Island, coastal islands from Cape Preston to Locker Island Soldier Point to Pirlangimpi including Seafull Island 60 km internesting buffer Brace point to One Tree Point, including all offshore islands 60 km internesting buffer Waigait Beach to south of Point Blaze, including all offshore islands 60 km internesting buffer.

Species	Scientific name	Aggregation area and use	BIAs within EMBA	Habitat Critical within EMBA
			Western Joseph Bonaparte Depression Melville Island, Cobourg Peninsula	
Leatherback turtle	*Dermochelys coriacea*	None within EMBA	None within EMBA	All sandy beaches from Coburg Peninsula to Cape Arnhem including Danger Point and Elcho Island 20 km internesting buffer
Olive ridley turtle	*Lepidochelys olivacea*	Foraging, migration – Joseph Bonaparte Gulf – Kimberley region	Western Joseph Bonaparte Depression Northern Joseph Bonaparte Gulf	Cape Leveque Prior Point and Llanggi Darcy Island Vulcan Island Soldier Point to Pirlangimpi including Seafull Island 20 km internesting buffer Brace Point to One Tree Point, including all offshore islands 20 km internesting buffer Croker Island, Coburg Peninsula, west of Murganella to the West Alligator River 20 km internesting buffer

7. Marine Mammals

Forty-four species of listed marine mammals are known to occur in Australian waters in the combined EMBA, according to the Protected Matters search (**Appendix A**). An examination of the species profile and threats database (DAWE 2020a) showed that some listed mammal species are not expected to occur in significant numbers in the marine and coastal environments in the combined EMBA due to their terrestrial distributions. Hence, these species are not discussed further.

Of the remaining listed species, five are listed as threatened and migratory, one is listed as threatened and ten are listed as migratory under the Commonwealth EPBC Act (BIAs for marine mammals are discussed in **Table 7-3**). These species are shown in **Table 7-1** along with their conservation listing under the WA BC Act and *Territory Parks and Wildlife Conservation Act 1976* (as applicable).

The section below gives further details on marine mammal species listed as threatened and migratory and a summary is presented in **Table 7-2**. Identified BIAs are presented in **Table 7-3**.

In addition, the New Zealand fur-seal *(Arctocephalus forsteri)*, has been identified as a species of relevance to the combined EMBA. The New Zealand fur seal is listed as a protected species under WA BC Act (other specially protected), but not listed as threatened under the EPBC Act.

Table 7-1: Marine mammals listed as threatened or migratory under the EPBC Act

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999 (Cwth)	BC Act 2016 (WA)	Other WA Conservation Code	TPWC Act 1976		
Sei whale *(Balaenoptera borealis)*	Vulnerable Migratory	Endangered	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Blue whale *(Balaenoptera musculus)*	Endangered Migratory	Endangered	-	-	Foraging, feeding or related behaviour known to occur within area Migration route known to occur within area	Yes – Refer to **Table 7-3**
Fin whale *(Balaenoptera physalus)*	Vulnerable Migratory	Endangered	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Southern right whale *(Eubalaena australis)*	Endangered Migratory	Vulnerable	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**
Humpback whale *(Megaptera novaeangliae)*	Migratory	Special conservation interest and Migratory	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**
Sperm whale *(Physeter macrocephalus)*	Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour known to occur within area	Yes – Refer to **Table 7-3**
Antarctic minke whale *(Balaenoptera bonaerensis)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Bryde's whale *(Balaenoptera edeni)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined

Species	Conservation Status				Likelihood of occurrence in EMBA	BIA in EMBA
	EPBC Act 1999 (Cwth)	BC Act 2016 (WA)	Other WA Conservation Code	TPWC Act 1976		
Pygmy right whale (*Caperea marginate)*	Migratory	Migratory	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Killer whale (*Orcinus orca)*	Migratory	Migratory	-	-	Species or species habitat may occur within area	None - No BIA defined
Australian Humpback Dolphin (Sousa sahulensis)	Migratory (as *Sousa chinensis)*	Migratory	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**
Spotted bottlenose dolphin (Arafura/ Timor Sea Populations) *(Tursiops aduncus)*	Migratory	Migratory	-	-	Species or species habitat known to occur within area	Yes – Refer to **Table 7-3**
Irrawaddy dolphin (Australian snubfin dolphin) *(Orcaella heinsohni)*	Migratory	Migratory	P4	-	Species or species habitat known to occur within area	Yes – Refer to **Table 7-3**
Dusky dolphin (*Lagenorhynchus obscurus)*	Migratory	Migratory	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Australian sea lion (*Neophoca cinerea)*	Endangered	Vulnerable	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**
Dugong (*Dugong dugon)*	Migratory	Migratory	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**

.

7.1 Threatened and Migratory Species

7.1.1 Sei Whale

Sei whales have a worldwide, oceanic distribution and migrate between low-latitude tropical and subtropical regions during the winter and temperate and subpolar latitudes in summer (Leaper et al. 2008). Sei whales tend to be found further offshore than other species of large whales (Bannister *et al*. 1996).

Sei whales move between Australian waters and Antarctic feeding areas; however, they are only infrequently recorded in Australian waters (Bannister *et al*. 1996) and their movements and distribution in Australian waters is not well known (DAWE 2020a). There are no known mating or calving areas in Australian waters (Parker 1978 in DAWE 2020a). The National Conservation Values Atlas currently record no BIAs for this species (DAWE 2020b). Surveys of the Bonney Upwelling (outside of the combined EMBA) between 2000 and 2003 recorded sightings of sei whales feeding during summer and autumn, indicating that this is potentially an important feeding ground (DAWE 2020b).

7.1.2 Blue Whale

Two sub-species of blue whale are recorded in Australian waters: the southern (or true) blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). Southern blue whales are believed to occur in waters south of 60°S and pygmy blue whales occur in waters north of 55°S (i.e. not in the Antarctic) (DEWHA 2008a). By this definition all blue whales in waters from Busselton to the NT are assumed to be pygmy blue whales and are discussed below.

Pygmy blue whale populations are distinguishable only acoustically as they do not display morphological differences (Leroy *et al*. 2021). Prior to 2020 there were believed to be three populations of the pygmy blue whale (B. m. brevicauda), however, evidence for a fourth pygmy blue whale acoustic population were found by Cerchio, S. et al. (2020), and a fifth was identified by Leroy et al. (2021).

Pygmy blue whales have a southern hemisphere distribution, migrating from tropical water breeding grounds in winter to temperate and polar water feeding grounds in summer (Bannister *et al*. 1996, Double *et al*. 2014), such as the Perth Canyon and adjacent waters (Rennie et al., 2009) and the Great Southern Australian Coastal Upwelling System (Möller et al., 2020). The WA migration path takes pygmy blue whales down the WA coast to coastal upwelling areas along southern Australia (Gill 2002) and south at least as far as the Antarctic convergence zone (Gedamke *et al*. 2007).

Tagging surveys have shown pygmy blue whales migrating northward relatively near to the Australian coastline (100 km) until reaching North West Cape after which they travelled offshore (240 km) to Indonesia (Double et al, 2014). Passive acoustic data documented pygmy blue whales migrating along the Western Australian shelf break (Woodside 2012). Tagging data collected by Gales *et al.* (2010) has provided the first definitive link between the blue whales that feed off the Perth Canyon and those that occur around Indonesia. This is movement is concordant with the proposed ‘Tasmania to Indonesia’ population described by Branch *et al.* (2007).

The northern migration passes the Perth Canyon from January to May and north bound animals have been detected off Exmouth and the Montebello Islands between April and August (Double *et al*.

2012a, McCauley & Jenner 2010). A noise monitoring study conducted in 2014-15 recorded pygmy blue whales moving in a northward direction in August 2014 and between late-May to early July 2015 (JASCO Applied Sciences, 2016; McPherson, Craig et al., 2015). During the southern migration, pygmy blue whales pass south of the Montebello Islands and Exmouth from October to the end of January, peaking in late November to early December (Double *et al*. 2012b). No detections of the species were made during the period of their southward migration during the noise monitoring study.

Generally, they appear to travel as individuals or in small groups based on acoustic data. For example, analysis of pygmy blue whale calls from noise loggers deployed around Scott Reef (2006 to 2009) for the Woodside Browse project showed that 78% of the calls were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley 2011; Woodside 2014).

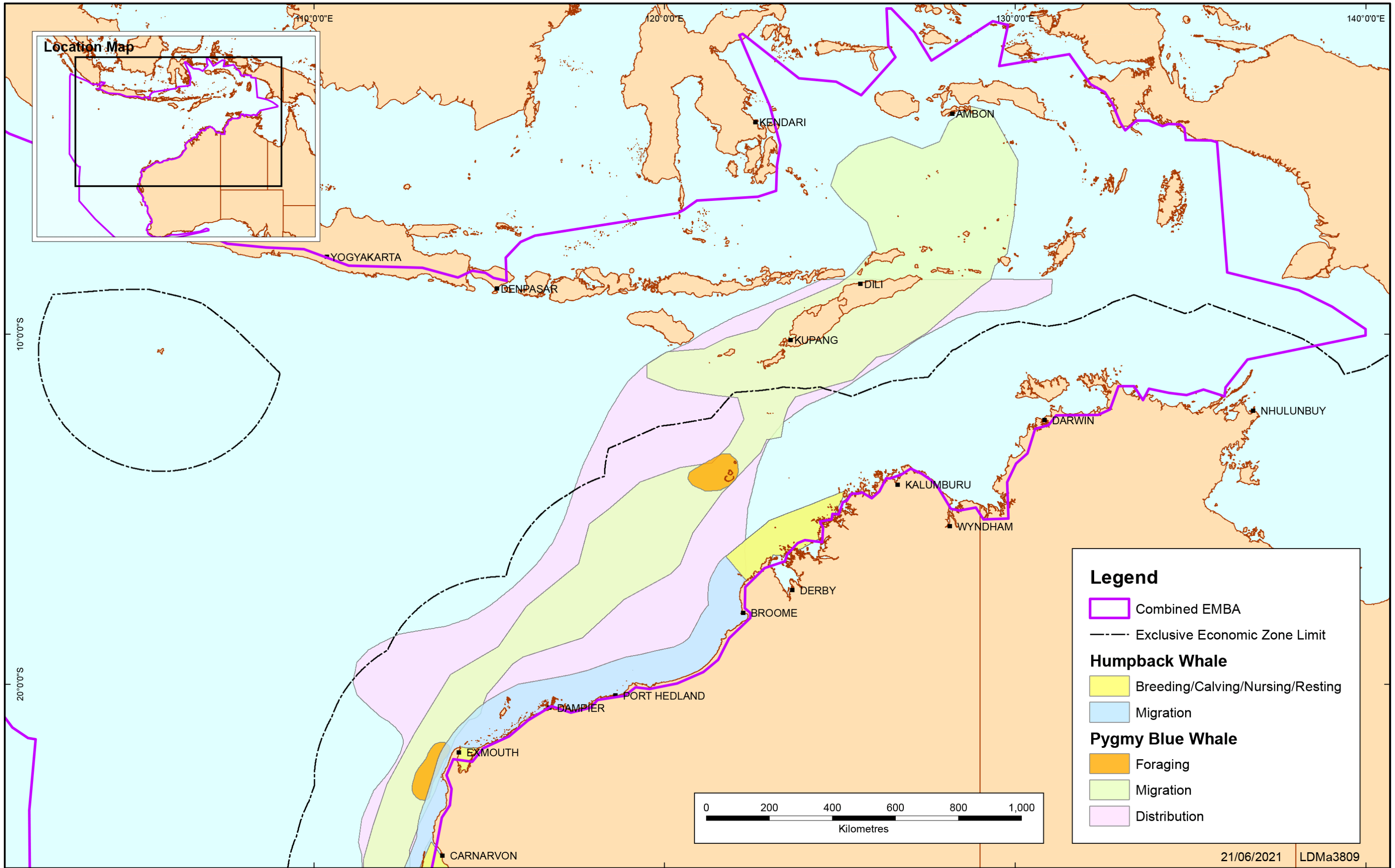
Pygmy blue whales appear to feed regularly along their migration route (i.e. at least once per week or more frequently) and are likely to have multiple food caches along their migratory route (e.g. Rowley Shoals and Ningaloo Reef) (ConocoPhillips 2018).

Recognised feeding areas of significance to this species, located within the combined EMBA include Ningaloo Reef and the Perth Canyon (DoE 2015a). The Ningaloo Reef area has the capacity to offer feeding opportunities to pygmy blue whales through unique biophysical conditions able to support large biomasses of marine species (Double *et al*. 2014).

Surface lunge feeding of pygmy blue whales has been observed at North West Cape and Ningaloo Reef in June (C. Jenner & M-N Jenner, unpublished data, 2001 in Double *et al*. 2014). Outside of the recognised feeding areas, possible foraging areas for pygmy blue whales include the greater region around the Perth Canyon, off Exmouth and Scott Reef in WA (DoE 2015a). These steep gradient features tend to stimulate upwelling and, therefore increased productivity (seasonally variable) (ConocoPhillips 2018). Hence, they provide a favourable foraging area.

Breeding areas have not yet been identified; however, it is likely that pygmy blue whales calve in tropical areas of high localised production such as deep offshore waters of the Banda and Molucca Seas in Indonesia (Double *et al*. 2014, DAWE 2020a). There are no known breeding areas of significance to blue whales in waters from Busselton to the NT.

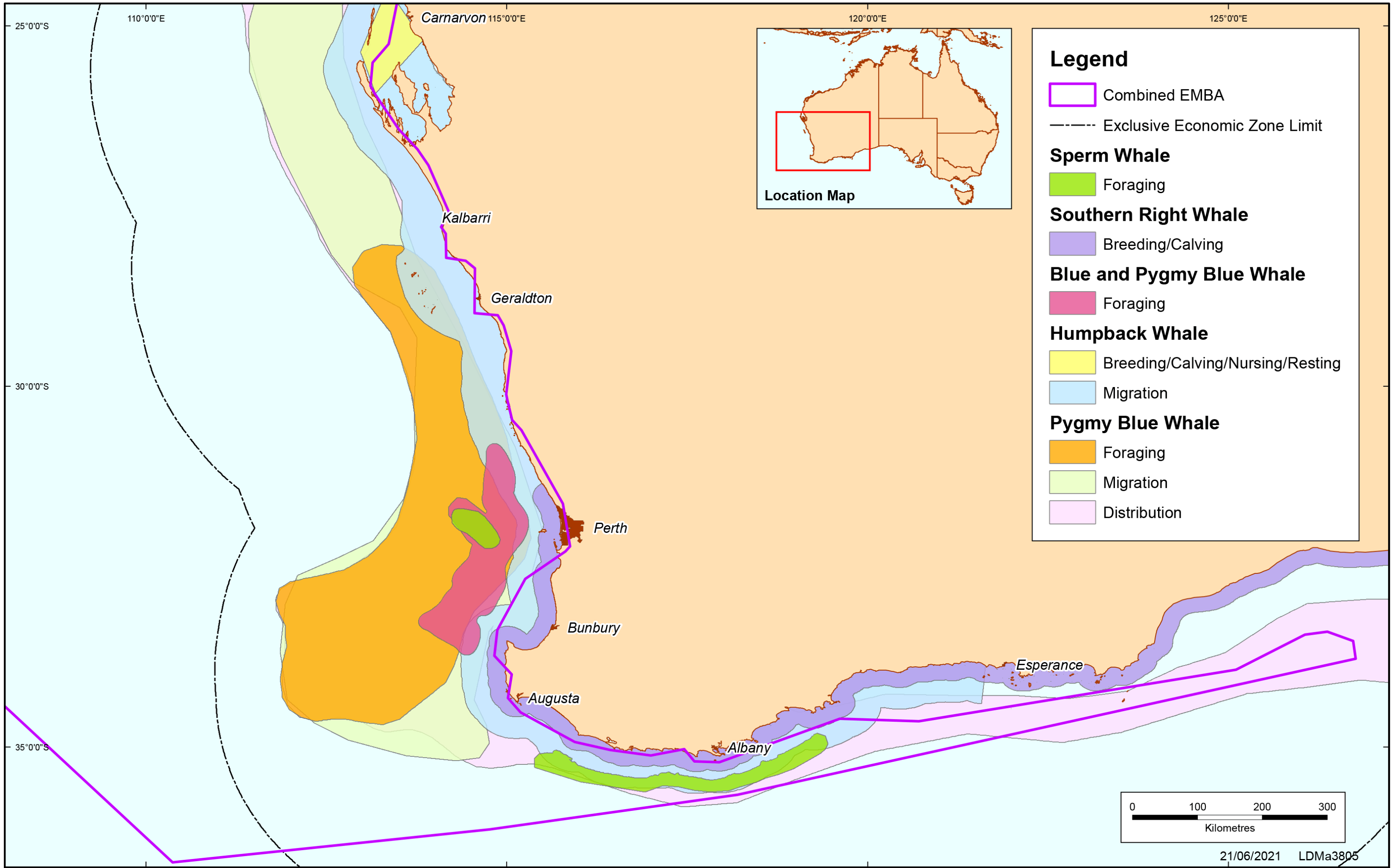
The BIAs for blue whale and pygmy blue whale are detailed in **Table 7-3** and depicted in **Figure 7-2** and **Figure 7-1.** However; a recent study by Thums *et al* (2022) used a combination of passive acoustic monitoring of the Northwest Australian coast (46 instruments from 2006 to 2019) and satellite telemetry data (22 tag deployments from 2009 to 2021) quantified the spatial extent of pygmy blue whale high use areas for foraging and migration and compared these areas to the BIAs. Thums *et al* (2022) designated three important foraging (and/or resting/breeding) areas, including; The Perth Canyon and vicinity, the shelf edge off Geraldton and; the shelf edge from Ningaloo Reef to the Rowley Shoals (not continuous).The study found that the Foraging BIA off the south-west of Western Australia encompassed 83% of the most important areas in that region, however; the 'Annual High Use Foraging' BIA within that BIA only encompassed 7% of the most important area. The most significant overlaps were seen with the Migration BIAs, whereby the most important migration area had an 82% overlap with the part of the Migration BIA that occurs in Australia. The Australian Government may now have to consider this quantitative assessment of important areas in future reviews of the BIAs (Thums *et al* 2022).



Santos

WHALE BIOLOGICALLY IMPORTANT AREAS
NORTHERN AUSTRALIA

Figure 7-1: Biologically important areas – whales – Northern WA



Santos

WHALE BIOLOGICALLY IMPORTANT AREAS
SOUTHERN WA

Figure 7-2: Biologically important areas – whales – Southern WA

7.1.3 Fin Whale

Fin whales have a worldwide distribution generally in deeper waters, with oceanic migrations between warm water breeding grounds and cold water feeding grounds.

The fin whale distribution in Australia is not clear due to the sparsity of sightings. Information is known primarily from stranding events and whaling records. According to the Species Profile and Threats database (DAWE 2020a); fin whales are thought to be present from Exmouth, along the southern coastline, to southern Queensland.

Migration paths are uncertain but are not thought to follow Australian coastlines (Bannister *et al*. 1996). There is insufficient data to prescribe migration times for fin whales. During summer and autumn this species has been recorded acoustically at the Rottnest Trench.

There are no known mating or calving areas in Australian waters (DoEE 2019a) and no BIAs for the fin whale are currently identified by the National Conservation Values Atlas (DAWE 2020b).

7.1.4 Southern Right Whale

The southern right whale is present in the southern hemisphere between approximately 30° and 60°S. The species feeds in the Southern Ocean in summer, moving close to shore in winter.

In Australian waters, southern right whales range from Perth, along the southern coastline, to Sydney. Sightings have been recorded as far north as Exmouth although these are rare (Bannister *et al*. 1996).

BIAs including calving and aggregation areas are recorded for this species along the southern coastline of Australia (DAWE 2020b). Details on the BIA for southern right whale are provided in **Table 7-3** and depicted in **Figure 7-2** and **Figure 7-1**.

7.1.5 Humpback Whale

Humpback whales have a worldwide distribution, migrating along coastal waters from polar feeding grounds to subtropical breeding grounds. Geographic populations are distinct and at least six southern hemisphere populations are thought to exist based on Antarctic feeding distribution and the location of breeding grounds on either side of each continent (Bannister *et al*. 1996). The largest known population of humpback whales breeds along the coast of Western Australia (Branch, 2011, Salgado Kent et al., 2012, IWC, 2014) and has a recognised resting ground in the Exmouth Gulf (Ivine & Kent 2018). The population of humpback whales migrating along the WA coastline was recently estimated to be greater than 33,000 whales and likely increasing at exceptionally high growth rates between 10–12% (Hedley *et al*. 2011, Salgado Kent *et al*. 2012).

Humpback whale populations have increased since being placed on the threatened species list for exploitation from whaling, resulting in a higher abundance of species off our Western Australian coastline. Effective from 26/02/2022, Humpback whales are no longer classed as vulnerable under the EPBC Act, however; they remain a Matter of National Environmental Significance as a listed Migratory Species and Cetacean under EPBC Act Division 3, where it is an offence to kill, injure, take, trade, keep, move or interfere with a cetacean. Humpback whales have been able to thrive and increase in numbers despite the heavy oil and gas exploration. A study presented by Bejder et al (2016) has prompted a review of the species being down listed under Commonwealth legislation and regulations, as they are not eligible for listing as a threatened species under all statutory criteria. The west coast Australian humpback whale population migrates from Southern Polar Ocean 'summer' feeding grounds to their northern tropical 'winter' calving/ breeding grounds in coastal waters of the

Kimberley. The northern migration tends to follow deeper waters of the continental shelf, whilst the southward migration concentrates whales closer to the mainland (Jenner *et al*. 2001; Irvine et al., 2018). Recent satellite tagging of southbound humpback whales indicate that whales generally migrated close to the coastline, within a few tens of kilometres of shore and in a corridor frequently less than 100 km (Double *et al*. 2010). Aerial surveys and noise logger recordings undertaken for Chevron's Wheatstone Project indicated that the main distribution of humpback whales was sighted at an average distance of 50 km from the mainland during the northern migration and 35 km during the southbound migration (RPS 2010a). Woodside have conducted aerial surveys that have confirmed that the reported distribution of migrating humpback whales off the North West Cape is consistent with baseline surveys first conducted in 2000 to 2001 (RPS, 2010 in Woodside 2020).

The precise timing of the migration varies between years by up to six weeks, influenced by water temperature, sea ice distribution, predation risk, prey abundance and the location of feeding grounds (DEWR 2007).

Peak northward migration across the North West Shelf is identified as from late July to early August, and peak southward migration from late August to early September (DoEE 2015c). Data collected between 1995 and 1997 by the Centre for Whale Research indicates that the period for peak northern migration into the calving grounds in the Kimberley is mid to late July. The peak for southern migration is in the first half of September (Jenner *et al.* 2001). Actual timing of annual migration may vary by as much as three weeks from year to year due to food availability in the Antarctic (DMP 2003).

Satellite tagging data collected for migrating northbound humpback whales identified a consistent narrow inshore distribution, unlike the southward migration. There was little evidence that the whales tended to venture further from shore and into deeper water at any point on their northward migration. Whales were seen with calves off the North West Cape outside the 'calving grounds; of Lacepede Islands to Camden Sound. This indicates some potential for this area being used as a 'calving site' as well as a migratory corridor. Consequently, the region from the Lacepede Islands to Camden Sound should not be seen as the exclusive 'calving ground' for this population (Double *et al.* 2012b).

Details on the BIA for humpback whales are provided in **Table 7-3** and depicted in **Figure 7-2** and **Figure 7-1**.

7.1.6 Sperm Whale

Sperm whales typically occur in WA along the southern coastline between Cape Leeuwin and Esperance (Bannister *et al.* 1996). Sperm whales are distributed worldwide in deep waters (greater than 400 m) off continental shelves and sometimes near shelf edges, averaging 20 to 30 nautical miles offshore (Hooker et al.1999, Pirotta et al., 2011). The sperm whale is known to migrate northwards in winter and southwards in summer, however, detailed information on the distribution of sperm whales is not available for the timing of migrations. Sperm whales have been recorded in deep water off the North West Cape on the west coast of Western Australia (RPS 2010b) and appear to occasionally venture into shallower waters in other areas (RPS 2010b). Details on the BIA for sperm whales are provided in **Table 7-3** and are shown in **Figure 7-2** and **Figure 7-1.**

7.1.7 Antarctic Minke Whale

The Antarctic minke whale is distributed throughout the Southern Hemisphere from 55°S to the Antarctic ice edge during the austral summer and has been recorded in all Australian States (Bannister et al. 1996; Perrin & Brownell 2002). Detailed information on timing and location of migrations and breeding grounds on the west coast of Australia is largely unknown. However, it is believed that the Antarctic minke whale migrates up the WA coast to approximately 20°S during Australian winter to feed and possibly breed (Bannister *et al.* 1996).

7.1.8 Bryde's Whale

The Bryde's whale is found all year round in tropic and temperate waters (Kato 2002). Two forms are recognised: inshore and offshore Bryde's whales. It appears that the inshore form is restricted to the 200 m depth isobar whilst the offshore form is found in deeper waters of 500-1,000 m (DoEE 2019c). Both forms are expected to be found in zones of upwelling where they feed on shrimp like crustaceans (Bannister *et al.* 1996). Little is known about the population abundance of Bryde's whale, the location of exact breeding and calving grounds and large-scale migration patterns (DoEE 2019c). It is however, suggested that the offshore form migrates seasonally, heading towards warmer tropical waters during the winter.

7.1.9 Pygmy Right Whale

The pygmy right whale is considered the most elusive baleen whale and as a result very little is known about the whale's distribution in Australian waters. Records of the pygmy right whale in Australian waters are distributed between 32°S and 47°S and are restricted in the west by the Leeuwin current (Kemper 2002). It is possible that the pygmy right whale will be encountered in the southern extent of the combined EMBA, particularly in coastal areas of upwelling (Kemper 2002).

7.1.10 Killer Whale

The killer whale has a widespread global distribution and has been recorded in waters of all Australian states/territories (Bannister *et al.* 1996). Whilst more commonly found in cold, deeper waters, killer whales have been observed along the continental slope, shelf and shallower coastal areas. Killer whales are known to make seasonal movements and are most likely to follow the migratory routes of their prey, however, little is known about these movements (DoEE, 2019). They are more likely to be observed around seal colonies, with a significant seal colony within the combined EMBA being located in WA at the Abrolhos Islands.

7.1.11 Indo-Pacific Humpback Dolphin

The Indo-pacific humpback dolphin is typically found in water less than 20 m deep but has been recorded in waters up to 40 m deep. This species is generally found in association with river mouths, mangroves, tidal channels and inshore reefs (DoEE 2016a). This species of dolphin is known to have resident groups that forage, feed, breed and calve in the state waters of Roebuck Bay, Dampier Peninsula, King Sound north, Talbot Bay, Anjo Peninsula, Vansittart Bay, Napier Broome Bay and Deception Bay (DoEE 2016a).

The Indo-Pacific humpback dolphin BIA in the combined EMBA is detailed in **Table 7-3** and shown on **Figure 7-3.**

7.1.12 Spotted Bottlenose Dolphin (Indo-Pacific bottlenose dolphin)

The spotted bottlenose dolphin (*Tursiops aduncus*) (Arafura/ Timor Sea populations) is generally considered to be a warm water subspecies of the spotted bottlenose dolphin, occurring in shallow (often <10 m deep) inshore waters (Bannister et al., 1996; Hale et al., 2000). The known distribution of the spotted bottlenose dolphin extends from Shark Bay north to the western edge of the Gulf of

Carpentaria in Australia (DoEE 2016b). The spotted bottlenose dolphin BIA in the combined EMBA is detailed in **Table 7-3** and shown on **Figure 7-3.**

7.1.13 Irrawaddy Dolphin (Australian Snubfin Dolphin)

The Irrawaddy dolphin, also known as the snubfin dolphin (*Orcaella heinsohni*) is known to occur within the waters off northern Australia, extending north from Broome in Western Australia to the Brisbane River in Queensland (DoEE 2016c). Surveys have indicated that the species is typically found in protected shallow nearshore waters, generally less than 20 m deep, adjacent to river and creek mouths close to seagrass beds (DoEE 2016c). The snubfin dolphin was not recorded during any of the aerial surveys undertaken along the Dampier Peninsula coastline in the vicinity of James Price Point but were observed in Roebuck Bay from vessels on several occasions (RPS, 2010b). Based on the extensive survey effort and amenable conditions within the James Price Point coastal area during the survey, it is concluded that this species is seldom found outside of shallow and sheltered bays and inlets (DSD 2010). The Irrawaddy dolphin BIA in the combined EMBA is detailed in **Table 7-3** and shown on **Figure 7-3.**

7.1.14 Dusky Dolphin

The dusky dolphin's distribution is strongly linked to colder waters. In Australia, the dusky dolphin has been sighted in southern Australia from WA to Tasmania. It is presumed to be primarily an inshore species but has been known to move further offshore, possibly due to its desire for colder waters (Gill *et al.* 2000). Dusky dolphins are expected to be limited in their distribution along the WA coastline due to the presence of the southward-flowing warm water of the Leeuwin Current.

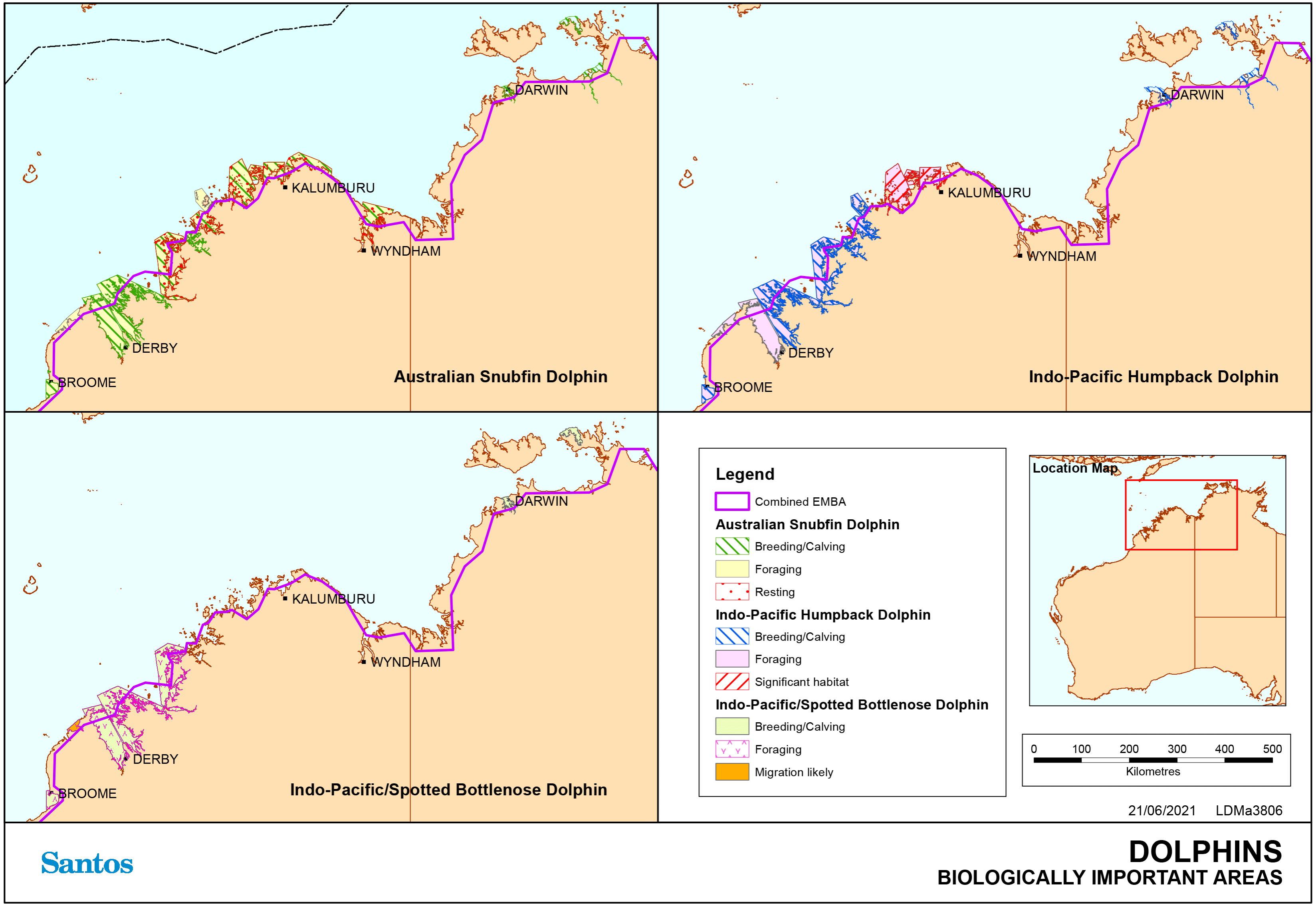
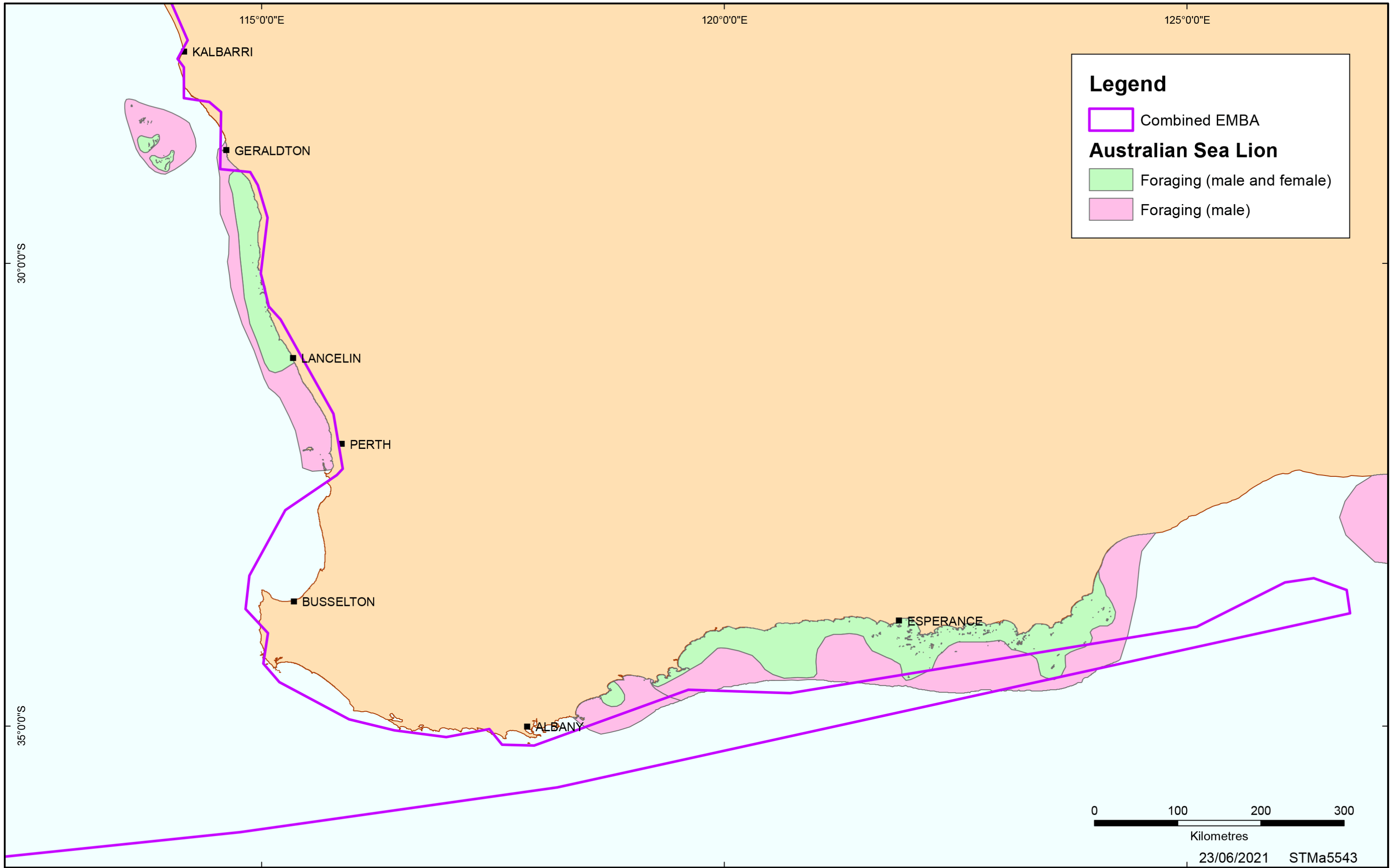

DARWIN
KALUMBURU
WYNDHAM
DERBY
BROOME
Australian Snubfin Dolphin
Indo-Pacific Humpback Dolphin
Indo-Pacific/Spotted Bottlenose Dolphin
Legend
Combined EMBA
Australian Snubfin Dolphin
Breeding/Calving
Foraging
Resting
Indo-Pacific Humpback Dolphin
Breeding/Calving
Foraging
Significant habitat
Indo-Pacific/Spotted Bottlenose Dolphin
Breeding/Calving
Foraging
Migration likely
Location Map
0 100 200 300 400 500
Kilometres
21/06/2021 LDMa3806
Santos
DOLPHINS
BIOLOGICALLY IMPORTANT AREAS

Figure 7-3: Biologically important areas – dolphins

7.1.15 Australian Sea Lion

The Australian sea lion is endemic to Australia. Breeding colonies are found only in South Australian and Western Australian waters. There are currently 76 known Australian sea lion pupping locations along the coast and offshore islands between the Houtman Abrolhos Islands in Western Australia to the Pages Islands in South Australia (DSEWPaC 2013c). The species has also been recorded at Shark Bay (DoE 2014a).

BIAs for foraging, haul-out and breeding sites identified by the National Conservation Values Atlas are located south of the waters from Busselton to the NT (DAWE 2020b). Male Australian sea lions have been recorded foraging in areas up to 60 km away from their birth colonies, with potentially larger dispersal ranges up to 180 km (Hamer *et al*. 2011). However, female Australian sea lions have restricted home ranges, with high rates of natal site fidelity and limited gene flow with other regions (Campbell 2005). The Australian sea lion BIA in the combined EMBA is outlined in **Table 7-3** and is depicted in **Figure 7-4.**



Santos

AUSTRALIA SEA LION BIAs

Figure 7-4: Biologically important areas – Australian sea lion

7.1.16 Dugongs

Dugongs (*Dugong dugon*) are large herbivorous marine mammals (up to 3 m) that feed off seagrass and generally inhabit coastal areas. Key populations along the WA coast are principally located at: Shark Bay (the largest resident population in Australia), Ningaloo Marine Park and Exmouth Gulf, the Pilbara coast and offshore areas including Montebello/ Barrow/ Lowendal Islands, and further north at Eighty Mile Beach and off the Kimberley Coast, particularly Roebuck Bay and Dampier Peninsula (Marsh *et al*. 2002; DSEWPaC 2012). Populations are also present at Ashmore Reef, and the north coast of the Tiwi Islands is recognised as a key site for the conservation of dugongs. A well-known major dugong aggregation of approximately 4,400 individuals occurs in waters seaward (within approximately 50 km) of the Tiwi Islands and ranks in the top eight of dugong populations in the world.

Dugong distribution and movement is based on the abundance, size and species of seagrass meadow. Dugongs can migrate hundreds of kilometres between seagrass habitats. Dugongs have been tracked moving long distances of up to 300 km between the Australia mainland and the Tiwi Islands (Whiting et al., 2009). Satellite-tracking data from dugongs tagged as part of the INPEX Ichthys Project baseline surveys observed that dugongs around the Vernon Islands, south of Melville Island, spent time in Darwin Harbour and around the Tiwi Islands (INPEX, 2010). Routine sightings occur in various locations along the NT coastline, including within Darwin Harbour, to the south of Melville Island.

Dugongs in the NT coastal waters have been observed foraging in intertidal rocky reef flats supporting sponges and algae as seagrass habitat is thought to be rare in the north marine region bioregion (INPEX, 2010; Whiting et al., 2009). However, seagrass communities are known to exist along the north coast of the Tiwi Islands.

The dugong BIAs in the combined EMBA are detailed in **Table 7-3** and shown in **Figure 7-5**.

7.1.17 New Zealand fur-seal

The New Zealand fur-seal (also known as the long-nosed fur seal) (*Arctocephalus forsteri*) is a specially protected species (other specially protected) under the BC Act. The New Zealand fur seal is found in Ngari Capes Marine Park (two colonies) and along other parts of Australia's southern coast.[4]

[4] Identified as a relevant species through review of *Biodiversity Conservation Act 2016* listed species for marine species without an EBPC Act listing.

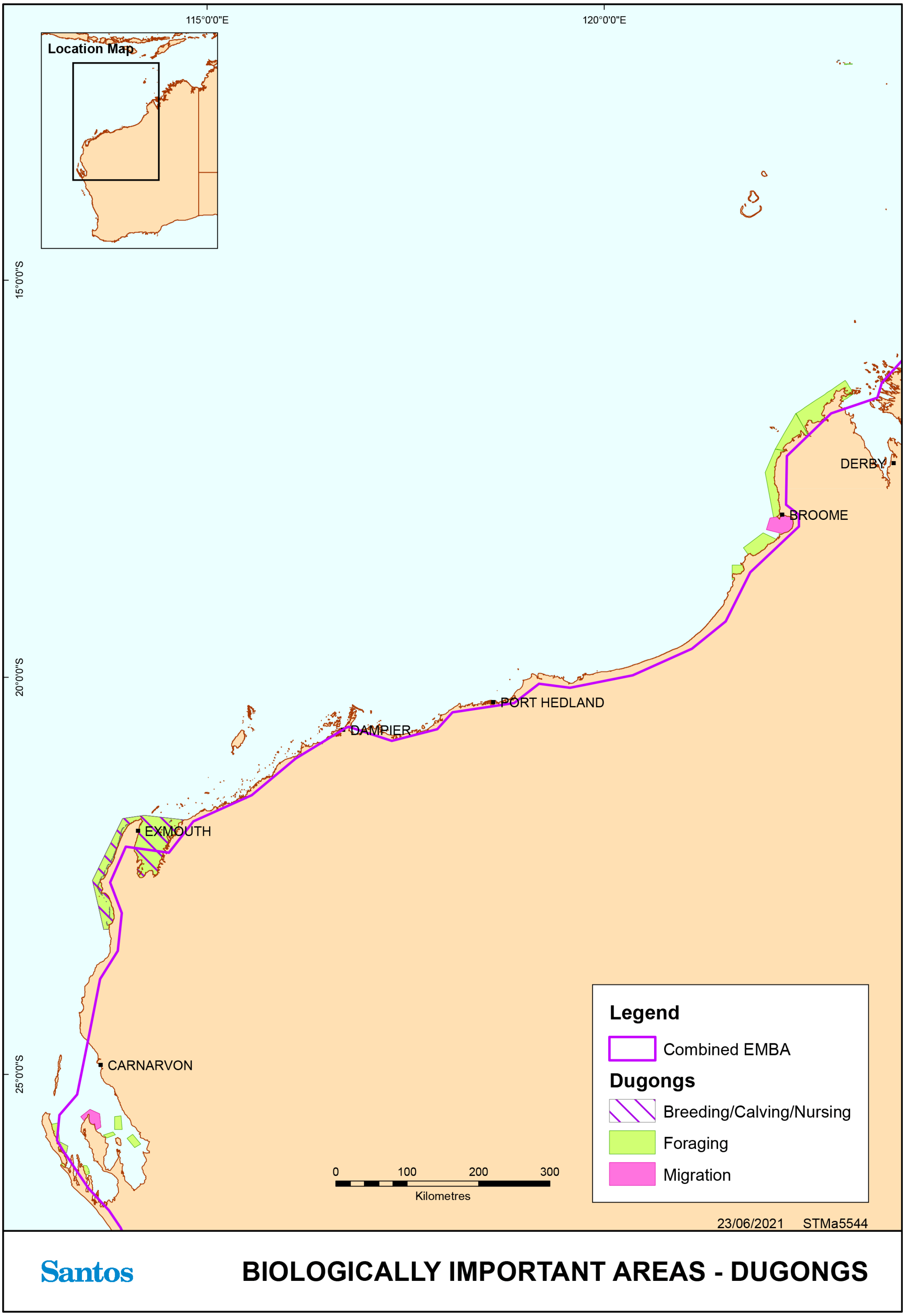


Figure 7-5: Biologically important areas – dugongs

Table 7-2: Summary of information for marine mammals listed as threatened under the EPBC Act

Aspect	Sei whale	Blue and pygmy blue whales	Fin whale	Southern right whale	Humpback whale	Australian sea lion
Species expected in area	Unknown	Yes	Unknown	Unlikely, southern distribution	Yes	Unlikely, southern distribution
Migration depth (m)	Unknown, prefers offshore waters	500-1,000	Unknown	n/a	Up to 100	n/a
Migration seasonality	Unknown	Apr to Aug (north), Oct to Jan (south)	Unknown	n/a	Jun to Nov	n/a

7.2 Biologically Important Areas / Critical Habitat – Marine Mammals

Table 7-3 below provides an overview of BIAs in the combined EMBA for marine mammals

The DAWE may also make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[5].

In addition, both the EPBC Act and WA BC Act and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species'. To date no critical habitat in WA has been listed under either Act. No provision is made under the Territory Parks and Wildlife Conservation Act 1976 for listing critical habitat.

Table 7-3: Biologically important areas – marine mammals

Species	Scientific name	Aggregation area and use	BIAs within EMBA
Blue and pygmy blue whales	*Balaenoptera musculus*	Migration – along the continental shelf edge off the WA coastline, extending offshore near Scott Reef and into Indonesian waters Foraging – along Ningaloo reef, around Scott Reef, around the Perth canyon Distribution – along the WA coastline towards and beyond Indonesia.	Blue and pygmy blue whale - Head of the Perth Canyon Outer continental shelf from Cape Naturaliste to south of Jurien Bay Outer Perth Canyon Head of the Perth Canyon Pygmy blue whale - Augusta to Derby. Tend to pass along the shelf edge at depths of 500 m to 1000 m; appear close to coast in the Exmouth-Montebello Islands area on southern migration. From Mandurah to south of Cape Naturaliste, seaward to the 50 m depth contour Indonesia- Banda Sea Ningaloo Perth canyon Scott Reef

[5] Further background information on BIA and identification of critical habitat in recovery plans is provided in **Section 5.4**.

Species	Scientific name	Aggregation area and use	BIAs within EMBA
Southern right whale	*Eubalaena australis*	Breeding/calving – along the south west and southern coastline of WA/SA	Bunbury area, WA Camac Island/Fremantle, WA Coast Cape Naturaliste to Cape Leeuwin Coast Perth region to Cape Naturaliste Geographe Bay, WA Perth to Kangaroo Island
Humpback whale	*Megaptera novaeangliae*	Breeding/calving/nursing/resting – Kimberley/Coastal North Lacepede Island, Campden Sound, Exmouth Gulf, Shark Bay Migration - northern migration deeper waters of the continental shelf, southward migration – along the WA mainland	Cape Leeuwin to Houtman Abrolhos Cape Naturaliste Cape Naturaliste to Cape Leeuwin Exmouth Gulf Flinders Bay Geographe Bay Houtman Abrolhos Islands Kimberley/Coastal North Lacepede Island, Camden Sound North of Houtman Abrolhos Shark Bay The migration corridor extends from the coast to out to approximately 100 km offshore in the Kimberley region extending south to North West Cape. From North West Cape to south of shark Bay the migration corridor is reduced to approximately 50 km. West coast - Lancelin to Kalbarri West coast- Bunbury to Lancelin including Rottnest Island
Sperm whale	*Physeter macrocephalus*	Foraging - west end of Perth Canyon and Albany Canyons	Western end of Perth canyon Albany Canyons - Immediately south of the continental shelf edge extending over the continental slope
Indo-Pacific humpback dolphin	*Sousa chinensis*	Breeding, calving, foraging – Kimberley coastal waters and islands Significant habitat – unknown behavior – Admiralty Gulf & Parry Harbour and Bougainville Peninsula Significant habitat - Vansittart Bay, Anjo Peninsula	Admiralty Gulf & Parry Harbour Bougainville Peninsula Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay) Carnot & Beagle bay King Sound North and Yampi Sound and Talbot Bay Fjord area near Horizontal Falls King Sound Southern Sector Maret and Biggee Island Pender bay Port Nelson, York Sound, Prince Frederick Harbour Prince Regent River Roebuck Bay Vansittart Bay, Anjo Peninsula Willie Creek

Species	Scientific name	Aggregation area and use	BIAs within EMBA
Indo-Pacific/spotted bottlenose dolphin	*Tursiops aduncus*	Breeding, calving, foraging – Kimberley coastal waters and islands Migration – Pender Bay	Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay) King Sound North and Yampi Sound and Talbot Bay Fjord area near Horizontal Falls King Sound Southern Sector Pender bay Roebuck Bay
Irrawaddy dolphin (Australian snubfin dolphin)	*Orcella heinsohni*	Breeding, calving, foraging, resting– Kimberley coastal waters and islands	Admiralty Gulf and Parry Harbour Bougainville Peninsula Camden Sound Area - Walcott Inlet, Doubtful Bay, Deception Bay, Augustus Island (Kuri Bay) Cape Londonderry and King George River Carnot and Beagle bay King Sound North and Yampi Sound and Talbot Bay Fjord area near Horizontal Falls King Sound Southern Sector Maret and Biggee Island Ord River Pender bay Port Nelson, York Sound, Prince Frederick Harbour Prince Regent River Roebuck Bay Vansittart Bay, Anjo Peninsula Willie Creek
Australian sea lion	*Neophoca cinerea*	Foraging – male and female – Houtman Abrolhos Island, mid-west coast (more restricted spatial extent than males) Foraging – males Houtman Abrolhos Island, mid-west coast down to Perth Breeding – Buller Island, North Fisherman Island, Beagle Island, Albrolhos Island Haul Out Sites – North Cervantes Island, Sandland Island, Albrolhos Island	Houtman Abrolhos Islands Mid-west coast, includes Beagle Island, Fisherman Island, Jurien Bay, Cervantes and Buller Colonies From Recherche Archipelago to Doubtful Islands – Key colonies, Kimberly island, Glenny and Wickham Island. Haul-Off rock
Dugong	*Dugong dugon*	Foraging –Dampier Peninsula, Roebuck Bay, Shark Bay, Exmouth and Ningaloo coastline Migration – Roebuck Bay and North East Peron Peninsula, Shark Bay Breeding/calving/nursing – Exmouth and the Ningaloo coastline	Ashmore Reef - Far West Ashmore Reef - South (located on sea reef side only, not interior) Between Peron Peninsula and Faure Island, Shark Bay Dirk Hartog Island, Shark Bay East of Faure Island, Shark Bay Exmouth Gulf Kimberley coast, Dampier Peninsula

Species	Scientific name	Aggregation area and use	BIAs within EMBA
			Middle Island, Kimberley coast North East Peron Peninsula, Shark Bay North of Faure Island, Shark Bay Pilbara and Kimberley coast near Dampier Peninsula Pilbara and Kimberley coast near James Price Point Roebuck Bay, Broome South Passage, Shark Bay Useless Loop, Shark Bay

8. Birds

Marine waters and coastal habitats in the combined EMBA contain key habitats that are important to birds, including offshore islands, sandy beaches, tidal flats, mangroves and coastal and pelagic waters. These habitats support a variety of birds which utilise the area in different ways and at different times of the year (DSEWPaC 2012a). Birds can be broadly grouped according to their preferred foraging habitat as coastal/ terrestrial birds, seabirds and shorebirds.

Coastal or terrestrial species inhabit the offshore islands and coastal areas of the mainland throughout the year. These species are either primarily terrestrial, or they may forage in coastal waters. Resident coastal and terrestrial species include osprey (*Pandion cristatus*), white-bellied sea eagle (*Haliaeetus leucogaster*), silver gull (*Larus novaehollandiae*) and eastern reef egret (*Egreta sacra*) (DEWHA 2008a).

Seabirds include those species whose primary habitat and food source is derived from pelagic waters. These species spend the majority of their lives at sea, ranging over large distances to forage over the open ocean. Seabirds present in the area include terns, noddies, petrels, shearwaters, tropicbirds, frigatebirds boobies and albatrosses (DEWHA 2008a).

Shorebirds, including waders, inhabit the intertidal zone and adjacent areas. Some shorebird species, including oystercatchers are resident (Surman & Nicholson 2013). Other shorebirds are migratory and include species that utilise the East Asian–Australasian Flyway, a migratory pathway for millions of migratory shorebirds that travel from Northern Hemisphere breeding grounds to Southern Hemisphere resting and foraging areas. Shorebirds that regularly migrate through the area include the Scolopacidae (curlews, sandpipers etc.) and Charadriidae (plovers and lapwings) families.

Surveys in the area by Santos and other agencies have built a picture of diverse avifauna. A summary of research is discussed below, followed by information on threatened and migratory birds. Wetlands of international importance are discussed in **Section 9.1.3**.

8.1 Regional Surveys

8.1.1 Abrolhos Islands

The Abrolhos Islands are one of the most significant seabird nesting areas in the eastern Indian Ocean with over two million birds breeding on the islands and small rocky atolls in the Abrolhos (DoF 2012). The mixture of species is unique, as subtropical and tropical species, and littoral and oceanic foragers, share the breeding islands. A total of 95 bird species have been recorded as residents or visitors to the Abrolhos Islands. Of these 35 species are known to breed at the Abrolhos (DoF, 2012):

+ Common noddy (rookery – Pelseart Island): The Abrolhos supports 80% of the Australian breeding population of the common noddy (*Anous stolidus*) with up to 250,000 common noddies breed at Pelsaert Island. These birds lay their eggs in spring, but the actual month can vary, depending on their food supply and the weather conditions existing in offshore waters (DoF 2012);
+ Caspian tern (rookeries – Leo Island, West Wallabi Island and Pelsaert Island): Unlike other more social terns, Caspian terns (*Hydroprogne caspia*) are usually solitary nesters. There are less than 150 of these breeding at the Abrolhos, across 22 islands (DoF 2012);
+ Wedge-tailed shearwaters (rookeries): The Abrolhos are the most important breeding sites in Australia for the wedge tailed shearwater (*Ardenna pacifica*), with between 500,000 and 1,000,000 of these birds breeding there every year, predominantly on West Wallabi Island. The wedge-tailed shearwater breeding colonies at the Abrolhos are the largest in Australia (DoF 2012);

- Bridled tern (rookeries – Gun Island, Leo Island, Pelsaert Island, Little North Island, Fisherman Islands, Beagle Islands and Penguin Island): Bridled terns (*Onychoprion anaethetus*) breed on 90 islands throughout the Abrolhos. These birds fly north for the winter, through Indonesia to waters around the Phillippines. There are approximately 4,000 bridled terns who return to the Abrolhos around October every year to lay their eggs. Bridled terns nest on more islands in the Abrolhos than any other bird species (DoF, 2012);
- Osprey (nesting area – Pelseart Island): Up to 100 eastern ospreys (*Pandion cristatus*) nest at a number of sites throughout all three island groups at the Abrolhos, including nesting platforms made from converted rock lobster pots and stacked fishing equipment on jetties (DoF 2012);
- White-bellied sea eagle (nesting area – West Wallabi Island): At the Abrolhos, there are up to 50 breeding white-bellied sea eagles (*Haliaeetus leucogaster*), spread across all three island groups (DoF 2012);
- Australian lesser noddy (feeding area and rookeries Morley Island, Wooded Island and Pelseart Island): In Australia the Australian lesser noddy is only known to breed in this area and is known to forage between the islands and the continental shelf edge; and
- Other areas rookeries identified for both the wedge-tailed shearwater and bridled tern within the south west area include Lancelin Island, Rottnest Island and Safety Bay.

8.1.2 North West Cape

Avifauna surveys of the North West Cape have recorded 144 bird species, one third of which are seabirds and shorebirds (resident and migratory) (May *et al*. 1983). Approximately 33 species of seabirds and shorebirds are found in the Ningaloo Marine Park with the main breeding areas at Mangrove Bay, Mangrove Point, Point Maud, the Mildura wreck site and Fraser Island (CALM & MPRA 2005a).

8.1.3 Muiron Islands and Exmouth Gulf Islands

Muiron Islands and Exmouth Gulf Islands are generally lacking in published bird observations data. Early indications from surveys commissioned by Santos in 2013/14 indicate that South and North Muiron Islands are regionally significant in terms of wedge-tailed shearwater (*Ardenna pacifica*) nesting, whilst Bessiers and Fly islands are also significant (Surman pers comm. 2013). Nine coastal/terrestrial species and 21 shorebirds were identified on the Muiron and Exmouth Gulf Islands during the first of these surveys and seven bird species were recorded nesting (Surman 2013).

8.1.4 Dampier Archipelago/Cape Preston Region

The Dampier Archipelago/Cape Preston region is a nesting area for at least 16 species of seabirds. Many of the islands and rocks in the area are known breeding grounds for birds, including wedge-tailed shearwaters (*Ardenna pacifica*), Caspian terns (*Sterna caspia*), bridled terns (*Onychoprion anaethetus*) and roseate terns (*Sterna dougallii*). Small islands and islets such as Goodwyn Island, Keast Island and Nelson Rocks provide important undisturbed nesting and refuge sites, and Keast Island provides one of the few nesting sites for pelicans in WA (CALM & MPRA 2005).

8.1.5 Barrow Island Group

Barrow Island and surrounding islands have a diverse avifauna comprising at least 119 species (Chevron 2010), including 11 resident land birds, eight resident seabirds, 17 seabirds, 22 species of migratory waders, six resident shorebirds and 43 irregular visitors (Surman 2003). The avifauna of Barrow Island is thus poor in terms of land birds and waterfowl compared to mainland areas of the Pilbara, but rich in migratory waders and seabirds. Compared to other nearby offshore islands, Barrow Island has substantially more migratory waders but fewer breeding seabirds (Surman 2003).

8.1.6 Lowendal Island Group and Airlie and Serrurier Islands

The Lowendal Island Group has a diverse avifauna comprising 89 recorded species (Dinara Pty Ltd. 1991, Burbidge *et al*. 2000). Six species of resident land birds and six species of raptors have been recorded at the Lowendal Islands (Surman & Nicholson 2012). Up to fourteen seabird species have been observed at any one time during annual surveys of the Lowendal Islands between 2004 and 2012. Surveys at the Montebello Islands have recorded 70 bird species. This includes 12 species of seabirds and 14 species of migratory shorebirds (Burbidge *et al*. 2000).

Wedge-tailed shearwaters have been identified to nest on Varanus, Airlie, Serrurier and Bridled Islands (Astron 2017a). Breeding participation on the islands appears to be largely influenced by pre-breeding oceanographic conditions (Astron 2017a). Monitoring in 2016/17 was undertaken by Santos and demonstrated the colony sizes for wedge-tailed shearwaters to be within or above previously reported ranges (Astron 2017a). This is informed though monitoring that has been undertaken under the Integrated Shearwater Monitoring Program (ISMP), established in 1994.

In 2016/17, areas of potential wedge-tailed shearwater nesting habitat were recorded on Varanus Island (5.53 ha) and Airlie Island (12.47 ha) and surrounding islands of Bridled (2.94 ha), Serrurier (130.89 ha), Abutilon (2.02 ha) and Parakeelya (1.66 ha) (Astron 2017a). The number of wedge-tailed shearwater breeding pairs was also estimated for each of Varanus (1,492 +/- 702), Airlie (600 +/- 124), Bridled (1,039 +/- 342), Serrurier (23,240 +/- 4,341), Abutilon (317 +/- 210) and Parakeelya (172 +/- 138) islands (Astron 2017a).

Other seabird species utilising Abutilon, Beacon, Bridled and Parakeelya islands for nesting include bridled terns, silver gulls, crested terns and lesser crested terns. Monitoring for these seabirds in 2016/17 was also completed by Santos, with monitoring results concluded to support previous trends for all species. Bridled terns mainly utilise Abutilon, Bridled and Parakeelya islands for breeding, with smaller numbers noted on Beacon and Varanus Islands. The bridled terns have not been recorded on Airlie Island and only in very small numbers on Varanus Island (Astron 2017b).

Silver gull numbers appear to be growing across the region (2010/2011). However, reasons for this are unknown but considered possibly to be due to greater prey availability or immigration from the mainland (Astron 2017b). Silver gulls have been found to utilise Bridled, Parakeelya, Abutilon and Beacon islands longer term for breeding. Silver gulls have not been identified to nest on Varanus island and were only recorded nesting on Airlie island for the first time in 2016/17 since monitoring commencement in 2004/05 (Astron 2017b).

The crested tern and lesser crested tern are noted as nomadic breeders that appear to use a consistent subset of islands for breeding. In 2016/17, Beacon Island was the favourable nesting site for the crested tern and lesser crested tern (Astron 2017b). Surveys in the vicinity of Port Hedland (Bennelongia 2011) recorded 23 species of migratory shorebird between 2002 and 2011. Terrestrial/coastal and seabird species were not targeted. A total of 4,248 migratory shorebirds of 18 species were observed during the field survey in April 2011.

8.2 Threatened Species

A Protected Matters search of the combined EMBA identified 33 bird species (**Appendix A**) listed as threatened under the EPBC Act.

An examination of the Species Profile and Threats database (DAWE 2020a) and The Action Plan for Australian Birds (Garnet 2011) showed that some listed bird species are not expected to occur in significant numbers in the marine and coastal environments in the combined EMBA due to their terrestrial or southern distributions. Hence, these species are not discussed further.

EPBC Act threatened species expected to occur in the area are listed in **Table 8-1** along with their WA and NT conservation status (as applicable), and discussed below. There are an additional 51 migratory species listed under the EPBC Act, with these detailed in **Section 8.3** (**Table 8-3**). BIAs for birds are detailed in **Table 8-7** and depicted in **Figure 8-1** and **Figure 8-2**.

Table 8-1: Birds listed as threatened under the EPBC Act

Species	Conservation Status				Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
Shorebirds						
Red knot (Calidris canutus)	Endangered, Migratory	Endangered	-	Vulnerable	Species or species habitat known to occur within area	None - No BIA defined
Christmas Island Goshawk (*Accipiter fasciatus natalis*)	Endangered	Endangered	-	-	Species or species habitat known to occur within area	None - No BIA defined
Curlew sandpiper (*Calidris ferruginea*)	Critically endangered, Migratory	Critically endangered	-	Vulnerable	Species or species habitat known to occur within area	None - No BIA defined
Great knot (*Calidris tenuirostris)*	Critically endangered, Migratory	Critically endangered	-	Vulnerable	Roosting known to occur within area	None - No BIA defined
Greater sand plover (*Charadrius leschenaultii)*	Vulnerable, Migratory	Vulnerable	-	Vulnerable	Roosting known to occur within area	None - No BIA defined
Lesser sand plover (*Charadrius mongolus)*	Endangered, Migratory	Endangered	-	Vulnerable	Roosting known to occur within area	None - No BIA defined
Western Alaskan bar-tailed godwit (*Limosa lapponica baueri)*	Vulnerable, Migratory[6]	Vulnerable, Specially protected (migratory)[7]	-	Vulnerable	Species or species habitat known to occur within area	None - No BIA defined
Northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri)*	Critically endangered, Migratory[7]	Critically endangered, Specially protected (migratory)[7]	-	Vulnerable	Species or species habitat known to occur within area	None - No BIA defined
Eastern curlew	Critically endangered,	Critically endangered	-	Vulnerable	Species or species habitat known to	None - No BIA defined

[6] Listed as migratory at species level

Species	Conservation Status				Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
(*Numenius madagascariensis)*	Migratory				occur within area	
Australasian bittern (*Botaurus poiciloptilus)*	Endangered	Endangered	-	-	Species or species habitat known to occur within area	None - No BIA defined
Australian painted snipe (*Rostratula australis)*	Endangered	Endangered	-	Vulnerable	Species or species habitat may occur within area	None - No BIA defined
Seabirds						
Australian lesser noddy (*Anous tenuirostris melanops)*	Vulnerable	Endangered	-	-	Breeding known to occur within area	Yes – refer to **Table 8-7**
Fairy prion (southern) (*Pachyptila tutur subantarctica)*	Vulnerable	-	-	-	Species or species habitat known to occur within area	None - No BIA defined
Southern royal albatross (*Diomedea epomophora)*	Vulnerable, Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Northern royal albatross (*Diomedea sanfordi)*	Endangered, Migratory	Endangered	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Amsterdam albatross (*Diomedea amsterdamensis*)	Endangered, Migratory	Critically endangered	-	-	Species or species habitat may occur within area	None - No BIA defined
Antipodean albatross (*Diomedea antipodensis)*	Vulnerable Migratory	-	-	-	Foraging, feeding or related behaviour likely to occur within area	None - No BIA defined
Sooty Albatross (*Phoebetria fusca)*	Vulnerable, Migratory	Endangered	-	-	Species or species habitat	None - No BIA defined

Species	Conservation Status				Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
					may occur within area	
Tristan albatross (*Diomedea dabbenea)*	Endangered, Migratory	Critically endangered	-	-	Species or species habitat may occur within area	None - No BIA defined
Wandering albatross (*Diomedea exulans)*	Vulnerable, Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA
Christmas island frigatebird (*Fregata andrewsi)*	Endangered, Migratory	Specially protected (migratory)	-	-	Foraging, feeding or related behaviour known to occur within area	None - No BIA defined
Southern giant petrel (*Macronectes giganteus)*	Endangered, Migratory	Specially protected (migratory)	-	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Northern giant petrel (*Macronectes halli)*	Vulnerable, Migratory	Specially protected (migratory)	-	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Abbott's booby (*Papasula abbotti)*	Endangered	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Soft-plumaged petrel (*Pterodroma mollis)*	Vulnerable	-	-	-	Foraging, feeding or related behaviour known to occur within area (high numbers)	Yes – refer to **Table 8-7**
Blue petrel (*Halobaena caerulea)*	Vulnerable	-	-	-	Species or species habitat may occur within area	None - No BIA defined
Australian fairy tern (*Sternula nereis nereis)*	Vulnerable	Vulnerable	-	-	Breeding known to occur within area. Foraging	Yes – refer to **Table 8-7**

Species	Conservation Status				Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
					(in high numbers)	
Indian yellow-nosed albatross (*Thalassarche carteri)*	Vulnerable, Migratory	Endangered	-	-	Foraging, feeding or related behaviour may occur within area	Yes – refer to **Table 8-7**
Shy albatross (*Thalassarche cauta)*	Endangered, Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA
White-capped albatross (*Thalassarche steadi)*	Vulnerable, Migratory	Vulnerable	-	-	Foraging, feeding or related behaviour likely to occur within area	None - BIA not found in EMBA
Black-browed albatross (*Thalassarche melanophris)*	Vulnerable, Migratory	Endangered	-	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Campbell albatross (*Thalassarche impavida)*	Vulnerable, Migratory	Vulnerable	-	-	Species or species habitat may occur within area	None - BIA not found in EMBA
Christmas Island white-tailed tropicbird (*Phaethon lepturus fulvus)*	Endangered	-	-	-	Species or species habitat may occur within area	None - No BIA defined

8.2.1 Shorebirds

Red Knot (New Siberian Islands and north-eastern Siberia)

The red knot is a migratory shorebird, and the species includes five subspecies, including two found in Australia, *Calidris canutus piersmai* and *Calidris canutus rogersi*. The red knot breeds in Siberia and spends the non-breeding season in Australia and New Zealand. During the non-breeding season, the species spends the majority of its time on tidal mudflats or sandflats where they feed on intertidal invertebrates, especially shellfish (Garnet *et al.* 2011).

Curlew Sandpiper

This species is a migratory shorebird that breeds in north Siberia and spends the non-breeding season from western Africa to Australia (Bamford *et al.* 2008). The curlew sandpiper occurs around coastal Australia and preferred habitats include coastal brackish lagoons, tidal mud and sand flats, estuaries, saltmarshes and less often inland. Their diet is mainly comprised of polychaete worms, molluscs and crustaceans (Higgins & Davies 1996 in Garnet *et al.* 2011).

Great Knot

The great knot is a migratory shorebird with a global distribution, breeding in north-east Siberia and spending the non-breeding season along coasts from Arabia to Australia. Non-breeding birds migrate to inlets, bays, harbours, estuaries and lagoons with large intertidal mud and sand flats where they feed on bivalves, gastropods, crustaceans and other invertebrates (Higgins & Davies 1996 in Garnet *et al.* 2011).

Greater Sand Plover and Lesser Sand Plover

The greater sand plover and lesser sand plover are congeners that breed in China, Mongolia and Russia. The greater sand plover spends the non-breeding season along coasts from Japan through southeast Asia to Australasia, while the lesser sand plover spends the non-breeding season along coasts from Taiwan to Australasia (Banford *et al*. 2008). Non-breeding birds occur along all Australian coasts, especially in the north for the greater sand plover and in the east for the lesser sand plover (DAWE 2020a).

Non-breeding birds forage on beaches, salt-marshes, coastal bays and estuaries, and feed on marine invertebrates including molluscs, worms, crustaceans and insects (Marchant & Higgins 1993 in Garnet *et al*. 2011).

Bar-tailed Godwit (Western Alaskan and Northern Siberian Subspecies)

Two subspecies of the bar-tailed godwit exist, as determined by their breeding locations in Siberia and Alaska (Bamford *et al*. 2008). Non-breeding birds migrate to the coasts of Australia. The western Alaskan subspecies occurs especially on the north and east coasts of Australia whilst the northern Siberian subspecies occurs especially along the coasts of north Western Australia (DAWE 2020a).

Non-breeding birds are found on muddy coastlines, estuaries, inlets, mangrove-fringed lagoons and sheltered bays, feeding on annelids, bivalves and crustaceans (Higgins and Davies 1996 in Garnet *et al*. 2011).

Eastern Curlew

The eastern curlew is a migratory shorebird that breeds in Siberia, Kamchatka and Mongolia and migrates to coastal East Asia and Australia. The South Korean Yellow Sea is an important staging post for this species. Non-breeding birds occur around coastal Australia, are more common in the north and have disappeared or become much rarer at many sites along the south coast (Garnet 2011).

Non-breeding birds are present at estuaries, mangroves, saltmarshes and intertidal flats, particularly those with extensive seagrass (Zosteraceae), where they feed on marine invertebrates, especially crabs and small molluscs (Higgins & Davies 1996 in Garnet 2011).

Australian Painted Snipe

The Australian painted snipe has been recorded at wetlands in all states of Australia (DoE 2014g). The Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (*Melaleuca*). The Australian painted snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber (DoE 2014g).

Australasian Bittern

The Australasian bittern is found in coastal and sub-coastal areas of south-eastern and south-western mainland Australia and the eastern marshes of Tasmania (Birdlife Australia 2017). The Australasian Bittern occurs mainly in freshwater wetlands and, rarely, in estuaries or tidal wetlands (Marchant & Higgins 1990). It favours wetlands with tall dense vegetation, where it forages in still, shallow water up to 0.3 m deep, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water. It favours permanent and seasonal freshwater habitats, particularly those dominated by sedges, rushes and reeds (e.g. *Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus*) or cutting grass (*Gahnia*) growing over a muddy or peaty substrate (Marchant & Higgins 1990). The diet of the Australasian Bittern includes aquatic animals such as small fish, frogs, freshwater crayfish, spiders, insects and small reptiles at night. Breeding occurs during summer from October to January.

All remaining natural habitat (including constructed wetlands) is considered critical habitat for this species. This species is known to occur on the western coastal plain between Lancelin and Busselton and the southern coastal region from Augusta to east of Albany within the combined EMBA (**Table 8-7**).

8.2.2 Seabirds

Australian Lesser Noddy

This species is usually found only around its breeding islands in the Houtman Abrolhos Islands in Western Australia (Storr *et al*. 1986). The Australian lesser noddy occupies coral-limestone islands that are densely fringed with white mangrove *Avicennia marina*, and it occasionally occurs on shingle or sandy beaches (Higgins & Davies 1996 in DAWE 2020a). This species is thought to be sedentary or resident, staying near to its breeding islands in the non-breeding season. It may leave nesting islands for short periods during the non-breeding season, and probably forages widely (Higgins & Davies 1996 in DAWE 2020a).

Breeding apparently occurs only on Morley, Wooded and Pelsaert Islands at the Houtman Abrolhos Islands (Higgins and Davies 1996 in DoE 2014b). Mangrove stands support approximately 68,000 breeding pairs spread over the three islands (Surman & Nicholson 2006). Breeding may also occur on Ashmore Reef (Stokes & Hinchey 1990). The breeding season extends from mid-August to early April (Higgins & Davies 1996 in DoE 2014b).

The National Conservation Values Atlas identifies BIAs for this species in the area of the Houtman Abrolhos islands (**Table 8-7**). The Species Group Report Card – Seabirds (DSEWPaC 2012b) states that the entire Australian population of this species breeds in the South-west Marine Region, south of Busselton.

Albatrosses

A Protected Matters search of the waters in the combined EMBA (**Appendix A**) identified several albatross species that may occur in the area, comprising of the southern royal albatross, northern royal albatross, Amsterdam albatross, Antipodean albatross, Tristan albatross, sooty albatross, wandering albatross, Indian yellow-nosed albatross, shy albatross, white-capped albatross, black-browed albatross and Campbell albatross. All these species predominantly occur in subantarctic to subtropical waters and breed on islands in the southern oceans (DAWE 2020a).

The National Conservation Values Atlas (DAWE 2020b) and the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC 2011) do not identify any BIAs for these species in the area from Busselton to the NT border. However, a BIA for the Indian yellow-nosed albatross is identified for foraging north to Shark bay and extending east into Bass Strait.

Christmas Island Frigatebird

The Christmas Island frigatebird is a very large seabird. Breeding colonies of the Christmas Island frigatebird is currently confined to Christmas Island in the Indian Ocean (Birdlife International 2019) but forages and roosts widely in south-east Asia and Indian Ocean No breeding colonies have ever been found away from Christmas Island. The Christmas Island Frigatebird predominantly nests in forests on shore terraces that are protected from prevailing south-east trade winds (TSSC 2020a). All forest containing nesting and roosting sites, including currently known nesting and roosting colonies and any other smaller groups of nests and roosts on Christmas Island is considered critical habitat (TSSC 2020a).

Christmas Island Goshawk

The Christmas Island Goshawk is considered to be the rarest endemic bird on Christmas Island, where it occurs in all habitats from primary and marginal rainforests to suitable areas of secondary regrowth vegetation. The total population size is thought to be very small, perhaps as few as 100 adults, and is probably limited by the availability of suitable rainforest habitat.

Crazy Ants pose an unknown but potentially critical threat to the survival of this bird. The National recovery plan for the Christmas Island Goshawk (*Accipiter fasciatus natalis*) aims to downgrade the Christmas Island Goshawk from Endangered to Conservation Dependent, primarily through successful implementation of the Invasive Ants on Christmas Island Action Plan and protection of habitat critical to the survival of the species from clearance. An assessment of goshawk population dynamics is the most essential requirement of this recovery plan, and community awareness and participation in the conservation of this endemic raptor are also important actions.

Southern Giant Petrel

The southern giant petrel is a highly migratory bird with a large natural range. This species occurs from Antarctic to subtropical waters and breeds on the Antarctic continent, peninsular and islands and on subantarctic islands and South America. Breeding occurs annually between August and March (DAWE 2020a).

The National Conservation Values Atlas (DAWE 2020b) and the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC 2011) do not identify any BIAs for this species in the area from Busselton to the NT border.

Northern Giant Petrel

The northern giant petrel occupies the Antarctic Polar Front. In summer, it occurs predominantly in sub-Antarctic to Antarctic waters, usually between 40 and 64° The northern giant-petrel breeds on sub-Antarctic islands. Its breeding range extends into the Antarctic zone at South Georgia. It nests in coastal areas where vegetation or broken terrain offers shelter, on sea-facing slopes, headlands, in the lee of banks, under or against vegetation clumps, below cliffs or overhanging rocks, or in hollows. On Campbell Island, it nests on the edge of the coastal plateau. Tussock-grass is widespread at many breeding sites. Its nests are built in secluded, coastal sites, sheltered by heavy vegetation. On Antipodes Island, it nests under *Senecio antipoda* (DoE 2014d).

The National Conservation Values Atlas (DAWE 2020b) does not identify any BIAs for this species in the area spanning SW WA to the NT border.

Soft-Plumaged Petrel

The soft-plumaged petrel is generally found over temperate and subantarctic waters in the South Atlantic, Southern Indian and western South Pacific Oceans. The species breeds colonially on islands in the southern oceans. Breeding occurs from August to May (Marchant & Higgins 1990 in DAWE 2020a).

A BIA for this species is identified for foraging in seas north to 21°30’S off WA.

Blue Petrel

The blue petrel is marine species of the Sub Antarctic and Antarctic seas. In summer, it occurs mainly over waters of -2 to 2° C in surface temperature, but it also ranges south to the edge of the pack-ice and north to approximately 30° south, or further north over cool currents (DoE 2014e). In the Antarctic, it generally avoids the pack-ice, and only occasionally approaches the edge of the ice. Given the location of the combined EMBA, this species is unlikely to occur.

The National Conservation Values Atlas (DAWE 2020b) does not identify any BIAs for this species in the area spanning SW WA to the NT border.

Abbott’s Booby

Currently, Abbott's booby is only known to breed on Christmas Island and to forage in the waters surrounding the island and south-east Asia (TSSC 2020b). Within Christmas Island, most nests are found in the tall plateau forest on the central and western areas of the island, and in the upper terrace forest of the northern coast.

The National Conservation Values Atlas (DoEE 2019b) does not identify any BIAs for this species in the area spanning SW WA to the NT border. Critical habitat is considered all known nesting trees and all forest vegetation within a 200m radius of known nesting trees on Christmas Island (TSSC 2020).

Australian Fairy Tern

The Australian fairy tern is distributed in a large geographic range between Australia, New Zealand and New Caledonia. Three subspecies have been identified, one of which is found in Australia. The Australian fairy tern occurs along the coasts of Victoria, Tasmania, South Australia and WA; occurring as far north as the Dampier Archipelago (DAWE 2020a). The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine islands, wetlands and mainland coastline (Higgins & Davies 1996 in DoE 2014b, Lindsey 1986).

Australian fairy terns nest on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The Australian fairy tern breeds from August to February depending on the location of the breeding colony (Higgins & Davies 1996 in DAWE 2020a). They generally nest in small colonies of up to 100 birds, although larger colonies of more than 1400 pairs have been reported in Western Australia (Hill *et al*. 1988).

The National Conservation Values Atlas (DAWE 2020b) identifies the vicinity of the lower north-west coast (north to Dampier Archipelago) and west coast (south to Peel inlet) as BIAs for foraging. Biologically important breeding areas were also identified scattered along the coast between Shark Bay and the Pilbara (**Table 8-7**).

Christmas Island White-tailed Tropicbird

The Christmas Island white-tailed tropicbird is endemic to Christmas Island and leaves the island to forage in the warm waters of the Indian Ocean (Garnett 2011). The white-tailed tropicbird roots at sea; only incubating or brooding adults remain on nests on the island at night (Stokes 1988).

The National Conservation Values Atlas (DAWE 2020b) does not identify any BIAs for this species within the combined EMBA.

Fairy Prion (southern)

The fairy prion is distributed off the cold-water coasts of Antarctica and southern Australia and New Zealand. The southern subspecies is known to breed on Macquarie Island, Langdon Point, Davis Point and Bishop and

Clerk islands (Garnett & Crowley 2000). It is estimated that the population of the fairy piron (southern) is a little over 50 pairs (Brothers 1984).

The National Conservation Values Atlas (DAWE 2020b) does not identify any BIAs for this species within the combined EMBA.

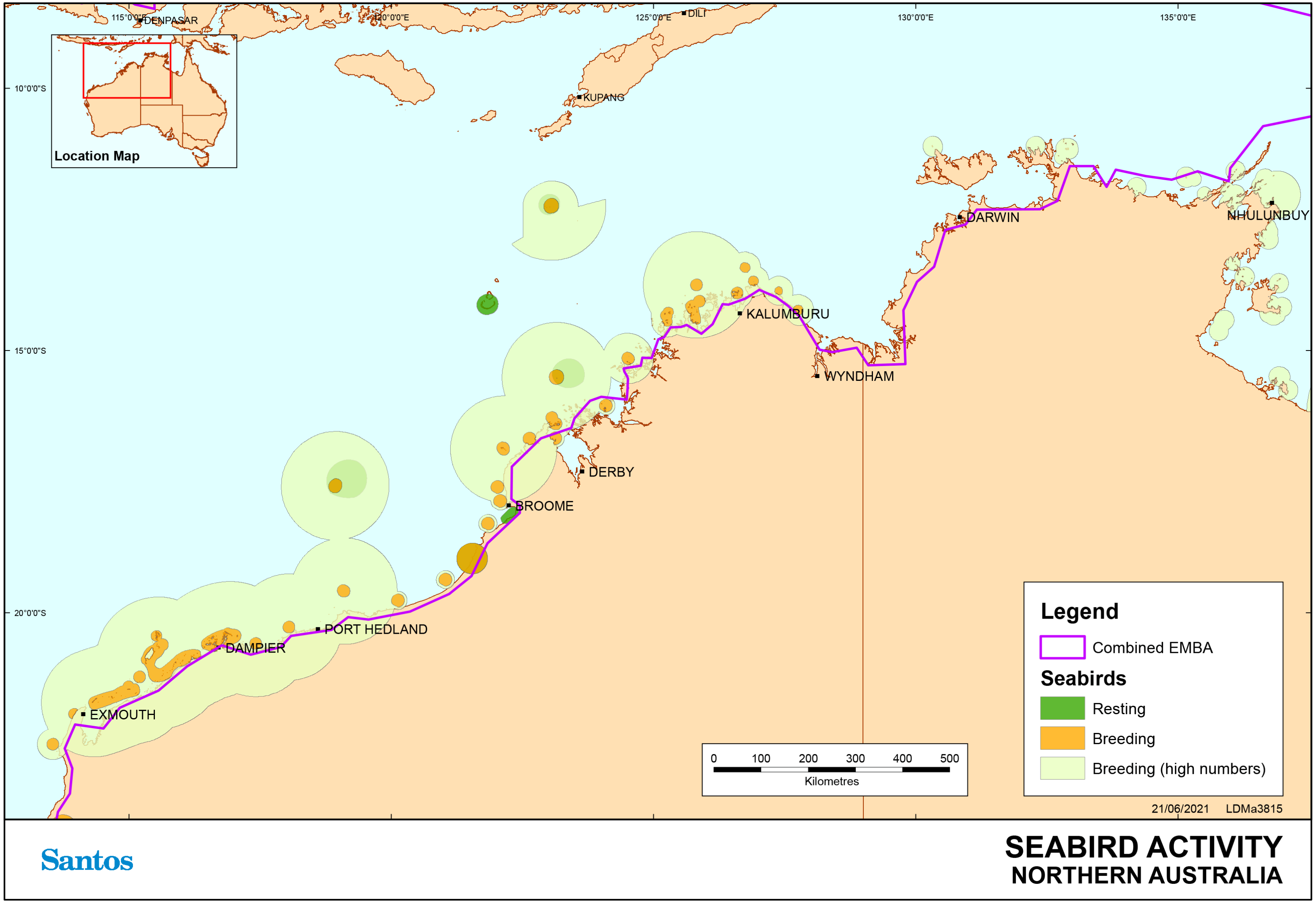


Figure 8-1: Biologically important areas – birds – Northern WA

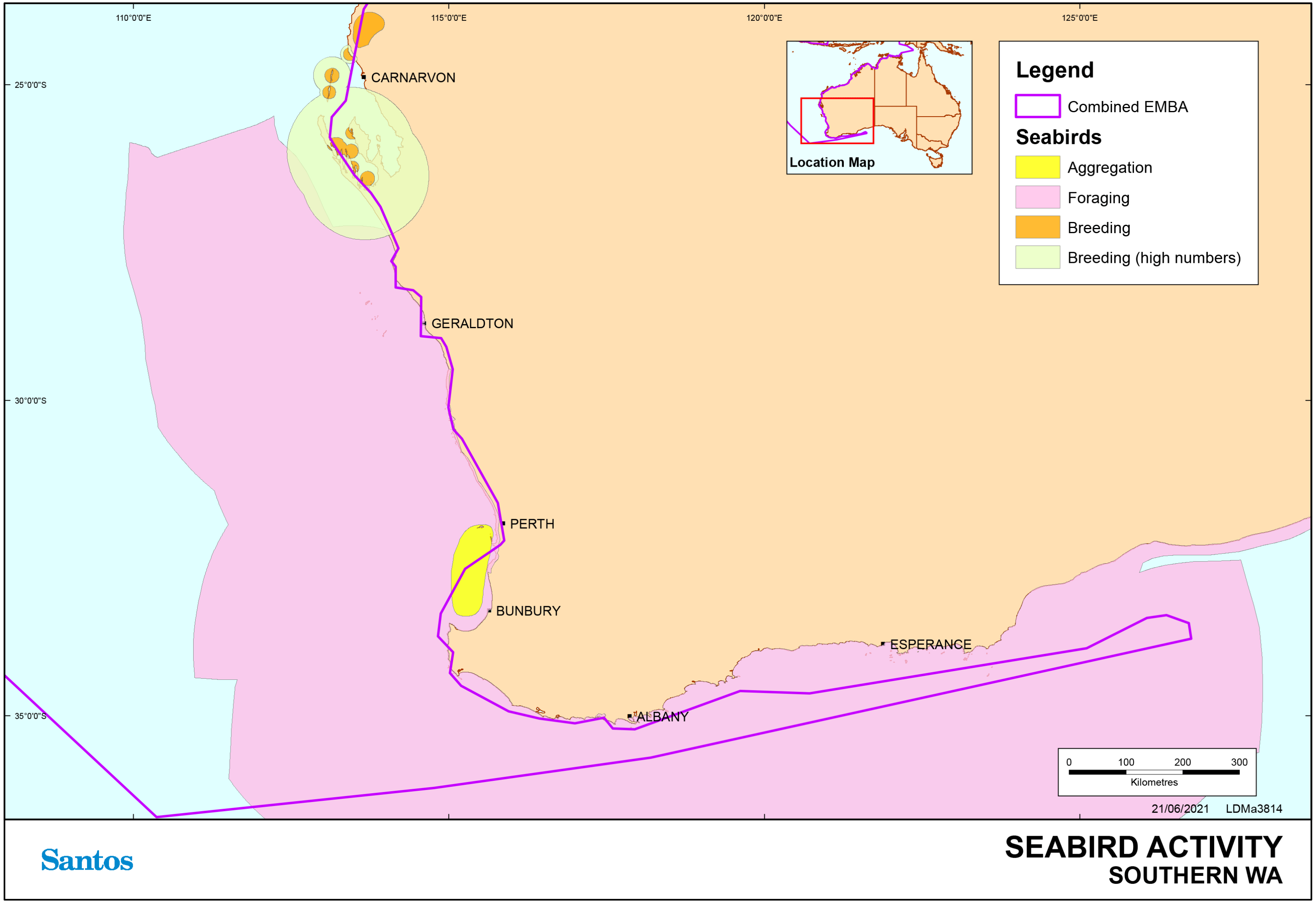


Figure 8-2: Biologically important areas – birds – Southern WA

Table 8-2: Summary of information for birds listed as threatened under the EPBC Act that may be in the combined EMBA

Species	Species Expected in EMBA	Breeding in the Area /Seasonality	Foraging
Shorebirds			
Red knot	Yes	No	Intertidal invertebrates
Curlew sandpiper	Yes	No	Polychaete worms, molluscs and crustaceans taken from shorelines
Great knot	Yes	No	Bivalves, gastropods, crustaceans and other invertebrates taken from shorelines
Greater sand plover/lesser sand plover	Yes	No	Marine invertebrates taken from shorelines
Bar-tailed godwit	Yes	No	Annelids, bivalves and crustaceans taken from shorelines
Eastern curlew	Yes	No	Marine invertebrates associated with seagrass
Australasian bittern	Yes	No	Other small animals, insects, snails and spiders
Australian painted snipe	Yes	No	Seeds and small invertebrates
Western Alaskan bar-tailed godwit	Yes	No	Worms, molluscs, crustaceans, insects
Northern Siberian bar-tailed godwit	Yes	No	Worms, molluscs, crustaceans, insects and some plant material
Seabirds			
Australian lesser noddy	May forage from Kalbarri to Shark Bay	No	Small fish taken from marine and coastal waters (DoE 2014b)
Amsterdam albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Antipodean albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Black-browed albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Campbell albatross	Low densities	No	Cephalopods, fish, salps, jellyfish and crustaceans taken from marine and coastal waters.
Indian yellow-nosed albatross	Low densities	No	Cephalopods, and fish taken from marine and coastal waters.
Northern royal albatross	Low densities	No	Cephalopods, fish, salps and crustaceans taken from marine and coastal waters.
Shy albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
Sooty Albatross	Low densities	No	Cephalopods, fish, crustaceans, siphonophores and penguin carrion taken from marine waters.

Species	Species Expected in EMBA	Breeding in the Area /Seasonality	Foraging
Southern royal albatross	Low densities	No	Cephalopods, and fish taken from marine and coastal waters.
Tristan albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine waters.
Wandering albatross	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters.
White-capped albatross	Low densities	No	Cephalopods and fish taken from marine and coastal waters.
Southern & Northern giant petrel	Low densities	No	Scavenges penguin, seal and whale carcasses. Hunts live birds, penguin chicks' cephalopods and krill. Marine and coastal waters (DoE 2014b)
Soft-plumaged petrel	Low densities	No	Cephalopods, fish and crustaceans taken from marine and coastal waters (DoE 2014b)
Australian fairy tern	Yes	Yes Aug to Feb	Bait fish taken from coastal waters
Fairy prion (southern)	Very low densities	No	Small pelagic crustaceans, small fish and squid
Christmas Island frigatebird	Low densities	No	Planktonic crustaceans, fish and squid
Abbott's booby	Low densities	No	Fish and squid
Blue petrel	Low densities	No	Crustaceans, small fish and squid
Christmas Island white-tailed tropicbird	Very low densities	No	Squid and flying fish

8.3 Migratory Species

The EPBC PMST search identified an additional 78 species listed as migratory under the EPBC Act that may occur within the combined EMBA. These species are listed in **Table 8-3**. All of these species are also listed as migratory under the BC Act, with the exception of the flesh-footed shearwater, which is listed as vulnerable under the BC Act. Those species that are listed as both migratory and threatened under either the EPBC Act and/or BC Act are outlined in **Table 8-1** and are not repeated within **Table 8-3**.

Table 8-3: Summary of migratory birds that may occur within the combined EMBA

Species	Common Name	Likelihood of occurrence in EMBA
Limnodromus semipalmatus	Asian dowitcher	Roosting known to occur within area
Limosa lapponica	Bar-tailed godwit	Species or species habitat known to occur within area
Limosa limosa	Black-tailed godwit	Roosting known to occur within area
Onychoprion anaethetus	Bridled tern	Breeding known to occur within area
Limicola falcinellus	Broad-billed sandpiper	Roosting known to occur within area
Sula leucogaster	Brown booby	Breeding known to occur within area

Species	Common Name	Likelihood of occurrence in EMBA
Hydroprogne caspia	Caspian tern	Breeding known to occur within area
Tringa nebularia	Common greenshank	Species or species habitat known to occur within area
Anous stolidus	Common noddy	Breeding known to occur within area
Tringa totanus	Common redshank	Roosting known to occur within area
Actitis hypoleucos	Common sandpiper	Species or species habitat known to occur within area
Thalasseus bergii	Crested tern	Breeding known to occur within area
Charadrius bicinctus	Double-banded plover	Roosting known to occur within area
Ardenna carneipes	Flesh-footed shearwater	Breeding known to occur within area
Apus pacificus	Fork-tailed swift	Species or species habitat likely to occur within area
Thalasseus bergii	Greater crested tern	Breeding known to occur within area
Fregata minor	Greater frigatebird	Breeding known to occur within area
Pluvialis squatarola	Grey plover	Roosting known to occur within area
Tringa brevipes	Grey-tailed tattler	Roosting known to occur within area
Fregata ariel	Lesser frigatebird	Breeding known to occur within area
Numenius minutus	Little curlew	Roosting known to occur within area
Tringa stagnatilis	Little greenshank	Roosting known to occur within area
Sternula albifrons	Little tern	Breeding known to occur within area
Calidris subminuta	Long-toed stint	Species or species habitat known to occur within area
Sula dactylatra	Masked booby	Breeding known to occur within area
Tringa stagnatilis	Marsh sandpiper	Roosting known to occur within area
Charadrius veredus	Oriental plover	Roosting known to occur within area
Glareola maldivarum	Oriental pratincole	Roosting known to occur within area
Pandion haliaetus	Osprey	Breeding known to occur within area
Pluvialis fulva	Pacific golden plover	Roosting known to occur within area
Calidris melanotos	Pectoral sandpiper	Species or species habitat known to occur within area
Gallinago stenura	Pin-tailed snipe	Roosting known to occur within area
Sula sula	Red-footed booby	Breeding known to occur within area
Phalaropus lobatus	Red-necked phalarope	Roosting known to occur within area
Calidris ruficollis	Red-necked stint	Roosting known to occur within area
Phaethon rubricauda	Red-tailed tropicbird	Breeding known to occur within area
Sterna dougallii	Roseate tern	Breeding known to occur within area
Arenaria interpres	Ruddy turnstone	Roosting known to occur within area
Philomachus pugnax	Ruff (reeve)	Roosting known to occur within area
Calidris alba	Sanderling	Roosting known to occur within area
Calidris acuminata	Sharp-tailed sandpiper	Roosting known to occur within area

Species	Common Name	Likelihood of occurrence in EMBA
Erythrotriorchis radiatus	Short-tailed shearwater	Species or species habitat may occur within area
Ardenna grisea	Sooty shearwater	Species or species habitat may occur within area
Calonectris leucomelas	Streaked shearwater	Species or species habitat known to occur within area
Gallinago magala	Swinhoe's snipe	Roosting known to occur within area
Xenus cinereus	Terek sandpiper	Roosting known to occur within area
Tringa glareola	Wandering Tattler	Roosting known to occur within area
Ardenna pacifica	Wedge-tailed shearwater	Breeding known to occur within area
Numenius phaeopus	Whimbrel	Roosting known to occur within area
Phaethon lepturus	White-tailed tropicbird	Breeding known to occur within area
Tringa glareola	Wood sandpiper	Roosting known to occur within area

Australia is signatory to three international treaties with China, Japan and the Republic of Korea to safeguard migratory bird species, predominantly shorebirds. To facilitate observance of the three agreements, 36 species of migratory shorebirds have been listed as specially protected under both the Commonwealth EPBC Act and the WA BC Act.

Eleven internationally recognised areas that can support shorebird migrations are protected as wetlands of international importance. These wetlands are discussed further in **Section 9.1.3**.

The EPBC Act Policy Statement 3.21 sets out criteria for determining the significance of sites to migratory shorebirds based on the number of migratory species and the proportion of a species population that is supported by the site (Commonwealth of Australia 2017b). Site significance can be difficult to assess, particularly for ephemeral inland wetlands. These areas may be used rarely, depending weather conditions, but still provide important habitat for migratory shorebird species.

Migratory shorebirds require a particular conservation approach due to their migration patterns that take them across international boundaries (Bamford *et al*. 2008). These species and their habitats are sensitive to threats due to their high site fidelity, tendency to aggregate, high energy demands and the need for habitat networks containing both roosting and foraging sites (Commonwealth of Australia 2017b). Migratory shorebirds are known to use networks of connected sites (also known as site complexes). They move within these networks depending on the time of day, availability of resources and environmental conditions at the site (Commonwealth of Australia 2017b).

The types of habitat used by migratory shorebirds in Australia vary across the species identified in the PMST search. Migratory shorebirds use both coastal and inland habitats that most commonly include:

+ Coastal habitats: coastal wetlands, estuaries, mudflats, rocky inlets, reefs and sandy beaches, sometimes supporting mangroves; and
+ Inland habitats: inland wetlands, floodplains and grassland areas, often with ephemeral water sources (Commonwealth of Australia 2017b).

Feeding guilds provide an explanation for much of the shorebird distribution pattern in the north Western Australia. For example, Rogers (1999) classified shorebirds (and others) in Roebuck Bay as belonging to seven guilds on the basis of prey choice and foraging method. In order of abundance, these are summarised in **Table 8-4**.

Table 8-4: Feeding guilds based on prey choice and foraging method (Rogers 1999) adapted from DEC (2003) and Bennelongia (2008)

Feeding habitat	Feeding guild	Species
Sea edge	Tactile hunters of macrobenthos	Great knot, red knot, bar-tailed godwit, black-tailed godwit, Asian dowitcher
Along sandy sea edges or near tidal creeks	Tactile hunters of microbenthos	Curlew sandpiper, red-necked stint, broad-billed sandpiper, marsh sandpiper, sharp-tailed sandpiper
Reefs or mangrove fringes	Visual hunters of slow surface-dwelling prey	Common sandpiper, sooty oystercatcher, pied oystercatcher, silver gull, ruddy turnstone
Sandier western parts of Roebuck Bay, often near-shore	Visual hunters of small fast prey	Grey plover, red-capped plover, greater sand plover, lesser sand plover, grey-tailed tattler, terek sandpiper
Soft mudflats in north-east Roebuck Bay	Visual hunters of fast large prey	Eastern curlew, whimbrel, greenshank, striated heron and black-necked stork
Soft mudflats in north-east Roebuck Bay	Kleptoparasites	Gull-billed tern (robs large crabs from whimbrels)
Creek-lines in eastern Roebuck Bay	Pelagic hunters of nekton (animals of the pelagic zone) and neuston (animals that live on the surface film)	Black-winged stilt, red-necked avocet, reef egret, little egret, great white egret, white-faced heron, royal spoonbill

The Wildlife Conservation Plan for Migratory Shorebirds (DoE 2015) provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia and, in recognition of their migratory habits, outlines national activities to support their appreciation and conservation throughout the East Asian-Australasian Flyway.

The following migratory shorebird species are subject to the Wildlife Conservation Plan for Migratory Shorebirds 2015 (DoE 2015).

Table 8-5: Birds subject to the Wildlife Conservation Plan for Migratory Shorebirds 2015

Migratory species	DoEE SPRAT information on distribution within the area of interest
Asian dowitcher	The Asian dowitcher is a regular visitor to the north-west between Port Hedland and Broome. Elsewhere they are sporadic and rare. In the NT, the Asian dowitcher is found in Darwin and Arnhem Land. In WA, the species has been recorded at Albany, Lake McLarty, Lake McLeod, north-east Pilbara and the south-west Kimberley division. It has also been recorded at the Port Hedland Saltworks, Roebuck Bay, Ashmore Reed and Eighty Mile Beach. The Australian population is approximately 500 (Bamford *et al*. 2008).
Bar-tailed godwit	The bar-tailed godwit has been recorded in the coastal areas of all Australian states. In WA, it is widespread around the coast, from Eyre to Derby, with a few scattered records elsewhere in the Kimberley. In the NT populations have been recorded from Darwin and Melville Island. Sites of international importance from WA and the NT include; + Eighty Mile Beach, WA (110,290 individuals); + Roebuck Bay, WA (65,000 individuals); + Milingimbi coast, NT (7,000 individuals); and + Elcho Island, NT (5,000 individuals).

Migratory species	DoEE SPRAT information on distribution within the area of interest
Black-tailed godwit	The black-tailed godwit is found in all states and territories of Australia; however, it prefers coastal regions and the largest populations are found on the north coast between Darwin and Weipa. The population that inhabits Roebuck Bay is approximately 7,374 (>1% of the species total population).
Broad-billed sandpiper	In WA, few records occur in the south-west, but the broad-billed sandpiper may be regular in small numbers at scattered locations, from Warden Lake Nature Reserve and Coramup Creek to Guraga Lake Nature Reserve and Hurstview Lake. Individuals mostly occur on the coasts of the Pilbara and Kimberley between Onslow and Broome but are also recorded north to the mouth of Lawley River, and inland at Lake Daley.
Common greenshank	The common greenshank occurs around most of the coast from Cape Arid in the south to Carnarvon in the north-west. In the Kimberley region, it is recorded in the south-west and the north-east, with isolated records from the Bonaparte Archipelago. WA has three sites of international importance for the common greenshank which include: + Eighty Mile Beach (2,240 individuals); + Wilson Inlet (568 individuals); and + Roebuck Bay (560 individuals). The NT does not have any sites of international importance.
Common redshank	In Western Australia (WA), the species is vagrant to the south-west with records at Peel Inlet, Coodanup, the Gascoyne region, Coral Bay and Carnarvon.
Common sandpiper	WA distribution includes: + Roebuck Bay; and + Nuytsland Nature Reserve. NT distribution includes: + Kakadu National Park; and + Darwin area.
Double-banded plover	The double-banded plover can be found in both coastal and inland areas. There are no nationally significant sites within WA.
Fork-tailed swift	In WA, there are sparsely scattered records of the fork-tailed swift along the south coast, ranging from near the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (Higgins 1999). In the NT scattered records exist around some offshore islands, mostly south to Victoria River Downs.
Great knot	The great knot has been recorded around the entirety of the Australian coast, with a few scattered records inland. The greatest numbers are found in northern Australia; where the species is common on the coasts of the Pilbara and Kimberley, from the Dampier Archipelago to the Northern Territory border. Important sites for great knot in Western Australia include: + Eighty Mile Beach (169,044 individuals); and + Roebuck Bay (22,600 individuals).
Greater sand plover	In Australia, the greater sand plover occurs in coastal areas in all states, though the greatest numbers occur in northern Australia, especially the north-west. In northern Australia, the species is especially widespread between North West Cape and Roebuck Bay in Western Australia and are sparsely scattered records from the largely inaccessible area between Roebuck Bay and Darwin.

Migratory species	DoEE SPRAT information on distribution within the area of interest
	Internationally important sites within Western Australia include: + Eighty Mile Beach (64,548 individuals); + Roebuck Bay (26,900 individuals); and + Ashmore Reef (1,196 individuals).
Grey plover	In Australia, the grey plover has been recorded in all states, where it is found along the coasts and are recorded frequently between Albany and the northern Kimberley coast. Internationally important sites include: + Eighty Mile Beach (1,650 individuals); + Roebuck Bay (1,300 individuals); + Peel Inlet (600 individuals); and + Nuytsland Nature Reserve (409 individuals).
Grey-tailed tattler	A recent review of the species indicated an estimated 90% of the East Asian-Australasian Flyway population (approximately 45 000 individuals) spend the non-breeding season in Australia (Bamford et al. 2008). There are a few scattered records for the species along the south coast near the Eyre Bird Observatory, Point Malcolm, Rossiter Bay, Shark Lake Nature Reserve and surrounding swampland. It is found in the south-west between Augusta and Cervantes. The grey-tailed tattler is widespread from Houtman Abrolhos and the mainland adjacent to the Kimberley Division. It has also been recorded inland at Lake Argyle and on islands off the coast.
Lesser sand plover	Within Australia, the lesser sand-plover is widespread in coastal regions and has been recorded in all states. It mainly occurs in northern and eastern Australia, in south-eastern parts of the Gulf of Carpentaria, western Cape York Peninsula and islands in Torres Strait, and along the entire east coast, though it occasionally also occurs inland. In Western Australia, the following are important sites: + Eighty Mile Beach (1,575 individuals); + Roebuck Bay (1,057 individuals); + Broome (745 individuals); and + Port Hedland Saltworks (668 individuals).
Little greenshank	The marsh sandpiper is found on coastal and inland wetlands throughout Australia found mainly on the coast in Western Australia. National sites of importance within Western Australia include: + Port Hedland Saltworks (500 individuals); + Peel inlet (276 individuals); and + Eighty Mile Beach (140 individuals).
Long-toed stint	In Western Australia, the species is found mainly along the coast, with a few scattered inland records. On the south coast the Long-toed Stint is found from Esperance to Albany and inland to Lake Cassencarry and Dumbleyung. On the south-west coast the species is known from the Vasse River estuary, Guraga Lake and the Namming Nature Reserve. The species has occasionally been recorded in the Gascoyne Region, around Lake Wooleen, Meeberrie Station and McNeill Claypan. It is widespread around the Pilbara region and the Kimberley Division between Karratha and Wyndham-Kununurra. Inland records include Lake Brown, Hannan Lake, Lake Biolet, Newman Sewage Farm and Lake Gregory.
Oriental plover	Internationally important marine sites: + Eighty Mile Beach, WA (approximately 57 619 individuals); and + Roebuck Bay, WA (Approximately 8 750 individuals).

Migratory species	DoEE SPRAT information on distribution within the area of interest
Oriental pratincole	Internationally important site: + Eighty Mile Beach, WA (2.88 million birds). The species occurs at numerous and widespread sites in northern Australia, especially near the Pilbara and Kimberley coasts of northern WA, and throughout the entire coastline of the NT.
Pacific golden plover	In Western Australia, the species is seldom recorded along the southern or south-western coasts but is more widespread along the Pilbara and Kimberley coasts between North-West Cape.
Pectoral sandpiper	In Australasia, the pectoral sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. The species is usually found in coastal or near coastal habitat but occasionally found further inland. It prefers wetlands that have open fringing mudflats and low, emergent or fringing vegetation, such as grass or samphire.
Red knot	The red knot large numbers are regularly recorded in north-west Australia, with 80 Mile Beach and Roebuck Bay being particular strongholds. The Australian population during the non-breeding period is estimated to be 135 000 (Hansen et al. 2016).
Red-necked phalarope	The red-necked phalarope is a regular at the Port Hedland Saltworks and Rottnest Island, Western Australia. The species is also found at the ICI Saltworks in South Australia.
Red-necked stint	The red-necked stint has been recorded in all coastal regions and found inland in all states when conditions are suitable. The red-necked stint probably travels in flocks and has been observed to feed in dense flocks. The Australian population was estimated at 353,000. Internationally important sites include: + Eighty Mile Beach (60,000 individuals); + Port Hedland Salt Works (23,000 individuals); + Roebuck Bay (19,800 individuals); + Wilson Inlet (15,252 individuals) + Alfred Cove Nature Reserve (10,000 individuals); + Lake Macleod (8,312 individuals); and + Peel Inlet (8,063 individuals).
Ruddy turnstone	The ruddy turnstone is widespread within Australia during its non-breeding period of the year. Australian sites of international importance include: + Eighty Mile Beach (3,480 individuals); + Ashmore Reef (2,230 individuals); + Roebuck Bay (2,060 individuals); + Barrow Island (1,733 individuals); and + Lacepede Islands (1,050 individuals).
Ruff (reeve)	In Western Australia, the species has been recorded at the lower King River and it is mostly found in the south-west region of the state. It has been sighted at the Vasse River estuary, north to Namming Lake and Lake McLarty. It has been periodically recorded at Port Hedland, Kununurra and the Argyle Diamond Mine. There are unconfirmed reports at Curlewis Camp, Millstream Chichester, Broome and Roebuck Bay.
Sanderling	They occur on most of the coast from Eyre to Derby, and also around Wyndham. They are more often recorded on the south and southwest coasts, north to around southern Shark Bay, with more sparsely scattered records further north in Gascoyne and Pilbara Regions and the Kimberley Division. Important sites include: + Eighty Mile Beach (2,230 individuals);

Migratory species	DoEE SPRAT information on distribution within the area of interest
	+ Ashmore Reef (1,132 individuals); and + Roebuck Bay (1,510 individuals).
Sharp-tailed sandpiper	They are widespread from Cape Arid to Carnarvon, around coastal and subcoastal plains of Pilbara Region to south-west and east Kimberley Division (Higgins & Davies 1996). Internationally important sites include: + Eighty Mile Beach (25 000 individuals); and + Port Hedland Saltworks (20 000 individuals). + Lake Gregory (10 000 individuals). + Peel-Harvey system (4 030 individuals).
Streaked shearwater	Exmouth Gulf to the north.
Swinhoe's snipe	No conclusive records exist for this species in Australia so the number of individuals that appear in Western Australia are unknown. In WA the species has been recorded in parts of the Pilbara, the Kimberley, Mount Goldsworthy, Mount Blaize. It has also been found in the north west-regions around the Mitchell Plateau
Terek sandpiper	In Western Australia (WA), the terek sandpiper is rarely seen on the south coast: occasionally around Eyre and several records around Albany. On Swan River plain, it has been recorded between Bunbury and the mouth of the Moore River. The species is widespread in the Pilbara region and Kimberley Division, from Dampier to Wyndham, with occasional records around Shark Bay. Internationally important sites include: + Eighty Mile Beach (8,000 individuals); and + Roebuck Bay (1,840 individuals).
Whimbrel	It is common and widespread from Carnarvon to the north-east Kimberley Division, Western Australia. It is occasionally seen on the south coast of Western Australia and has occasionally been recorded in south-west Western Australia and further north to Shark Bay. Internationally important sites include: + Roebuck Bay (1,020 individuals).
Wood sandpiper	The wood sandpiper has its largest numbers recorded in north-west Australia, with all areas of national importance located in Western-Australia: + Parry Floodplain (Wyndham) (355 individuals) + Camballin (185 individuals) + Lake Argyle (90 individuals) + Shark Bay area, (80 individuals) + Vasse-Wonnerup estuary (61 individuals) + Lake McLarty (64 individuals) + Kogolup Lakes (60 Individuals)

Shorebird migration patterns are seasonal and vary according to species (DSEWPaC 2012). Generally, shorebirds migrate to northern Australia in August to November. Many birds remain in northern Australia but others disperse southwards (Bennelongia 2011). Migratory shorebird numbers on northern beaches peak in November then again in March as the majority of birds begin their return to the northern hemisphere between March and May. Most migratory shorebirds do not breed in Australia and juvenile birds may spend several years in Australia before reaching maturity and returning north to breed (DEWHA 2009).

The Wildlife Conservation Plan for Migratory Seabirds (DoE 2020) seeks to facilitate a nationally coordinated effort to protect and conserve EPBC Act listed seabirds and provides an over-arching framework for their research and management, while encouraging an effort to address threats to seabirds and their habitats.

The following seabird species are subject to the Wildlife Conservation Plan for Migratory Shorebirds 2020 (DoE 2020).

Table 8-6: Birds subject to the Wildlife Conservation Plan for Seabirds 2020

Migratory species	DoEE SPRAT information on distribution within the area of interest
Red-tailed Tropicbird	The Australian population is poorly known owing to the numerous breeding sites and protracted and asynchronous breeding season making an accurate census difficult. The largest population breeds on Christmas Island (>2,000 pairs) with additional key breeding locations on Cocos (Keeling) Group, islands of Ashmore Reef Marine Park, Lord Howe Island, Norfolk Island, Coral Sea Marine Park and two known islands and cays in the Great Barrier Reef Marine Park.
White-tailed Tropicbird	In Australia, the White-tailed Tropicbird (Indian Ocean) breeds in the Cocos-Keeling Islands, at Ashmore Reef and Rowley Shoals off the northern coast of Western Australia. Over the past few years, birds have been sighted with increased frequency on West Island and Home Island (also in the main atoll) in the Cocos-Keeling Islands. The White-tailed Tropicbird (Indian Ocean) ranges widely over the oceans surrounding its breeding locations (Marchant & Higgins 1990). The breeding population of the White-tailed Tropicbird (Indian Ocean) in Australia is estimated at 120 birds.
Broad-billed Prion	The species has an extremely large range extending from the Southern Ocean to the South Atlantic Ocean. Adults are thought to remain in waters adjacent to breeding colonies, however, young birds seem to occur farther north to Australia and South Africa. The global population has been estimated to exceed 15 million individuals (Brooke 2004). The population is suspected to be decreasing owing to predation from invasive species.
Fairy Prion	Two subspecies breed in Australia, turtur and subantarctica. The subspecies subantarctica has previously been detected breeding on two rock stacks off Macquarie Island in 1979 and Bishop and Clerk Island in 1993.
Wedge-tailed Shearwater	The Wedge-tailed Shearwater breeds on the east and west coasts of Australia and on off-shore islands. The species is common in the Indian Ocean, the Coral Sea and the Tasman Sea (Lindsey 1986). In Western Australia breeding occurs on islands off the west coast of WA including the Cocos-Keeling Island. At WA breeding sites there are at least one million breeding pairs.
Flesh-footed Shearwater	The Flesh-footed Shearwater is a locally common visitor to waters of the continental shelf and continental slope off south-western Western Australia to south-eastern Queensland and around Lord Howe Island. Pairs breed on 41 islands off the coast of south-western Western Australia and Lord Howe Island in south-western Western Australia. Flesh-footed Shearwaters have been recorded as vagrants at Norfolk Island and are possibly regular visitors to Norfolk from breeding colonies on Lord Howe Island and around New Zealand (Moore 1985).
Sooty Shearwater	In Australia, there are known colonies on 17 islands, all of which contain fewer than 1,000 pairs, however; Population estimates and trends are unknown.
Short-tailed Shearwater	This species breeds on Tasmanian offshore islands and off the coast of southern Australia, with the bulk of the population in the south-east. National trends are unknown, however the species is monitored at some locations in Tasmania, Victoria and NSW.
Streaked Shearwater	The Streaked shearwater undergoes trans-equatorial migration traveling south during winter, to the coasts of Vietnam, New Guinea, the Philippines, Australia, southern India and Sri Lanka.

Migratory species	DoEE SPRAT information on distribution within the area of interest
	The global population has been estimated to number 3 million individuals.
Lesser Frigatebird	It has been suggested that the frigatebird roost at Weipa and survey data suggests Ashmore Reef Marine Park comprises significant numbers and is believed to account for ≥1% of the global population.
Great Frigatebird	Important populations in Western Australian seas include those at North Keeling Island, the islands of Ashmore Reef Marine Park and Adele Island.
Masked Booby	In Australia, the Masked Booby ranges from the Dampier Archipelago in Western Australia (WA), along the entire north coast and east coast to Brisbane. Individuals regularly occur on islands off Australia, including Lord Howe, Norfolk, Kermadec and the Cocos-Keeling Islands. The total Australian Masked Booby population is estimated to be between 3750–4270 breeding pairs.
Red-footed Booby	This Red-footed Booby is found in tropical islands in most oceans, excluding the eastern Atlantic. It winters at sea in the same area, ranging north of the Tropic of Cancer and south of the Tropic of Capricorn. This species is largely pelagic occurring farther from land than other booby species. The most important breeding population in Australia occurs in Pulu Keeling National Park in the Indian Ocean, which regularly supports more than 30,000 pairs.
Brown Booby	In Australia, the Brown Booby is found from Bedout Island in Western Australia, around the coast of the Northern Territory to the Bunker Group of islands in Queensland with occasional reports further south in New South Wales (NSW) and Victoria. The species is reported further south to Tweed Heads, NSW, and to near Onslow, Western Australia and may be becoming more common in these areas. Within Australian seas, including Christmas and Cocos-Keeling Islands in the eastern Indian Ocean, the total breeding population was 59 940–73 900 pairs in a 1996–97 survey. The global population estimate for the species is 200 000.
Common Noddy	In Australia, the Common Noddy occurs mainly in ocean off the Queensland coast, but the species also occurs off the north-west and central Western Australia coast. The species is also rarely encountered off the coast of the Northern Territory, where only one breeding location with about 100-130 birds is known. In 1996, the total Australian population of the Common Noddy was estimated to be between 174 480 and 214 130 breeding pairs.
Bridled Tern	In Western Australia, Bridled Terns are breeding at Cape Leeuwin (extending round the southern coast to Seal Rocks) north to Shark Bay and in Pilbara region and Kimberley Division. At sea, distribution extends from Cape Leeuwin north to Dirk Hartog Island, with isolated mainland coastal records at Point Maud and Ningaloo, and from Barrow Island to the Dampier Archipelago, and at sea off the Kimberley coast from waters west of the Dampier Peninsula to Ashmore Reef and Joseph Bonaparte Gulf. The total population in Western Australia is estimated to be at least 30 000–40 000 pairs and apparently increasing.
Little Tern	The Australian breeding population can be divided into two major subpopulations (northern and eastern) with the northern subpopulation that breeds across northern Australia, from about Broome in north-western Western Australia through coastal Northern Territory to the Gulf of Carpentaria and eastern Cape York Peninsula.
Caspian Tern	Within Western Australia, the Caspian tern is widespread in coastal regions, from the Great Australian Bight to the Dampier Peninsula. There are sparse records on the coasts east of King Sound and in eastern regions.

Migratory species	DoEE SPRAT information on distribution within the area of interest
	Breeding occurs from the Recherche Archipelago to Dirk Hartog Island and Faure Island in Shark Bay, and also in the Pilbara region from around Point Cloates to North Turtle Island, and more rarely, in the Kimberley.
Roseate Tern	The total global population of the Caspian Tern is estimated to be 240 000–420 000 birds in 2010.
Osprey	The breeding range of the Eastern Osprey around the northern coast of Australia (including many offshore islands) extends from Albany in Western Australia to Lake Macquarie in NSW; with a second isolated breeding population on the coast of South Australia. The species is most abundant in northern Australia, where high population densities occur in remote areas. A population on Barrow Island was estimated at 20 pairs in 1978.

Like many birds, seabirds often migrate after the breeding season. Of these, the migration taken by the Arctic Tern (Sterna paradisaea) is the farthest of any bird, crossing the equator in order to spend the Austral summer in Antarctica (Egevang et al. 2010; Fijim et al. 2013). Other species also undertake trans-equatorial trips, both from the north to the south, and from south to north (DoE 2020).

Other species migrate shorter distances away from the breeding sites, their distribution at sea determined by the availability of food. If oceanic conditions are unsuitable, seabirds will immigrate to more productive areas, sometimes permanently if the bird is young (Oro et al. 2004). After fledging, juvenile birds often disperse further than adults, and to different areas, so are commonly sighted far from a species' normal range. Some species, such as some of the storm petrels, diving petrels and cormorants, rarely disperse at all, staying near their breeding colonies year-round (DoE 2020).

8.4 Biologically Important Areas / Critical Habitat– Birds

Table 8-7 below provides an overview of BIAs in the combined EMBA for birds. The DAWE may make recovery plans for threated fauna listed under the EPBC Act. The EPBC Act requires that 'habitat critical to the survival of the listed threatened species' is identified in recovery plans, relevant recovery plans are listed in **Section 13.2**[7].

In addition, both the EPBC Act and WA BC Act and associated regulations (2018) provide for the listing of critical habitat - habitat 'critical to the survival of the threatened species'. No provision is made under the Territory Parks and Wildlife Conservation Act 1976 for listing critical habitat.

Table 8-7: Critical habitat/ biologically important areas - birds

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Australian fairy tern	*Sternula nereis*	Foraging – Kimberley, Pilbara and Gascoyne coasts and islands	Found in the vicinity of lower north-west coast (north to Dampier Archipelago), west coast (south to Peel Inlet) and south coast (from Flinders Bay east to Israelite Bay), including islands (as far offshore as Trimouille Island and Houtman Abrolhos. Pilbara and Gascoyne coasts and islands
Australian lesser noddy	*Anous tenuirostris melanops*	Foraging - Houtman Abrolhos Islands	Houtman Abrolhos Islands

[7] Further background information on BIA and identification of critical habitat in recovery plans is provided in Section 5.4.

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Bridled tern	*Onychoprion anaethetus*	Foraging - West coast of Western Australia and around to Recherche Archipelago	West coast of WA and around to Recherche Archipelago including offshore waters
Brown Booby	*Sula leucogaster*	Breeding, foraging - Kimberley and northern Pilbara coasts and islands also Ashmore Reef.	Kimberley and northern Pilbara coasts and islands also Ashmore Reef.
Caspian tern	*Sterna caspia*	Foraging - mainly islands (as far offshore as Adele, Bedout, Trimouille and the Houtman Abrolhos)	In WA found on most coasts, mainly islands (as far offshore as Adele, Bedout, Trimouille and the Houtman Abrolhos) and at Lake Argyle, Lake Gregory and Lake MacLeod; accidental elsewhere in the interior.
Common noddy	*Anous stolidus*	Foraging	Around Houtman Abrolhos Around Lancelin Island
Flesh footed shearwater	*Ardenna carneipes*	Foraging, aggregation (pre-migration) - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Foraging from Cape Naturaliste to Eyre, 1-150 km offshore. Pre-departure zone in some years from Rottnest Island to Bunbury.
Greater crested tern	*Thalasseus bergii*	Breeding (high numbers)	Melville Island
Greater frigatebird	*Fregata minor*	Breeding, foraging - Kimberley and Ashmore Reef	Kimberley and Ashmore Reef
Great-winged petrel	*Pterodroma macroptera*	Foraging - Offshore south of Shark Bay	Offshore south of Shark Bay, extending around south-west corner of WA and east past Kangaroo Island
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Foraging - south-west marine region, north to Shark Bay and extending east into Bass Strait	Throughout offshore waters of south-west marine region, north to Shark Bay and extending east into Bass Strait
Lesser crested tern	*Sterna bengalensis*	Breeding, foraging - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
Lesser frigatebird	*Fregata ariel*	Breeding, foraging – Kimberley and Pilbara coasts and islands also Ashmore Reef.	Kimberley and Pilbara coasts and islands also Ashmore Reef.
Little penguin	*Eudyptula minor*	Foraging - Perth to Bunbury	Perth to Bunbury
Little shearwater	*Puffinus assimilis*	Foraging - From Kalbarri to Eucla	From Kalbarri to Eucla including offshore waters
Little tern	*Sternula albifrons*	Breeding, foraging, resting - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef Resting - Roebuck Bay	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef Roebuck Bay Ramsar site
Pacific gull	*Larus pacificus*	Foraging –west coast and islands	West coast and islands from Point Quobba (24º30'S) south to Wedge Island (formerly south to Warnbro Sound and at Cape Naturaliste); casual further north (Point Cloates and Lake MacLeod).

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Red-footed Booby	*Sula sula*	Breeding, foraging - northwest Kimberley and Ashmore reef	Northwest Kimberley and Ashmore reef
Roseate tern	*Sterna dougallii*	Breeding, foraging – Islands and coastline in the Kimberley, Pilbara and Gascoyne regions Resting – Eighty Mile Beach	Eighty Mile Beach (northern end) Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef Low Rocks and Stern Island in Admiralty Gulf North-east and North-west Twin Islets near the mouth of King sound North-western and west coasts and islands from Sir Graham Moore Is (13º50'S), south to Mandurah (32º32'S) and as far offshore as Ashmore Reef, Bedout Island and the Houtman Abrolhos.
Soft plumage petrel	*Pterodroma mollis*	Foraging - seas north to 21º30'S	In WA found in seas north to 21º30'S.
Sooty tern	*Sterna fuscata*	Foraging – Timor Sea	Timor Sea S to 14º30, off northwest coast from Lacepede I SW to 117ºE including Abrolhos, Fisherman & Lancelin Is, accidental on lower west coast to Hamelin Bay. Breeding visitor (late Aug - early May) Abrolhos & Lancelin Is; casual winter (Nov - Apr) to Fisherman
Wedge-tailed shearwater	*Ardenna pacifica*	Breeding, foraging – west coast from Ashmore Reef to Carnac I. Kimberley, Pilbara, Gascoyne coasts, Ashmore reef	Breeding (in hundreds of thousands) off west coast from Ashmore Reef (12º15'S) to Carnac Island (32º07'S), and ranging in western seas between 12º00'S and 33º20'S. Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef
White-faced storm petrel	*Pelagodroma marina*	Foraging (in high numbers) - Offshore areas of the south-west marine region and into the adjacent south-east marine region and the north-west marine region to north of Shark Bay	Offshore areas of the south-west marine region and into the adjacent south-east marine region and the north-west marine region to north of Shark Bay
White-tailed tropic bird	*Phaethon lepturus*	Breeding, foraging - Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef	Kimberley, Pilbara and Gascoyne coasts and islands including Ashmore Reef

9. Protected Areas

A number of areas in the combined EMBA are protected under state and federal legislation. Protected areas include World Heritage Areas, Wetlands of International Importance (Ramsar), Wetlands of National Importance, National and Commonwealth Heritage Places, and terrestrial conservation reserves (National Parks, Nature Reserves and Conservation Parks) that bound marine waters. These areas are listed in **Table 9-1**, and shown in **Figure 9-2**, **Figure 9-3**, **Figure 9-4** and **Figure 9-4** and discussed below. Other protected areas include Key Ecological Features (discussed in **Section 10**) and State and Commonwealth Marine Parks/Reserves (discussed in **Section 11** and **Section 12**). A Protected Matters search of the combined EMBA (**Appendix A**) identified several protected areas which were deemed to be irrelevant to Santos' petroleum activities due to their terrestrial location (e.g. Forrestdale and Thomsons Lakes – Ramsar wetland).

The Register of the National Estate (RNE) provides a listing of more than 13,000 natural, historic and indigenous sites of significance. However, in 2012 all references to the RNE were removed from the EPBC Act and the *Australian Heritage Council Act 2003*.The RNE is now maintained on a non-statutory basis as a publicly available archive and educational resource. The RNE places are not discussed further here but are listed in **Appendix A**.

Table 9-1: Summary of protected areas in waters within the combined EMBA

Area type	Title
World Heritage Area	Shark Bay
	The Ningaloo Coast
	Kakadu National Park
Wetland of International Importance (Ramsar)	Eighty Mile Beach
	Roebuck Bay
	Ashmore Reef National Nature Reserve
	Becher Point wetlands
	Peel-Yalgorup System
	Vasse-Wonnerup System
	Hosnies Spring
	Cobourg Peninsula
	Kakadu National Park
	Ord River Floodplain
	The Dales
Wetlands of National Importance	Ashmore Reef
	Mermaid Reef
	Vasse-Wonnerup Wetland System
	"The Dales", Christmas Island
	Adelaide River Floodplain System
	Eighty Mile Beach System
	Exmouth Gulf East
	Hosnies Spring, Christmas Island

Area type	Title
	Kakadu National Park
	Mary Floodplain System
	Hutt Lagoon System
	Lake Macleod
	Lake Thetis
	Learmonth Air Weapons Range – Saline Coastal Flats
	Leslie (Port Hedland) Saltfields System
	Prince Regent River System
	Roebuck Bay
	Rottnest Island Lakes
	Shark Bay East
	Cape Leeuwin System
	Doggerup Creek System
	Cape Range Subterranean Waterways
	Cobourg Peninsula System
	Daly-Reynolds Floodplain-Estuary System
	Finniss Floodplain and Fog Bay Systems
	Moyle Floodplain and Hyland Bay System
	Murgenella-Cooper Floodplain System
	Ord Estuary System
	Port Darwin
	Shoal Bay - Micket Creek
	Yalgorup System
National Heritage Place	HMAS Sydney II and HSK Kormoran Shipwreck Sites (Historic)
	Batavia Shipwreck Site and Survivor Camps Area 1629- Houtman Abrolhos (Historic)
	Dirk Hartog Landing Site 1616 - Cape Inscription Area (Historic)
	Dampier Archipelago (including Burrup Peninsula) (Indigenous)
	Kakadu National Park (Natural)
	The West Kimberley (Natural)
	The Ningaloo Coast (Natural)
	Shark Bay (Natural)
	Fitzgerald River National Park (Natural)
	Lesueur National Park (Natural)
Commonwealth Heritage Place	Scott Reef and Surrounds – Commonwealth Area
	Ningaloo Marine Area - Commonwealth Waters
	Mermaid Reef - Rowley Shoals

Area type	Title
	Ashmore Reef National Nature Reserve
	Garden Island
	Christmas Island Natural Areas
	Yampi Defence Area
	Learnmonth Air Weapons Range Facility
	Bradshaw Defence Area
	Lancelin Defence Training Area
Threatened Ecological Communities	Monsoon Vine Thickets on the Ridge on the Coastal Sand Dunes of Dampier Peninsula
	Roebuck Bay mudflats
	Subtropical and Temperate Coastal Saltmarsh
	Trombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)
Terrestrial Conservation Reserves e.g. national parks, nature reserves, and conservation parks.	Numerous bounding marine waters – refer to **Section 9.6.**

9.1 World Heritage Areas

There are two World Heritage Areas located in marine waters of WA, both of which occur in the waters from the South Australian border to the NT border: the Ningaloo Coast and Shark Bay (DEC 2012). One WHA is within the combined EMBA adjacent to NT, although most of the area is terrestrial: Kakadu National Park.

9.1.1 Shark Bay

Shark Bay was included on the World Heritage List in 1991 and is one of the few properties inscribed for all four outstanding natural universal values:

- An outstanding example representing the major stages in the earth's evolutionary history;
- An outstanding example representing significant ongoing ecological and biological processes;
- An example of superlative natural phenomena; and
- Containing important and significant habitats for in situ conservation of biological diversity.

Since 1997, an agreement established the joint management of the Shark Bay WHA by the Australian Commonwealth government and the Western Australian state government, with the operational responsibility by the Western Australian agencies (DEWHA 2008a). This agreement also created a Community Consultative Committee and a Scientific Advisory Committee, both of which provide advice as required. The entire WHA encompasses islands and peninsulas, with an area of approximately 2.2 million hectares (70% of which is marine waters), and includes the following areas (UNESCO 2020):

- Hamelin Pool Marine Nature Reserve;
- Francois Peron National Park;
- Shell Beach Conservation Park;
- Monkey Mia Reserve;
- Monkey Mia Conservation Park;

- Zuytdorp Nature Reserve;
- Bernier, Dorre and Koks Islands Nature Reserves;
- Dirk Hartog Island National Park; and
- Various pastoral leases.

The marine environment of the Shark Bay World Heritage Area is protected as a State Marine Reserve and is discussed further in **Section 11.1.3**.

9.1.2 The Ningaloo Coast

The Ningaloo Coast was included on the World Heritage List in 2011 and was inscribed for outstanding natural universal values as follows:

- An example of superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance;
- outstanding examples representing major stages of Earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; and
- the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

The Ningaloo Coast WHA includes (DEWHA 2010b):

- Ningaloo Marine Park (Commonwealth waters);
- Ningaloo Marine Park (Western Australia state waters);
- Muiron Island Marine Management Area (including the Muiron Islands);
- Jurabi Coastal Park;
- Bundegi Coastal Park;
- Cape Range National Park; and
- Learmonth Air Weapons Range.

The Ningaloo Coast World Heritage Area (including the Muiron Islands) is managed under a plan that is consistent with the World Heritage Convention and Australia's World Heritage management principles. World Heritage Management principles are set out in regulations and cover matters relevant to the preparation of management plans, the environmental assessment of actions that may affect the property and community consultation processes.

The Australian World Heritage management principles are outlined under Schedule 5 of the EPBC regulations (2000). The objective is to ensure that any likely impact of an action on the World Heritage values of the property should be considered. Any action should be consistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property.

The marine environment of the Ningaloo Coast World Heritage Area is protected as a State Marine Park, a Commonwealth Marine Park, and is discussed further in **Section 11.1.4** and **Section 12.3.4**, respectively.

9.1.3 Kakadu National Park

Kakadu National Park was included on the World Heritage List in 1981 and was inscribed for outstanding natural universal values as follows:

+ An example of superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance;
+ outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; and
+ the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

The Kakadu National Park WHA covers an area of around 1,916,000ha and is the largest national park in Australia. The WHA is managed by the Director of National Parks who performs functions and exercises powers under the *Environment Protection and Biodiversity Conservation Act 1999* (the Act) in accordance with the park's management plan and relevant decisions of the Kakadu National Park Board of Management. Approximately 50% of Kakadu National Park is Aboriginal land under the Aboriginal Land rights (Northern Territory) Act 1976.

9.2 Wetlands of International Importance (Ramsar)

There are eleven wetlands of international importance (Ramsar wetlands) in waters from the South Australian border to the NT; all were listed in 1990 with the exception of the Cobourg Peninsula which was listed in 1974, Kakadu National Park which was listed in 1980 and further expanded in 1995, Becher Point which was listed in 2001, and The Dales which was listed in 2002. The Ashmore Reef National Nature Reserve (listed in 2002) is also a Commonwealth Marine Park and is discussed further in **Section 12.3.12.**

9.2.1 Eighty Mile Beach

The Eighty Mile Beach Ramsar site comprises a 220 km beach between Port Hedland and Broome with extensive intertidal mudflats and Mandora Salt Marsh, located 40 km east (Hale & Butcher 2009) totalling 175,487 ha. Eighty Mile Beach is characterised by extensive mudflats supporting an abundance of macroinvertebrates which provide food for large numbers of shorebirds.

Eighty Mile Beach is one of the most important sites for migratory shorebirds in the East Asian Australasian Flyway, with 42 migratory shorebird species recorded at this location. It is estimated that 500,000 shorebirds use Eighty Mile Beach as a migration terminus annually (Hale and Butcher 2009), and more than 472,000 migratory waders have been counted on the mudflats during the September to November period. The location of Eighty Mile Beach makes it a primary staging area for many migratory shorebirds on their way to and from Alaska and eastern Siberia (Hale & Butcher 2009). Although many birds move further on their journey, others remain at the site for the non-breeding period.

Eighty-mile Beach supports more than one per cent of the flyway population (or one per cent of the Australian population for resident species) of 21 waterbirds, including 17 migratory species and four Australian residents. It is one of the most important sites in the world for the migration of Great Knot.

Eighty Mile Beach also supports a high diversity and abundance of wetland birds. A total of 97 wetland bird species have been recorded within the beach portion of the Ramsar site (Hale & Butcher 2009). This includes 42 species that are listed under international migratory agreements CAMBA (38), JAMBA (38) and ROKAMBA

(32) as well as an additional 22 Australian species that are listed under the EPBC Act. In addition, there is a single record for Nordmann's Greenshank (*Tringa guttifer*) from the beach, which is listed as endangered under the IUCN Red List (IUCN 2019).

The Mandora Salt Marsh area contains an important and rare group of wetlands (Lake Walyarta and East Lake), including raised peat bogs, a series of small permanent mound springs and the most inland occurrence of mangroves in WA (Hale & Butcher 2009). A small number of tidal creeks dissect the beach, including Salt Creek which is fed partly from groundwater and has permanent surface water. The Mandora Salt Marsh lakes fill predominantly from rainfall and runoff in the wet season then dry back to clay beds. The mound springs likely come from water deep within the Broome sandstone aquifer rising through fractures in the rock, and resulting in permanent mostly freshwater surface water. Flatback turtles (*Natator depressus*), listed as vulnerable under the EPBC Act, regularly nest at scattered locations along Eighty Mile Beach.

Eighty Mile Beach is used for beach based recreation, including four-wheel driving, motorcycling, fishing and shell collecting. Mandora Salt Marsh is mainly used for cattle grazing. The site is traditionally part of Karajarri Country in the north, Nyangumarta Country in the south and Ngarla Country in the southern end of Eighty Mile Beach. The site has artefacts such as middens, pinka (large baler shells used to scoop and carry water for drinking), wilura (used for sharpening spear heads), axes, and flakes, and kurtanyanu and jungari (grinding stones). The Ramsar wetland is managed under the Eighty Mile Beach Marine Park Management Plan 2014-2024 (DPAW, 2014).

9.2.2 Roebuck Bay

The Roebuck Bay Ramsar site is located at Roebuck Bay near Broome in northern WA totalling 34,119 ha. Roebuck Bay has a large tidal range which exposes around 160 km^2 of mudflat, covering most of the Ramsar site (DoE 2014c). Waters more than 6 m deep at low tide are excluded from the site (Bennelongia 2009). The eastern edge of the site is made up of microscale linear tidal creeks (DoE 2014c).

The intertidal mud and sand flats support a high abundance of bottom dwelling invertebrates (between 300—500 benthic invertebrate species), which are a key food source for waterbirds (Bennelongia 2009). The site is one of the most important migration stop-over areas for shorebirds in Australia and globally. For many shorebirds, Roebuck Bay is the first Australian landfall they reach on the East Asian Australasian Flyway. The total numbers of waders using the site each year is estimated at over 300,000 (DoE 2014c). The northern beaches and Bush Point provide important high tide roost sites.

The site receives tidal seawater as well as fresh surface and groundwater, and the balance between the two influences the residual groundwater salinity and the distribution of plants and animals (DoE 2014c). Mangrove swamps line the eastern and southern edges of the site and extend up into the linear tidal creeks (DoE 2014c). They are important nursery areas for marine fishes and crustaceans, particularly prawns.

Extensive seagrass beds occur in the bay, providing an important feeding ground for dugongs and loggerhead and green turtles (Bennelongia 2009). Flatback turtles nest in small numbers, while marine fish (including sawfish) regularly breed in the tidal creeks and mangroves. Dolphins also regularly use the site (DoE 2014c).

The site is used for recreational or tourism activities such as fishing, crabbing, sightseeing and bird watching. Broome Bird Observatory, a small reserve at the northern end of the site, engages in shorebird research and public education.

Roebuck Bay lies in the traditional estate of Indigenous people belonging to both Jukun and Yawuru groups. The site was an important area for seasonal meetings, exchanging gifts, arranging marriages and settling disputes. Numerous shellfish middens, marking former camping places, can still be seen along coastal cliffs and dunes. Indigenous people continue to make extensive use of Roebuck Bay's natural resources for activities such as gathering shellfish, fishing and hunting. The Ramsar wetland is currently managed under the Preliminary Draft Roebuck Bay Ramsar Site Management Plan (RBWG, 2010).

9.2.3 Ashmore Reef National Nature Reserve

In addition to being listed as a National Nature Reserve, Ashmore Reef has been designated a Ramsar Wetland of International Importance due to the importance of the islands in providing a resting place for migratory shorebirds and supporting large breeding colonies of seabirds (Hale and Butcher, 2013). The reserve provides a staging point for many migratory wading birds from October to November and March to April as part of the migration between Australia and the northern hemisphere (Commonwealth of Australia, 2002). Migratory shorebirds use the reserve’s islands and sand cays as feeding and resting areas during their migration.

Ashmore is the largest of the atolls in the Timor Province bioregion. The three islands within the site are also the only vegetated islands in the bioregion. Each of the wetland types present are in near natural condition and the site has the largest seagrass coverage in the bioregion. The reserve supports 64 species of internationally and nationally threatened species. This includes 41 species of hard reef forming coral, eight fish, six reptiles (including endangered and critically endangered sea turtles and seasnakes), five sea cucumbers, two giant clams, one soft coral and the dugong.

Ashmore Reef plays a primary role in the maintenance of biodiversity in reef systems in the region. The Reserve supports 275 species of reef building coral, 13 species of sea cucumbers, and high numbers of mollusc species. There are over 760 fish species, 13 species of sea snake, 99 species of decapod crustacean and 47 species of waterbird listed as migratory under international treaties. It supports breeding of 20 species of waterbirds including the brown booby, lesser frigatebird, crested tern, bridled tern, sooty tern and common noddy. The Ramsar site is also important for feeding for green turtles, hawksbill turtle and loggerhead turtle and critical nesting and inter-nesting habitats for green and hawksbill turtles.

Ashmore Reef regularly supports more than 20,000 waterbirds and has been known to support more than 65,000 waterbirds. The Ramsar site regularly supports more than one per cent of at least six species of waterbird including the sooty tern, bar-tailed godwit, grey-tailed tattler, ruddy turnstone, sanderling and greater sand plover. The Ramsar site is managed under the Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve Management Plan (Commonwealth of Australia, 2002).

9.2.4 Becher Point

The Becher Point Wetlands Ramsar site is a system of about sixty small wetlands located near Rockingham in south-west Western Australia and covers 677 ha. The wetlands are made up of chains of small, linear ovoid or irregular shaped basins arranged in five groups, each roughly parallel to the coast and separated by sand ridges (DoE 2014l). The wetlands are an example of shrub swamps and seasonal marshes that have formed in an extensive sequence of inter-dunal depressions that have arisen from seaward advancement of the coastline over recent millennia.

The wetlands in the site are shallow and fill seasonally. Rainfall in winter and spring recharges the groundwater, which rise up to waterlog the wetland basins. The wetlands then dry out again for summer to autumn. When flooded the wetlands are mainly freshwater (DoE 2014l).

The wetlands support sedgelands, herblands, grasslands, open-shrublands and low open-forests. The sedgelands that occur within the linear wetland depressions of the Ramsar site are a nationally listed threatened ecological community. At least four species of amphibians and 21 species of reptiles have been recorded within the wetlands, as well as the Southern Brown Bandicoot (DoE 2014l). The Ramsar wetland is managed under the Rockingham Lakes Regional Park Management Plan (DEC, 2010c).

9.2.5 Peel-Yalgorup System

The Peel-Yalgorup System located adjacent to the city of Mandurah in Western Australia, is a large and diverse system of shallow estuaries, coastal saline lakes and freshwater marshes. The site includes the Peel Inlet, Harvey Estuary, Lake McLarty, Lake Mealup and ten Yalgorup National Park wetlands and covers an area of 26, 530 ha (DoE 2014m). Lake Clifton, which is part of the wetlands is one of the few locations in the word where thrombolites occur in inland, hyposaline waters. Thrombalites are underwater rock-like structures that are formed by the activities of microbial communities.

The Peel-Yalgorup System Ramsar site is the most important area for waterbirds in south-western Australia, supporting in excess of 20,000 waterbirds annually (DoE 2014m). It also supports a wide variety of invertebrates and estuarine and marine fish. The Ramsar site is managed under the Swan Coastal Plain South Management Plan (DPAW, 2016c).

9.2.6 Vasse-Wonnerup System

The Vasse-Wonnerup System Ramsar wetland is situated in the Perth Basin, south-western Western Australia and covers an area of 1,115 ha. It is an extensive, shallow, nutrient-enriched wetland system of highly varied salinities. The site is located on a narrow, flat plain separated from the ocean by a narrow system of low dunes. The system is comprised of two former estuaries – the Vasse and Wonnerup lagoons (DoE 2014n).

The system supports tens of thousands of resident and migrant waterbirds of a wide variety of species. More than 33,000 waterbirds have been counted at the Vasse-Wonnerup System and more than 80 species have been recorded in the System including Red-necked Avocets and Black-winged Stilts, Wood Sandpiper, Sharp tailed Sandpiper, Long-toed Stint, Curlew Sandpiper and Common Greenshank (DoE 2014n). This Rasmar site is also managed under the Swan Coastal Plain South Management Plan (DPAW, 2016c).

9.2.7 Hosnies Spring

The Hosnies Spring Ramsar site is located on Christmas Island and is a small area of shallow freshwater streams and seepages, 20–45 metres above sea-level on the shore terrace of the east coast of the island covering an area of approximately 199 ha. The site includes surrounding terrestrial areas with rainforest grading to coastal scrub and includes an area of shoreline and coral reef (DoEE 2019).

The Hosnies Spring Ramsar site supports a unique wetland of Christmas Island with the mangrove forest present at the site unique within the bioregion and possibly worldwide. The two species of mangroves that make up the stand, which normally grow intertidally, grow to a height of 24–37 m above sea level that have been estimated to have persisted for 120,000 years. Additionally, the site is important to blue crabs which rely on the freshwater provided by the spring and as a likely migratory route for the endemic red crab during breeding migrations (DoEE 2019). The Ramsar site is managed under the Christmas Island National Park Management Plan (DNP, 2002).

9.2.8 The Dales

The Dales Ramsar site is located on Christmas Island and is comprised of a near-pristine system of seven watercourses collectively known as The Dales and covers an area of 585 ha. The Dales includes permanent and perennial streams, permanent springs, and include the majority of surface water on the Island. Most rainfall on Christmas Island filters down through the soil and limestone, and surface runoff only occurs after heavy rain. The Dales contain numerous wetland types including surface and karst features, and inland and coastal wetlands (DoEE 2019a).

The Dales support a number of unique ecological and geomorphic features including anchialine cave communities, surface karst including the unique stepped tufa deposits at Hugh's waterfall, a stand of Tahitian chestnuts, a large number of endemic terrestrial species and a significant number of seabirds including Abbott's booby, red-footed booby and the brown booby, all of which breed at the site, and provide essential habitat for the Christmas Island frigatebird (DoEE 2019a). This Ramsar site is also managed under the Christmas Island National Park Management Plan (DNP, 2002).

9.2.9 Cobourg Peninsula

Under the Ramsar convention, the Cobourg peninsula site is listed as a Wetland of International Importance. The site is located 163km north-east of Darwin within the Timor Sea Drainage Division. Within 220’700 hectares, the site covers the entire peninsula and several nearby islands including the Sir George Hope Islands, Sandy Island No. I and II, Allaru Island, High Black Rock and Buford Island. Under the Cobourg Peninsula Aboriginal Land, Sanctuary and Marine act 1996, Cobourg peninsula and surrounding waters was declared a Nation Park (Garig Gunak Barlu National Park) BMT WBM (2011).

The Cobourg site is composed of a diverse coastal and inland wetland types. Wetland types present include intertidal forested wetlands and salt flats, seasonal freshwater marshes and permanent freshwater pools. Ramsar topology identifies ten coastal and ten inland types within the site. The site contains unique biodiversity and wildlife including terrestrial, riverine, freshwater, brackish and coastal/marine ecosystems. Identifiable wetland types include intertidal forested wetland and salt flats, seasonal freshwater marshes, and permanent freshwater pools.

Cobourg Peninsula is listed as a Wetland of International importance due to the diversity of coastal and inland wetland types that support population of threatened species, including a number of endangered turtles. The Cobourg site meets five of the current nine nomination criteria of the Ramsar Convention and is therefore recognised as a representative wetland habitat that is at bioregional level, support of populations of threatened species, support for key life-cycle functions such as marine turtle and waterbird breeding, refugia values, and its importance for supporting fish and nursery spawning habitats BMT WBM (2011). The Ramsar site is managed under the Cobourg Marine Park Plan of Management (DNREAS, 2011).

9.2.10 Kakadu National Park

Kakadu National Park Ramsar site is composed of a diversity of coastal and inland wetland types that range form intertidal forested wetlands and mudflats to seasonal freshwater marshes and permanent freshwater pools. Ramsar topology identifies 13 coastal types and 15 inland types throughout Kakadu National Park. Hydrology, fire regimes and notable biological processes, with supporting processes including climate, tidal hydraulics, groundwater, water quality, geology and geomorphology are ecosystem processes present in Kakadu National Park habitats (BMT WBM, 2010).

The site also meets all nine Nomination Criteria of the Convention, recognising the representative wetland habitats of the site at a bioregional level, support of populations of vulnerable wetland species, its characteristics as a centre of endemism and high biodiversity including its diversity of habitats, support for key life-cycle functions such as waterbird breeding and refugia values, its importance for supporting substantial populations of waterbirds and fish diversity and fish nursery and spawning habitats and its support of at least one percent of the national population of several non-avian wetland species (BMT WBM, 2010). The Ramsar site is managed under the Kakadu National Park Management Plan 2016-2026 (DNP, 2016).

9.2.11 Ord River Flood Plains

Site lies within the Victoria-Bonaparte bioregion and contains a wide range of wetland types and includes all inland and marine components. This Ramsar site comprises of Parry Lagoons, Ord Estuary and the False Mouths of the Ord. Parry Lagoons includes both the permanent waterholes, such as Marglu Billabong, as well as the broader area of the flood plain within the Parry Lagoons Nature Reserve that are subject to periodic inundation. The area from the boundary near Adolphis Island to the Rocks is known as the Ord Estuary. The False Mouths of the Ord is an area of extensive intertidal creeks and flats in the north of the Ramsar site.

The Ord River Floodplain Ramsar site meets seven of the nine Nomination Criteria. The site represents the best example of wetlands associated with the floodplain, and estuary of a tropical river system in the Kimberly Region of Western Australia. Ord River contains extensive and diverse mangrove community containing 14 of the 18 species of mangrove known to occurs in Western Australia (Hale, 2008).

A number of threatened species including Freshwater Sawfish (*Pristis microdon*), the Green Sawfish (*Pristis zijsron*) and the Australian Painted Snipe (*Rostratula australis*), which are listed as vulnerable under the EPBC Act are supported in this area. The site also provides one of the two known habitats for the nationally endangered Northern River Shark (*Glypis* sp. C). The Ord River Floodplain Ramsar site provides an important nursery, breeding and feeding ground for at least 50 species of fish and a migratory route for 15 diadromous species.

There is sufficient evidence to suggest the sire regularly supports 20,000 birds in the site alone, although it should be acknowledged that there are difficulties associated with surveying the Ord River Floodplain. According to the 4th edition of Waterbird Population Estimates, the site regularly supports 1% of the population of Plumed Whistling Duck and Little Curlew (Hale, 2008). The Ramsar site is managed under the Ord River and Parry Lagoons Nature Reserves Management Plan (DEC, 2012c).

9.3 Wetlands of National Importance

9.3.1 Ashmore Reef

See the Ashmore Reef National Nature Reserve (**Section 9.2.3**) and Ashmore Reef Marine Park (**Section 12.3.12**).

9.3.2 Mermaid Reef

See the Mermaid Reef Marine Park (**Section 12.3.9**).

9.3.3 Vasse-Wonnerup Wetland System

See the Vasse-Wonnerup Wetland System (**Section 9.2.6**).

9.3.4 "The Dales", Christmas Island

See The Dales Ramsar site (**Section 9.2.8**).

9.3.5 Eighty Mile Beach System

See Eighty Mile Beach Ramsar site (**Section 9.2.1**).

9.3.6 Exmouth Gulf East

The Exmouth Gulf East wetlands are located in the eastern section of Exmouth Gulf from Giralia Bay to Urala Creek Locker Point. The wetland comprises of numerous tidal creeks, indentations and islands of dry land, mudflats, saline coastal flats and extensive mangroves (DAWE 2020a).

The site is one of the major population centres for dugongs in WA and its seagrass beds and extensive mangroves provide nursery and feeding areas for marine fishes and crustaceans in the Gulf. In addition, there are at least 29 species of birds which utilise the wetland, including 16 migratory shorebirds and several terns (DAWE 2020a).

9.3.7 Hosnies Spring, Christmas Island

See Hosnie's Spring Ramsar site (**Section 9.2.7**).

9.3.8 Hutt Lagoon System

The Hutt Lagoon System wetlands (3,000 ha) are located within the Geraldton Sandplains and comprises of Hutt Lagoon and the lakes and marshes immediately north-west and south-east of the lagoon, notably Utcha Swamp. The system is a coastal brine lake which runs parallel to the coast (DAWE 2020b).

Hutt Lagoon is a migratory stop-over for migratory waders, however numbers using the area vary greatly between years and are likely to be lower when northern and inland waterbodies are extensively flooded. Breeding shorebirds include the Australasian grebe (*Tachybaptus novaehollandiae*), grey teal (*Anas gibberifrons*) and eurasian coot (*Fulica atra*) at Utcha Swamp (DAWE 2020b).

9.3.9 Lake Macleod

The Lake Macleod wetland (150,000 ha) is located in the Carnarvon bioregion and includes distinct "inner wetlands" (sinkholes, channels, lakes, marshes) in the west and "floodout marshes" at river mouths in the north-east. The wetland also includes a lakebed that is infrequently inundated. The lake lies parallel to the Indian Ocean, north of the Gascoyne River and located 30 km away from Shark Bay East wetland (DAWE 2020c).

The Lake Macleod is a major migration stop-over and drought refuge area for shorebirds; it is one of the most important non-tidal stop-over sites in Australia. It also supports Australia's largest inland community of mangroves and associated fauna. Fifty-eight species have been identified within the wetland with 29 being shorebirds and eight gulls and terns, with seven species found breeding (DAWE 2020c).

9.3.10 Lake Thetis

The Lake Thetis wetland (7 ha) is located in the Swan bioregion and comprises of seasonal marshes that form in interdunal areas to the south of the lake. Lake Thetis is distinguished by the presence of both a variety of benthic microbial communities (mats) and stromatolites. No threatened species or migratory species have been observed to utilise this wetland (DAWE 2020d).

9.3.11 Learmonth Air Weapons Range – Saline Coastal Flats

The Learmonth Air Weapons Range – Saline Coastal Flats wetland (300 ha) represents typical saline coastal flats subject to inundation and ponding. The vegetation typically has a low species richness, but its floristic composition and structure is highly distinctive and supports habitat specific fauna (DAWE 2020e).

Species composition of the wetland has little information however it is likely to possess a relatively diverse community (DAWE 2020e).

9.3.12 Leslie (Port Hedland) Saltfields System

The Leslie (Port Hedland) Saltfields System (13,000 ha) comprises a large saltfield, fringing coastal flats, tidal creeks and mudflats between the saltfields and the Indian Ocean.

The wetland is likely a major migration stop-over area for shorebirds in the East Asia-Australasia Flyway. It is possibly the most important stop-over site in the Flyway for the broad-billed sandpiper (*Limicola falcinellus*) and an important site for oriental plover (*Charadrius veredus*). It is also likely to be the most important site in Australia for Asian dowitcher (*Limnodromus semipalmatus*) and red-necked phalarope (*Phalaropus lobatus*) (DAWE 2020f).

9.3.13 Prince Regent River System

The site comprises of the entire Prince Regent River system and large areas of mangrove on either side of the river mouth in Saint George Basin (14,300 ha). The site is a tropical estuary and river system incised in a plateau and is characterised by mangrove-fringed embayments (DAWE 2020g).

The site comprises of a diverse assemblage of flora and fauna, and includes mangroves, riverine vegetation, waterbirds, frogs, reptiles and fish. The site includes some of the most suitable and extensive breeding habitat for the saltwater crocodile in WA, well developed river banks with thick stands of reed and grasses (DAWE 2020g).

9.3.14 Roebuck Bay

See Roebuck Bay Ramsar site (**Section 9.2.2**).

9.3.15 Rottnest Island Lakes

The Rottnest Island Lakes wetland site comprises of a cluster of 18 lakes and swamps on the north-east part of Rottnest Island (180 ha). The site is a breeding area for Australian shelduck (*Tadorna tadornoides*) and major breeding area for Australian fairy tern (*Sterna nereis nereis*). The lakes are also a major migration stop-over area for shorebirds in south-western Australia and provide a significant drought refuge area for shorebirds, notably the banded stilt (*Cladorhynchus leucocephalus*) (DAWE 2020h).

9.3.16 Shark Bay East

The Shark Bay East wetland site extends along 250 km of coastline in the east arm of Shark Bay, from the mouth of the Gascoyne River (Carnarvon) south to latitude 26 S. The site comprises tidal wetlands and marine waters that are less than 6 m deep at low tide (up to approximately 10 km from shore). The wetland is a large, shallow marine embayment that support extensive seagrass beds and substantial areas of intertidal mud/sand-flats and mangrove swamp (DAWE 2020i).

The mangroves, algae and seagrasses present at the side are important for both dugongs and green turtles. A total of 69 species have been identified within the wetland including the threatened little tern (*Sterna albifrons*) and 33 shorebirds. A total of six species have been identified to be breeding within the wetland (Australian pelican, great egret, little egret, unidentified cormorants and striated herons). The site is also a stop-over for 24 species of migratory shorebirds (DAWE 2020i).

9.3.17 Cape Leeuwin System

The Cape Leeuwin System site is a small coastal valley, approximately 20 ha in size. Seepage from a series of freshwater springs feed an elongate swamp on the floor of the valley and moistens areas of the limestone and granite coastline to the west (DAWE 2020j). The site has been identified as the habitat for the largest known population of the rare aquatic gastropod mollusc; the Cape Leeuwin freshwater snail (*Austroassiminea letha* (Sr)) (DAWE 2020j).

9.3.18 Doggerup Creek System

The Doggerup Creek System site (2,500 ha) supports extensive flats subject to inundation in the north and east of its catchment. The site includes lakes (e.g. Doggerup, Samuel and Florence Lakes) and many small unnamed swamps. The site is an example of an `acid peat flat' with small permanent lakes and river (DAWE 2020k).

The wetland plant communities include 32 species at Doggerup Lake, 19 at Lake Samuel and 35 at Lake Florence. The site is a major habitat for two aestivating inland fishes, *Galaxiella nigrostriata* and

Lepidogalaxias salamandroides, that are endemic to the far south coast of WA. No threatened species have been identified within the site and it is not considered to be an important wetland for migratory shorebirds (DAWE 2020k).

9.3.19 Cape Range Subterranean Waterways

The Cape Range Subterranean Waterways wetland site comprises of the subterranean waterways, sinkholes, general groundwater and artificial wells of the coastal plain and foothills of Cape Range north of a line between Norwegian Bay, at the foot of the peninsula on the west coast, and the Bay of Rest in Exmouth Gulf (DAWE 2020l).

The site is one of the only examples of subterranean karst wetland system (apart from Barrow Island) in arid north-western Australia. Two threatened species have been identified within the wetland and include the blind cave eel and the blind gudgeon (DAWE 2020l).

9.3.20 Yalgorup System

See Peel-Yalgorup System Ramsar site (**Section 9.2.5**).

9.3.21 Adelaide River Floodplain System

Several swamps, lakes, lagoons and dams are included in the 134,800-hectare site. Four principal plant structural formations are present consisting of mangal low closed-forest (mangroves) mainly in the far north-west but extending along the river to south of the site, scattered chenopod low shrubland (samphire) in the far north, patches of melaleuca open-forest near the floodplain edges and missed closed grassland/sedgeland (seasonal floodplain) over most of the site (Jaensch, 1993).

The site is of particular significance as it contains one of the largest blocks of mangroves associated with the Top End floodplain as well as near-permanent marsh (Fogg Dam and Melacca Swamp), a rare wetland type in the Northern Territory. A rare species of the wetland plant Goodenia quadrigida also occurs within the floodplain. Surface inflow from the Adelaide-Margaret River System as well as numerous creeks (e.g. Hollands, Sunday and Buffalo Creeks) and Manton River provides a water supply for the area. The total volume of inflow is moderately high. The area provides a good example of the major floodplain-tidal wetland system typical of the Top End Region with substantial area of each component wetland type (Jaensch, 1993).

Adelaide River Floodplain system is a major breeding area for multiple species such as the Magpie Goose (*Anseranas semipalmata*), Saltwater Crocodile (*Crocodylus porosus*) and herons and allies. It is also a major dry season refuge area for waterbirds and a significant migration stop-over area for shorebirds (Jaensch, 1993).

9.3.22 Kakadu National Park

See Kakadu National Park Ramsar site (**Section 9.2.10**).

9.3.23 Mary Floodplain System

Included in the 127,600hectare site is the entire floodplain of the Mary River, from near Bark Hit Inn downstream to Van Diemen Gulf (including intertidal mudflats) and including Swim Creek Plain. Three principal plant formations occur within the site. These include melaleuca open-forest (paperbark swamp), scattered chenopod low shrubland (samphire) in the north and centre-north; and the remainder, mixed closed- grassland/sedgeland (seasonal floodplain). Mangroves occur in the far north fringing the coast and at estuary mouths. The site includes some of the largest areas of wooded swamp in the Northern Territory. 21 of the 36 described floodplain flora communities occur in the Mary Floodplain system (Jaensch, 1993).

Water supply mainly occurs from the surface inflow form the Mary-McKinlay River system as well as many creeks. Mudflats, estuaries, and saline coastal flats are tidal. Tidal areas of mudflats and estuaries are inundated twice daily compared to the large parts of coastal flats that may be only periodically inundated. The floodplain water supply is seasonal, with near-permanent water in deeper channels and billabongs, as well as Eleocharis swamp. The site is a good example of a major floodplain-tidal wetland system typical of the Top End Region and features a complex network of channels and billabongs (Jaensch, 1993).

Mary Floodplain System provides a major breeding area for the Magpie Goose (*Anseranas semipalmata*) as well as refuge during dry season for waterbirds (geese, ducks and herons) and Saltwater Crocodiles (*Crocodylus porosus*). At least 75 species recorded within the area, of those 33 species were listed under treaties and 11 species were found breeding. The mudflat and coastal flats support at least several thousand migrant shorebirds at a time (Jaensch, 1993).

9.3.24 Cobourg Peninsula System

See Cobourg Peninsula Ramsar site (**Section 9.2.9**).

9.3.25 Daly-Reynolds Floodplain-Estuary System

The Daly-Reynold Floodplain-Estuary System includes the entire floodplain of the Daly River, entire floodplain of the Reynolds River and the tidal mudflats of north-east Anson Bay and is in the Darwin Coastal and Daly Basin biographical regions. Six principal plant formations exist within the 159,300-hectare site. This includes mixed closed-grassland/sedgeland (seasonal floodplain) over most of the site; Melaleuca open-forest (paperbark swamp) in patches throughout, Coolibah/Gutta-percha low woodland over grassland in the far south-east; closed-forest (monsoon vine-thicket) around the Daly River in the far south-east; mangal low closed-forest (mangroves), discontinuously along the Daly River estuary (to 1 km wide); and scattered chenopod low shrubland (samphire) at/near the coast and river mouth. The site provides a good example of a major floodplain-tidal wetlands system as it contains substantial areas of all the principal features of such a system in the Top End Region. It is also one of the largest floodplains in the Northern Territory (Jaensch, 1993).

31 of the 36 described floodplain flora communities occur on the Daly-Reynolds Floodplain. The Daly-Reynolds Floodplain-Estuary System plays an important ecological role by providing a top three breeding ground for Magpie goose (*Anseranas semipalmata*), as well as herons, allies and Saltwater Crocodiles. Additionally the site is a major dry season refuge area for waterbirds and a significant migration stop-over area for shorebirds. The site also contains more than 80 fauna species, 30 of which are listed under treaties. Up to 2100 shorebirds are known to frequent this site as a migratory stop over (Jaensch, 1993).

9.3.26 Finniss Floodplain and Fog Bay Systems

The floodplain and bay systems provide a good example of a beach-fringed, curved bay with intertidal mudflats and intact floodplain with extensive paperback swamps. Plant structural formations within the area include mixed closed grassland/sedgeland and melaleuca open forests. Small areas of mangal and samphire occur near the estuaries and the south-west part of the bay. Surface inflow from the Finniss River, and several creeks supply the site with water (Jaensch, 1993).

At least 70 species of fauna are recorded in the area, 20 of which are listed under treaties. Finnis Floodplain and Fog Bay Systems are major breeding areas for Magpie goose and Saltwater Crocodile, a significant dry season refuge area for water birds and a major migration stop-over for over 25’000 shorebirds. 24 of the described floodplain flora communities along with the best floating mats in the Northern territory occur within this site (Jaensch, 1993).

9.3.27 Moyle Floodplain and Hyland Bay System

Plant structural formations of the area consist of closed grassland/sledgeland latiform arrangements, some fringing and scattered patches of melaleuca open-forests, and mangal low closed forest (mangroves) along the lower river. Surface inflow to floodplain areas from multiple creeks and Moyle River is the main source of water supply.

The Moyle Floodplain and Hyland Bay System is one of the least distributed examples of a Top End floodplain system associated with a small river a mudflat-fringed bay. The site is a major breeding area for magpie goose, a refuge for waterbirds (whistling duck) in the dry season, migration stop over area for shorebirds and a major breeding area for Saltwater Crocodiles. 27 of the described floodplain flora communities occur at this site. 47 fauna species are known to occur on the floodplain and adjacent coast, 26 of which are listed under treaties (Jaensch, 1993).

9.3.28 Murgenella-Cooper Floodplain System

Murgenella-Cooper Floodplain System includes the entire contiguous floodplains and saline coastal flats, estuaries, and tidal mudflats of Murgenella, Cooper and Salt-Water Creeks within 81,500 hectares. Surface flow from Cooper Creek and several unnamed creeks provide water supply for the area. Plant structural formations that are present include mixed closed grassland/sedgeland over most of the site, scattered chenopod low shrubland and narrow areas of mangal closed-forest (mangroves) along tidal channels and at the coast. The site provides a good example of floodplain-tidal wetland system of the Top End Region, with relatively low volume of freshwater inflow (Jaensch, 1993).

13 of the 36 described floodplain flora communities occur within the site. The site is a major breeding ground for Magpie Goose, cormorants, herons and allies, a major dry season refuge area for waterbirds and a major migration stop-over area for more than 10’000 shorebirds. At least 71 species of fauna are recorded in the area, 26 of which are on treaties (Jaensch, 1993).

9.3.29 Ord Estuary System

See Ord River Flood Plains Ramsar site (**Section 9.2.11**).

9.3.30 Port Darwin

The entire Port Darwin site covers 48,800 hectares. The whole site is tidal with mangal low closed-forest (mangroves) plant structural formations present. The site provides a good example of a shallow branching embayment of the Top End Region, supporting one of the largest discrete areas of mangrove swamp in the Northern Territory (Jaensch, 1993).

36 flora species, 23 of them trees and tall shrubs are present within the mangrove communities. Including Northern territory endemic *Avicennia integra*. The mangrove communities of this site are the most extensive and species rich of any Northern Territory embayment. The site is a major nursery for estuarine and offshore fish and crustaceans in the Beagle Gulf area. 48 fauna species, with 25 listed under treaties existing within this site. Rare species such as Red-necked Phalarope have also been recorded within the site. Furthermore, Woods Inlet is frequented by the uncommon dolphin *Orcaella brevirostris*. At least 72 fish species occur within the site as well as there being an unusual richness in sponges (220 species), soft and hard coral as well as invertebrates (Jaensch, 1993).

9.3.31 Shoal Bay - Micket Creek

Shoal bay is approximately 10km immediately north-east of the City of Darwin and the site includes King Creek and Noogoo swamp within 1,600 hectares. The site contains wetland marshes, mangrove woodlands, beaches, mudflats, creeks and estuaries and is a good example of a spring fed coastal wetland system. Micket Creek is a tidal estuary flowing into Shoal Bay while King Creek and water from Noogoo Swamp all flow into Shoal Bay. All areas contain remnants of monsoon forest interspersed with open woodland bounded by grassed backsoil plain (Hodgson, 1995).

Within the site there are some notable species. It has a bird habitat of over 200 species and provides a dry season refuge for waterfowl and birds of prey. Migratory birds regularly use the areas of mudflats with more than 15,000 wader species and 25 of them listed on international agreements with Japan and China. The Nationally endangered Littler Tern and two other uncommon species, the Eastern Grass Owl and Peregrin Falcon have been recorded within Shoal Bay – Micker Creek (Hodgson, 1995).

9.4 National Heritage Places

Natural, historic and indigenous places that are of outstanding heritage value to the Australian nation are recorded as National Heritage Places. Eleven National Heritage Places are found in waters from the South Australian border to the NT, with ten of these occurring within the combined EMBA. Kakadu National Park, Shark Bay and The Ningaloo Coast are listed as both World Heritage Areas and National Heritage Places, and are discussed in **Section 9.1**.

9.4.1 HMAS Sydney II and HSK Kormoran Shipwreck Sites

The naval battle fought in 1941 between the Australian warship HMAS Sydney II and the German commerce raider HSK Kormoran off the Western Australian coast during World War II was a defining event in Australia's cultural history. The loss of HMAS Sydney II, along with its entire crew of 645 following the battle with HSK Kormoran, remains Australia's worst naval disaster (DoE 2014d).

The shipwreck sites are comprised of two areas located approximately 290 km west-southwest of Carnarvon. The shipwrecks of the HMAS Sydney II and HSK Kormoran are located on the seabed approximately 22 km apart (DoE 2014d).

9.4.2 Batavia Shipwreck site and Survivor Camps Area 1629 - Houtman Abrolhos

The Batavia was included on the National Heritage List in 2006. This shipwreck is the oldest of the known Verenigde Oost-Indische Compagnie (VOC) wrecks on the WA coast and has a unique place in Australian shipwrecks. Because of its relatively undisturbed nature the archaeological investigation of the wreck itself has revealed a range of objects of considerable value to the artefact specialist and historian. The recovered sections of the hull of the Batavia that have been reconstructed in the Western Australian Maritime Museum and provides information on 17th century Dutch ship building techniques, while the remains of the cargo carried by the vessel have provided economic, and social evidence of the operation of the Dutch port at Batavia (now Jakarta) in the early 17th century (DoE 2014d).

9.4.3 The West Kimberley

The West Kimberley was included on the National Heritage List in 2011 and has numerous values which contribute to the significance of the property, including indigenous, historic, aesthetic, cultural and natural heritage values (DoE 2014d). Of these values, the most relevant to the marine environment is Roebuck Bay as a migratory hub for shorebirds. These values are discussed in **Section 9.2.2**. The area is characterised by a diversity of landscapes and biological richness found in its cliffs, headlands, sandy beaches, rivers, waterfalls and islands.

9.4.4 The Ningaloo Coast

See the Ningaloo Coast World Heritage Area (**Section 9.1.2**).

9.4.5 Shark Bay

See Shark Bay World Heritage Area (**Section 9.1.1**).

9.4.6 Dirk Hartog Landing Site 1616 - Cape Inscription Area

Cape Inscription is the site of the oldest known landings of Europeans on the Western Australian coastline (from Dirk Hartog of the Dutch East India Company's ship the Eendracht in October 1616), and is associated with a series of landings and surveys by notable explorers over a 250-year period (DoEE 2019b). The landing site forms part of the Dirk Hartog Island and is about 1,110 ha located 100 km south west of Carnarvon (DoEE 2019b).

9.4.7 Dampier Archipelago (including Burrup Peninsula)

The Dampier Archipelago (including the Burrup Peninsula) contains one of the densest concentrations of rock engravings in Australia, with some sites containing thousands or tens of thousands of images. At a national level it has an exceptionally diverse and dynamic range of schematised human figures and provides an unusual and outstanding visual record of the Aboriginal responses to the rise of sea levels at the end of the last Ice Age (DoEE 2019c).

The site is about 36,860 ha at Dampier and comprises of nine distinct areas of the Burrup Peninsula Areas and part of the following surrounding islands: West Intercourse Island, West Mid Intercourse Island, Enderby Island, Goodwin Island, West Lewis Island and East Lewis Island, Rosemary Island, Brigadier Island, Miller Rocks, Lady Nora Island and Elphick Nob, Malus Islands, Angel Island, Gidley Island, Cohen Island, Keast Island and Collier Rocks, Tozer Island, Dolphin Island, and Unnamed Island (DoEE 2019c).

9.4.8 Fitzgerald River National Park

The Fitzgerald River National Park contains an exceptional concentration of plant species richness and endemism. At an international level it is recognised as a biodiversity hotspot of south western Australia and at a national level it has an exceptional endemism and diversity for plant species. The diversity is considered high due to a wide range of landforms, geology and soil types that supports a diverse community of shrublands and heath, often dominated by eucalypt mallee species (DoEE 2019d).

The national park is approximately 297,244 ha located between Bremer Bay and Hopetoun in the south west of Western Australia. The park contains extensive marine plain sediments deeply incised by several rivers, creating valleys and tablelands. The park's coastline is diverse, consisting of long beaches, quartzite cliffs, extensive sand drifts and inlets. Along the Hamersley and Fitzgerald River valleys are spongolite cliffs that were formed more than 36 million years ago (Eocene period) and consist of sea sponge fossils (DoEE 2019d)

9.4.9 Lesueur National Park

The Lesueur National Park contains an exceptional concentration of plant species richness and endemism. At an international level it is recognised as a biodiversity hotspot of south western Australia and at a national level it has an exceptional endemism and diversity for plant species. The diversity is considered high due to a wide range of landforms, geology and soil types that supports a diverse community of shrublands and heath (DoEE 2019e).

The national park is approximately 27,235 ha located near the towns of Green Head and Jurien Bay. Coastal areas consist of recent (Holocene) sand deposits and mobile dunes extending inland for approximately two kilometres. The dunes are bordered by a series of mainly saline lakes with some freshwater springs and swamps on the eastern margins. Further inland are older (Quaternary) dune systems that have been compacted in places to form limestone. The park supports approximately 122 birds, including a diverse range of honeyeaters, fairy wrens and thornbills (DoEE 2019e).

9.4.10 Kakadu National Park

See Kakadu National Park World Heritage Area (**Section 9.1.3**).

9.5 Commonwealth Heritage Places

The Commonwealth Heritage Places List comprises natural, indigenous and historic heritage places which are either entirely within a Commonwealth area, or outside the Australian jurisdiction and owned or leased by the Commonwealth or a Commonwealth Authority. Ten Commonwealth Heritage Places are found in or adjacent to the combined EMBA. Three of these places (Ashmore Reef, Mermaid Reef and the Ningaloo Marine Area – Commonwealth Waters) are found in Marine Parks and are discussed further in **Section 12**. The HMAS Sydney II and HSK Kormoran Shipwreck Sites is listed under both National and Commonwealth Heritage Lists and discussed in **Section 9.4.1**.

9.5.1 Scott Reef and Surrounds – Commonwealth Area

Scott Reef is a large, emergent shelf atoll located on the edge of the broad continental shelf, about 300 km from mainland north-western Australia. The listing comprises the areas of Scott Reef that are within Commonwealth waters to the 50 m BSL bathymetric contour. This includes North Reef, an annular reef, 16.3 km long and 14.4 km wide and parts of the lagoon of South Reef, a crescent shaped reef 17 km across (DoE 2014d).

The place is regionally significant both because of its high representation of species not found in coastal waters off Western Australia and for the unusual nature of its fauna which has affinities with the oceanic reef habitats of the Indo-West Pacific as well as the reefs of the Indonesian region (DoE 2014d).

9.5.2 Mermaid Reef – Rowley Shoals

See the Mermaid Reef Marine Park (**Section 12.3.9**).

9.5.3 Ningaloo Marine Area – Commonwealth Waters

See the Ningaloo Coast World Heritage Area (**Section 9.1.2**).

9.5.4 Ashmore Reef National Nature Reserve

See the Ashmore Reef Marine Park (**Section 12.3.12**).

9.5.5 Garden Island

Garden Island is located to the south of Perth, 5 km northwest of Rockingham. It was registered in 2004 based on various fauna, geological, European and Aboriginal heritage and vegetation values. It was the original first site occupied by Governors Stirling's Party in 1829, with prior use by Aborigines and the French (being called Ile de Buache by the French in 1801). The island is virtually free from widespread feral animal colonisation, providing important habitat for various species that have reduced on the mainland. The island provides breeding habitat for bridled tern (*Onychoprion anaethetus*), rainbow bee-eaters (*Merops ornatus*) and osprey (*Pandion haliaetus*), which nest on the rocks surrounding the island. Important feeding habitat for the Sanderling (*Calidris alba*) is provided by sandy beaches on the west coast of the island.

The island provides nesting habitat on beaches for the breeding migrant fairy tern (*Sterna nereis*), which requires undisturbed nesting periods. The mature relatively undisturbed heath, scrub and low forest communities unburnt since the 1920's in the northern section of the island are especially important as a reference site for natural history. The least disturbed examples of calcaronite reef structures dune and tamate landscapes in the metropolitan region are present on the western side of the island (DoEE 2016b).

9.5.6 Christmas Island Natural Areas

Christmas Island is located is approximately 1,500 km from Exmouth and is approximately 2,200 ha above Low Water and 3,600 ha below Low Water in the Indian Ocean. The island is an uplifted coral atoll with its characteristic steep series of rainforest-covered terraces and sheer limestone cliffs. It was registered in 2004 based on various fauna, vegetation, geological and cultural heritage values. The evolutionary significance of Christmas Island is demonstrated both by its high level of endemism and by its unique assemblage of plant and animal species. The island hosts seventeen endemic plant species and rich endemic fauna includes three mammal species, ten bird species, five reptile species, one crab species, two insects, three marine fish species and several marine sponge species (DoEE 2019f).

The rainforests of Christmas Island are biogeographically significant; species have evolved from being either shoreline forest or early rainforest succession species to those that fill a tall climax rainforest role. The Island contains unique plant communities of high conservation and scientific interest including a variety of elevated and relict cycad and back-mangrove communities of international significance (DoEE 2019f).

The island is also one of the world's most significant seabird islands, both for the variety and numbers of sea-birds, with over 100 species of bird having been recorded, including eight species that breed on the island. The island rainforest provides significant habitat for two endemics the nationally endangered Abbott's booby and the nationally vulnerable Christmas Island frigate bird (DoEE 2019f).

The fringing simple reefs and adjacent waters of Christmas Island support provides habitat for two nationally vulnerable species of turtle, the green and hawksbill which nest on two of the Island's beaches and two nationally vulnerable shark species (DoEE 2019f).

9.5.7 Yampi Defence Area

The Yampi Defence Area is located at the confluence of the Dampierland, Central and Northern Kimberley biogeographic regions and has a diverse range of ecosystems of landforms, soils and vegetation representative of the transition from the sandstone plateaux of the wetter north-west Kimberley, to the broad plains and pindan scrub of the drier south-west Kimberley (DoEE 2019g).

The diversity of landforms in the place and the resultant high concentration of small refugial habitats support a regionally rich vertebrate fauna. The bird fauna is significant as it represents a suite of species which are at or near the southern edge of their range in the semi-humid zone of the Kimberley. The place is also an important zone of overlap between many northern and southern species and sub-species. The vertebrate fauna shows its closest similarity to those recorded from the wetter areas of the west Kimberley that lie further to the north. The place supports several fauna and flora species that are listed as specially protected, threatened or having priority status in Western Australia in addition to four fauna species that are nationally vulnerable and one nationally endangered (DoEE 2019g).

9.5.8 Learmonth Air Weapons Range Facility

The Learmonth Air Weapons Range Facility is located 30 km south west of Learmonth within Cape Range and Adjacent Coastal Plain, which is listed on the Register of the National Estate. As the Learmonth Air Weapons Range Facility is located within Cape Range it is of considerable importance of showing he sea level and landform changes for the past 1.8 million years (DoEE 2019h).

The area is important to a number of cave fauna of Cape Range and is considered of exceptional biogeographical importance. It hosts a high number of endemic aquatic stygofauna with ecosystems found within this area are considered rare within Western Australia and are considered to be of considerable scientific interest. The area also supports several species of terrestrial fauna that are isolated populations, populations at the extent of their range and a number of fauna and flora species that are endemic to southern WA and restricted to sandy coastal habitats along the western coast (DoEE 2019h).

9.5.9 Lancelin Defence Training Area

The Lancelin Defence Training Area is located approximately 11 k north of Lancelin township situated on the Swan Coastal Plain and consists of three main land systems that include Quindalup and Spearwood Dune Systems (together making up the Coastal Belt), and the Bassendean Dunes (DoEE 2019i).

The area supports a high diversity of vegetation types, flora species, fauna habitat types and a high diversity of terrestrial fauna.

9.5.10 Bradshaw Defence Area

The Bradshaw Defence Area is located in the Northern Territory and is bounded by the Fitzmaurice and Victoria Rivers on the shores of the Joseph Bonaparte Gulf and the Bradshaw Defence field training area.

The complex topography of the Bradshaw area results in a broad range of highly distinct environments and habitats that include lowland woodlands, heaths, grasslands, sandstone escarpments, monsoon rainforest patches and wetlands. Compared to surrounding areas, the vegetation within the Bradshaw area is more diverse and incorporates more than one fifth of the vegetation types that occur in the Top End of the Northern Territory and includes grassland, woodland flora that are restricted on a national level (DAWE, 2002).

The topological complexity that results in a broad range of environments also contributes to the unusually rich vertebrate fauna. The species richness of frogs, reptiles and mammals is considered significant at a national level. Furthermore, it is also worth noting that the Bradshaw area supports many species that have declined elsewhere in Australia (DAWE, 2002).

9.6 Coastal Terrestrial Conservations Reserves – bound by marine waters

Conservation reserves are created under the Land Administration Act 1997, and once reserved and set aside for conservation purposes are regulated under the *Conservation and Land Management Act (CALM) 1984*. Most conservation reserves in WA are vested in (owned) by the WA Conservation and Parks Commission, an independent statutory body established by the CALM Act 1984, and most are managed by the Department of Biodiversity, Conservation and Attractions – Parks and Wildlife Service. Most conservation areas in the NT are managed under the *Territory Parks and Wildlife Conservation Act*.

In WA there are three main types of terrestrial conservation reserves with legislative protection:

+ Nature reserves – established for wildlife and landscape conservation; scientific study; and preservation of features of archaeological, historic or scientific interest;
+ National parks – as above but also to be used for enjoyment by the public. Have national or international significance; and
+ Conservation parks – as above but have local or regional significance.

Nature reserves can have an extra classification applied to them and become ‘A class’ reserves, which generally require an Act of Parliament to alter.

In NT there are a number of types of terrestrial conservation reserves with legislative protection, those present within the combined EMBA include coastal reserves, national parks and conservation parks.

There are numerous terrestrial conservation reserves located adjacent to the coast in the combined EMBA. The oceanward boundary of the reserves varies. In some cases, the reserves extend to the low water mark, i.e. including the inter-tidal zone (particularly applicable to older gazetted reserves and terrestrial reserves not surrounded by a marine reserve). While in other cases, the terrestrial reserves extend to the high-water mark e.g. Lowendal Islands Nature Reserve (particularly applicable to terrestrial reserves adjacent to more recently gazetted marine parks). In other cases, the seaward boundary of the reserves is not defined. Management plans also contain the caveat for further consideration of the most appropriate tenure for intertidal areas and management arrangements.

Further information on coastal terrestrial reserves is provided below in **Section 9.6.1** (national parks) and **Section 9.6.2** (nature reserves and conservations parks).

9.6.1 Coastal National Parks

Protected coastal national parks managed under the CALM Act 1984 in the combined EMBA are listed in **Table 9-2**. The table also includes: any applicable management plan; whether the park includes the inter-tidal area; and the name of any adjacent state marine reserve. All WA National Parks are WA Class A reserves and IUCN Class 2.

Table 9-2: Coastal National Parks – coastal boundary in relation to inter-tidal zone

National Park	IBRA bioregion[8]	Management plan	Includes inter-tidal zone	Adjacent Marine Management Park (see Section 11)
Reserves of Northern WA (see Figure 9-6)				
Lawley River	Northern Kimberley	-	No [9]	Kimberley Marine Park
Mitchell River		-		
Prince Regent		-		
Reserves of North-West WA (see Figure 9-7)				
Murujuga	Pilbara	Murujuga National Park management plan 78 (DEC 2013)	Yes [10]	-
Cape Range	Carnarvon	Cape Range National Park Management Plan (DEC 2010a)	No	Ningaloo Marine Park
Reserves of Southern WA – (see Figure 9-8)				
Francois Peron	Carnarvon	Shark Bay Terrestrial Reserves and Proposed Reserve Additions Management Plan (2012)	No	Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve
Dirk Hartog	Yalgoo		Yes – intertidal zone on western side of Dirk Hartog is included (as no marine park on western side of island)	
Houtman Abrolhos Islands	Geraldton Sandplains	-	No - extends to the high water mark only.	Abrolhos Commonwealth Marine Park

[8] IBRA classifies Australia's landscapes into large geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information (DoEE 2012).

National Park	IBRA bioregion[8]	Management plan	Includes inter-tidal zone	Adjacent Marine Management Park (see Section 11)
Kalbarri	Geraldton Sandplains	Kalbarri National Park Management Plan (DPAW 2015)	Yes [10]	-
Namburg	Geraldton Sandplains	Namburg National Park Management Plan (1998)	Yes	-
Yalgorup	Swan Coastal Plain	Yalgorup National Park Management Plan (CALM 1995)	Yes [10]	-
Leeuwin - Naturaliste	Warren	Leeuwin-Naturaliste Capes Area Parks and Reserves Management Plan (DPAW 2015)	No	Ngari Capes Marine Park
Torndirrup	Warren	Albany coast draft management plan 2016 (DPaW 2016b)	Yes[10]	
Walpole-Nornalup	Warren	Walpole Wilderness and Adjacent Parks and Reserves Management Plan (DEC 2008) Walpole and Nornalup Inlets Marine Park Management Plan No 62 (DEC 2009b)	Yes[10]	Walpole and Nornalup Inlets Marine Park
Waychinicup	Southern Jarrah Forest and Fitzgerald	Albany coast draft management plan 2016 (DPAW 2016)	Yes[10]	
West Cape Howe	Warren	Albany coast draft management plan 2016 (DPaW 2016)	Yes[10]	
D'Entrecasteaux	Warren	Shannon and D'Entrecasteaux National Parks Management Plan No. 71 (DEC 2012b)	Yes[10]	
Fitzgerald River	Fitzgerald	Fitzgerald River National Park Management Plan 1991 – 2001 No. 15 (CALM 1991)	Yes[10]	
Reserves of the Northern Territory (NT) – (see Figure 9-5)				
Djukbinj National Park	Darwin Coastal and Pine Creek	-	Yes[10]	-
Garig Gunak Barlu National Park	Tiwi Cobourg	Cobourg Marine Park Plan of Management (PAWCNT, 2011)	Yes[10]	Cobourg Marine Park

National Park	IBRA bioregion[8]	Management plan	Includes inter-tidal zone	Adjacent Marine Management Park (see Section 11)
Mary River National Park	Darwin Coastal	Mary River National Park Joint Management Plan March 2015 (PAWCNT, 2015)	Yes[10]	-
Keep River National Park	Victoria Bonaparte	-	Yes[10]	-
Charles Darwin National Park	Darwin Coastal	Charles Darwin National Park Plan of Management (NT government, nd)	Yes[10]	-

9.6.2 Coastal Nature Reserves and Conservation Parks

Protected coastal nature reserves and conservation parks managed under the CALM Act 1984 in the combined EMBA are listed in **Table 9-3** and shown in **Figure 9-6**, **Figure 9-7** and **Figure 9-8** for the north, north-west and south of WA respectively. Protected lands in the NT are shown in Figure 9-5 as gazetted under the (NT) Crown Lands Act 1992. The table also includes reserve class; IUCN classification; any applicable management plan; whether the reserve includes the inter-tidal area; and the name of any adjacent state marine reserve (may also describe inter-tidal areas values).

The CALM Act does not require management plans to be in place for conservation reserves at all time, instead they are required to be made as is reasonably practicable regarding resources. This means some conservation reserves do not have a management plan, or do not have a recent management plan.

Table 9-3: Nature Reserves (NR) and Conservation Parks (CP) in EMBA

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Reserves of Northern WA (see Figure 9-6)					
Ord River NR	-	1a	-	No [9]	North Kimberley Marine Park
Pelican Island NR	-	1a			
Lesueur Island NR	A	1a			
Low Rocks NR	A	1a			
Browse Island NR	A	1a	-	Yes [10]	-
Scott Reef NR	-	1a	-	Yes [10]	-
Adele Island NR	A	1a	-	Yes [10]	-
Tanner Island NR	A	1a	-	Yes [10]	-
Lacepede Islands NR		1a	-	Yes [10]	-

[9] Inferred as adjacent marine park boundary is the high water mark and dual tenure cannot exist.

[10] Conservatively inferred as no adjacent Marine Park.

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Coulomb Point NR	A	1a	-	Yes [10]	-
Yawaru Birragun CP; Yawuru Northern Intertidal Area	- & A	2 & 6	Yawaru Birragun Conservation Park Management Plan (DPaW 2016). *Yawuru Intertidal Area management plan is not yet available.*	Yes	-
Jinmarnkur CP	C	-	Parks and reserves of the south-west Kimberley and north-west Pilbara Draft Management Plan (DPAW 2016). *Covers 80 Mile Beach coastal reserves.*	No	Eighty Mile Beach Marine Park
Jinmarnkur Kulja NR	A	-			
Kujungurru Warrarn NR	A	1a			
Kujungurru Warrarn CP	C	-			
Unnamed	A	-			
Jarrkunpungu NR	A				
Bedout Island NR	A	1a	-	Yes [10]	-
North Turtle Island NR	A	1a	-	Yes [10]	-
Reserves of North-West WA (see Figure 9-7)					
Unnamed (Dampier Archipelago) NR	A	1a	Dampier Achipelago Management Plan (CALM 1990). *Covers 25 of the islands*	Yes	-
Swan Island NR	A	1a	-	Yes[10]	Kimberly Marine Park
Unnamed NR		1a	-	Yes [10]	-
North Sandy Island NR	A	1a	-	Yes [10]	-
Montebello Islands CP	A	2	-	Partially [11]	Montebello Islands Marine Park
Lowendal Island NR		1a	-	No	Barrow Island Marine Management Area and Marine Park. Lowendal Island NR only partially bounded
Barrow Island NR	A	1a	Barrow Island Group Nature Reserves (DPAW 2015)	Yes	
Boodie, Double and Middle Islands NR	-	1a		Yes	
Great Sandy Island NR	B	1a	-	Yes	Barrow Island Marine Management Area
Weld Island NR	-	1a	-	Yes [10]	-
Little Rocky Island NR	A	1a	-	Yes [10]	-

[11] Reserve R42197 includes the inter-tidal zone and reserve R42196 does not.

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Airlie Island NR	-	1a	-	Yes [10]	-
Thevenard Island Nature	-	1a	-	Yes [10]	-
Bessieres Island NR	A	1a	-	Yes [10]	-
Serrurier Island NR	-	1a	-	Yes [10]	-
Round Island NR	-	1a	-	Yes [10]	-
Locker Island NR	A	1a	-	Yes [10]	-
Rocky Island NR	-	1a	-	Yes [10]	-
Gnandaroo Island NR	A	1a	-	Yes [10]	-
Victor Island NR	-	1a	-	Yes [10]	-
Y Island NR	-	1a	-	Yes [10]	-
Tent Island NR	-	1a	-	Yes [10]	-
Burnside and Simpson Island NR	-	1a	-	Yes [10]	-
Whalebone Island NR		1a	-	Yes [10]	-
Whitmore, Roberts, Doole Islands & Sandalwood Landing NR	-	1a	-	Yes [10]	-
Muiron Islands NR	-	1a	Jarabi and Bundegi Coastal Parks and Muiron Islands (CALM 1999)	No [9]	Muiron Islands Marine Management Area
OneTree Point NR	A	1a	-	Yes [10]	
Reserves of Southern WA – (see Figure 9-8)					
Koks Island NR	A	1a	Shark Bay Terrestrial Reserves and Proposed Reserve Additions Management Plan (DPAW 2012)	Yes [10]	-
Bernier and Dorre Islands NR	A	4			
Shell Beach CP	-	3		No	Shark Bay Marine Park
Freycinet, Double Islands etc NR	A	1a			Shark Bay Marine Park
Zuytdorp NR	-	1a		Yes [10]	-
Beekeepers NR	-	1a	-	Yes [10]	-
Beagle Islands NR	A	1a	Turquoise Coast Nature Reserve Management Plan (CALM 2004).	Yes	-
Lipfert, Milligan, etc Islands NR	A	1a			-
Fisherman Islands NR	A	1a			Jurien Bay Marine Park: extends from
Sandland Islands NR	A	1a			

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Boullanger, Whitlock, Favourite, Tern and Osprey Islands NR	A	1a	*Covers chain of approximately 40 protected islands lying between Lancelin and Dongara.*		Greenhead south to Wedge Island
Escape Island NR	A	1a			
Essex Rocks NR	A	1a			
Outer Rocks NR	A	1a			
Ronsard Rocks NR	A	1a			
Cervantes Islands NR	A	1a			
Buller, Whittell and Green Islands NR	A	1a			
Wedge Island NR	A	1a			
Lancelin and Edwards Islands NR	A	1a			-
Southern Beekeepers NR	-	1a	Namburg National Park Management Plan (CALM 1998)	No	-
Wanagarren NR	-	1a		Yes	
Nilgen NR	-	1a		Yes	
Unnamed CP (R 49994) west of Wilbinga	-	2	-	Yes [10]	-
Unnamed CR (R 42469) at Woodman Point	-	-	Woodman Park Regional Park Management Plan (DEC 2010b)	No	-
Unnamed CP at Woodman Point (R 49220)	-	2		No	-
Carnac Island NR	A	1a	Carnac Island Nature Reserve Management Plan (CALM 2003)	Yes	-
Penguin Island CP	A	3	Shoalwater Islands Management Plan (CALM 2002)	No	Shoalwater Islands Marine Park
Shoalwater Islands NR	A	1a		Yes	
Port Kennedy Scientific Park	A	1a	Rockingham Lakes Regional Park (DEC 2015)	No	-
Leschenault Peninsula CP	A	2	Leschenault Peninsula Management Plan (CALM 1998)	Yes	-
Sugar Loaf Rock NR	A	1a	Leeuwin-Naturaliste Capes Area Parks and Reserves Management Plan (DPAW 2015)	Yes	Ngari Capes Marine Park
Hamelin Island NR	A	1a		Yes	
Seal Island NR	A	1a		Yes	
St Alouarn Island NR	A	1a		Yes	
Flinders Bay NR	A	1a		Yes	
Quagering NR	A	1a	-	Yes[10]	-
Doubtful Islands NR	A	1a	-	Yes	Bremer Marine Park
Quarram NR	A	1a	-	Yes	

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Chatham Island NR	A	1a	-	Yes	South-west corner Marine Park
Two Peoples Bay NR	A	4	Albany coast draft management plan 2016 (DPAW 2016b)	Yes[10]	-
Breaksea Island NR	A	1a		Yes[10]	-
Bald Island NR	A	1a		Yes[10]	-
Eclipse Island NR	A	1a		Yes[10]	-
Michaelmas Island NR	A	1a		Yes[10]	-
Glasse Island NR	A	1a	-	Yes[10]	-
Arpenteur NR	-	1a	-	No	-
Figure 9-5					
Channel Point Coastal Reserve	-	5	-	Yes[10]	-
Casuarina Coastal Reserve	1 and 3	5	Casuarina Coastal Reserve Management Plan (PAWCNT, 2016)	Yes[10]	-
Shoal Bay Coastal Reserve	-	6	-	Yes[10]	-
Tree Point Conservation Area	-	5	-	Yes[10]	-

Further information is provided below in relation to Varanus Island and Airlie Island Nature Reserves. Santos' Varanus Island Processing Hub and Airlie Island (operations ceased) co-exist with the reserves.

Lowendal Islands Nature Reserve - Varanus Island

Varanus Island is part of the Lowendal Islands group, a Nature Reserve (Class C). The Lowendal Islands comprise more than 40 limestone islands, islets and rocky stacks. There is not currently a DBCA Management Plan covering the Lowendal Islands Nature Reserve. Varanus Island is the largest island in the Lowendal Islands and is approximately 2.5 km long and 600m wide at its widest point. Its highest point is approximately 30m above sea level.

Described ecological conservation values of marine relevance include: Wedge-tailed Shearwater nesting (see **Section 8.1.6**); Loggerhead and Hawksbill Turtle nesting (see **Section 6.1.1** and **Section 6.1.3**), Flatback Turtle nesting (Section 6.1.4). The Lowendal Islands are described as particularly important for tern breeding (DEC 2002), further information on terns is provided in **Section 8.2.1**.

Airlie Island Nature Reserve

Airlie Island Nature Reserve is an ungazetted 'C' class nature (Reserve identifier: 40323, Crown Lease 1901/100) located on Airlie Island. Airlie Island is a small sand cay (26 Ha) located 35 km NNE of Onslow. It is part of the Pilbara Inshore Islands chain. A management plan for the nature reserves of the Pilbara Inshore Islands is currently under development (DBCA 2019) i.e. there is not currently a DBCA Management Plan covering Airlie Island Nature Reserve.

Santos

Described ecological conservation values of marine relevance include: a wedge-tailed shearwater nesting (see **Section 8.1.6**); silver gull nesting (see **Section 8.1.6**) and low levels of green turtle and hawksbill turtle nesting (see **Section 6.1.2** and **6.1.3**).

9.7 Threatened Ecological Communities

An ecological community is a naturally occurring group of plants, animals and other organisms interacting in a unique habitat. Ecological communities are listed under the EPBC Act as threatened if the community is at risk of extinction.

Similarly, ecological communities can be listed under the WA BC Act as threatened if facing a risk of becoming a collapsed ecological community. To date no ecological communities are listed as threatened under the WA Act, however several ecological communities are currently endorsed by the WA Minister of Environment as Threatened Ecological Communities (TECs) through the previous non-statutory process.

TECs of relevance (likely to exist in marine water inter-tidal areas) in the combined EMBA are listed in **Table 9-1** and further described below.

Table 9-4: Relevant TEC in the marine EMBA

Species	Conservation Status		
	EPBC Act 1999 (Cwth)	BC Act 2016 (WA)	Otherwise endorsed by the WA Minister for Environment
Monsoon Vine Thicket on the Ridge on the Coastal Sand Dunes of Dampier	Endangered	-	Vulnerable
Roebuck Bay mudflats	-	-	Vulnerable
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	-	-

9.7.1 Monsoon Vine Thicket on the Ridge on the Coastal Sand Dunes of Dampier

Monsoon vine thicket occurs as semi - deciduous and evergreen vine thicket communities on and behind landward slopes of coastal sand dunes on the Dampier Peninsula in the Kimberley Region. This community is closely associated with coastal dunes elsewhere on the Dampier Peninsula and is listed as Endangered under the EPBC Act (Government of Western Australia 2010; DoEE 2016b). The community is also endorsed by the WA Minister for Environment as a threatened ecological community (non-statutory process).

9.7.2 Roebuck Bay Mudflats

Roebuck Bay mudflats (Kimberley region) have been endorsed by the WA Minister for Environment as a threatened ecological community (non-statutory process). The TEC is not listed under the EPBC Act.

Roebuck Bay mudflats (Kimberley region) are described as a 'species rich faunal community of the intertidal mudflats of Roebuck Bay' in the Kimberley region. Classed as Vulnerable (B). Roebuck Bay is a tropical marine embayment with extensive, biologically diverse, intertidal mudflats.

Roebuck Bay is protected as a designated Ramsar Wetland of International Importance (**Section 9.2.2**) and Marine Park (see **Sections 11.1.17** and **12.3.10**).

9.7.3 Subtropical and Temperate Coastal Saltmarsh

Subtropical and Temperate Coastal Saltmarsh occurs within the subtropical and temperate climatic zones and is present in coastal areas under regular or intermittent tidal influences and occurs over six State jurisdictions (Queensland, New South Wales, Victoria, Tasmania and WA). In WA it occurs from the south coast up to the southern part of Shark Bay. The community is made up of mainly salt tolerant vegetation which include halophytes as well as a number of non-vascular plant species. The community is listed as vulnerable under the EPBC Act (DoE 2014k).

9.7.4 Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)

The Lake Clifton thrombolite community is restricted to Lake Clifton, which occurs on the Swan Coastal Plain region of WA. Lake Clifton is situated within the Yalgorup National Park and is the northernmost lake in the Peel-Yalgorup Lakes System, which consists of several hypersaline and brackish lakes (Moore 1990). The Lake Clifton thrombolite community occurs on a relict foredune plain of Holocene age sands. The main known occurrence of the ecological community is a stretch, approximately 15 km long and up to 15 m wide, along the north-eastern shoreline of Lake Clifton. There are other small clusters of thrombolites within the Lake, also at the northern end. The thrombolites cover a total area of approximately four square kilometres (Moore 1990). This structure is the largest known example of a living, non-marine microbialite reef in the southern hemisphere.

The Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton) is listed as critically endangered under the EPBC Act because it has a very restricted distribution and recent investigations indicate that *Scytonema*, a key cyanobacterium for thrombolite formation has gone from being a dominant species to no longer being found in Lake Clifton thrombolites.

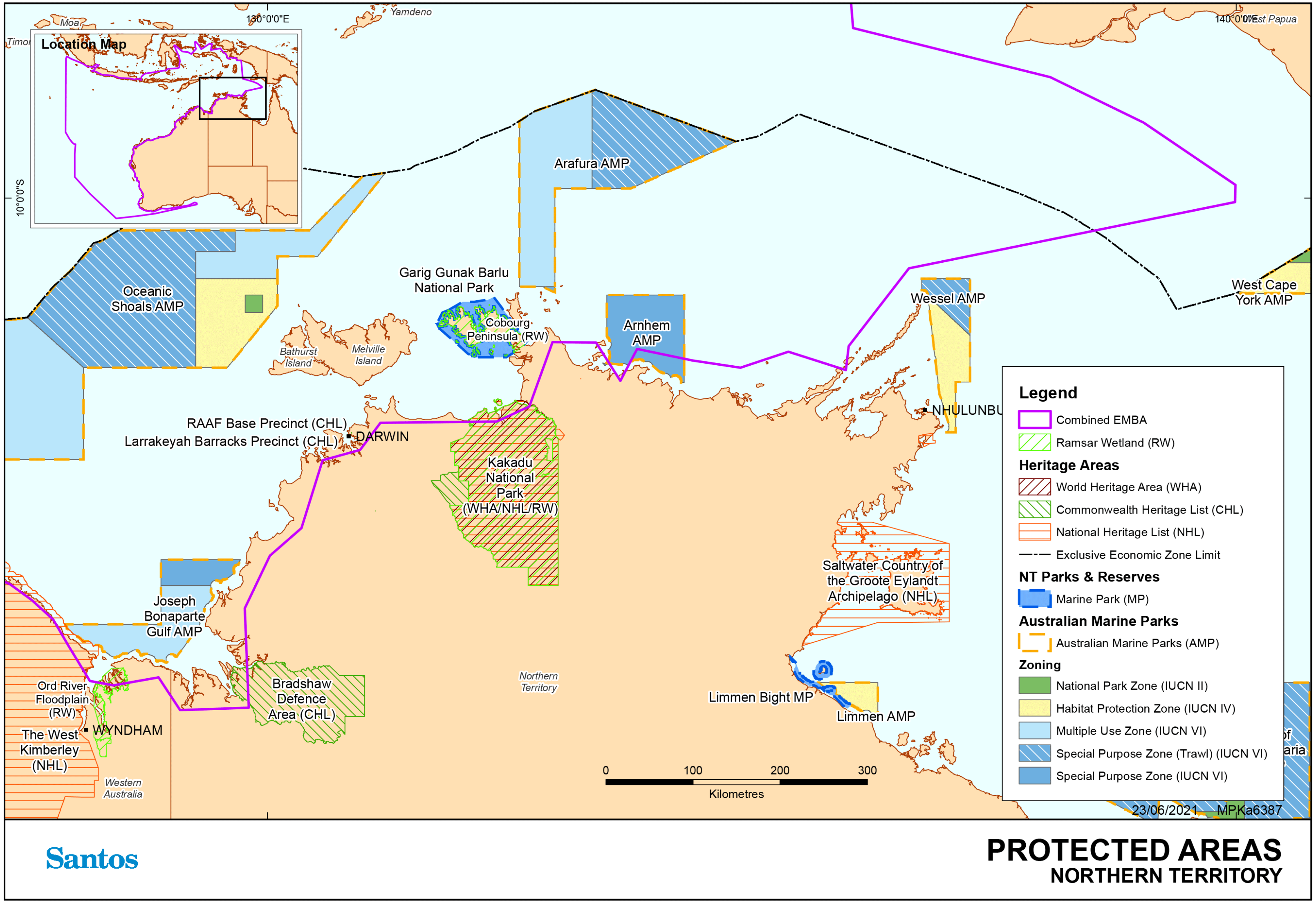


Figure 9-1: Protected areas in NT

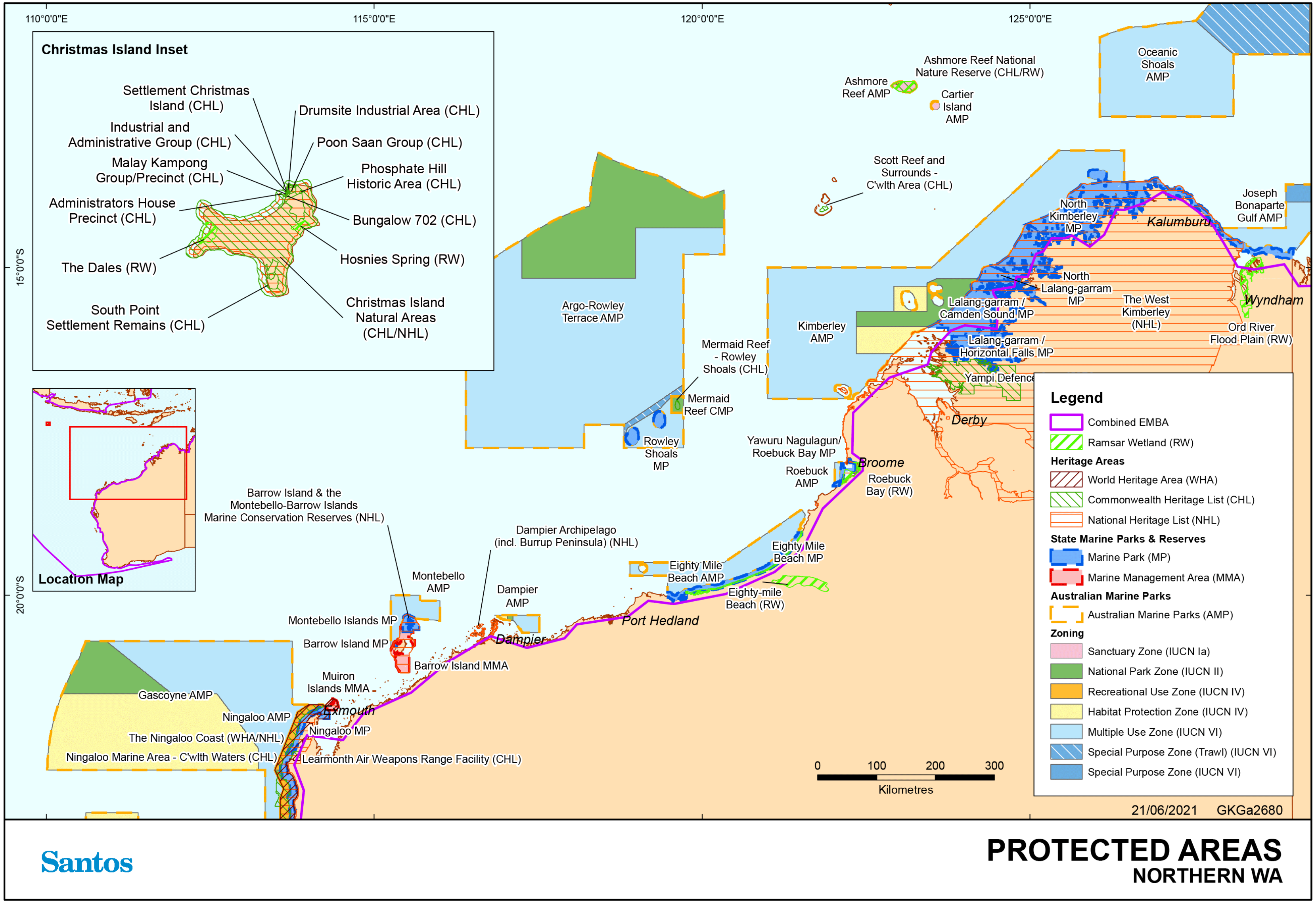


Figure 9-2: Protected areas in Northern WA

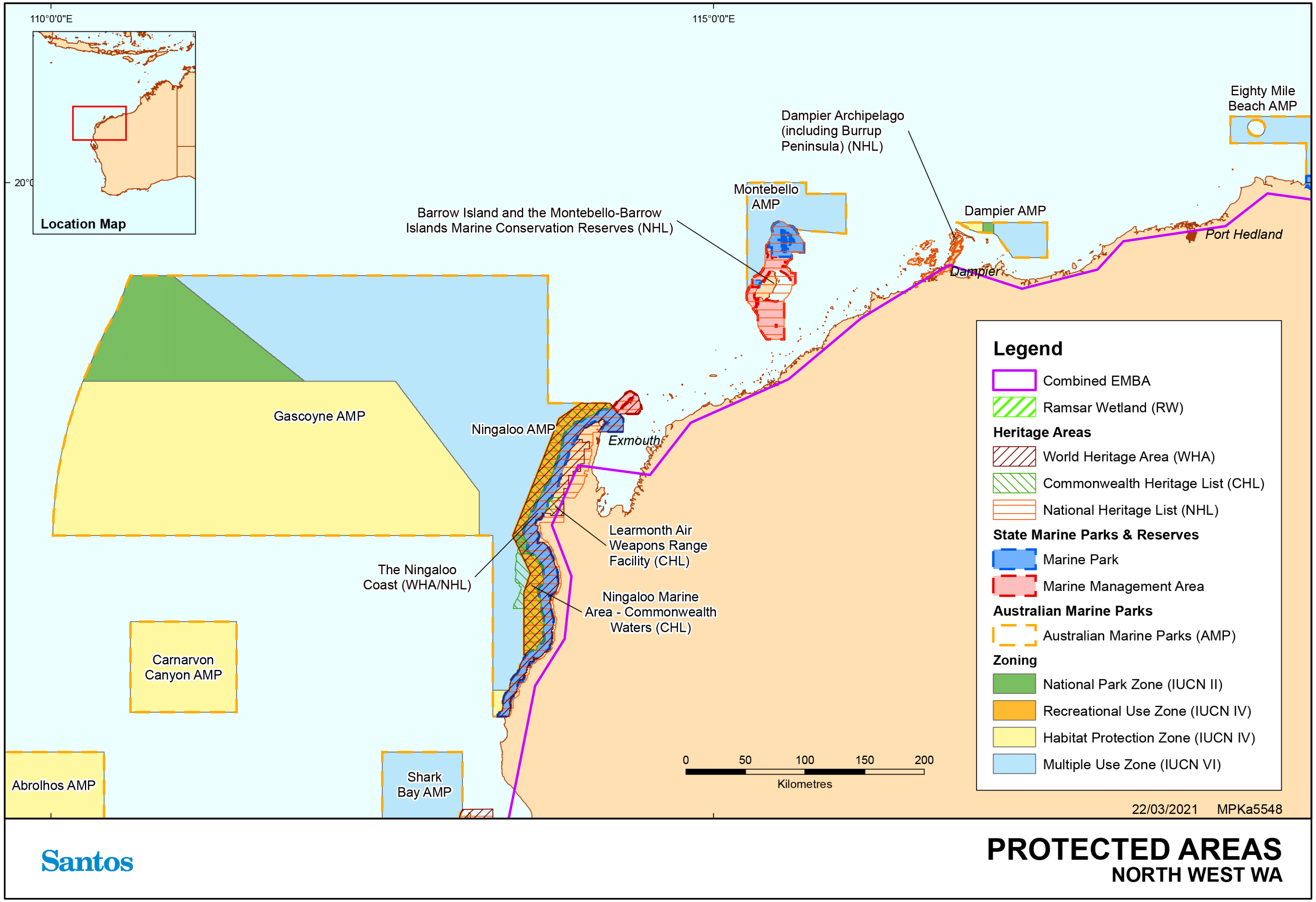


Figure 9-3: Protected areas in North West WA

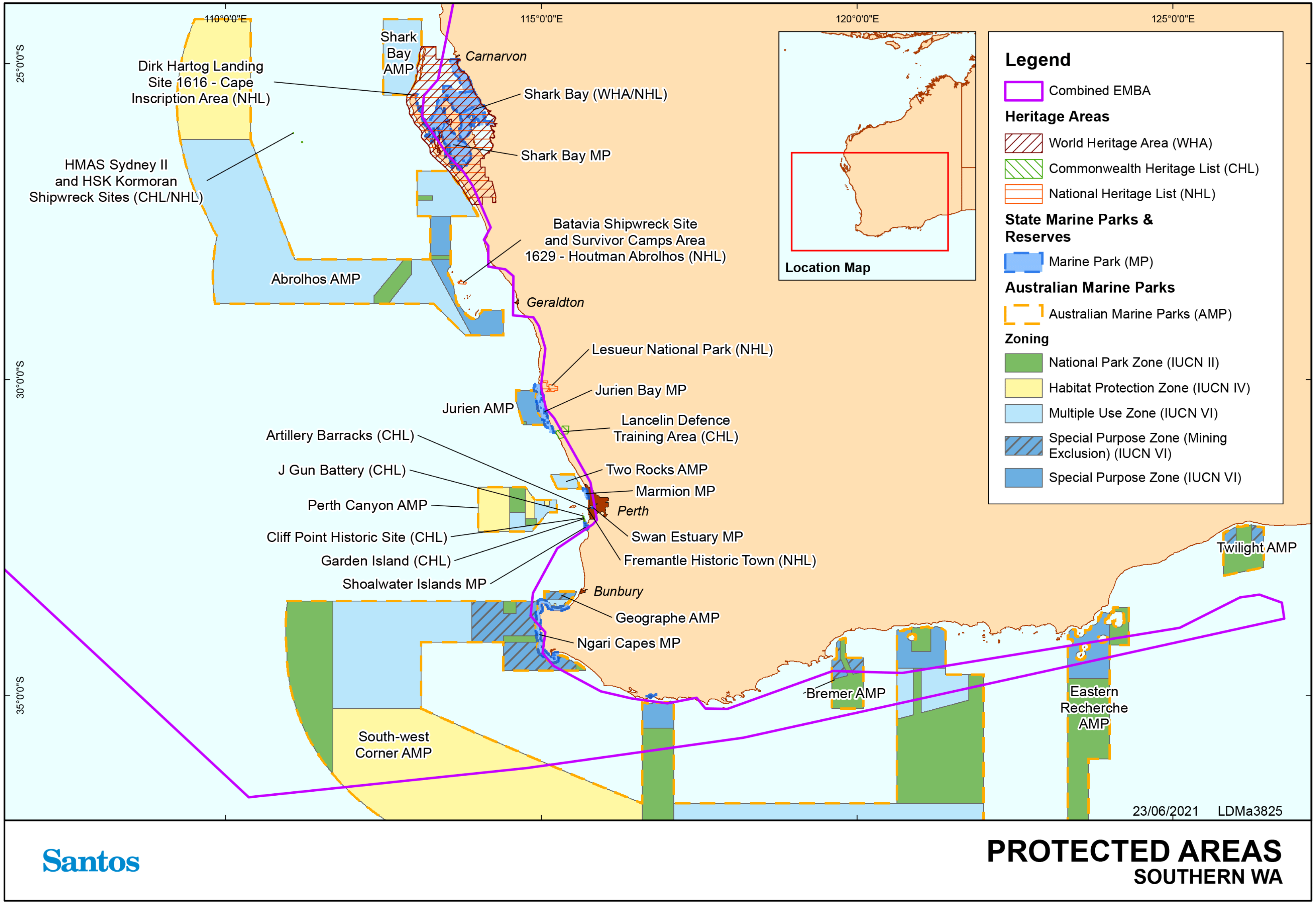


Figure 9-4: Protected areas in Southern WA

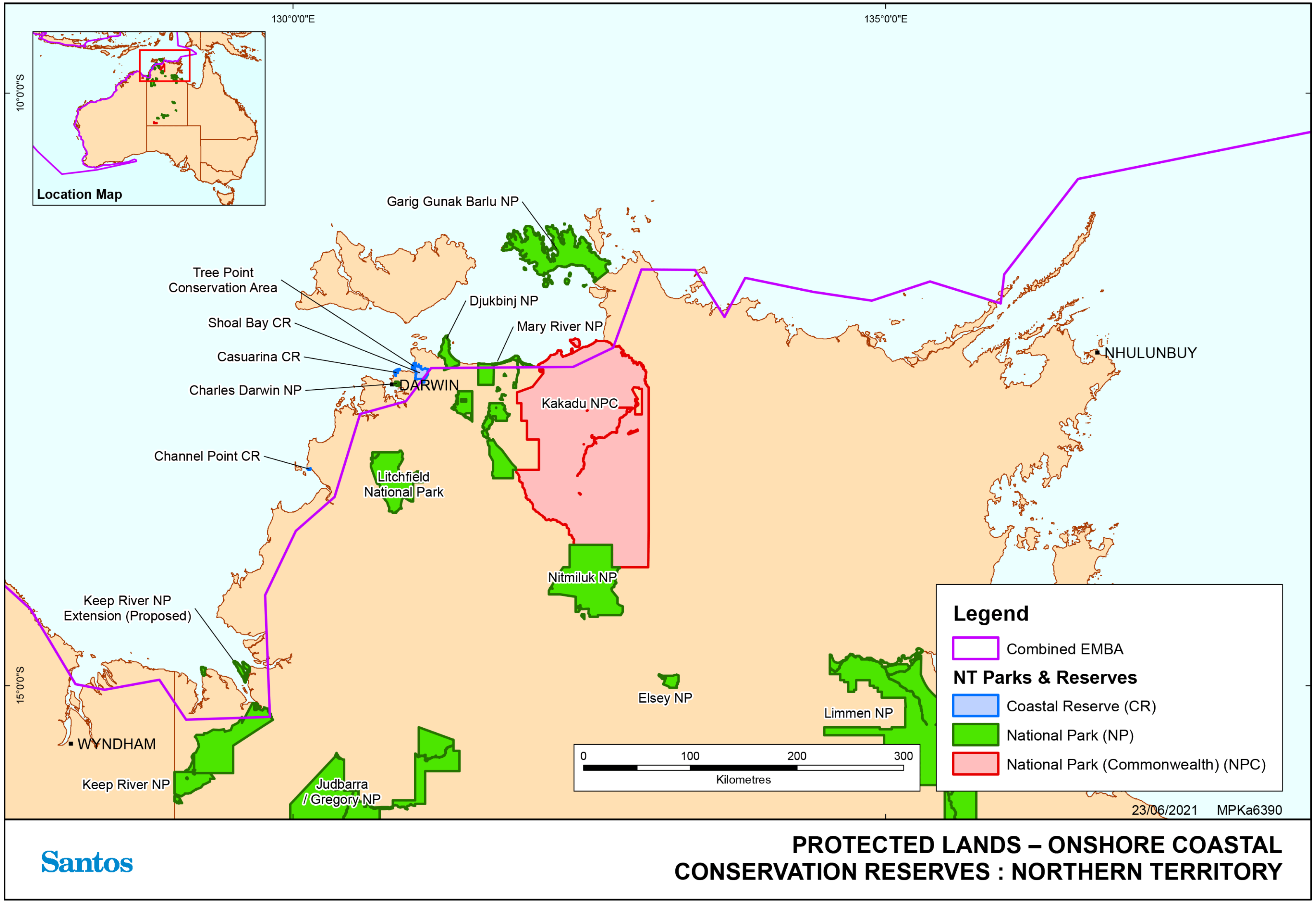
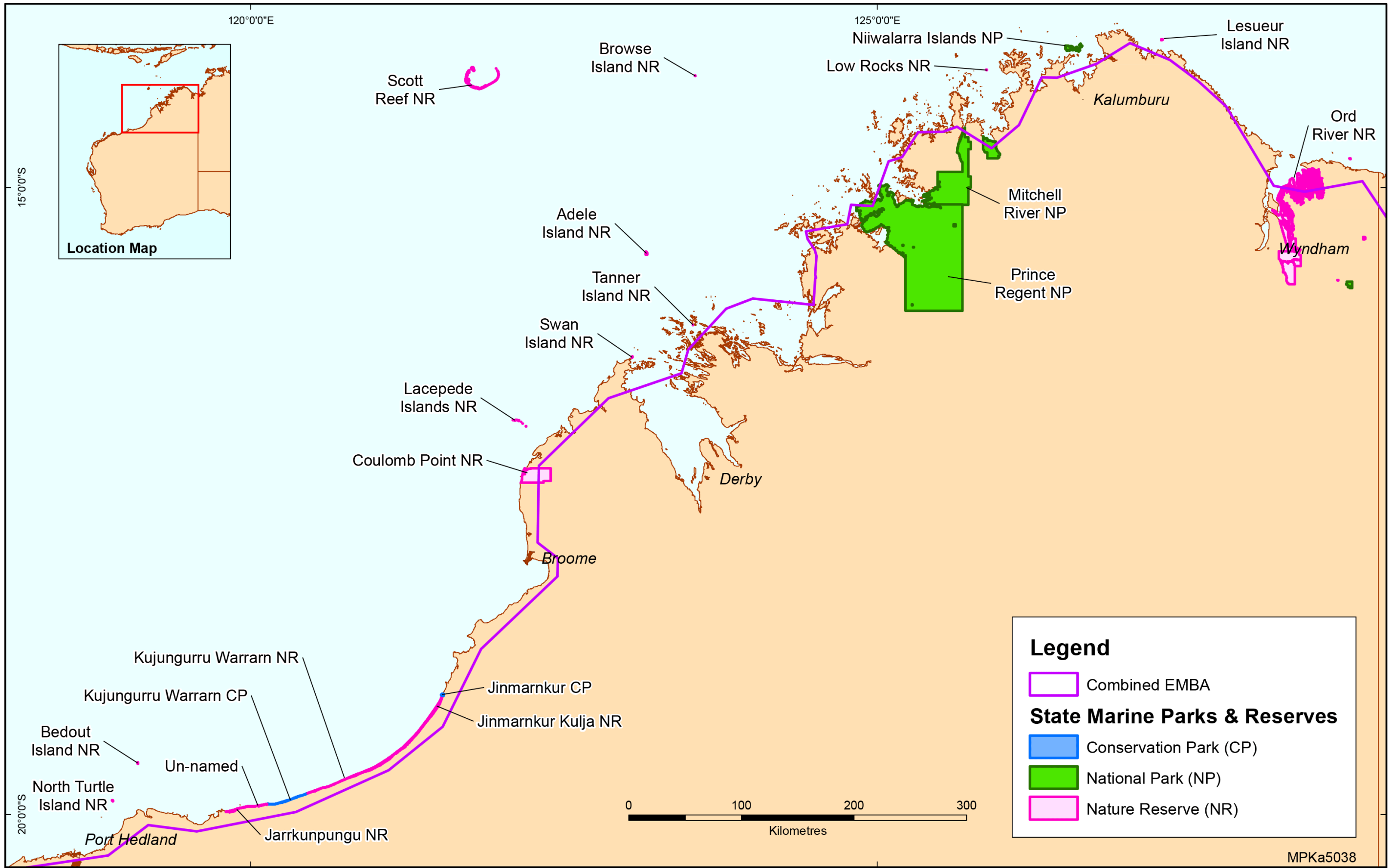


Figure 9-5: Protected Lands (CALM Act 1984) – terrestrial coastal reserves bounding marine waters in NT



Santos

PROTECTED LANDS – ONSHORE COASTAL CONSERVATION RESERVES (MANAGED UNDER CALM ACT 1984): NORTHERN WA

Figure 9-6: Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in northern WA[12]

[12] Yawaru Minyirr Buru Conservation Reserve (adjacent to Roebuck Bay) not shown as exact spatial extent unavailable, however the adjacent inter-tidal waters are managed under adjacent Roebuck Bay Marine Park (described in **Section 11.1.17**).

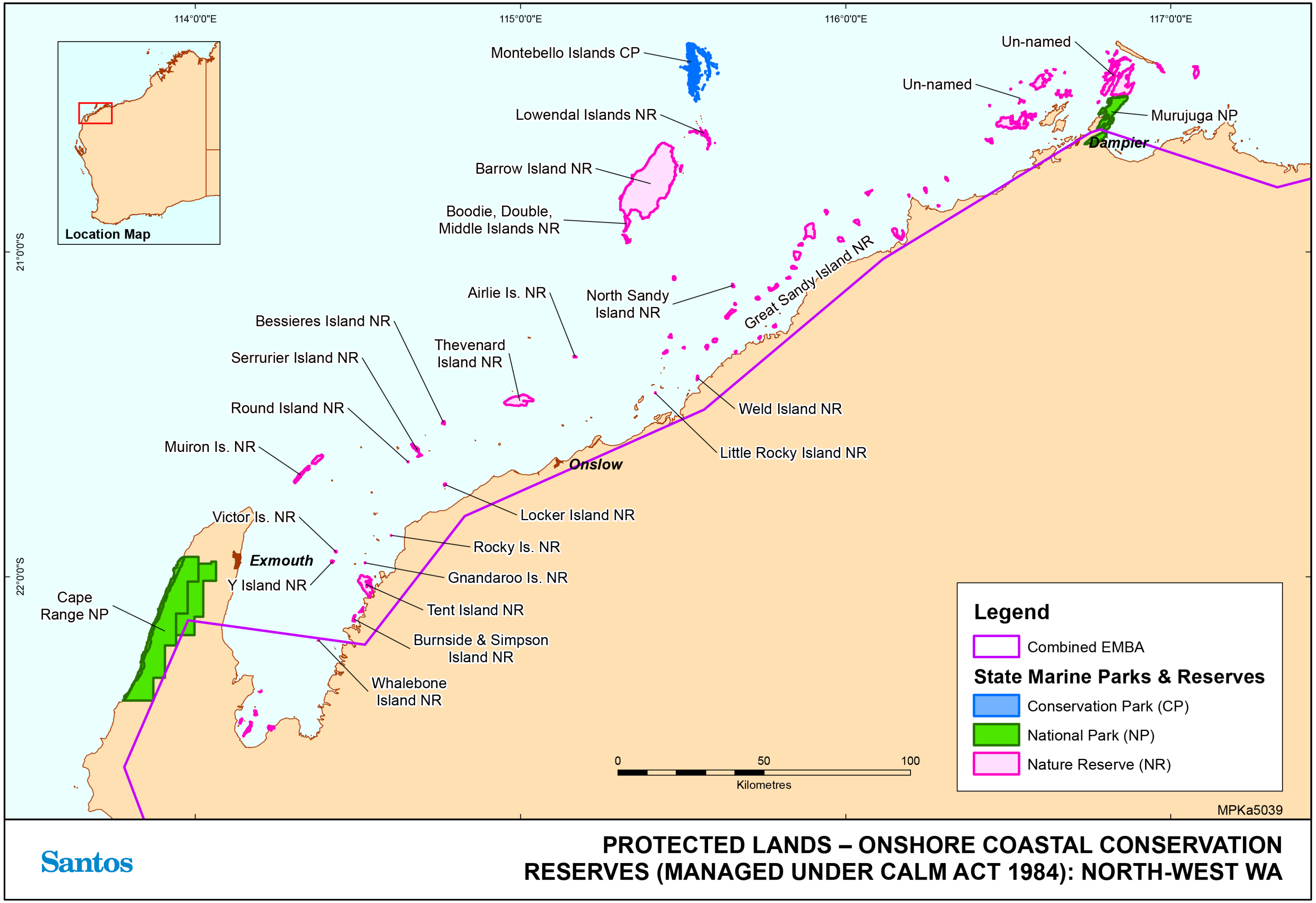
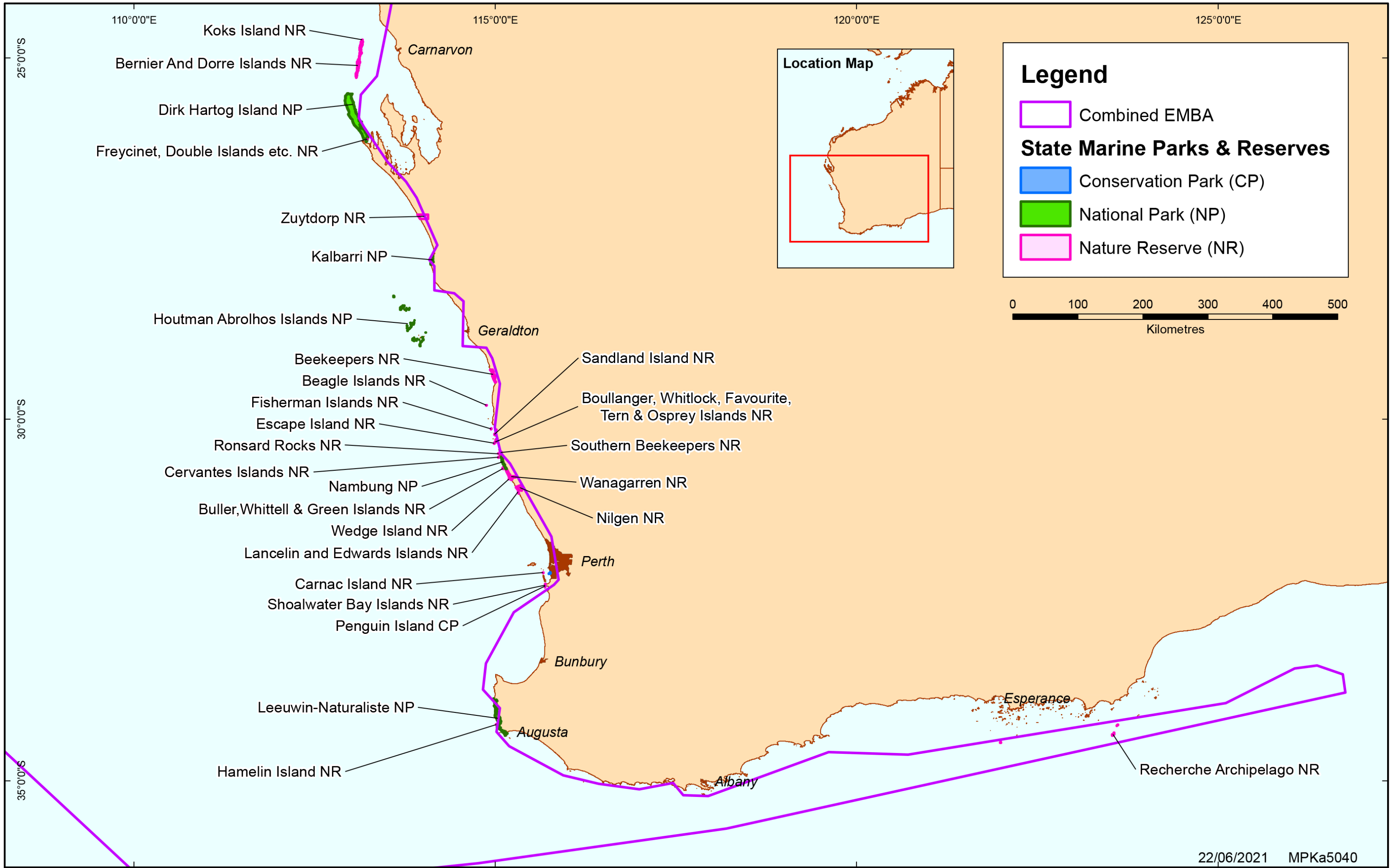


Figure 9-7: Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in North-West WA

Santos



Santos

PROTECTED LANDS – ONSHORE COASTAL CONSERVATION RESERVES (MANAGED UNDER CALM ACT 1984): SOUTHERN WA

Figure 9-8: Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in Southern WA[13]

9.8 International Protected Areas

There are 54 National Parks in Indonesia, six are World Heritage Sites, nine are part of the World Network of Biosphere Reserves and five are wetlands of international importance under the Ramsar convention. A total of nine parks are largely marine (ADB 2014). the combined EMBAA number of marine national parks, nature reserves and protected areas are overlapped by the combined EMBA. A summary of these is provided below. The waters and islands of these protected areas are frequented by tourists undertaking diving, snorkelling, sailing and other marine nature based tourism with many attractions such as shipwrecks and whale sharks as well as the extensive terrestrial ecosystems. Traditional fishing also occurs throughout the parks where allowed.

9.8.1 World Heritage and Protected Sites

9.8.1.1 Komodo

Komodo National park is located within the lesser Sunda Island between the provinces of East Nusa Tenggara and West Nusa Tenggara. Within the 1733km^2 site, three larger island (Komodo, Padar and Rincach) and 26 smaller ones are included. The marine fauna and flora are generally the same as that found throughout the Indo Pacific area, though species richness is very high, notable marine mammals include blue whale (*Balaenoptera musculus*) and sperm whale (*Physeter catodon*) as well as 10 species of dolphin, dugong (*Dugong dugon*) and five species of sea turtles (WHC, 2021). Fringing and patch coral reefs are extensive and most developed on the north-east side of Komodo (Indahnesia, 2011). The property is identified as a global conservation priority area, comprising unparalleled terrestrial and marine ecosystems (WHC, 2021).

The islands have an irregular coastline characterized by bays, beaches and inlets separated by headlands, often with sheer cliffs falling vertically into the surrounding seas.

9.8.1.2 Siberut

Siberut is located about 155km off the coast of West Sumatra across the Mentawaian strait and covers an area of 4050km^2. Sand beaches, lagoons, mangroves, and coral sea gardens create ecosystems within the site (Indahnesia, 2011).

9.8.1.3 Ujung Kulon

Ujung Kulon covers 1230km^2 of area. The coastline features various ecosystems such as sandy beaches, lagoons, rocky outcrops, as well as mangrove swamps. The water is an unusually warm 29 to 30 degrees Celsius and is home to multiple species of coral and fish (Indahnesia, 2011). The property includes the Ujung Kulon peninsula and several offshore islands that demonstrate on-going evolutionary processes (WHC, 2021).

9.8.2 Marine National Parks

9.8.2.1 Laut Sawu

The Laut Sawu Marine National Park located within the Lesser Sunda Ecoregion in the Savu Sea and covers a reported 35,211 km^2 (Protected Planet 2017). It was established in 2009 and has an IUCN Category II status (Protected Planet 2017). The marine park area is a known migration route for several cetacean species, including the blue whale and sperm whale. Other cetacean species such as pygmy killer whales, melon-head whale, short-finned pilot whales and numerous dolphin species (including Risso's dolphin, Fraser's dolphin, common dolphin, bottlenose dolphin and spinner dolphin) are known to frequent the marine park area. Several species of marine turtle, including the green turtle, hawksbill turtle and leatherback turtle have also been recorded in the marine park area.

The marine park area covers a range of habitats and species diversity, including:

+ 532 corals species which include 11 endemic and sub endemic species;
+ 350 reef fish species;
+ fifteen mangrove species are recorded that represented 9 families of mangrove;
+ ten seagrass species;
+ deep-water habitats such as seamounts, deep-water canyons, straits (migratory corridors);
+ large persistent pelagic habitats;
+ main migratory corridors and habitats for 14 whale species, seven dolphin's species, and dugong; and
+ habitats for five sea turtle species (green, leatherback, olive ridley, loggerhead, and flatback) as well as for large marine fauna such as sharks, napoleon, parrotfish and groupers (Savu Sea National Marine Conservation Area undated).

9.8.2.2 Kepulauan Seribu

Kepulauan Seribu, also known as Thousand Islands National Park, consists of a string of 105 islands within a reported area of 1074.89km^2. It is designated with an IUCN category II status. The closest island lies in Jakarta Bay, only a few kilometres from off mainland Jakarta with islands stretching as far as 45km north into the Java Sea (Indahnesia, 2011). Some islands are uninhabited, others have resorts or are privately owned. The coastlines are dominated by sandy beaches with some of the islands declared as protected historical sites to protect the artifacts and ruins on the islands dating back to the 19th century. Extensive coral reefs surround the islands. A Hawksbill turtle preservation program is in places in the park to protect the species that are found in the waters and nest on sandy beaches there (UNDP Indonesia, 2017). Mangroves are also found in the park, including plantations to increase the mangrove coverage.

9.8.2.3 Teluk Cenderawasih

Teluk Cenderawasih National Park is the largest marine park in Indonesia, with the reported area being 14535 km^2. It is designated with an IUCN category II status. The National Park is in Cenderawasih Bay, south-east of Bird's Head Peninsula, and includes the Islands of Misowaar, Nusrowi, Roon, Rumberpon and Yoop. The Park protects a rich marine ecosystem where over 150 coral species have been recorded. It is therefore considered to be a potential World Heritage Site (Indahnesia, 2011).

3.8% of the site consists of island tropical forest ecosystems, where some 46 species of plant have been recorded on the islands. 0.9% of the site is specifically mangrove ecosystems. Although only 5.5% of the site consists of coral reef ecosystems, 150 species of coral have been recorded. This coral reef ecosystem forms part of the Coral Triangle region. Within the remaining area of the site, over 200 fish species, various species of molluscs, whale sharks, four species of turtle as well as mammals such as the dugong, blue whale and dolphins inhabit the 89.8% of marine water ecosystems.

9.8.2.4 Taka Bonerate

Taka Bonerate National Park includes the Takabonerate Atoll Islands within a 5307 km^2 area within the Flores Sea. Taka Bone Rate consists of separate table reefs, enclosing a lagoon filled with massive reefs and is a site of major ecological importance (Indahnesia, 2011). According to the Indonesian Department of Forestry, the site has 261 species of coral, 295 species of coral fish, 244 species of molluscs as well as many other species such as turtles including green turtles that are known to nest on sandy beaches within the park (UNDP Indonesia, 2017).

9.8.2.5 Bunaken

Bunaken National Park is located in the north of the Sulawesi Islands, located near the centre of the Coral Triangle, it is designated with an IUCN category II status. This site typifies Indonesian tropical water ecosystems, consisting of seagrass plains, coral reefs and coastal ecosystems. 97% of the site is classified as marine habitat with the remaining being terrestrial, including 5 islands (Indahnesia, 2011). 390 species of coral, 90 fish species as well as mollusc, reptile, marine and mammal species have all been recorded.

9.8.2.6 Kapulauan Wakatobi

Kapulauan Wakatobi is located south of Sulawesi Island of Indonesia within a 13900km^2 area. It is designated with an IUCN category II status. Types of vegetation found in the National Park include mangrove forests, coastal forests, lowland swamp forests, riverbank vegetation, lowland rainforests, mountain rainforests and coral reefs (Indahnesia, 2011). There are 25 groups of coral reefs, including fringing reefs, barrier reefs and atolls. 396 species of coral belonging to 68 genera and 15 families populate the coral reef. Turtles are found nesting on the beaches and in the waters of the marine park.

9.8.2.7 Meru Betiri

Meru Betiri National Park lies within the province of East Java and extends over 580km^2. Of that area, 8.45 km^2 is marine (Indahnesia, 2011). The beaches of the park provide nesting grounds for endangered turtle species such as leatherback turtles, hawksbill turtles, green turtles, and olive ridley turtles (ADB 2014). The coastal vegetation is mostly found around Sukamade Bay and Meru Bay. Mangrove vegetation is largely found at the eastern side of the Rajegwesi Bay. The dominant genera are *Rhizophora, Avicennia* and *Bruguiera*. At the outlet of the Sukamade River, there is *Nypa fruticans*.

9.8.2.8 Togian Islands

The Togian Islands National Park, otherwise known as Kepulauan Togean, is a largely marine national park and provides habitat and breeding areas for hawksbill and green turtles and dugongs (Indahnesia, 2011). Mangroves forests are found within the marine park and extensive coral reefs.

9.8.3 Marine Nature Reserves and Conservation Areas

9.8.3.1 Karimunjawa

Karimunjawa is a national marine park in the Karimumjawa archipelago, 80km north of Jepara in the Java sea. The national park was formally declared a marine protected area in 2001 and has an IUCN category Ia status.

Karimunja has five types of ecosystems; coral reef, seagrass and seaweed, mangrove forest, coastal forest and low land tropical rainforest. The coral reefs of Karimunja are composed of fringing and barrier reefs along with several patch reefs. More than 90 species of coral biota is known to make up these ecosystems that creates a habitat for over 242 species of ornamental fish. Protected coral biota such as black coral, hornet helmet, titron trumpet, green shell and organ pipe coral, can be found here.

The 300 hectares of mangrove forests contain 32 species of mangroves and habitat many endemic species such as the dewadaru tree (*Fragraea elliptica*), setgi (*Pemphis acidula*) and kalimsada (*Cordia Subcordata*). Around 40 species of bird habitat this area as well as other terrestrial animals. Several species of turtles are known to use this national park as a breeding ground. Marine species within the area are particularly diverse, and in more abundance than the terrestrial populations.

9.8.3.2 Savu Sea National Marine Conservation Area

Savu Sea National Marine Conservation Area is located between the islands Sumba and Timor encompassing Pulau Roti and Sawu. The park includes coral reefs, mangroves, seagrass and deepwater habitats such as seamounts and deepwater canyons. Savu Sea NMCA is located within the Lesser Sunda seascape which is regarded as a high priority seascape for marine biodiversity conservation (Huffard et al. 2012). The Lesser Sundas is the main corridor between the Indian and Pacific Oceans including for migrating whales and commercially-important pelagic fishes (Huffard et al. 2012). Savu Sea NMCA covers ranges of species diversities and habitats within its region which includes:

- 532 corals species, 11 endemic and sub endemic species;
- 350 reef fish species;
- 15 mangrove species are recorded that represented nine families of mangrove;
- 10 sea grass species in two families;
- Deep-water habitats such as seamounts, deep-water canyons, straits (migratory corridors) and large persistent pelagic habitats were covered within Savu Sea NMP boundaries;
- Main migratory corridors and habitats for 14 whales species, seven dolphins species and one dugong species; and
- Habitats for five sea turtles species (green, leatherback, olive ridley, loggerhead, and flat back), as well as for large marine fauna such as sharks, napoleon, parrotfish and groupers (Savu Sea Management Plan 2014).

10. Key Ecological Features

10.1 Introduction

Key ecological features (KEFs) are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity. KEFs meet one or more of the following criteria (DSEWPaC 2012a):

- A species, group of species or a community with a regionally important ecological role;
- A species, group of species or a community that is nationally or regionally important for biodiversity;
- An area or habitat that is nationally or regionally important for:
  - Enhanced or high biological productivity;
  - Aggregations of marine life; or
  - Biodiversity and/or endemism
- A unique seafloor feature with ecological properties of regional significance.

Twenty eight key ecological features of the Commonwealth waters in the combined EMBA (covering the NMR, the NWMR and the SWMR) have been identified in the protected matters search (**Figure 10-2,Figure 10-3** and **Figure 10-1**) and are discussed in this section.

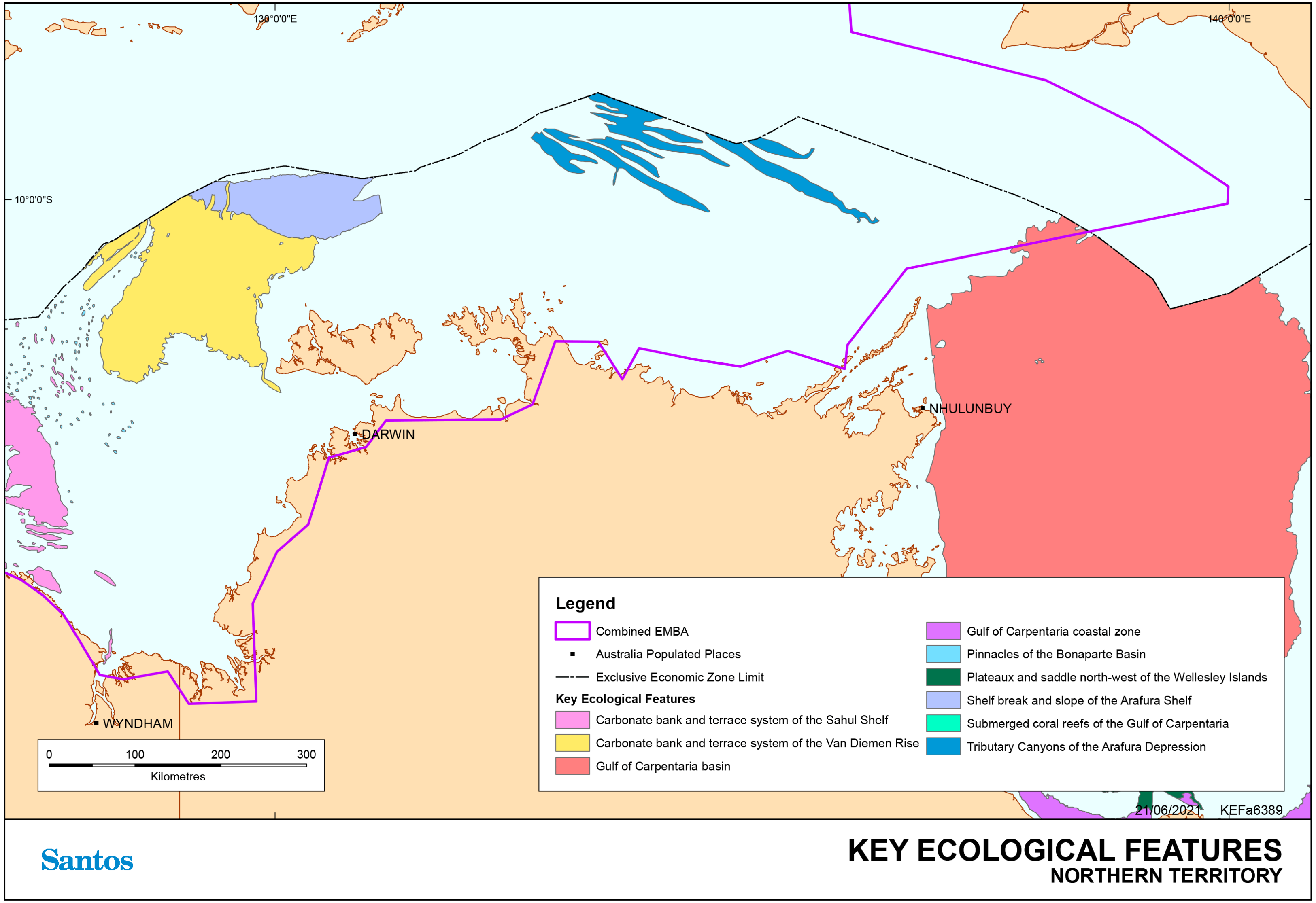


Figure 10-1: Key ecological features of NT

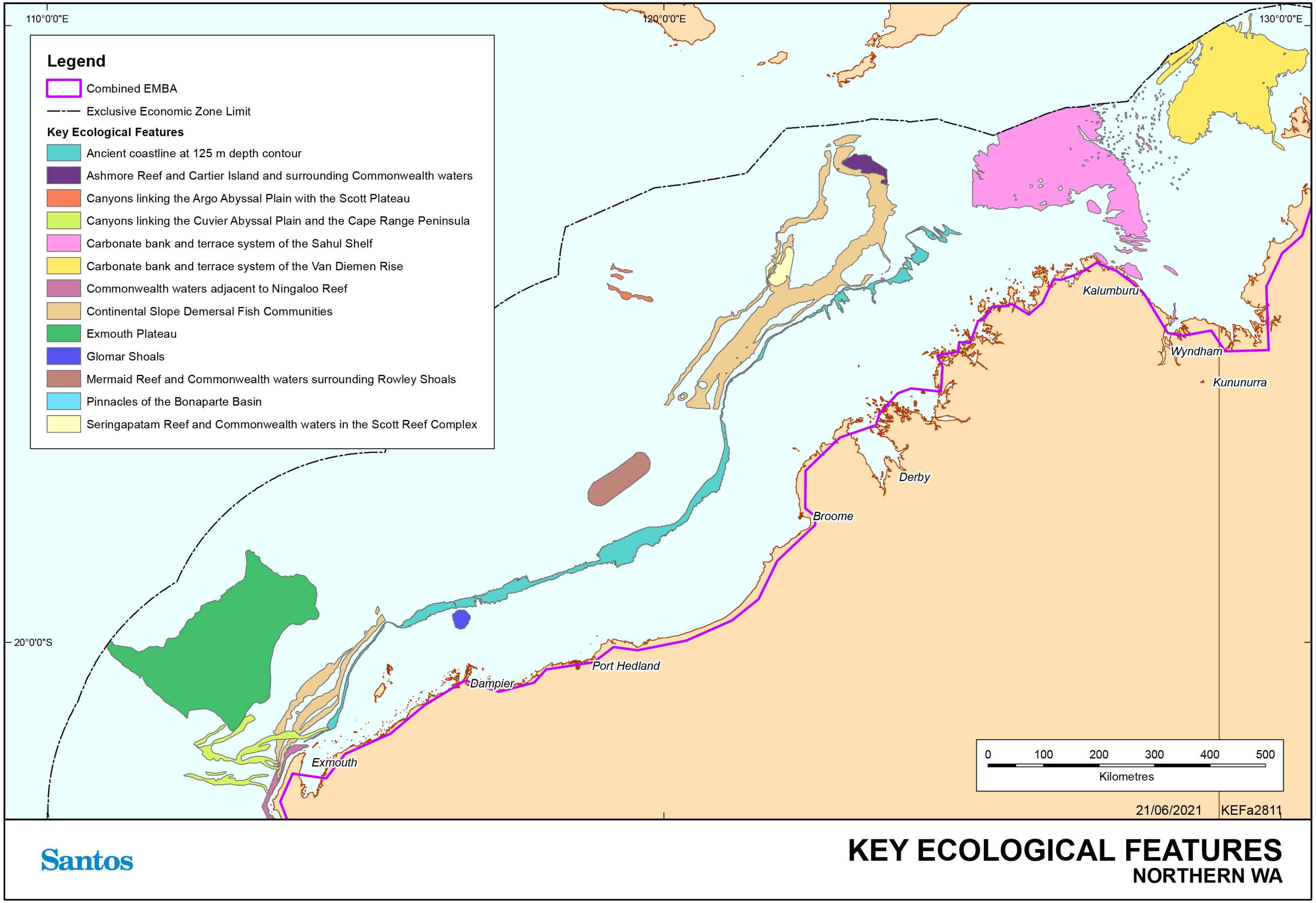


Figure 10-2: Key ecological features of Northern WA

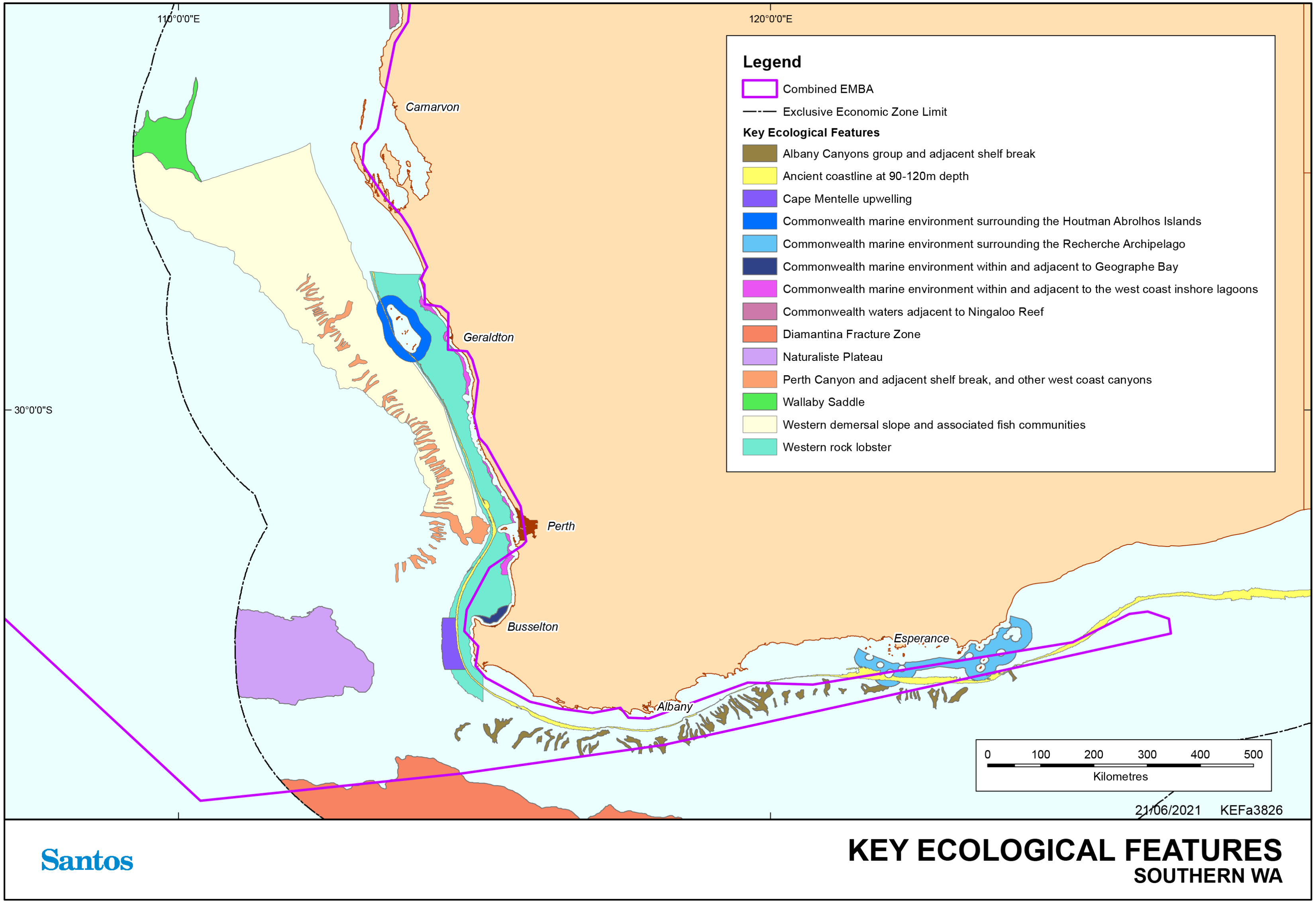


Figure 10-3: Key ecological features of Southern WA

10.1.1 Commonwealth Marine Environment Surrounding the Houtman Abrolhos Islands (and Adjacent Shelf Break)

The Commonwealth marine environment surrounding the Houtman Abrolhos Islands (and adjacent shelf break) is defined as a KEF for its high levels of biodiversity and endemism in benthic and pelagic habitats. The Houtman Abrolhos Islands and surrounding reefs support a unique mix of temperate and tropical species, resulting from the southward transport of species by the Leeuwin Current over thousands of years. The reefs are composed of 184 known species of corals that support about 400 known species of demersal fish, 492 known species of molluscs, 110 known species of sponges, 172 known species of echinoderms and 234 known species of benthic algae (DEWHA 2008b). The Houtman Abrolhos Islands are the largest seabird breeding station in the eastern Indian Ocean (DSEWPaC 2012a). They support more than one million pairs of breeding seabirds. The Houtman Abrolhos Islands and surround waters are also BIAs for Australian sea lions for foraging and breeding (DEWHA 2010b).

10.1.2 Commonwealth Marine environment surrounding the Recherche Archipelago

The Recherche Archipelago is a chain of approximately 105 islands and 1 500 islets extending over 470 km of coastline near Esperance, Western Australia. This area is defined as a KEF as it is a region of high biodiversity, The Recherche Archipelago is the most extensive area of reef in the South-west Marine Region. Its reef and seagrass habitat support a high species diversity of warm temperate species, including 263 known species of fish, 347 known species of molluscs, 300 known species of sponges, and 242 known species of macroalgae. The islands also provide haul-out (resting areas) and breeding sites for Australian sea lions and New Zealand fur seals (DSEWPaC 2012)

10.1.3 Perth Canyon and Adjacent Shelf Break, and other West-Coast Canyons

The Perth Canyon is defined as a KEF for its high biological productivity and aggregations of marine life and unique seafloor features with ecological properties of regional significance. The Perth Canyon is the largest known undersea canyon in Australian waters. In the Perth Canyon, interactions between the Leeuwin Current and the Canyon topography induce clockwise-rotating eddies that transport nutrients upwards in the water column from greater depths (DoEE 2019a). Due to the Canyon's depth and Leeuwin Current's barrier effect, this remains a subsurface upwelling which supports ecological complexity that is typically absent from canyon systems in other areas (Pattiaratchi 2007). This nutrient-rich cold-water habitat attracts feeding aggregations of deep-diving mammals, such as pygmy blue whales and large predatory fish that feed on aggregations of small fish, krill and squid (DSEWPaC 2012a). The Perth Canyon also marks the southern boundary for numerous tropical species groups on the shelf, including sponges, corals, decapods and xanthid crabs (DoEE 2017a).

10.1.4 Commonwealth Marine Environment within and adjacent to the West-Coast Inshore Lagoons

This key ecological feature is composed by a chain of inshore lagoons of limestone reef (as deep as 30 m) extending along the Western Australian coast from south of Mandurah to Kalbarri. The mix of sheltered and exposed seabeds form a complex mosaic of habitats. The lagoons are dominated by seagrass and epiphytic algae (Dambacher et al. 2009). Although macroalgae (principally Ecklonia spp.) and seagrass appear to be the primary source of production, scientists suggest that groundwater enrichment may supplement the supply of nutrients to the lagoons. The lagoons are associated with high biodiversity and endemism, containing a mix of tropical, subtropical and temperate flora and fauna.

The inshore lagoons are important areas for the recruitment of the commercially and recreationally important western rock lobster, dhufish, pink snapper, breaksea cod, baldchin and blue gropers, abalone and many other reef species. The area includes breeding and nursery aggregations for many temperate and tropical marine species (Goldberg & Collings 2006 in McClatchie et al. 2006). Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor and Australian salmon.

10.1.5 Commonwealth Marine Environment within and Adjacent to Geographe Bay

The Commonwealth marine environment within and adjacent to Geographe Bay is defined as a KEF for its high productivity and aggregations of marine life and high levels of biodiversity and endemism. Geographe Bay is known for its extensive beds of tropical and temperate seagrass that account for about 80 % of benthic primary production in the area (DEH 2006). This habitat supports a diversity of species, many of them not found anywhere else (DSEWPaC 2012a). The bay provides important nursery habitat for many species, including juvenile dusky whaler sharks. It is also an important resting area for migrating for humpback whales (McCauley *et al.* 2000).

10.1.6 Cape Mentelle Upwelling

The Cape Mentelle upwelling is defined as a KEF for its high productivity and aggregation soft marine life. The Cape Mentelle upwelling draws relatively nutrient-rich water from the base of the Leeuwin Current, up the continental slope and onto the inner continental shelf, where it results in phytoplankton blooms at the surface. The phytoplankton blooms provide the basis for an extended food chain characterised by feeding aggregations of small pelagic fish, larger predatory fish, seabirds, dolphins and sharks (DSEWPaC 2012a). The Cape Mentelle upwelling has a disproportionate influence on the overall-nutrient poor nature of the region's water.

10.1.7 Naturaliste Plateau

The Naturaliste Plateau is defined as a KEF for its unique seafloor feature with ecological properties of regional significance. The Naturaliste Plateau is Australia's deepest temperate marginal plateau and occurs an area where numerous water bodies and currents converge. It is also the only seafloor feature in the region that interacts with the subtropical convergence front (DoEE 2019b). Although there is very little known about the marine life of the plateau, it is speculated that the combination of its structural complexity, mixed water dynamics and relative isolation indicate that it supports deep-water communities with high species diversity and endemism (DEWHA 2008b; DSEWPaC 2012a). The Plateau acts as an underwater 'biogeographical island' on the edge of the abyssal plain, providing habitat for fauna unique to these depths (Richardson et al. 2005). The Plateau is also within a deep eddy field that is thought to be associated with high productivity and aggregations of marine life (Pattiaratchi 2007). Proximity to the nearby subtropical convergence front is thought to have a significant influence on the biodiversity of the Plateau (DEWHA 2008b).

10.1.8 Western Demersal Slope and associated Fish Communities

The Western Demersal Slope and associated Fish Communities, also known as the Demersal Slope and associated Fish Communities of the Central Western Province, is defined as a key ecological community for its high levels of biodiversity and endemism. It is located on the edge of the shelf to the limit of the exclusive economic zone from Perth to the northern boundary of the SWMR. The western demersal slope provides important habitat for demersal fish communities, with a high level of diversity and endemism. A diverse assemblage of demersal fish species below a depth of 400 m is dominated by relatively small benthic species such as grenadiers, dogfish and cucumber fish. Unlike other slope fish communities in Australia, many of these species display unique physical adaptations to feed on the sea floor (such as a mouth position adapted to bottom feeding), and many do not appear to migrate vertically in their daily feeding habits (DSEWPaC 2012a, Williams *et al.* 2001). A total of 480 fish species have been described that inhabit the slope of this bioregion with 31 considered to be endemic to the bioregion (DoEE 2019a). Demersal fish communities within the area have recorded higher diversity when compared to other oceanic regions which have been more intensively sampled. The increased diversity within the area has been attributed to the overlap of ancient and extensive Indo-west Pacific and temperate Australasian fauna (Williams et al. 2001).

10.1.9 Western Rock Lobster

The Western Rock Lobster KEF is defined due to its presumed ecological role on the West Coast Continental Shelf. This species is the dominant large benthic invertebrate in the region. The lobster plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles as they are preyed upon by octopus, cuttlefish, baldchin groper, dhufish, pink snapper, wirrah cod and breaksea cod (DEWHA 2008b, DSEWPaC 2012a). The high biomass of western rock lobsters and their vulnerability to predation suggest that they are an important trophic pathway for a range of inshore species that prey upon juvenile lobsters (DEWHA 2008b).

10.1.10 Wallaby Saddle

The Wallaby Saddle is defined as a KEF for its high productivity and aggregations of marine life. The Wallaby Saddle is an abyssal geomorphic feature located on the upper continental slope at a depth of 4,000–4,700 m (DSEWPaC 2012a). The feature connects the north-west margin of the Wallaby Plateau with the margin of the Carnarvon Terrace (Falkner *et al*. 2009 in DSEWPaC 2012a). The Wallaby Saddle is situated within the Indian Ocean water mass and is thus differentiated from systems to the north that are dominated by transitional fronts or the Indonesian Throughflow (DSEWPaC 2012a). Little is known about the Wallaby Saddle; however, the area is considered one of enhanced productivity and low habitat diversity (Brewer *et al*. 2007). The Wallaby Saddle is associated with historical aggregations of sperm whales (DEWHA 2008c).

10.1.11 Commonwealth Waters Adjacent to Ningaloo Reef

The Commonwealth Waters adjacent to Ningaloo Reef KEF is defined for high productivity and aggregations of marine life. The Ningaloo Reef extends almost 300 km along the Cape Range Peninsula to the Red Bluff and is globally significant as the only extensive coral reef in the world that fringes the west coast of a continent. Commonwealth waters adjacent to the reef are thought to support the rich aggregations of marine species at Ningaloo Reef through upwellings associated with canyons on the adjacent continental slope and interactions between the Ningaloo and Leeuwin currents (Brewer *et al*. 2007, DEWHA 2008d, DSEWPaC 2012a). The narrow continental shelf (10 km at its narrowest) means that the nutrients channelled to the surface via canyons are immediately available to reef species. Terrestrial nutrient input is low, hence this deep-water source is a major source of nutrients for Ningaloo Reef and therefore very important in maintaining this system (DEWHA 2008c).

The reef is known to support an extremely abundant array of marine species including over 200 species of coral and more than 460 species of reef fish, as well as molluscs, crustaceans and other reef plants and animals (DEWHA 2008c). Marine turtles, dugongs and dolphins frequently visit the reef lagoon. The Commonwealth waters around Ningaloo include areas of potentially high and unique sponge biodiversity (DEWHA 2008c). Upwellings on the seaward side support aggregations such as whale sharks and manta rays (these waters are the main known aggregation area for whale sharks in Australian waters). Humpback whales are seasonal visitors to the outer reef edge and seasnakes, sharks, large predatory fish and seabirds also utilise the reef and surrounding waters.

The Ningaloo Marine Park includes this Key Ecological Feature and is discussed in **Section 12.3.4**.

10.1.12 Canyons Linking the Cuvier Abyssal Plain with the Cape Range Peninsula

The Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula are defined as a KEF as they are unique seafloor features with ecological properties of regional significance.

Cape Range Peninsula and the Cuvier Abyssal Plain are linked by canyons, the largest of which are the Cape Range Canyon and Cloates Canyon. These two canyons are located along the southerly edge of Exmouth Plateau adjacent to Ningaloo Reef and are unique due to their close proximity to the North West Cape (DSEWPaC 2012a). The Leeuwin Current interacts with the heads of the canyons to produce eddies resulting in delivery of higher nutrient, cool waters from the Antarctic intermediate water mass to the shelf (Brewer *et al*. 2007). Strong internal tides also create upwelling at the canyon heads (Brewer *et al*. 2007). Thus the canyons, the Exmouth Plateau and the Commonwealth waters adjacent to Ningaloo Reef interact to create the conditions for enhanced productivity seen in this region (Sleeman *et al*. 2007 in DSEWPaC 2012a). The canyons are also repositories for particulate matter deposited from the shelf and sides of the canyons and serve as conduits for organic matter between the surface, shelf and abyssal plains (DSEWPaC 2012a).

The soft bottom habitats within the canyons themselves are likely to support important assemblages of epibenthic species. Biological productivity at the head of Cape Range Canyon in particular, is known to support species aggregations, including whale sharks, manta rays, humpback whales, sea snakes, sharks, large predatory fish and seabirds. The canyons are thought to be significant contributors to the biodiversity of the adjacent Ningaloo Reef, as they channel deep water nutrients up to the reef, stimulating primary productivity (DEWHA 2008c).

10.1.13 Exmouth Plateau

The Exmouth Plateau is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance. The Exmouth Plateau covers an area of 49,310 km^2 and is located approximately 150 km northwest of Exmouth. The plateau ranges in water depths from 800 to 4,000 m (Heap & Harris 2008 in DSEWPaC 2012a). The plateau's surface is rough and undulating at 800–1,000 m depth. The northern margin is steep and intersected by large canyons (e.g. Montebello and Swan canyons) with relief greater than 50 m. The western margin is moderately steep and smooth and the southern margin is gently sloping and virtually free of canyons (Falkner *et al*. 2009 in DSEWPaC 2012a).

The Exmouth Plateau is a regionally and nationally unique tropical deep sea plateau. It that may serve an important ecological role by acting as a topographic obstacle that modifies the flow of deep waters that generate internal tides, causing upwelling of deeper water nutrients closer to the surface (Brewer *et al.* 2007). Sediments on the plateau suggest that biological communities include scavengers, benthic filter feeders and epifauna. Whaling records from the 19th century suggest that the Exmouth Plateau may have supported large populations of sperm whales (Bannister *et al*. 2007). Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton (Brewer *et al.* 2007).

10.1.14 Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals

Mermaid Reef and Commonwealth waters surrounding Rowley Shoals is defined as a KEF for its enhanced productivity and high species richness. The Rowley Shoals are a group of three atoll reefs—Clerke, Imperieuse and Mermaid reefs—located about 300 km north-west of Broome. Mermaid Reef lies 29 km north of Clerke and Imperieuse reefs and is totally submerged at high tide. Mermaid Reef and Commonwealth Waters surrounding Rowley Shoals are regionally important in supporting high species richness, higher productivity and aggregations of marine life associated with the adjoining reefs themselves (Done et al. 1994). Rowley shoals contain 214 coral species and approximately 530 species of fishes (Gilmour et al. 2007), 264 species of molluscs and 82 species of echinoderms (Done et al. 1994; Gilmour et al. 2007). Both coral communities and fish assemblages differ from similar habitats in eastern Australia (Done et al. 1994).

Mermaid Reef falls under Commonwealth jurisdiction and forms the Mermaid Reef Commonwealth Marine Park. Clerke and Imperieuse reefs constitute the Rowley Shoals Marine Park, which falls under Western Australian Government jurisdiction (EA 2000). The Rowley Shoals are discussed with the Commonwealth and State Marine Park (**Sections 11.1.9** and **12.3.9**).

10.1.15 Glomar Shoals

The Glomar Shoals are a submerged feature situated at a depth of 33–77 m, approximately 150 km north of Dampier on the Rowley Shelf (Falkner *et al*. 2009 in DSEWPaC 2012a). They consist of a high percentage of marine-derived sediments with high carbonate content and gravels of weathered coralline algae and shells (McLoughlin & Young 1985 in DSEWPaC 2012a). The area's higher concentrations of coarse material compared to surrounding areas are indicative of a high energy environment subject to strong seafloor currents (Falkner *et al*. 2009 in DSEWPaC 2012a).

Biological communities found at the Glomar Shoals have not been comprehensively studied, however the shoals are known to be an important area for a number of commercial and recreational fish species such as rankin cod, brown striped snapper, red emperor, crimson snapper, bream and yellow-spotted triggerfish. Catch rates at the Glomar Shoals are high, indicating that the area is a region of high productivity (Falkner *et al*. 2009, Fletcher & Santoro 2009 in DSEWPaC 2012a). It is unclear if the removal of non-target species due to the commercial fishing over the shoals is having an impact on its value (DSEWPaC 2012a).

The Glomar Shoals are regionally important for their potentially high biological diversity and localised productivity. Biological data specific to the Glomar Shoals is limited, however the fish of the shoals are probably a subset of reef-dependent species and anecdotal evidence suggests they are particularly abundant (DSEWPaC 2012a).

10.1.16 Ancient Coastline at 125 m Depth Contour

The shelf of the North-west Marine Region contains several terraces and steps which reflect changes in sea level that occurred over the last 100,000 years. The most prominent of these features occurs at a depth of 125m as an escarpment along the North West Shelf and Sahul Shelf (DSEWPaC 2012a). Where the ancient submerged coastline provides areas of hard substrate it may contribute to higher biological diversity. Little detailed knowledge is available, but the hard substrate of the escarpment is likely to support sponges, crinoids, molluscs, echinoderms (DSEWPaC 2012a). It is understood that changes in topography at these depths are critical points for the generation of internal waves (Holloway *et al.* 2001 cited in DEWHA 2008c), playing a minor role in aiding localised upwelling or at least regional mixing associated with the seasonal changes in currents and winds. It is also believed that this prominent floor feature could be important as a migratory pathway for cetaceans and pelagic species such as the whale shark and humpback whale, as they move north and south between feeding and breeding grounds (DEWHA 2008c).

Parts of the ancient coastline are thought to provide biologically important habitats in areas otherwise dominated by soft sediments. The topographic complexity of these escarpments may also facilitate vertical mixing of the water column providing a relatively nutrient-rich environment for species present on the escarpment (DSEWPaC 2012a). This enhanced productivity could potentially be attracting baitfish, which in turn provide food for the migratory species. The pressures of potential concern on the biodiversity value of this feature generally include ocean acidification as a result of climate change (DoEE 2019a).

10.1.17 Ancient Coastline at 90-120 m Depth

This coastline is found in the South-west Marine Region and contains several terraces and steps reflecting a gradual increase in sea level across the shelf that occurred during the Holocene. Some of these features create escarpments of distinct elevation, creating topographic complexity through the exposure of rocky substrates. The most prominent of these occurs close to the middle of the continental shelf off the Great Australian Bight at a depth of 90-120 m, which provides a complex habitat for a number of species (DSEWPaC 2012c). The area has important conservation value due to its potential for high productivity, biodiversity and aggregations of marine life. Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment of exposed hard substrates, where it is dominated by sponge communities of significant biodiversity and structural complexity (DSEWPaC 2012c). These sponge communities have been recorded to contain sponges up to one metre across, which implies that some of the sponges in this region are likely to be many decades old (DSEWPC 2012c). It has been suggested that in certain places, the area may support some demersal fish species, travelling to the upper continental slope from across the continental shelf. The transportation of fine grained sediments off shelf occurs as a physical process down to depths of approximately 120 m, and influence the benthic invertebrate communities of the Great Australian Bight (DSEWPaC 2012c). Both species richness and biomass in the area, has been associated as declining with increasing depth and percentage of fines in sediment (Ward *et al.* 2006 cited in DSEWPaC 2012c).

10.1.18 Canyons Linking the Argo Abyssal Plain with Scott Plateau

The Scott Plateau connects with the Argo Abyssal Plain via a series of canyons, the largest of which are the Bowers and Oates canyons (DSEWPaC 2012a). The canyons are believed to be up to 50 million years old and excavated during the evolution of the region through sediment and water movements (DEWHA 2008d). The canyons cut deeply into the south-west margin of the Scott Plateau and act as conduits for transport of sediments from an approximate depth of 2,000–3,000 m to depths of more than 5,500 m (DSEWPaC 2012a). The water masses at these depths are deep Indian Ocean water on the Scott Plateau and Antarctic bottom water on the Argo Abyssal Plain. Both water masses are cold, dense and nutrient-rich (Lyne *et al*. 2006 in DSEWPaC 2012a). The high productivity of the region is believed to be led by topographically induced water movements through the canyons and the action of internal waves in these canyons as well as around islands and reefs. The canyons are therefore thought to be linked to small and periodic upwellings that enhance this biological productivity (DEWHA 2008d).

The Canyons linking the Argo Abyssal Plain and Scott Plateau are likely to be important features due to their historical association with sperm whale aggregations (DSEWPaC 2012a). Historical records of whaling in the Timor region indicate that the number of sperm whales was high in the region in the past. Though current numbers are unknown, it is possible that they congregate around the canyon heads adjacent to the Scott Plateau, encouraged by the high biological productivity, supporting stocks of their prey (DEWHA 2008d). There is anecdotal evidence that supports the idea that the Scott Plateau itself may be a breeding ground for sperm and beaked whales. It is also likely that important demersal communities occur in the canyons, as they do in the Scott Plateau supported by the localised upwelling, which in turn attract larger predatory fish, sharks and cetaceans (DEWHA 2008d).

10.1.19 Continental Slope Demersal Fish Communities

The Australian Continental Slope provides important habitat for demersal fish communities, characterised by high endemism and species diversity. Specifically, the continental slope between North West Cape and the Montebello Trough is the most diverse slope bioregion in Australia with more than 500 fish species, 76 of which are endemic (Last *et al*. 2005 in DSEWPaC 2012).

The Continental Slope consists of two distinct community types, associated with the upper and mid slope, 225 – 500 m and 750 – 1000 m respectively. The Timor Province and Northwest Transition bioregions are the second-richest areas for demersal fish across the entire continental slope (DSEWPaC 2012). The bacteria and fauna that is present in the system on the Continental Slope are the basis for the food web for demersal fish and higher order consumers in the system. Further information of this system has been poorly researched, though it has been suggested that it is a detritus-based system, where infauna and epifauna become prey for a range of teleost fish, molluscs and crustaceans (Brewer *et al.* 2007). The higher order consumers supported by this system are likely to be carnivorous fish, deep water sharks, large squid and toothed whales (Brewer *et al.* 2007). The pelagic production is known to be phytoplankton based, with hotspots located around oceanic reefs and islands (Brewer *et al.* 2007).

It is believed that the loss of the benthic habitat along this continental shelf region would likely lead to a decline in the species diversity and endemism that this feature is associated with (DoEE 2019a). The endemism of the region is not supported by large data sets and is scarce. It is consequently not well understood what interactions exist between the physical processes and trophic structures that lead to this high diversity of fish and the suggested presence of endemic species in the region (DoEE 2019a).

10.1.20 Seringapatam Reef and Commonwealth Waters in the Scott Reef Complex

Scott and Seringapatam reefs are part of a series of submerged reef platforms that rise steeply from the sea floor between the 300–700 m contours on the north-west continental slope and lie in the Timor Province (Falkner et al. 2009). Scott Reef consists of two separate reef formations, North Reef and South Reef. The total area of the key ecological feature is approximately 2,418 km². As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region.

Scott and Seringapatam reefs and the waters surrounding them attract aggregations of marine life including humpback whales on their northerly migration, Bryde’s whales, pygmy blue whales, Antarctic minke whales, dwarf minke whales, minke whales, dwarf sperm whales and spinner dolphins (Jenner et al. 2008; Woodside 2009). Whale sharks and several species of sea snakes have also been recorded in this area (Donovan et al. 2008). Green and hawksbill turtles nest during the summer months on Sandy Islet on South Scott Reef. These species also internest and forage in the surrounding waters (Guinea 2006). Scott Reef is a particularly biologically diverse system and includes more than 300 species of reef-building corals, approximately 400 mollusc species, 118 crustacean species, 117 echinoderm species and around 720 fish species (Woodside 2009). Corals and fish at Scott Reef have higher species diversity than the Rowley Shoals (Done et al. 1994).

Scott Reef is listed as Commonwealth Heritage Places and is discussed in **Section 9.5.1**.

10.1.21 Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters

Ashmore Reef and Cartier Island are situated on the shallow upper slope of the Sahul Shelf, north of Scott and Seringapatam reefs. Rising from a depth of more than 100 m, the reef platform is at the edge of the North West Shelf and covers an area of 239 km². Ashmore Reef Commonwealth Marine Reserve encloses an area of about 583 km² of seabed (EA 2002). Cartier Island lays about 350 km off Australia’s Kimberley coast, 115 km south of the Indonesian island of Roti and 45 km south-east of Ashmore Reef Commonwealth Marine Reserve. Cartier Island Commonwealth Marine Reserve covers 167 km² (EA 2002). Species at Ashmore Reef and Cartier Island include more than 225 reef-building corals, 433 molluscs, 286 crustaceans, 192 echinoderms, and the most diverse variety of fish of any region in Western Australia with 709 species (EA 2002).

Sandy beaches provide important habitat for nesting green and hawksbill turtles throughout the year. Seagrass present at Ashmore Reef provides critical breeding (April–May) and foraging (throughout the year) habitat for a genetically distinct population of dugong with their range probably extending to other submerged shoals within the area (Brown & Skewes 2005; Whiting 1999). The emergent habitat at Ashmore also provides important nesting sites for seabirds, many of which are migratory. Ashmore's islands are regarded as supporting some of the most important seabird rookeries on the North West Shelf seasonally supporting up to 50,000 seabirds (26 species) and up to 2,000 waders (30 species, representing almost 70% of wader species that regularly migrate to Australia) (Milton 2005). Large colonies of sooty terns, crested terns, bridled terns and common noddies breed on the east and middle islands. Smaller breeding colonies of little egrets, eastern reef egrets, black noddies and possibly lesser noddies also occur. Migratory wading birds include eastern curlews, ruddy turnstones, whimbrels, bar-tailed godwits, common sandpipers, Mongolian plovers, red-necked stints and tattlers, during October–November and March–April as part of the migration between Australia and the Northern Hemisphere (Milton 2005).

10.1.22 Carbonate Bank and Terrace System of the Sahul Shelf

The Carbonate Banks and Terrace System of the Sahul Shelf are located in the western Joseph Bonaparte Gulf and to the north of Cape Bougainville and Cape Londonderry. The banks consist of a hard substrate and flat tops at depths of 150–300 m. Each bank occupies an area generally less than 10 km^2 and is separated from the next bank by narrow sinuous channels with depths up to 150 m. The origin of the banks is uncertain, though the area contains predictably high levels of productivity, in comparison to the generally low productivity of the region (DSEWPaC 2012).

The banks are foraging areas for loggerhead, olive ridley and flatback turtles and provide habitat for humpback whales, and green and freshwater sawfish (Donovan *et al*. 2008 in DSEWPaC 2012). The hard substrate of the banks is thought to support diverse organisms including sessile benthic invertebrates such as sponges, soft and hard corals, gorgonians, bryozoans, ascidians and associated reef fish and elasmobranchs (Brewer *et al*. 2007). Cetaceans, green and fresh sawfish are also likely to occur in the area, as well as possibly the Australian snubfin dolphin, a migratory species occurring mostly on the northern extent of the Sahul Shelf (DSEWPaC 2012).

According to DSEWPaC (2012) the carbonate banks and terrace system of the Sahul Shelf are regionally important because of their role in enhancing productivity relative to their surrounds. Little is known about the banks, terraces and associated channels but they are believed to be areas of enhanced productivity and biodiversity due to the upwellings of cold nutrient-rich water at the heads of the channels and the availability of hard substrate (Brewer *et al*. 2007).

10.1.23 Pinnacles of the Bonaparte Basin

The limestone Pinnacles of the Bonaparte Basin are located in the mid-outer shelf of the western Joseph Bonaparte Gulf and comprise of 61% of the limestone pinnacles in the Northwest Marine Region and 8% of the total limestone pinnacles found within the Australian Exclusive Economic Zone (Baker *et al.* 2008). The pinnacles range from water depths of 30 to 80 m providing hard substrate in a relatively sparse soft sediment habitat for sessile species. The pinnacles are thought to be remnants of the calcareous shelf and coastal features from previous low sea level stands, and have been recorded to be up to 50 m in height and range from 50 to 100 km long (Baker *et al.* 2008, Heyward *et al.* 1997).

Diverse communities of sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers have been recorded (Brewer *et al.* 2007, Nichol *et al.* 2013). Foraging and general use has been recorded within the pinnacles by marine turtles and the area has also been suggested to be used by freshwater and green sawfish as well as humpback whales (Donovan *et al.* 2008). The pinnacles have been recognised as a sponge biodiversity hotspot which has recorded greater diversity and communities than that of the surrounding seafloor (NERP MBH 2014).

According to DSEWPaC (2012) the Pinnacles of the Bonaparte Basin are regionally important because of its biodiversity values (unique sea-floor feature with ecological properties of regional significance), which apply to both the benthic and pelagic habitats. The hard substrate of the pinnacles are likely to support a high number of species, although a better understanding of the species richness and diversity associated with these structures is required.

10.1.24 Diamantina Fracture Zone

The Diamantina Fracture Zone is located south of the Naturaliste Plateau covering a range of more than 100,000 km^2 in water depths greater than 3,000 m. The ridge, troughs and seamounts that form the fracture zone have been recorded to have a relief up to 4,000 m which has resulted in highly variable environmental conditions (Stow 2006, Richardson *et al.* 2005). The Diamantina Fracture Zone encompasses the deepest known points in Australia's exclusive economic zone, reaching depths of more than 6,000 metres.

Limited information is available for the Diamantina Fracture Zone, however it is likely that due to the highly variable environmental conditions within the distinctive community structures and unique habitats have the potential to form. The presence of seamounts and ridges has the potential to increase local primary and secondary productivity, which may in turn promote phytoplankton growth. Increased phytoplankton has been recorded to increase the diversity and abundance of marine life (e.g. whales, dolphins, fish and benthic species) (Rowden *et al.* 2010). The area is expected to sustain similar habitats to that of and around the Tasmanian Seamounts due to similar depths in the South-east Marine Region (Richardson et al. 2005).

According to DSEWPaC (2012) the Diamantina Fracture Zone is regionally important because of to enhance productivity and assist with dispersal and migration of species across the region and wider abyssal plain (Wilson & Kaufman 1987, in Richardson *et al.* 2005). While research on the Diamantina Fracture Zone is limited, its size, physical complexity and isolation indicate that it is likely to support deepwater communities characterised by high species diversity and endemism.

10.1.25 Demersal Slope and Associated Fish Communities of the Central Western Province

The demersal slope and associated fish communities of the Central Western Province is located on the edge of the shelf to the limit of the exclusive economic zone from Perth to the northern boundary of the SWMR. The area supports a diverse demersal fish species assemblage of relatively small benthic species (e.g. grenadier, dogfish and cucumber fish) at depths greater than 400 m. Fish species within this area have adapted physically to feed on the seafloor and do not appear to migrate vertically to feed (Williams et al. 2001).

According to DSEWPaC (2012), the demersal slope and associated fish communities of the Central Western Province are recognised as a KEF for their high levels of biodiversity and endemism. A total of 480 fish species have been described that inhabit the slope of this bioregion with 31 considered to be endemic to the bioregion. Demersal fish communities within the area have recorded higher diversity when compared to other oceanic regions which have been more intensively sampled. The increased diversity within the area has been attributed to the overlap of ancient and extensive Indo-west Pacific and temperate Australasian fauna (Williams et al. 2001).

10.1.26 Albany Canyons Group and Adjacent Shelf Break

The Albany Canyons group and adjacent shelf break is located along a 700 km extent ranging from Cape Leeuwin to the east of Esperance and consists of 32 deep canyons which cut into the continental slope. Sonar surveys have indicated that individual canyons can extent up to 90 km long at water depths of 2,000 m. The canyons can start at the uppermost continental slope and reach the lowermost slope and extend onto the abyssal plain (Exon *et al.* 2005).

Due to close spacing of the numerous canyons, a wide range of depth dependent benthic habitats are connected increasing the habitat heterogeneity along the south western Australian continental margin. Offshore transport increases the sediment load and organic material is received from productive shelf waters. The closely spaced canyons have the potential to allow increased amounts of organic matter to reach the abyssal plain which may increase biodiversity in comparison to other areas within the south west Marine Region. (Richardson e*t al.* 2005).

According to DSEWPaC (2012), the Albany Canyons group and adjacent shelf break is regionally important and recognised as a key ecological feature for its high productivity, aggregations of marine life, and as a unique seafloor feature with ecological properties of regional significance (Pattiaratchi 2007). Both benthic and demersal habitats within the feature are of conservation value. The canyons are known to be a feeding area for the sperm whale (Bannister *et al.* 1996) and sites of orange roughy aggregations (Caton & McLoughlin 2004).

10.1.27 Carbonate Bank and Terrace System of the Van Diemen Rise

The bank and terrace system of the Van Diemen Rise covers approximately 31,278 km^2 and forms part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east. The feature is characterised by carbonate terrace, banks, channels and valleys, with variability in water depth and substrate composition considered to contribute to the presence of unique ecosystems in the channels. The variability in water depth and substrate composition across the feature may contribute to the presence of unique ecosystems in the channels. The carbonate banks and shoals found within the Van Diemen Rise make up 80% of the banks and shoals, 79% of the cannels and valleys, and 63% of the terrace found across the North Marine Region. The carbonate banks and shoals rise from depths of 100 m- 200 m to withing 10 m -40 m of the sea surface (Anderson et al. 2011).

The feature provides habitat for a high diversity of sponges, soft corals and other sessile filter feeders; epifauna and infauna; and olive ridley turtles, sea snakes and sharks. Rich sponge gardens and octocorals have been identified on the eastern Joseph Bonaparte Gulf along the banks, ridges and some terraces. Plains in deep hole/valleys are characterised by scattered epifauna and infauna that include polychaetes and ascidians. Epibenthic communities such as the sponges found in the channels are likely to support fish and second-order consumers. Pelagic fish such as mackerel, red snapper and a distinct gene pool of gold band snapper are found in the Van Diemen Rise.

10.1.28 Gulf of Carpentaria Basin

The Gulf of Carpentaria basin is defined as a key ecological feature for its regional importance for biodiversity, endemism and aggregations of marine life. These values apply to both the benthic and the pelagic habitats within the feature.

The Gulf of Carpentaria is believed to be one of the few remaining near-pristine marine environments in the world (Wightman et al. 2004). Primary productivity in the basin is mainly driven by cyanobacteria that fix nitrogen (Burford et al. 2009), but is also strongly influenced by seasonal processes. The soft sediments of the basin are characterised by moderately abundant and diverse communities of infauna and mobile epifauna dominated by polychaetes, crustaceans, molluscs and echinoderms.

The Gulf of Carpentaria basin also supports assemblages of pelagic fish species including planktivorous and schooling fish, and top predators such as shark, snapper, tuna and mackerel (Smith et al. 2006). The Gulf is also an important migratory route for seabirds, shore birds and marine turtles.

10.1.29 Shelf Break and Slope of the Arafura Shelf

The Shelf Break and Slope of the Arafura Shelf is an important ecological feature that creates a unique seafloor which enhances biological productivity on the edge of the shelf and attracts feeding aggregations of pelagic marine organisms. The productivity of this area has been recognised as nationally and/or regionally important (Last et al. 2005).

Although the ecosystem processes in this area are largely unknown it is thought that the oceanographic processes associated with the Indonesian Throughflow current and monsoonal winds are strong influence (DEWHA, 2007).

The physical characteristics of the Shelf Break and Slope of the Arafura Shelf comprise of continental slope, patch reefs and hard substrate pinnacles (Harris et al. 2005).

Phytoplankton and invertebrates have been sampled at this KEF and the primary production of phytoplankton is thought to be the basis for offshore food webs in the area (DEWHA, 2007). Records show approximately 284 demersal fish species in the area (Last et al. 2005) and other marine species that have been recorded include marine turtles, whale sharks and predatory fish species including sharks (DEWHA, 2008a).

10.1.30 Tributary Canyons of the Arafura Depression

The Tributary Canyons of the Arafura Depression is an important ecological feature characterised by high nutrients from upwellings of deep ocean water, which enhance productivity of the area (DEWHA, 2008a). This is thought to occur as a result of movements of water through the canyons and surface water circulating as a result of monsoonal winds (Wilson, 2005).

Surveys of the area identified around 245 macroscopic species including a variety of invertebrates and six small fish species (Wilson, 2005). The area also contains coral communities and attract aggregations of marine life (DEWHA, 2008a). Larger species found at this key ecological feature include predatory fish, whale sharks, sawfish and marine turtles (mostly olive ridley) (DEWHA, 2008a).

The national and/or regional importance of the Tributary Canyons of the Arafura Depression is associated with its high productivity, high levels of biodiversity and endemism.

11. State Marine Conservation Reserves

11.1 Introduction

Marine parks and reserves have been progressively established in Western Australia since 1987 and the Northern Territory since 1983. The Conservation and Parks Commission (CPC) is the vesting authority for marine parks and reserves under the provisions of the *Conservation and Land Management Act 1984*. Parks and Wildlife, within the Department of Biodiversity, Conservation and Attractions (DBCA), is responsible for day to day management of the parks.

There are three categories of state marine conservation reserves: marine parks; marine management areas; and marine nature reserves.

Marine parks are created to protect natural features and aesthetic values while allowing recreational and commercial uses that do not compromise conservation values. There are currently 25 marine parks within the combined EMBA (refer **Figure 9-2**, **Figure 9-3 Figure 9-4** and **Figure 9-4**).

Marine parks are multiple-use reserves that cater for a wide range of activities. Within marine parks there may be four types of management zones: recreation zones: general use zones; no-take areas known as sanctuary zones; and special purpose zones.

Each marine park has a 'management plan' that contains strategies to protect the high value assets in the park, as well as permitted activities tables. These tables provide explicit regulatory management.

Sanctuary zones are 'no-take' areas created primarily for conservation and scientific research and are designed to protect a particular significant ecosystem or habitat. Low-impact tourism may be permitted, but no recreational or commercial fishing, aquaculture, pearling, petroleum drilling or production is allowed.

Marine management areas provide an integrated management structure over areas that have high conservation value and intensive multiple-use. There are two marine management areas within the combined EMBA (described below).

There is currently only one state marine nature reserve: Hamelin Pool Nature Reserve part of the Shark Bay World Heritage Area (**Section 9.1.1**).

Within the NT component of the combined EMBA, there are no marine based conservation reserves. There were three coastal reserves (Channel Point Coastal Reserve, Casuarina Coastal Reserve and Shoal Bay Coastal Reserve), one conservation area (Tree Point Conservation Area) and two national parks (Djukbinj National Park Garig Gunak Barlu National Park) identified in the PMST report as being situated adjacent to the combined EMBA. Three more were identified as being present (Mary River National Park, Keep River National Park, Charles Darwin National Park) in the combined EMBA from mapping. However, these are all terrestrial based reserves and have not been discussed in further detail.

11.1.1 Ngari Capes Marine Park

The Ngari Capes Marine Park is gazetted as a Class A Marine Park. The park is located off the southwest coast of Western Australia, approximately 250 km south of Perth, covering approximately 123,790 ha. The seaward boundary of the marine park is congruent with the seaward limit of Western Australian waters (three nautical miles from the territorial baseline). The north-eastern boundary in Geographe Bay is located near the intersection of the Shire of Busselton boundary with the coastline. The Shire of Busselton–Shire of Capel boundary is approximately 30 m north-east of the marine park boundary, while the south-eastern boundary in Flinders Bay is located at 115˚17’00” E. The marine park consists of four areas that are representative of the Leeuwin–Naturaliste marine bioregion: Geographe Bay; Cape Naturaliste to Cape Mentelle coast; the

Cape Mentelle to Cape Leeuwin coast; and Flinders Bay. These areas show distinct differences in geomorphology, oceanography, habitats and flora and fauna.

The Ngari Capes Marine Park was identified as one of the most diverse temperate marine environments in Australia. Warm, tropical waters of the Leeuwin Current mix with the cool waters of the Capes Current, resulting in high finfish diversity, including tropical and temperate species (see fish in **Section 5.1.1**) and internationally significant seagrass diversity with seagrasses occurring at depths greater than 40 m (see seagrasses in **Section 3.2**). The marine park also surrounds a number of islands that are important seabird nesting habitat and pinniped haul-outs (places where seals and sea lions leave the water and come onto land), including Hamelin Island, Sugarloaf Rock and the Saint Alouarn Islands which include Flinders Island, Seal Island and Square Rock (DEC 2013). These islands are vested with the Conservation Commission as nature reserve and are managed by DBCA for the purpose of conservation. The marine park is also adjacent to the Leeuwin Naturaliste National Park which extends to the high water mark (DEC 2013).

The Ngari Capes marine park was also created for its high social values. The unique geographical location of this region exposes it to large, uninterrupted ocean swells and results in the South West capes area being recognised as one of the world’s premier surfing regions. Many activities occurring in the region are marine based, including commercial and recreational fishing, swimming, surfing, diving, snorkelling, boating, and marine nature-based tourism.

11.1.2 Jurien Bay Marine Park

The Jurien Bay Marine Park is a Class A marine park located on the central west coast of Western Australia about 200 km north of Perth and covers an area of 82,375 ha (CALM 2005b). Its western boundary is the seaward limit of Western Australian coastal waters. Its northern boundary is the northern point of Dynamite Bay at Green Head (30° 4' 7.9" South), and its southern boundary is located just south of Wedge (30° 50' 20" South) and is contiguous with the southern boundary of the Wanagarren Nature Reserve.

Jurien Bay Marine Park is considered to be broadly representative of the Central West Coast limestone reef system, which is a major marine ecosystem within this bioregion. The marine biota of the area consists of an unusual mix of tropical and temperate species as well as many endemic species (Larkum & Hartog, 1989). The Marine Park is dominated by five major marine habitat types: seagrass meadows; bare or sparsely vegetated mobile sand; shoreline and offshore intertidal reef platforms; subtidal limestone reefs; and reef pavement (CALM 2005b). Marine wildlife includes 14 species of cetaceans, a variety of sea and shorebirds which nest on the islands and the Australian sea lion (North Fisherman Island to the north of Jurien Bay is one of the main breeding sites for sea lions in the Central West Coast region and it is believed this breeding population is genetically distinct from the southern coast population – Gales et al. 1992). Commercial fishing for western rock lobster as well commercial wetlining, abalone, shark netting, beach seining for mullet and collecting of specimen shells and aquarium fish are carried out within the marine park.

11.1.3 Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve

The Shark Bay Marine Reserves comprise the Shark Bay Marine Park and the Hamelin Pool Marine Nature Reserve. The Shark Bay Marine Park was gazetted on 30 November 1990 as A Class Marine Park Reserve No. 7 and vested in the National Park and Nature Conservation Authority (NPNCA) under the CALM Act. The marine park encompasses an area of 748,725 ha (CALM 1996).

The Bay is located near the northern limit of a transition region between temperate and tropical marine fauna. Of the 323 fish species recorded from Shark Bay, 83% are tropical species with 11% warm temperate and 6% cool temperate species. Similarly, of the 218 species of bivalves recorded in Shark Bay, 75% have a tropical range and 10% a southern Australian range, with 15% being endemic to the west coast (CALM 1996).

Key features of Shark Bay Marine Park include (CALM 1996, DSEWPaC 2013b):

- 12 species of seagrass making it one of the most diverse seagrass assemblages in the world;
- Seagrass that covers over 4,000 km^2 of the bay. The 1,030 km^2 Wooramel Seagrass Bank is the largest structure of its type in the world;
- An estimated population of about 11,000 dugongs, one of the largest populations in the world;
- Humpback and southern right whales use the bay as a migratory staging post;
- Bottlenose dolphins occur in the bay, and green turtle and loggerhead turtle nest on the beaches;
- Large numbers of sharks including whaler, tiger shark and hammerhead are present as well as an abundant population of rays, including the manta ray;
- Hamelin Pool in Shark Bay contains the most diverse and abundant examples of stromatolite forms in the world, representative of life-forms which lived some 3,500 million years ago; and
- Shark Bay Marine Park does not cover Bernier and Dorre Islands and only coastal waters inshore of Dirk Hartog Island (east of eastern shoreline).

Shark Bay was included on the World Heritage List in 1991 primarily on the basis of three natural features: vast seagrass beds; dugong population; and stromatolites (microbial colonies that form hard, dome-shaped deposits and are among the oldest forms of life on Earth) (DSEWPaC 2013b; see **Section 9.1**).

There is no zoning within the Hamelin Pool Marine Nature Reserve. This area is a 'look but don't take' area managed solely for the conservation of globally outstanding marine life. Hamelin Pool is one of only two known places in the world with living examples of marine stromatolites (DEC 2010). The shores of Hamelin Pool are also important for the formation of extensive marine algal mats formed by microbial algae. If damaged, the mats and stromatolites can take many hundreds of years to recover (DEC 2010).

11.1.4 Ningaloo Marine Park

The Ningaloo Marine Park was declared in May 1987 under the National Parks and Wildlife Conservation Act 1975 (Commonwealth). The Ningaloo Coast, incorporating both key marine and terrestrial values was later granted World Heritage Status in June 2011. In November 2012, the Ningaloo Marine Park (Commonwealth Waters) was renamed to be incorporated in the North-west Commonwealth Marine Reserves Network. The park covers an area of 263,343 km^2, including both State and Commonwealth waters, extending 25 km offshore.

The park protects a large portion of Ningaloo Reef, which stretches over 300 km from North West Cape south to Red Bluff. It is the largest fringing coral reef in Australia, forming a discontinuous barrier that encloses a lagoon that varies in width from 200 m to 7 km. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). The Ningaloo Marine Park forms the backbone of the nature-based tourism industry, and recreational activities in the Exmouth region. Seasonal aggregations of whale sharks, manta rays, sea turtles and whales, as well as the annual mass spawning of coral attract large numbers of visitors to Ningaloo each year (CALM 2005).

The reef is composed of partially dissected basement platform of Pleistocene marine or Aeolian sediments or tertiary limestone, covered by a thin layer of living or dead coral or macroalgae. Key features that characterise the Ningaloo Reef include (CALM 2005):

- Over 217 species of coral (representing 54 genera);

- Over 600 species of mollusc (clams, oysters, octopus, cuttlefish, snails);
- Over 460 species of fish;
- Ninety-seven species of echinoderms (sea stars, sea urchins, sea cucumbers);
- Habitat for numerous threatened species, including whales, dugong, whale sharks and turtles; and
- Habitat for over 25 species of migratory wading birds listed in CAMBA and JAMBA.

11.1.5 Muiron Islands Marine Management Area

The Ningaloo Marine Park Management Plan (CALM 2005) created a MMA for the Muiron Islands, immediately adjacent to the northern end of the Park. This is managed as an integrated area together with the Ningaloo Marine Park, but its status as a MMA means that some activities, including oil and gas exploration, are still permitted under a strict environmental assessment process involving DMIRS.

The Muiron Islands, located 15 km northeast of the North West Cape, comprise the North and South Muiron Islands and cover an area of 1,400 ha (AHC 2006). They are low limestone islands (maximum height of 18 m above sea level (ASL)) with some areas of sandy beaches, macroalgae and seagrass beds in the shallow waters (particularly on the eastern sides) and coral reef up to depths of 5m, which surrounds both sides of South Muiron Island and the eastern side of North Muiron Island. The Muiron Islands MMA was WA's first MMA, gazetted in November 2004. It covers an area of 28,616 ha and occurs entirely within state waters (CALM 2005).

11.1.6 Barrow Island Marine Park

The Barrow Island Marine Park covers 4,169 ha, all of which is zoned as sanctuary zone (the Western Barrow Island Sanctuary Zone) (DEC 2007). It includes Biggada Reef, an ecologically significant fringing reef, and Turtle Bay, an important turtle aggregation and breeding area (DEC 2007). Representative areas of seagrass, macroalgal and deep water habitat are also represented within the marine park (DEC 2007). Passive recreational activities (such as snorkelling, diving and boating) are permitted but extractive activities such as fishing and hunting are not.

11.1.7 Barrow Island Marine Management Area

The Barrow Island Marine Management Area (MMA) is the largest reserve within the Montebello/ Barrow Islands marine conservation reserves, covering 114,693 ha (DEC 2007). The MMA includes most of the waters around Barrow Island, the Lowendal Islands and the Barrow Island Marine Park, with the exclusion of the port areas of Barrow Island and Varanus Island.

The MMA is not zoned apart from one specific management zone: the Bandicoot Bay Conservation Area. This conservation area is on the southern coast of Barrow Island and has been created to protect benthic fauna and seabirds. It includes the largest intertidal sand/mudflat community in the reserves, is known to be high in invertebrate diversity and is an important feeding area for migratory birds.

As for the other reserves in the Montebello/Barrow Islands marine conservation reserves, the Barrow Island MMA includes significant breeding and nesting areas for marine turtles and the waters support a diversity of tropical marine fauna, important coral reefs and unique mangrove communities (DEC 2007). Green, hawksbill and flatback turtles regularly use the island's beaches for breeding, and loggerhead turtles are also occasionally sighted.

11.1.8 Montebello Islands Marine Park

Montebello/ Barrow/ Lowendal Islands are part of a shallow submarine ridge, which extends north from the mainland near Onslow. The ridge contains extensive areas of intertidal and shallow subtidal limestone pavement surrounding the numerous, mostly small islands which are found in the region. The seabed is generally less than 5 m deep and consists of sand veneered limestone pavement with patches of fringing coral reef (DEC 2007).

The island chain lies entirely within WA State waters, with the State-Commonwealth boundary extending out to encompass the islands and waters 3 nm west of Barrow Island and north of the Montebello Islands. These islands are protected within as marine conservation reserves: Montebello Islands Marine Park, Barrow Islands Marine Park and Barrow Island Marine Management Area.

The Montebello Islands Marine Park (58,331 ha) consists of two sanctuary zones, two recreation zones, one special purpose zone for benthic protection, eleven special purpose zones for pearling and general use zones.

The Montebello Islands comprise over 100 islands, the majority of which are rocky outcrops; rocky shore accounts for 81% of shoreline habitat (DEC 2007a).

The ecological and conservation values of the Montebello and Barrow Islands Marine Conservation Reserve (MCR) include important habitats including corals reefs and bommies, mangroves, seagrass and macroalgae meadows, rocky shorelines and hard substrate, intertidal sand and mudflat communities. These habitats provide protection, food and habitat for a large diversity of species, including dugongs, turtles, whales, other protected cetaceans and birds as well as sea snakes and fish. The area is considered to have a high biodiversity. The islands also provide feeding and resting areas for migrating shorebirds and seabird nesting areas.

Socio-economic values of the Montebello and Barrow Islands MCR include hydrocarbon exploration and production, pearling, nature-based tourism, commercial and recreational fishing, water sports, European history and maritime heritage and scientific research (DEC 2007)

Special purpose zones for pearling are established for the existing leaseholder to allow pearling to be the priority use of these areas (DEC 2007a). Commercial fishing includes a trap fishery for reef fishes, mainly in water depths of 30–100 m, and wet lining for reef fish and mackerel. Fish trawling also occurs in the waters near to the Montebello Islands. A tourist houseboat operates out of Claret Bay, at the southern end of Hermite Island, during the winter months. The Montebello Islands are becoming more frequently used by recreational boaters for camping, fishing and diving activities.

11.1.9 Rowley Shoals Marine Park

The Rowley Shoals (including the Commonwealth-managed Mermaid Reef Marine National Nature Reserve) are located approximately 300 km west-northwest of Broome, lying between 17°07’S, 119°36’E and 17°35’S, 118°56’E and encompassing approximately 87,674 ha (DEC 2007b).

The Rowley Shoals is ecologically significant in that the reefs form part of a series of important ecological “stepping stones” for a range of reef biota originating in Indonesian/west Pacific waters. Their position off the north-west Australian coast, an area of few offshore reef systems, provides an important upstream source for recruitment to reefs further south (DEC 2007b). Marine wildlife includes 184 species of corals, primarily Indo-West Pacific species, indicating the strong affinity of the Rowley Shoals communities with Indonesia. In terms of other species, at least 264 species of molluscs, 82 species of echinoderms and 389 species of finfish were also identified (DEC 2007b). The faunal assemblages of the Rowley Shoals Marine Park are regionally significant as they contain large numbers of species not found in the more turbid coastal

Santos

environments of tropical Western Australia (DEC 2007b). There is a relatively low level of recreational and commercial activity, mostly atribuated to the remoteness of the Shoals with access difficult from both Indonesia and mainland Australia (DEC 2007b).

11.1.10 Lalang-garram/Camden Sound Marine Parks

The Lalang-garram/Camden Sound Marine Park was created on 19 June 2012 under Section 13 of the Conservation and Land Management Act 1984 (CALM Act). It is a multiple zone marine park that includes; Sanctuary, Special Purpose, and General Use zones (DPaW 2013). The marine park falls within the west Kimberley, which was recently added to the Australian National Heritage List because of its natural, indigenous and historic values to the nation.

The marine park is located about 150 km north of Derby (or 300 km north of Broome) and lies within the traditional country of three Aboriginal native title groups. The Dambimangari people's determination overlies the majority of the marine park. A section of the Wunambal Gaambera people's Uunguu determination includes a small portion of St George Basin, while a small section of the Mayala people's claim (native title not determined at the time of writing of Management Plan) overlies the southwest corner of the marine park (DPaW 2013).

The marine park covers an area of approximately 705,000 ha. It recognises and provides special management arrangements for this area of the Kimberley, which is a principal calving habitat of the humpback whale (*Megaptera novaeangliae*) population that migrates annually along Western Australia's coast. The marine park also conserves a range of species listed as having special conservation status including marine turtles, snubfin and Indo-Pacific humpback dolphins, dugong, saltwater crocodiles, and several species of sawfish. The park also includes a wide range of marine habitats and associated marine life, such as coral reef communities, rocky shoals, and the extensive mangrove forests and marine life of the St George Basin and Prince Regent River (DPaW 2013).

11.1.11 Marmion Marine Park

Marmion Marine Park was Western Australia's first marine park, declared in 1987 and is a multi-use reserve (CALM 2002). Marmion Marine Park is located offshore from Perth's northern suburbs, between Trigg Island and Burns Beach.

Habitats in the area include intertidal reef platforms, coastal sand beaches, a high limestone reef about 1 km from shore, Little Island and the Three Mile Reef system. Of note are complex assemblages of sea floor communities, including seagrass meadows, algal limestone pavement communities and crevice animal associations (CALM 2002).

The marine park provides an important habitat for marine mammals, such as sea lions, dolphins and whales. The island nature reserves within Marmion Marine Park provide an important habitat for several species of seabirds and haul-out areas for Australian sea lions, especially at Little Island and Burns Rocks (CALM 2002).

11.1.12 Swan Estuary Marine Park

The Swan Estuary Marine Park (A Class marine reserve number 4) was gazetted on 25 May 1990. The Swan Estuary Marine Park and Adjacent Nature Reserves Management Plan 1999-2009 was gazetted 7 April 2000 (CALM 1999).

The Swan Estuary Marine Park encompasses Alfred Cove, 200 ha adjacent to the suburbs of Attadale and Applecross; Pelican Point, a 45 ha area in Crawley; and Milyu, 95 ha adjacent to the Como foreshore (CALM 1999). All three localities are within 20 minutes of the Perth CBD.

These areas encompass mudflats, seagrass beds and intertidal vegetation such as sedges and saltmarsh, which provide many different habitats for a host of animals. The most important of these, due to their international significance, are the migratory wading birds. They come from as far afield as Asia, Mongolia and Siberia. About 33 of these species are protected, including the red-necked stint (CALM 1999).

11.1.13 Shoalwater Islands Marine Park

The Shoalwater Islands Marine Park is located within the Perth metropolitan area, adjacent to the city of Rockingham and was gazetted in 1990 (DEC 2007). There are three sanctuary zones, two special purpose zones and a large general use zone in the park.

The Shoalwater Island region is dominated by beach and rocky shore shoreline habitats. The many jagged edged islands and rocky islets of the marine park provide important roosting and nesting areas for numerous bird species. The marine park has some of the healthiest seagrass meadows in the Perth metropolitan area, consisting of long lived species such as *Posidonia* spp. and *Amphibolis* spp. Seagrass meadows provide an important habitat and nursery area for a large number of marine species such as fish, rock lobsters, worms, shellfish, crustaceans, fish sharks and rays (DEC 2007).

The habitats of the marine park are important for the feeding, resting and breeding of little penguins and other sea and shore birds. Penguin Island which is found within the marine park has the largest breeding colony of little penguin on the west coast of Australia (DEC 2007). The bottlenose dolphin is the most common marine mammal, and Australian sea lions are commonly seen throughout the park.

11.1.14 Eighty Mile Beach Marine Park

The Eighty Mile Beach Marine Park, located between Port Hedland and Broome, was gazetted on 29 January 2013. It covers an area of approximately 200,000 ha stretching for some 220 km from Cape Missiessy to Cape Keraudren, and includes sanctuary, recreation, general use and special purpose zones. The park is managed under the Eighty Mile Beach Marine Park Management Plan 2014-20124 (DPaW, 2014).

The listed ecological values of the Eighty Mile Beach Marine Park include the high sediment and water quality, the juxtaposition of the beach, coastal topography and seabed and the diverse and ecologically important habitats and marine/coastal flora and fauna. The listed habitat values of the marine park are as follows:

+ The intertidal sand and mudflat communities supporting a high abundance and diversity of invertebrate life and providing a valuable food source for shorebirds (including migratory species) and other fauna;
+ The diverse subtidal filter-feeding communities;
+ Macroalgal and seagrass communities providing habitat and feeding opportunities for fish, invertebrates and dugongs;
+ High diversity intertidal and subtidal coral reef communities; and
+ Mangrove communities and adjacent saltmarshes provide nutrients to the surrounding waters and habitat for fish and invertebrates.

The listed marine and coastal fauna values are as follows:

+ A high diversity and abundance of nationally and internationally important shorebirds and waders (including migratory species) are found in the marine park;

- Flatback turtles are endemic to northern Australia and nest at Eighty Mile Beach;
- Dugongs and several whale and dolphin species inhabit or migrate through the marine park;
- A highly diverse marine invertebrate fauna provides an important food source for a variety of animals, including birds, fish and turtles, along with recreational and commercial fishing opportunities;
- A diversity of fish species provides recreational and commercial fishing opportunities; and
- A diversity of sharks and rays, including several protected species, are found in the park.

In addition to these natural values, the marine park contains land and sea important to traditional Indigenous owners through identity and place, family networks, spiritual practice and resource gathering. The marine park also has a history of European activity including exploration, pastoralism and commercial fishing (e.g. the pearl oyster fishery). The park contains a historical WWII plane wreck (*Dornier Do-24 X-36*) and shipwrecks (two pearl luggers). The marine park provides tourism opportunity and recreational value through its remoteness, diversity and abundance of habitats and marine fauna and the pristine nature of the marine and coastal environment.

The marine park contains vast intertidal sand and mudflats that extend up to 4 km wide at low tide and provide a rich source of food for many species. Eighty Mile Beach Marine Park is one of the world's most important feeding grounds for small wading birds that migrate to the area each summer, travelling from countries thousands of kilometres away (DPaW 2014) (see **Section 9.2.1**).

11.1.15 Lalang-garram/ Horizontal Falls and North Lalang-garram Marine Parks

The Lalang-garram/ Horizontal Falls and North Lalang-garram Marine Parks were established in 2016 under the State Government's *Kimberley Science and Conservation Strategy* and are jointly managed by Dambimangari Traditional Owners and the Department of Parks and Wildlife (DPaW 2016). The marine parks fall within the west Kimberly region, included in the Australian National Heritage List for its nationally significant natural, indigenous and historic values (DoEE 2019c).

The Lalang-garram/ Horizontal Falls Marine Park extends from Talbot Bay (*Ganbadba*) in the west to Walcott Inlet (*Iledda*) and Glenelg River (*Molor Moloiyn*) in the east and covers approximately 353,000 ha (DPaW 2016). The marine park protects the internationally recognised Horizontal Falls and is important for the region's tourism. The North Lalang-garram Marine Park lies between the Lalang-garram / Camden Sound and North Kimberley Marine Parks and covers approximately 110,000 ha (DPaW 2016).

The area's large tidal range results in extensive intertidal areas with diverse ecosystems such as fringing coral reefs, mangroves and mudflat communities. Subtidal habitats and communities common to the marine parks include filter feeding communities of sponges and hard and soft corals. These intertidal and subtidal habitats provide critical foraging and nursery areas for dugong, marine turtles, estuarine crocodiles, snubfin and Indo-Pacific humpback dolphins, several species of sawfish and migratory seabirds. The marine parks are also a principal calving habitat for humpback whales (DPaW 2016).

11.1.16 North Kimberley Marine Park

The North Kimberley Marine Park was established in December 2016 as a Class A marine park under the CPC (DPaW 2016a). The marine park comprises four separate management areas including, Uunguu, Balanggarra, Miriuwung Gajerrong, and Wilinggin. It is a multiple zone marine park that includes: eight sanctuary zones, nine special purpose zones (recreation and conservation), two special use zone (cultural heritage), and general use areas (DPaW 2016a). The marine park is managed in accordance with the provisions of the CALM

Act with joint management between the Department of Parks and Wildlife and Traditional Owners of the area.

The area within the marine park is recognised for its Aboriginal cultural and heritage values, natural values including coral reefs, marine turtle species, dugongs, seagrass and macroalgal communities, mangroves and saltmarshes, finfish, and water and sediment quality, as well as for its social values (i.e. recreation, tourism and community values) and commercial values and resource use (e.g. commercial fishing). The marine park lies within the Indian Ocean and Timor Sea of Western Australia's Kimberley region, covering an area of approximately 1,845,000 hectares (DPaW 2016a). The south-western boundary is approximately 270 km northeast of Derby.

11.1.17 Yawuru Nagulagun/ Roebuck Bay Marine Park

The Yawuru Nagulagun/Roebuck Bay Marine Park was approved by the State Minister for Environment in October 2016 and declared as a Class A reserve over the subtidal and intertidal areas of Roebuck Bay (excluding the Kimberley Ports Authority waters), (DBCA, 2017a). The Marine Park is managed with a joint management framework between Parks and Wildlife and Yawuru Registered Native Title Body Corporation (RNTBC). The intent is to manage the areas from the offshore waters around Roebuck and Broome, collectively referred to as the Yawuru conservation estate, as one ecological system (DPaW 2016b). The development of the joint management plan is in accordance with the Conservation and Land Management Act 1984 (Yawuru Organisation 2017) as well as contributes to the State Governments commitment under the Kimberly Science and Conservation Strategy, released in June 2011.

The Yawuru people have lived along the foreshores of Roebuck Bay for thousands of years, the Bay is part of the Yawuru traditional estate (DPaW 2016b). Roebuck Bay is an internationally significant Ramsar wetland, declared in 1990, and an important feeding ground for many species of migratory shorebirds. It hosts possibly the greatest diversity of shorebird species at any site across the globe (DBCA 2017b). The Bay has some of the most productive tropical intertidal flats in the world, and is consequently an important ground for Yawuru fishing, hunting and gathering of sea food. The Bay hosts communities of seagrass and macroalgae, providing food for protected species such as the dugong and flatback turtle. Marine mammals also pass through the waters of the Bay such as the Australian snubfin dolphin and the humpback dolphin, the humpback whale can also be found during annual migration (DPaW 2016b).

11.1.18 Bardi Jawa Gaarra Marine Park

As part of a network of marine protected areas in state waters, DBCA has established the Bardi Jawa Gaarra Marine Park Joint Management Plan 2022 (DBCA, 2022). This plan is intended to guide management of the park for ten years, or until a new plan is developed. The plan was jointly developed, and will be jointly implemented, by DBCA and the Bardi and Jawi traditional owners. The plan is expected to come into effect in 2024, with approximately 204,000 hectares of protected area. The park forms part of a network of marine protected areas in state waters along the Kimberley coast.

The Bardi Jawa Gaarra Marine Park contains important cultural values for the Bardi and Jawi traditional owners, including hunting and fishing, cultural activities and business. The Bardi Jawa Gaarra Marine Park Joint Management Plan 2022 (DBCA, 2022) recognises the importance of these values, and includes relevant key performance indicators:

+ Relationship to country
+ Looking after country
+ Language and traditional knowledge

- Enjoyment of country and customary activities

These cultural values are dependent on the physical and biological characteristics of the park.

The physical setting for the Bardi Jawa Gaarra Marine Park is in coastal waters, where there is a large tidal range. The climate is tropical, with wet and dry seasons. Most rainfall occurs during the wet season. Water and sediment quality is expected to be high due to a lack of industrial activity within the park. Habitats within the park include (DBCA, 2022):

- coral and reef communities
- mangroves, creeks, and saltmarsh communities
- seagrass and macroalgal communities
- subtidal filter-feeding communities
- intertidal sand and mud flat communities and freshwaters soaks

The Bardi Jawa Gaarra Marine Park hosts a range of biological values, including (DBCA, 2022):

- marine turtles
- fish, sharks and rays
- dugongs
- whales and dolphins
- estuarine crocodiles
- seabirds and shorebirds
- invertebrates

Other activities that occur within the Bardi Jawa Gaarra Marine Park include research, recreational and commercial fishing, pearl aquaculture, and research.

11.1.19 Mayala Marine Park

The Mayala Marine Park is a component of the network of marine protected areas in state waters along the Kimberley coastline,and lies adjacent to the Bardi Jawa Gaarra Marine Park described above. The park is not yet gazetted, nor has a management plan been finalised. The Proposed Mayala Marine Park Indicative Joint Management Plan (DBCA, 2020) was published for public comment in 2020, and the park is expected to be gazetted by 2024. The park will be jointly managed by the Mayala traditional owners and DBCA.

The Mayala Marine Park contains important cultural values for the Mayala traditional owners, including hunting and fishing, cultural activities and sites of cultural and spiritual importance. The *Proposed Mayala Marine Park Indicative Joint Management Plan* (DBCA, 2020) recognises the importance of these values, and proposes the following strategic objectives:

- Relationship to country
- Looking after country
- Language and traditional knowledge
- Enjoyment of country and customary activities

The Mayala Marine Park contains a range of physical and biological environmental values. The *Proposed Mayala Marine Park Indicative Joint Management Plan* (DBCA, 2020) identifies the same physical and biological environmental values as described above for the Bardi Jawa Gaarra Marine Park (refer to **Section 11.1.18**).

11.1.20 Lalang-gaddam Marine Park

The Lalang-gaddam Marine Park is an amalgamation of the Lalang-garram / Camden Sound, Lalang-garram / Horizontal Fall and the North Lalang-garram Marine Park, and the proposed Maiyalam Marine Park. The *Lalang-gaddam amended Joint Management Plan for the Lalang-garram / Camden Sound, Lalang-garram / Horizontal Falls and North Lalang-garram Marine Parks and Indicative Joint Management Plan for the Proposed Maiyalam Marine Park* (DBCA, 2020) states the amalgamation is intended to:

+ Provide clearer direction for joint management and governance outcomes
+ Aid in communication and engagement with the Dambeemangardee Community and other park users

The amendment to the plan is expected to come into effect in 2024 and is intended to be in effect for 10 years. The strategic objective of the amendment is to protect and conserve the value of the land for the culture and heritage of Dambeemangardee people.

The *Lalang-gaddam amended Joint Management Plan for the Lalang-garram / Camden Sound, Lalang-garram / Horizontal Falls and North Lalang-garram Marine Parks and Indicative Joint Management Plan for the Proposed Maiyalam Marine Park* (DBCA, 2020) states the following key performance indicators:

+ Cultural connection and cultural laws and protocols
+ Looking after country
+ Traditional knowledge and language
+ Customary use

The Lalang-gaddam Marine Park has a range of physical and biological environmental values. The *Lalang-gaddam amended Joint Management Plan for the Lalang-garram / Camden Sound, Lalang-garram / Horizontal Falls and North Lalang-garram Marine Parks and Indicative Joint Management Plan for the Proposed Maiyalam Marine Park* (DBCA, 2020) identifies the same physical and biological environmental values as described above for the Lalang-gaddam Marine Park (refer to **Section 11.1.18**). The plan also recognises tourism, recreational fishing, commercial fishing and aquaculture as important values within the park, which are also identified as sources of risk that require management.

12. Australian Marine Parks

12.1 Introduction

In agreement with the States and NT governments, the Australian Commonwealth government was committed to establish Commonwealth marine parks as a component of the National Representative System of Marine Protected Areas (DoE 2014) (See **Figure 9-2, Figure 9-3** and **Figure 9-4**). In November 2012, the Commonwealth Marine Reserves Network was proclaimed with the purpose of protecting the biological diversity and sustainable use of the marine environment (Director of National Parks 2012a). Commonwealth Marine Reserves were renamed as Australian Marine Parks in October 2017. Six marine regions are included in the Australian Marine Parks Network, including the Coral Sea, the South-west, the Temperate East, the South-east, the North and the North-west. The South-east network 10-year Management Plan came into effect on 1 July 2013. The remaining networks 10-year Management Plans were approved and came into effect on 1 July 2018.

The new management plans establish the management and zoning of the designated marine parks. The marine park networks pertinent to the combined EMBA include:

+ The South-West Marine Parks Network;
+ The North-West Marine Parks Network; and
+ The North Marine Parks Network.

The South-West Marine Parks Network comprises 14 marine parks. Seven of these occur in West Australian waters in the combined EMBA, including:

+ Abrolhos Commonwealth Marine Park;
+ Jurien Marine Park;
+ Two Rocks Marine Park;
+ Perth Canyon Marine Park;
+ Geographe Marine Park;
+ South-west Corner Marine Park; and
+ Bremer Marine Park
+ Eastern Recherche Marine Park

The North-West Marine Parks Network comprises 13 marine parks which all occur in West Australian waters pertinent to the combined EMBA:

+ Carnarvon Canyon Marine Park;
+ Shark Bay Marine Park;
+ Gascoyne Marine Park;
+ Ningaloo Marine Park;
+ Montebello Marine Park;
+ Dampier Marine Park;
+ Eighty Mile Beach Marine Park;

+ Argo-Rowley Terrace Marine Park;
+ Mermaid Reef Marine Park;
+ Roebuck Marine Park;
+ Kimberley Marine Park;
+ Ashmore Reef Marine Park; and
+ Cartier Island Marine Park.

The Northern Marine Parks Network comprises eight marine parks. Four of these occur in Western Australian or Northern Territory waters within the combined EMBA:

+ Oceanic Shoals Marine Park;
+ Arafura Marine Park;
+ Arnhem Marine Park; and
+ Joseph Bonaparte Gulf Marine Park.

the combined EMBAThe sizes of these marine parks range from 300—152,000 km^2, and the water depths within the marine parks vary from approximately 15—1,500 m deep. The EPBC Act requires that each management plan assign an International Union for the Conservation of Nature (IUCN) category to each marine park. Additionally, the Act also allows for the management plan to divide a marine park into zones and to assign a category to each zone, which may differ from the overall category of the marine park. Zoning considers the purposes for which the marine parks were declared, the objectives of the relevant management plans, the values of the marine park and requirements of the EPBC Act and EPBC Regulations.

the combined EMBAThe North-West Marine Parks Network includes six different types of zoning:

+ Sanctuary Zone (IUCN Category Ia);
+ National Park Zone (IUCN Category II);
+ Recreational Use Zone (IUCN Category IV);
+ Habitat Protection Zone (IUCN Category IV);
+ Multiple Use Zone (IUCN Category VI); and
+ Special Purpose Zone (Trawl) (VI).

The South-west Marin Parks Network includes six different types of zoning:

+ National Park Zone (IUCN Category II);
+ Habitat Protection Zone (IUCN Category IV);
+ Multiple Use Zone (IUCN Category VI);
+ Special Purpose Zone (Mining Exclusion) (IUCN Category VI);
+ Special Purpose Zone (IUCN Category VI); and
+ Special Purpose Zone (Trawl) (IUCN Category VI).

Five types of zones are represented within the North Marine Parks Network:

+ National Park Zone (IUCN Category II)

- Habitat protection zone (IUCN Category IV)
- Multiple use zone (IUCN Category VI)
- Special Purpose Zone (Trawl) (IUCN Category VI)
- Special Purpose Zone (IUCN Category VI)

A summary of the South-West, North-West and North Marine Parks Networks is provided in **Table 12-1**.

12.2 South-West Marine Parks Network

The South-West Commonwealth Marine Parks Network is aligned to the South-West Marine Region. The network covers 508,371 km^2 and includes 14 marine parks (Director of National Parks, 2018a). Broad values of the South-west Australian Marine Parks include:

- Natural values;
- Cultural values;
- Heritage values; and
- Socio-economic values.

Further detail on each of the relevant marine parks those that fall within the combined EMBA is provided below.

12.2.1 Abrolhos Marine Park

The Abrolhos Marine Park (including zones within the combined EMBA: Marine National Park Zone – IUCN Category II-2,548 km^2; Habitat Protection Zone – IUCN Category VI-23,239 km^2; Multiple Use Zone – IUCN Category VI-56,545 km^2; Special Purpose Zone – IUCN Category VI-5,729 km^2) covers an area of approximately 88,060 km^2 and protects the following conservation values (Director of National Parks, 2018a):

- Important foraging areas for the:
  - Threatened Australian lesser noddy;
  - Northernmost breeding colony of the threatened Australian sea lion;
  - Great white sharks; and
  - Migratory common noddy, wedge-tailed shearwater, bridled tern, Caspian tern and roseate tern.
- Important migration habitat for the protected humpback whale and pygmy blue whales;
- The second largest canyon on the west coast, the Houtman Canyon;
- Examples of the northernmost ecosystems of the Central Western Province and South-west Shelf Transition (including the Central West Coast meso-scale bioregion);
- Examples of the deeper ecosystems of the Abrolhos Islands meso-scale bioregion;
- Examples of the shallower, southernmost ecosystems of the Central Western Shelf Province provincial bioregion including the Zuytdorp meso-scale bioregion;
- Examples of the deeper ecosystems of the Central Western Transition provincial bioregion;
- Examples of diversity of seafloor features including: southern most banks and shoals of the North-west region; deep holes and valleys; slope habitats; terrace and shelf environments; and

- Seven KEFs.

The Abrolhos Marine Park is adjacent to the Shark Bay World Heritage Property. The marine park does not contain any Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains 11 known shipwrecks listed under the *Underwater Culture Heritage Act 2018*. Commercial tourism, fishing, recreation and mining are important supported socio-economic activities in the park.

12.2.2 Jurien Marine Park

The Jurien Marine Park (including zones within the combined EMBA): Marine National Park Zone -IUCN Category II – 31 km^2 Special Purpose Zone -IUCN Category VI – 1,820 km^2) covers an area of approximately 1,851 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Threatened Australian sea lion;
  - Threatened white shark; and
  - Migratory roseate tern, bridled tern, wedge-tailed shearwater, and common noddy.
- Important migration habitat for the protected humpback whale;
- Examples of the ecosystems of two provincial bioregions: the central part of the South-west Shelf Transition (which includes the Central West Coast meso-scale bioregion) and small parts of the Central Western Province;
- Three KEFs; and
- Heritage values represented by the SS Cambewarra and Oleander historic shipwreck.

The Jurien Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, recreation and mining are important supported socio-economic activities in the park.

12.2.3 Two Rocks Marine Park

The Two Rocks Marine Park (including zones within the combined EMBA): Multiple Use Zone - IUCN Category VI – 867 km^2; Marine National Park Zone - IUCN Category II – 15 km^2) covers an area of approximately 882 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Threatened Australian sea lion; and
  - Migratory roseate tern, bridled tern, Caspian tern, wedge-tailed shearwater, and common noddy.
- Important migratory areas for protected humpback whales and pygmy blue whales;
- Seasonal calving habitat for the threatened southern right whale;
- Examples of the ecosystem of the southernmost parts of the South-west Shelf Transition (including the Central West Coast meso-scale bioregion); and
- Three KEFs.

The Two Rocks Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, recreation and scientific research are important supported socio-economic activities in the park.

12.2.4 Perth Canyon Marine Park

Perth Canyon Marine Park (including zones within the combined EMBA): Marine National Park Zone – IUCN Category II – 1,241 km^2; Habitat Protection Zone – IUCN Category IV –4,352 km^2; Multiple Use Zone – IUCN Category VI – 1,816 km^2) covers an area of approximately 7,409 km^2 and protects the following conservation values (Director of National Parks 2018a):

+ Globally important seasonal feeding aggregation for the threatened blue whale;
+ Important foraging areas for the:
  - Threatened soft-plumaged petrel;
  - Migratory sperm whale; and
  - Migratory wedge-tailed shearwater.
+ Important migratory areas for protected humpback whales and blue whales;
+ Seasonal calving habitat for the threatened southern right whale;
+ Examples of the ecosystems of the southernmost parts of the Central Western Province and South-west Shelf Transition (including the Central West Coast meso-scale bioregion), and the northernmost parts of the South-west Transition and Southwest Shelf Province (including the Leeuwin-Naturaliste meso-scale bioregion); and
+ Four KEFs.

The Perth Canyon Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, shipping, recreation and defence training are important supported socio-economic activities in the park.

12.2.5 Geographe Marine Park

Geographe Marine Park (including zones within the combined EMBA): Marine National Park Zone - IUCN Category II – 15 km^2; Special Purpose Zone - IUCN VI – 650 km^2; Multiple Use Zone - IUCN Category VI – 291 km^2; Habitat Protection Zone (IV) 21 km^2) covers an area of approximately 977 km^2 and protects the following conservation values (Director of National Parks 2018a):

+ Important foraging areas for the:
  - Threatened soft-plumaged petrel; and
  - Migratory wedge-tailed shearwater.
+ Important pre-migration aggregation area for the migratory flesh-footed shearwater;
+ Important migratory habitat for the protected humpback whale and blue whale;
+ Seasonal calving habitat for the threatened southern right whale.
+ Seasonal calving habitat for the threatened southern right whale.
+ Representation of the South-west Shelf Province on the continental shelf as well as the Leeuwin-Naturaliste meso-scale bioregion;

- Two KEFs; and
- Representation of the seagrass habitats of the Geographe Bay key ecological feature, which in this location extend the furthest into Commonwealth waters.

The Geographe Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains eight known shipwrecks listed under the *Underwater Culture Heritage Act 2018.* Commercial tourism, fishing and recreation are important supported socio-economic activities in the park.

12.2.6 South-west Corner Marine Park

The South-west Corner Marine Park (including zones within the combined EMBA: Marine National Park Zone - IUCN II – 54,841 km^2; Multiple Use Zone - IUCN VI –106,602 km^2; Special Purpose Zone (Mining exclusion) - IUCN VI – 9,550 km^2, Special Purpose Zone – IUCN VI – 5753 km^2; Habitat Protection Zone - IUCN IV – 95,088 km2) covers an area of approximately 271,833 km2 within the combined EMBA and protects the following conservation values (Director of National Parks 2018a):

- Important migratory area for protected humpback whales and blue whales;
- Important foraging areas for the:
  - Threatened white shark;
  - Threatened Australian sea lion;
  - Threatened Indian yellow-nosed albatross and soft-plumaged petrel;
  - Sperm whale;
  - Migratory flesh-footed shearwater, short-tailed shearwater and Caspian tern; and
  - Seasonal calving habitat for the threatened southern right whale.
- Representation of three provincial bioregions (the South-west Transition and Southern Province in the off-shelf area, and the South-west Shelf Province on the continental shelf) and two meso-scale bioregions (southern end of the Leeuwin-Naturaliste meso-scale bioregion and western and central parts of the Western Australia South Coast meso-scale bioregion);
- Representation of the Donnelly Banks, east of Augusta, characterised by higher productivity and including nursery habitats; and
- Six KEFs.

The South-west Corner Marine Park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). The marine park contains ten known shipwrecks listed under the *Underwater Culture Heritage Act 2018*. Commercial tourism, fishing, shipping and recreation are important supported socio-economic activities in the park.

12.2.7 Bremer Marine Park

The Bremer Marine Park: National Park Zone – IUCN II – 3,172 km^2; Special Purpose Zone (Mining exclusion) - IUCN VI – 1,300 km^2, which covers an area of approximately 4,472 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Contains habitats, species and ecological communities associated with two bioregions: Southern Province and South-west Shelf Province;

- Two key ecological features (Albany Canyon group and adjacent shelf break and ancient coastline between 90 m and 120 m depth);
- Important foraging areas for:
- Threatened white shark;
- Threatened Australian sea lion;
- Threatened Indian yellow-nosed albatross, Australian fairy tern and soft-plumaged petrel; and
- Migratory flesh-footed shearwater, short-tailed shearwater, bridled tern and Caspian tern.
- Important migratory pathway for humpback whales;
- Significant calving habitat for the threatened southern right whale; and
- Important aggregation area for killer whales

The marine park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018a). Commercial tourism, fishing, shipping and recreation are important supported socio-economic activities in the park.

12.2.8 Eastern Recherche Marine Park

The Eastern Recherche Marine Park (Special Use Zone – IUCN Category V) is part of the South-West Marine Park Network. It lies adjacent to the Recherche Archipelago about 135km east of Esperance and includesimportant foraging areas for:

- Threatened white shark;
- Threatened Australian sea lion
- Pygmy blue whales are distributed across the marine park
- Southern right whales migrate through the region to important nursery areas in coastal waters.

The marine park does not contain any international, Commonwealth or National heritage listings (Director of National Parks 2018a) but it is adjacent to the Recherche Archipelago which is home to the only breeding population of great-winged petrels in Australia.

12.3 North-West Marine Park Network

The North-West Marine Parks Network is aligned to the North-west Marine Region. The network covers 335, 341 km^2 and includes 13 marine parks (Director of National Parks, 2018b). Broad values of the North-west Commonwealth Marine Reserves Network include:

- Natural values;
- Cultural values;
- Heritage values; and
- Socio-economic values.

Further detail on each of the relevant marine parks within the combined EMBA is provided below.

12.3.1 Carnarvon Canyon Marine Park

The Carnarvon Canyon Marine Park (Habitat Protection Zone – IUCN Category IV) covers an area of approximately 6,177 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ The Carnarvon Canyon a single channel canyon with seabed features that include slope, continental rise and deep holes and valleys;
+ The Carnarvon Canyon ranges in depth from 1500 m to over 5,000 m, thereby providing habitat diversity for benthic and demersal species; and
+ Central Western Transition provincial bioregion ecosystem examples are found here, which are characteristic of the biogeographic faunal transition between tropical and temperate species.

There is limited information about species' use of this Marine Park (Director of National Parks 2018b). The marine park does not contain any international, Commonwealth or National Heritage listings (Director of National Parks 2018b). Commercial fishing, tourism, shipping and mining are important supported socio-economic activities in the marine park.

12.3.2 Shark Bay Marine Park

The Shark Bay Marine Park (Multiple Use Zone – IUCN Category VI) covers an area of approximately 7,443 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging areas adjacent to important breeding areas for several species of migratory seabirds;
+ Part of the migratory pathway of protected humpback whales;
+ Internesting habitat for marine turtles;
+ Waters that are adjacent to the largest nesting area for loggerhead turtles in Australia;
+ Marine park and adjacent coastal areas important for shallow-water snapper;
+ Protection to shelf and slope habitats as well as a terrace feature;
+ Examples of the shallower ecosystems of the Central Western Shelf Province and Central Western Transition provincial bioregions including the Zuytdorp meso-scale bioregion; and
+ Connectivity between the inshore waters of the Shark Bay World Heritage Area and the deeper waters of the area.

Whilst no listed international, Commonwealth or National Heritage places are within the marine park, the park is adjacent to Shark Bay World Heritage Area (Director of National Parks 2018b). Commercial tourism, fishing, mining and recreation are important socio-economic values of the park.

12.3.3 Gascoyne Marine Park

The Gascoyne Marine Park (Multiple Use Zone – IUCN Category VI-33,652 km^2; Habitat Protection Zone – IUCN Category IV-38,982 km^2; Marine National Park Zone – IUCN Category II-9,132 km^2) covers an area of approximately 81,766 km^2 and protects the following conservation values (Director of National Parks 2018a):

+ Important foraging areas for: migratory seabirds threatened and migratory hawksbills and flatback turtles; and vulnerable and migratory whale shark;
+ A continuous connectivity corridor from shallow depths around 15 m out to deep offshore waters on the abyssal plain at over 5,000 m in depth;

- Seafloor features including canyon, terrace, ridge, knolls, deep hole/valley and continental rise. It also provides protection for sponge gardens in the south of the reserve adjacent to Western Australian coastal waters;
- Ecosystems examples from the Central Western Shelf Transition, the Central Western Transition and the Northwest province provincial bioregions as well as the Ningaloo meso-scale bioregion;
- Four KEFs for the region:
  - Canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula (enhanced productivity, aggregations of marine life and unique sea-floor feature);
  - Exmouth Plateau (unique sea-floor feature associated with internal wave generation);
  - Continental slope demersal fish communities (high species diversity and endemism – the most diverse slope bioregion in Australia with over 500 species found with over 64 of those species occurring nowhere else); and
  - Commonwealth waters adjacent to Ningaloo Reef.
- The canyons in this reserve are believed to be associated with the movement of nutrients from deep water over the Cuvier Abyssal Plain onto the slope where mixing with overlying water layers occurs at the canyon heads. These canyon heads, including that of Cloates Canyon, are sites of species aggregation and are thought to play a significant role in maintaining the ecosystems and biodiversity associated with the adjacent Ningaloo Reef; and
- The reserve therefore provides connectivity between the inshore waters of the existing Ningaloo Commonwealth marine park and the deeper waters of the area.

The park is also adjacent to World Heritage listings associated with the Ningaloo Coast. Commercial tourism, commercial fishing, mining and recreation are important socio-economic values of the park (Director of National Parks 2018b).

12.3.4 Ningaloo Marine Park

Ningaloo Marine Park stretches approximately 300 km along the west coast of the Cape Range Peninsula and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park (Director of National Parks, 2018b). Ningaloo Reef is the longest fringing barrier reef in Australia forming a discontinuous barrier that encloses a lagoon that varies in width from 200 m to 7 km. Gaps that regularly intercept the main reef line provide channels for water exchange with deeper, cooler waters (CALM 2005). It is the only example in the world of extensive fringing coral reef on the west coast of a continent.

The Ningaloo Marine Park (Recreational Use Zone – IUCN Category II) covers an area of approximately 2,435 km^2 and protects the following conservation values (Director of National Parks 2018a):

- Important habitat (foraging areas) for vulnerable and migratory whale sharks;
- Areas used for foraging by marine turtles adjacent to important internesting sites;
- Part of the migratory pathway of the protected humpback whale;
- Foraging and migratory pathway for pygmy blue whales;
- Breeding, calving, foraging and nursing habitat for dugong;

- Shallow shelf environments which provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features;
- Seafloor habitats and communities of the Central Western Shelf Transition;
- Three KEFs; and
- The Ningaloo Coast World Heritage Property, the Ningaloo Coast National Heritage listing and Ningaloo Marine Area Commonwealth Heritage Listing.

Commercial tourism and recreation are important socio-economic values of the marine park (Director of National Parks 2018b).

12.3.5 Montebello Marine Park

The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western Australian state water boundary and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks. The Montebello Marine Park (Multiple Use Zone – IUCN Category VI) covers an area of approximately 3,413 km^2 and protects the following conservation values (Director of National Parks 2018b):

- Foraging areas for migratory seabirds that are adjacent to important breeding areas;
- Areas used by vulnerable and migratory whale sharks for foraging;
- Foraging areas marine turtles which are adjacent to important nesting sites;
- Section of the north and south bound migratory pathway of the humpback whale;
- Shallow shelf environments with depths ranging from 15–150 m which provides protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features;
- Seafloor habitats and communities of the Northwest Shelf Province provincial bioregions as well as the Pilbara (offshore) meso-scale bioregion; and
- One KEF for the region is the ancient Coastline (a unique seafloor feature that provides areas of enhanced biological productivity).

Commercial tourism, commercial fishing, mining and recreation are important socio-economic values for the park.

12.3.6 Dampier Marine Park

The Dampier Marine Park (Marine National Park Zone – IUCN Category I-73 km^2; Habitat Protection Zone – IUCN Category IV-104 km^2; Multiple Purpose Zone – IUCN Category VI-1,074 km^2) covers an area of approximately 1,252 km^2 and protects the following conservation values (Director of National Parks 2018b):

- Foraging areas for migratory seabirds that are adjacent to important breeding grounds;
- Important foraging areas for marine turtles adjacent to significant nesting sites;
- Part of the migratory pathway of the protected humpback whale;
- Protection for offshore shelf habitats and shallow shelf habitats adjacent to the Dampier Archipelago; and
- Communities and seafloor habitats of the Northwest Shelf Province provincial bioregion as well as the Pilbara (nearshore) and Pilbara (offshore) meso-scale bioregions are included.

Port activities, commercial fishing and recreation are important activities in the marine park (Director of National Parks 2018b). No heritage listings apply to the marine park.

12.3.7 Eighty Mile Beach Marine Park

The Eighty Mile Beach Marine Park (Multiple Use Zone – IUCN Category VI) is adjacent to the Western Australia Eighty Mile Beach Marine Park, 74 km north-east of Port Hedland and covers an area of approximately 10,785 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Breeding, foraging and resting habitat for seabirds (one of the world's most important feeding grounds for migratory shorebirds and waders and is listed under the Ramsar Convention);
+ Internesting and nesting habitat for marine turtles (it supports a significant nesting population of flatback turtles, which are endemic to northern Australia);
+ Foraging, nursing and pupping habitat for sawfish;
+ Migratory pathway for humpback whales;
+ Coastal waters provide critical habitat for several shark and ray species at varying life stages;
+ The Nyangumarta, Karajarri and Ngarla people's sea country extends into Eighty Mile Beach Marine Park. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities; and
+ Three known shipwrecks listed under the *Underwater Cultural Heritage Act 2018*: Lorna Doone (wrecked in 1923), Nellie (wrecked in 1908), and Tifera (wrecked in 1923).

Tourism, commercial fishing, pearling and recreation are important activities in the Marine Park (Director of National Parks 2018b).

12.3.8 Argo-Rowley Terrace Marine Park

The Argo-Rowley Marine Park is located approximately 270 km north-west of Broome, Western Australia, and extends to the limit of Australia's exclusive economic zone. The Marine Park (Multiple Use Zone – IUCN Category VI-108,812 km^2; Marine National Park Zone – IUCN Category II-36,050 km^2; Special Purpose Zone – IUCN Category VI-1,141 km^2) covers an area of approximately 146,003 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging areas that are important for migratory seabirds as well as the endangered loggerhead turtle;
+ Important habitat and foraging for sharks;
+ Migratory pathway for pygmy blue whales (Director of National Parks 2018b);
+ Protection for communities and habitats of the deeper offshore waters (220 m to over 5,000 m) of the region;
+ Seafloor features including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope;
+ Communities and seafloor habitats of the Northwest Transition and Timor Province provincial bioregions;
+ Connectivity between the existing Mermaid Reef Marine National Nature Reserve and reefs of the Western Australian Rowley Shoals Marine Park and the deeper waters of the region;
+ Two KEFs in the reserve include:

- The canyons linking the Argo Abyssal Plain with the Scott Plateau (unique seafloor feature with enhanced productivity and feeding aggregations of species); and
- Mermaid Reef and the Commonwealth waters surrounding Rowley Shoals (an area of high biodiversity with enhanced productivity and feeding and breeding aggregations).

No heritage listings apply to this marine park (Director of National Parks 2018b). Commercial fishing, mining and recreation are important socio-economic values for the park.

12.3.9 Mermaid Reef Marine Park

The Mermaid Reef Marine Park (Multiple Use Zone – IUCN Category VI) lays approximately 280 km north-west of Broome, Western Australia, adjacent to the Argo–Rowley Terrace Marine Park and approximately 13 km from the Western Australian Rowley Shoals Marine Park. It covers an area of 540 km² and protects the following conservation values (Director of National Parks 2018b):

+ Mermaid Reef and Commonwealth waters surrounding Rowley Shoals are valued for its high productivity, aggregations of marine life and high species richness;
+ Mermaid Reef, Clerke Reef and Imperieuse Reef are biodiversity hotspot and key topographic feature of the Argo Abyssal Plain;
+ Rowley Shoals present some of the best geological examples of shelf atolls in Australian waters, and are ecologically significant in that they are considered ecological steppingstones for reef species originating in Indonesian/Western Pacific waters, are one of a few offshore reef systems on the north-west shelf, and may also provide an upstream source for recruitment to reefs further south;
+ Breeding habitat for seabirds;
+ Migratory pathway for the pygmy blue whale; and
+ One known shipwreck listed under the *Underwater Cultural Heritage Act 2018*: Lively (wrecked in 1810).

Tourism, recreation, and scientific research are important activities in the Marine Park (Director of National Parks 2018b).

12.3.10 Roebuck Marine Park

The Roebuck Marine Park (Multiple Use Zone – IUCN Category VI) covers an area of approximately 304 km^2 and protects the following conservation values (Director of National Parks 2018b):

+ Foraging habitat area for migratory seabirds adjacent to important breeding areas;
+ Foraging area adjacent to important nesting sites for flatback turtles;
+ Parts of the migratory pathway of the protected humpback whale;
+ Habitat adjacent to important foraging, nursing and pupping areas for freshwater, green and dwarf sawfish;
+ Foraging and calving areas for Australian snubfin, Indo-Pacific humpback and Indo-Pacific bottlenose dolphins;
+ Foraging habitat for dugong;
+ Protection for shallow shelf habitats ranging in depth from 15–70 m;
+ Ecosystems example of the Northwest Shelf Province provincial bioregion and the Canning meso-scale bioregion; and

+ Sea country valued for indigenous cultural identity, health and well-being for the Yawuru people (Director of National Parks 2018b).

No heritage listings apply to the marine park. Commercial tourism, fishing, pearling and recreation are important socio-economic values of the marine park (Director of National Parks 2018b).

12.3.11 Kimberley Marine Park

The Kimberley Marine Park (Multiple Use Zone – IUCN Category VI) is located approximately 100 km north of Broome, Western Australia, and extends from the Western Australian state water boundary north from the Lacepede Islands to the Holothuria Banks offshore from Cape Bougainville. It is adjacent to the Western Australian Lalanggarram / Camden Sound Marine Park and the North Kimberley Marine Park. It covers an area of 74,469 km², and protects the following conservation values (Director of National Parks 2018b):

+ Northwest Shelf Province;
  - Diverse benthic and pelagic fish communities
  - Ancient coastline thought to be an important seafloor feature
  - Migratory pathway for humpback whales
+ Northwest Shelf Transition;
  - High levels of species diversity
  - Endemism occur among demersal fish communities on the continental slope
+ Timor Province;
  - Reefs and islands of the bioregion are regarded as biodiversity hotspots
  - Endemism in demersal fish communities of the continental slope is high (two distinct communities have been identified on the upper and mid slopes)
  - Ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitats in areas otherwise dominated by soft sediments;
  - Continental slope demersal fish communities characterised by high diversity of demersal fish assemblages;
  - breeding and foraging habitat for seabirds;
  - Internesting and nesting habitat for marine turtles;
  - Breeding, calving and foraging habitat for inshore dolphins;
  - Calving, migratory pathway and nursing habitat for humpback whales;
  - Migratory pathway for pygmy blue whales;
  - Foraging habitat for dugong and whale sharks;
  - The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul Nyul people's sea country extends into the Kimberley Marine Park. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities; and
  - More than 40 known shipwrecks listed under the *Underwater Cultural Heritage Act 2018*.

Tourism, commercial fishing, mining, recreation, including fishing, and traditional use are important activities in the Marine Park (Director of National Parks 2018b).

12.3.12 Ashmore Reef Marine Park

The Ashmore Reef Marine Park (Sanctuary Zone – IUCN Category Ia; Recreational Use Zone – IUCN Category II) covers an area of approximately 583 km^2 (Director of National Parks 2018b). It forms part of the North-west Park Network. As the only oceanic reef in the north-east Indian Ocean with vegetated islands (East, Middle and West Islands), Ashmore is also the largest of three emergent, oceanic reefs in the region (DSEWPaC 2012). Both the Ashmore and Cartier Islands fall under the legal memorandum of understanding between Indonesia and Australia, as both areas are located within Australia's external territory (DSEWPaC 2012).

Ashmore Reef Marine Park is located on Australia's North West Shelf in the Indian Ocean, about 450 nautical miles (840 km) west of Darwin and 330 nautical miles (610 km) north of Broome. The reserve covers 583 km^2 and includes two extensive lagoons, shifting sand flats and cays, seagrass meadows, a large reef flat covering an area of 239 km^2. Within the reserve are three small islands known as East, Middle and West Islands (DoE, 2002).

Ashmore was designated a Ramsar Wetland of International Importance in 2003 due to the importance of its islands providing a resting place for migratory shorebirds and supporting large seabird breeding colonies.

The proclaimed marine park will protect the following conservation values (DoE 2014):

- Ecosystems, habitats and communities associated with; the North West Shelf; Timor Province; and emergent oceanic reefs;
- The island and reef habitats:
  - Contains critical nesting and internesting habitat for green turtles (including one of three genetically distinct breeding populations in the North-west Marine Region). Low level nesting activity by loggerhead turtles has also been recorded;
  - Large and significant feeding populations of green, hawksbill and loggerhead turtles occur around the reefs (it is estimated that approximately 11,000 marine turtles feed in the area throughout the year);
  - Supports a small dugong population of less than 50 individuals that breed and feed around the reef. This population is thought to be genetically distinct from other Australian populations;
  - Migratory pathway for pygmy blue whales (Director of National Parks 2018b);
  - Support some of the most important seabird rookeries on the North West Shelf including colonies of bridled terns, common noddies, brown boobies, eastern reef egrets, frigatebirds, tropicbirds, red-footed boobies, roseate terns, crested terns and lesser crested terns;
  - Is an important staging points/feeding areas for many migratory seabirds; and
  - Is internationally significant for its abundance and diversity of sea snakes.
- Two KEFs:
- Ashmore Reef and Cartier Island and surrounding Commonwealth waters; and
- Continental slope demersal fish communities (Director of National Parks 2018b);
- Cultural and heritage sites, including;

+ Ashmore lagoon as a rest/staging area for traditional Indonesian fishers

- Indonesian artefacts; and
- Grave sites.
- Commonwealth heritage listing – Ashmore Reef

Ashmore Reef and nearby islands and reefs are associated with benthic communities consisting predominantly of sand and coral rubble, with noteworthy hard coral, soft coral, algae and seagrasses (Heyward *et al.* 2012; Skewes et al., 1999a, 1999b). The reefs host similar benthic communities, with areas of relatively high live coral cover, although episodes of coral bleaching have been recorded (Heyward *et al.* 2012). Benthic organisms that depend on photosynthesis such as seagrasses, macroalgae and zooxanthellate corals are typically restricted to shallower waters around the reefs, although in the clear tropical waters may be found at considerable depths. Given the shallowest sampling location is greater than 60 m, and that most sampling locations are greater than 100 m deep, diverse benthic communities driven by primary producers such as seagrasses, algae and zooxanthellate corals are not expected to occur at the sampling locations. Data collected in the vicinity of Ashmore Reef indicates that corals are likely to spawn during March and April (Heyward *et al.* 2010).

Soft sediments are widespread in the region, with sediment infauna communities in the region dominated by polychaetes and crustaceans. These taxa accounted for over 80% of benthic infauna sampled, both in terms of numbers of species and individual organisms (Smith *et al.* 1997).

Commercial tourism, recreation and scientific research are important socio-economic values of the marine park (Director of National Parks 2018b).

12.3.13 Cartier Island Marine Park

The Cartier Island Marine Park (Sanctuary Zone – IUCN Category Ia) is located approximately 45 km south-east of Ashmore Reef Marine Park and 610 km north of Broome, Western Australia. Both Marine Parks are in Australia's External Territory of Ashmore and Cartier Islands and are also within an area subject to a Memorandum of Understanding (MoU) between Indonesia and Australia, known as the MoU Box. The Marine Park covers an area of 172 km² and protects the following conservation values (Director of National Parks 2018b):

- Ashmore Reef and Cartier Island and surrounding Commonwealth waters;
- Areas of enhanced productivity in an otherwise low-nutrient environment;
- Regional importance for feeding and breeding aggregations of birds and marine life;
- Continental slope demersal fish communities;
- Area of high diversity in demersal fish assemblages;
- Area of high diversity and abundance of hard and soft corals, gorgonians (sea fans), sponges and a range of encrusting organisms;
- Breeding and foraging habitat for seabirds;
- Internesting, nesting and foraging habitat for marine turtles;
- Foraging habitat for whale sharks;
- Internationally significant for its abundance and diversity of sea snakes;
- One known shipwreck listed under the *Underwater Cultural Heritage Act 2018*: the Ann Millicent (wrecked in 1888).

Scientific research is an important activity in the Marine Park (Director of National Parks 2018b).

12.4 North Marine Park Network

The North Marine Parks Network is aligned to the North Marine Region. The network covers 157,480 km^2 (Director of National Parks 2018c). Broad values of the North Network include:

+ Natural values;
+ Cultural values;
+ Heritage values; and
+ Socio-economic values.

Further detail on the applicable Oceanic Shoals Marine Park is provided below.

12.4.1 Oceanic Shoals Marine Park

The Oceanic Shoals Marine Park (zones within EMBA: Multiple Use Zone - IUCN Category VI- 32,488 km^2; Special Purpose Zone – IUCN VI-24,443 km^2) and is wholly contained within the combined EMBA.

The marine park protects the following conservation values (DoE 2014):

+ Important resting area for turtles between egg laying (internesting area) for the threatened flatback turtle and olive ridley turtle;
+ Important foraging area for the threatened loggerhead turtle and olive ridley turtle;
+ Examples of the ecosystems of two provincial bioregions: the Northwest Shelf Transition Province (which includes the Bonaparte, Oceanic Shoals, and Tiwi meso-scale bioregions) and the Timor Transition Province;
+ KEFs represented in the park are (Director of National Parks 2018c):
  - Carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature);
  - Carbonate banks and terrace system of the Sahul Shelf (unique sea-floor feature);
  - Pinnacles of the Bonaparte Basin (enhanced productivity, unique sea-floor feature); and
  - Shelf break and slope of the Arafura Shelf (unique sea-floor feature).

No heritage listings apply to the marine park. Commercial fishing and mining are important socio-economic values for the park (Director of National Parks 2018c).

A spatial predictive benthic habitat model of the Oceanic Shoals Marine Park has been developed by AIMS, as part of the Australian National Environmental Science Programme, to determine the spatial heterogeneity of the benthic environment and key classes of organisms within the reserve. The benthic habitat model maps the 10 broad classes of benthic organisms; alcyons, gorgonians, soft corals, hard corals, halimeda, macroalgae, seagrass, filterers (e.g. sponges), burrowers (e.g. sea urchins) and no biota detected (Radford and Puotinen 2016).

12.4.2 Arafura Marine Park

The Arafura marine park covers 22,924 km^2 and is comprised of a Multiple Use Zone and Special Purpose Zone (Trawl). The marine park is wholly contained within the combined EMBA. It is located approximately

256 km from Darwin and extends to the outer edge of the Exclusive Economic Zone and the water depth ranges from 15 m to 500 m (Director of National Parks 2018c).

The Arafura Marine Park has been deemed significant because "*it contains habitats, species and ecological communities associated with the Northern Shelf Province and Timor Transition. It includes one key ecological feature: the tributary canyons of the Arafura Depression (valued as a unique seafloor feature with ecological properties of regional significance). It is near to important wetland systems including the Cobourg Peninsula Ramsar site, and provides important foraging habitat for seabirds*" (Director of National Parks, 2018c)

The Arafura Marine Park has both cultural and natural values.

The marine park protects the following natural values (Director of National Parks, 2018c):

+ Ecosystems representative of the Northern Shelf Province
+ Ecosystems representative of the Timor Transition
+ BIAs for Marine Turtles
+ BIAs for Seabirds
+ Tributary canyons of the Arafura Depression key ecological features.

The sea country of the marine park is part of the responsibility of the Yuwurrumu members of the Mandilarri-Ilduji, the Mangalara, the Murran, the Gadura-Minaga and the Ngaynjaharr clans. Sea country is valued for Indigenous cultural identity and Indigenous people have been sustainably using and managing their sea country, including the sea country within the Arafura Marine Park for tens of thousands of years (Director of National Parks, 2018c).

12.4.3 Arnhem Marine Park

The Arnhem Marine Park covers an area of 7125 km² and water depth ranges from less than 15 m to 70 m. The marine park is entirely comprised of a Special Purpose Zone (VI) and the majorityof the marine park is contained within the combined EMBA. It is located approximately 100 km south-east of Croker Island and 60 km south-east of the Arafura Marine Park. It extends from Northern Territory waters surrounding the Goulburn Islands, to the waters north of Maningrida (Director of National Parks 2018c).

The Arnhem Marine Park has been deemed significant because "*it contains habitats, species and ecological communities associated with the Northern Shelf Province. It includes dynamic habitats due to gently sloping shelf topped with a number of pinnacles, at depths ranging from 5 m to 30 m. It is near to important wetland systems including the Blyth-Cadell Floodplain and Boucaut Bay Nationally Important Wetland and provides important foraging habitat for seabirds*" (Director of National Parks 2018c).

The Arnhem Marine Park has both cultural and natural values.

The marine park protects the following natural values (Director of National Parks, 2018c):

+ Ecosystems representative of the Northern Shelf Province
+ Nutrient-rich coastal water contributing to high biological biodiversity
+ BIAs for Marine Turtles
+ BIAs for Seabirds

The sea country of the marine park is part of the responsibility of the coastal Aboriginal people of West Arnhem land. Sea country is valued for Indigenous cultural identity and Indigenous people have been sustainably using and managing their sea country, including the sea country within the Arnhem Marine Park for tens of thousands of years (Director of National Parks, 2018c).

No heritage listings apply to the marine park. Commercial fishing, tourism and recreation are important socio-economic values for the park (Director of National Parks 2018c).

12.4.4 Joseph Bonaparte Marine Park

The Joseph Bonaparte Gulf Marine Park is located approximately 15 km west of Wadeye, Northern Territory, and approximately 90 km north of Wyndham, Western Australia, in the Joseph Bonaparte Gulf. It is adjacent to the Western Australian North Kimberley Marine Park. The marine park covers an area of 8597 km² and water depth ranges between less than 15 m and 100 m, and is wholly contained within the combined EMBA. The marine park is comprised of two zones; Special Purpose Zone (VI) and Multiple Use Zone (VI) (Director of National Parks, 2018c).

The Joseph Bonaparte Marine Park has been deemed significant because "*it contains habitats, species and ecological communities associated with the Northwest Shelf Transition bioregion. It includes one key ecological feature: the carbonate bank and terrace system of the Sahul Shelf (valued as a unique seafloor feature with ecological properties of regional significance). The Marine Park contains a number of prominent shallow seafloor features including an emergent reef system, shoals, and sand banks. It is near an important wetland systems including the Ord River floodplain Ramsar site and provides connectivity between the nearshore and sea environments. The Marine Park includes habitats connecting to and complementing the adjacent Western Australian North Kimberley Marine Park*" (Director of National Parks, 2018c).

The Joseph Bonaparte Marine Park has both cultural and natural values.

The marine park protects the following natural values (Director of National Parks, 2018c):

- Ecosystems representative of the Northwest Shelf Transition
- BIAs for Marine Turtles
- BIA for the Australian Snubfin Dolphin
- KEFs represented in the park are:
  - Carbonate bank and terrace system of the Sahul Shelf (unique sea-floor feature)

The sea country of the marine park is part of the responsibility of the Miriuwung, Gajerrong, Doolboong, Wardenybeng and Gija and Balangarra people. Sea country is valued for Indigenous cultural identify and Indigenous people have been sustainably using and managing their sea country, including the sea country within the Arnhem Marine Park for tens of thousands of years (Director of National Parks, 2018c).

No heritage listings apply to the marine park, however the marine park is adjacent to the West Kimberly National Heritage Place. Tourism, commercial fishing, mining and recreation are important socio-economic values for the park (Director of National Parks 2018c).

Santos

Table 12-1 Summary of marine network values, pressures, management programs and actions applicable to the combined EMBA

Marine network	Values	Pressures	Management programs and actions
SOUTH WEST	+ Nine bioregions + Key ecological features + EPBC listed species + Biologically important areas + Sea country indigenous values + Historic shipwrecks + Adjacent to Shark Bay World Heritage Area + Shipping and port activities + Commercial fishing + Marine tourism	+ Climate change + Hydrological changes from coastal development and agriculture (increase sediment loads and pollutants) + Illegal/unregulated/unreported fishing + Bycatch of non-target species + Habitat modification from mining + Human presence + Invasive species + Marine pollution	+ Communication, education and awareness programs + Promote suitable tourism experience + Facilitate partnerships between tourism operators and Indigenous operators + Indigenous engagement program + Marine monitoring programs + Park management via assessments / authorisation program for marine park activities + Marine park management and development of suitable infrastructure + Compliance planning and surveillance

Marine network	Values	Pressures	Management programs and actions
NORTH WEST	+ Eight bioregions + Key ecological features + EPBC listed species + Biologically important areas + Sea country indigenous values + Native title determinations + Traditional Indonesian fishers + World Heritage Properties (Ningaloo Coast, Shark Bay) + Ashmore Reef Marine Park and Eighty-Mile Beach Ramsar sites + Shipping and port activities + Commercial fishing, pearling, aquaculture + Marine tourism + Scientific research	+ Climate change + Hydrological changes from coastal development and agriculture (increase sediment loads and pollutants) + Illegal/unregulated/unreported fishing + Bycatch of non-target species + Habitat modification from mining + Human presence + Invasive species + Marine pollution	+ Communication, education and awareness programs + Promote suitable tourism experience + Facilitate partnerships between tourism operators and Indigenous operators + Indigenous engagement program + Marine monitoring programs + Park management via assessments / authorisation program for marine park activities + Marine park management and development of suitable infrastructure + Compliance planning and surveillance
NORTH	+ One bioregion + Key ecological features + EPBC listed species + Biologically important areas + Historic shipwrecks	+ Climate change + Hydrological changes reliance upon the large number of estuaries and waterways that feed into the Gulf of Carpentaria and the waters adjacent to the Northern Territory coastline + Illegal/unregulated/unreported fishing + Bycatch of non-target species + Physical Habitat modification + Marine pollution	+ Communication, education and awareness programs + Promote suitable tourism experience + Facilitate partnerships between tourism operators and Indigenous operators + Indigenous engagement program + Marine monitoring programs + Park management via assessments / authorisation program for marine park activities + Marine park management and development of suitable infrastructure + Compliance planning and surveillance

13. Conservation Management Plans

In order to protect, maintain and enhance recovery of certain threatened species and ecological communities the DAWE may prepare conservation management plans in the form of Conservation Advice or Recovery Plans.

13.1 Conservation Advice

When a native species or ecological community is listed as threatened under the EPBC Act, conservation advice is developed to assist its recovery. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of a newly listed species or ecological community.

13.2 Recovery Plans

The Australian Government Minister for the Environment may make or adopt and implement recovery plans for threatened fauna, threatened flora (other than conservation dependent species) and threatened ecological communities listed under the Commonwealth EPBC Act. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long-term survival in the wild of a threatened species or ecological community.

Table 13-1: Summary of EPBC Act recovery plans applicable to the combined EMBA

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
Bird	Australian lesser noddy	Approved Conservation Advice for *Anous tenuirostris melanops* (Australian lesser noddy) (2015)	Habitat modification by pied cormorants (Houtman Abrolhos)
			Catastrophic destruction of habitat by cyclones
	Migratory species within the combined EMBA: + Asian dowitcher; + Bar-tailed godwit; + Black-tailed godwit; + Broad-billed sandpiper; + Common greenshank; + Common redshank; + Common sandpiper; + Curlew Sandpiper; + Double-banded plover; + Eastern Curlew; + Fork-tailed swift; + Grey plover; + Grey-tailed tattler; + Long-toed stint; + Little greenshank + Oriental plover; + Oriental pratincole; + Pacific golden plover; + Pectoral sandpiper; + Red-necked phalarope; + Red-necked stint; + Red knot; + Ruddy turnstone; + Ruff (reeve);	Wildlife Conservation Plan for Migratory Shorebirds (2015)	Habitat loss and degradation
			Pollution and Contaminants
			Invasive species
			Anthropogenic disturbance
			Climate change and variability
			Overharvesting of shorebird prey
			Fisheries bycatch
			Direct mortality (hunting)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	+ Sanderling; + Sharp-tailed sandpiper; + Streaked shearwater; + Terek sandpiper; + Whimbrel; and + Wood sandpiper.		
	Migratory and/or marine species within the combined EMBA + Red-tailed Tropicbird; + White-tailed Tropicbird; + Broad-billed Prion; + Fairy Prion; + Wedge-tailed Shearwater; + Flesh-footed Shearwater; + Sooty Shearwater; + Short-tailed Shearwater; + Streaked Shearwater; + Lesser Frigatebird; + Great Frigatebird; + Masked Booby; + Red-footed Booby; + Brown Booby; + Common Noddy; + Bridled Tern; + Little Tern; + Caspian Tern; + Roseate Tern and; + Osprey.	Wildlife Conservation Plan for Migratory Seabirds (2020)	Habitat loss and modification Climate variability and change Geological processes (volcanism, earthquake, tsunami and landslips) Invasive species Native wildlife Fisheries interactions and by-catch Prey depletion Resource extraction Renewable energy (collision/limited foraging) Anthropogenic disturbance Direct mortality (hunting) Transport Drones Pollution and contaminants Aquaculture Disease
	Christmas Island frigatebird		Introduction of a new disease

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		Conservation Advice for the Christmas Island frigatebird *Fregata andrewsi* (2020a) Recovery Plan for the Christmas Island Frigatebird (*Fregeta andrewsi*) (2004)	Disturbance of habitat
			Fisheries – prey depletion
			Illegal killing and hunting in south-east Asia
			Invasive weeds
			Fisheries - bycatch
			Drowning in artificial water bodies
			Heavy metal contamination
			Marine debris - plastics
	Australasian bittern	Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern) (2019)	habitat loss through water reductions and transition from ponded rice to other farming systems
			habitat degradation through increased salinity, siltation and pollution; grazing by livestock and feral animalsan d changes in abundance of plant species
			Climate change through changes in water availability; changes in fire regimes and salinisation of coastal wetlands
			Infrastructure through urban development
			Predation by introduced vertebrate pests such as foxes and cats
	Red knot	Approved Conservation Advice for *Calidris canutus* (Red knot) (2016) Wildlife Conservation Plan for Migratory Shorebirds (2015)	Habitat loss and habitat degradation
			Over-exploitation of shellfish
			Pollution/contamination impacts
			Disturbance
			Direct mortality (hunting)
			Diseases
			Extreme weather events
			Climate change impacts

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	Curlew sandpiper	Approved Conservation Advice for *Calidris ferruginea* (Curlew Sandpiper) (2015)	Ongoing human disturbance
			Habitat loss and degradation from pollution
			Changes to the water regime
			Invasive plants
	Great knot	Approved Conservation Advice for *Calidris tenuirostriss* (Great knot) (2016) Wildlife Conservation Plan for Migratory Shorebirds (2015).	Habitat loss and habitat degradation
			Pollution/contaminants
			Disturbance
			Diseases
			Direct mortality (hunting)
			Climate change impacts
	Greater sand plover	Approved Conservation Advice for *Charadrius leschenaultii* (Greater sand plover) (2016) Wildlife Conservation Plan for Migratory Shorebirds (2015)	Habitat loss and habitat degradation
			Pollution/contamination impacts
			Disturbance
			Direct mortality (hunting)
			Diseases
			Climate change impacts
	Lesser sand plover	Approved Conservation Advice for *Charadrius mongolus* (Lesser sand plover) (2016) Wildlife Conservation Plan for Migratory Shorebirds (2015)	Habitat loss and habitat degradation
			Pollution/contamination impacts
			Disturbance
			Direct mortality (hunting)
			Diseases
			Climate change impacts
	Antipodean albatross		Incidental catch resulting from fishing operations

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Amsterdam albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Tristan albatross		Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Southern royal albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Wandering albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Northern royal albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Blue petrel	Approved Conservation Advice for *Halobaena caerulea* (blue petrel) (2015)	Habitat loss, disturbance and modification
			Predation
	Western Alaskan bar-tailed godwit	Wildlife Conservation Plan for Migratory Shorebirds (2015)	Habitat loss and habitat degradation
			Over-exploitation of shellfish

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan)) (2016)	Pollution/contamination impacts
			Disturbance
			Direct mortality (hunting)
			Diseases
			Extreme weather events
			Climate change impacts
	Northern Siberian bar-tailed godwit	Approved Conservation Advice for *Limosa lapponica menzbieri* (Bar-tailed godwit (northern Siberian)) (2016)	Habitat loss and habitat degradation
			Over-exploitation of shellfish
			Pollution/contamination impacts
			Disturbance
			Direct mortality (hunting)
			Diseases
			Extreme weather events
			Climate change impacts
	Southern giant petrel	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Loss of nesting habitat
			Competition for nest space
	Northern giant petrel	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Eastern curlew	Approved Conservation Advice *for Numenius madagascariensis* (eastern curlew) (2015)	Ongoing human disturbance
			Habitat loss and degradation from pollution
			Changes to the water regime
			Invasive plants
	Fairy prion (southern)	Approved Conservation Advice for *Pachyptila turtur subantarctica* (fairy prion (southern)) (2015)	Competition with blue petrels
			Soil erosion
			Fire
	Abbott's booby	Conservation Advice for the Abbott's booby *Papasula abbotti* (2020b)	Vegetation clearing – edge effects from previous clearing and new vegetation clearing
			Climate change – severe storm events and prey depletion
			Introduction of a new disease

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Invasive weeds
			Yellow crazy ants – habitat modification
			Fisheries – prey depletion
			Marine debris - plastics
	Christmas Island white-tailed tropicbird	Conservation Advice for *Phaethon lepturus fulvus* white-tailed tropicbird (Christmas Island) (2014)	Introduced predators on Christmas Island
			Crazy ants
	Sooty albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Soft-plumaged petrel	Approved Conservation Advice for *Pterodroma mollis* (soft-plumaged petrel) (2015)	Accidental introduction of predators (relevant only to Maatsuyker Island, located offshore of Tasmania)
	Australian painted snipe	Commonwealth Conservation Advice on *Rostratula australis* (Australian painted snipe) (2013)	Loss and degradation of wetlands, through drainage and the diversion of water for agriculture and reservoirs
			Grazing and associated trampling of wetland vegetation/nests, nutrient enrichment and disturbance to substrate by livestock

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Climate change
			Predation by feral animals
			Introduction of weeds
	Australian fairy tern	Commonwealth Conservation Advice on *Sternula nereis nereis* (fairy tern) (2011)	Predation by introduced mammals and native birds
			Disturbance by humans, dogs and vehicles
			Increasing salinity in waters adjacent to Fairy Tern colonies
			Irregular water management
			Weed encroachment
			Oil spills, particularly in Victoria (potential threat)
	Indian yellow-nosed albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Shy albatross	Conservation Advice *Thalassarche cauta* Shy Albatross (2020c)	Fisheries bycatch
			Disease
			Competition for nesting habitat

Santos

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Marine plastics
			Human disturbance
			Previous harvesting for feathers and eggs
			Climate change
	White-capped albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Campbell albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Black-browed albatross	National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Incidental catch resulting from fishing operations
			Competition with fisheries for marine resources
			Dependence on discards
			Marine pollution
			Climate change
			Intentional shooting/killing
			Feral pest species
			Human disturbance at the nest
			Parasites and diseases
			Loss of nesting habitat
			Competition for nest space
	Round Island Petrel	Conservation Advice *Pterodroma arminjoniana* Round Island Petrel (2015)	Introduced pests and predators
			Cyclones
Mammals	Sei whale	Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015)	Climate and oceanographic variability and change
			Anthropogenic noise and acoustic disturbance
			Habitat degradation including pollution (increasing port expansion and coastal development)
			Pollution (persistent toxic pollutants)
			Vessel strike

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Prey depletion due to fisheries (potential threat)
			Resumption of commercial whaling (potential threat)
	Blue whale	Blue Whale Conservation Management Plan 2015 - 2025 (2015)	Whaling
			Climate Variability and Change
			Noise Interference
			Habitat Modification
			Vessel Disturbance
			Overharvesting of prey
	Fin whale	Approved Conservation Advice for *Balaenoptera physalus* (fin whale) (2015)	Climate and oceanographic variability and change
			Anthropogenic noise and acoustic disturbance
			Habitat degradation including coastal development, port expansion and aquaculture
			Pollution (persistent toxic pollutants)
			Fisheries catch, entanglement and bycatch
			Vessel strike
			Resource depletion due to fisheries (potential threat)
			Resumption of commercial whaling (potential threat)
	Southern right whale	Conservation Management Plan for the Southern Right Whale 2011 – 2021 (2012)	Entanglement
			Vessel disturbance
			Whaling
			Climate variability and change
			Noise interference
			Habitat modification
			Overharvesting of prey

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	Australian sea-lion	Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*) (2013)	Fishery bycatch (primary threat)
			Entanglement in marine debris (primary threat)
			Marine aquaculture
			Habitat degradation
			Human disturbance
			Direct killing (primary threat)
			Disease
			Pollution and oil spills
			Noise
			Competition and prey depletion
			Climate change
Reptiles	Short-nosed seasnake	Approved Conservation Advice on *Aipysurus apraefrontalis* (Short-nosed seasnake) (2011)	Degradation of reef habitat, primarily as a result of coral bleaching (primary threat)
			Oil and gas exploration
			Incidental catch and death in commercial prawn trawling fisheries
	Leaf-scaled seasnake	Approved Conservation Advice on *Aipysurus foliosquama* (Leaf-scaled seasnake) (2011)	Degradation of reef habitat, primarily as a result of coral bleaching (primary threat)
			Oil and gas exploration
			Incidental catch and death in commercial prawn trawling fisheries (north-west marine area)
			Unsustainable and illegal fishing practices (currently the most significant threat in the Ashmore region)
	Loggerhead turtle	Recovery plan for marine turtles in Australia 2017 – 2027 (2017) Loggerhead turtle – WA genetic stock	Fisheries bycatch – international (moderate), domestic (high)
			Indigenous take (moderate)
			Terrestrial predation (moderate)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Habitat modification – infrastructure/coastal development (moderate), dredging/trawling (moderate)
			Chemical and terrestrial discharge – acute (high), chronic (low)
			Marine debris – entanglement and ingestion (moderate; unknown)
			Climate change and variability (high)
			International take – outside Australia's jurisdiction (moderate), within Australia's jurisdiction (low)
			Light pollution (moderate)
			Vessel disturbance (moderate)
			Noise interference – acute (moderate), chronic (moderate; unknown)
			Recreational activities (low)
			Diseases and pathogens (low; unknown)
			Fisheries bycatch – international (moderate), domestic (high)
			Cumulative impacts of threats
	Green turtle	Recovery plan for marine turtles in Australia 2017 – 2027 (2017) Green turtle – NWS genetic stock (NWS), Scott-Browse genetic stock (ScBr), Ashmore genetic stock (AR)	Fisheries bycatch – international (moderate), domestic (moderate)
			Indigenous take (moderate)
			Terrestrial predation NWS – moderate, AR –high; unknown, ScBr – moderate; unknown)
			Habitat modification – infrastructure/coastal development (NWS – moderate, AR – low, ScBr – high), dredging/trawling (NWS – moderate, AR – low, ScBr – low)
			Chemical and terrestrial discharge – acute (NWS, AR, ScBr –high), chronic (NWS – moderate, AR – high, ScBr – high)
			Marine debris – entanglement (NWS – moderate, AR – very high, ScBr – moderate; unknown) and ingestion (NWS – low; unknown, AR – moderate, ScBr – moderate)
			Climate change and variability (NWS – moderate, AR – very high, ScBr – high)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			International take – outside Australia's jurisdiction (moderate; unknown for NWS and ScBr), within Australia's jurisdiction (moderate; unknown for NWS and ScBr)
			Light pollution (NWS – high, AR – moderate, ScBr – moderate)
			Vessel disturbance (moderate)
			Noise interference – acute (NWS – moderate; unknown, AR – low, ScBr – moderate), chronic (NWS – moderate; unknown, AR – low, ScBr – moderate; unknown)
			Recreational activities
			Diseases and pathogens (low; unknown for AR and ScBr)
			Cumulative impacts of threats
	Leatherback turtle	Approved Conservation Advice on *Dermochelys coriacea* (2008)	Incidental capture in commercial fisheries
			Harvest of eggs and meat
			Ingestion of marine debris
			Boat strike
			Predation on eggs by wild dogs, pigs and monitor lizards
			Degradation of foraging areas
			Changes to breeding sites
		Recovery plan for marine turtles in Australia 2017 – 2027 (2017)	Fisheries bycatch – international (high), domestic (high)
			Indigenous take (low)
			Terrestrial predation (moderate; unknown)
			Habitat modification – infrastructure/coastal development (moderate), dredging/trawling (low)
			Chemical and terrestrial discharge – acute (low), chronic (low; unknown)
			Marine debris – entanglement (moderate) and ingestion (high)
			Climate change and variability (high)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			International take – outside Australia's jurisdiction (high), within Australia's jurisdiction (low)
			Light pollution (low)
			Vessel disturbance (moderate)
			Noise interference – acute (low; unknown), chronic (low; unknown)
			Recreational activities (low)
			Diseases and pathogens (low; unknown)
			Fisheries bycatch – international (high), domestic (high)
			Cumulative impacts of threats
	Hawksbill turtle	Recovery plan for marine turtles in Australia 2017 – 2027 (2017) Hawksbill turtle – WA genetic stock	Fisheries bycatch – international (moderate), domestic (moderate)
			Indigenous take (moderate)
			Terrestrial predation (moderate)
			Habitat modification – infrastructure/coastal development (moderate), dredging/trawling (moderate)
			Chemical and terrestrial discharge – acute (moderate), chronic (moderate)
			Marine debris – entanglement (moderate) and ingestion (low; unknown)
			Climate change and variability (high)
			International take – outside Australia's jurisdiction (very high), within Australia's jurisdiction (moderate)
			Light pollution (high)
			Vessel disturbance (moderate)
			Noise interference – acute (moderate), chronic (moderate; unknown)
			Recreational activities (low)
			Diseases and pathogens (low; unknown)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Cumulative impacts of threats
	Olive ridley turtle	Recovery plan for marine turtles in Australia 2017 – 2027 (2017) Olive ridley turtle – Northern Territory genetic stock	Fisheries bycatch – international (moderate), domestic (high)
			Indigenous take (moderate)
			Terrestrial predation (moderate; unknown)
			Habitat modification – infrastructure/coastal development (low), dredging/trawling (low)
			Chemical and terrestrial discharge – acute (high), chronic (moderate)
			Marine debris – entanglement (very high) and ingestion (moderate; unknown)
			Climate change and variability (very high)
			International take – outside Australia's jurisdiction (moderate), within Australia's jurisdiction (moderate)
			Light pollution (moderate)
			Vessel disturbance (moderate)
			Noise interference – acute (low), chronic (low; unknown)
			Recreational activities (low)
			Diseases and pathogens (low; unknown)
			Cumulative impacts of threats
	Flatback turtle	Recovery plan for marine turtles in Australia 2017 – 2027 (2017) Flatback turtle – Pilbara coast genetic stock (Pil), South-west Kimberley coast genetic stock (swKim) and Cape Domett (CD)	Fisheries bycatch – international (low), domestic (moderate)
			Indigenous take (moderate)
			Terrestrial predation (moderate)
			Habitat modification – infrastructure/coastal development (Pil – high, swKim – moderate), dredging/trawling (moderate)
			Chemical and terrestrial discharge – acute (high), chronic (moderate)
			Marine debris – entanglement (moderate) and ingestion (low)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Climate change and variability (Pil – high, swKim – moderate)
			International take – outside Australia's jurisdiction (low), within Australia's jurisdiction (low)
			Light pollution (Pil – high, swKim – moderate)
			Vessel disturbance (moderate)
			Noise interference – acute (moderate), chronic (moderate; unknown)
			Recreational activities (Pil – low, swKim – moderate)
			Diseases and pathogens (low; unknown)
			Cumulative impacts of threats
Sharks and fish	Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (2014)	Mortality due to incidental capture by commercial and recreational fisheries
			Mortality die to shark control programs
			Ecotourism
			Public aquarium trade
			Pollution and disease
			Ecosystem effects - habitat modification and climate change
	Great white shark	Recovery plan for the White Shark (*Carcharodon carcharias*) (2013)	Mortality related to being caught accidentally (bycatch) or illegally (targeted) by commercial and recreational fisheries, including issues of post release mortality
			Mortality related to shark control activities such as beach meshing or drumlining (east coast population)
			Illegal trade in white shark products
			Ecosystem effects as a result of habitat modification and climate change
			Ecotourism
	Northern river shark	Approved Conservation Advice for *Glyphis garricki* (northern river shark) (2014)	Commercial fishing activities
			Recreational fishing

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Indigenous fishing
			Illegal, unreported and unregulated fishing
			Habitat degradation and modification
			Marine debris
			Collection of animals for display in public aquaria (no known occurrences to date)
		Sawfish and River Sharks Multispecies Recovery Plan (2015)	Fishing activities including: being caught as by-catch in the commercial and recreational sectors; through indigenous fishing; and illegal, unreported and unregulated fishing
			Habitat degradation and modification
	Dwarf sawfish	Approved Conservation Advice on *Pristis clavata* (dwarf sawfish) (2009)	Being caught as bycatch in commercial and recreational net fishing
			Illegal, unreported and unregulated fishing
			Habitat degradation due to increasing human development
		Sawfish and River Sharks Multispecies Recovery Plan (2015)	Fishing activities including: being caught as by-catch in the commercial and recreational sectors; through indigenous fishing; and illegal, unreported and unregulated fishing
			Habitat degradation and modification
	Freshwater sawfish	Approved Conservation Advice for *Pristis pristis* (largetooth sawfish) (2014)	Commercial fishing activities
			Recreational fishing
			Indigenous fishing
			Illegal, unreported and unregulated fishing
			Habitat degradation and modification
			Marine debris
			Collection of animals for display in public aquaria
		Sawfish and River Sharks Multispecies Recovery Plan (2015)	Fishing activities including: being caught as by-catch in the commercial and recreational sectors; through indigenous fishing; and illegal, unreported and unregulated fishing
			Habitat degradation and modification

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	Green sawfish	Approved Conservation Advice for *Pristis zijsron* (green sawfish) (2008)	Capture as bycatch and byproduct in gillnet and trawl fisheries
			Illegal capture for fins and rostra
			Habitat degradation through coastal development
		Sawfish and River Sharks Multispecies Recovery Plan (2015)	Fishing activities including: being caught as by-catch in the commercial and recreational sectors; through indigenous fishing; and illegal, unreported and unregulated fishing
			Habitat degradation and modification
	Whale shark	Approved Conservation Advice for *Rhincodon typus* (whale shark) (2015)	Intentional and unintentional mortality from fishing outside of Australian waters
			Boat strike from large vessels
			Habitat disruption from mineral exploration, production and transportation
			Disturbance from domestic tourism operations
			Marine debris
			Climate change
	Blind gudgeon	Approved Conservation Advice for *Milyeringa veritas* (blind gudgeon) (2008)	Habitat degradation and modification associated with sedimentation from mining/construction, canal development, water abstraction, point source pollution from sewage, landfill, dumping and mining; and diffuse pollution from urban development/ petroleum infrastructure
	Blind cave eel	Approved Conservation Advice for *Ophisternon candidum* (blind cave eel) (2008)	Habitat degradation and modification associated with sedimentation from mining/construction, canal development, water abstraction, point source pollution from sewage, landfill, dumping and mining; and diffuse pollution from urban development
	Balston's pygmy perch	Approved Conservation Advice for *Nannatherina balstoni* (Balston's pygmy perch) (2008)	Habitat degradation and modification associated with flow and increased salinisation, siltation and eutrophication that occur through changes to flow regimes (regulation and abstraction), road maintenance, mineral sand exploration and mining, ground water extraction and agricultural and forestry practices in the uppermost catchment
	Black-stripe minnow	Approved Conservation Advice for *Galaxiella nigrostriatal* (Black-striped minnow) (2018)	Climate change – increased air and water temperatures, decreased rainfall, increased evaporation, lowering groundwater table.
			Invasive species (*Gambusia holbrooki*), aggressive interactions and competition

14. Social, Economic and Cultural Features

14.1 Industry

In 2018/19, Western Australia's petroleum industry was worth $38.4 billion per annum. The petroleum sector accounted for 26% of the total value of WA's mineral and petroleum sales in 2018/19, with 20 per cent of all mineral and petroleum sales coming from Liquefied Natural Gas (LNG). Currently Western Australia has four operating LNG projects; the North West Shelf, Gorgon, Pluto and Wheatstone. There are also a number of Floating Production and Storage Offtake (FPSO) facilities in the Timor Sea and North West Shelf, as denoted on **Figure 14-1, Figure 14-2** and **Figure 14-3**. Offshore development is focussed in the Carnarvon Basin, Browse Basin and on the North West Shelf (DMP 2014). There are also domestic gas plants on Varanus Island in the North West Shelf, Devil Creek Onshore Gas Plant and Macedon Gas Plant in the Pilbara region and an oil facility near Dongara called Cliff Head. There are several exploration and production permits and leases throughout WA and Commonwealth waters in the combined EMBA. Existing petroleum infrastructure, permits and licences are shown in **Figure 14-1, Figure 14-2** and **Figure 14-3**.

14.2 Other Infrastructure

The Jasuraus submarine communication cable links Australia with Indonesia. The cable was installed as a link from Australia to provide telephone services connection to the world in 1995-1996. Travelling north out of Port Hedland for approximately 210 km the cable then heads north-west toward Jakarta, Indonesia. The cable runs up through Permit Areas WA-435-P and WA437-P. Its capacity and major role was overtaken in 2000 by other subsea cables out of Australia. However, Telstra continues to manage the cable as it remains an emergency backup link out of Australia. The cable includes two submerged repeaters in the wider region.

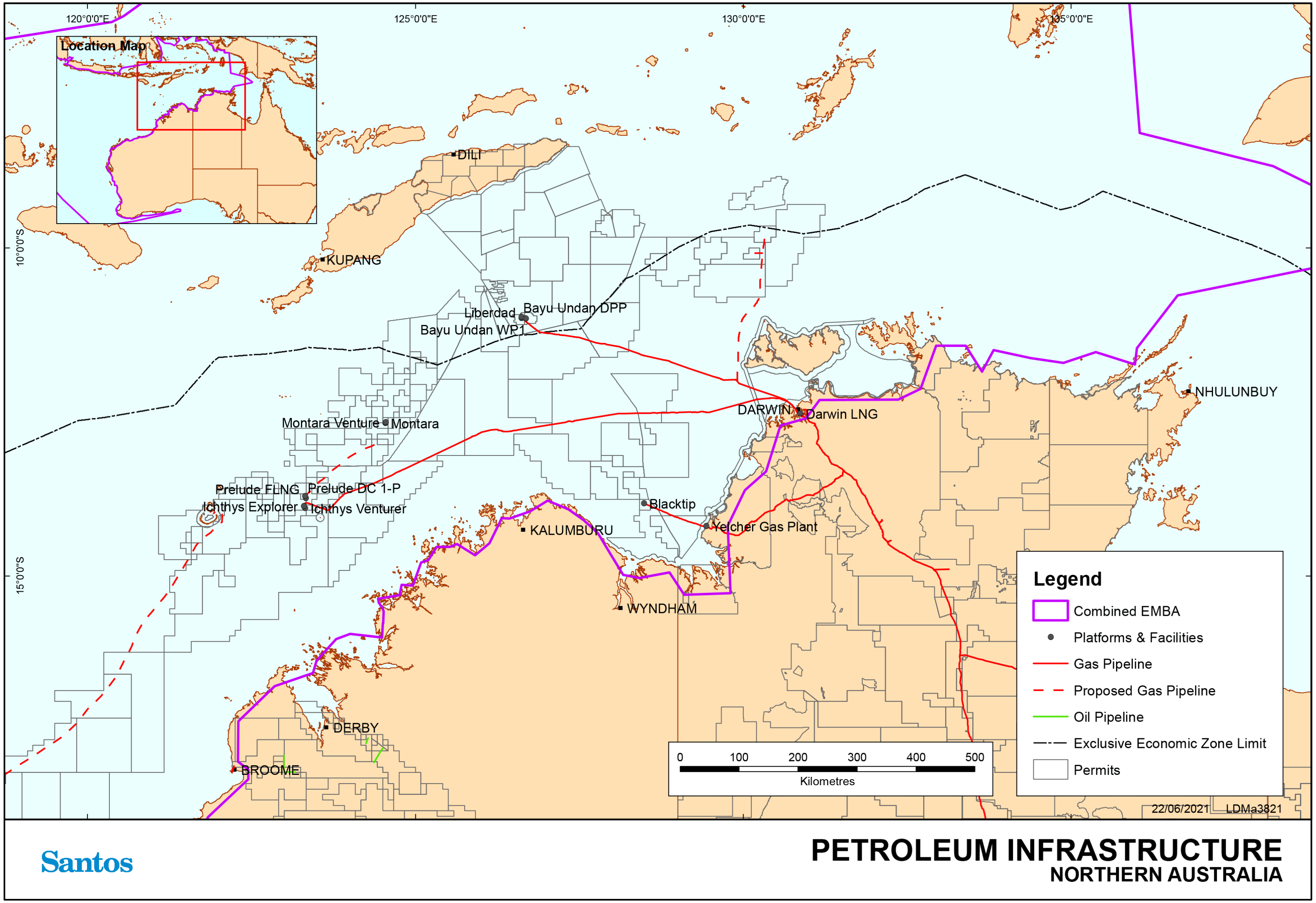


Figure 14-1: Existing petroleum infrastructure, permits and licences – Northern WA

Santos

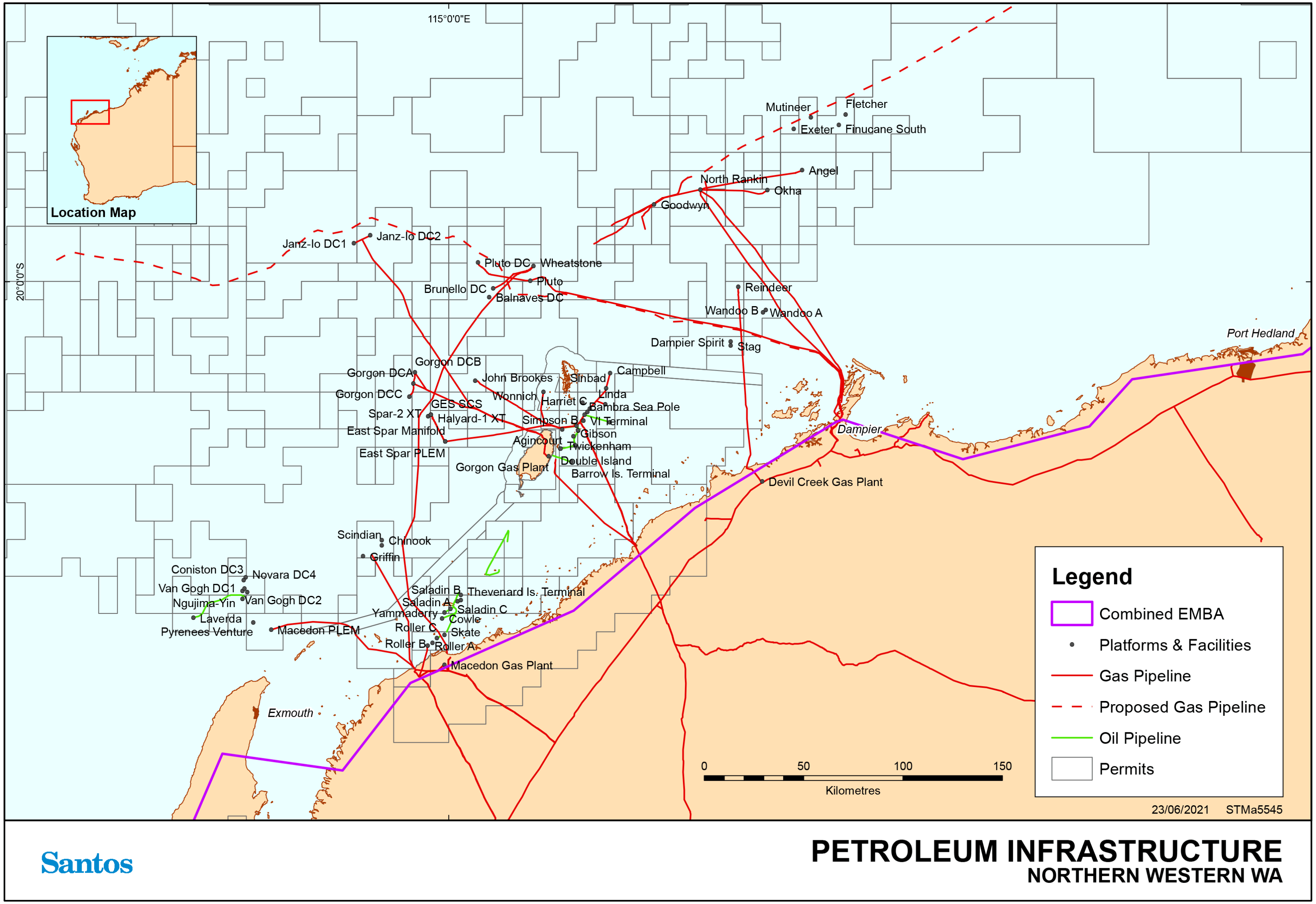


Figure 14-2: Existing petroleum infrastructure, permits and licences – Northern Western WA

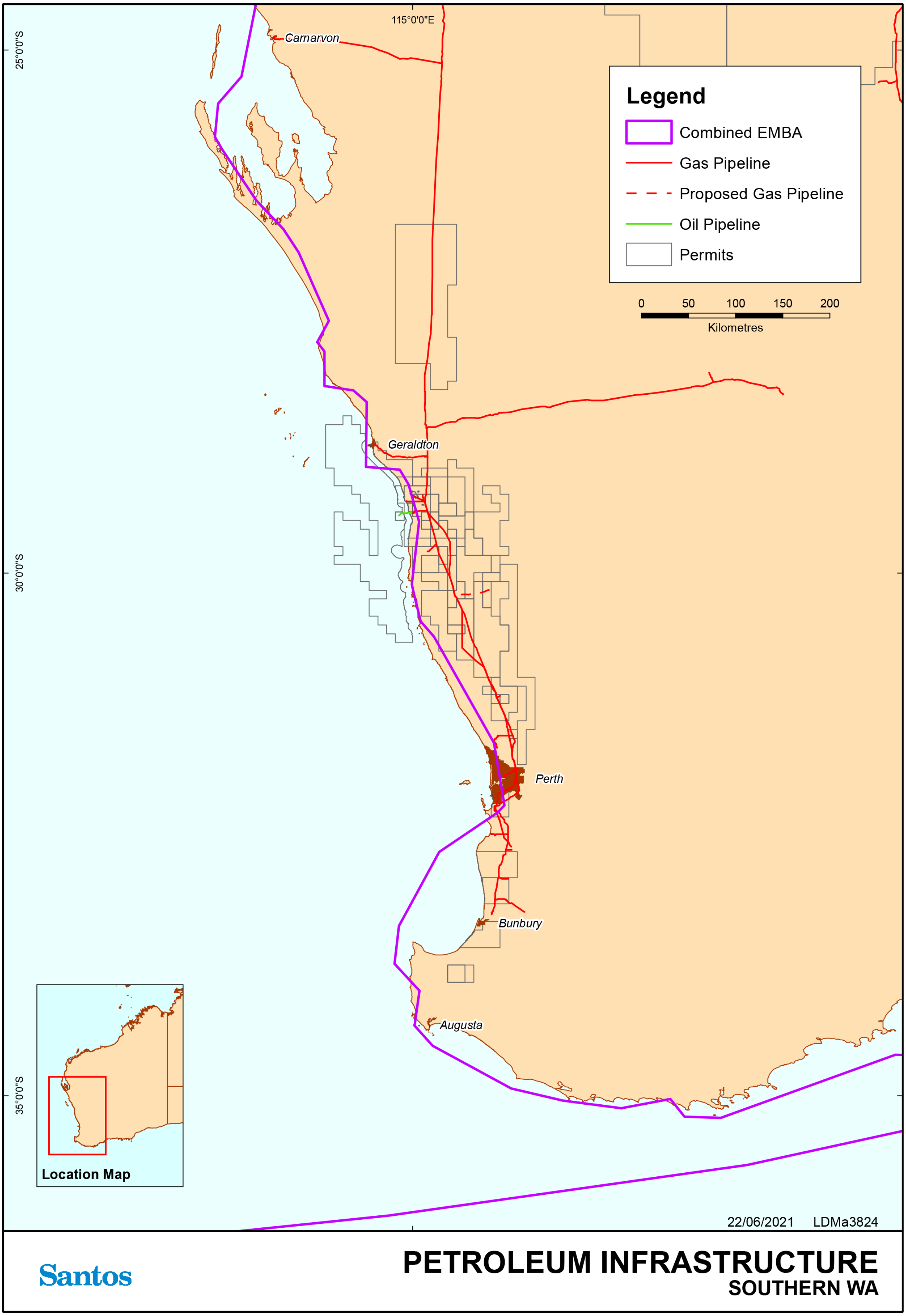


Figure 14-3: Existing petroleum infrastructure, permits and licences –Southern WA

14.3 Shipping

The Western Australian coastline supports twelve ports including the major ports of Dampier, Port Hedland and Broome which are operated by their respective port authorities. Large cargo vessels move through the region to and from Fremantle, transiting along coastline. Commercial shipping also moves to and from marine terminals associated with the oil and gas industry (see **Section 14.1**). Other large ports include Geraldton, Busselton, Albany and Esperance. Closer proximity shipping also includes construction vessels/barges/dredges, domestic support vessels, and offshore survey vessels.

The Australian Maritime Safety Authority (AMSA) has established a network of shipping fairways off the north-west coast of Australia to manage traffic patterns (AMSA 2013). The Shipping Fairways are designed to keep shipping traffic away from offshore infrastructure and aims to reduce the risk of collision (AMSA 2013).

Use of the fairways is strongly recommended but not mandatory. The International Regulations for *Preventing Collisions at Sea 1972* apply to all vessels navigating within or outside the shipping fairways. The use of these fairways does not give vessels any special right of way (AMSA 2012).

Under the *Commonwealth Navigation Act 2012*, certain vessels operating in Australian waters are required to report their location on a daily basis to the Rescue Coordination Centre (RCC) in Canberra. This Australian Ship Reporting System (AUSREP) is an integral part of the Australian Maritime Search and Rescue system and is operated by AMSA through the RCC. Vessels recorded in waters in the combined EMBA through the AUSREP system in 2021 are shown in **Figure 14-4**.

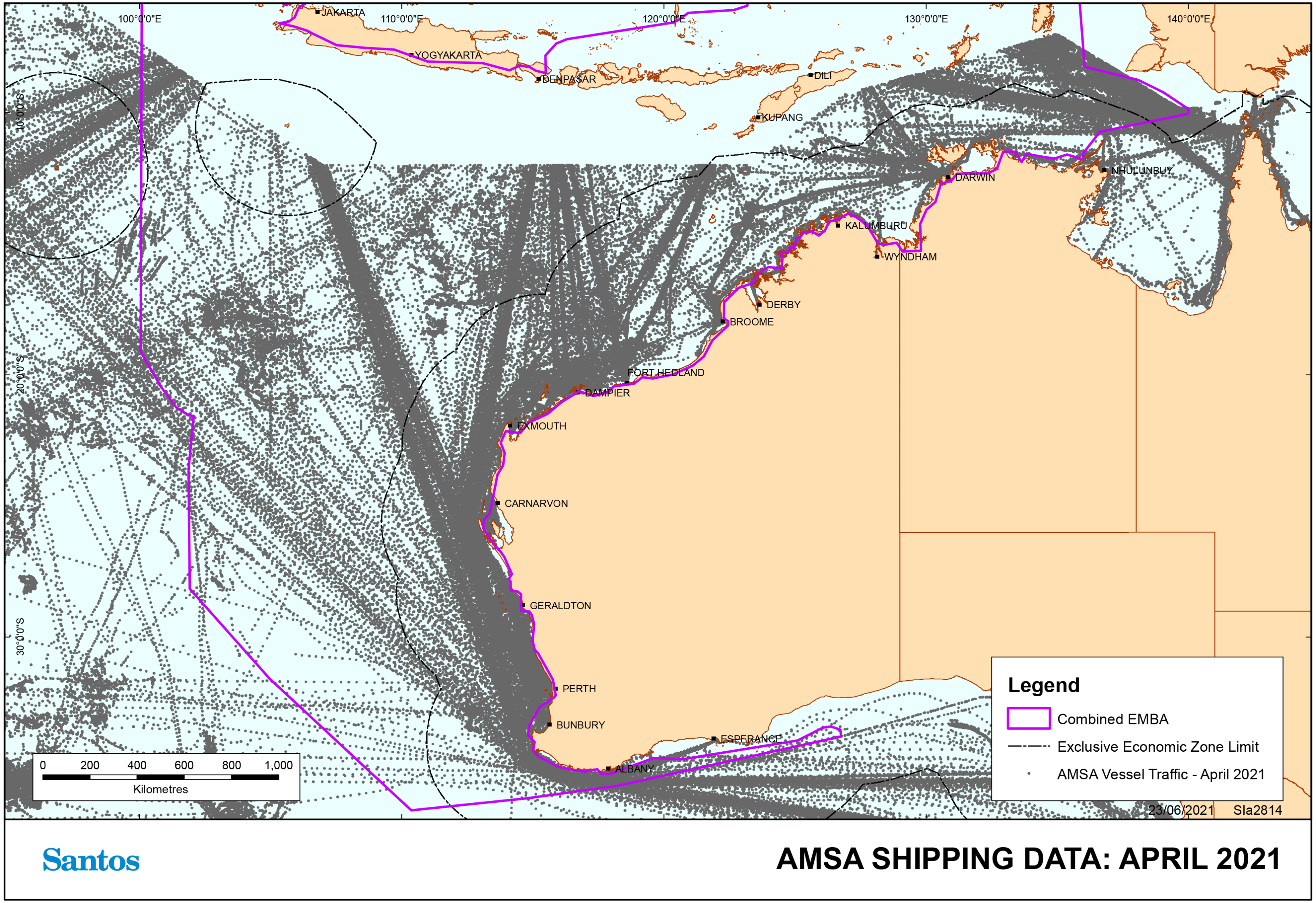


Figure 14-4: AMSA ship locations and shipping routes

14.4 Defence Activities

Key defence bases and facilities are illustrated in **Figure 14-5.**

The Naval Communication Station Harold E. Holt is located on the northwest coast of Australia, 6 km north of Exmouth. The town of Exmouth was built at the same time as the communications station to provide support to the base and to house dependent families of US Navy personnel (Shire of Exmouth 2018, DoE 2014).

The station provides very low frequency radio transmission to US Navy and Royal Australian Navy ships and submarines in the western Pacific Ocean and eastern Indian Ocean. With a transmission power of 1 megawatt, it is the most powerful transmission station in the southern hemisphere (Shire of Exmouth 2018, DoE 2014).

Two Royal Australian Airforce (RAAF) bases are located in the northwest of WA; Learmonth RAAF Base, near Exmouth and Curtin RAAF Base near Derby (RAAF 2014).

Designated military exercise areas occur over waters and airspace of the north west of WA and may be activated following the required notifications.

Additional defence activities that occur within the combined EMBA include:

+ Broome training depot;
+ Exmouth admin and high frequency transmitting;
+ Exmouth Very Low Frequency transmitting station;
+ Geraldton training depot “A” Company 16th Battalion;
+ HMAS Stirling-Rockingham;
+ HMAS Stirling-Garden Island;
+ Karratha training depot;
+ Learmonth – air weapons range;
+ Learmonth radar site – Vlaming Head Exmouth; and
+ Yampi Sound training area.
+ Bradshaw Defence field training area
+ Artillery Barracks – Fremantle
+ Camble Barracks- Swanborne
+ Irwin Barracks – Karrakatta
+ Lancelin Training Area
+ Leeuwin Barracks- East Fremantle
+ Preston Point Training Depot
+ Rockingham – Navy CPSO
+ Swanbourne Rifle Range

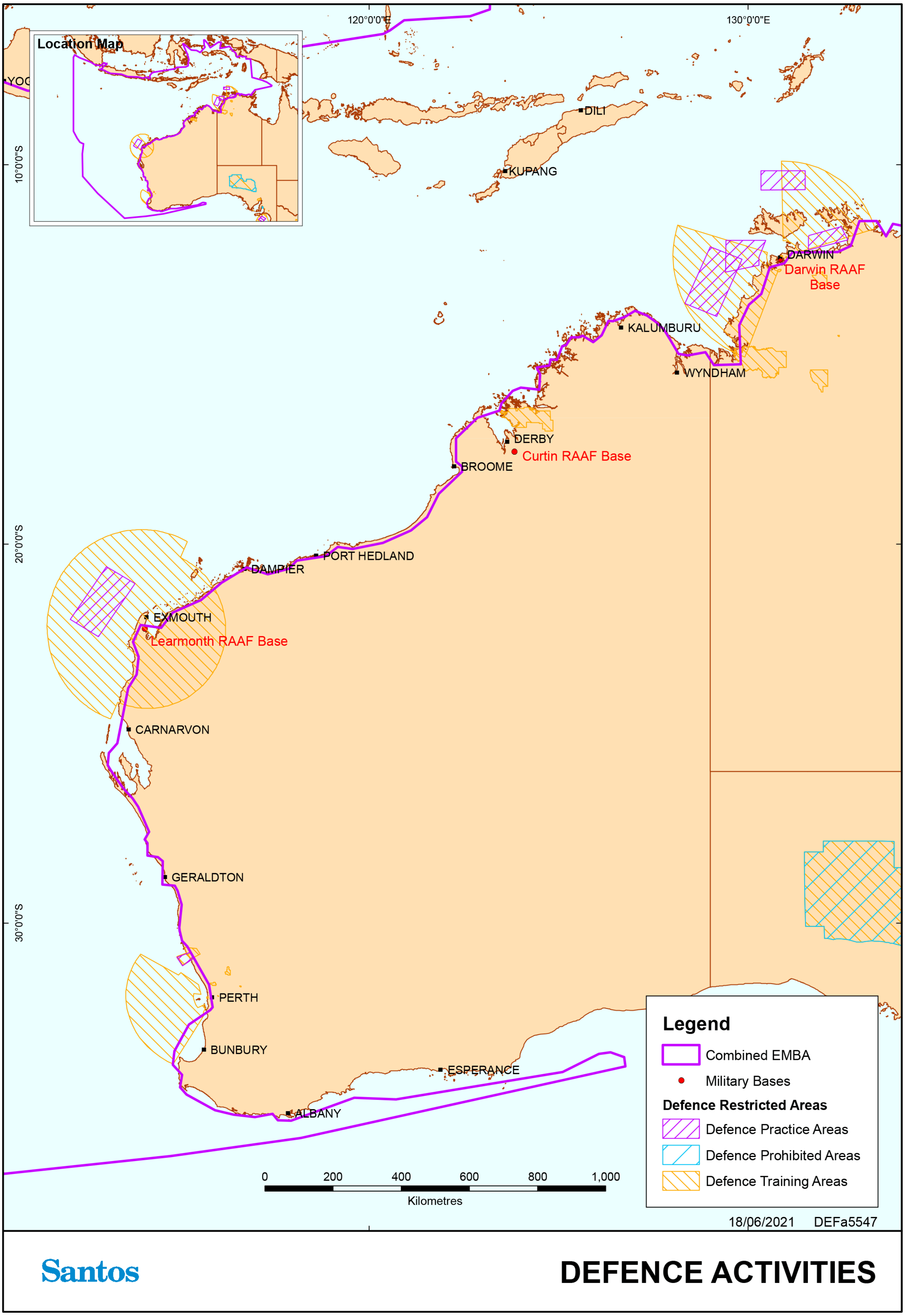


Figure 14-5: Defence activities

14.5 Tourism

The Kimberley, Pilbara and Gascoyne regions are popular visitor destination for Australian and international tourists. Tourism is concentrated in the vicinity of population centres including Broome, Dampier, Exmouth, Coral Bay and Shark Bay.

Marine and coastal use is also clustered around major population centres along the WA coastline including Perth, Bunbury, Geraldton, Margaret River, Jurien Bay, August and Albany.

Marine tourism to offshore Islands includes various Pilbara nearshore Islands (Muiron, Serrurier, Sholl and Montebello) and the Abrolhos Islands near Geraldton. Currently visitation to the Abrolhos is low because the park is only accessible via recreational boat, charter flight or commercial tour (either on a boat or aircraft); however, there is an increasing number of visitors, with visitations peaking between February and May (DBCA, 2022). The Montebello Islands are ranked among the world's most bio-diverse marine environments (DBCA) and are attracting a growing number of nature-based tourism operators, with people participating in activities such as fishing, diving, wildlife viewing, island exploration and surfing (DEC, 2007).

Tourism contributes to local economies in terms of both income and employment and tourists include local, interstate and international visitors. Popular water-based activities include fishing, swimming, snorkelling/ diving, surfing/windsurfing/kiting and boating, while popular land based activities include bushwalking, camping, bird watching and four-wheel driving.

Seasonal nature-based tourism such as humpback whale watching, whale shark encounters and tours of turtle hatching mainly occurring around Ningaloo Reef, Cape Range National Park, Broome and Perth (Tourism Western Australia 2014). Seasonal aggregations of whale sharks, manta rays, sea turtles and whales, as well as the annual mass spawning of coral attract large numbers of visitors to Ningaloo each year (CALM 2005).

14.6 Cultural Heritage

Four places of cultural significance are protected as National Heritage Places in the waters from Busselton to the NT. The Dampier Archipelago (including Burrup Peninsula), Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos, Dirk Hartog Landing Site 1616 – Cape Inscription area and the HMAS Sydney II and HSK Kormoran Shipwreck Site are discussed in **Section 9**. Additional Commonwealth Heritage Places denoted for their historic value in the combined EMBA are listed in **Appendix A**.

14.6.1 Indigenous Heritage

Indigenous people have a strong ongoing association with the area that extends from the beginning of human settlement in Australia some 50,000 years ago. The close, long standing relationship between Aboriginal peoples and the coastal and marine environments of the area is evident in indigenous culture today, in addition to archaeological sites such as the Burrup Peninsula. The Indigenous peoples of the northwest continue to rely on coastal and marine environments and resources for their cultural identity, health and wellbeing, as well as their domestic and commercial economies (DEWHA 2008a). Within the combined EMBA, Barrow Island, Montebello Islands, Exmouth, Ningaloo Reef, Kimberly Coast, Eighty Mile Beach, Roebuck Bay, Dampier Peninsula and the South West and the adjacent foreshores have a long history of occupancy by Indigenous communities. Areas that are covered by registered native title claims are likely to practice indigenous fishing techniques at various sections of the WA coastline, most notably in the Kimberley coastal region and islands.

Marine resource use by Indigenous people is generally restricted to coastal waters. Fishing, hunting and the maintenance of maritime cultures and heritage through ritual, stories and traditional knowledge continue as important uses of the nearshore region and adjacent areas. However, while direct use by Aboriginal people deeper offshore waters is limited, many groups continue to have a direct cultural interest in decisions affecting the management of these waters. The cultural connections Aboriginal people maintain with the sea may be affected, for example, by offshore fisheries and industries. In addition, some Indigenous people are involved in commercial activities such as fishing and marine tourism, so have an interest in how these industries are managed in offshore waters with respect to their cultural heritage and commercial interests (DEWHA 2008a).

In the Northern Territory there are a number of sacred and significant sites located on the Tiwi Islands. There are currently four registered sacred sites on the Tiwi Islands (Aboriginal Areas Protection Authority, 2016). Another 56 sites of significance to Tiwi Islanders have been recorded, including two sites on the NT mainland (Tiwi Land Council, 2003). The Tiwi Islands sites hold importance as they have high spiritual and cultural history value (Tiwi Land Council 2003).

14.6.2 Maritime Heritage

Details of recorded shipwreck sites are available on the Australian National Shipwreck Database are managed by the DAWE although precise locations of the wrecks are sometimes unknown. the combined EMBA. Key shipwrecks in the North West Marine Region are shown in **Figure 14-10** to **Figure 14-6**, in addition to the Ann Millicent (DEWHA 2008a). Under the Commonwealth *Underwater Culture Heritage Act 2018* all shipwrecks older than 75 years are protected, while those dated pre-1900 are protected by WA law under the *Maritime Archaeology Act 1973*. Within the combined EMBA, there are 1033 shipwrecks known to be in excess of 75 years old.

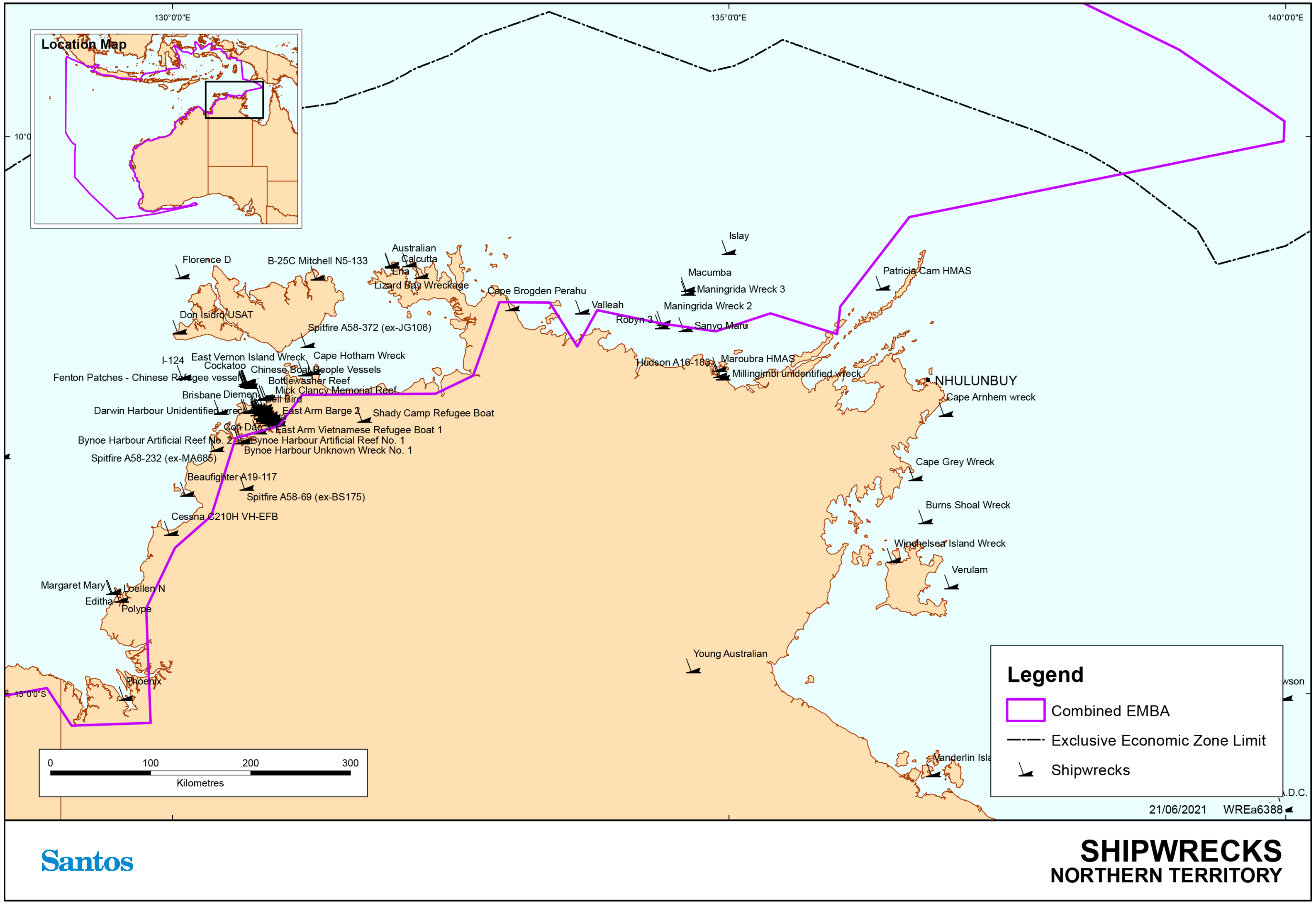


Figure 14-6: Shipwrecks –NT

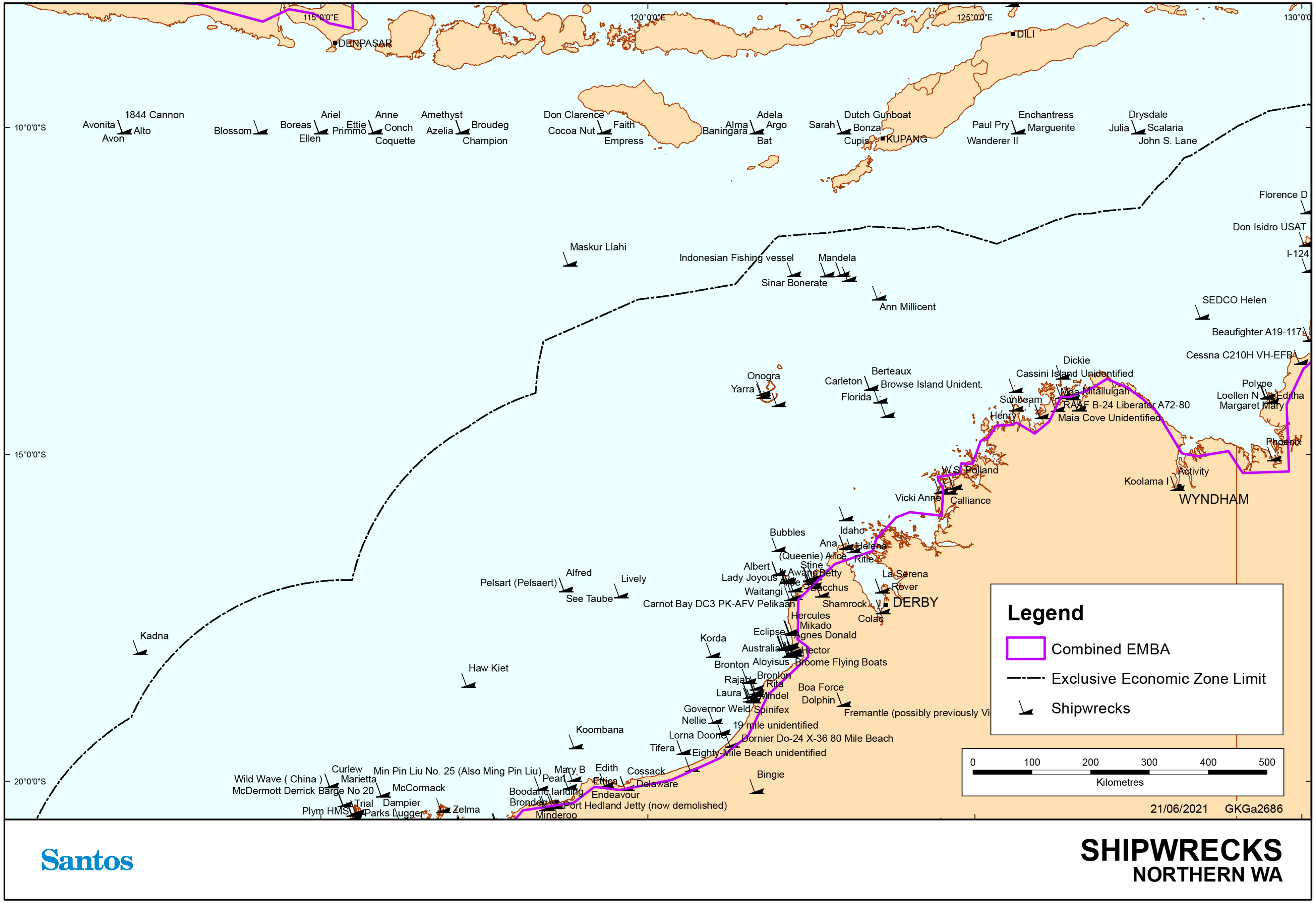


Figure 14-7: Shipwrecks – Northern WA

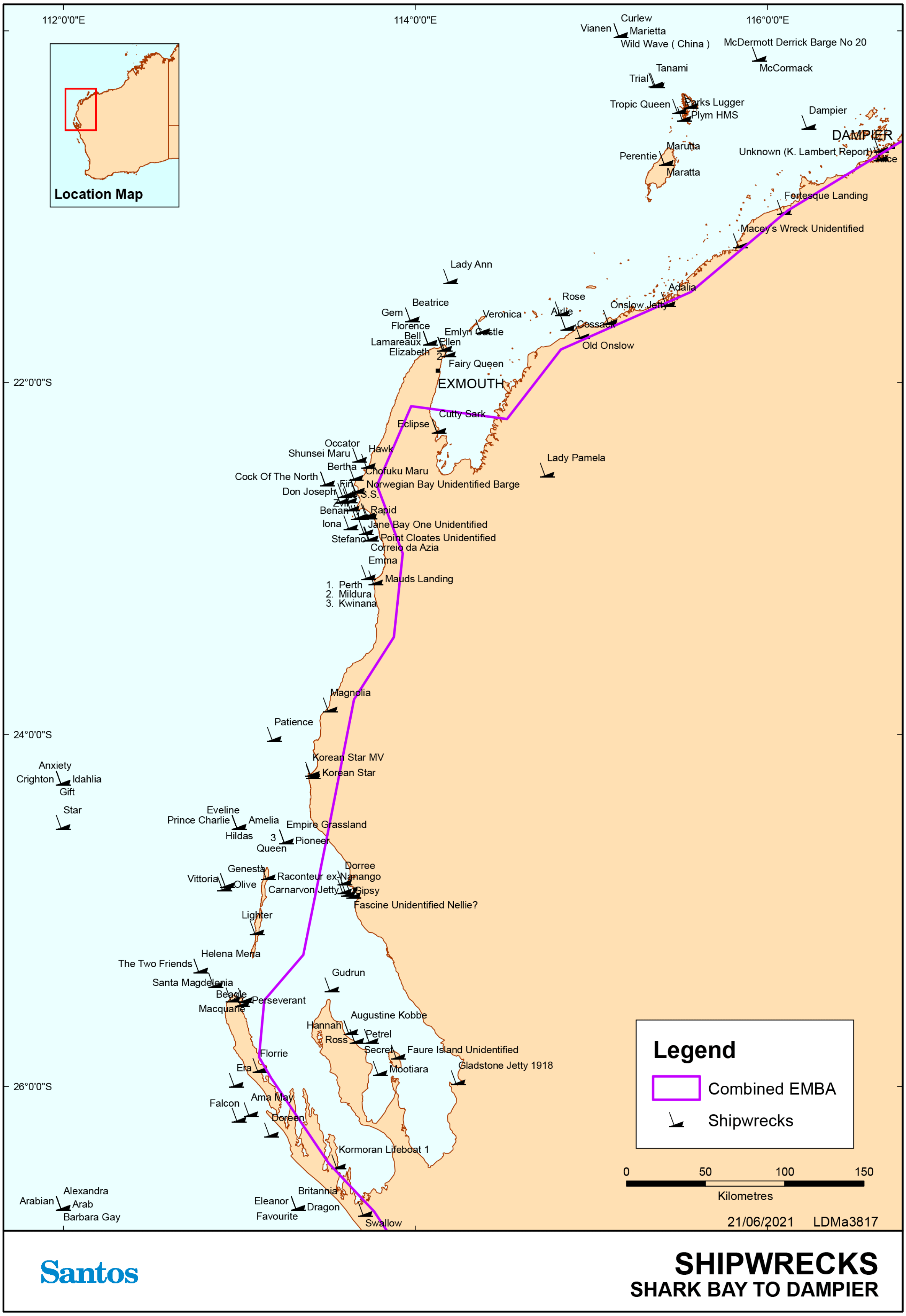


Figure 14-8: Shipwrecks – Shark Bay – Dampier

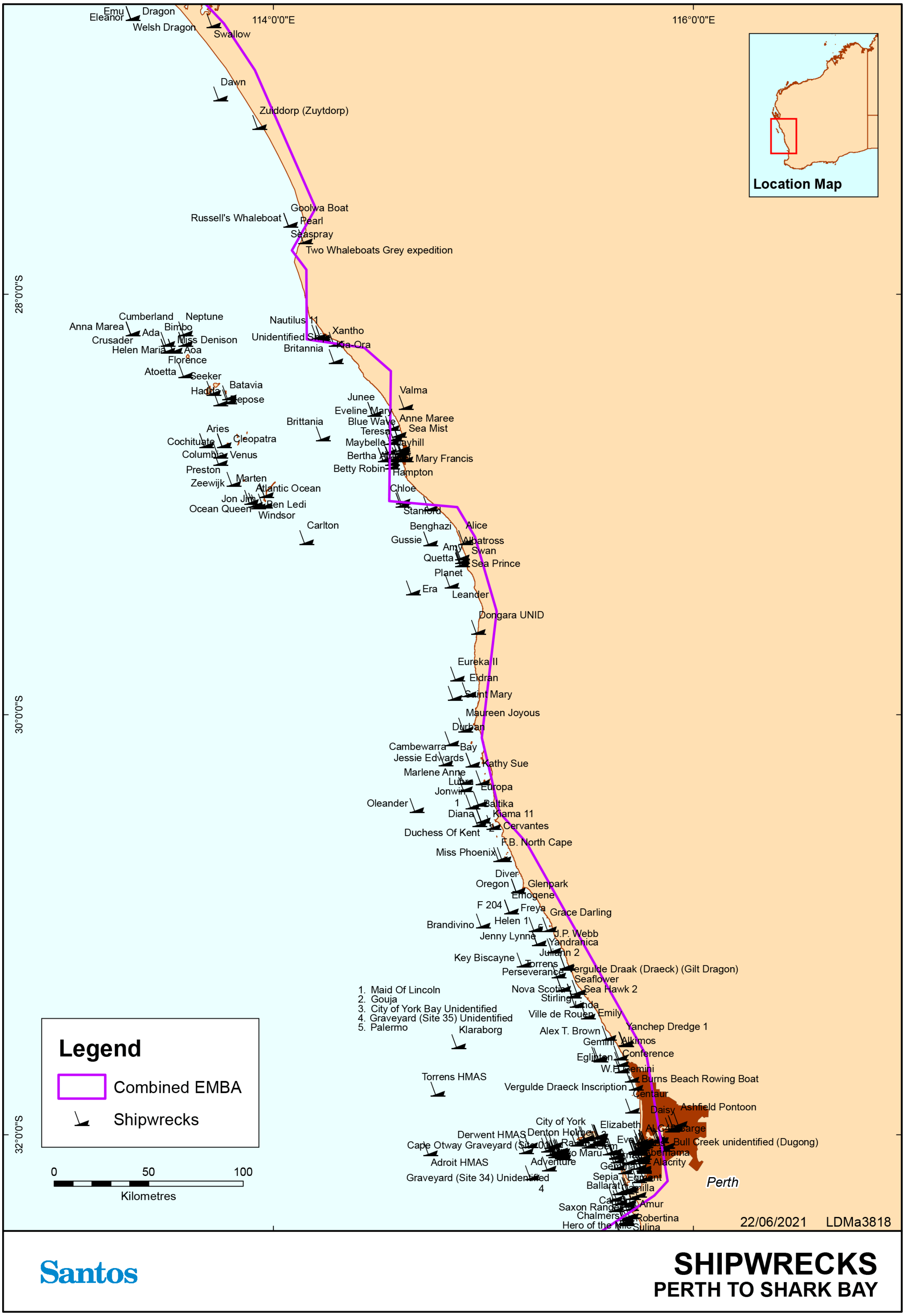


Figure 14-9: Shipwrecks – Perth – Shark Bay

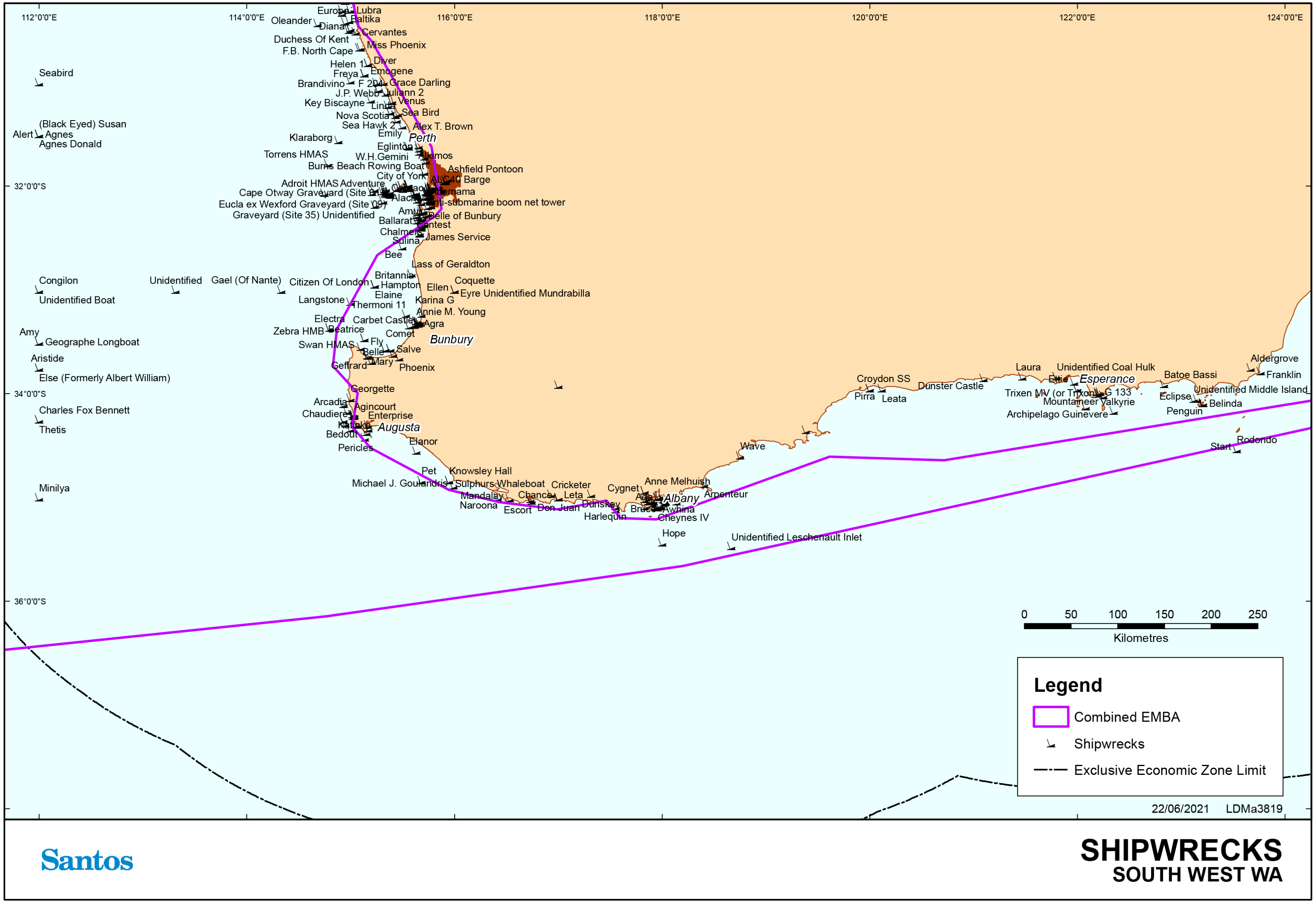


Figure 14-10: Shipwrecks – South West WA

14.7 Commercial Fisheries

A valuable and diverse commercial fishing industry is supported by both the offshore and coastal waters in the North Coast, Gascoyne, West Coast and South Coast Bioregions between the WA and NT and South Australian borders. The major fisheries in this area target tropical finfish, large pelagic fish species, crustaceans (prawns and scampi), Western Rock Lobster and pearl oysters (Fletcher and Santoro 2013). A number of smaller fisheries also exist in this area including the octopus and beche-de-mer fisheries.

14.7.1 State Fisheries

State fisheries are managed by the WA Department of Primary Industries and Regional Development (DPIRD) (formerly Department of Fisheries (DoF)) with specific management plans, regulations and a variety of subsidiary regulatory instruments under the *Fish Resources Management Act 1994* (WA). The information on State managed fisheries has been derived from '*The State of the Fisheries'* Report 2018/2019 (Gaughan *et al.* 2020) and direct consultation with DPIRD. Santos consults regularly with State fisheries relevant to activity operational areas, mainly by distribution of an Annual Consultation Update by post.

State commercial fisheries that exist between Kalbarri (WA) and the NT border are shown in **Figure 14-12**. Fisheries in the Northern Territory are shown in **Figure 14-11**. A summary of all commercial fisheries in the area is also provided in **Table 14-1**. These are:

North Coast Bioregion

- Onslow Prawn Managed Fishery (OPMF);
- Nickol Bay Prawn Managed Fishery (NBPMF) – referred to as Nickol Bay Prawn Limited Entry Fishery in **Figure 14-12;**
- Broome Prawn Managed Fishery (BPMF);
- Kimberley Prawn Managed Fishery (KPMF);
- Kimberley Gillnet & Barramundi Managed Fishery (KGBF);
- Kimberley Developing Mud Crab Fishery[14]**;**
- Northern Demersal Scalefish Managed Fishery (NDSF);
- North Coast Traditional Trochus Fishery[14];
- Pilbara Demersal Scalefish Fisheries[14]**;**
- Pilbara Developing Crab Fishery[14]**;**
- Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF);
- Pilbara Trap Managed Fishery (PTMF);
- Pilbara Line Fishery;
- Western Australian Sea Cucumber Fishery;
- Mackerel Managed Fishery (Area 1 – Kimberley and Area 2 – Pilbara);

[14] Not shown in **Figure 14-12**

- Western Australian Pearl Oyster Fishery – referred to as Pearl Oyster Managed Fishery in **Figure 14-12;**
- Northern Shark Fisheries (closed[14]**)** including:
- Western Australian North Coast Shark Fishery[14]; and
- Joint Authority Northern Shark Fishery[14]
- North Coast Trochus Fishery[14]; and
- Pilbara Developing Crab Fishery[14]**.**

Northern Territory

- Coastal Line Fishery;
- Aquarium Fishery;
- Trepang Fishery;
- Development Small Pelagic Fishery;
- Coastal Net Fishery;
- Spanish Mackerel Fishery;
- Offshore Net and Line Fishery;
- Timor Reef Fishery;
- Demersal Fishery; and
- Barramundi Fishery.

Gascoyne Bioregion

- Exmouth Gulf Prawn Managed Fishery;
- Gascoyne Demersal Scalefish Managed Fishery;
- Shark Bay Scallop Managed Fishery – referred to as Shark Bay Scallop Limited Entry Fishery on **Figure 14-12;**
- Shark Bay Prawn Managed Fishery – referred to as Shark Bay Prawn Limited Entry Fishery on **Figure 14-12;**
- Shark Bay Beach Seine and Mesh Net Managed Fishery[14]**;**
- Shark Bay Crab Interim Managed Fishery; and
- Mackerel Fishery (Area 3 – Gascoyne/West Coast).

West Coast Bioregion

- Roe's Abalone[14]**;**
- Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWRMF) (Closed) – referred to as Abrolhos Islands and Mid-West Trawl Limited Entry Fishery in **Figure 14-12;**
- West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF);

- South West Trawl Managed Fishery – referred to as South West Trawl Limited Entry Fishery in **Figure 14-12;**
- Mandurah to Bunbury Developing Crab Fishery[14]**;**
- Cockburn Sound Crab Managed Fishery[14]**;**
- Cockburn Sound Line and Pot Managed Fishery[14]**;**
- Cockburn Sound Mussel Managed Fishery[14]**;**
- Warnbro Sound Crab Managed Fishery (closed) [14]**;**
- West Coast Nearshore and Estuarine Finfish Fisheries, including:
- Cockburn Sound Fish Net Managed Fishery[14]**;**
- West Coast Beach Baited Managed Fishery[14]**;**
- South West Beach Seine Fishery[14]**;** and
- West Coast Estuarine Managed Fishery[14]**;**
- Temperate Demersal Gillnet and Demersal Longline Fisheries, including:
- West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (West Coast Bioregion) [14]**;**
- West Coast Deep Sea Crab (Interim) Managed Fishery – referred to as West Coast Deep Sea Crustacean Managed Fishery in **Figure 14-12;**
- West Coast Nearshore Net Managed Fishery [14]**;**
- Octopus Interim Managed Fishery [14]**;**
- West Coast Rock Lobster Managed Fishery; and
- West Coast Purse Seine Fishery [14]**.**

South Coast Bioregion

- Greenlip/Brownlip Abalone Fishery [14]**;**
- South Coast Crustacean Managed Fishery [14]**;**
- South Coast Deep-Sea Crab Fishery [14]**;**
- South Coast Estuarine Managed Fishery[14]**;**
- South Coast Open Access Netting Fishery [14]; and
- South West Coast Beach Net [14]**.**
- South Coast Salmon Managed Fishery;
- South Coast Trawl Fishery;
- South West Coast Salmon Managed Fishery [14]**;**
- Temperate Demersal Gillnet and Demersal Longline Fisheries including:

- Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (South Coast Bioregion)
- South West Trawl Managed Fishery (SWTMF) – referred to as South Coast Trawl Limited Entry Fishery in **Figure 14-12**; and
- Windy Harbour/Augusta Rock Lobster Managed Fishery [14]**.**

Whole of State Fisheries

- Marine Aquarium Fish Managed Fishery (MAFMF);
- Specimen Shell Managed Fishery; and
- Hermit Crab Fishery (HCF) [14].

Some of the fisheries listed above will be more susceptible to impacts than others, particularly fisheries without the ability to escape impacts. For example, above average water temperatures over the last three years will have had an impact on prawn fisheries in Exmouth and scallops and blue swimmer crabs in Shark Bay which have been significantly affected by the initial heat wave event of 2010/11 (Caputi *et al*. 2014).

14.7.2 Commonwealth Fisheries

Commonwealth fisheries are those within the 200 nautical mile Australian Fishing Zone (AFZ) managed by Australian Fisheries Management Authority (AFMA) and are, on the high seas, and, in some cases, by agreement with the States and Territory, to the low water mark. Information on Commonwealth managed fisheries has been derived from '*Fishery Status'* Report 2019 (Department of Agriculture 2019)

Commonwealth fisheries who have permits to operate in the combined EMBA include as shown in **Figure 14-13**:

- North West Slope Trawl (NWST);
- Northern Prawn Fishery (NPF);
- Southern Bluefin Tuna Fishery (SBFTF);
- Western Tuna and Billfish Fishery (WTBF) (including Southern Tuna and Billfish Fishery);
- Small Pelagic Fishery (SPF);
- Southern and Eastern Scalefish and Shark Fishery (SESSF) – not shown in **Figure 14-13**;
- Skipjack Tuna Fishery (STF) (referred to as Western Skipjack Tuna Fishery in **Figure 14-13); and**
- Western Deepwater Trawl (WDTF) (referred to as Western Deepwater Trawl Fishery in **Figure 14-13**).

Commonwealth commercial fisheries between Kalbarri (WA) and the NT Border are shown **Figure 14-13** and summarised in **Table 14-1**.

14.7.3 Indonesian Commercial and Subsistence Fishing

Within the northern and north-western extent of the combined EMBA is a defined area where a Memorandum of Understanding (MoU) exists between the Australian and Indonesian Governments. The Agreement between the Government of Australia and the Government of the Republic of Indonesia Relating to Cooperation in Fisheries (1992 Fisheries Cooperation Agreement) provides the framework for fisheries and marine cooperation between Australia and Indonesia, and facilitates information exchange on research, management and technological developments, complementary management of shared stocks, training and technical exchanges, aquaculture development, trade promotion and cooperation to deter illegal fishing.

Cooperation under the Agreement today takes place under the auspices of the Working Group on Marine Affairs and Fisheries. Established in 2001, the Working Group on Marine Affairs and Fisheries is the primary bilateral forum to enhance collaboration across the spectrum of marine and fisheries issues relevant to the areas of the Arafura and Timor seas. The Working Group brings together the fisheries, environment and scientific research portfolios and agencies from both countries.

The MoU Box (shown on **Figure 14-13**) is an area of Australian water in the Timor Sea where Indonesian traditional fishers, using traditional fishing methods only, are permitted to operate. Officially it is known as the Australia-Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974.

As part of negotiations to delineate seabed boundaries, Australia and Indonesia entered into the MoU which recognises the rights of access for traditional Indonesian fishers in shared waters to the north of Australia. This access was granted in recognition of the long history of traditional Indonesian fishing in the area. The MoU provides Australia with a tool to manage access to its waters while for Indonesia, it enables Indonesian traditional fishers to continue their customary practices and target species such as trepang, trochus, abalone and sponges. Guidelines under the MoU were agreed in 1989 in order to clarify access boundaries for traditional fishers and take into account the declaration of the 200 nautical mile fishing zones. Because of its approximate shape the MoU area became known as the MoU Box.

Between 2006 and 2008, a series of surveys were undertaken to understand the traditional practice of Indonesian fishers that journey to Scott Reef within the MoU boundary (ERM 2008, 2009). The majority of perahu (vessels) that travel to Scott Reef originate from the islands of Rote (near West Timor) and Tonduk and Raas (in East Java). Some crew from the Rote perahus are recruited from the region of Alor (one of the Lesser Sundas chain, located north of East Timor and east of Bali). In 2007, an estimated 800 fishers (approximately 80 vessels) travelled from these home islands to Scott Reef, mainly to collect trepang. Similar vessel numbers sailed to Scott Reef in 2008.

Journeys to Scott Reef are generally restricted to drier months when wind speeds and directions are more desirable. Most Indonesian fishers travel to Scott Reef during July to October, although a few Rotenese make the journey to Scott Reef in the early season between April and June. Other fishers plan to go after Aidil Fitri, a religious holiday widely celebrated on Tonduk Island that celebrates the end of Ramadan.

The fishers focus their activities in and around the shallow water lagoons of Scott Reef primarily targeting trepang; and opportunistically gather trochus shells. They also catch fish largely for subsistence purposes although the average fish catch per lete-lete (traditional Indonesian fishing vessel) in 2008 increased to commercial volumes. Although deeper waters are more plentiful in trepang, deep diving is generally not undertaken by the fishers due to the MoU stipulation on the exclusive use of traditional equipment only (Woodside Energy Limited 2011).

14.8 Aquaculture

14.8.1 South West Bioregion

The predominant aquaculture activity undertaken in this region is the production of mussels and oysters from Oyster Harbour at Albany. This activity is restricted to this area where there are sufficient nutrient levels related to terrestrial run-off to provide the planktonic food necessary to promote growth of filter-feeding bivalves fishing (Fletcher and Santoro 2015). The high-energy environment and limited protected deep waters limits other forms of aquaculture such as sea cage farming.

Further invertebrate aquaculture operations are expected within Albany following recent funding and declaration of the Albany Aquaculture Development Zone by DPIRD. Two zones have already been declared with the Oyster Harbour area declared in August 2020 and the Princess Royal Harbour and King George Sound areas declared in December 2021. Once fully established, the Albany Aquaculture Development Zone will be the largest single zone dedicated to marine shellfish farming in Australia (DPIRD, 2020).

Further aquaculture in the region includes the Rare Foods Australia (formerly Ocean Grown Abalone) Project in Flinders Bay in the South West region of Western Australia. The project is the world's first commercial abalone ranch using concrete artificial reef structures, known as ABITATs. The ABITATs are lowered into two lease areas where the ranches are self-sustaining and the abalone nurture and feed from the ocean until they are ready for harvest (information available from . https://rarefoodsaustralia.com.au/a-world-first-ocean-ranching/)

14.8.2 West Coast Bioregion

The principal aquaculture development activities in this region are the production of blue mussels (*Mytilus galloprovincialis*) and marine algae (*Dunaliella salina*) and the emerging black pearl industry based on the production of *Pinctada margaritifera* at the Abrolhos Islands. The main mussel farming area is in southern Cockburn Sound, where conditions are sheltered and the nutrient and planktonic food levels are sufficient to promote good growth rates fishing (Fletcher and Santoro 2015).

Further aquaculture operations are expected following the establishment of the Mid-West Aquaculture Development Zone by DPIRD, which aims to provide a platform to stimulate aquaculture investment and development in the bioregion (Gaughan and Santoro 2020).

14.8.3 Gascoyne Coast Bioregion

Hatchery production of oysters is the core of the pearling industry in the Gascoyne region. Hatcheries in Carnarvon and Exmouth supply spat to pearl farms in the north-west and several hatcheries supply juveniles to the black-lip pearl oyster to developing black pearl farms in the region. Pearl production is carried out on a small scale in Shark Bay and Exmouth Gulf. The local aquiculture sector is also focussing on the production of aquarium species.

14.8.4 North Coast Bioregion

Aquaculture development in this region is dominated by the production of pearls from the species *Pinctada maxima.* Each year, approximately 500,000 wild individuals are harvested, with the majority being from Eighty Mile Bean in Broome, Western Australia (sourced from Fisheries Research and Development Cooperation in Thomas and Miller 2022). A large number of pearl oysters for seeding is obtained from wild stocks and supplemented by hatchery-produced oysters with major hatcheries operating at Broome and the Dampier Peninsular. Pearl farm sites are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands. Developing marine aquaculture initiatives in this region include growing trochus and barramundi.

The Pearl Oyster Fishery of Western Australia operates in shallow coastal waters (DoF 2006). All the leases are within the 35m diving depth, with commercial diving predominantly occurring in nearshore habitats of 8-15 m depths (Thomas and Miller, 2022). Through consultation the Pearl Producer's Association (PPA) have raised concern that spawning stock is found to the 100 m depth contour. However, this is not supported in the study by Condie *et al* (2006) who modelled oyster larva transport in the Eighty Mile Beach region and found that while some larvae travelled more than 60 km, most were transported less than 30 km. The model results suggest that spawning in the Eighty Mile Beach region is concentrated around the 8 to 15m depth range, with potential smaller contributions from the northeast. These spawning events are likely to lead to successful recruitment locally and alongshore to the southwest.

They also feed larvae into neighbouring shallow coastal environments (through tidal oscillations) and deeper waters to the west (>20 m). However, spat abundances seem to be low in these areas, suggesting that recruitment is strongly limited by habitat availability and possibly high mortality rates in shallow water. High local abundances of broodstock and spat observed occasionally in deeper water (<30 m) seem to be supported by intermittent larval transport from inshore populations. Spawning in this area seems to contribute little to recruitment in the inshore populations.

Further aquaculture in this region mainly focuses on barramundi farming within Cone Bay, with two aquaculture licences granted in this area located about 200 km north-east of Broome (Gaughan and Santoro 2020).

Further aquaculture operations have expanded in the region with the establishment of the Kimberley Aquaculture Development zone, which encompasses almost 2,000 ha of coastal waters within Cone Bay supporting the production of up to 20,000 t of finfish annually (Gaughan and Santoro 2020).

14.8.5 Northern Territory

The Northern Territory boasts a diverse and vibrant aquaculture industry. An extensive range of commercial activity includes barramundi farming, trepang (sea cucumber), pearling and the collection of marine fish and coral for the tropical aquarium market. A pond-based barramundi farm on the Adelaide River produces more than 1,000 tonnes of Barramundi a year (Northern Territory Government, 2016). Giant clams are also farmed with trials on Groote Eylandt and Goulburn Island growing sea clams in sea-based cages. The silver-lipped pearl oyster is farmed in four main areas of the NT: Bynoe Harbour, Beagle Gulf, Cobourg Peninsula and Croker Island around the islands north west of Nhulunbuy.

14.8.6 Indonesian Aquaculture

An analysis by WorldFish has indicated that aquaculture will overtake capture fisheries as the major source of fish in Indonesia before 2030 (Phillips *et al.* 2015). By volume, Indonesian aquatic production is dominated by seaweeds, but by value, domestically consumed species such tilapia and milkfish, together with export-orientated commodities such as shrimp and tuna, are of greater importance (Phillips *et al*. 2015).

Carrageenan seaweed farming based primarily on the cultivation of *Kappaphycus* and *Eucheuma* species has grown significantly in Indonesia. Due to the simple farming techniques required, low requirements of capital and material inputs, and short production cycles it has become a favourable livelihood for smallholder farmers and fishers (Valderrama *et al*. 2013). Indonesia's coastline provides ideal conditions for fish farming in "brackish waters". Aquaculture in Indonesia is predominantly used for seaweed production, whilst offshore fish cultivation remains relatively undeveloped (Global Business Guide 2014).

14.9 Recreational Fisheries

14.9.1 South West Bioregion

The South West Bioregion includes the water from Augusta to Eucla on the Western Australia/South Australia border. The continental shelf waters of this region are generally temperate but low in nutrients due to the seasonal presence of the tail of the tropical Leeuwin current and limited terrestrial run-off. As much of the south coast is remote or difficult to access, recreational beach and boat fishing tends to be concentrated around the main population and holiday centres. The major target species for beach and rock anglers are salmon, herring, whiting and trevally, while boat anglers target pink snapper, queen snapper, Bight redfish, a number of shark species, salmon fish and King George whiting. Another component of the recreational fishery is dinghy and shoreline fishing off estuaries and rivers where the main angling targets are black bream and whiting. Recreational netting primarily targeting mullet also occurs in these estuaries (WAFIC 2016).

14.9.2 West Coast Bioregion

The marine environment of the West Coast Bioregion which lies between Kalbarri and Augusta is predominantly a temperate oceanic zone, but it is heavily influenced by the Leeuwin current, which transports warm tropical water southward along the edge of the continental shelf. This region contains the state's major population centres and is the most heavily used bioregion for recreational fishing (Fletcher and Santoro 2015). The range of recreational fishing opportunities includes estuarine fishing, beach fishing and boat fishing either in embayments or offshore for demersal and pelagic game species often around the islands and out to the continental shelf (WAFIC 2016).

14.9.3 Gascoyne Coast Bioregion

The Gascoyne Coast Bioregion extends from just north of Kalbarri to the Ashburton River, south of Onslow. The marine environment of this region represents a transition between the fully tropical waters of the north-west shelf of the north coast region and the temperate waters of the west coast region. This region has been identified as one of the 18 world 'hotspots' in terms of tropical reef endemism and the second most divers marine environment in the world in terms of tropical reef species. This region is a focal point for winter recreational fishing and is a key component of many tourist visits. Angling activities include beach and cliff fishing (e.g. Steep Point and Quobba), embayment and shallow-water boat angling (e.g. Shark Bay, Exmouth Gulf and Ningaloo lagoons), and offshore boat angling for demersal and larger pelagic species (e.g. off Ningaloo). The predominant target species include the tropical species such as emperors, tropical snappers, groupers, mackerels, trevallies and other game fish. Temperate species at the northern end of their ranges such as pink snapper, tailor and whiting also provide significant catches, particularly in Shark Bay (WAFIC 2016).

14.9.4 North Coast Bioregion

The North Coast Bioregion (Pilbara/Kimberley) runs from the Ashburton River to the Western Australia/Northern Territory border (WAFIC 2016). The oceanography of this region includes waters of Pacific Ocean origin that enter through the Indonesian archipelago bringing warm, low salinity waters polewards via the Indonesian throughflow and Holloway currents which flow seasonally and interact with Indian ocean waters. Recreational fishing is experiencing a significant growth in this region, with a distinct seasonal peak in winter when the local population increases by significant numbers of metropolitan and inter-state tourists. This has been added to by the increased recreational fishing by those involved in the construction or operation of major developments in this region. Owing to the high tidal range, much of the angling activity is boat-based with beach fishing limited to periods of flood tides and high water. Numerous creek systems, mangroves, rivers and ocean beaches provide shore and small boat fishing for a variety of species including barramundi, tropical emperors, mangrove jack, trevallies, sooty grunter, threadfin, mud crabs and cods. Offshore islands, coral reef systems and continental shelf waters provide species of major recreational interest including saddletail snapper and red emperor, cods, coral and coronation trout, sharks, trevally, tuskfish, mackerels and billfish (WAFIC 2016).

14.9.5 Northern Territory

The most recent available data on recreational fishing in the Greater Darwin area indicates that line fishing (using bait, lures or flies) was the most common fishing method used, accounting for 72% of the total effort, followed by Mud Crab potting (23%). The use of cast nets and other fishing methods was far less common. Approximately 70% of all recreational fishing effort occurred in estuarine waters (Matthews et al, 2019). The Darwin Harbour region and its associated arms and creeks supported 40% of the total fishing effort, followed by Bynoe Harbour (14%) and Shoal Bay (6%). The offshore regions seaward of Bynoe Harbour and Dundee were the most popular sites for those fishers venturing beyond estuarine waters. Most of the catch (84%) comprised of fish species (i.e. bony fish and sharks/rays) with the bulk of the remaining catch consisting of crabs and prawns.

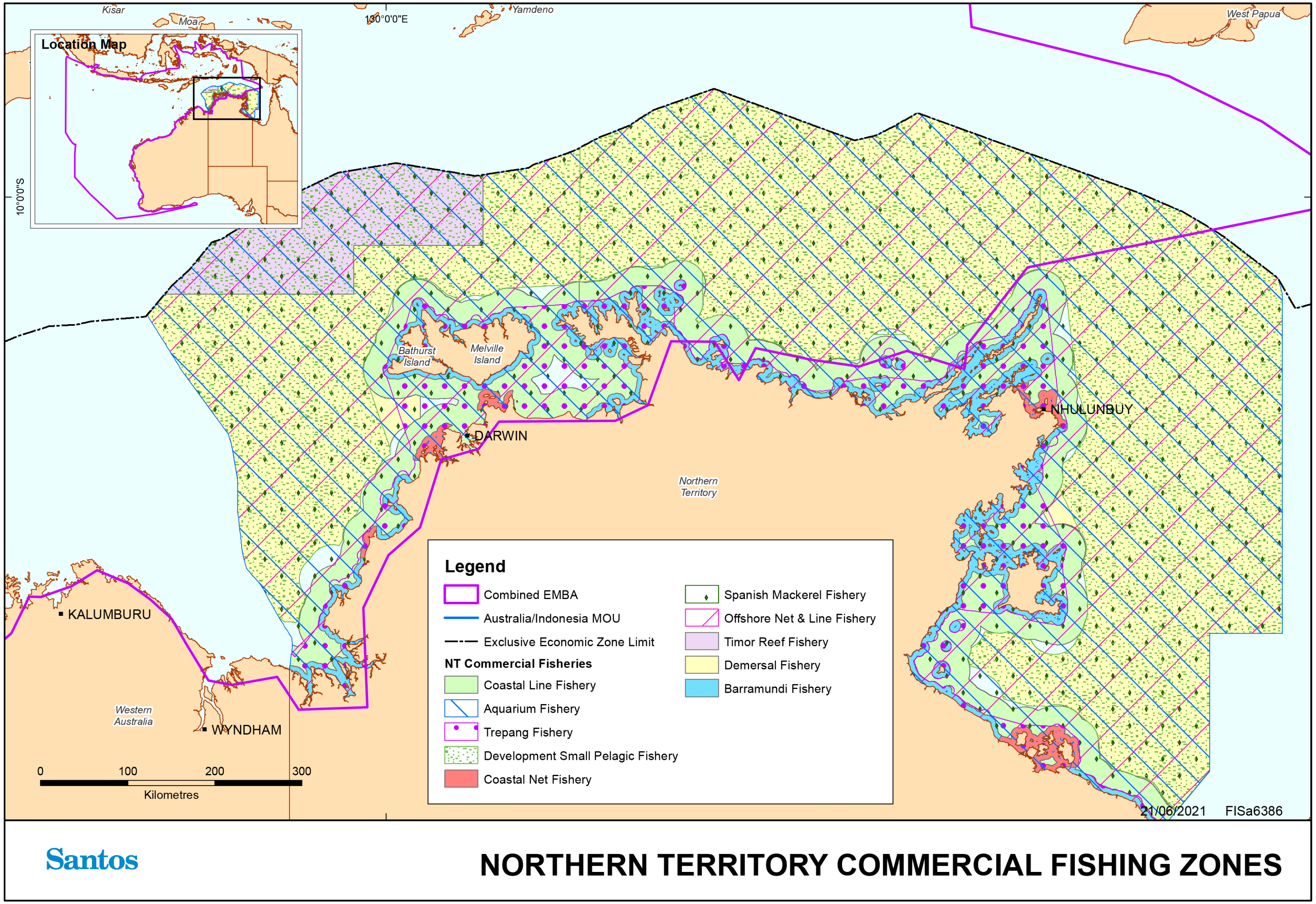


Figure 14-11:NT state commercial fishing zones

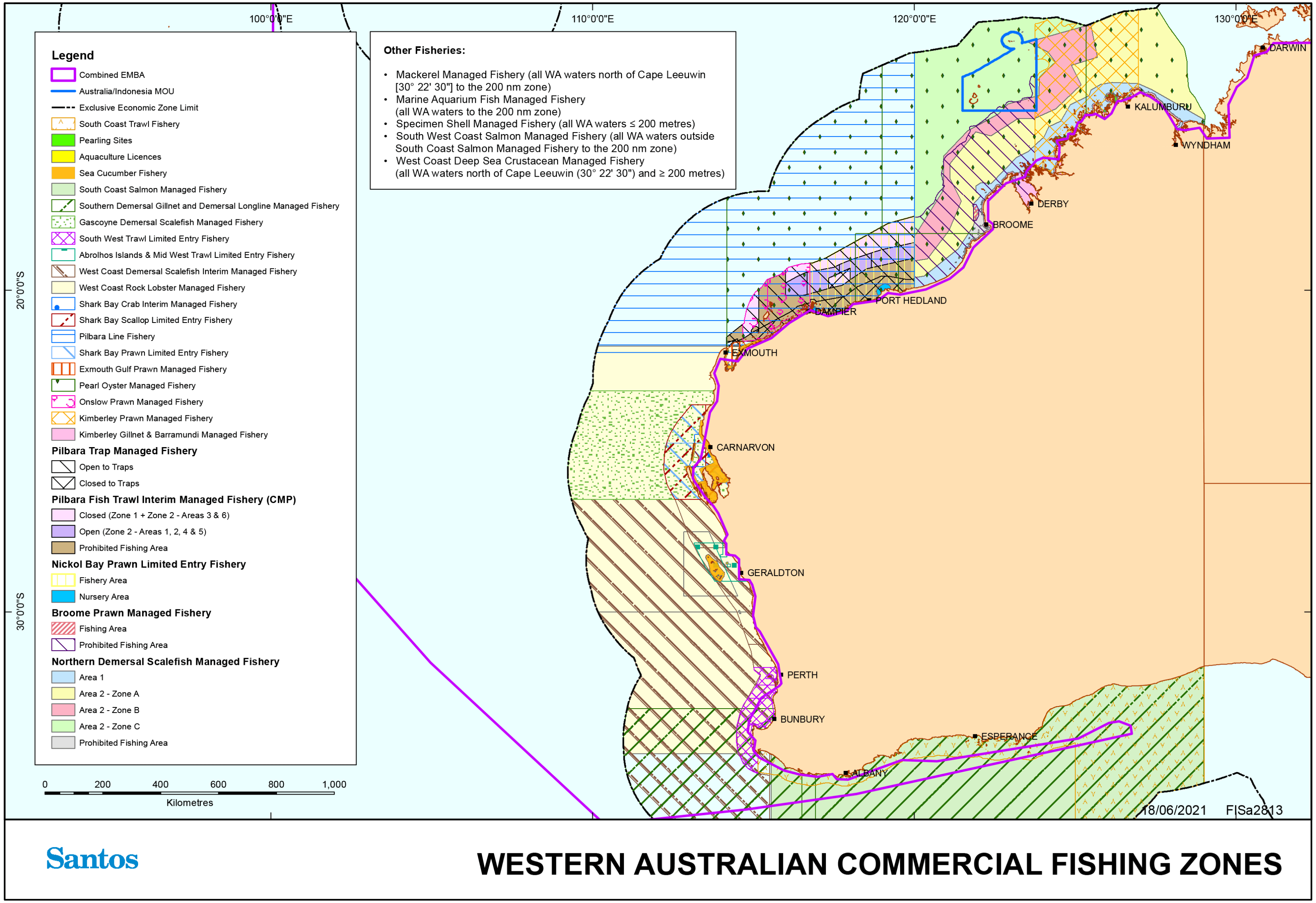


Figure 14-12:WA state commercial fishing zones

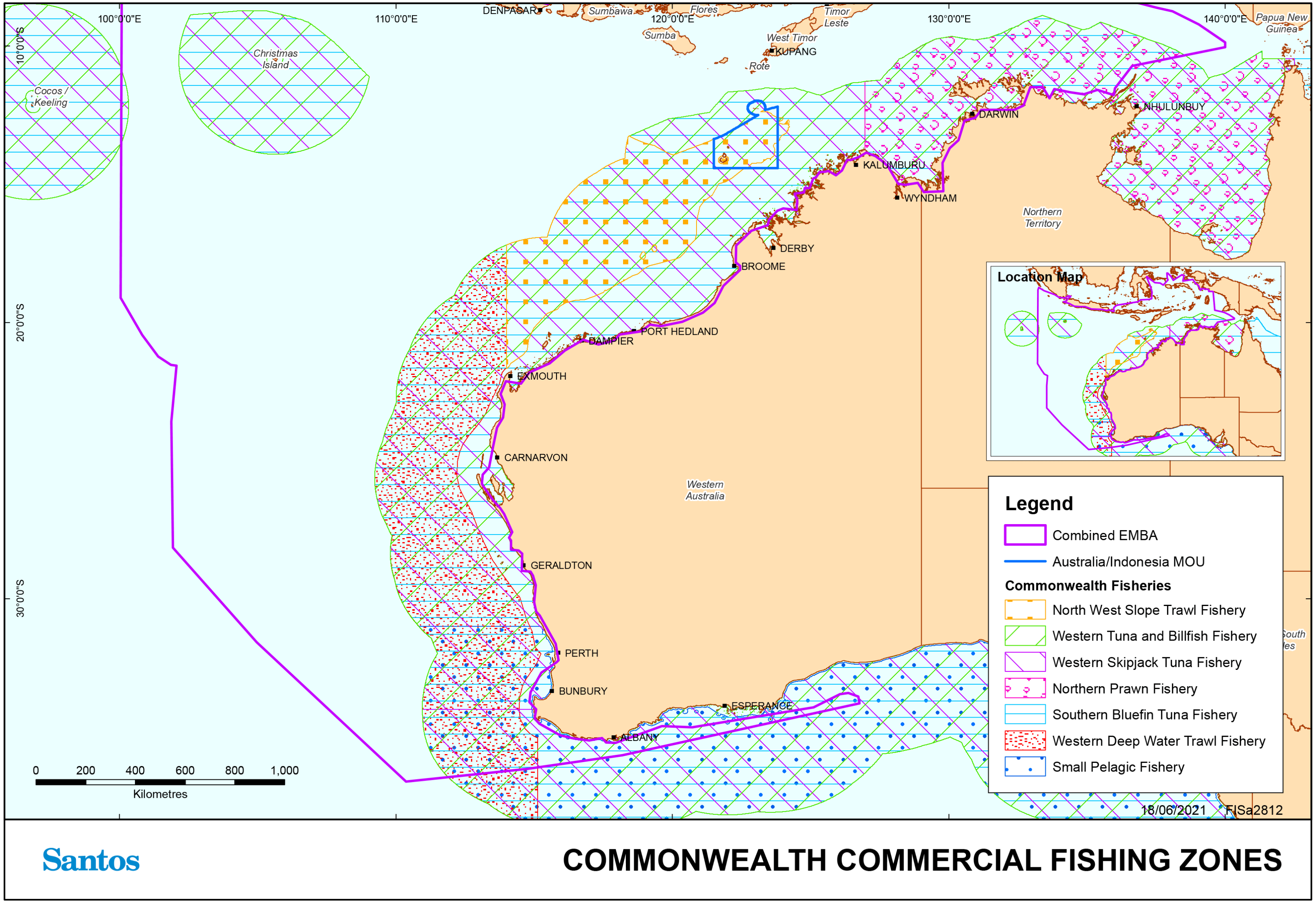


Figure 14-13: Commonwealth commercial fishing zones

Table 14-1: Commercial fisheries with permits to operate within the combined EMBA

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
State Managed Fisheries				
Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF)	Saucer scallops (*Ylistrum balloti*), with a small component targeting the western king prawn (*Penaeus latisulcatus*)	2017/2018: 651 tonnes	Operates using low opening otter trawl systems.	All the waters of the Indian Ocean adjacent to Western Australia between 27°51´ south latitude and 29°03´ south latitude on the landward side of the 200 m isobath'.
Aquarium Fishery	Multi-species catch including; invertebtrates (hermit crabs, various snails, whelks and hard and soft corals) and finfish (rainbowfish, catfishes and scats).	Unknown	Dive-based method of collection, using barrier, cast, scoop, drag and skimmer nets, hand pumps, freshwater pumps and handheld instruments.	The Aquarium fishery is a small-scale, multi-species fishery that prospects freshwater, estuarine and marine habitats to the outer boundary of the AFZ. Most of the harvest occurs within 100km of Darwin, though one license holder does collect from two offshore locations; Evans Shoal and Lynedoch Bank. Fishing activities may occur year round.
Barramundi Fishery	Barramundi King threadfin	The fishery is restricted to 14 licences all of which are currently allocated to fishers.	Gill nets	The annual commercial barramundi fishing season in the NT is from 1 February to 30 September. Fishing is allowed from the high water mark to three nautical miles seaward of the low water mark. The area is restricted to waters seaward from the coast, river mouths and legislated closed lines
Broome Prawn Managed Fishery (BPMF)	Western king prawns (*Penaeus latisulcatus*) and coral prawns (a combined category of small penaeid species).	Extremely low fishing effort occurred as only a single boat undertook trial fishing to investigate whether catch rates were sufficient for commercial fishing. This resulted in negligible landings of western king prawns with no byproduct recorded.	Otter trawl	The BPMF operates in a designated trawl zone off Broome. The boundaries of the BPMF are 'all Western Australian waters of the Indian Ocean lying east of 120° east longitude and west of 123°45' east longitude on the landward side of the 200 m isobath'. The actual trawl area is contained within a delineated small area north west of Broome.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Coastal Line Fishery	Black jewfish Golden snapper	Fishery is restricted to 52 licenses, with approximately one third of these being active in 2015.	Lines, nets and traps	Fishing occurs along the NT coast between high water marks and 15 nm from low water mark. Majority of activity is concentrated around rocky reefs along the coastline within 100km from Darwin. Fishing activities occur year-round.
Coastal Net Fishery	Mullet	This fishery is restricted to five licences, all of which are allocated.	Nets	The fishery extends from the high water mark to three nautical miles out from the low water mark. The fishery is divided into regions including: • Darwin – from Cape Hotham to Native Point and Cape Ford to Cape Dooley • Gove – between Cape Arnhem and Cape Wilberforce • Borroloola – from Bing Bong Creek and Pelican Spit.
Cockburn Sound Mussel Managed Fishery	Blue mussels (*Mytilus edulis*)	2015: Unspecified	Agriculture	Main mussel farming occurs in southern Cockburn Sound.
Cockburn Sound Crab Managed Fishery	Blue Swimmer (*Portunus armatus)* Blue swimmer crab (*Portunus armartus)*	2017/2018: 5: closed to commercial and recreational fishing since April 2014	Drop nets, scoop nets, diving	Encompasses the inner waters of Cockburn Sound, from South Mole at Fremantle to Stragglers Rocks, through Mewstone to Carnac Island and Garden Island, along the eastern shore of Garden Island and back to John Point on the mainland.
Cockburn Sound Line and Pot Managed Fishery	Southern garfish (*Hyporhamphus melanochir*), Australian herring (*Arripis geogianus*)	2017/2018: 257 tonnes	Line (fish) Shelter and trigger pots (octopus)	Encompasses the inner waters of Cockburn Sound, from South Mole at Fremantle to Stragglers Rocks, through Mewstone to Carnac Island and Garden Island, along the eastern shore of Garden Island and back to John Point on the mainland.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Demersal Fishery	Red snappers Goldband snappers	There are currently 19 licenses issued for the fishery, with around 9 active.	Handline Dropline Fish traps Although, essentially trap-based since 2002	This fishery extends from waters 15nm from the coastal waters mark to the outer limit of the AFZ, excluding the area of the Timor Reef Fishery.
Exmouth Gulf Prawn Managed Fishery	Western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.) and banana prawns (*Penaeus merguiensis*).	2017/2018: 713 tonnes	Low opening otter trawls.	Sheltered waters of Exmouth Gulf Essentially the western half of the Exmouth Gulf (eastern part is a nursery ground). The Muiron Islands and Point Murat provide the western boundary; Serrurier Island provides the northern limit
Gascoyne Demersal Scalefish Managed Fishery (GDSMF)	Targets pink snapper (*Pagrus auratus*) and goldband snapper (*Pristipomoides multidens*). Other demersal species caught include the rosy snapper (*P. filamentosus*), ruby snapper (*Etelis carbunculus*), red emperor (*Lutjanus sebae*), emperors (Lethrinidae, including spangled emperor*, Lethrinus nebulosus*, and redthroat emperor, *L. miniatus*), cods (Epinephelidae, including Rankin cod, *Epinephelus multinotatus* and goldspotted rockcod, *E. coioides*), pearl perch (*Glaucosoma burgeri*), mulloway (*Argyrosomus japonicas*), amberjack (*Seriola dumerili*) and trevallies (Carangidae).	2017/2018: Snapper: 133 tonnes Other demersals: 144 tonnes	Mechanised handlines	The GDSF operates in the waters of the Indian Ocean and Shark Bay between latitudes 23°07'30"S and 26°30'S. Vessels are not permitted to fish in inner Shark Bay.
Abalone Managed Fishery	Greenlip abalone (*Haliotis laevigata*) Brownlip abalone (*H. conicopora)*	2017/2018: 98 tonnes	Dive fishery The principal harvest method is a diver working off 'hookah' (surface supplied breathing apparatus) or SCUBA using an abalone 'iron' to prise the	Shallow coastal waters off the south-west and south coasts of Western Australia Covers all Western Australian coastal waters, which are divided into eight management areas. Commercial fishing for greenlip/brownlip abalone is managed in three separate areas.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			shellfish off rocks – both commercial and recreational divers employ this method.	
Hermit Crab Fishery (HCF)	Australian land hermit crab (*Coenobita variabilis*)	2017/2018: 58,643 (lowest reported in the last 10 years (2008-2017; catch range 58,643-118,203).	Land based hand collection typically using four-wheel drives to access remote beaches	Operates in Western Australian waters north of the Exmouth Gulf (22°30'S)
Kimberley Developing Mud Crab Managed Fishery	Mud crab (*Scylla serrata*)	2017/2018: 60 tonnes (also includes catch data from Pilbara Developmental crab fishery)	Mud Crab traps	This fishery operates between Broome and Cambridge Gulf. Three commercial operators are permitted to fish from King Sound to the Northern Territory border, with closed areas around communities and fishing camps. One Aboriginal Corporation is permitted to fish in King Sound, with the other Aboriginal Corporation permitted to fish in a small area on the western side of the Dampier peninsula, north of Broome. Notices issued under the *Fish Resources Management Act 1994* prohibit all commercial fishing for mud crabs in Roebuck Bay and an area of King Sound near Derby.
Kimberley Gillnet and Barramundi Managed Fishery (KGBF)	Barramundi *(Lates calcarifer),* King threadfin *(Polydactylus macrochir),* Blue threadfin *(Eleutheronema tetradactylum)*	2017/2018: 79.9 tonnes	Gill net in inshore waters	Nearshore and estuarine zones of the North Coast Bioregion from the WA/NT border (129ºE) to the top end of Eighty Mile Beach, south of Broome (19ºS). The waters of the KGBF are defined as 'all Western Australian waters north of 19° south latitude and west of 129° east longitude and within three nautical miles of the high water mark of the mainland of Western Australia and the waters of King Sound south of 16°21.47′ south latitude.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Kimberley Prawn Managed Fishery (KPMF)	Banana prawns (*Penaeus merguiensis*) Tiger prawns (*Penaeus esculentus*) Endeavour prawns (*Metapenaeus endeavouri*) Western king prawns (*Penaeus latisulcatus*)	2017/2018: 269 tonnes	Otter trawl	The KPMF operates off the north of the state between Koolan Island and Cape Londonderry. The boundaries of the KPMF are 'all Western Australian waters of the Indian Ocean lying east of 123°45′ east longitude and west of 126°58′ east longitude'. It abuts the western boundary of the Commonwealth Northern Prawn Fishery (NPF).
Mandurah to Bunbury Developing Crab Fishery	Blue swimmer crab (*Portunus armartus)*	2017/2018: 5.2 tonnes	Drop nets, scoop nets, diving	Fishery extends from south of the Shoalwater Islands Marine Park (32°22'40''S) to Point McKenna near Bunbury (33°16'S) and offshore to 115°30'E. The fishery is divided into two zones with crab fishing historically being permitted within Area 1, Comet Bay between 32°22''40''S and 32°30'S, and Area 2, Cape Bouvard to the southern boundary of the fishery. In 2015 crab fishing within Area 2 ceased.
Marine Aquarium Fish Managed Fishery (MAFMF)	Over 250 target species of finfish. (228 species caught in 2012). Fishermen can also take coral, live rock, algae, seagrass and invertebrates. The main fish species landed in 2012 were scribbled angelfish (*Chaetodontoplus duboulayi*) and green chromis (*Chromis cinerascens*) The main coral species landed in 2012 were the coral like anemones of the Corallimorpharia.	2017/2018: Total catch of 150,544 fishes, 21.9 t of coral, live rock & living sand and 322 L of marine plants.	Hand harvest while diving or wading. Hand held nets	Dive based fishery operating all year throughout WA waters, but restricted by diving depths. The MAFMF is able to operate in all State waters (between the Northern Territory border and South Australian border). The fishery is typically more active in waters south of Broome with higher levels of effort around the Capes region, Perth, Geraldton, Exmouth and Dampier. Operators in the MAFMF are also permitted to take coral, live rock, algae, seagrass and invertebrates under the Prohibition on Fishing (Coral, 'Live Rock' and Algae) Order 2007 and by way of Ministerial Exemption (Gaughan & Santoro, 2018).

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Nickol Bay Prawn Managed Fishery (NBPMF)	Primarily targets banana prawns (*Penaeus merguiensis*)	2017/2018: 227 tonnes	Otter trawl	Operates along the western part of the North-West Shelf in coastal shallow waters The boundaries of the NBPMF are 'all the waters of the Indian Ocean and Nickol Bay between 116°45' east longitude and 120° east longitude on the landward side of the 200 m isobath'. The NBPMF incorporates the Nickol Bay, Extended Nickol Bay, Depuch and De Grey size managed fish grounds (State of the Fisheries 2014-15).
North Coast Trochus Fishery	Trochus (*Tectus niloticus*)	2017/2018: Unspecified	Harvested by with handheld levers or chisels	Indigenous fishery operating within King Sound
Northern Demersal Scalefish Managed Fishery (NDSF)	Red emperor (*Lutjanus sebae*) Goldband snapper (*Pristipomoides multidens*)	2017/2018:1317 tonnes (total) Goldband snapper (not including other jobfish): 473 tonnes Red emperor: 34 – 47 tonnes	The permitted means of operation within the fishery include handline, dropline and fish traps, but since 2002 it has essentially been a trap-based fishery which uses gear time access and spatial zones as the primary management measures (State of the Fisheries 2014-15).	The Northern Demersal Scalefish Managed Fishery (NDSF) operates off the northwest coast of Western Australia in the waters east of 120° E longitude. These waters extend out to the edge of the Australian Fishing Zone (200 nautical miles). The Fishery consists of three zones; Zone A is an inshore area, Zone B comprises the area with most historical fishing activity and Zone C is an offshore deep slope developmental area. The fishery is further divided into two fishing areas; an inshore sector and an offshore sector. The inshore waters in the vicinity of Broome are closed to commercial fishing.
WA North Coast Shark Fisheries	Sandbar (*Carcharhinus plumbeus*), hammer head (*Sphyrnidae*), blacktip (*Carcharhinus melanopterus*) and lemmon sharks (*Negaprion brevirostris*).	2017/2018: closed since 2008/2009	Gill net, longline	Comprised of the State-managed WA North Coast Shark Fishery in the Pilbara and western Kimberley, and the Joint Authority Northern Shark Fishery in the eastern Kimberley.
Octopus Interim Managed Fishery	*Octopus cf. tetricus*, with occasional bycatch of *O. ornatus* and *O. cyanea* in the northern parts of the fishery, and	2017/2018: Commercial: 257 tonnes	Line and pots Trawl and trap (land Octopus as byproduct)	Fishery in development phase. Four main categories in WA waters. Octopus are primarily caught in the Developing Octopus Interim

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
	O.maorum in the southern and deeper sectors.	Recreational: 1 tonne		Managed Fishery (largest fishery) are limited to the boundaries of the developmental fishery, which is an area bounded by the Kalbarri Cliffs (26°30'S) in the north and Esperance in the south. Passive and by-product harvests of octopus occur in both the Cockburn Sound (Line and Pot) Managed Fishery and the West Coast Rock Lobster Managed Fishery.
Offshore Net and Line Fishery	Blacktip sharks Grey mackerel,	The number of licences for the fishery is restricted to 17 and only 10 boats operated in 2015. Limited effort was undertaken in the outer offshore area of the fishery during 2012.	Lines and nets	The fishery covers an area of over 522,000 km2 and extends from the NT high water mark to the boundary of the AFZ. Majority of the fishing effort is in the coastal zone (within 12 nm of the coast) and immediately offshore in the Gulf of Carpentaria.
Onslow Prawn Managed Fishery (OPMF)	Western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus* spp.)	2017/2018: Negligible (Minimal fishing occurred in 2017)	Otter trawl	Operates along the western part of the North-West Shelf with most prawning activities concentrated in the shallower water off the mainland. The boundaries of the OPMF are 'all the Western Australian waters between the Exmouth Prawn Fishery and the Nickol Bay prawn fishery east of 114º39.9' on the landward side of the 200 m depth isobath'.
Pilbara Developmental Crab Fishery	Blue Swimmer (*Portunus armatus)* Mud Crab (*Scylla* spp)	2017/2018: 60 tonnes (total number includes Kimberley Developing Mud Crab Fishery)	Variety of gear but mostly commercial crab pots (Hourglass traps used in inshore waters from Onslow through to Port Hedland with most commercial and activity occurring in and around Nickol Bay)	The majority of the commercially and recreationally-fished stocks are concentrated in the coastal embayments and estuaries between Geographe Bay in the south west and Nickol Bay in the north. Crabbing activity along the Pilbara coast is centred largely on the inshore waters from Onslow through to Port Hedland, with most commercial and recreational activity occurring in and around Nickol Bay.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			Recreational fishers use drop nets or scoop nets, with diving for crabs becoming increasingly popular	
Pilbara Fish Trawl (Interim) Managed Fishery (PFTIMF)	Variety of demersal scalefish including goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*), bluespotted emperor (*Lethrinus punctulatus*), crimson snapper (*Lutjanus erythropterus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod (*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor (*Lethrinus nebulosus*) and frypan Moses' snapper (*Argyrops Lutjanusspinifer russelli*).	2017/2018: 1,780 tonnes	Demersal trawl	The Pilbara Fish Trawl (Interim) Managed Fishery is situated in the Pilbara region in the north west of Australia. It occupies the waters north of latitude 21°35'S and between longitudes 114°9'36"E and 120°E. The Fishery is seaward of the 50 m isobath and landward of the 200 m isobath. The Fishery consists of two zones; Zone 1 in the south west of the Fishery (which is closed to trawling) and Zone 2 in the North, which consists of six management areas.
Pilbara Trap Managed Fishery (PTMF)	Blue-spot emperor (*Lethrinus hutchinsi*), Red snapper (*Lutjanus erythropterus*), Goldband snapper (*Pristipomoides multidens*), Scarlet perch (*Lutjanus malabaricus*), Red emperor (*Lutjanus sebae*), Spangled emperor (*Lethrinus nebulosus*), Rankin cod (*Epinephelus multinotatus*)	2017/2018: 400–600 tonnes	Use of rectangular traps with single opening and 50 mm x 70 mm rectangular mesh panels. Trap fishing normally targets areas around rocky outcrops and reefs	Permitted to operate within waters bounded by a line commencing at the intersection of 21°56´ S latitude and the high water mark on the western side of the North West Cape.
Pilbara Line Managed Fishery	Variety of demersal scalefish including goldband snapper (*Pristipomoides multidens*), red emperor (*Lutjanus sebae*), bluespotted emperor (*Lethrinus punctulatus*), crimson snapper (*Lutjanus erythropterus*), saddletail snapper (*Lutjanus malabaricus*), Rankin cod	2017/2018: 50–115 tonnes	Line	The Pilbara Trap Managed Fishery lies north of latitude 21°44´ S and between longitudes 114°9´36´´ E and 120° E on the landward side of a boundary approximating the 200 m isobath and seaward of a line generally following the 30 m isobath.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
	(*Epinephelus multinotatus*), brownstripe snapper (*Lutjanus vitta*), rosy threadfin bream (*Nemipterus furcosus*), spangled emperor (*Lethrinus nebulosus*) and frypan snapper (*Argyrops spinifer*), Ruby snapper (*Etelis carbunculus*) and eightbar grouper (*Hyporthodus octofasciatus)*			
Roe's Abalone	Western Australian Roe's abalone (*Haliotis roei*)	2017/2018: Commercial: 49 tonnes Recreational: 23 tonnes	Dive and wade fishery. The commercial fishery harvest method is a single diver working off a 'hookah' (surface-supplied breathing apparatus) using an abalone 'iron' to prise the shellfish off rocks. Abalone divers operate from small fishery vessels (generally less than 9 metres in length).	Operating in shallow coastal waters along WA's western and southern coasts from Shark Bay to the SA border. Divided into 8 management areas. Commercial fishing for Roe's abalone is managed in 6 separate regions from the South Australian border to Busselton Jetty – Areas 1, 2, 5, 6, 7 and 8. Area 8 of the fishery was not fished in 2013.
Shark Bay Crab Interim Managed Fishery	Blue swimmer crab (*Portunus armatus*)	2017/2018: 443 tonnes total Crab: 153 tonnes	Trawl and trap	Waters of Shark Bay north of Cape Inscription, to Bernier and Dorre Islands and Quobba Point. In addition, two fishers with long-standing histories of trapping crabs in Shark Bay are permitted to fish in the waters of Shark Bay south of Cape Inscription.
Shark Bay Prawn Managed Fishery	Western king prawn (*Penaeus latisulcatus*), brown tiger prawn (*Penaeus esculentus*), Variety of smaller prawn species including endeavour prawns (*Metapenaeus* spp.) and coral prawns (various species).	2017/2018: 1,608 tonnes	Low opening otter trawls	The boundaries of the Shark Bay Prawn Managed Fishery are located in and near the waters of Shark Bay

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Shark Bay Scallop Managed Fishery	Saucer Scallop (*Ylistrum balloti*)	2017/2018: 1,632 tonnes	Low opening otter trawls	The boundaries of the Shark Bay Scallop Managed Fishery are located in and near the waters of Shark Bay
South Coast Open Access Netting Fishery	Insufficient information	Insufficient information	Insufficient information	Bunbury to the South Australian Border
Specimen Shell Managed Fishery (SSF)	Shells (cowries, cones) The Specimen Shell Managed Fishery (SSF) is based on the collection of individual shells for the purposes of display, collection, cataloguing, classification and sale. Just under 200 (196) different Specimen Shell species were collected in 2012, using a variety of methods.	2017/2018: 7,806 shells	Hand harvest while diving or wading along coastal beaches below the high water mark An exemption method being employed by the fishery is using a remote controlled underwater vehicle at depths between 60 and 300 m.	Dive based fishery operating all year throughout WA waters, but restricted by diving depths. The fishing area includes all Western Australian waters between the high water mark and the 200 m isobath. While the fishery covers the entire WA coastline, there is some concentration of effort in areas adjacent to population centres such as Broome, Karratha, Exmouth, Shark Bay, metropolitan Perth, Mandurah, the Capes area and Albany.
South Coast Salmon Managed Fishery	WA salmon (*Arripis truttaceus*)	2017: 50 tonnes	Beach seine net, rod and line	Licensees operate from 18 designated beaches within the South Coast Bioregion, many of which have huts that are referred to as salmon camps.
South West Coast Salmon Managed Fishery	WA salmon (*Arripis truttaceus*)	Insufficient information	Insufficient information	Insufficient information
South West Coast Beach Net	Insufficient information	Insufficient information	Insufficient information	Insufficient information
South West Trawl Managed Fishery (SWTMF)	Saucer scallops (*Ylistrum balloti*)	2017/2018: 460 t meat weight (2,301 t whole weight)	Otter trawls	Waters between 31°34′27′′S and 115°8′8′′E where it intersects with the high water mark at Cape Leeuwin and on the landward side of the 200 m isobath.
Spanish Mackerel Fishery	Narrow-barred spanish Mackerel	In 2012, there were 16 fishery licences of which 12 were actively operating (DPIF 2014).	Near-surface trolling gear from vessels or handline.	The fishery extends from the NT waters seaward off the coast and river mouths to the outer limit of the AFZ. The majority of the fishing effort occurs

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
		The 2012 fishing effort was 719 boat-days; a decrease from 813 boat-days in 2011 but an increase from the 672 boat-days in 2010.		coastal areas around reefs, shoals and headlands. The majority of the catch is taken in the Kimberley Area and north of Port Hedland.
Temperate Demersal Gillnet and Demersal Longline Fisheries (TDGDLF)	Gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*Carcharhinus plumbeus*).	2017/2018: 2016-17Sharks and rays: 936 tonnes Scalefish: 133 tonnes	Demersal gillnets and power-hauled reels (to target sharks) Demersal longline	The Temperate Demersal Gillnet and Demersal Longline fisheries consists of Zone 1 of the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery and the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery. The Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLF) spans the waters from 33° S latitude to the WA/SA border and comprises three management zones Zone 1 extends southwards from 33° S to 116° 30' E longitude off the south coast. Zone 2 extends from 116°30' E to the WA/SA border (129° E). A small number of Zone 3 units permit fishing throughout Zone 1 and eastwards to 116° 55'40" E. The West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF) technically extends northwards from 33° S latitude to 26° S longitude. However, the use of shark fishing gear has been prohibited north of 26° 30' S (Steep Point) since 1993. Demersal gillnet and longline fishing inside the 250 metre depth contour has been prohibited off the Metropolitan coast (between latitudes 31° S and 33° S) since November 2007.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Trepang Fishery	Sea cucumber (sandfish species)	The fishery is restricted to six licences, all of which are currently allocated.	Trepang are harvested by hand, either on foot or by diving.	Commercial fishing for sea cucumber is allowed from the high water mark to three nautical miles seaward from the territorial sea baseline. Most sea cucumbers are collected along the Arnhem Land coast, mainly around the Cobourg Peninsula and Groote Eylandt
Timor Reef Fishery	Goldband snapper	Consultation undertaken in 2016 confirmed there are only two active fishers currently operating in the fishery	Drop lines primarily in the 100 m–200 m depth range	Operates in remote offshore waters in the Timor Sea in a defined area approximately 370 km north-west of Darwin.
Warnbro Sound Crab Managed Fishery	Blue Swimmer (*Portunus armatus)* Blue swimmer crab (*Portunus armartus)*	2017/2018: closed to commercial and recreational fishing	Drop nets, scoop nets, diving	Includes Warnbro sound and adjacent water, extending from Becher Point to John Point.
West Coast Deep Sea Crustacean (Interim) Managed Fishery	Crystal (Snow) crabs (*Chaceon albus*), Giant (King) crabs (*Pseudocarcinus gigas*) and Champagne (Spiny) crabs (*Hypothalassia acerba*).	2017/2018: 164.4 tonnes	Baited pots operated in a longline formation in the shelf edge waters (>150 m)	North of latitude 34° 24' S (Cape Leeuwin) and west of the Northern Territory border on the seaward side of the 150 m isobath out to the extent of the AFZ, mostly in 500 to 800 m of water.
West Coast Demersal Scalefish (Interim) Managed Fishery	West Coast Inshore Demersals: West Australian Dhufish (*Glaucosoma hebraicum*), Pink snapper (*Pagrus auratus*) with other species captured including Redthroat Emperor (*Lethrinus miniatus*), Bight Redfish (*Centroberyx gerrardi*) and Baldchin Groper (*Choerodon rubescens*). West Coast Offshore Demersals: Eightbar Grouper *Hyporthodus octofasciatus*, Hapuku *Polyprion oxygeneios*, Blue-eye Trevalla *Hyperoglyphe antarctica* and Ruby Snapper *Etelis carbunculus*.	2017/2018: 248 tonnes	Handline and drop line	The WCDSIMF encompasses the waters of the Indian Ocean just south of Shark Bay (at 26°30’S) to just east of Augusta (at 115°30’E) and extends seaward to the 200 nm boundary of the Australian Fishing Zone (AFZ). The commercial fishery is divided into five management areas comprising four inshore areas and one offshore area. The inshore areas, i.e. Kalbarri, Mid-West, Metropolitan and South-West, extend outwards to the 250 m depth contour, while the Offshore Area extends the entire length of the fishery from the 250 m depth contour to the boundary of the AFZ.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
West Coast Estuarine Managed Fishery	Blue swimmer crab (*Portunus armartus)*	2017/2018: 353 tonnes (blue swimmer crab) commercial and 58-77 tonnes recreational	Drop nets, scoop nets, diving (crabs)	Includes the waters of the Swan and Canning Rivers (Area 1), the waters of the Peel Inlet and Harvey Estuary, together with the Murray Serpentine, Harvey and Dandalup Rivers (Area 2) and waters of the Hardy Inlet (Area 3). Of these areas only Areas 1-2 are permitted for crab fishing.
West Coast Nearshore and Estuarine Finfish Fisheries	<u>Nearshore:</u> whitebait (*Hyperlophus vittatus*), western Australian salmon (*Arripis truttaceus*), Australian herring (*Arripis georgianus*), southern school whiting (*Sillago bassensis*), yellowfin whiting (*Sillago schomburgkii*), yelloweye mullet (*Aldrichetta forsteri*), tailor (*Pomatomus saltarix*), southern garfish (*Hyporhamphus melanochir*), silver trevally (*Pseudocaranx georgianus*) and King George whtiting (*Sillaginodes punctate*). <u>Estuarine:</u> sea mullet (*Mugil cephalus*), estuary cobbler (*Cnidoglanis macrocephalus*) and black bream (*Acanthopagrus butcheri*).	2017/2018: 353 tonnes	Haul, beach seine and gill netting (commercial). Line fishing (recreational)	Five commercial fisheries target nearshore and/or estuarine finfish in the West Coast Bioregion. <u>Nearshore:</u> Cockburn Sound Fish Net Managed Fishery operating within in Cockburn sound, South West Coast Salmon Managed Fishery operating on various beaches south of the Perth Metropolitan area, West Coast Beach Bait Managed Fishery operating on beaches spanning from Moore River to Tim's Thicket and the South West Beach Seine Fishery operating on various beaches from Tim's Thicket southwards to Port Geographe Bay Marina. <u>Estuarine:</u> West Coast Estuarine Managed Fishery operating in the Swan/Canning and Peel Harvey estuaries, and in the Hardy Inlet
West Coast Nearshore Net Managed Fishery	Southern garfish (Hyporhamphus melanochir), Australian herring (Arripis georgianus),	Insufficient information	Insufficient information	Insufficient information
West Coast Purse Seine Fishery	Scaly mackerel (*Sardinella lemuru*), pilchard (*S. sagax*), Australian anchovy (*Engraulis australis*), yellowtail scad (*Trachurus novaezelandiae*) and maray (*Etrumeus teres*).	2017/2018: 1,095 tonnes	Purse seine gear	Waters between Ningaloo and Cape Leeuwin including three separate zones: Northern Development (22°00'S to 31°00'S), Perth Metropolitan (31°00'S to 33°00'S) and Southern Development Zone (33°00'S to Cape Leeuwin).

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
West Coast Rock Lobster Managed Fishery (WCRLMF)	Western rock lobster (*Panulirus cygnus*)	2016: 272 – 400 tonnes (346-481 tonnes based on updated average weight)	Baited traps (pots). Pots and diving (recreational catch)	The fishery is situated along the west coast of Australia between Latitudes 21°44´ to 34°24´ S. The fishery is managed in three zones: Zone A – Abrolhos Islands, north of latitude 30° S excluding the Abrolhos Islands (Zone B) and south of latitude 30° S (Zone C).
West Coast Demersal Gillnet and Demersal Longline (WCDGDLF)*	Gummy shark (*Mustelus antarcticus*), dusky shark (*Carcharhinus obscurus*), whiskery shark (*Furgaleus macki*) and sandbar shark (*C. plumbeus*)	2016/2018: 936 tonnes of sharks and rays	Demersal gillnets and demersal longline (not widely used)	Operates between 26° and 33° S.
Mackerel Fishery	Spanish mackerel *(Scomberomorus commerson)*, grey mackerel *(S.semifasciatus)*, with other species from the genera *Scomberomorus*, *Grammatorcynus* and *Acanthocybium* also contributing to commercial catches.	2016: Commercial: The commercial catch of spanish mackerel was 276 tonnes in 2016 (Gaughan & Santoro, 2018)	Trolling or handline Near-surface trolling gear from vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel *(S.semifasciatus)*	The Fishery extends from the West Coast Bioregion to the WA/NT border, to the 200 nautical mile AFZ with most effort and catches recorded north of Geraldton, especially from the Kimberley and Pilbara coasts of the Northern Bioregion. Restricted to coastal and shallower waters. Catches are reported separately for three Areas: Area 1 - Kimberley (121º E to WA/NT border); Area 2 -Pilbara (114º E to 121º E); Area 3 - Gascoyne (27º S to 114º E) and West Coast (Cape Leeuwin to 27º S).
Western Australian Pearl Oyster Managed Fishery	Indo- Pacific silver-lipped pearl oyster (*Pinctada maxima*).	2018: 468,573 shells	Drift diving restricted to shallow diveable depths. The collection of pearl oysters for the Pearl Oyster Managed Fishery is restricted to shallow diving depths below 35 m. Divers are attached to large outrigger booms on a vessel and towed slowly over the pearl oyster beds, harvesting	The fishery is separated into four zones: Pearl Oyster Zone 1: NW Cape (including Exmouth Gulf) to longitude 119°30’E. There are five licensees in this zone. No fishing in this zone since 2008 Pearl Oyster Zone 2: East of Cape Thouin (118°20´ E) and south of latitude 18°14´ S. The 9 licensees in this zone also have full access to Zone 3. This zone is the mainstay of the fishery.

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			legalised oysters by hand as they are seen.	Pearl Oyster Zone 3: West of longitude 125°20´ E and north of latitude 18°14´ S. The 2 licensees in this zone also have partial access to Zone 2. Pearl Oyster Zone 4: East of longitude 125°20´ E to the Western Australia/Northern Territory border. Although all licensees have access to this zone, exploratory fishing has shown that stocks in this area are not economically viable. However, pearl farming does occur.
Western Australian Sea Cucumber Fishery (formerly known as Beche-de-mer)	Sandfish (*Holothuria scabra*) and deepwater redfish (*Actinopyga echinites*).	2016: 93 tonnes	Hand-harvest fishery, with animals caught principally by diving, and a smaller amount by wading.	The Western Australian Sea Cucumber Fishery is permitted to operate throughout WA waters with the exception of a number of specific closures around the Dampier Archipelago, Cape Keraudren, Cape Preston and Cape Lambert, the Rowley Shoals and the Abrolhos Islands. The fishery is primarily based in the northern half of the State, from Exmouth Gulf to the Northern Territory border.
Commonwealth Managed Fisheries				
North West Slope Trawl	Scampi (crayfish): velvet scampi (*Metanephrops velutinus*) and boschmai scampi (*Metanephrops boschmai*). Deepwater prawns (penaeid and carid): pink prawn (*Parapenaeus longirostris*), red prawn (*Aristaeomorpha foliacea*), striped prawn (*Aristeus virilis*), giant scarlet prawn (*Aristaeopsis edwardsiana*), red carid prawn (*Heterocarpus woodmasoni*) and white carid prawn (*Heterocarpus sibogae*). Snapper.	2017-18: 79.7 total tonnes.	Demersal crustacean trawl seaward of the 200 m isobath.	Extends from 114° E to approximately 125° E off the WA coast between the 200 m isobath and the outer limit of the Australian Fishing Zone (AFZ).

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
Western Skipjack Tuna Fishery	Skipjack tuna (*Katsuwonus pelamis*)	2017-18: None in either zones	Purse seine	The Skipjack Tuna Fishery is split into two sectors; east and west. The Western Skipjack Tuna Fishery is located in all Australia waters west of 142° 30' 00°E, out to 200 nm from the coast. There has been no fishing effort in the Skipjack Tuna Fishery since the 2008-09 season, and in that season activity concentrated off South Australia (Department of Agriculture 2019).
Small Pelagic Fishery	Australian sardine (*Sardinops sagax*), blue mackerel (*Scomber australasicus*), jack mackerel (*Trachurus declivis*) and redbait (*Emmelichthys nitidus*).	2018-19: 9,424 tonnes	Purse-seine and midwater trawling	Extends from Queensland to southern Western Australia.
Southern Bluefin Tuna Fishery	Southern bluefin tuna (*Thunnus maccoyii*).	2017-18: 6,159 tonnes	Purse seine vessels primarily in Great Australian Bight all year round and longline off southern NSW in winter. Around 98% of Australia's SBT quota is taken by 5–10 purse seine vessels fishing for 13–25 kg southern bluefin tuna.	Fishery includes all waters of Australia, out to 200 nm from the coast. No current effort on the North West Shelf, fishing activity is concentrated in the Great Australian Bight and off South-east Australia (Department of Agriculture 2019).
Western Deepwater Trawl Fishery	A diverse range of species are caught, ranging from tropical and ruby snappers on the shelf edge to orange roughy (*Hoplostethus atlanticus*), oreo dories and bugs (*Ibacus* spp.) in the deeper temperate waters.	2017-18: 101.9 tonnes	Demersal fish trawl seaward of the 200 m isobath.	Its northernmost point is from the boundary of the AFZ to longitude 114° E, and its southernmost point is from the boundary of the AFZ to longitude 115°08' E. Deep water off WA, from the 200 m isobath to the edge of the AFZ.
Western Tuna and Billfish Fishery	Broadbill swordfish (*Xiphias gladius*), albacore tuna (*Thunnus alalunga*), striped marlin (*Kajikia audax*), bigeye tuna (*T. obesus*) and yellowfin tuna (*T. albacares*).	2018: 278 tonnes	Pelagic, longline, minor line and purse seine.	Extends westward from Cape York Peninsula (142°30' E) off Queensland to 34° S off the WA west coast. It also extends eastward from 34° S off the west coast of WA across the Great Australian Bight to 141° E at the South Australian–Victorian border. In recent years,

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
				fishing effort has concentrated off south-west Western Australia and South Australia with no current effort on the North West Shelf (Department of Agriculture 2019).

Source: Apache (2008); Australian Fisheries Management Authority (2011); Department of Fisheries (2013), Stakeholder consultation.

[1]Sources for catch data: Department of Agriculture 2019; Gaughan *et al*, 2019; DPIRD 2018.

15. Document review

This document is to be reviewed annually at a minimum. The review and revision will consider any changes to the spatial scope of the document, i.e. the Environment that May be Affected (EMBA), as well as any changes to EPBC Act Matters of National Environmental Significance (MNES) from one review year to the next, regardless of any changes to the spatial extent of the combined EMBA. A review of changes to MNES shall consider at a minimum any changes to EPBC Act species lists, species management/recovery plans and MNES spatial layers. Changes are to be recorded within the MNES review register (**Appendix B**).

16. References

16.1 Physical Environment

Asian Development Bank (ADB) 2014. State of the Coral Triangle: Indonesia. Mandaluyong City, Philippines 2014.

Baumgartner, M. F. (1997). The Distribution of Risso's Dolphin (Grampus griseus) with Respect to the Physiography of the Northern Gulf of Mexico. *Marine Mammal Science*, 13(4):614–638.

BHPB 2005. Pyrenees Development. Draft EIS. BHP Billiton Petroleum. Perth

Blaber SJM and Young JW and Dunning, MC 1985. Community structure and zoogeographic affinities of the coastal fishes of the Dampier region of north-western Australia. *Australian Journal of Marine and Freshwater Research* 36(2): 247–266

BoM (Bureau of Meteorology) 2013. Climatology of Tropical Cyclones in Western Australia. Bureau of Meteorology, Canberra, ACT. Available at http://www.bom.gov.au/cyclone/climatology/wa.shtml [Accessed 31 July 2013]

Condie, S, Andrewartha, J, Mansbridge, J and Waring, J 2006. Modelling circulation and connectivity on Australia's North West Shelf. North West Shelf Joint Environmental Management Study: Technical Report No. 6. CSIRO Marine and Atmospheric Research, Hobart, Tasmania

DEC 2013. Ngari Capes Marine Park management plan 2013 Shelf, Western Australian Department of Environment and Conservation, Perth

DEH (2005a). PB23 – Christmas Island Province factsheet.

DEH (2005b). PB22 – Cocos (Keeling) Island Province factsheet.

DEWHA 2008a. The North-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA 2008b. The South-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA 2008c. The North Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). 2012. Marine Bioregional Plan for the North Marine Region. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory.

[DoNP] Director of National Parks. (2012). Christmas Island National Park Management Plan 2014 – 2024.

[DoNP] Director of National Parks. (2017). Draft South-west Commonwealth Marine Reserves Network Management Plan 2017. Canberra.

Fugro, 2006a. Barossa-1 Site Survey – Volume 1 -Survey Results. Prepared for ConocoPhillips Australia Exploration Pty Ltd., Perth, Western Australia.

Fugro, 2006b. Darwin Offshore Growth Opportunities Offshore Geophysical Surveys 2005-2006 – Report for the Caldita to Bayu- Darwin Parallel Route North Intersection Volume 1A – Results and Appendicies. Parepared for ConocoPhillips Australia Exploration Pty Ltd., Perth, Western Australia.

Fugro, 2015. Barossa Field Meteorological, Current Profile, Wave and CTD Measurements – Final Report. Reporting Period: 8 July 2014 to 16 July 2015. Report prepared for ConocoPhillips Australia Pty Ltd., Perth, Western Australia

Heyward, A, Revill, A and Sherwood, C 2006. Review of research and data relevant to marine environmental management of Australia's North West Shelf North West Shelf Joint Environmental Management Study: Technical Report No. 1. CSIRO Marine and Atmospheric Research, Hobart, Tasmania

Holloway, PE 1983. Tides on the Australian north west shelf. *Australian Journal of Marine and Freshwater Research*, 34(1): 213–230

Holloway, PE and Nye, HC 1985 Leeuwin current and wind distributions on the southern part of the Australian North West Shelf between January 1982 and July 1983. *Australian Journal of Marine and Freshwater Research* 36(2): 123–137

Jacobs 2016 Barossa Environmental Studies – Water Quality Field Survey Report -Report prepared for ConocoPhillips, Perth, Western Australia.

Jones, A et al. (2019). Assessing Potential Environmental Influences on Killer Whale (Orcinus Orca) Distribution Patterns in the Bremer Canyon, South-West Australia. *Australian geographer,* 50(3):381.

McKinnon, AD, Meekan, MG, Carleton, JH, Furnas, MJ, Duggan, S and Skiring, W 2003 Rapid changes in shelf water and pelagic communities on the southern Northwest Shelf, Australia, following a tropical cyclone. *Continental Shelf Research* 23: 93–111

McLoughlin, RJ and Young, PC. 1985. Sedimentary provinces of the fishing grounds of the North-West Shelf of Australia: Grain-Size frequency analysis of surficial sediments. *Australian Journal of Marine and Freshwater Research* 36: 671–81

Moors-Murphy, HB. (2014). Submarine Canyons as Important Habitat for Cetaceans, with Special Reference to the Gully: A Review. Deep Sea Research Part II: *Topical Studies in Oceanography*, 104: 6–19.

NSR 1995. Wandoo full field development. Public Environmental Report for Ampolex Ltd, NSR Environmental Consultants Pty Ltd. November 1995

Pearce, A and Pattiaratchi, C. 1999. The Capes Current: a summer countercurrent flowing past Cape Leeuwin and Cape Naturaliste, Western Australia. *Continental Shelf Research* 19: 401-420

Przeslawski, R., Daniell, J., Anderson, T., Barrie, J.V., Battershill, C., Heap, A., Hughes, M., Li, J., Potter, A., Radke, R., Siwabessy, J., Tran, M, Whiteway, T., Nichol, S., 2011. Seabed Habitats and Hazards of the Joesph Bonaparte Gulf and Timor Sea, Northern Australia. Geoscience Australia, record 2011/40. Geoscience Australia, Canberra, Australian Capital Territory.

SSE 1991. Normal and extreme environmental design criteria. Campbell and Sinbad locations, and Varanus Island to Mainland Pipeline. Volume 1. Prepared for Hadson Energy Limited by Steedman Science and Engineering. Report E486. March 1991

SSE 1993. Review of oceanography of North West Shelf and Timor Sea regions pertaining to the environmental impact of the offshore oil and gas industry. Vol I prepared for Woodside Offshore Petroleum and the APPEA Review Project of Environmental Consequences of Development Related to the Petroleum Production in the Marine Environment: Review of Scientific Research, Report E1379, October 1993

WNI 1995. Preliminary report on ambient and non-cyclonic design criteria for the Stag location. WNI Science & Engineering. December 1995

WNI 1996. Metocean Conditions on the North West Shelf of Australia, Cape Lambert to the North West Cape Relating to Jack-up Drilling Operation. (DR-50-ED-001). July 1996

Woodside 2005. The Vincent Development. Draft EIS. EPBC Referral 2005/2110. Woodside Energy, Perth

16.2 Benthic and Pelagic Habitats

Adam, A.A.S. et al. 2022. Population connectivity and genetic offset in the spawning coral Acropora digitifera in Western Australia, *Molecular Ecology*, 31(13): 3533–3547

AIMS 2014. Benthic habitat characterisation of Montgomery Reef, Kimberley region, Western Australia. Available at http://data.aims.gov.au/metadataviewer/uuid/b4175af1-e213-4ac7-a7e8-baa121f709b2 [Accessed April 2014]

Amalfi C 2006. Flowers of the Ocean: WA's Expansive Seagrass Meadows; Western Fisheries Nov 2006, pg. 6-9

Australian Ocean Data Network 2017, Australian Phytoplankton Database, Integrated Marine Observing System. Available from: https://portal.aodn.org.au/ [Accessed: 20/11/2017]

Bancroft KP & JA Davidson 2000. Bibliography of marine scientific research relevant to the conservation of Ningaloo Marine Park and adjacent waters. Marine Conservation Branch, Department of Conservation and Land Management, Perth, Western Australia

BHPBIO 2011. Proposed Outer Harbour Development, Port Hedland Public Environmental Review/Draft Environmental Impact Statement. BHP Billiton Iron Ore, Perth, Western Australia

Blakeway D & Radford BTM 2004. Scleractinian corals of the Dampier Port and inner Mermaid Sound: species list, community composition and distributional data. Corals of the Dampier Harbour: Their survival and reproduction during the dredging programs of 2004, 1–8

Brooke BP 1997. Geomorphology of the islands and reefs of the central western Kimberley coast In: Marine Biological Survey of the Central Kimberley Coast, Western Australia, Ed DI Walker, University of Western Australia, Western Australia

Brewer DT, Lyne V, Skewes TD and Rothlisberg P 2007. Trophic Systems of the North West Marine Region Prepared for the Department of the Environment, Water, Heritage and the Arts by CSIRO Marine and Atmospheric Research, Cleveland, Queensland

Brewer, D.T., Potter, A., Skewes, T.D, Lyne, V., Andersen, J., Davies, C., Taranto, T.,Heap, A. D., Murphy, N. E., Rochester, W. A., Fuller, M., Donovan, A. 2009. Conservation values in Commonwealth waters of the Christmas and Cocos (Keeling) Islands remote Australian Territories. Report to Department of Environment and Water Resources. CSIRO, Cleveland. 216 pp

Brown K & Skewes T 2005. A preliminary assessment of the ecology of seagrasses at Ashmore Reef. In: Understanding the Cultural and Natural Heritage Values and Management Challenges of the Ashmore Region, Proceedings of a Symposium organised by the Australian Marine Sciences Association and the Museum and Art Gallery of the Northern Territory, Darwin, 4-6 April 2001. Edited *by* B Russell, H Larson, CJ Glasby, RC Willan, and J Martin. Museum and Art Galleries of the Northern Territory & Australian Marine Sciences Association, Darwin, Northern Territory. pp. 143–152

CALM, NPNCA 1996. Shark Bay Marine Reserves Management Plan 1996–2006. Management Plan No. 34. Department of Conservation and Land Management and National Parks and Nature Conservation Authority, Perth, Western Australia

CALM, MPRA 2005a. Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015. Management Plan No. 52. Department of Conservation and Land Management and Marine Parks and Reserves Authority, Perth, Western Australia

CALM, MPRA 2005b. Indicative Management Plan for the Proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area. Department of Conservation and Land Management and Marine Parks and Reserves Authority, Perth, Western Australia

Ceccarelli DM, Richards ZT, Pratchett MS, and Cvitanovic C (2011) Rapid increase in coral cover on an isolated coral reef, the Ashmore Reef National Nature Reserve, north-western Australia. Marine and Freshwater Research 62(10): 1214

Chevron 2010. Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project Volume 1 (Chapters 1 to 6), 6.0 Overview of Existing Environment. Chevron Australia Pty Ltd, Perth, Western Australia

ConocoPhillips 2018. Barossa Area Development Offshore Project Proposal. ConocoPhillips, Perth, Western Australia

DEC 2008. Preliminary reconnaissance survey of benthic habitats in the Anjo Peninsula area, Kimberley Bioregion, Western Australia. Prepared for Northern Development Taskforce, Department of Industry and Resources by Department of Environment and Conservation, Perth, Western Australia, October 2008

DEC 2013. Ngari Capes Marine Park management plan 2013. Department of Environment and Conservation, Perth

DEWHA 2008a. The North-west Marine Bioregional Plan Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North-west Marine Region. Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA 2008b. The South-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA 2008c. The North Marine Bioregional Plan Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North Marine Region. Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory

DeVantier, L., Turak, E., Allen, G. 2008. Lesser Sunda Ecoregional Planning Coral Reef Stratification: Reef- and Seascapes of the Lesser Sunda Ecoregion. Report to the Nature Conservancy. Bali, Indonesia. 72 pp.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC). 2012. Marine Bioregional Plan for the North Marine Region. Deppartment of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory

Director of National Parks 2012. Christmas Island National Park – Draft management Plan 2012-2022 Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory

DoF 2007. Plan of Management for the Kalbarri Blue Holes Fish Habitat Protection Area. Department of Fisheries, Fisheries Management Paper No. 188, Perth, Western Australia

DoF 2012. Exploring the Houtman Abrolhos Islands. Published by Department of Fisheries, Perth, Western Australia. Publication No. 105, June 2012.

Done TJ Williams D Mc B, Speare P, Turak E, Davidson J, DeVantier LM, Newman SJ & Hutchins JB 1994. Surveys of Coral and Fish Communities at Scott Reef and Rowley Shoals. Australian Institute of Marine Science, Townsville, Queensland

DPAW 2009. Shark Bay World Heritage Area. Department of Parks and Wildlife, Perth, Western Australia. Available at http://www.sharkbay.org/Stromatolitesfactsheet.aspx [Accessed April 2014]

DPAW 2013. Lalang-garram/ Camden Sound Marine Park Management Plan 73 2013–2023. Department of Parks and Wildlife, Perth, Western Australia

EA 2000. Mermaid Reef Marine National Nature Reserve Plan of Management 2000-2007. Environment Australia, Canberra, Australian Capital Territory

Evans K, Bax NJ & Smith DC 2016, Marine environment: State and trends of indicators of marine ecosystem health: Physical, biogeochemical and biological processes. In: Australia State of the Environment 2016, Australian Government Department of the Environment and Energy, Canberra.

Fry G, Heyward A, Wassenberg T, Taranto T, Stiegliz T and Colquhoun J 2008. Benthic habitat surveys of potential LNG hub locations in the Kimberley region. A CSIRO and AIMS Joint Preliminary Report for the Western Australian Marine Science Institution, Perth, Western Australia, 18 July 2008

Gage JD, Tyler PK 1992. Deep-sea Biology: A Natural History of Organisms at the Deep Sea Floor. Cambridge University Press, Cambridge, UK

Gilmour, J, Smith, L, Cook, K and Pincock, S 2013. Discovering Scott Reef: 20 years of exploration and research. Australian Institute of Marine Science, Perth, Western Australia.

Gilmour, J.P. et al. 2016. Biannual Spawning and Temporal Reproductive Isolation in Acropora Corals, *PLOS ONE*. Edited by N. Johnson, 11(3), p. e0150916. Available at: https://doi.org/10.1371/journal.pone.0150916

Gilmour JP, Cook KL, Ryan NM, Puotinen ML, Green RH, Shedrawi G, Hobbs J-PA, Thomson DP, Babcock RC, Buckee J, Foster T, Richards ZT, Wilson SK, Barnes PB, Coutts TB, Radford BT, Piggott CH, Depczynski M, Evans SN, Schoepf V, Evans RD, Halford AR, Nutt CD, Bancroft KP, Heyward AJ, Oades D 2019. The state of Western Australia's coral reefs. Coral Reefs, vol. 38, pp. 651-667

Griffith JK 1997. The Corals Collected During September/October at Ashmore Reef, Timor Sea. Parks Australia

Griffith JK 2004. Scleractinian corals collected during 1998 from the Dampier Archipelago, Western Australia. Records of the Western Australian Museum Supplement No. 66: 101–120

Hale J, Butcher R 2013. Ashmore Reef Commonwealth Marine Reserve Ramsar Site Ecological Character Description. A report to the Department of the Environment, Canberra, Australian Capital Territory

Hanson C.E. & McKinnon A.D 2009, Pelagic ecology of the Ningaloo region, Western Australia: influence of the Leeuwin Current, Journal of the Royal Society of Western Australia, vol. 92, pp. 129-137

Heyward, A, Revill, A and Sherwood, C 2006. Review of research and data relevant to marine environmental management of Australia's North West Shelf North West Shelf Joint Environmental Management Study: Technical Report No. 1. CSIRO Marine and Atmospheric Research, Hobart, Tasmania

Heyward, A.J., Pincerato, E.J., and Smith, L. (eds). 1997. Big Bank Shoals of the Timor Sea: An Environmental Resource Atlas. BHP Petroleum, Melbourne, Victoria

Heyward, A., Radford, B., Burns, K., Colquhoun, J., Moore, C. 2010. Montara Surveys: Final report on Benthic Surveys at Ashmore, Cartier and Seringapatam Reefs. Australian Institute of Marine Science, Crawley Western Australia

Heyward, A., Jones, R., Travers, M., Burns, K., Suosaari, G., Colquhoun, J., Case, M., Redford, B., Meekan, M., Markey, K., Schenk, T., O'Leary, R.A., Brooks, K., Tinkler, P., Cooper, T., Emslie, M. 2012. Montara: 2011 shallow reef surveys at Ashmore, Cartier and Seringapatam reefs (Monitoring Study No. S6B Coral Reefs). Australian Institute of Marine Science, Townsville

Heyward, A., Radford, B., Cappo, M., Wakeford, M., Fisher, R., Colquhoun, J., Case, M., Stowar, M. and Miller K. 2017. Barossa Environmental Baseline Study, Regional Shoals and Shelf Assessment 2015 Final Report. A report for ConocoPhillips Australia Exploration Pty Ltd by the Australian Institute of Marine Science, Perth 2017

Hooper J, Ekins M 2004. Collation and Validation of Museum Collection Databases related to the Distribution of Marine Sponges in Northern Australia. (Contract National Oceans Office C2004/020), Unpublished Report to the National Oceans Office, Brisbane: Queensland Museum

Huisman J 2004. Marine benthic flora of the Dampier Archipelago, Western Australia. pages 61–68 In: D.S. Jones (ed.) Marine Biodiversity of the Dampier Archipelago, Western Australia 1998–2002, Report of the Western Australian Museum, 2004, 401 pp., Western Australian Museum, Perth

Huisman JM, Leliaert F, Verbruggen H, Townsend RA 2009. Marine Benthic Plants of Western Australia's Shelf Edge Atolls. Records of the Western Australian Museum Supplement No. 77: 50–87

Hutumo M and Moosa MK 2005. Indonesian marine and coastal biodiversity: present status. Indian Journal of Marine Sciences. 34: 88-97

INPEX 2008. Presentation at the Northern Development Taskforce Site Evaluation Workshop. Broome, WA, 24 July 2008

IRCE 2002. Victoria, Little Sandy and Pedrika wells environmental monitoring programme. Prepared for Apache Energy Ltd by IRC Environment, Perth, Western Australia

IRCE (2003) Environmental monitoring of drilling discharges in shallow water habitats. Prepared for Apache Energy Ltd by IRC Environment, Perth, Western Australia

IRCE (2004) Biannual Coral Monitoring Survey 2004. Prepared for Apache Energy Ltd by IRC Environment, Perth, Western Australia

IRCE (2006) Biannual Macroalgae Monitoring Survey 2005. Prepared for Apache Energy Ltd by IRC Environment, Perth, Western Australia

IRCE 2007. Annual Marine Monitoring 2007: Lowendal and Montebello Islands Macroalgal Survey. Prepared for Apache Energy Ltd by IRC Environment, Perth, Western Australia

Jackson WJ, Argent RM, Bax NJ, Clark GF, Coleman S, Cresswell ID, Emmerson KM, Evans K, Hibberd MF, Johnston EL, Keywood MD, Klekociuk A, Mackay R, Metcalfe D, Murphy H, Rankin A, Smith DC & Wienecke B (2017). Australia state of the environment 2016: overview, independent report to the Australian Government Minister for the Environment and Energy, Australian Government Department of the Environment and Energy, Canberra.

Keesing JK, Irvine TR, Alderslade P, Clapin G, Fromont J, Hosie AM, Huisman JM, Philips JC, Naughton KM, Marsh LM, Slack-Smith SM, Thomson DP, Watson JE (2011). Marine benthic flora and fauna of Gourdon Bay and the Dampier Peninsula in the Kimberley region of north-western Australia. Journal of the Royal Society of Western Australia 94, no. 2 (2011): 285-301

Kendrick GA, Huisman JM and Walker DI (1990). Benthic Macroalgae of Shark Bay, Western Australia. Botanica Marina 33: 47–54

Lanyon JM & Marsh H 1995. Temporal changes in the abundance of some tropical intertidal seagrasses in North Queensland. Aquatic Botany 49:217–237

Last P, Lyne V, Yearsley G, Gledhill D, Gomon M, Rees T & White W, (2005) Validation of National Demersal Fish Datasets for the Regionalisation of the Australian Continental Slope and Outer Shelf (>40 m depth), Department of Environment and Heritage and CSIRO Marine

LEC, Astron 1993. Griffin Gas Pipeline Development Consultative Environmental Review. Prepared for BHP Petroleum and Doral Resources by LeProvost Environmental Consultants and Astron Engineering, Perth, Western Australia

Marsh LM 1990. Hermatypic corals of Shark Bay, Western Australia. In: Research in Shark Bay – Report of the France-Australe Bicentenary Expedition Committee, eds PF Berry, SD Bradshaw, BR Wilson, Western Australian Museum, Perth, pp 115–128

Masini R, Sim C, Simpson C 2009. Protecting the Kimberley: a synthesis of scientific knowledge to support conservation management in the Kimberley region of Western Australia, Part A. Department of Environment and Conservation, Perth, Western Australia

McCook L J, Klumpp DW, McKinnon AD 1995. Seagrass communities in Exmouth Gulf, Western Australia. A preliminary survey. Journal of the Royal Society of Western Australia 78: 81–87

McLeay LJ, Sorokin SJ, Rogers PJ, Ward TM 2003. Benthic Protection Zone of the Great Australian Bight Marine Park: 1 Literature Review. Report to Department of Environment and Heritage. South Australian Research and Development Institute.

McKinney, D 2009. A survey of the scleractinian corals at Mermaid, Scott, and Seringapatam Reefs, Western Australia, Records of the Western Australian Museum, Supplement, 77(1): 105. Available at: https://doi.org/10.18195/issn.0313-122x.77.2009.105-143.

NASA 2017, Global Patterns and Cycles, Earth Observatory. Available from: https://earthobservatory.nasa.gov/Features/Phytoplankton/page4.php [Accessed 24/11/2017].

Orr M, Zimmer M, Jelinski DE, & Mews M 2005. Wrack deposition on different beach types: spatial and temporal variation in the pattern of subsidy. Ecology 86(6), 2005, pp. 1496–1507

Pattiaratchi C. 2007, Understanding areas of high productivity within the South-West Marine Region, Prepared for the Department of the Environment, Water, Heritage and the Arts.

Pike G & Leach GJ 1997. Handbook of Vascular Plants of Ashmore and Cartier Islands. Parks and Wildlife Commission of the Northern Territory and Parks Australia, Canberra, Australian Capital Territory

Pratchett MS, Munday P, Wilson SK, Graham NA, Cinner JE, Bellwood DR, Jones GP, Polunin & McClanahan TR 2008. Effects of climate-induced coral bleaching on coral-reef fishes. Ecological and economic consequences. Oceanography and Marine Biology: Annual Review 46: 251-296

Prince RIT 1986. Dugong in northern waters of Western Australia 1984. Technical Report No7, Department of Conservation and Land Management, WA

Radform, B. and Puotinen, M. 2016. Spatial Benthic Model for the Oceanic Shoals Commonwealth Marine Reserve. Australian Institute of Marine Science, Perth, Western Australia. Available at: https://northwestatlas.org/node/1710 [accessed 10/12/2019]

Rees M, Heyward A, Cappo M, Speare P, Smith L 2004. Ningaloo Marine Park – Initial Survey of Seabed Biodiversity in Intermediate and Deeper Waters. Prepared for Australian Government Department of the Environment and Heritage by Australian Institute of Marine Science, Townsville, Queensland

Richards ZT, Bryce M, Bryce C (2013) New records of atypical coral reef habitat in the Kimberley, Australia. Journal of Marine Biology 2013, 363894

RPS Environmental 2008. INPEX environmental impact assessment studies – Technical appendix: Marine Ecology. Prepared for INPEX Browse LTD by RPS Environmental, Perth, Western Australia

RPS BBG 2005. Gorgon Development of Barrow Island Technical Report Marine Benthic Habitats. Report No. R03207. Prepared for ChevronTexaco Australia Pty Ltd by RPS Bowman Bishaw Gorham, Perth, Western Australia, April 2005

Russell BC, Hanley JR 1993. History and Development. In: Survey of the Marine Biological and Heritage Resources of Cartier and Hibernia Reefs, Timor Sea. Northern Territory Museum of Arts and Sciences, Darwin

Seagrass-Watch 2019. Kimberley Region. Available at http://www.seagrasswatch.org/WA.html [Accessed December 2019]

Skewes, T., Dennis, D., Jacobs, D., Gordon, S., Taranto, T., Haywood, M., Pitcher, C., Smith, G., Milton, D., Poiner, I., 1999a. Survey and Stock Size Estimates of the Shallow Reef (0-15 M Deep) and Shoal Area (15-50 M Deep) Marine Resources and Habitat Mapping Within the Timor Sea MOU74 Box. Volume 1: Stock Estimates and Stock Status. CSIRO Marine Research, Hobart

Skewes, T., Gordon, S., McLeod, I., Taranto, T., Dennis, D., Jacobs, D., Pitcher, C., Haywood, M., Smith, G., Poiner, I., Milton, D., Griffin, D., Hunter, C., 1999b. Survey and Stock Size Estimates of the Shallow Reef (0-15 m Deep) and Shoal Area (15-50 m Deep) Marine Resources and Habitat Mapping within the Timor Sea MOU74 Box. Volume 2: Habitat Mapping and Coral Dieback. CSIRO Marine Research, Hobart.

Smith, L., Humphrey, C., Hortle, R., Heyward, A., Wilson, D., 1997. Biological Environment, in: Heyward, A., Pinceratto, E., Smith, L. (Eds.), Big Bank Shoals of the Timor Sea: An Environmental Resources Atlas. BHP Petroleum & Australian Institute of Marine Science, Melbourne, pp. 15–94

SKM 2009b. Browse Kimberley LNG DFS#10 – Intertidal Survey. Prepared for Woodside Energy Limited by Sinclair Knight Merz Pty Ltd, Perth, Western Australia

The Ecology Lab 1997. Macroalgal Habitats of the Lowendal/Montebello Island Region. Prepared for Apache Energy Ltd by The Ecology Lab, September 1997

Thomas, L. et al. 2017. Restricted gene flow and local adaptation highlight the vulnerability of high-latitude reefs to rapid environmental change, *Global Change Biology*, 23(6): 2197–2205

Underwood, J.N 2009. Genetic diversity and divergence among coastal and offshore reefs in a hard coral depend on geographic discontinuity and oceanic currents: Genetic divergence in a hard coral, *Evolutionary Applications*, 2(2): 222–233

Underwood, J.N. et al. 2020. Extreme seascape drives local recruitment and genetic divergence in brooding and spawning corals in remote north-west Australia, *Evolutionary Applications*, 13(9): 2404–2421.

URS 2006. Report on Environmental Surveys Undertaken at Scott Reef in February 2006. Prepared for Woodside Energy Limited by URS Australia Pty Ltd, Perth, Western Australia

URS 2009. Report Annual Marine Monitoring – Macroalgae. Prepared for Apache Energy Ltd by URS Australia Pty Ltd, Perth, Western Australia, August 2009

URS 2010a. Ichthys Gas Field Development Project Studies of the Offshore Marine Environment. Prepared for INPEX Browse Ltd, Perth Western Australia, INPEX Document No. C036-AH-REP-0023

URS 2010b. Benthic Primary Producer (Seagrass and Macroalgae) Habitats of the Wheatstone Project Area. Report R1442. Prepared for Chevron Australia Pty Ltd by URS Australia Pty Ltd, Perth, Western Australia

van Keulen M, Langdon MW 2011. Ningaloo Collaboration Cluster: Biodiversity and ecology of the Ningaloo Reef lagoon. Ningaloo Collaboration Cluster Final Report No. 1c

Vergès A., Vanderklift M. Doropoulos C. and Hyndes G. 2011. Spatial Patterns in Herbivoury on a Coral Reff Are Influenced by Structural Complexity but not by Algal Traits. PloS one. 6. e17115. 10.1371/journal.pone.0017115.

Veron JEN 1986. Reef building corals. In: Berry, P.F. (ed.). Faunal surveys of the Rowley Shoals, Scott Reef and Seringapatam Reef, north-western Australia. Records of the Western Australian Museum, Supplement No. 25:25–35

Veron JEN 1993. Hermatypic corals of Ashmore Reef and Cartier Island. In: Marine Faunal Surveys of Ashmore Reef and Cartier Island, North-western Australia, ed. P.F. Berry. Western Australian Museum, Perth

Veron JEN, Marsh LM 1988. Hermatypic corals of Western Australia; Records and Annotated Species List. Records of the Western Australian Museum, Supplement No. 29. Western Australian Museum, Perth, Western Australia

Walker DI 1989. Seagrass in Shark Bay – the foundations of an ecosystem. In: Seagrasses: A Treatise on the Biology of Seagrass with Special Reference to the Australian Region, eds A W D Larkum, A J McComb, S A Shepherd, Elsevier, Amsterdam, pp.182-210

Walker DI 1995. Seagrasses and macroalgae. In FE Wells, R Hanley and DI Walker (Eds) Marine Biological Survey of the Southern Kimberley, Western Australia. Western Australian Museum, Perth, Western Australia

Walker DI 1997. Marine Biological survey of the central Kimberley coast, Western Australia. University of Western Australia, Perth, Western Australia

Walker DI, Wells FE & Hanley R 1996. Survey of the marine biota of the eastern Kimberley, Western Australia. University of Western Australia, Western Australian Museum and the Museum and Art Gallery of the Northern Territory

Walker DI & Prince RIT 1987. Distribution and biogeography of seagrass species on the northwest coast of Australia. Aquatic Botany 29:19–32

Waples K & Hollander E 2008. Ningaloo Research Progress Report: Discovering Ningaloo – latest findings andtheir implications for management. Ningaloo Research Coordinating Committee, Department of Environment and Conservation, WA

Western Australian Museum (WAM). 2009. A Marine Biological Survey of Mermaid Reef (Rowley Shoals), Scott and Seringapatam Reefs, Western Australia 2006. Edited by C Bryce. Records of the Western Australian Museum Supplement 77.

Wells FE, Walker DI & Jones DS (eds) 2003. The marine flora and fauna of Dampier, Western Australia. Western Australian Museum, Perth, Western Australia

Whiting S 1999. Use of the remote Sahul Banks, North-western Australia, by dugongs, including breeding females. Marine Mammal Science 15: 609–615

Williams A, Dunstan P, Althaus F, Barker B, McEnnulty F, Gowlett-Holmes K & Keith G (2010) Characterising the seabed biodiversity and habitats of the deep continental shelf and upper slope off the Kimberley coast, NW Australia. Report produced for Woodside Energy Ltd. CSIRO, pp. 95

Wilson, DF. 2005. Arafura Sea Biological Survey Report on RV Southern Surveyor Expedition 05/2005., A National Oceans Office, Australian Museum and CSIRO project, Hobart.

Wilson J, Darmawan A, Subijanto J, Green Aand Sheppard S. 2011. Scientific Design of a Resilient Network of Marine Protected Areas. Lesser Sunda Ecoregion, Coral Triangle. The Nature Conservancy. Asia Pacific Marine Program Report No. 2/11. March 2011

Wilson B 2013. The Biogeography of the Australian North West Shelf: Environmental Change and Life's Response. Elsevier. Western Australian Museum, Perth, Western Australia

Woodside 2011. Browse LNG Development Draft Upstream Environmental Impact Statement. EPBC Referral 2008/4111. Woodside Energy Ltd, Perth, Western Australia, November 2011

Woodside Energy Limited, Australian Institute of Marine Science, Western Australian Museum 2010. Scott Reef Status Report 2010.

16.3 Shoreline Habitats

Alongi DM 2002. Present state and future of the world's mangrove forests. Environmental Conservation 29, 331–349. doi:10.1017/S0376892902000231

Alongi DM (2009). The Energetics of Mangrove Forests. Springer.

Asian Development Bank. 2014. *State of the Coral Triangle: Indonesia.* Asian Development Bank, Mandaluyong City, Philippines.

Astron (2014) Apache OSMP - Desktop Mangrove Assessment. Prepared for Apache Energy Ltd by Astron Environmental Services, Perth, Western Australia, November 2013. Report reference 564-13-1MSR-1Rev0-140225

Astron (2016) Quadrant Environmental Monitoring Program Varanus Island Mangrove Monitoring Annual Report 2016. Prepared for Quadrant Energy Australia Ltd by Astron Environmental Services, Perth, Western Australia, February 2016. Report reference EA-60-RI-10155

Ayukai T (1998) Introduction: carbon fixation and storage in mangroves and their relevance to the global climate change – a case study in Hinchinbrook Channel in North-eastern Australia. Mangroves and Salt Marshes V2 No 4, Kluwer Academic Publishers.

CALM (2005) Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 Management Plan No. 52. Department of Conservation and Land Management, Western Australia.

CALM, MPRA (2005) Indicative Management Plan for the Proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area

Chatto R. and Baker, B. 2008. The Distribution and Status of Marine Turtle Nesting in the Northern Territory, Technical Report 77. Parks and Wildlife Commissiong of the Northern Territory, Darwin, Northern Territory.

Cresswell I, Semeniuk V, (2011) Mangroves of the Kimberley coast: ecological patterns in a tropical ria coast setting. Journal of the Royal Society of Western Australia 94, 213–237.

ConocoPhillips, 2020. Barossa Gas Export Pipeline Installation Environment Plan. ConocoPhillips, Western Australia.

DEC (2007) Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-2017. Management Plan Number 55. Department of Conservation and Land Management, Western Australia.

DEC (2013) Ngari Capes Marine Park management plan 2013– 2023, Management plan number 74. Department of Environment and Conservation, Perth.

DEWHA 2008. The North Marine Bioregional Plan Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North Marine Region. Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory

DPAW 2013. Lalang-garram/ Camden Sound Marine Park Management Plan 73 2013–2023. Department of Parks and Wildlife, Perth, Western Australia

DoF (2012) Exploring the Houtman Abrolhos Islands. Published by Department of Fisheries, Perth, Western Australia. Publication No. 105, June 2012.

Duke N, Wood A, Hunnam K, Mackenzie J, Haller A, Christiansen N, Zahmel K, Green T (2010) Shoreline ecological assessment aerial and ground surveys 7-19 November 2009.

Duke NC, Ball MC, Ellison JC (1998) Factors influencing biodiversity and distributional gradients in mangroves. Global Ecology and Biogeography Letters 7, 27–47.

EPA (2001) Guidance Statement for Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline. Guidance Statement No. 1. Environmental Protection Authority Western Australia Perth

Garnet S.T. and Crowley, G.M. (2000) The action plan for Australian birds 2000. Environment Australia, Canberra.

Gueho, R (2007) Rhythms of the Kimberley: a seasonal journey through Australia's north. Fremantle Press, Australia.

IUCN 2019. The IUCN Red List of Threatened Species. Version 2019-3. http://www.iucnredlist.org. Downloaded on 16 December 2019.

Johnstone R (1984) Intergradation between Lemon-breasted Flycatcher *Microeca flavigaster* Gould and Brown-tailed Flycatcher *Microeca tormenti* Mathews in Cambridge Gulf, Western Australia. Records of the Western Australian Museum 11, 291–295.

Kangas M, McCrea J, Fletcher W, Sporer E and Weir V (2006) Exmouth Gulf Prawn Fishery ESD Report Series No.1 Department of Fisheries Western Australia.

Kathiresan, K., Bingham, B.L., 2001. Biology of mangroves and mangrove ecosystems. Advances in marine biology 40, 81–251.

Kenyon R, Loneragan N, Manson F, Vance D, Venables W (2004). Allopatric distribution of juvenile red-legged banana prawns (*Penaeus indicus* H. Milne Edwards, 1837) and juvenile white banana prawns (*Penaeus merguiensis* De Man, 1888), and inferred extensive migration, in the Joseph Bonaparte Gulf, northwest Australia. Journal of Experimental Marine Biology and Ecology 309, 79–108.

Mangrove Watch Australia (2014) Pilbara Mangroves, MangroveWatch, Australia. Available at http://www.mangrovewatch.org.au/index.php?option=com_content&view=category&layout=blog&id=84&Itemid=300201 [Accessed February 2020]

Nagelkerken I, van der Velde G, Gorissen MW, Meijer GJ, Van't Hof T, den Hartog C, 2000. Importance of Mangroves, Seagrass Beds and the Shallow Coral Reef as a Nursery for Important Coral Reef Fishes, Using a Visual Census Technique. Estuarine, Coastal and Shelf Science 51, 31–44. doi:10.1006/ecss.2000.0617

NOAA (2010) Oil Spills in Mangroves, Planning and Response. National Oceanic and Atmospheric Administration. US Department of Commerce, Office of Response and Restoration.

Pedretti YM, Paling EI (2001) WA Mangrove Assessment Project 1999-2000. Marine and Freshwater Research Laboratory, Murdoch University, Perth, Western Australia.

Rule M, Kendrick A, Huisman J (2012) Mangroves of the Shark Bay Marine Park. Information Sheet 46/2012 Science Division. Department of Environment and Conservation.

Semeniuk V (1993) The mangrove systems of Western Australia: 1993 Presidential Address. Journal of the Royal Society of Western Australia 76:99-122.

Tomascik T., Mah, A.j., Nontji, A., and Moosa, M.K. 1997. The Ecology of the Indonesian Seas, Volume VIII, Part 2. Oxford Universities Press, United Kingdom.

URS 2010. Ichthys Gas Field Development Project Studies of the Offshore Marine Environment. Prepared for INPEX Browse Ltd, Perth Western Australia, INPEX Document No. C036-AH-REP-0023

Waples K (2007) Kimberley Biodiversity Review. WAMSI. Western Australia.

Wilson B, 1994. A representative Marine Reserve System for Western Australia.

Wilson B (2013) The Biogeography of the Australian North West Shelf: Environmental Change and Life's Response. Elsevier.

Zell L (2007) Kimberley Coast. Wild Discovery.

16.4 Intertidal Habitats

Barter M (2002) Shorebirds of the Yellow Sea: importance, threats and conservation status. Australian Government Publishing Service, Canberra, Australia.

Bennelongia Pty Ltd (2010) Analysis of possible change in ecological character of the Roebuck Bay and Eighty Mile Beach Ramsar sites.

BirdLife International (2018) Important Bird Areas Data Zone [Online]. Available from: http://www.birdlife.org [Accessed December 2018]

CALM (1996) Shark Bay Marine Reserves. Management Plan. 1996-2006. Marine Conservation Branch, Management Plan No. 34. Department of Conservation and Land Management, Western Australia.

DEC (2012) Indicative Management Plan for the Proposed Eight Mile Beach Marine Park. Department of Environment and Conservation, Western Australia.

DEC (2013) Ngari Capes Marine Park management plan 2013– 2023, Management plan number 74. Department of Environment and Conservation, Perth.

DPaW 2013. Lalang-garram / Camden Sound Marine Park management plan no. 73 2013–2023, Department of Parks and Wildlife, Perth, Western Australia.

Devantier, L. (2008). Reef- and Seascapes of the Lesser Sunda Ecoregion. 10.13140/RG.2.1.1956.8800.

Department of Sustainability, Environment, Water, Population and Communities (2013a) Conservation Advice for Subtropical and Temperate Coastal Saltmarsh. Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC (2013b) World Heritage Places – Shark Bay, Western Australia. Available at: https://www.environment.gov.au/heritage/places/world/shark-bay [Accessed 17 July 2013]

DoF (2012) Exploring the Houtman Abrolhos Islands. Published by Department of Fisheries, Perth, Western Australia. Publication No. 105, June 2012.

Duke N, Wood A, Hunnam K, Mackenzie J, Haller A, Christiansen N, Zahmel K, Green T (2010) Shoreline ecological assessment aerial and ground surveys 7-19 November 2009.

Garnet ST and Crowley GM (2000) The action plan for Australian birds 2000. Environment Australia Canberra.

Gibson, L. and Wellbelove, A (2010) Protecting critical marine habitats: The key to conserving our threatened marine species: a Humane Society International and WWF-Australia Report.

Hanley JR and Morrison PF (2012) A Guide to the intertidal flora and fauna of the Point Samson Fish Reserve. Sinclair Knight Merz and Rio Tinto Australia Pty Ltd.

IUCN 2019. The IUCN Red List of Threatened Species. Version 2019-3. http://www.iucnredlist.org. Downloaded on 16 December 2019.

Jones DS (2004) Marine biodiversity of the Dampier Archipelago Western Australia 1998-2002.

Masini R, Sim C, Simpson C (2009) Protecting the Kimberley: A synthesis of scientific knowledge to support conservation management in the Kimberley region of Western Australia.

Sinclair Knight Merz (2009) Baseline Intertidal Report. Cape Lambert Port B Development. Rio Tinto Australia Pty Ltd.

Sinclair Knight Merz (2010) Browse Kimberley LNG DFS10 – Intertidal Survey. James Price Point Intertidal Survey.

Sinclair Knight Merz (2011) Port Hedland Outer Harbour Development. Marine Coastal Intertidal Benthic Habitats Impact Assessment. Prepared for BHPBIO Pty Ltd.

Robertson, A.I., 1988. Decomposition of mangrove leaf litter in tropical Australia. Journal of Experimental Marine Biology and Ecology 116, 235–247. doi:10.1016/0022-0981(88)90029-9

Robson BJ, Burford M, Gehrke P, Revill A, Webster I, Palmer D (2008) Response of the lower Ord River and estuary to changes in flow and sediment and nutrient loads (Water for a Healthy Country Flagship Report). CSIRO.

Wade S, Hickey R, (2008). Mapping Migratory Wading Bird Feeding Habitats using Satellite Imagery and Field Data, Eighty-Mile Beach, Western Australia. Journal of Coastal Research 243, 759–770. doi:10.2112/05-0453.1

Wildsmith MD, Potter IC, Valesini FJ, Platell ME (2005) Do the assemblages of benthic Macroinvertebrates in nearshore waters of Western Australia vary among habitat types, zones and seasons? Journal of Marine Biology 85: 217-232.

Wilson B, 1994. A representative Marine Reserve System for Western Australia.

Wilson B (2013) The Biogeography of the Australian North West Shelf: Environmental Change and Life's Response. Elsevier.

Zell L (2007) Kimberley Coast. Wild Discovery.

16.5 Fish and Sharks

Allen, GR. (1989). Fishes. In Survey of the Marine Fauna of Cocos (Keeling) Islands, Indian Ocean. (Ed. P.F. Berry). (Western Australian Museum: Perth, Western Australia).

Allen, GR. and Smith-Vaniz, W.F. (1994). Fishes of the Cocos (Keeling) Islands. In Ecology and Geomorphology of the Cocos (Keeling) Islands. Atoll Research Bulletin, 399–414, Chapter 140.

BBG (1994) Dampier Port Authority, Environmental Management Plan. Report prepared by Bowman Bishaw Gorham Perth, for the Dampier Port Authority, Dampier.

Borrell A, Aguilar A, Gazo M, Kumarran RP, Cardona L 2011. Stable isotope profiles in whale shark (Rhincodon typus) suggest segregation and dissimilarities in the diet depending on sex and size. Environmental Biology of Fishes, 92: 559-567.

Bradshaw CJA, Mollet HF, Meekan MG 2007. Inferring population trends for the world's largest fish from mark-recapture estimates of survival. Journal of Animal Ecology 76: 480-489

Bray, D.J. & Gomon, M.F. 2017. *Galaxiella nigrostriata* in Fishes of Australia. Available at: http://fishesofaustralia.net.au/home/species/2130 [accessed 27/11/2019]

Brewer DT, Lyne V, Skewes TD and Rothlisberg P 2007. Trophic Systems of the North West Marine Region. Prepared for the Department of the Environment, Water, Heritage and the Arts by CSIRO Marine and Atmospheric Research, Cleveland, Australia.Cailliet, G.M. 1996. An Evaluation of Methodologies to Study the Population Biology of White Sharks. In: Klimley, A.P. & D.G. Ainley, (eds.) Great White Sharks The biology of *Carcharodon carcharias*. Page(s) 415-416. United States of America: Academic Press Limited.

Bulman C (2006) Trophic Webs and Modelling of Australia's North West Shelf. North West Shelf Joint Environmental Management Study: Technical Report No. 9. CSIRO Marine and Atmospheric Research, Hobart, Tasmania, CSIRO Marine and Atmospheric Research.

CALM (1996) Shark Bay Marine Reserves. Management Plan. 1996-2006. Marine Conservation Branch, Management Plan No. 34. Department of Conservation and Land Management.

CALM (2005) Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005 – 2015 Management Plan No. 52. Department of Conservation and Land Management, Perth, Western Australia.

Cailliet, G.M. (1996). An Evaluation of Methodologies to Study the Population Biology of White Sharks. In: Klimley, A.P. & D.G. Ainley, eds. Great White Sharks The biology of Carcharodon carcharias. Page(s) 415-416. United States of America: Academic Press Limited.

Chen C-T, Liu K-M, Joung S-J (1997) Preliminary report on Taiwan's whale shark fishery. Traffic Bulletin, 17: 53-57.

Chevron 2011. Technical Appendix 06 Draft Marine Fauna Management Plan. Appendix D: Sawfish Management Summary Report. Document No. WS0-0000-HES-PLN-CVX-000-00037-000. Rev E

Chidlow J, Gaughan D and McAuley RB (2006) Identification of Western Australian Grey Nurse Shark aggregation sites. Final report to the Australian Government, Department of the Environment and Heritage. Fisheries research report No. 155. Department of Fisheries, Western Australia, 48p.

CITES (2004). Convention of International Trade in Endangered Species of Wild Fauna and Flora - Appendix II Listing of the White Shark (revision 1). Available from: https://www.environment.gov.au/system/files/resources/2a4abfb5-236c-43bf-ad9d-b6d29c507f04/files/great-white-cites-appendix2-english.pdf [accessed February 2020].Clark, E and Nelson, D. (1997). Young whale sharks, *Rhincodon typus*, feeding on a copepod bloom near La Paz, Mexico. Environmental Biology of Fishes. 50. 63-73. 10.1023/A:1007312310127.

Commonwealth of Australia, 2015. Sawfish and River Sharks Multispecies Recovery Plan. Available from: http://www.environment.gov.au/system/files/resources/062794ac-ef99-4fc8-8c18-6c3cd5f6fca2/files/sawfish-river-sharks-multispecies-recovery-plan.pdf. [Accessed February 24 2020].

Compagno, L J (2001) Sharks of the World: An Annotated and Illustrated Catalogue of Shark Species Known to Date. Vol. 2, Bullhead, Mackeral and Carpet Sharks (Heterodontiformes, Lamniformes and Orectolobiformes) (Vol. 2, No. 1). Food & Agriculture Org.

Compagno, LJV & Last, PR 1999. Order Pristiformes. Pristidae: sawfishes, in KE Carpenter & VH Niem (eds), FAO species identification guide for fishery purposes – the living marine resources of the western central Pacific, vol. 3, Batoid fishes, chimaeras and bony fishes, part 1 (*Elopidae* to *Linophyroidae*), FAO, Rome, pp. 1410–1417.

Couturier, LIE, Rohner, CA, Richardson, AJ, Pierce, SJ, Marshall, AD, Jaine, FRA, Townsend, KA, Bennett, MB, Weeks, SJ, & Nichols, PD. (2013). Unusually high levels of n-6 polyunsaturated fatty acids in whale sharks and reef manta rays. *Lipids,* 48(10):1029-1034.

de Lestang P & Jankowski A (2017). A Guide to the Common Marine Fishes of Barrow Island. Chevron. Available from: https://australia.chevron.com/-/media/australia/publications/documents/nature-book-fish.pdf [Accessed 26/02/20].

DEC (2007a) Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017: Management Plan No. 55. Department of Environment and Conservation, Perth, Western Australia.

DEC (2007b) Management Plan for the Rowley Shoals Marine Park 2007–2017: Management Plan No. 56. Department of Environment and Conservation, Perth, Western Australia

DEC (2013) Ngari Capes Marine Park management plan 2013– 2023, Management plan number 74. Department of Environment and Conservation, Perth.

DEH (2006) A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0. Department of the Environment and Heritage, Canberra, Australia.

DEWHA (2008a) The north-west marine region bioregional profile: a description of the ecosystems, conservation values and uses of the north-west marine region, Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA), Canberra.

DEWHA (2008b). The South-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA 2008c. The North Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, Australian Capital Territory

DEWHA (2009) DEWHA Fact Sheet – Three sharks listed as migratory species under the EPBC Act. Department of the Environment, Water, Heritage and the Arts, Canberra, Australia.

DEWHA (2012a) Species group report card – bony fishes. Supporting the marine bioregional plan for the North-west Marine Region. Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA), Canberra.

DEWHA (2012b) Species group report card – sharks and saw fishes. Supporting the marine bioregional plan for the North-west Marine Region. Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA), Canberra.

DoE (2014a) *Ophisternon candidum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 21 Mar 2014

DoE (2014b) *Pristis clavata* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 18 Mar 2014

DoE (2014c) *Pristis pristis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 25 Mar 2014

DoE (2014c) *Pristis zijsron* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 25 Mar 2014

DoE (2015) Approved Conservation Advice *Rhincodon typus* (whale shark). Threatened Species Scientific Committee, Department of the Environment, Canberra, Australian Capital Territory

DoEE (2016a). *Nannatherina balstoni* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 2 Aug 2016

DoF (2012) Exploring the Houtman Abrolhos Islands. Published by Department of Fisheries, Perth, Western Australia. Publication No. 105, June 2012.

DSEWPaC (2012) Marine Bioregional Plan for the North-west Marine Region. Prepared under the Environment Protection and Biodiversity Conservation Act 1999. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory

Eckert, S.A, and Stewart, B. S. (2001) Telemetry and satellite tracking of whale sharks, *Rhincodon typus*, in the sea of Cortez, Mexico, and the north Pacific Ocean. Environmental Biology of Fishes 60: 299-308.

Fletcher, WJ. and Santoro, K. (2013). Status Reports of the Fisheries and Aquatic Resources of Western Australia 2012/13(eds). The State of the Fisheries. Department of Fisheries, Western Australia.

Fox, NJ and Beckley, LE (2005). Priority areas for conservation of Western Australian coastal fishes: A comparison of hotspot, biogeographical and complementarity approaches. Biological Conservation, 125: 399-410.

Gaughan, D.J., Molony, B. and Santoro, K. (eds) 2019. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2017/18: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Gelsleichter J, Musick JA & Nichols S (1999). Food habits of the smooth dogfish, *Mustelus canis*, dusky shark, *Carcharhinus obscurus*, Atlantic sharpnose shark, *Rhizoprionodon terraenovae*, and the sand tiger, *Carcharias taurus*, from the northwest Atlantic Ocean, Environmental Biology of Fishes, vol. 54, pp. 205–217.

Humphreys B & J Blyth (1994) Subterranean Secrets. Landscope - WA's Conservation, Forests and Wildlife Magazine. 9, No. 3:22-27.

Humphreys WF & MN Feinberg (1995) Food of the blind cave fishes of North-western Australia. *Records of the Western Australian Museum*. 17:29-33.

Humphreys WF (1999) The distribution of Australian cave fishes. Records of the Western Australian Museum. 19:469-472.

Hutchins JB (2003). Checklist of marine fishes of the Dampier Archipelago, Western Australia. Pp. 453-478. In: Wells, F.E., Walker D.I. & Jones D.S. (eds). *The Marine Flora and Fauna of Dampier, Western Australia*. Western Australian Museum, Perth.

Hutchins JB (2004) Fishes of the Dampier Archipelago, Western Australia pp. 343-398. In: Jones D.S. (ed). Report on the results of the Western Australia Museum/Woodside Energy Ltd. Partnership to explore the Marine Biodiversity of the Dampier Archipelago. Western Australia 1998-2002. Records of the Western Australian Museum Supplement No. 66: 343-398.

IUCN 2019. The IUCN Red List of Threatened Species. Version 2019-3. http://www.iucnredlist.org. Accessed 16 December 2019.

Jarman SN, Wilson SG (2004) DNA-based species identification of krill consumed by whale sharks. *Journal of Fish Biology*, 65: 586-591

Kemps, H (2010) Ningaloo: Australia's Untamed Reef. Quinns Rocks: MIRG Australia

Kospartov, M., Beger, M., Ceccarelli, D., and Richards, Z. (2006). An assessment of the distribution and abundance of sea cucumbers, trochus, giant clams, coral, fish and invasive marine species at Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve: 2005. Report prepared by UniQuest Pty Ltd for the Department of the Environment and Heritage, Canberra, ACT.

Last P, Lyne V, Yearsley G, Gledhill D, Gomon M, Rees T and White, W (2005) Validation of national demersal fish datasets for the regionalisation of the Australian continental slope and outer shelf (>40 m depth). Department of Environment and Heritage and CSIRO Marine Research, Australia. 99pp

Last PR & Stevens JD (2009) Sharks and rays of Australia, 2nd edn, CSIRO Publishing, Collingwood.

Mackie M, Nardi A, Lewis P and Newman S (2007) Small Pelagic Fishes of the North-west Marine Region, Prepared for the Department of the Environment and Water Resources by Department of Fisheries, Perth, Western Australia.

Lara, M, Virtue, P, Pethybridge, HR, Meekan, MG, Thums, M & Nichols, PD. (2016). Intraspecific variability in diet and implied foraging ranges of whale sharks at Ningaloo Reef, Western Australia, from signature fatty acid analysis. *Marine Ecology Progress Series,* 554:115-128.

Marcus, L., Virtue, P, Pethybridge, HR,. Meekan, MG, Thums, M & Nichols, PD. (2016).Intraspecific Variability in Diet and Implied Foraging Ranges of Whale Sharks at Ningaloo Reef,Western Australia, from Signature Fatty Acid Analysis. Marine Ecology Progress Series554: 115–28

McAuley, R. 2004. Western Australian Grey Nurse Shark Pop Up Archival Tag Project. Final Report to Department of Environment and Heritage. Page(s) 55.

Meekan MG, Bradshaw CJA, Press M, McLean C, Richards A, Quasnichka S, Taylor JA (2006) Population size and structure of whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia. Marine Ecology Progress Series 319: 275-285

Meekan MG, Jarman SN, McLean C, Schultz MB (2009) DNA evidence of whale sharks (*Rhincodon typus*) feeding on red crab (*Gecarcoidea natalis*) larvae at Christmas Island, Australia. Marine and Freshwater Research 60: 607-609

Meekan, MG, Virtue, P, Marcus, L, Clements, KD, Nichols, PD & Revill, AT. (2022). The world's largest omnivore is a fish. *Ecology* (Durham) e3818.

Norman, B (2005) *Rhincodon typus*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Accessed 31 May 2013.

Norman, B.M. and Stevens, JD (2007) Size and maturity status of the whale shark (*Rhincodon typus*) at Ningaloo Reef in Western Australia. Fisheries Research, 84: 81-86.

Otway NM, & PC Parker (2000) The Biology, Ecology, Distribution, Abundance and Identification of Marine Protected Areas for the Conservation of Threatened Grey Nurse Sharks in South-east Australian Waters. NSW Fisheries Office of Conservation.

Peverell SC (2005) Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on sawfish ecology, Environmental Biology of Fishes, vol. 73, pp. 391–402.

Pierce, SJ., Pardo, SA., Rohner, CA., Matsumoto, R., Murakumo, K., Nozu, R. & Meekan, M.G. (2021). Whale Shark Reproduction, Growth, and Demography. Whale Sharks: Biology, Ecology, and Conservation.

Pogonoski JJ, DA Pollard & JR Paxton (2002) Conservation Overview and Action Plan for Australian Threatened and Potentially Threatened Marine and Estuarine Fishes. [Online]. Canberra, ACT: Environment Australia. Available from: https://www.environment.gov.au/system/files/resources/ca415225-5626-461c-a929-84744e80ee36/files/marine-fish.pdf [Accessed February 2020].

Pollard, DA MP Lincoln-Smith & A.K. Smith (1996) The biology and conservation of the grey nurse shark (*Carcharias taurus* Rafinesque 1810) in New South Wales, Australia. Aquatic Conservation: Marine and Freshwater Ecosystems. 6.

Rowat, D & KS Brooks. (2012). A Review of the Biology, Fisheries and Conservation of the Whale Shark Rhincodon Typus. *Journal of fish biology*, 80(5).

Russell, B., Larson, H., Hutchins, J., and Allen, G.R. (2005). Reef Fishes of the Sahul Shelf. In Understanding the Cultural and Natural Heritage Values and Management Challenges of the Ashmore Region, Proceedings of a Symposium organised by the Australian Marine Sciences Association and the Museum and Art Gallery of the Northern Territory, Darwin, 4-6 April 2001. Edited by B. Russell, H. Larson, C.J. Glasby, R.C. Willan, and J. Martin. Museum and Art Galleries of the Northern Territory & Australian Marine Sciences Association, Darwin, Northern Territory. pp. 83–105.

Sainsbury KJ, Campbell RA and Whitlaw AW (1992) Effects of trawling on the marine habitat on the North West Shelf of Australia and implications for sustainable fisheries management. In: Hancock D. A. (Editor). *Sustainable Fisheries through Sustaining Fish Habitat*. Canberra Australia. Australian Government Publishing Service, 1993, 137–145. Aust Soc. for Fish. Biol. Workshop, Victor Harbour, SA, 12–13 August 1992.

Smale MJ (2005) The diet of the ragged-tooth shark *Carcharias taurus* Rafinesque 1810 in the Eastern Cape, South Africa, African Journal of Marine Science, vol. 27, pp. 331–335.

Stevens JD, McAuley RB, Simpfendorfer CA & Pillans RD (2008) Spatial distribution and habitat utilisation of sawfish (Pristis spp) in relation to fishing in northern Australia, report to the Australian Government Department of Environment and Heritage, Canberra.

Stevens JD, Pillans, RD and Salini J (2005) Conservation Assessment of *Glyphis sp.* A (Speartooth Shark), *Glyphis sp.* C (Northern River Shark), *Pristis microdon* (Freshwater Sawfish) and *Pristis zijsron* (Green Sawfish). [Online]. Hobart, Tasmania: CSIRO Marine Research. Available from: https://www.environment.gov.au/system/files/resources/d1696b5b-6a2e-4920-a3e2-16e5a272349a/files/assessment-glyphis.pdf [Accessed February 2020].

Thorburn DC, DL Morgan, AJ Rowland & HS Gill (2007) Freshwater sawfish *Pristis microdon* Latham, 1794 (Chondrichthyes: Pristidae) in the Kimberley region of Western Australia. *Zootaxa*. 1471:27-41.

Thorburn, DC, Morgan, DL, Rowland, AJ & Gill HS (2004) The northern river shark (*Glyphis sp*.C) in Westenr Australia, Report to the National Trust

Thorburn, DC, Morgan, DL, Rowland, AJ, Gill, HS & Paling, E (2008) Life history notes of the critically endangered dwarf sawfish, *Pristis clavata*, Garman 1906 from the Kimberley region of Western Australia', Environmental Biology of Fishes, vol. 83, pp. 139–145

Tyminski, John P et al. (2015). Vertical Movements and Patterns in Diving Behavior of Whale Sharks as Revealed by Pop-Up Satellite Tags in the Eastern Gulf of Mexico: *PloS one*, 10(11).

Whisson, G & Hoshke, A (2013). *In situ* video monitoring of finfish diversity at Ningaloo Reef, Western Australia. Galaxea, Journal of Coral Reef Studies. The Japanese Coral Reef Society. Vol. 15, pp 72-28

Wilson, S Polovina, J Stewart, B & Meekan, M (2006) Movements of whale sharks (*Rhincodon typus*) tagged at Ningaloo Reef. Marine Biology, vol. 147, pp. 1157-1166.

Womersley, Freya C et al. (2022) Global Collision-Risk Hotspots of Marine Traffic and the World's Largest Fish, the Whale Shark. Proceedings of the National Academy of Sciences, 119(20).

16.6 Marine Reptiles

AIMS (Australian Institute of Marine Science). (2021). Hawksbill and green turtle distribution and important areas. As part of the Northwest Shores to Shoals Research Program, supported by Santos. Available at: https://northwestatlas.org/nwa/nws2s-megafauna#green_bia

Astron Environmental Services (2013a) Exmouth Islands Turtle Monitoring Program – Desktop Review and Gap Analysis. Rev B, 26 September 2013, unpublished report for Apache Energy Ltd, Perth.

Astron Environmental Services (2014) Exmouth Islands Turtle Monitoring Program – January 2014 Field Survey. Rev A, 11 February 2014, unpublished report for Apache Energy Ltd, Perth.

Astron (2017) Quadrant Environmental Monitoring Program Varanus and Airlie Islands Turtle Monitoring Annual Report 2016/17, Prepared for Quadrant Energy Australia Ltd by Astron Environmental Services, Perth, Western Australia, June 2017. Report reference EA-60-RI-10173.

BHPB (2005) Pyrenees Development: Draft Environmental Impact Statement. BHP Billiton, Perth, Western Australia.

Baldwin R, Hughes GR and Prince RIT (2003) Loggerhead turtles in the Indian Ocean. In: AB Bolten and BE Witherington (eds) Loggerhead Sea Turtles, Smithsonian Books, Washington.

DEC (2009a) Management Plan for the Commercial Harvest and Farming of Crocodiles in Western Australia 1 January 2009-31 December 2013.

CALM (2005a) Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005 – 2015 Management Plan No. 52. Department of Conservation and Land Management, Perth, Western Australia.

Chaloupka M and Prince RIT (2012) Estimating demographic parameters for a critically endangered marine species with frequent reproductive omission: Hawksbill turtles nesting at Varanus Island, Western Australia. Marine Biology 159(2): 355-363.

Chevron (2005) Environmental Impact Statement/Environmental Review and Management Programme for the proposed Gorgon Development. Chevron Australia Pty Ltd, Perth, Western Australia.

Chevron (2008) Gorgon Gas Development Revised and Expanded Proposal Public Environmental Review Operated by Chevron Australia in joint venture with Gorgon Project. EPBC Referral 2008/4178Assessment No. 1727. Chevron Australia Pty Ltd, Perth, Western Australia, September 2008.

Commonwealth of Australia (2017a), Recovery Plan for Marine Turtles in Australia 2017 – 2027.

DEWHA (2008a) The North-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, ACT.

DSEWPaC (2012a) *Eretmochelys imbricata* – Hawksbill Turtle. Available from: http://www.environment.gov.au/cgibin/sprat/public/publicspecies.pl?taxon_id=1766. Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC (2012b) Marine bioregional plans. Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT. Available at http://www.environment.gov.au/marine/marine-bioregional-plans/about

DSEWPaC (2012c) *Natator depressus* – Flatback Turtle. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257. Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC (2012d) Species Group Report Card – Reptiles. Supporting the draft marine bioregional plan for the North-west Marine Region. Department of Sustainability, Environment, Water, Populations and Communities, Canberra, Australia.

DoE (2014) *Aipysurus foliosquama* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1118. Accessed 23 July 2014

DoEE (2019) Species Profile and Threats Database [Online] Department of Environment and Energy Canberra, Commonwealth of Australia Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Fossette, S, Ferreira, LC, Whiting, SD, Pendoley, JKK, Shimada, T, Speirs, M, Tucker, AD, Wilson, P & Thums, M. (2021). Movements and distribution of hawksbill turtles in the Eastern Indian Ocean. *Global Ecology and Conservation,* 29. e01713.

Fukuda, Y., P. Whitehead & G. Boggs (2007). Broad-scale environmental influences on the abundance of saltwater crocodiles (Crocodylus porosus). Australia. Wildlife Research. 34:167-176.

Hamann, M, Jessop, T. Limpus, C. and Whittier, J.M. (2002). Interactions among endocrinology, seasonal reproductive cycles and the nesting biology of the female green sea turtle. Marine Biology. 140. 823-830. 10.1007/s00227-001-0755-8.

Keesing, J.K. (Ed.) 2019. Benthic habitats and biodiversity of the Dampier and Montebello Australian Marine Parks. Report for the Director of National Parks. CSIRO, Australia.

Kendall WL and Bjorkland R (2001) Using open robust design models to estimate temporary emigration from capture - recapture data. Biometrics: 57,1113 – 1122.

Limpus CJ (2007) A biological review of Australian marine turtle species. 5. Flatback turtle*, Natator depressus* (Garman). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

Limpus CJ (2008a) A biological review of Australian marine turtle species. 2. Green turtle*, Chelonia mydas* (Linneaus). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

Limpus CJ (2008b) A biological review of Australian marine turtle species. 1. Loggerhead turtle*, Caretta caretta* (Linneaus). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

Limpus CJ 2009a. A biological review of Australian marine turtle species.3. Hawksbill turtle, *Eretmochelys imbricata* (Linneaus). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

Limpus CJ (2009b) *A Biological Review of Australian Marine Turtles*, Queensland Environmental Protection Agency, Queensland.

Limpus CJ (2009c) A biological review of Australian marine turtle species. 6. Leatherback turtle, *(Dermochelys coriacea*). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

Limpus C.J and McLachlin N (1994) The conservation status of the Leatherback Turtle, *Dermochelys coriacea*, in Australia. In: James R (ed.) Proceedings of the Australian Marine Turtle Conservation Workshop, Gold Coast 14-17 November 1990. pp. 63-67. Queensland Department of Environment and Heritage. Canberra: ANCA.

Limpus, C. and N. Nicholls. 1994. Progress report on the study of the interaction of the El Nino Southern Oscillation on annual Chelonia mydas numbers at the Southern Great Barrier Reef rookeries. Australian Marine Turtle Conservation Workshop. Queensland Dept of Environment and Heritage Australian Nature Conservation Agency, Sea World, Nara Resort, Gold Coast.Limpus, C. J. and N. Nicholls. 1988. The Southern Oscillation Regulates the Annual Numbers of Green Turtles (Chelonia-Mydas) Breeding Around Northern Australia. Wildlife Research 15: 157- 161.

McMahon, CR, Bradshaw, JA & Hays, GC. (2007). Satellite tracking reveals unusual diving characteristics for a marine reptile, the olive ridley turtle Lepidochelys olivacea. *Marine Ecology Progress Series.* 329:239-252.

Minton SA & Heatwole H (1975) Sea snakes from three reefs of the Sahul Shelf. In: Dunson, W. A., ed. The Biology of Sea Snakes. Page(s) 141-144. Baltimore: University Park Press.

Morris K (2004) Regional significance of marine turtle rookeries on the Lowendal Islands. Unpublished information provided to Apache Energy Ltd.

Northern Territory Government (n.d.) Threatened Species of the Northern Territory Green Turtle Chelonia mydas. The Northern Territory Government, Northern Territory.

Oliver GA (1990) Interim Guidelines for Operations – Serrurier Island Nature Reserve. Department of Conservation and Land Management, Perth, Western Australia.

Pendoley KL (2005) Sea Turtles and the Environmental Management of Industrial Activities in North West Western Australia, PhD Thesis, Murdoch University, Australia. 310pp.

Pendoley Environmental (2009) Marine Turtle Beach Survey: Forty Mile Beach Area, North East and South West Regnard Island. Report to Apache Energy Ltd.

Pendoley Environmental (2011) Varanus Island Marine Turtle Tagging Programme 2009 - 2010. Report to Apache Energy Ltd.

Pendoley Environmental (2013) Varanus Island Marine Turtle Tagging Program 2012 – 2013 Season. Report to Apache Energy Ltd.

Pendoley, KL, Schofield, G., Whittock, P. A., Ierodiaconou, D., & Hays, G. C. (2014). Protected species use of a coastal marine migratory corridor connecting marine protected areas. Marine Biology, 1-12.

Pendoley Environmental (2019) Varanus Island Turtle Monitoring Report: Annual Report 2018/19. Unpublished report for Santos Ltd.

Polovina, JJ, Balazs, GH, Howell, EA, Parker, DM, Seki, MP & Dutton, PH. (2004). Forage and migration habitat of logger-head (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean. *Fish Oceanogr,* 13:36–51.

Prince RIT (1994) Status of the Western Australian Marine Turtle Populations: The Western Australian Marine Turtle Project 1986–1990. Report prepared for the Queensland Department of Environment and Heritage and Australian Nature Conservation Agency.

Solow, Andrew & Bjorndal, Karen & Bolten, Alan (2002). Annual Variation in Nesting Numbers of Marine Turtles: The Effect of Sea Surface Temperature on Re-migration Intervals. Ecology Letters. 5. 742 – 746. 10.1046/j.1461-0248.2002.00374.x.

Waayers D (2010) A Holistic Approach to Planning for Wildlife Tourism: A Case Study of Marine Turtle Tourism and Conservation in the Ningaloo Region, Western Australia. PhD Thesis, Murdoch University, Perth.

Waayers, D and Stubbs, J. (2016) A Decade of Monitoring Flatback Turtles in Port Hedland, Western Australia, 2004/05 – 2013/14. Prepared for Care for Hedland Environmental Association, Port Hedland, Western Australia.

Woodside (2002) WA-271-P Field Development: Environmental Impact Statement. Woodside Energy Ltd., Perth.

Cogger HG (2000) Reptiles and Amphibians of Australia - 6th edition. Sydney, NSW: Reed New Holland

Heatwole H and Cogger HG (1993). Family Hydrophiidae, in: Glasby CG, Ross GJB and Beesley PL (eds) Fauna of Australia Volume 2A: Amphibia and Reptilia. AGPS Canberra. 439pp

Guinea ML & SD Whiting (2005) Insights into the distribution and abundance of sea snakes at Ashmore Reef. The Beagle (Supplement 1). Page(s) 199-206

McCosker JE (1975). Feeding behaviour of Indo-Australian Hydrophiidae. In: Dunson W A (eds.) The Biology of Sea Snakes. Page(s) 217-232. Baltimore: University Park Press

Minton S and H Heatwole (1975) Sea snakes from three reefs of the Sahul Shelf. Chapter 5 (pp. 141-144) In: Dunson W A (eds.) The Biology of Sea Snakes, University Park Press, Baltimore, 530 pp.

Storr GM, Smith LA and Johnstone RE (1986) Snakes of Western Australia. First edition. Perth: Western Australian Museum.

16.7 Marine Mammals

Bannister, J.L., C.M. Kemper & R.M. Warneke (1996). *The Action Plan for Australian Cetaceans*. Canberra: Australian Nature Conservation Agency. Available from: http://www.environment.gov.au/resource/action-plan-australian-cetaceans.

Bejder M, Johnston D.W., Smith J, Friedlaender A, Bejder L (2016) Embracing conservation success of recovering humpback whale populations: Evaluating the case for downlisting their conservation status in Australia. Marine Policy 66 (2016) 137–141.

Branch TA, Stafford KM, Palacios DM, Allison C, Bannister JL, Burton CLK, Cabrera E, Carlson CA, Galletti vernazzani B, Gill PC, Hucke-gaete R, Jenner KC, Jenner M-N, Matsuoka K, Mikhalev YA, Miyashita MG, Morrice S, Nishiwaki VJ, Sturrock D, Tormosov RC, Anderson AN, Baker PB, Best P, Borsa T, Brownell Jr. RL, Childerhouse SK, Findlay P, Gerrodette, T, Ilangakoon, AD, Joergensen, M, Kahn, B, Ljungblad, DK, Maughan, B, Mccauley, RD, Mckay, S, Norris, TF, Oman whale and Dolphin research group, Rankin, S, Samaran, F, Thiele, D, Van Waerebeek K & Warneke RM (2007) Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and Northern Indian Ocean. Mammal Rev. 37(2):116–175

Campbell R (2005) Historical distribution and abundance of the Australian sea lion (*Neophoca cinerea*) on the west coast of Western Australia. Fisheries Research Report no. 148. Department of Fisheries, Perth, Western Australia

Cerchio, S. *et al*. (2020). A new blue whale song-type described for the Arabian sea and western Indian Ocean. Endanger. Species Res. 43, 495–515

ConocoPhillips 2018. Barossa Area Development Offshore Project Proposal. ConocoPhillips, Perth, Western Australia

DAWE (2020) National Conservation Values Atlas [Online] Department of Environment and Energy Canberra, Commonwealth of Australia Available from: http://www.environment.gov.au/webgis-framework/apps/ncva/ncva.jsf

DAWE (2021) *Xeromys myoides* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: https://www.environment.gov.au/sprat. Accessed Fri, 18 Jun 2021.

DEWHA (Department of the Environment, Water, Heritage and the Arts) (2010a) Blue, Fin and Sei Whale Recovery Plan 2005 - 2010. [Online] Department of the Environment and Heritage Canberra, Commonwealth of Australia Available from: https://www.environment.gov.au/system/files/resources/7dc702c7-80c8-4df5-84b6-cfcbc1da5561/files/cetaceans-assessment.pdf

DEWHA (Department of the Environment, Water, Heritage and the Arts) (2008) The South-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. [Online] Canberra: DEWHA Available from: https://parksaustralia.gov.au/marine/pub/scientific-publications/archive/south-west-marine-bioregional-plan.pdf

DEWR (Department of Environment and Water Resources) (2007) Whales and dolphins identification guide. Department of Environment and Water Resources, Canberra. http://www.environment.gov.au/system/files/resources/9c058c02-afd1-4e5d-abff-11cac2ebc486/files/blue-whale-conservation-management-plan.pdf.

Department of the Environment (DoE) (2015) Conservation Management Plan for the Blue Whale. A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999*. Department of the Environment. Canberra.

DoEE (2016a). *Sousa sahulensis*— Indo-Pacific Humpback Dolphin. Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=50 [Accessed on 3 August 2016]

DoEE (2016b). *Tursiops aduncus* — Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin. Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68418 [Accessed on 3 August 2016]

DoEE (2016c) *Orcaella heinsohni* — Australian Snubfin Dolphin. Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=81322 [Accessed on 3 August 2016]

Department of Agriculture, Water and the Environment (DAWE) (2020a) Species Profile and Threats Database [Online]. Department of Agriculture, Water and the Environment. Canberra, Commonwealth of Australia. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Agriculture, Water and the Environment (DAWE) (2020b) National Conservation Values Atlas [Online]. Department of Agriculture, Water and the Environment. Canberra, Commonwealth of Australia. Available from: http://www.environment.gov.au/webgis-framework/apps/ncva/ncva.jsf

Department of State Development (DSD) 2010. Browse Liquified Natural Gas Precinct – Strategic Assessment Report. Part 3 – Environmental Assessment - Marine Impacts. December 2010

Double MC, Andrews-Goff V, Jenner KCS, Jenner M-N, Laverick SM, Branch TA & Gales N (2014) Migratory movements of pygmy blue whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as revealed by satellite telemetry. PLOS one, April 2014 9(4)

Double, M.C. et al. (2014) Migratory Movements of Pygmy Blue Whales (Balaenoptera musculus brevicauda) between Australia and Indonesia as Revealed by Satellite Telemetry, PLOS one, 9(4)

Double MC, Gales N, Jenner KCS & Jenner M-N (2010) Satellite tracking of south-bound female humpback whales in the Kimberley region of Western Australia. Final report to the Australian Marine Mammal Centre, Tasmania, September 2010

Double MC, Jenner KCS, Jenner M-N, Ball I, Laverick S, Gales N (2012a) Satellite tracking of northbound humpback whales (*Megaptera novaeangliae*) off Western Australia. Final report to the Australian Marine Mammal Centre, Tasmania May 2012.

Double MC, Jenner KCS, Jenner M-N, Ball I, Laverick S, Gales N (2012b) Satellite tracking of pygmy blue whales (*Balaenoptera musculus brevicauda*) off Western Australia. Final report to the Australian Marine Mammal Centre, Tasmania, May 2012

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012) Conservation Management Plan for the Southern Right Whale. [Online] Department of Sustainability, Environment, Water, Population and Communities Canberra, Commonwealth of Australia Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans

DSEWPaC (2013c) Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*). [Online] Department of Sustainability, Environment, Water, Population and Communities Canberra, Commonwealth of Australia Available from: http://www.environment.gov.au/system/files/resources/1eb9233c-8474-40bb-8566-0ea02bbaa5b3/files/neophoca-cinerea-recovery-plan.pdf

Gales N, Double MC, Robinson S, Jenner C, Jenner M, King E, Gedamke J, Childerhouse S & Paton D (2010) Satellite tracking of Australian humpback (*Megaptera novaeangliae*) and pygmy blue whales (*Balaenoptera musculus brevicauda).* Report number SC/62/SH21 presented to the Scientific Committee of the International Whaling Commission, June 2010, Morocco

Gedamke J, Gales N, Hildebrand J & Wiggins S (2007) Seasonal occurrence of low frequency whale vocalisations across eastern Antarctic and southern Australian waters, February 2004 to February 2007. IWC SC/59/SH5

Gill, P.C., G.J.B. Ross, W.H. Dawbin & H. Wapstra (2000). Confirmed sightings of dusky dolphins *(Lagenorhynchus obscurus)* in southern Australian waters. *Marine Mammal Science*. 16:452-459

Gill PC (2002) A blue whale (*Balaenoptera musculus*) feeding ground in a southern Australian coastal upwelling zone. J. Cetacean Res. Manage. 4(2):179—184

Hale, P.T., Barreto, A.S., Ross, G.J.B. (2000) Comparative morphology and distribution of the aduncus and truncatus forms of bottlenose dolphin Tursiops in the Indian and Western Pacific Oceans. Aquatic Mammals 26, 101–110.

Hamer, DJ, Ward, TM, Shaughnessy, PD & Clark, SR 2001 Assessing the effectiveness of the Great Australian Bight Marine Park in protecting the endangered Australian sea lion *Neophoca cinerea* from bycatch mortality in shark gillnets. End. Species Res. 14: 203—216

Hedley, SL, Bannister, JL & Dunlop, RA 2011 Abundance estimates of Southern Hemisphere Breeding Stock 'D' Humpback Whales from aerial and land-based surveys off Shark Bay, Western Australia, 2008. J. Cetacean Res. Manage. (special issue 3): 209—221

INPEX Browse. 2010. Icthys Gas Field Development Project: draft environmental impact statement. INPEX Browse, Perth.

Irvine, L. and Kent, C.S. (2018) The distribution and relative abundance of marine mega-fauna, with a focus on humpback whales (Megaptera novaeangliae), in Exmouth Gulf, Western Australia

Irvine, L.G., Thums, M., Hanson, C.E., McMahon, C.R. & Hindell, M.A. (2018) Evidence for a widely expanded humpback whale calving range along the West Australian coast. Marine Mammal Science, 34(2): 294-310.

JASCO Applied Sciences, 2016. Underwater Acoustics: Boise and the Effects on Marine Mammals. Compiled by Christine Erbe, Perth, Western Australia.

Jenner, KCS, Jenner, M-N & McCabe, KA, 2001 Geographical and temporal movements of humpback whales in Western Australian waters. APPEA Journal Vol 41(2001), pp 749—765

Kato, H. (2002). Bryde's Whales *Balaenoptera edeni* and *B. brydei*. **In:** Perrin W.F., B. Wrsig & H.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. Page(s) 171-177. Academic Press.

Kemper, C.A. (2002). Distribution of the pygmy right whale, *Caperea marginata*, in the Australasian region. *Marine Mammal Science*. 18(1):99-111.

Leaper, R, Bannister, J. L., Branch, T. A., Clapham, P. J., Donovan, G. P., Matsuoka, K., Reilly, S., and Zerbini, A. N. (2008). A review of abundance, trends and foraging parameters of baleen whales in the Southern Hemisphere, CCAMLR-IWC-WS-08/04 presented to IWC/CCAMLR workshop, Hobart, 2008.

Marsh, H, Eros, C, Penrose, H & Hugues, J 2002, Dugong - Status Report and Action Plans for countries and territories, UNEP Early Warning and Assessment Report Series 1.

McCauley RD (2011) Woodside Kimberley sea noise logger program, Sept-2006 to June-2009: Whales, fish and man-made noise. Report prepared for Woodside Energy Ltd., Perth, Western Australia.

McCauley RD & Jenner C (2010) Migratory patterns and estimated population size of pygmy blue whales (*Balaenoptera musculus brevicauda*) traversing the Western Australian coast based on passive acoustics. SC/62/SH26 in Proceedings of the 62nd IWC Annual Meeting, Agadir, Morocco (June 21–25). Available as SC-62-SH26.pdf in archive at https://iwc.int/document_1453 (Accessed February 2020).

McPherson, C, Kowarski, K, Delarue, , Whitt, C, MacDonnell, Martin, B. (2015). Passive Acoustic Monitoring of Ambient Noise and Marine Mammals – Barossa Field: Juley 2014 to July 2015 (No. JASCO Document 00997, Version 1.0). Technical report by JASCO Applied Sciences (Australia) Pty Ltd. For Jacobs.

Möller, L.M. et al. (2020) Movements and behaviour of blue whales satellite tagged in an Australian upwelling system, *Scientific Reports*, 10(1): 21165f

Perrin, W.F. & R.L. Brownell, Jr (2002). Minke Whales *Balaenoptera acutorostrata* and *B. bonaerensis*. **In:** Perrin W.F., Würsig B. & H.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. Page(s) 750-754. Academic Press.

Rennie, S, Hanson, C.E, McCauley, R.D, Pattiaratchi, C, Burton, C, Bannister, J, Jenner, C, Jenner, M.N, (2009). Physical properties and processes in the Perth Canyon, Western Australia: links to water column production and seasonal pygmy blue whale abundance. In: J. Mar. Syst., 77, pp. 21–44.

RPS 2010a. Technical Appendix – Marine Mammals. Wheatstone Project EIS/ERMP. Unpublished report for Chevron Australia Pty Ltd, March 2010

RPS. 2010b. Marine Megafauna Report Browse MMFS 2009. Prepared for Woodside Energy Ltd.

Salgado Kent, C, Jenner, C, Jenner, M, Bouchet, P & Rexstad, E. 2012 Southern Hemisphere Breeding Stock D humpback whale population estimates from North West Cape, Western Australia. J. Cetacean Res. Manage. 12(1): 29—38

Whiting, A.U., Thomson, A., Chaloupka, M., Limpus, C. J., 2009. Seasonality, abundance and breeding biology of one of the largest populations of nesting flatback turtles, Nataor depressus: Cape Domett, Western Australia. Australian Journal of Zoology 56, 297-303.

Woodside (2012) Rosebud 3D Marine Seismic Survey Environment Plan Summary. Available online at: https://docs.nopsema.gov.au/A251121

Woodside Energy (2014) Browse FLNG Development Draft Environmental Impact Statement, EPBC Referral 2013/7079, November 2014.

Woodside 2020. WA-49-L Gemtree Anchor Hold Testing. NOPSEMA Reference 5049. Accessed at https://info.nopsema.gov.au/activities/406/show_public.

16.8 Birds

Astron (2017a), Quadrant Environmental Monitoring Program Varanus and Airlie Islands Shearwater Monitoring Annual Report 2016/17, Prepared for Quadrant Energy Australia Ltd by Astron Environmental Services, Perth, Western Australia, June 2017. Report reference EA-60-RI-10174

Astron (2017b), Quadrant Environmental Monitoring Program Varanus and Airlie Islands Seabird Monitoring Annual Report 2016/17, Prepared for Quadrant Energy Australia Ltd by Astron Environmental Services, Perth, Western Australia, September 2017. Report reference EA-60-RI-10184

Bamford M, Watkins D, Bancroft W, Tischler G & Wahl J (2008) Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites. Wetlands International – Oceania, Canberra, Australia

Bennelongia (2008) Report on shorebird numbers and shorebird values at Cape Preston. Prepared for Citic Pacific Mining by Bennelongia Environmental Consultants, Report 2008/52

Bennelongia (2011) Port Hedland Migratory shorebird survey report and impact assessment. Prepared for BHP Billiton Iron Ore by Bennelongia Environmental Consultants, Report 2011/124

Birdlife Australia (2017) Australasian Bittern [Online]. Available from: http://birdlife.org.au/bird-profile/australasian-bittern. [Accessed November 2017].

Brooke, M. (2004). Albatrosses and Petrels Across The World. Oxford University Press, Oxford, UK.

Brothers NP (1984) Breeding, distribution and status of burrow-nesting petrels at Macquarie Island. *Australian Wildlife Research* **11**, 113–131.

Burbidge AA, Blyth JD, Fuller PJ, Kendrick PG, Stanley FJ & Smith LA (2000) The Terrestrial Vertebrate Fauna of the Montebello Islands, Western Australia. CALMScience 3: 95-107

CALM & MPRA (2005a) Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015. Management Plan No. 52. Department of Conservation and Land Management and Marine Parks and Reserves Authority. Perth, WA

CALM & MPRA (2005b) Indicative Management Plan for the Proposed Dampier Archipelago Marine Park and Cape Preston Marine Management Area. Department of Conservation and Land Management and Marine Parks and Reserves Authority. Perth, WA

Chevron (2010) A Guide to the Birds of Barrow Island. Available from: https://australia.chevron.com/-/media/australia/publications/documents/nature-book-birds.pdf

Commonwealth of Australia (2017b) EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species. Commonwealth of Australia.

DEWHA (Department of the Environment, Water, Heritage and the Arts) (2008a) The North-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. [Online]. Canberra: DEWHA. Available from: https://parksaustralia.gov.au/marine/pub/scientific-publications/archive/north-west-bioregional-plan.pdf

Dinara Pty Ltd. (1991) Report on results of shearwater monitoring on Varanus Island, Western Australia for the inclusion in the Hadson Energy Triennial report 1991.

DoE (2014c). *Aipysurus foliosquama* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1118. Accessed 23 July 2014

DoE (2014d) *Fregata andrewsi* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1011. Accessed 23 July 2014

DoE (2014e) *Macronectes halli* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1061. Accessed 23 July 2014

DoE (2014f) *Halobaena caerulea* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1059. Accessed 23 July 2014

DoE (2014g) *Papasula abbotti* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59297. Accessed 23 July 2014

DoE (2014h) *Rostratula australis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=77037. Accessed 23 July 2014

Department of Agriculture, Water and the Environment (DAWE) (2020a) Species Profile and Threats Database [Online]. Department of Agriculture, Water and the Environment. Canberra, Commonwealth of Australia. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Agriculture, Water and the Environment (DAWE) (2020b) National Conservation Values Atlas [Online]. Department of Agriculture, Water and the Environment. Canberra, Commonwealth of Australia. Available from: http://www.environment.gov.au/webgis-framework/apps/ncva/ncva.jsf

DoF 2012. Exploring the Houtman Abrolhos Islands. Published by Department of Fisheries, Perth, Western Australia. Publication No. 105, June 2012.

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012a) Species group report card- seabirds. Supporting the marine bioregional plan for the North-west Marine Region. Commonwealth of Australia, 2012

DSEWPaC (2012b) Species group report card- seabirds. Supporting the marine bioregional plan for the South-west Marine Region. Commonwealth of Australia, 2012

DSEWPaC (2011) National recovery plan for threatened albatrosses and giant petrels 2011-2016. Commonwealth of Australia, Hobart

Egevang, C., Stenhouse I.J., Phillips R.A., Petersen A., Fox, J.W and Silk, J.R.D. (2010) Tracking of Arctic Terns Sterna paradisaea reveals longest animal migration. Proceedings of the National Academy of Sciences of the United States of America 107: 2078 – 2081

Fijn, R.C.; Hiemstra, D.; Phillips, R.A.; van der Winden, J. (2013). Arctic Terns Sterna paradisaea from the Netherlands migrate record distances across three oceans to Wilkes Land, East Antarctica. Ardea. 101: 3–12

Garnett, S.T. & G.M. Crowley (2000). The Action Plan for Australian Birds 2000. Canberra, ACT: Environment Australia and Birds Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html. [Accessed 21/11/2017]

Garnet ST, Szabo JK, Dutson G (2011) The Action Plan for Australian Birds 2010. CSIRO Publishing, Melbourne

Hansen, B.D., Fuller, R.A., Watkins, D., Rogers, D.I., Clemens, R.S., Newman, M., Woehler, E.J. and Weller, D.R. (2016) Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species. Unpublished report for the Department of the Environment. BirdLife Australia, Melbourne.

Higgins PJ & Davies SJJF eds (1996) Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press

Hill R, Bamford M, Rounsevell D & Vincent J (1988) Little Terns and Fairy Terns in Australia - an RAOU Conservation Statement. RAOU Report Series. 53:1-12

Lindsey TR (1986) The Seabirds of Australia. North Ryde, NSW: Angus and Robertson

Marchant S & Higgins PJ eds. (1990) Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks. Melbourne, Victoria: Oxford University Press

Marchant S & Higgins PJ (Eds) (1993) Handbook of Australian, New Zealand and Antarctic Birds. Volume Two - Raptors to Lapwings. Oxford University Press, Melbourne

May RF, Lenanton RCJ & Berry PF (1983) Ningaloo Marine Park. Report and recommendations by the Marine Parks and Reserves Selection Working Group. National Parks Authority, Perth, Western Australia

Moore, J.L. (1985). Norfolk Island notes. Notornis. 32:311-318

Oro, D., Cam, E., Pradel, R. and Martinetz-Abrain, A. (2004). Influence of food availability on demography and local population dynamics in a long-lived seabird. Proceedings of the Royal Society B. 271 (1537): 387–396

Rogers, D. 1999. What determines shorebird feeding distribution in Roebuck Bay? Chapter 9, 145-174. In Pepping, M., Piersma, T., Pearson, G. and Lavaleye, M. (eds) 1999. Intertidal sediments and benthic animals of Roebuck Bay, Western Australia. Netherlands Institute for Sea Research Report 3, Texel, Netherlands, 1-214

Stokes, T. 1988. A review of the birds of Christmas Island, Indian Ocean. Australian National Parks & Wildlife Service Occasional Paper 16.

Stokes T & Hinchey M (1990) Which small Noddies breed at Ashmore Reef in Eastern Indian Ocean? Emu. 90:269-271

Storr GM, Johnstone RE & Griffin P (1986). Birds of the Houtman Abrolhos, Western Australia. Records of the Western Australian Museum Supplement. 24

Surman CA (2003) Second Field Survey of the Avifauna of the Barrow Island-Double Island Area, December 2003. Prepared for Apache Energy Ltd

Surman CA (2013) Scientific monitoring program 07 seabirds and shorebirds. Unpublished report to Apache Energy Ltd

Surman CA & Nicholson LW (2006) ‘Seabirds,’ in S McClatchie, J Middleton, C Pattiaratchi, D Currie & G Kendrick (eds), The South-west Marine Region: ecosystems and key species groups, Australian Government Department of the Environment and Water Resources, Hobart

Surman CA & Nicholson LW (2012) Monitoring of annual variation in seabird breeding colonies throughout the Lowendal Group of islands: 2012 Annual Report. Unpublished report prepared for Apache Energy Ltd. by Halfmoon Biosciences. 42pp.

Surman CA & Nicholson LW (2013) Monitoring of annual variation in seabird breeding colonies throughout the Lowendal Group of islands: 2013 Annual Report. Lowendal Island Seabird Monitoring Program (LISMP). Unpublished report prepared for Apache Energy Ltd. by Halfmoon Biosciences. 59pp.

Threatened Species Scientific Committee (2020a). Conservation Advice for the Christmas Island Frigatebird *Fregeta andrewsii.* Canberra: Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1011-conservation-advice-19102020.pdf. In effect under the EPBC Act from 19-Oct-2020.

Threatened Species Scientific Committee (2020b). Conservation Advice the Abbott's booby *Papasula abbotti*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/59297-conservation-advice-19102020.pdf. In effect under the EPBC Act from 19-Oct-2020.

16.9 Protected Areas

Asia Development Bank (ADB) 2014. State of the Coral Triangle: Indonesia. Mandaluyong City, Philippines 2014.

Bennelongia Pty Ltd (2009) Ecological Character Description for Roebuck Bay. Report prepared for the Department of Environment and Conservation, Perth, Western Australia. Available at < https://www.dpaw.wa.gov.au/images/documents/conservation-management/wetlands/ramsar/roebuck-bay-ecd_final-with-disclaimer.pdf> [Accessed April 2014]

BMT WBM (2010) Ecological Character Description for Kakadu National Park Ramsar Site. Prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Available online: https://www.environment.gov.au/system/files/resources/72c10ebd-7eeb-4841-89ab-a5004052f2ae/files/2-ecd.pdf [Accessed June 2021].

BMT WBM (2011) Ecological Character Description for Cobourg Peninsula Ramsar Site. Prepared for the Australian Government, Canberra. https://www.environment.gov.au/system/files/resources/21746527-9ee4-44eb-a2a6-aa08463d985b/files/1-ecd_0.pdf [Accessed June 2021]..

CALM (Department of Conservation and Land Management) (1990) Dampier Archipelago Nature Reserves Management Plan. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/dampier_archipelago.pdf [Accessed Jan 2019]

CALM (Department of Conservation and Land Management) (1991). Fitzgerald River National Park Management Plan 1991 – 2001 No. 15. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/fitzgerald_river.pdf [Accessed December 2019]

CALM (WA Department of Conservation and Land Management)(1995). Yalgorup National Park Management Plan.

CALM (WA Department of Conservation and Land Management) (1998a). Namburg National Park Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/nambung.pdf. [Accessed Jan 2019]

CALM (WA Department of Conservation and Land Management) (1998b). Leschenault Peninsula Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/leschenault.pdf. [Accessed Jan 2019]

CALM (WA Department of Conservation and Land Management)(1999). Jarabi and Bundegi Coastal Parks and Muiron Islands Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/jurabi.pdf [Accessed Jan 2019]

CALM (WA Department of Conservation and Land Management) (2002). Shoalwater Islands Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/shoalwater_islands.pdf. [Accessed Jan 2019]

CALM (WA Department of Conservation and Land Management) (2003). Carnac Island Nature Reserve Management Plan (2003). Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/2003240-carnac_plan.pdf. [Accessed Jan 2019]

CALM (WA Department of Conservation and Land Management) (2004). Turquoise Coast Nature Reserve Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/turquoise_coast_final.pdf [Accessed Jan 2019]

Commonwealth of Australia, 2002. Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve Management Plans. Environment Australia.

DAWE 2020a. Australian Wetlands Database, Important Wetlands, Exmouth Gulf East Wetland. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA007 [Accessed 19 March 2020].

DAWE 2020b. Australian Wetlands Database, Important Wetlands, Hutt Lagoon System. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA035 [Accessed 19 March 2020].

DAWE 2020c. Australian Wetlands Database, Important Wetlands, Lake Macleod. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA009 [Accessed 19 March 2020].

DAWE 2020d. Australian Wetlands Database, Important Wetlands, Lake Thetis. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA084 [Accessed 19 March 2020].

DAWE 2020e. Australian Wetlands Database, Important Wetlands, Learmonth Air Weapons Range – Saline Coastal Flats. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA084 [Accessed 19 March 2020].

DAWE 2020f. Australian Wetlands Database, Important Wetlands, Leslie (Port Hedland) Saltfields System. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA068 [Accessed 19 March 2020].

DAWE 2020g Australian Wetlands Database, Important Wetlands, Prince Regent River System. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA064 [Accessed 19 March 2020].

DAWE 2020h. Australian Wetlands Database, Important Wetlands, Rottnest Island Lakes. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA089 [Accessed 19 March 2020].

DAWE 2020i. Australian Wetlands Database, Important Wetlands, Shark Bay East. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA011 [Accessed 19 March 2020].

DAWE 2020j. Australian Wetlands Database, Important Wetlands, Cape Leeuwin System. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA103 [Accessed 19 March 2020].

DAWE 2020k. Australian Wetlands Database, Important Wetlands, Doggerup Creek System. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA104 [Accessed 19 March 2020].

DAWE 2020l. Australian Wetlands Database, Important Wetlands, Cape Range Subterranean Waterways. http://www.environment.gov.au/cgi-bin/wetlands/report.pl?smode=DOIW;doiw_refcodelist=WA006 [Accessed 19 March 2020].

DBCA (WA Department of Biodiversity, Conservation, and Attractions) (2019). Pilbara Inshore Islands. Frequently Asked Questions.

DEC (Department of Environment and Conservation) 2002. A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions.

DEC (WA Department of Environment and Conservation) (2010a). Cape Range National Park Management Plan

DEC (WA Department of Environment and Conservation) (2010b). Woodman Park Regional Park Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/woodman_pt_mgmt_plan_-_draft_9_web_feb_10.pdf. [Accessed Jan 2019]

DEC (WA Department of Environment and Conservation) (2010c). Rockingham Lakes Regional Park Management Plan. Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/rockingham_lakes_regional_park_management_plan__cover.pdf [Accessed July 2021]

DEC (WA Department of Environment and Conservation) (2013). Murujuga National Park management plan

DEC (Department of Environment and Conservation) (2011) Interim Recovery Plan 2011-2016 for Sedgelands in Holocene dune swales, Interim Recovery Plan No. 314

DEC (Department of Environment and Conservation) (2012a) World Heritage Areas. Available at https://www.environment.gov.au/heritage/about/world-heritage [Accessed June 2013]

DEC (WA Department of Environment and Conservation) (2012b). Shannon and D'Entrecasteaux National Parks Management Plan No. 71. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/shannon_and_dentrecasteaux_national_parks_management_plan_71_2012.pdf. [Accessed December 2019]

DEC (WA Department of Environment and Conservation) (2012c). Ord River and Parry Lagoons Nature Reserves Management Plan. Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/ord-river-and-parry-lagoons-nature-reserves-management-plan-2012_webversion.pdf [Accessed July 2021].

DEC (WA Department of Environment and Conservation) (2008). Walpole Wilderness and Adjacent Parks and Reserves Management Plan. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/wwa_mp_070708_nomaps.pdf. [Accessed December 2019]

DEC (WA Department of Environment and Conservation) (2009). Walpole and Nornalup Inlets Marine Park Management Plan No 62. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/wni_mp2009_2.pdf. [Accessed December 2019]

DEC (WA Department of Environment and Conservation) (2015). Rockingham Lakes Regional Park. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/rockingham_lakes_regional_park_management_plan__cover.pdf. [Accessed Jan 2019]

DEWHA (2008) Shark bay World Heritage Property Strategic Plan 2008-2020. Department of the Environment, Water, Heritage and the Arts, Canberra, Australia

DEWHA (2010b) Ningaloo Coast World Heritage Nomination. Department of the Environment, Water, Heritage and the Arts, Canberra, Australia. Available at < http://www.environment.gov.au/node/19787> [Accessed April 2014]

DNP (Director of National Parks) (2002). Christmas Island National Park Management Plan.

DNP (Director of National Parks) (2016). Kakadu National Park Management Plan 2016-2026. Available from: https://www.environment.gov.au/system/files/resources/1f88c5a3-409c-4ed9-9129-ea0aaddd4f33/files/kakadu-management-plan-2016-2026.pdf [Accessed July 2021]

DNREAS (Department of Natural Resources, Environment, The Arts and Sport) (2011). Cobourg Marine Park Plan of Management. Available from: https://dtc.nt.gov.au/__data/assets/pdf_file/0006/249045/Cobourg-Marine-Park.pdf [Accessed July 2021]

DoE (Department of Environment) 2012. Interim Biogeographic Regionalisation for Australia, Version 7. Available at: http://www.environment.gov.au/system/files/pages/5b3d2d31-2355-4b60-820c-e370572b2520/files/bioregions-new.pdf [Accessed January 2019]

DoE (Department of Environment) (2014a) World Heritage Places - The Ningaloo Coast Western Australia. Available at: http://www.environment.gov.au/node/19787 [Accessed April 2014]

DoE (2014b) Shark Bay, Western Australia, Work Heritage Values. Available at: http://www.environment.gov.au/heritage/places/world/shark-bay [Accessed April 2014]

DoE (2014c) Australian Ramsar Wetlands Database: Roebuck Bay. Available at http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=33 [Accessed July 2013]

DoE (2014d) Australian Heritage Database. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl [Accessed April 2014]

DoE (2014e) Australian Heritage Database. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105967 [Accessed December 2014]

DoE (2014f) Australian Heritage Database. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105578 [Accessed December 2014]

DoE (2014g) Australian Heritage Database. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105551 [Accessed December 2014]

DoE (2014h) Claypans of the Swan Coastal Plain in Community and Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=121 [Accessed December 2014]

DoE (2014i) Aquatic Root Mat Community in Caves of the Swan Coastal Plain in Community Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=12 [Accessed December 2014]

DoE (2014j) Sedgelands in Holocene dune swales of the southern Swan Coastal Plain in Community and Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=19 [Accessed December 2014]

DoE (2014k) Subtropical and Temperate Coastal Saltmarsh in Community and Species Profile and Threats Database. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=118 [Accessed December 2014]

DoE (2014l) Australian Wetlands Database, Ramsar wetlands, Becher Point. Available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=54 [Accessed December 2014]

DoE (2014m) Australian Wetlands Database, Ramsar wetlands, Peel-Yalgorup System. Available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=36 [Accessed December 2014]

DoE (2014n) Australian Wetlands Database, Ramsar wetlands, Vasse-Wonnerup System. Available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=38 [Accessed December 2014]

DoEE (2019) Australian Wetlands Database, Ramsar wetlands, Hosnies Spring. Available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=40 [Accessed November 2019]

DoEE (2019a) Australian Wetlands Database, Ramsar wetlands The Dales. Available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=61 [Accessed December 2014]

DoEE (Department of Environment and Energy) (2019b). Australian Heritage Database, Dirk Hartog Landing Site 1616 - Cape Inscription Area, Dirk Hartog Island, WA, Australia. Available at http: http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105808 [Accessed November 2019]

DoEE (2019c). Australian Heritage Database, Dampier Archipelago (including Burrup Peninsula), Karratha Dampier Rd, Dampier, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105727 [Accessed November 2019]

DoEE (2019d). Australian Heritage Database, Fitzgerald River National Park, South Coast Hwy, Ravensthorpe, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105974 [Accessed November 2019]

DoEE (2019e). Australian Heritage Database, Lesueur National Park, Coorow Green Head Rd, Green Head, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105967 [Accessed November 2019]

DoEE (2019f). Australian Heritage Database, Christmas Island Natural Areas, Settlement, EXT, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=place_name%3DChristmas%2520Island%2520Natural%2520Areas%3Bkeyword_PD%3Don%3Bkeyword_SS%3Don%3Bkeyword_PH%3Don%3Blatitude_1dir%3DS%3Blongitude_1dir%3DE%3Blongitude_2dir%3DE%3Blatitude_2dir%3DS%3Bin_region%3Dpart;place_id=105187 [Accessed November 2019]

DoEE (2019g). Australian Heritage Database, Yampi Defence Area, Koolan Island, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=place_name%3DYampi%2520Defence%2520Area%3Bkeyword_PD%3Don%3Bkeyword_SS%3Don%3Bkeyword_PH%3Don%3Blatitude_1dir%3DS%3Blongitude_1dir%3DE%3Blongitude_2dir%3DE%3Blatitude_2dir%3DS%3Bin_region%3Dpart;place_id=105418 [Accessed November 2019]

DoEE (2019h). Australian Heritage Database, Learmonth Air Weapons Range Facility, Learmonth, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=place_name%3DLearmonth%2520Air%2520Weapons%2520Range%2520Facility%3Bkeyword_PD%3Don%3Bkeyword_SS%3Don%3Bkeyword_PH%3Don%3Blatitude_1dir%3DS%3Blongitude_1dir%3DE%3Blongitude_2dir%3DE%3Blatitude_2dir%3DS%3Bin_region%3Dpart;place_id=105551 [Accessed November 2019]

DoEE (2019i). Australian Heritage Database, Lancelin Defence Training Area, Mimegarra Rd, Lancelin, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=place_name%3DLancelin%2520Defence%2520Training%2520Area%3Blist_code%3DCHL%3Bkeyword_PD%3Don%3Bkeyword_SS%3Don%3Bkeyword_PH%3Don%3Blatitude_1dir%3DS%3Blongitude_1dir%3DE%3Blongitude_2dir%3DE%3Blatitude_2dir%3DS%3Bin_region%3Dpart;place_id=105578 [Accessed November 2019]

DoE (2015a) Australian Heritage Database. Available at: http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=106003 [Accessed January 2015]

DoE (2015b) Proteaceae Dominated Kwongkan Shrublands of the Southeast Coastal Floristic Province of Western Australia in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=126&status=Endangered [Accessed January 2015]

DoEE (2016a) Yampi Defence Area, Koolan Island, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105418 [Accessed 2 August 2016]

DoE (2014b) *Pristis clavata* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68447. [Accessed 18 Mar 2014]

DoEE (2016b) Garden Island, Garden Island, WA, Australia. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;place_id=105274 [Accessed 2 August 2016]

DPAW (WA Department of Parks and Wildlife) (2012). Shark Bay Terrestrial Reserves and Proposed Reserve Additions Management Plan . Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/sharkbay_managementplanno75_2012.pdf [Accessed Jan 2019]

DPAW (WA Department of Parks and Wildlife) (2014). Eighty Mile Beach Marine Park Management Plan 2014-2024. Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/eighty-mile-beach-management-plan.pdf [Accessed July 2021]

DPAW (WA Department of Parks and Wildlife) (2015). Kalbarri National Park Management Plan. Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/kallbarri_web_mgt_plan.pdf [Accessed February 2020]

DPAW (WA Department of Parks and Wildlife) (2015). Barrow Island Group Nature Reserves Management Plan. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/barrow_group_nature_reserves_management_plan_finalweb.pdf [Accessed Jan 2012]

DPAW (WA Department of Parks and Wildlife) (2015). Leeuwin-Naturaliste Capes Area Parks and Reserves Management Plan. Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/Leeuwin-Naturaliste_management_plan_2015_WEB.pdf. [Accessed Jan 2019]

DPAW (WA Department of Parks and Wildlife) (2016). Parks and reserves of the south-west Kimberley and north-west Pilbara Draft Management Plan (2016). Available at: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/20160400_swest_kimberley_draft_mp_v7.pdf

DPAW (WA Department of Parks and Wildlife) (2016). Yawaru Birragun Conservation Park Management Plan. Available at https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/ybcp_mangement_plan_web.pdf [Accessed Jan 2019]

DPAW (WA Department of Parks and Wildlife) (2016b). Albany coast draft management plan 2016. https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/albany_coast_draft_management_plan.pdf [Accessed December 2019]

DPAW (WA Department of Parks and Wildlife) (2016c). Swan Coastal Plain South Management Plan. Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/swan_coastal_plain_south_management_plan.pdf [Accessed July 2021]

Hale, J (2008), Ecological Character Description of the Ord River Floodplain Ramsar Site, Report to the Department of Environment and Conservation, Perth, Western Australia. Available online: https://www.dpaw.wa.gov.au/images/documents/conservation-management/wetlands/ramsar/ord-floodplain-ecd_final-with-disclaimer.pdf [Accessed June 2021].

Hale J & Butcher R (2009) Ecological Character Description of the Eighty Mile Beach Ramsar Site. Report to the Department of Environment and Conservation, Perth, Western Australia. Available at https://www.dpaw.wa.gov.au/images/documents/conservation-management/wetlands/ramsar/eighty-mile-beach-ecd_final-with-disclaimer.pdf [Accessed April 2014]

Hale, J., Butcher, R., 2013. Ashmore Reef Commonwealth Marine Reserve Ramsar Site ecological character description (A report to the Department of the Environment). Department of the Environment, Canberra.

Huffard, C & Erdmann, M.V. & Gunawan, T.. (2012). Defining geographic priorities for marine biodiversity conservation in Indonesia.

Indahnesia, 2011. Indonesian National Parks. Available online: https://indahnesia.com/indonesia [Accessed June 2021].

Moore L, Knot B and Stanley N (1983) The Stromatolites of Lake Clifton, Western Australia – Living Structures Representing the Origins of Life. Search 14:11-12.

Roebuck Bay Working Group (RBWG) (2010). Preliminary Draft Roebuck Bay Ramsar Site Management Plan. Available from: https://www.roebuckbay.org.au/pdfs/RBRSMP-Preliminary-Draft-021209.pdf [Accessed July 2021]

Savu Sea National Marine Conservation Area, Undated. Coral Triangle Atlas – Savu Sea National Marine Conservation Area information requirements for inclusion in CTMPAs Categories 3 or 4. Available at http://ctatlas.reefbase.org/pdf/monitoring/CTMPAS%20SavuSea%20July%202014.pdf [Accessed August 2016]

UNESCO (2020) Shark Bay, Western Australia. Available at: https://whc.unesco.org/en/list/578 [Accessed February 2020]

UNDP Indonesia (2017). The Magnificent Seven: Indonesia's Marine National Parks. Available online: file:///C:/Users/envir/Downloads/The%20Magnificent%20Seven%20Indonesias%20Marine%20National%20Parks%20(1).pdf [Accessed June 2021].

World Heritage Convention (WHC) 2021. World Heritage List. Available online: https://whc.unesco.org/en/list [Accessed June 2021].

16.10 Key Ecological Features

Anderson, T.J., Nichol, S., Radke L., Heap, A.D., Battershill C., Hughes, M., Siwabessy, P.J., Barrie, V., Alvarez de Glasby, B., Tran, M., Daniell, J. and Shipboard Party.(2011) Seabed Environments of the Eastern Joesph Bonaparte Gulf, Norther Australia GA0325/Sol5117 – Post-Survey Report. GeoScience Australia, Canberra, Australian Capital Territory.

Baker C, Potter A, Tran M, Heap AD (2008) Geomorphology and sedimentology of the North-west Marine Region of Australia. Record 2008/07, Geoscience Australia, Canberra

Bannister, J.L., C.M. Kemper & R.M. Warneke (1996). The Action Plan for Australian Cetaceans., Canberra: Australian Nature Conservation Agency. http://www.environment.gov.au/resource/action-plan-australian-cetaceans

Bannister, JL, Josephson, EA, Reeves, RR & Smith, TD, (2007). There she blew! Yankee sperm whaling grounds, 1760-1920. DJ Starkey, P Holm & M Barnard, (Eds). Oceans past: management insights from the history of marine animal populations, Earthscan Research Editions, Oxford.

Blaber SJM, Dichmont CM, Buckworth RC, Badrudin, Sumiono B, Nurhakim, Iskandar B, Fegan B, Ramm DC & Salini JP (2005) Shared stocks of snappers (Lutjanidae) in Australia and Indonesia: integrating biology, population dynamics and socio-economics to examine management scenarios, Reviews in Fish Biology and Fisheries, vol. 15, pp. 111-127

Blaber SJM, Dichmont CM, White W, Buckworth R, Sadiyah L, Iskandar B, Nurhakim S, Pillans R, Andamari R, Dharmadi & Fahmi (2009) Elasmobranchs in southern Indonesian fisheries: the fisheries, the status of the stocks and management options, Reviews in Fish Biology and Fisheries, vol. 19, pp. 367-391

Brewer DT, Lyne V, Skewes TD, Rothlisberg, P (2007) Trophic systems of the North West Marine Region. Report to the Australian Government Department of the Environment and Water Resources, CSIRO, Cleveland

Burford, MA, Rothlisberg, PC & Revill, AT, (2009). Sources of nutrients driving production in the Gulf of Carpentaria, Australia: a shallow tropical shelf system. Marine and Freshwater Research, 60: 1-10.

Caton A & McLoughlin, K, (Eds) (2004). Fishery status reports 2004: status of fish stocks managed by the Australian Government., Bureau of Rural Sciences, Canberra.

Dambacher, JM, Rochester, W & Dutra, L, (2009). Addendum to ecological indicators for the exclusive economic zone waters of the South-west Marine Region., report for the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Department of Agriculture, Water and the Environment (2002) – Australian Heritage Database http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=list_code%3DCHL%3Blegal_status%3D35%3Bkeyword_PD%3D0%3Bkeyword_SS%3D0%3Bkeyword_PH%3D0;place_id=105655 [Accessed June 2021].

DEH (Australian Government Department of the Environment and Heritage), (2006). A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0., Department of the Environment and Heritage, Canberra, Australia.

DEWHA (2007). Characterisation of the marine environment of the north marine region: outcomes of an expert workshop convened in Darwin., Northern Territory, 2-3 April 2007, DEWHA, Canberra. http://www.environment.gov.au/resource/characterisation-marine-environment-north-marine-region-outcomes-expert-workshop-2-3-april

DEWHA (2008a). The North Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the North Marine Region. Canberra: DEWHA.

DEWHA (2008b). The South-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the South-West Marine Region. Canberra: DEWHA.

DEWHA (2008c) A characterisation of the marine environment of the North-west Marine Region: Perth workshop report. A summary of an expert workshop convened in Perth, Western Australia. 5-6 September 2007, DEWHA, Hobart

DEWHA (2008d) The North-west Marine bioregional plan: bioregional profile. A description of the ecosystems, conservation values and uses of the North-west Marine Bioregion. DEWHA, Canberra

DEWHA, (2010). Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*), Technical Issues Paper., Australian Government, Canberra.

DoEE (2016a) Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton) in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Available from: https://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=96&status=Critically+Endangered. [Accessed 2016-08-02T13:56:21AEST]

DoEE (2016b) Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Available from: https://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=105. Accessed 2016-08-02T14:04:23AEST

Done TJ, Williams DMcB, Speare PJ, Davidson J, DeVantier LM, Newman SJ, Hutchins JB (1994) Surveys of coral and fish communities at Scott Reef and Rowley Shoals. Australian Institute of Marine Science, Townsville

Donovan A, Brewer D, van der Velde T, Skewes T (2008) Scientific descriptions of four selected key ecological features in the North-west Bioregion: final report. Report to the Australian Government Department of Environment, Water, Heritage and the Arts, CSIRO Marine and Atmospheric Research, Cleveland

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012) Commonwealth marine environment report card. Commonwealth of Australia

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012b) Marine bioregional plan for the South-west Marine Region

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012c) Commonwealth marine environment report card: supporting the marine bioregional plan for the South-west Marine Region

DSEWPaC (Department of Sustainability, Environment, Water, Population and Communities) (2012d) Commonwealth marine environment report card. Commonwealth of Australia

EA 2000. Mermaid Reef Marine National Nature Reserve Plan of Management 2000-2007. Environment Australia, Canberra, Australian Capital Territory

EA (Environment Australia) (2002) Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve (Commonwealth waters) management plans. EA, Canberra

Exon, NF, Hill, PJ, Mitchell, C & Post, A (2005). Nature and origin of the submarine Albany canyons off southwest Australia. Australian Journal of Earth Sciences, 52: 101-115.

Falkner I, Whiteway T, Przeslawski R, Heap AD (2009) Review of ten key ecological features in the Northwest Marine Region. Record 2009/13, Geoscience Australia, Canberra

Fletcher WJ, Santoro K (eds) (2009) State of the fisheries report 2008/09. Department of Fisheries, Western Australia, Perth

Gilmour, J, Cheal, A, Smith, L, Underwood, J, Meekan, M, Fitzgibbon, B & Rees, M, (2007). Data compilation and analysis for Rowley Shoals: Mermaid, Imperieuse and Clerke reefs., Report to the Department of Environment and Water Resources, Australian Institute of Marine Science, Perth.

Guinea, M, (2006). Sea turtles, sea snakes and dugongs of Scott Reef, Seringapatam Reef and Browse Island with notes on West Lacepede Island., Report submitted to the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Government of Western Australia (2010). Browse Liquified Natural Gas Plant Strategic Assessment Report. Part 4 Environmental Assessment – Terrestrial Impacts. December 2010.

Heap AD, Harris PT (2008) Geomorphology of the Australian margin and adjacent seafloor. Australian Journal of Earth Sciences 55:555–585

Heyward A, Pinceratto E, Smith L (1997) Big bank shoals of the Timor Sea: an environmental resource atlas. Australian Institute of Marine Science, Melbourne

Hodgson, P (1995). Directory of Important Wetlands in Australia - Information sheet (Shoal Bay – Micket Creek NT032). Compiled by Wetlands Unit, Australian Nature Conservation Agency. Minor additions by S. J. Moore of Moore Environmental Consulting and L. N. Lloyd of Lloyd Environmental Consultants in 1999. DEO-NT update 1999.. Available online: https://www.environment.gov.au/cgi-bin/wetlands/report.pl [Accessed June 2021].

Hooper JNA, Ekins M (2004) 'Collation and validation of museum collection databases related to the distribution of marine sponges in Northern Australia. Unpublished report to the National Oceans Office, Hobart

Jaensch, RP (1993).Directory of important wetlands in Australia. Compiled for the Wildlife Division, Conservation Commission of the Northern Territory, January-February 1993. Updated by P. Whitehead and R. Chatto November 1995. Database available online: https://www.environment.gov.au/cgi-bin/wetlands/report.pl [Accessed June 2021].

Jenner C, Jenner M, Pirzl R (2008) A study of cetacean distribution and oceanography in the Scott Reef/Browse Basin development areas during the austral winter of 2008. Centre for Whale Research (WA), Perth

Kemps, H (2010) Ningaloo: Australia's Untamed Reef. Quinns Rocks: MIRG Australia.

Last P, Lyne V, Yearsley G, Gledhill D, Gomon M, Rees T, White, W (2005) Validation of national demersal fish datasets for the regionalisation of the Australian continental slope and outer shelf (>40 m depth). Australian Government Department of the Environment and Heritage & CSIRO Marine and Atmospheric Research, Hobart

Limpus C (2008) A biological review of Australian marine turtles 2. Green turtle *Chelonis mydas* (Linnaeus). Environment Protection Agency, Queensland

Lyne V, Fuller M, Last P, Butler A, Martin M, Scott R (2006) Ecosystem characterisation of Australia's North West Shelf. North West Shelf Joint Environmental Management Study Technical Report 12, CSIRO Marine and Atmospheric Research, Hobart

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, N. Jenner M-, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch & K. McCabe, (2000). Marine seismic surveys: analysis and propagation of air-gun signals; and effects of exposure on humpback whales, sea turtles, fishes and squid., Prepared for the Australian Petroleum Production & Exploration Association (APPEA) by the Centre for Marine Science and Technology, Curtin University of Technology, R99-15.

McClatchie, S, Middleton, J, Pattiaratchi, C, Currie, D & Kendrick, G, (Eds), (2006). The South-west Marine Region: ecosystems and key species groups., Australian Government Department of the Environment and Water Resources, Canberra.

McLoughlin RJ, Young PC (1985) Sedimentary provinces of the fishing grounds of the North West Shelf of Australia: grain-size frequency analysis of surficial sediments. Australian Journal of Marine and Freshwater Research 36: 671–81

Milton DA (2005) Birds of Ashmore Reef National Nature Reserve: an assessment of its importance for seabirds and waders. The Beagle, Records of the Museums and Art Gallery of the Northern Territory, suppl. 1: 133–141

NERP MBH National Environmental Research Program Marine Biodiversity Hub (2014). Exploring the Oceanic Shoals Commonwealth Marine Reserve., NERP MBH, Hobart.

Northern Territory Government (ND). Charles Darwin National Park Plan of Management. Available online: https://depws.nt.gov.au/__data/assets/pdf_file/0005/249044/charlesdarwinpom.pdf

Pattiaratchi, C, (2007). Understanding areas of high productivity within the South-west Marine Region., Report to the Department of the Environment, Water, Heritage and the Arts, Canberra.

Parks And Wildlife Commission of the Northern Territory (2011). Cobourg Marine Park Plan of Management. Prepared by the Cobourg Peninsula Sanctuary and Marine Park Board and Parks and Wildlife Service of the Northern Territory, Department of Natural Resources, Environment, The Arts and Sport Available online: https://depws.nt.gov.au/__data/assets/pdf_file/0006/249045/Cobourg-Marine-Park.pdf

Parks And Wildlife Commission of the Northern Territory (2015). Mary River National Park Joint Management Plan March 2015. Available online: https://depws.nt.gov.au/__data/assets/pdf_file/0006/260493/Mary-River-final-JMP_March2015_sml.pdf

Parks And Wildlife Commission of the Northern Territory (2016). Casuarina Coastal Reserve Management Plan April 2016

Richardson, L, Mathews, E & Heap, A, (2005). Geomorphology and sedimentology of the south western planning area of Australia: review and synthesis of relevant literature in support of regional marine planning., Record 2005/17, Geoscience Australia, Canberra.

Rowden, AA, Dower, JF, Schlacher, TA, Consalvey, M, Clark, MR (2010). Paradigms in seamount ecology: fact, fiction and future. Marine Ecology, 31: 226-241.

Salini JP, Ovenden JR, Street R, Pendrey R, Haryanti & Ngurah (2006) Genetic population structure of red snappers (*Lutjanus malabaricus* Bloch & Schneider, 1801 and *Lutjanus erythropterus* Bloch, 1790) in central and eastern Indonesia and Australia, Journal of Fish Biology, vol. 68 (supplement B), pp. 217-234

Sleeman JC, Meekan MG, Wilson SG, Jenner CKS, Jenner MN, Boggs GS, Steinberg CC, Bradshaw CJA (2007) 'Biophysical correlates of relative abundances of marine megafauna at Ningaloo Reef, Western Australia', Marine and Freshwater Research, vol. 58, pp. 608–623

Smith, ADM, Hobday, AJ, Webb, H, Daley, R, Wayte, S, et al., (2006). Ecological risk assessment for the effects of fishing., Final report R04/1072 for the Australian Fisheries Management Authority, Canberra.

Stambler N (2011) Zooxanthellae: the yellow symbionts inside animals, in Dubinsky Z, Stambler N (eds), Coral reefs: an ecosystem in transition. Springer, London

Stow, DAV (2006). Oceans: an illustrated reference., University of Chicago Press.

Underwood JN (2009) Genetic diversity and divergence among coastal and offshore reefs in a hard coral depend on geographic discontinuity and oceanic currents. Evolutionary Applications 2: 1–11

Underwood JN, Smith LD, van Oppen MJH, Gilmour J (2009) Ecologically relevant dispersal of a brooding and a broadcast spawning coral at isolated reefs: implications for managing community resilience. Ecological Applications 19: 18–29

Whiting S (1999) Use of the remote Sahul Banks, northwestern Australia, by dugongs, including breeding females. Marine Mammal Science 15: 609–615

Wightman, G, Danaher, K, Dunning, M, Beumer, J & Michie, M, (2004). Mangroves. National Oceans Office, (Eds). A description of key species groups in the northern planning area, National Oceans Office, Hobart.

Williams, A, Koslow, JA & Last, PR (2001). Diversity, density and community structure of the demersal fish fauna of the continental slope off western Australia (20 to 35° S). Marine Ecology Progress Series, 212: 247-63.

Wilson, RR & Kaufman, RS (1987). Seamount biota and biography. B Keating, P Fryer, R Batiza, & G Boehlert, (Eds). Seamounts, islands and atolls. Geophysical Monograph Series, 43: 355-377.

16.11 State Marine Parks

AHC (2006) Cape Range National Park and Surrounds, Exmouth, WA. A WWW publication accessed December 2006 at http://www.environment.gov.au/. Australian Heritage Commission, Canberra.

CALM (1996) Shark Bay Marine Reserves. Management Plan. 1996-2006. Marine Conservation Branch, Management Plan No. 34. Department of Conservation and Land Management.

CALM (1999) Swan Estuary Marine Park and Adjacent Nature Reserves Management Plan 1999-2009. Management Plan No. 41. Department of Conservation and Land Management.

CALM (2002) Management Plan for Marmion Marine Park 1992-2002: Management Plan No.23. Department of Conservation and Land Management.

CALM (2004) Indicative Management Plan for the Proposed Montebello/Barrow Islands Marine conservation Reserves, 2004.Marine Conservation Branch, Department of Conservation and Land Management.

CALM (2005) Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005 – 2015 Management Plan No. 52. Department of Conservation and Land Management, Perth, Western Australia.

Department of Biodiversity, Conservation and Attractions, DBCA (2017a). Parks and Wildlife Services: Approved Management Plans. Accessible from: https://www.dpaw.wa.gov.au/parks/management-plans/approved-management-plans. [20 Dec 2017]

DBCA (2020a). Proposed Mayala Marine Park Indicative Joint Management Plan 2020. Department of Biodiversity, Conservation and Attractions, Perth, Western Australia. Accessible from: https://www.dpaw.wa.gov.au/images/documents/conservation-management/managementplans/Proposed%20Mayala%20Marine%20Park%20indicative%20joint%20management%20plan.pdf

DBCA (2020b). Lalang-gaddam amended Joint Management Plan for the Lalang-garram / Camden Sound, Lalang-garram / Horizontal Falls and North Lalang-garram Marine Parks and Indicative Joint Management Plan for the Proposed Maiyalam Marine Park. Department of Biodiversity, Conservation and Attractions, Perth, Western Australia. Accessible from: https://www.dpaw.wa.gov.au/images/documents/conservation-management/managementplans/Lalang-gaddam%20marine%20park%20amended%20and%20indicative%20joint%20management%20plan.pdf

DBCA (2022). Bardi Jawa Gaarra Marine Park Joint Management Plan 2022. Joint Management Plan 99. Department of Biodiversity, Conservation and Attractions, Perth, Western Australia. Accessible from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/Bardi%20Jawi%20Gaarra%20Marine%20Park%20Joint%20Management%20Plan.pdf

DEC (2005) Jurien Bay Marine Park Management Plan 2005– 2015, Management plan number 49. Department of Environment and Conservation, Perth, Western Australia

DEC (2007a) Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007–2017: Management Plan No. 55. Department of Environment and Conservation, Perth, Western Australia.

DEC (2007b) Management Plan for the Rowley Shoals Marine Park 2007–2017: Management Plan No. 56. Department of Environment and Conservation, Perth, Western Australia.

DEC (2007c). Management Plan for the Shoalwater Islands Marine Park 2007-2017: Management Plan No. 58. Department of Environment and Conservation, Perth, Western Australia.

DEC (2009b) Walpole and Nornalup Inlets Marine Park Management Plan 2009-2019. Management Plan No. 62. Department of Environment and Conservation, Perth, Western Australia.

DEC (2010). Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve Recreational Guide. Available at: https://parks.dpaw.wa.gov.au/sites/default/files/downloads/parks/20180017%20WEB%20VERSION%20SHARK%20BAY%20MARINE%20RESERVES.pdf [Accessed January 2015]

DEC (2013) Ngari Capes Marine Park management plan 2013– 2023, Management plan number 74. Department of Environment and Conservation, Perth.

DPAW 2013. Lalang-garram/ Camden Sound Marine Park Management Plan 73 2013–2023. Department of Parks and Wildlife, Perth, Western Australia

DPAW 2014. Eighty Mile Beach Marine Park Management Plan 80 2014-2024. Department of Parks and Wildlife, Perth, Western Australia

DEWHA (2008) The North-west Marine Bioregional Plan: Bioregional profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region. Department of the Environment Water, Heritage and the Arts, Canberra, ACT.

DPaW 2016, Lalang-garram/ Horizontal Falls and North Lalang-garram marine parks joint management plan 2016. Management Plan 88. Department of Parks and Wildlife, Perth.

DoEE (2019c), Australia's National Heritage List. Available from: http://www.environment.gov.au/heritage/places/national-heritage-list [Accessed 16 December 2019].

DPaW (2013) Lalang-garram / Camden Sound Marine Park management plan no. 73 2013–2023, Department of Parks and Wildlife, Perth, Western Australia.

DPaW (2013a) New and proposed marine parks and reserves. Online, retrieved 23rd April 2014. Available at: https://www.dbca.wa.gov.au/parks-and-wildlife-service/plan-for-our-parks

DPaW (2014) Eighty Mile Beach Marine Park Management Plan 2014-2024. Management Plan No. 80. Department of Parks and Wildlife, Perth, Western Australia.

Department of Parks and Wildlife (2016a). North Kimberley Marine Park Joint management plan 2016 Uunguu, Balanggarra, Miriuwung Gajerrong, and Wilinggin management areas, Number Plan 89 Department of Parks and Wildlife, Perth.

Department of Parks and Wildlife, DPaW (2016b). Yawuru Nagulagun/Roebuck Bay Marine Park: Joint management plan 2016.

DSEWPaC (2013a) Shark Bay, Western Australia, Work Heritage Values. [Online, retrieved 17 July 2013] Available at: https://www.environment.gov.au/heritage/places/world/shark-bay

Yawuru Organisation (2017). Environmental Services for Yawuru Protected Areas. Accessible from: http://www.yawuru.org.au/country/environmental-services/. [20 Dec 2017]

DBCA (2017b). Explore Parks WA: Yawuru Nagulagun/Roebuck Bay Marine Park. Accessible from: https://parks.dpaw.wa.gov.au/park/yawuru-nagulagun-roebuck-bay. [20 Dec 2017]

16.12 Australian Marine Parks

DSEWPaC (2012) Marine bioregional plan for the North-west Marine Region. Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT. 269 pp.

Director of National Parks (2012a) Concerning the Proposed Proclamation of 40 Commonwealth marine reserves (and the related revocation of seven existing Commonwealth reserves and the revocation of the Coral Sea Conservation Zone); and The amendment of the names of four existing Commonwealth marine reserves. Report to the Director of National Parks under the Environment Protection and Biodiversity Conservation Act 1999 Section 351.

Director of National Parks (2018a), South-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra.

Director of National Parks (2018b), North-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra.

Director of National Parks (2018c), North Marine Parks Network Management Plan 2018, Director of National Parks, Canberra.

16.13 Conservation Management Plans

Hill, R. and Dunn A. (2004), National Recovery Plan for the Christmas Island Frigatebird *Fregata andrewsi.* Commonwealth of Australia, Canberra.

Department of Sustainability, Environment, Water, Population and Communities (2011), National recovery plan for threatened albatrosses and giant petrels 2011-2016, Commonwealth of Australia, Hobart

Commonwealth of Australia (2015), Conservation Management Plan for the Blue Whale—A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999, Commonwealth of Australia, 2015.

Commonwealth of Australia (2012), Conservation Management Plan for the Southern Right Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011 - 2021, Commonwealth of Australia, 2012.

Commonwealth of Australia (2013), Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*) 2013.

Commonwealth of Australia (2017), Recovery Plan for Marine Turtles in Australia 2017 – 2027.

Commonwealth of Australia (2014), Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) 2014.

Commonwealth of Australia (2013), Recovery Plan for the White Shark (*Carcharodon carcharias*) 2013.

Commonwealth of Australia (2015), Sawfish and River Sharks - Multispecies Recovery Plan 2015.

Commonwealth of Australia (2020), National Recovery Plan for the Australian Fairy Tern (Sternula nereis nereis) 2020

Commonwealth of Australia (2015), Wildlife Conservation Plan for Migratory Shorebirds, Commonwealth of Australia, 2015

Commonwealth of Australia (2020), Wildlife Conservation Plan for Seabirds, Commonwealth of Australia 2020

Threatened Species Scientific Committee (2015). Conservation Advice *Anous tenuirostris melanops* Australian lesser noddy, Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/26000-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Threatened Species Scientific Committee (2020a). Conservation Advice for the Christmas Island Frigatebird *Fregeta andrewsii.* Canberra: Department of Agriculture, Water and the Environment. Available from:

http://www.environment.gov.au/biodiversity/threatened/species/pubs/1011-conservation-advice-19102020.pdf. In effect under the EPBC Act from 19-Oct-2020.

Threatened Species Scientific Committee (2020b). Conservation Advice the Abbott's booby *Papasula abbotti*. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/59297-conservation-advice-19102020.pdf. In effect under the EPBC Act from 19-Oct-2020.

Threatened Species Scientific Committee (2020c). Conservation Advice for *Thalassarche cauta* Shy Albatross. Canberra: Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/89224-conservation-advice-03072020.pdf. In effect under the EPBC Act from 03-Jul-2020.

Threatened Species Scientific Committee (2019), Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern). Canberra, ACT: Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1001-conservation-advice-18012019.pdf. In effect under the EPBC Act from 18-Jan-2019.

Threatened Species Scientific Committee (2016). Conservation Advice *Calidris canutus* Red knot. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/855-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Department of the Environment (2015). Conservation Advice *Calidris ferruginea* curlew sandpiper. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf. In effect under the EPBC Act from 26-May-2015.

Threatened Species Scientific Committee (2016). Conservation Advice *Calidris tenuirostriss* Great knot. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/862-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016). Conservation Advice *Charadrius leschenaultii* Greater sand plover. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016). Conservation Advice *Charadrius mongolus* Lesser sand plover. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/879-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2015). Conservation Advice *Halobaena caerulea* blue petrel. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1059-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Threatened Species Scientific Committee (2016). Conservation Advice *Limosa lapponica baueri* Bar-tailed godwit (western Alaskan). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/86380-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Threatened Species Scientific Committee (2016). Conservation Advice *Limosa lapponica menzbieri* Bar-tailed godwit (northern Siberian). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/86432-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016.

Department of the Environment (2015). Conservation Advice *Numenius madagascariensis* eastern curlew. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf. In effect under the EPBC Act from 26-May-2015.

Threatened Species Scientific Committee (2015). Conservation Advice *Pachyptila turtur subantarctica* fairy prion (southern). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64445-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Department of the Environment (2014). Conservation Advice *Phaethon lepturus fulvus* white-tailed tropicbird (Christmas Island). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/26021-conservation-advice.pdf. In effect under the EPBC Act from 06-Nov-2014.

Threatened Species Scientific Committee (2015). Conservation Advice *Pterodroma Mollis* soft-plumaged petrel. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1036-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Department of Sustainability, Environment, Water, Population and Communities (2013). Approved Conservation Advice for *Rostratula australis* (Australian painted snipe). Canberra: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-conservation-advice.pdf. In effect under the EPBC Act from 15-May-2013.

Department of Sustainability, Environment, Water, Population and Communities (2011). Approved Conservation Advice for *Sternula nereis nereis* (Fairy Tern). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/82950-conservation-advice.pdf. In effect under the EPBC Act from 03-Mar-2011.

Threatened Species Scientific Committee (2015). Conservation Advice *Balaenoptera borealis* sei whale. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/34-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Threatened Species Scientific Committee (2015). Conservation Advice *Balaenoptera physalus* fin whale. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/37-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Threatened Species Scientific Committee (2015). Conservation Advice *Megaptera novaeangliae* humpback whale. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

Department of Sustainability, Environment, Water, Population and Communities (2011). Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1115-conservation-advice.pdf. In effect under the EPBC Act from 15-Feb-2011.

Department of Sustainability, Environment, Water, Population and Communities (2011). Approved Conservation Advice for *Aipysurus foliosquama* (Leaf-scaled Sea Snake). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1118-conservation-advice.pdf. In effect under the EPBC Act from 15-Feb-2011.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1768-conservation-advice.pdf. In effect under the EPBC Act from 08-Jan-2009.

Department of the Environment (2014). Approved Conservation Advice for *Glyphis garricki* (northern river shark). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/82454-conservation-advice.pdf. In effect under the EPBC Act from 11-Apr-2014.

Department of the Environment, Water, Heritage and the Arts (2009). Approved Conservation Advice for *Pristis clavata* (Dwarf Sawfish). Canberra, ACT: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/68447-conservation-advice.pdf. In effect under the EPBC Act from 20-Oct-2009.

Department of the Environment (2014). Approved Conservation Advice for *Pristis pristis* (largetooth sawfish). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf. In effect under the EPBC Act from 11-Apr-2014.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Green Sawfish. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/68442-conservation-advice.pdf. In effect under the EPBC Act from 07-Mar-2008.

Threatened Species Scientific Committee (2015). Conservation Advice *Rhincodon typus* whale shark. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66680-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

16.14 Commercial and Recreational Fisheries

Apache (2008) Van Gogh Oil Development Draft Public Environmental Report (EPBC Referral 2007/3213). Apache Energy Ltd, Perth, Western Australia, February 2008.

Caputi, N., Jackson, G. and Pearce, A. (2014). The marine heat wave off Western Australia during the summer of 2010/11 – 2 years on. Fisheries Research Report No. 250. Department of Fisheries, Western Australia. 40pp.

Condie SA, Mansbridge JV, Hart AM and Andrewartha JR (2006) Transport and Recruitment of Silver-lip Pearl Oyster Larvae on Australia's North West Shelf. In Journal of Shellfish Research, Vol. 25, No. 1. pp 179 – 185.

Department of Agriculture (2019) Fishery Status Reports 2019. Department of Agriculture, Canberra, Australian Capital Territory.

DEWHA (2008a). North-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region. Department of Environment Water Heritage and the Arts, Canberra, Australian Capital Territory.

DPIRD (2018) Department of Primary Industries and Regional Development. Annual Report 2018. Government of Western Australia.

DPIRD (2020) Department of Primary Industries and Regional Development. Aquaculture. Development Plan for Western Australia. Government of Western Australia.

Environmental Resources Management (ERM) 2008, Indonesian Fishers SIA Report (Phase 1) 2007. Report produced for Woodside Energy Limited. 170 pp.

Environmental Resources Management (ERM) 2009, Browse LNG Development: Social Study on Indonesian Fishers (Phase 2) 2008. Report produced for Woodside Energy Limited. 93 pp

Fletcher, W J and Santoro, K. (2013) Status Reports of the Fisheries and Aquatic Resources of Western Australia 2012/13 (eds).: The State of the Fisheries. Department of Fisheries, Western Australia.

Fletcher, W.J. and Santoro, K. (eds). (2015). Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: The State of the Fisheries. Department of Fisheries, Western Australia.

Gaughan, D.J., Molony, B. and Santoro, K. (eds). 2019. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2017/18: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Gaughan, D.J. and Santoro, K. (eds). 2020. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2018/19: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Phillips M, Henriksson PJG, Tran N, Chan CY, Mohan CV, Rodriguez U-P, Suri S, Hall S and Koeshendrajana S. 2015. Exploring Indonesian aquaculture futures. Penang, Malaysia: WorldFish.Program Report: 2015-39.

Valderrama, D., Cai, J., Hishamunda, N. & Ridler, N., eds. 2013. Social and economic dimensions of carrageenan seaweed farming. Fisheries and Aquaculture Technical Paper No. 580. Rome, FAO. 204 pp.

WAFIC 2016. Western Australia Fishing Industry Council Incorporated. Available at: http://www.wafic.org.au/region/west-coast/ [Accessed August 2016]

Woodside Energy Limited (Woodside) (2011) Browse LNG Development, Draft Upstream Environmental Impact Statement, EPBC Referral 2008/4111, November 2011.

16.15 Social, Economic and Cultural Features

Global Business Guide (2014). http://www.gbgindonesia.com/en/agriculture/article/2014/indonesia_s_aquaculture_and_fisheries_sector.php

AMSA (Australian Marine Safety Authority) (2012) Marine Notice 15/2012, Shipping Fairways off the north-west coast of Australia. Australian Maritime Safety Authority, Australian Government

AMSA (2013) North West Shipping Management. Australian Maritime Safety Authority. Canberra.

Aboriginal Areas Protection Authrotiy 2016. Sacred Sites – Tiwi Islands. Aboriginal Areas Protection Authortiy, Darwin, Northern Territory. Available at: http://www.aapant.org.au/sacred-sites/sacred-sites-nt/tiwi-islands (accessed 2021)

DBCA (Department of Biodiversity, Conservation and Attractions). (2022). Houtman Abrolhos Islands National Park management plan 97, 2022. Department of Biodiversity, Conservation and Attractions, Perth.

DEC (Department of Environment and Conservation). (2007). MANAGEMENT PLAN FOR THE MONTEBELLO/BARROW ISLANDS MARINE CONSERVATION RESERVES 2007-2017. Management Plan No. 55, Department of Environment and Conservation

DEWHA (Department of the Environment, Water, Heritage and the Arts) (2008a) The North-West Marine Bioregional Plan: Bioregional Profile: A Description of the Ecosystems, Conservation Values and Uses of the North-West Marine Region. [Online]. Canberra: DEWHA. Available from: https://www.environment.gov.au/system/files/resources/2e286b1a-c6e2-4e3d-95cf-c98a8dea60fd/files/bioregional-profile.pdf

DoE (Department of Environment) (2014) Australian Heritage Database. Available at http://www.environment.gov.au/cgi-bin/ahdb/search.pl [Accessed June 2021]

DMP (Department of Mines and Petroleum) (2014) Petroleum in Western Australia. East Perth, Western Australia, April 2014.

Matthews, S. R., Penny, S. S and Steffe A. (2019). A Survey of Recreational Fishing in the Greater Darwin Area 2015. Northern Territory Government, Australia. Fishery Report No 121

Shire of Exmouth (2018) HEH Naval Communication Station. Available at https://www.exmouth.wa.gov.au/Profiles/exmouth/Assets/ClientData/Ningaloo_Coast_World_Heritage_Area_Cultural_History.pdf [Accessed April 2014]

Royal Australian Air Force (RAAF) (2014) Bases Western Australia. Available at https://www.airforce.gov.au/about-us/bases [Accessed April 2014]

Tiwi Land Council 2003. Natural Resource Management Strategy. Tiwi Land Council. Available at http://www.tiwilandcouncil.com/publications/land.htm (accessed 22/01/2017)

Tourism Western Australia (2014) Visitor Fact Sheets – Tourism Regional Level. Available at http://www.tourism.wa.gov.au/Research_and_Reports/Regional_Fact_Sheets/Pages/Regional_Fact_Sheets.aspx [Accessed April 2014]

Appendix A: EPBC Act Protected Matters Reports

Due to restrictions on spatial file size and features that can be uploaded to the PMST (DAWE, 2021 available at:https://haveyoursay.agriculture.gov.au/upgrading-the-protected-matters-search-tool/widgets/360422/documents) the EMBA shapefile was separated into smaller sections to produce separate reports, which were then combined to produce the final report.

As described in Caveat 3 of the PMST report, where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

This may cause some species to show up in the PMST report solely due to the polygon capture techniques utilised by the tool, which affect the resolution of the report (for example, near coastal boundaries). Hence any terrestrial species that are not expected to occur in significant numbers in the marine and coastal environments in the combined EMBA were not described further in **Section 6, 7** and **8**.

Appendix B: MNES Review Register

Santos

Table B 1: Review Register

Taxon	2022 Rev 10	Reason for Change	Sections Updated within this Document
Threatened Species			
Table 5-1	Various species updated as per BC Act update (Gazette 144 of 2022)	Legislation update	Table 5-1
Table 7-1	Various species updated as per BC Act update (Gazette 144 of 2022)	Legislation update	Table 7-1
Table 8-1	Various species updated as per BC Act update (Gazette 144 of 2022)	Legislation update	Table 8-1
Abbott's booby	*Papasula abbotti*	Incorrect spelling of scientific name	Table 8-6
Abbott's booby	Changed BIA from 'Yes' to 'No' – as BIA is no longer listed	Legislative update	Table 8-1
Abbott's booby	Removed from BIA table as the BIA is no longer listed	Legislative update	Table 8-6
Australian fairy tern	Terminology added (Foraging)	Legislative update	Table 8-1
Sea Birds	*Anous tenuirostris melanops*	Incorrect spelling	Table 8-6
Black-browed albatross	Terminology added (Migratory)	EP Act Legislative update	Table 8-1
Christmas Island frigatebird	Changed BIA from 'Yes' to 'No' – as BIA is no longer listed	Legislative update	Table 8-1
Christmas Island frigatebird	Removed from BIA table as the BIA is no longer listed	Legislative update	Table 8-6
Humpback whale	Updated EPBC status and outlined that despite removal from threatened species list, that they are still protected under EPBC Act Division 3	Legislative update	Section 7.1.5
Humpback whale	Terminology deleted (Vulnerable)	Ep Act Legislative update	Table 7-1
Humpback whale	Removed Conservation Advice for Megaptera novaeangliae (humpback whale) (2015) as it is no longer approved/current	Removed Conservation Advice for Megaptera novaeangliae (humpback whale) (2015) as it is no longer approved/current	Table 13-1
Mammals	EPBC terminology altered from Vulnerable to Endangered	EP Act Legislative update	Table 7-1
Red Knot	Population numbers added	Not included in current revision	Table 8-5

Hawksbill Turtle	Added new tagging research identifying that turtles migrating from WA remain on the continental shelf during certain phases.	Literature update – information in current revision was outdated	Section 6.1.3
Hawksbill Turtle	Added NWSS and Fossette *et al* findings on BIA overlaps	Literature update as per Santos comments on Rev9A	Section 6.1.3
Flatback Turtle	Added information on homing instinct, growth rates / population assessment implications (Turner Tomaszewicz et al, 2022)	Literature update as per Santos comments on Rev9A	Section 6.1.4
Olive Ridley Turtle	Updated information based on recent tagging study showing deeper diving capabilities.	Literature update	Section 6.1.6
Sei Whale	Provided reference on migration description	Missing reference in document	Section 7.1.1
Blue Whale	Provided additional paragraph describing existing acoustic populations (including 2 recent discoveries).	Literature update	Section 7.1.2
Blue Whale	Updated info on feeding grounds	Existing information was lacking and out of date.	Section 7.1.2
Blue Whale	Provided reference for migration pattern	Missing reference in document	Section 7.1.2
Humpback Whale	Added information on WA having the largest known population	Literature update	Section 7.1.5
Sperm Whale	Updated depth range from 200 to 400m based on two more recent references	Outdated figure	Section 7.1.6
Whale Shark	Added additional information on high proportion of surface swimming and recent tracking study demonstrating risk to vessel collisions.	Literature update	Section 5.3.4
Whale Shark	Updated info from various references on sexual maturity/surface feeding and associated vulnerabilities	Literature update as per Santos comments on Rev9A	Section 5.3.4
Migratory Species			
None			
Provinces			
Southwest Shelf Province	Added information on Bremer Canyon	Santos Rev 9A comment	Section 2.1.4
Coral Reefs	Added the 2011 Ningaloo reef bleaching event, as well as the 2016 bleaching event at Scott reef.	Referenced bleach event in current revision outdated	Section 3.1

Northwest Transition	Added reference to the 2009 Mermaid reef coral survey and that it is comparable to the original 1993 survey referenced.	Outdated survey findings.	Section 3.1.6
Northwest Transition	Added paragraph outlining that recent genetic studies on offshore reefs within the region have shown high genetic diversity and potential vulnerability to impacts due to isolation and reliance on local recruitment.	Literature update	Section 3.1.6
Timor Province	Added number of Scleractinian coral taxa found at Scott reef as of 2013.	No description of coral taxa numbers provided	Section 3.1.9
Protected Areas			
State Marine Conservation Reserves	Added recently proposed marine reserves: • Bardi Jawa Gaarra Marine Park • Mayala Marine Park • Laland-gaddam Marine Park	Newly proposed marine protected areas in Kimberley coastal (i.e., state) waters. Expected to be gazetted in 2024.	New sections 11.1.18,11.1.19 and 11.1.20
Social, Economic and Cultural Features			
Recreational Fisheries: Southwest Bioregion	Updated info on the Albany Aquaculture Development Zone and included information on the Rare Foods Australia (Ocean Grown Abalone) Project	As per Santos Comment on Rev 9A	Section 14.9.1
Tourism			
Tourism	Added additional information on the Abrolhos and Montebello Islands where information specific to tourism growth was available	As per Santos Comment on Rev 9A	Section 14.1.4
Other edits			
General grammar/minor terminology	Minor edits on grammar, terminology (e.g. Santos WA removed) etc have been updated as per Santos' Review of Rev9A	As per Santos Comment on Rev 9A	Throughout
Appendix A (PMST)	Included additional information on how the PMST search was conducted and how the tool has been updated (as per caveat 3 referenced in all PMST reports)	As per Santos Comment on Rev 9A	Appendix A
Coral Reefs	Added the 2011 Ningaloo reef bleaching event, as well as the 2016 bleaching event at Scott reef.	Referenced bleach event in current revision outdated	Section 3.1
Northwest Transition	Added reference to the 2009 Mermaid reef coral survey and that it is comparable to the original 1993 survey referenced.	Outdated survey findings.	Section 3.1.6
Northwest Transition	Added paragraph outlining that recent genetic studies on offshore reefs within the region have shown high genetic diversity and potential vulnerability to impacts due to isolation and reliance on local recruitment.	Literature update	Section 3.1.6

Timor Province	Added number of Scleractinian coral taxa found at Scott reef as of 2013.	No description of coral taxa numbers provided	Section 3.1.9
Asian Dowitcher	Population numbers added	Environment.gov.au update	Table 8-5
Grey-tailed Tattler	Population numbers added	Not included in current revision	Table 8-5
Oriental Plover	Population numbers updated	Environment.gov.au update	Table 8-5
Pacific Golden Plover	Internationally important location removed	No longer on the government.gov.au site	Table 8-5
Sharp-tailed Sandpiper	Added internationally important sites	Not included in current revision	Table 8-5
Whimbrel	Added internationally important sites	Not included in current revision	Table 8-5
Seabirds	Added species listed under the Wildlife Conservation Plan for Seabirds (2020) to table + Red-tailed Tropicbird; + White-tailed Tropicbird; + Broad-billed Prion; + Fairy Prion; + Wedge-tailed Shearwater; + Flesh-footed Shearwater; + Sooty Shearwater; + Short-tailed Shearwater; + Streaked Shearwater; + Lesser Frigatebird; + Great Frigatebird; + Masked Booby; + Red-footed Booby; + Brown Booby; + Common Noddy; + Bridled Tern; + Little Tern; + Caspian Tern; + Roseate Tern and;	New Conservation plan (effective June 2022)	Table 13-1

	+ Osprey;		

Appendix F: Values and sensitivities search results

Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 05-Jul-2024
WA-20-L Permit Area, no buffer

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	24
Listed Migratory Species:	33

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	59
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	9
Key Ecological Features (Marine):	1
Biologically Important Areas:	4
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda westralis Red-tailed Tropicbird (Indian Ocean), Indian Ocean Red-tailed Tropicbird [91824]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
FISH		
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
MAMMAL		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
REPTILE		
Aipysurus apraefrontalis Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
SHARK		
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sphyrna lewini		
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Phaethon lepturus		
White-tailed Tropicbird [1014]		Species or species habitat likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata		
Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Carcharhinus longimanus		
Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus		
Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus		
Longfin Mako [82947]		Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]		Breeding known to occur within area
Mobula alfredi as Manta alfredi		
Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat may occur within area
Mobula birostris as Manta birostris		
Giant Manta Ray [90034]		Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat likely to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Solenostomus cyanopterus		
Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus		
Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus		
Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris		
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptile		
Aipysurus apraefrontalis		
Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii		
Dubois' Sea Snake, Dubois' Seasnake, Reef Shallows Sea Snake [1116]		Species or species habitat may occur within area
Aipysurus foliosquama		
Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus laevis		
Olive Sea Snake, Olive-brown Sea Snake [1120]		Species or species habitat may occur within area
Aipysurus mosaicus as Aipysurus eydouxii		
Mosaic Sea Snake [87261]		Species or species habitat may occur within area
Aipysurus tenuis		
Brown-lined Sea Snake, Mjoberg's Sea Snake [1121]		Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Ephalophis greyae as Ephalophis greyi Mangrove Sea Snake [93738]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis czeblukovi Fine-spined Sea Snake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Sea Snake, Bar-bellied Sea Snake [1104]		Species or species habitat may occur within area
Hydrophis kingii as Disteira kingii Spectacled Sea Snake [93511]		Species or species habitat may occur within area
Hydrophis macdowelli as Hydrophis mcdowelli MacDowell's Sea Snake, Small-headed Sea Snake, [75601]		Species or species habitat may occur within area
Hydrophis major as Disteira major Olive-headed Sea Snake [93512]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Sea Snake, Ornate Reef Sea Snake [1111]		Species or species habitat may occur within area
Hydrophis peronii as Acalyptophis peronii Horned Sea Snake [93509]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hydrophis platura as Pelamis platurus Yellow-bellied Sea Snake [93746]		Species or species habitat may occur within area
Hydrophis stokesii as Astrotia stokesii Stokes' Sea Snake [93510]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Habitat Critical to the Survival of Marine Turtles [Resource Information]

Scientific Name	Behaviour	Presence
Aug - Sep		
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Development of Angel gas and condensate field, North West Shelf	2004/1805	Controlled Action	Post-Approval
Development of Browse Basin Gas Fields (Upstream)	2008/4111	Controlled Action	Completed
Not controlled action			
Project Highclere Geophysical Survey	2021/9023	Not Controlled Action	Completed
Not controlled action (particular manner)			
3D Marine Seismic Survey in WA 457-P & WA 458-P, North West Shelf, offshore WA	2013/6862	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
DAVROS MC 3D marine seismic survey northwaet of Dampier, WA	2013/7092	Not Controlled Action (Particular Manner)	Post-Approval
Decommissioning of the Legendre facilities	2010/5681	Not Controlled Action (Particular Manner)	Post-Approval
Deep Water Northwest Shelf 2D Seismic Survey	2007/3260	Not Controlled Action (Particular Manner)	Post-Approval
Demeter 3D Seismic Survey, off Dampier, WA	2002/900	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Glomar Shoals	North-west

Biologically Important Areas [Resource Information]

Scientific Name	Behaviour	Presence
Marine Turtles		
Natator depressus		
Flatback Turtle [59257]	Internesting buffer	Known to occur
Seabirds		
Ardenna pacifica		
Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Sharks		
Rhincodon typus		
Whale Shark [66680]	Foraging	Known to occur
Whales		
Megaptera novaeangliae		
Humpback Whale [38]	Migration (north and	Known to occur

Scientific Name	Behaviour	Presence
	south)	

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 05-Jul-2024
WA-20-L EMBA, no buffer

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	24
Listed Migratory Species:	33

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	59
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	9
Key Ecological Features (Marine):	1
Biologically Important Areas:	4
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Calidris acuminata		
Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus		
Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda westralis		
Red-tailed Tropicbird (Indian Ocean), Indian Ocean Red-tailed Tropicbird [91824]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
FISH		
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
MAMMAL		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
REPTILE		
Aipysurus apraefrontalis Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
SHARK		
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sphyrna lewini		
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Phaethon lepturus		
White-tailed Tropicbird [1014]		Species or species habitat likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata		
Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat may occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Carcharhinus longimanus		
Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat may occur within area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus		
Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Vulnerable	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat likely to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Solenostomus cyanopterus		
Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus		
Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus		
Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris		
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptile		
Aipysurus apraefrontalis		
Short-nosed Sea Snake, Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii		
Dubois' Sea Snake, Dubois' Seasnake, Reef Shallows Sea Snake [1116]		Species or species habitat may occur within area
Aipysurus foliosquama		
Leaf-scaled Sea Snake, Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus laevis		
Olive Sea Snake, Olive-brown Sea Snake [1120]		Species or species habitat may occur within area
Aipysurus mosaicus as Aipysurus eydouxii		
Mosaic Sea Snake [87261]		Species or species habitat may occur within area
Aipysurus tenuis		
Brown-lined Sea Snake, Mjoberg's Sea Snake [1121]		Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Ephalophis greyae as Ephalophis greyi Mangrove Sea Snake [93738]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis czeblukovi Fine-spined Sea Snake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Sea Snake, Bar-bellied Sea Snake [1104]		Species or species habitat may occur within area
Hydrophis kingii as Disteira kingii Spectacled Sea Snake [93511]		Species or species habitat may occur within area
Hydrophis macdowelli as Hydrophis mcdowelli MacDowell's Sea Snake, Small-headed Sea Snake, [75601]		Species or species habitat may occur within area
Hydrophis major as Disteira major Olive-headed Sea Snake [93512]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Sea Snake, Ornate Reef Sea Snake [1111]		Species or species habitat may occur within area
Hydrophis peronii as Acalyptophis peronii Horned Sea Snake [93509]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hydrophis platura as Pelamis platurus Yellow-bellied Sea Snake [93746]		Species or species habitat may occur within area
Hydrophis stokesii as Astrotia stokesii Stokes' Sea Snake [93510]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area

Whales and Other Cetaceans

[Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat may occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat may occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Habitat Critical to the Survival of Marine Turtles [Resource Information]

Scientific Name	Behaviour	Presence
Aug - Sep		
Natator depressus Flatback Turtle [59257]	Nesting	Known to occur

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Development of Angel gas and condensate field, North West Shelf	2004/1805	Controlled Action	Post-Approval
Development of Browse Basin Gas Fields (Upstream)	2008/4111	Controlled Action	Completed
Not controlled action			
Project Highclere Geophysical Survey	2021/9023	Not Controlled Action	Completed
Not controlled action (particular manner)			
3D Marine Seismic Survey in WA 457-P & WA 458-P, North West Shelf, offshore WA	2013/6862	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
DAVROS MC 3D marine seismic survey northwaet of Dampier, WA	2013/7092	Not Controlled Action (Particular Manner)	Post-Approval
Decommissioning of the Legendre facilities	2010/5681	Not Controlled Action (Particular Manner)	Post-Approval
Deep Water Northwest Shelf 2D Seismic Survey	2007/3260	Not Controlled Action (Particular Manner)	Post-Approval
Demeter 3D Seismic Survey, off Dampier, WA	2002/900	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Glomar Shoals	North-west

Biologically Important Areas [Resource Information]

Scientific Name	Behaviour	Presence
Marine Turtles		
Natator depressus		
Flatback Turtle [59257]	Internesting buffer	Known to occur
Seabirds		
Ardenna pacifica		
Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Sharks		
Rhincodon typus		
Whale Shark [66680]	Foraging	Known to occur
Whales		
Megaptera novaeangliae		
Humpback Whale [38]	Migration (north and	Known to occur

Scientific Name	Behaviour	Presence
	south)	

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

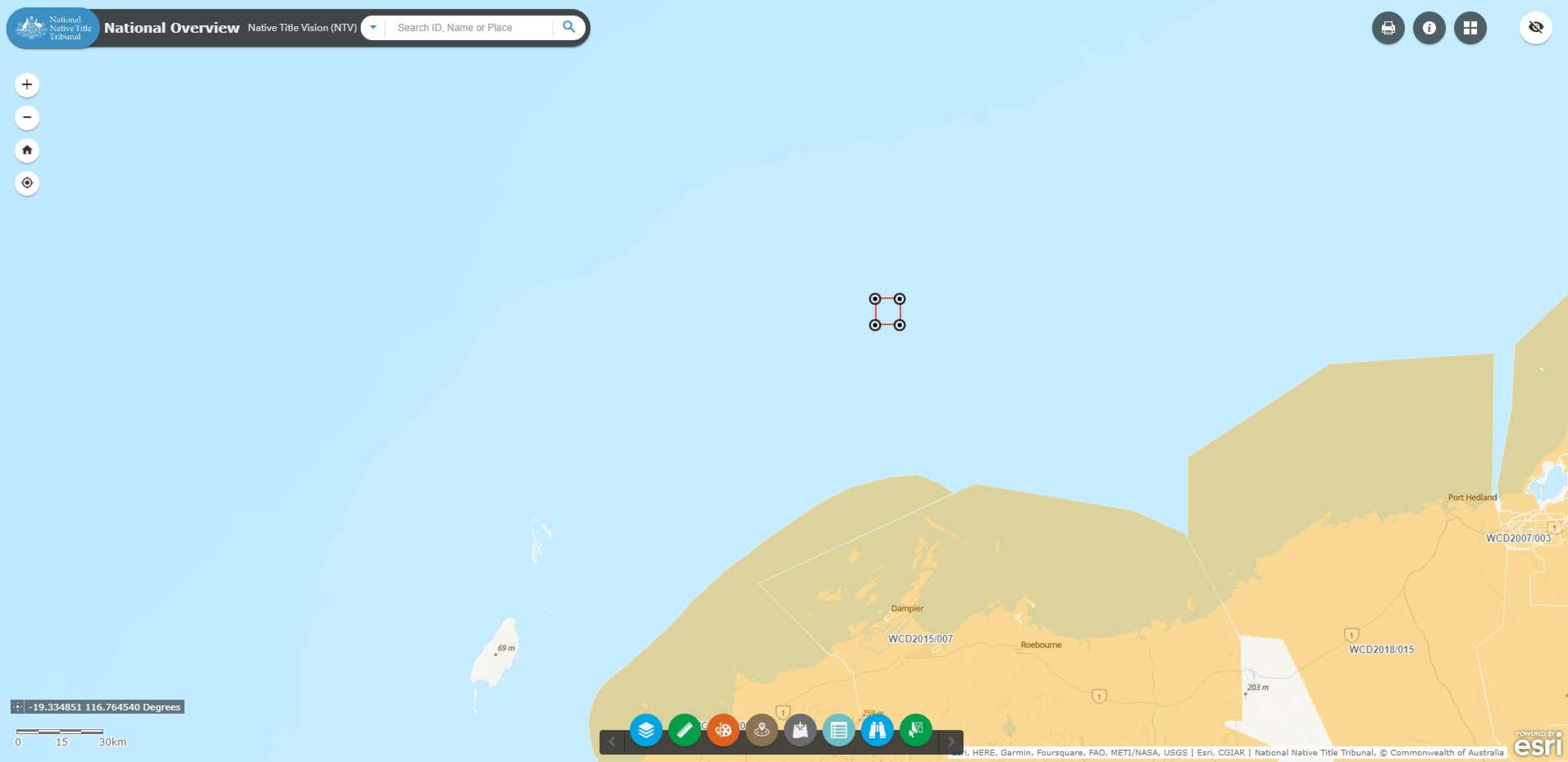
This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

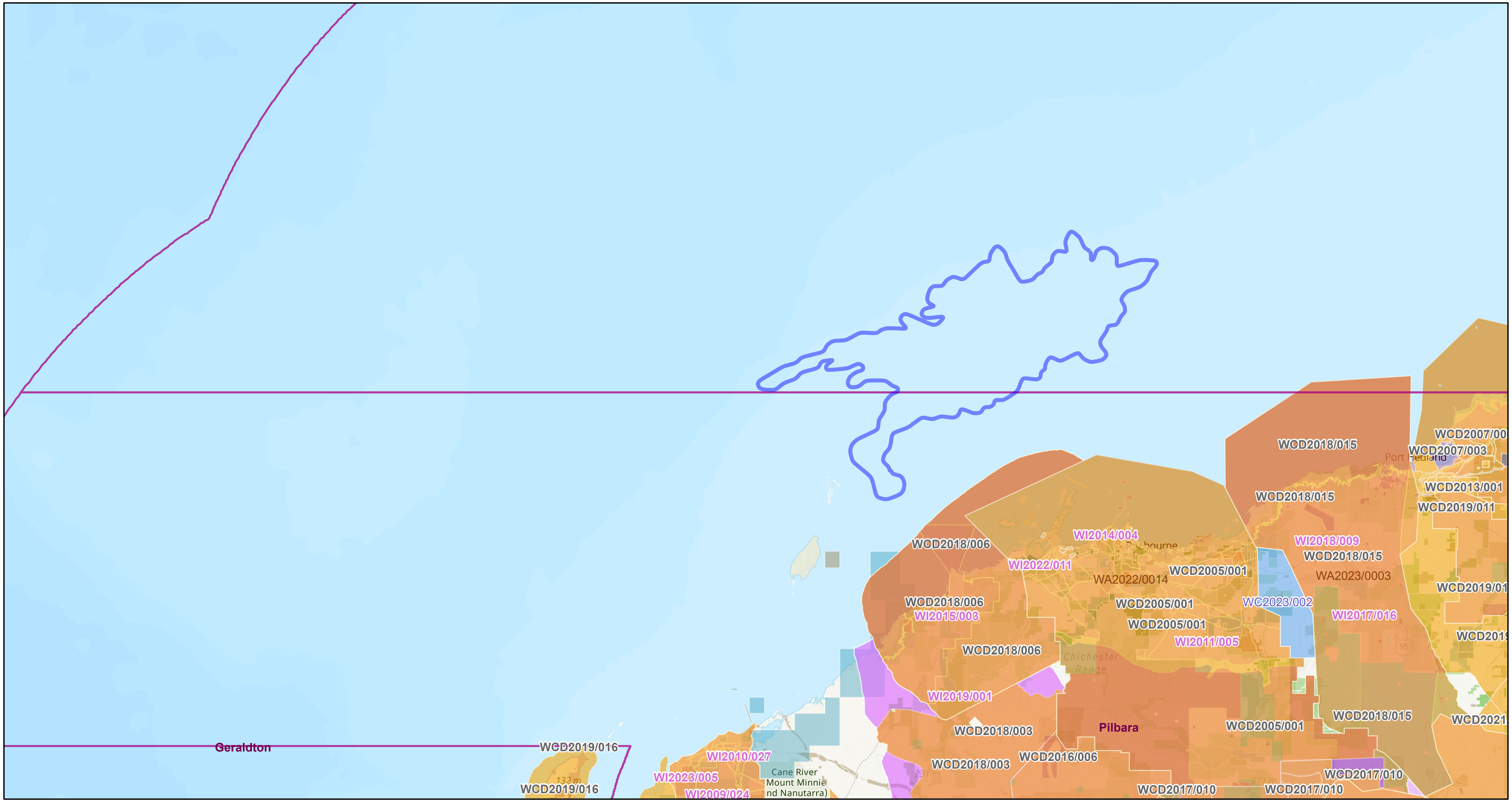
The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111


National Native Title Tribunal
National Overview
Native Title Vision (NTV)
Search ID, Name or Place
Dampier
WCD2015/007
Roebourne
Port Hedland
WCD2007/003
WCD2018/015
69 m
203 m
-19.334851 116.764540 Degrees
0
15
30km
Esri, HERE, Garmin, Foursquare, FAO, METI/NASA, USGS | Esri, CGIAR | National Native Title Tribunal, © Commonwealth of Australia
POWERED BY esri

WA-20-L EMBA 2024



5/27/2024, 1:59:59 PM

1:2,311,162

0 25 50 100 mi
0 40 80 160 km

style1
RATSIB Areas

Determinations
In effect - Finalised

Determined Outcomes
Native title does not exist
Native title exists (exclusive)
Native title exists (non-exclusive)
Native title extinguished

Indigenous Land Use Agreements
ILUA registered
Applications (RNTC)
Applications (Schedule)
Section 31 Agreements

Future Act Determination Applications
Future Act Objections
Future Act Notices (Current)

Esri, TomTom, Garmin, FAO, NOAA, USGS, Esri, USGS

Native TitleVision
Esri, USGS | Esri, TomTom, Garmin, Foursquare, FAO, METI/NASA, USGS | National Native Title Tribunal, © Commonwealth of Australia |

Appendix G: Initial consultation

Table I-1: Consultation summary for previous versions of the EP

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td colspan="3">Commonwealth departments/agencies</td></tr>
<tr><td rowspan="3">Australian Border Force (Maritime Border Command)</td><td colspan="2">Australian Border Force was provided the consultation package via email on 6 December 2021.
No formal response has been received from Australian Border Force.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td><td>Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Australian Fisheries Management Authority (AFMA)</td><td colspan="2">AFMA was provided the consultation package via email on 6 December 2021.
AFMA responded on 7 December 2021 noting its expectation for consultation with fishers who have entitlements to fish within the proposed area. AFMA advised this can be done through the relevant fishing industry associations or directly with fishers who hold entitlements in the area. Santos has consulted with relevant fishing industry associations as outlined in Table 4.1 on the basis that these fisheries have not been active in WA-20-L in recent years.
Santos responded to AFMA on 14 December 2021 acknowledging that while there was no recent fishing activity in WA-20-L for the proposed activity Santos has consulted the following representative organisations on behalf of relevant Commonwealth fishing licence holders:
Australian Southern Bluefin Tuna Industry Association, representing Southern Bluefin Tuna Fishery licence holders
Tuna Australia, representing Western Tuna and Billfish Fishery licence holders
Commonwealth Fisheries Association, representing Western Skipjack Tuna Fishery licence holders
This stakeholder also receives Santos' Quarterly Consultation Update for WA.
Santos has also consulted DAWE (now DAFF) given its interests in the management of Commonwealth fisheries.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future</td></tr>
<tr><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td><td>Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Australian Hydrographic Office (AHO)</td><td colspan="2">AHO was provided the consultation package via email on 6 December 2021.
AHO acknowledged receipt of the consultation package 8 December 2021.
No formal response has been received from the AHO.
AHO notification requirements, as requested by AMSA and Defence, are addressed in Table 8-4.</td></tr>
</table>

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="3"></td><td colspan="2">This stakeholder also receives Santos' Quarterly Consultation Update for WA.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td><td>Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Australian Maritime Safety Authority (AMSA) – maritime safety</td><td colspan="2">AMSA was provided the consultation package via email on 6 December 2021.
AMSA responded on 7 December 2021 requesting timely and relevant Maritime Safety Information is promulgated for the area and nature of operations as follows:
Contact the AHO at datacentre@hydro.gov.au no less than four weeks before operations, with details relevant to the operations. The AHO will promulgate the appropriate Notice to Mariners, which will ensure other vessels receive information on activities. [REQUEST 001]
Notify AMSA's Joint Rescue Coordination Centre (JRCC) by email rccaus@amsa.gov.au for promulgation of radio-navigation warnings at least 24-48 hours before operations commence. The JRCC will require vessel details (including name, callsign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone numbers), area of operation, requested clearance from other vessels and any other information that may contribute to safety at sea. JRCC will also need to be advised when operations start and end. [REQUEST 002]
Provide updates to both the Australian Hydrographic Office and the JRCC on progress and, importantly, any changes to the intended operations. [REQUEST 003]
Exhibit appropriate lights and shapes to reflect the nature of operations –we remind vessels of their obligation to comply with the International Rules for Preventing Collisions at Sea (COLREGs), in particular, the use of appropriate lights and shapes to reflect the nature of your operations (e.g., restricted in the ability to manoeuvre). Vessels should also ensure their navigation status is set correctly in the ship's Automatic Identification System (AIS) unit. [REQUEST 004]
To obtain a vessel traffic plot showing AIS traffic data for your area of interest, please visit AMSA's spatial data gateway and Spatial@AMSA portal to download digital data sets and maps. [INFORMATION 001]
Santos responded to AMSA on 10 January 2022 and addressed the matters raised in its feedback of 7 December 2021 with respect to vessel-based activities (refer assessment of stakeholder objections, claims, information and requests below). Santos also sought further feedback from AMSA on Santos' proposal to leave the wellhead in situ.
AMSA responded on 17 January 2022 and provided the following response:
AMSA does not believe there is anything in MARPOL that would cover the proposed Legendre-1 wellhead to be permanently in situ. [INFORMATION 002]
AMSA recommend that Santos consider, if it hasn't already done so, contacting the Department of Agriculture, Water and the Environment (DAWE) for comments with respect to sea dumping. [REQUEST 005]</td></tr>
</table>

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="9"></td><td colspan="2">Santos responded on 21 January 2022 and addressed feedback provided in AMSA's email 17 January 2022 (refer assessment of stakeholder objections, claims, information and requests below).
This stakeholder also receives Santos' Quarterly Consultation Update for WA.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td><td>Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests</td></tr>
<tr><td>[REQUEST 001] Santos will notify the AHO no less than four weeks before operations commence where practicable.
Notification requirements are addressed in Table 8-4.</td><td>Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.</td></tr>
<tr><td>[REQUEST 002] Santos will notify AMSA's JRCC at least 24–48 hours before operations commence for each activity and advise when operations start and end.
Notification requirements are addressed in Table 8-4</td><td>Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.</td></tr>
<tr><td>[REQUEST 003] Santos will notify both AHO and AMSA's JRCC on any changes to the intended operations.
Notification requirements are addressed in Table 8-4</td><td>Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.</td></tr>
<tr><td>[REQUEST 004] Santos noted the advice on obligations to comply with COLREGs, in particular, the use of appropriate lights and shapes to reflect the nature of operations and this is addressed in Section 6.2.</td><td>Santos responded to AMSA and noted the information provided.</td></tr>
<tr><td>[INFORMATION 001] Santos notes the information provided on traffic data.</td><td>Santos responded to AMSA and noted the information provided.</td></tr>
<tr><td>[INFORMATION 001] Santos notes the information provided on MARPOL.</td><td>Santos responded to AMSA and noted the information provided.</td></tr>
<tr><td>REQUEST 005] Santos is not required to consult DAWE with respect to sea dumping permission as the well was abandoned prior to the Sea Dumping Act coming into force.</td><td>Santos responded to AMSA and noted that sea dumping permission was not required for the activity.</td></tr>
<tr><td>Australian Maritime Safety Authority (AMSA) – marine pollution</td><td colspan="2">AMSA was provided the consultation package via email on 6 December 2021.
No formal response has been received from AMSA.
Management of oil spill preparedness is addressed in the WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01).
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests	Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests
	No assessment required.	No response required.
Department of Agriculture, Water and the Environment (DAWE, now DAFF) – marine pests	DAWE was provided the consultation package via email on 6 December 2021. No formal response has been received from the DAWE. Management of invasive marine pest species is addressed in **Section 7.3**. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests	Statement of response, or proposed response, to the objections and claims (OPGGS(E) Regulation 16 (b)(iii)), and information and requests
	No assessment required.	No response required.
Department of Agriculture, Water and the Environment (DAWE, now DAFF) – fisheries	DAWE was provided the consultation package via email on 6 December 2021. No formal response has been received from the DAWE. Santos has assessed the impact to fish and commercial fisheries in Section 6. While there has been no recent fishing effort in these fisheries, Santos has also consulted AMFA and representative bodies given their interest in petroleum activities where licence holders are entitled to fish. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Department of Agriculture, Water and the Environment (DAWE, now DAFF) – biosecurity	DAWE was provided the consultation package via email on 6 December 2021. No formal response has been received from the DAWE. Santos has assessed the biosecurity impacts in **Section 7.3**. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="2"></td><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Department of Industry Science, Energy and Resources (DISER)</td><td colspan="2">DISER was provided the consultation package via email on 6 December 2021.
No formal response has been received from DISER.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Director of National Parks (DNP)</td><td colspan="2">The DNP was provided the consultation package via email on 6 December 2021.
DNP responded via email on 10 January 2022 and provided the following response:
The DNP thanked Santos for the opportunity to comment on the information sheet about Santos' activities including a monitoring and research programme and the presence of the Legendre-1 wellhead (WA-20-L). [INFORMATION 001]
Based on the information sheet provided, DNP noted that the planned activities do not overlap any Australian Marine Parks. Therefore, there are no authorisation requirements from the DNP. [INFORMATION 002]
DNP did not have any claims and objections at this time but indicated it would like to understand the research and monitoring programme further. Specifically, if the gas bubbles are found to be impacting the environment, what steps will be taken to mitigate those impacts. [REQUEST 001]
Santos noted from Santos consultation information that several Biologically Important Areas (BIAs) and a Key Ecological Feature (KEF) are located within WA-20-L. [INFORMATION 003] These BIAs and KEFs are identified values of the Montebello and Dampier marine parks and activities that could affect these areas should be factored into risk assessments. [REQUEST 002]
DNP requested that in preparing the EP, Santos should consider the Australian marine parks and their representativeness. In the context of the management plan objectives and values, Santos should ensure that the EP: [REQUEST 003]
identifies and manages all impacts and risks on Australian marine park values (including ecosystem values) to an acceptable level and has considered all options to avoid or reduce them to as low as reasonably practicable
clearly demonstrates that the activity will not be inconsistent with the management plan.
DNP advised that the North West Marine Parks Network Management Plan 2018 came into effect on 1 July 2018 and provided further information on values for Dampier and Montebello marine parks. DNP also advised that Australian marine park values are broadly defined into four categories: natural (including ecosystems), cultural, heritage and socio-economic. Information on the values for the marine parks is also located on the Australian Marine Parks Science Atlas. [INFORMATION 004]
In the case of an emergency response, the DNP should be made aware of oil/gas pollution incidences which occur within a marine park or are likely to impact on a marine park as soon as possible. Notification should be provided to the 24-hour Marine Compliance Duty Officer. The notification should include [REQUEST 004]:</td></tr>
</table>

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="5"></td><td colspan="2">titleholder details
time and location of the incident (including name of marine park likely to be effected)
proposed response arrangements as per the Oil Pollution Emergency Plan (e.g. dispersant, containment, etc.)
confirmation of providing access to relevant monitoring and evaluation reports when available; and
contact details for the response coordinator.
Note that the DNP may request daily or weekly Situation Reports, depending on the scale and severity of the pollution incident.
Santos responded to DNP on 24 January 2022 and addressed the matters raised in their correspondence of 10 January 2022 (refer assessment of stakeholder objections, claims, information and requests below).
DNP was sent an activity update via email on 21 July 2022, providing additional information about the monitoring and research programme for the gas bubble seepage.
DNP responded by email on 27 July 2022 and provided the following response:
DNP acknowledged the email from Santos and that the Environment Plan would be resubmitted in August 2022. [INFORMATION 005]
DNP requested its previous feedback to be carried over into the updated Environment Plan and that no further information was required at this time. [REQUEST 005]
Santos responded to DNP on 2 August 2022 and addressed the matters raised in their correspondence of 27 July 2022 (refer assessment of stakeholder objections, claims, information and requests below).
Santos has assessed the impact to Australian marine reserves in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td><td>Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests</td></tr>
<tr><td>[INFORMATION 001] Santos notes feedback from DNP on being offered an opportunity to comment on activities as advised in Santos' consultation materials.</td><td>Santos responded to DNP and acknowledged the feedback provided.</td></tr>
<tr><td>[INFORMATION 002] Santos notes that no authorisations are required from the DNP.</td><td>Santos responded to DNP and acknowledged the advice provided.</td></tr>
<tr><td>[REQUEST 001] Santos notes DNP has no claims or objections to proposed activities and advised that Santos had assessed the environmental impacts of the gas bubbles as being negligible, based on studies to date of gas composition, gas flow rates, water quality and sediment quality data.
Santos advised that monitoring of the gas bubbles would continue in 2022, outcomes of which would be fed into an adaptive management</td><td>Santos responded to DNP on 24 January 2022 and acknowledged its request.
Santos provided an activity update to DNP on 21 July 2022.</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	plan, taking account of any changes to measured environmental impacts over time as well as technical assessments to determine feasible mitigation measures. Santos advised it would provide more information to DNP as the program is matured, monitoring is undertaken, and results assessed.	
	[INFORMATION 3] Santos notes acknowledgement from DNP that several Biologically Important Areas (BIAs) and a Key Ecological Feature (KEF) are located within WA-20-L.	Santos responded to DNP and acknowledged the feedback provided.
	[REQUEST 002] Santos acknowledges identified BIAs and KEFs should be factored into risk assessments.	Santos responded to DNP and confirmed that BIAs and KEFs had been considered in risk assessments.
	[REQUEST 003] Santos has considered NOPSEMA Guidance Note Petroleum Activities and Australian Marine Parks (N-04750-GN1785 A620236, 03/06/2020). Santos has identified the relevant Australian Marine Parks and their values (Section 3).	Santos responded to DNP and confirmed it has followed the NOPSEMA guidance note in preparation of the EP.
	[INFORMATION 004] Santos has considered information within the Australian Marine Parks North-West Marine Parks Network Management Plan (2018) and Australian Marine Parks Science Atlas. Refer to (Section 6 and 7).	Santos responded to DNP and acknowledged the advice provided.
	[REQUEST 004] Santos has addressed DNP emergency notification requirements in Table 8-4 of the EP and the OPEP.	Santos responded to DNP the OPEP for the activity includes DNPs notification requirements. These can be found in Section 7 of the OPEP.
	[INFORMATION 005] Santos notes DNP's acknowledgement of the Environment Plan resubmission.	Santos responded to DNP and acknowledged the advice provided.
	[REQUEST 005] Santos has included DNP's previous feedback in the resubmission of this Environment Plan.	Santos responded to DNP and acknowledged its request.
State departments/agencies		
Department of Biodiversity and Conservation Attractions (DBCA)	The DBCA was provided the consultation package via email on 6 December 2021. DBCA responded on 13 December 2021 and advised it had no comments on proposed activities based on the consultation information provided by Santos. [INFORMATION 001] Santos responded on 23 January 2022 acknowledging DBCA's feedback. Santos has assessed the impact to Western Australian marine reserves in Section 6 and 7.	

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests	Assessment of the merits of objections and claims (OPGGS(E) Regulation 16 (b)(ii)), information and requests
	[INFORMATION 001] No assessment required.	Santos responded to DBCA and acknowledged its advice.
WA Department of Mines, Industry Regulation and Safety (DMIRS)	DMIRS was provided the consultation package via email on 6 December 2021. No formal response has been received from DMIRS. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
WA Department of Primary Industries & Regional Development (DPIRD)	DPIRD was provided the consultation package via email on 6 December 2021. DPIRD was sent an activity update via email on 21 July 2022, providing additional information about the monitoring and research programme for the gas bubble seepage. This information was also sent to WAFIC and Recfishwest, which asked during initial consultation to be kept informed about the programme. No formal response has been received from DPIRD. Santos has assessed the impact to fish and commercial fisheries in Section 6 and 7. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
WA Department of Transport (DoT)	DoT was provided the consultation package via email on 6 December 2021. DoT responded on 8 December 2021 advising: If there is a risk of a spill impacting State waters from the activity, please ensure that the Department of Transport is consulted as outlined in the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (July 2020). [REQUEST 001] This stakeholder also receives Santos' Quarterly Consultation Update for WA.	

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="3"></td><td colspan="2">Santos responded to DoT on 23 January 2022 addressing its consultation expectations outlined in its email of 8 December 2021 (refer assessment of stakeholder objections, claims, information and requests below).</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>[REQUEST 001] Santos will ensure consultation with the DoT as outlined in the Department of Transport Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (July 2020).</td><td>Santos responded to DoT and acknowledged its request.</td></tr>
<tr><td colspan="3">Industry Bodies</td></tr>
<tr><td rowspan="3">Australian Energy Producers (formerly Australian Petroleum Production & Exploration Association (APPEA))</td><td colspan="2">AEP was provided the consultation package via email on 6 December 2021.
No formal response has been received from AEP.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Australian Southern Bluefin Tuna Industry Association (ASBTIA)</td><td colspan="2">ASBTIA was provided the consultation package via email on 6 December 2021.
No formal response has been received from ASBTIA.
This stakeholder also receives Santos' Quarterly Consultation Update for WA.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Commonwealth Fisheries Association (CFA)</td><td colspan="2">CFA was provided the consultation package via email on 6 December 2021.
No formal response has been received from CFA.
This stakeholder also receives Santos' Quarterly Consultation Update for WA.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Marine Tourism WA (MTWA)	MTWA was provided the consultation package via email on 14 September 2021 following a phone call to understand the potential for charter boat activity in the region. No formal response has been received from MTWA. This stakeholder also receives Santos' Quarterly Consultation Update for WA. All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Pearl Producers Association (PPA)	PPA was provided the consultation package via email on 6 December 2021. No formal response has been received from PPA. All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
RecfishWest	RecfishWest was provided the consultation package via email on 6 December 2021. RecfishWest responded by email on 22 December 2021 and provided the following feedback: RecfishWest thanked Santos for the opportunity to comment on the Legendre Decommissioning Environmental Plan. [INFORMATION 001] RecfishWest provided information on recreational fishing in Western Australia, noting the importance of recreational fishing to lifestyle of the Pilbara region. [INFORMATION 002] RecfishWest noted that the area is sometimes frequented by recreational fishers, noting that permit WA-20-L overlaps the Glomar Shoals, which is an important site for recreational fishers. [INFORMATION 003] RecfishWest recommended contacting and speaking to the two main fishing clubs in Karratha to assess potential impacts on local recreational fishers [REQUEST 001] and provided contact details for these clubs. [INFORMATION 004]	

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="5"></td><td colspan="2">RecfishWest looked forward to receiving additional information to assist it assess activities and potential impacts. [REQUEST 002]
RecfishWest requested to be regularly updated on proposed activities and to continue discussions with Santos, as activities might have impacts on recreational fishers, charter operators, and marine ecosystems. [REQUEST 003]
RecfishWest provided relevant contact details for ongoing consultation. [INFORMATION 005]
Santos responded to RecfishWest on 6 January 2022 and addressed the matters raised in its feedback of 22 December 2021 (refer assessment of stakeholder objections, claims, information and requests below). Santos followed up its email of 6 January 2022 with a phone call on 12 January 2022 and email on 14 January 2022 to confirm RecfishWest request for additional information to assess activities and potential impacts, as well as the relevancy of engaging regional fishing clubs.
RecfishWest responded on 14 January 2022 confirming:
Validity of passing on consultation information to Karratha-based fishing clubs. [INFORMATION 006]
It was glad that the gas bubbles will be monitored and requested to be notified if the results of this monitoring show any impacts on the marine environment [REQUEST 004]
RecfishWest position on subsea infrastructure, noting it does not consider a singular subsea structure in the marine environment (such as this wellhead) as an 'artificial reef'. [INFORMATION 007]
Santos responded to RecfishWest on 24 January 2022 and addressed the matters raised in its feedback of 6 January 2022 (refer assessment of stakeholder objections, claims, information and requests below).
Recfishwest was sent an activity update via email on 21 July 2022, providing additional information about the monitoring and research programme for the gas bubble seepage.
This stakeholder also receives Santos' Quarterly Consultation Update for WA.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>[INFORMATION 001] Santos acknowledged feedback from RecfishWest on the Legendre Decommissioning EP.</td><td>Santos responded to RecfishWest and noted the information provided.</td></tr>
<tr><td>[INFORMATION 002] Santos has acknowledged comments from RecfishWest on the importance of recreational fishing as a key economic and social activity for the Pilbara region.</td><td>Santos responded to RecfishWest and noted the information provided.</td></tr>
<tr><td>[INFORMATION 003] Santos acknowledged feedback from RecfishWest that recreational fishers frequent the area given the proximity to Glomar Shoals.</td><td>Santos responded to RecfishWest and noted the information provided.</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	[REQUEST 001] Santos confirmed it was amenable to consulting Karratha-based fishing clubs but sought further clarification from asked RecfishWest on the expected level of interest from these clubs given the extent of the proposed decommissioning was for a single wellhead to be left in situ and the ongoing presence of the gas bubble seepage.	Santos responded to RecfishWest and sought further clarification on its request.
	[INFORMATION 004] Santos noted contact details provided for Karratha-based fishing clubs.	Santos responded to RecfishWest and noted the information provided.
	[REQUEST 002] Santos noted the request from RecfishWest for further information to assess potential impacts from proposed activities.	Santos responded to RecfishWest and sought further clarification on its request.
	[REQUEST 003] Santos noted the request from RecfishWest for regular updates on proposed decommissioning activities.	Santos responded to RecfishWest and sought further clarification on its request.
	[INFORMATION 005] Santos noted RecfishWest contact details for ongoing consultation activities.	Santos responded to RecfishWest and noted the information provided.
	[INFORMATION 006] Santos noted RecfishWest confirmation for consultation to be sent to Karratha-based fishing clubs.	Santos responded to RecfishWest confirming it had provided information to the King Bay and Nickol Bay Fishing Clubs, confirming that King Bay Fishing Club would pass on the information to members were best placed to travel safely to the Legendre-1 location.
	[REQUEST 004] Santos noted Recfishwest's request in its email of 14 January 2022 to be kept informed about the gas bubble seepage.	Santos provided an activity update on 21 July 2022.s
	[INFORMATION 007] Santos noted RecfishWest request to be notified if monitoring results show any impacts on the marine environment.	Santos responded to RecfishWest and advised that further monitoring is planned to support the assessment of potential environmental impacts, with outcomes of the monitoring program feeding into an adaptive management plan. Santos advised it would be pleased to provide an update to RecfishWest on the outcomes of the program.
	[INFORMATION 006] Santos noted RecfishWest position on subsea infrastructure and artificial reef definition.	Santos responded to RecfishWest and noted the information provided.
Tuna Australia	Tuna Australia was provided the consultation package via email on 6 December 2021. No formal response has been received from Tuna Australia. This stakeholder also receives Santos' Quarterly Consultation Update for WA.	

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td></td><td colspan="2">All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td></td><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td></td><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Western Australian Fishing Industry Council (WAFIC)</td><td colspan="2">WAFIC was provided the consultation package via email on 6 December 2021.
WAFIC responded by email on 15 December 2021 and provided the following feedback:
WAFIC objected to the wellhead being left in situ. WAFIC also confirmed Pilbara Trawl licence holders objected to the wellhead being left in situ. [OBJECTION 001]
WAFIC advised it was not clear based on consultation information provided what impacts the gas bubble seepage would have on the marine environment and aquatic resources. As a result, WAFIC requested responses from Santos to the following questions:
Will the leaking get worse? [REQUEST 001]
Is it acceptable industry practise to let something just leak? [REQUEST 002]
What are the actual risks, words like low and very small are not appropriate? [REQUEST 003]
Does it pose a risk to commercial fishing operations and human safety? [REQUEST 004]
What are expected ecotoxicity impacts, has Santos undertaken a study to fully understand it? If so, can you please share the results? [REQUEST 005]
What are the long-term impacts of the leak? [REQUEST 006]
What long-term monitoring will be done? [REQUEST 007]
Has Santos accounted for the cumulative impacts, if every titleholder had the same issue and simply wanted to leave a wellhead leaking, what would that do the marine environment? [REQUEST 008]
Has Santos undertaken studies on the degradation of the wellhead which will result in trace elements in the marine environment? If so, can you please provide it. [REQUEST 009]
As described by NOPSEMA, it's not clear how the Legendre proposal is "delivering equal or better environmental outcomes" (https://www.nopsema.gov.au/sites/default/files/documents/2021-07/A720369.pdf), can you please advise how Santos is meeting these requirements? [REQUEST 010]
WAFIC stated that Western Australia had an international reputation for clean oceans and this reputation supports the WA fishing industry to export product all over the world. WAFIC further stated that gas leaks and infrastructure/plastics left in the marine environment because of decommissioning would have a direct impact on the commercial fishing industry's reputation and markets. [CLAIM 001]. WAFIC added that cumulative impacts must be considered. [CLAIM 002]
WAFIC asked Santos to share its policy position/criterion for decommissioning. [REQUEST 011]</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	WAFIC asked Santos to share the results of the snag risk assessment mentioned in its consultation material. [REQUEST 012] WAFIC sent a follow-up email to Santos on 11 January 2022 to confirm Santos had received its previously provided advice. Santos acknowledged receipt of WAFIC's email of 11 January 2022 and on 14 January 2022 emailed WAFIC requesting a meeting to address its objections, claims and requests for information. WAFIC responded on 18 January 2022 and suggested a meeting date of 20 January 2022. Santos responded on 18 January 2022 and suggested an alternate date of 2 February 2022, accounting for WAFIC attendee availability and ongoing consideration of WAFIC's feedback. Santos met with WAFIC on 2 February 2022 and made a presentation to discuss WAFIC's interests and concerns, ahead of providing a formal response to WAFIC's feedback of 15 December 2021. Santos sent an email to WAFIC on 10 February 2022 providing responses to its feedback of 15 December, incorporating feedback provided at the meeting of 2 February 2022. In responding, Santos aggregated WAFIC's feedback into the areas of human safety, ongoing gas seepage, marine environmental impacts and risks, ecotoxicity impacts, wellhead snag risk, wellhead degradation and assessment of environmental outcomes for the fate of the Legendre-1 wellhead. A copy of the meeting presentation was provided. Santos also provided general comment on its approach to decommissioning and consultation, as well as opportunities for WAFIC involvement in the development of the proposed Legendre monitoring program and fisher involvement in relevant field studies. Santos and WAFIC met again on 16 May 2022 to provide an update on the monitoring and research programme for the gas bubble seepage. A key outcome of the meeting was for an activity update to be produced for use with stakeholders who wished to be kept informed of the monitoring program, including commercial fishers and DPIRD if requested. WAFIC was sent an activity update via email on 21 July 2022, providing additional information about the monitoring and research programme for the gas bubble seepage. All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	[OBJECTION 001] Santos has acknowledged the objection from WAFIC and on behalf of licence holders in State-managed trawl fisheries.	[OBJECTION 001] Santos responded to WAFIC and noted its objection. In response, Santos provided by information at the meeting of 2 February 2022 and by email on 10 February 2022: A summary of an independent snag risk assessment undertaken for the proposed activity which, given the water depth of the wellhead location, there would be sufficient time and room to manoeuvre to avoid the obstacle, which has been marked on nautical charts since 1968.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
		A summary of a wellhead degradation assessment, which predicted that as the wellhead integrity reduces in time, sections of the wellhead may break off and fall onto the surrounding seabed. This would affect habitat (i.e., unconsolidated sediments) within 5 m of the wellhead. Santos advised that iron, the main constituent (~98%) of the wellheads and casing material, was not considered a significant contaminant in the marine environment.
	[REQUESTS 001 TO 012] Santos has acknowledged comments from WAFIC on human safety, ongoing gas seepage, marine environmental impacts and risks, ecotoxicity impacts, wellhead snag risk, wellhead degradation and assessment of environmental outcomes for the fate of the Legendre-1 wellhead.	[REQUESTS 001 to 012] Santos responded to WAFIC at the meeting of 2 February 2022 and by email on 10 February 2022, and providing the following key points: Santos has not assessed the gas bubble seepage as being of risk to human safety, given the low gas rates observed. Santos is undertaking subsurface reservoir modelling in 2022 to estimate possible seepage rates under different scenarios. The modelling, as well as planned well integrity studies, will help inform possible remedial options. The risk to the marine environment and the quality of commercial fish is considered very low due to: Most gas will be released to air at sea surface Gas is detectable only at meters from source in water column Rapid dispersion by tides and currents Benthic food sources impacted at scale of meters, if at all Santos will be undertaking the monitoring using suitably qualified scientists commencing 2022 to obtain in-field measurements of gas seepage rates through time, further sampling and analysis of water and sediment, and ecotoxicology of fish at gas seep locations and reference locations. Summaries from the EP on wellhead snag risk and degradation. A summary of impact and risk assessment for the purposes of determining what is an equal or better environmental outcome with regards to the fate of the Legendre-1 wellhead.
	[CLAIM 001 AND 002] Santos acknowledged comments from WAFIC at the meeting of 2 February 2022 about potential reputational and market	[CLAIM 001 AND 002] Santos responded to WAFIC and noted its concerns, providing a summary of expected impacts from the gas seepage and wellhead degradation. Santos also sought to work with

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td></td><td>impacts from gas leaks and infrastructure/plastics left in the marine environment.</td><td>WAFIC to ensure research data collected was relevant to the fishing industry's needs.</td></tr>
<tr><td colspan="3">Commercial fisheries – State Managed</td></tr>
<tr><td rowspan="3">Mackerel Managed Fishery (Area 2)</td><td colspan="2">Licence holders in the Mackerel Managed Fishery (Area 2) were provided the consultation package via letter on 6 December 2021.
Licence holders were sent a reminder mail via letter on 31 December, noting that the consultation period for proposed activities closed on 10 January 2022.
No formal responses have been received from licence holders.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Pilbara Line Fishery</td><td colspan="2">Licence holders in the Pilbara Line Fishery were provided the consultation package via email on 6 December 2021.
Licence holders were sent a reminder mail via email on 31 December, noting that the consultation period for proposed activities closed on 10 January 2022.
No formal responses have been received from licence holders.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td>Pilbara Demersal Trap Managed Fishery</td><td colspan="2">Licence holders in the Pilbara Demersal Trap Managed Fishery were provided the consultation package via letter on 6 December 2021.
Licence holders were sent a reminder mail via letter on 31 December, noting that the consultation period for proposed activities closed on 10 January 2022.
No formal responses have been received from licence holders.
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
</table>

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="2"></td><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>No assessment required.</td><td>No response required.</td></tr>
<tr><td rowspan="3">Pilbara Trawl Interim Managed Fishery</td><td colspan="2">Licence holders in the Pilbara Trawl Interim Managed Fishery were provided the consultation package via letter on 6 December 2021.
Licence holders were sent a reminder mail via letter on 31 December, noting that the consultation period for proposed activities closed on 10 January 2022.
No formal responses have been received from licence holders, though WAFIC advised in its email of 15 December 2021 that Pilbara Trawl licence holders had objected to the wellhead being left in situ. [OBJECTION 001]
All listed fisheries are described in Section 3.6.1, and potential impact to fisheries, fish habitat and commercial fishers are discussed in Section 6 and 7.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
<tr><td>[OBJECTION 001] Santos notes information provided by WAFIC on behalf of licence holders in the Pilbara Trawl Interim Managed Fishery.</td><td>[OBJECTION 001] Santos has responded to WAFIC and noted its objection, providing a summary of assessments in the EP on snag risk and wellhead degradation.</td></tr>
<tr><td colspan="3">Other stakeholders</td></tr>
<tr><td rowspan="2">King Bay Fishing Club</td><td colspan="2">King Bay Fishing Club was provided the consultation package via email on 14 January 2022.
King Kay Fishing Club responded on 16 January 2022 advising that it had some members that ventured as far offshore as the Legendre-1 wellhead and could send Santos consultation information to club members.
Santos phoned the Club on 21 January 2022 to confirm the number of fishers and prevalence of recreational fishing at locations offshore commensurate with distance offshore of the Legendre-1 wellhead.
The Club advised only a small number of recreational fishers had the capacity and capability to travel such distances safely. The Club offered to send Santos consultation materials to select fishers. [INFORMATION 001]
Santos responded by email on 24 January 2022 acknowledging feedback from the fishing club 2022 in its email of 16 January 2022 (refer assessment of stakeholder objections, claims, information and requests below).
No responses have been received by fishing club members.
Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.</td></tr>
<tr><td>Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))</td><td>Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	[INFORMATION 001] Santos acknowledges feedback from the fishing club that care needs to be taken in communicating the wellhead location and its guidance to send the information to those fishers who have the capacity and capability to responsibly travel safely to the location.	Santos responded to King Bay Fishing Club noting its guidance and supported further distribution of consultation information to those fishers identified as being relevant to the proposed activity.
Nickol Bay Fishing Club	Nickol Bay Fishing Club was provided the consultation package via email on 14 January 2022. A follow up email was sent on 25 January 2022. No formal response has been received from Nickol Bay Fishing Club. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Australian Marine Oil Spill Centre (AMOSC)	AMOSC was provided the consultation package via email on 6 December 2021. No formal response has been received from AMOSC. This stakeholder also receives Santos' Quarterly Consultation Update for WA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.
Centre of Decommissioning Australia (CODA)	CODA was provided the consultation package via email on 6 December 2021. No formal response has been received from CODA. Santos considers the level of consultation to be adequate and will address any comments from this stakeholder should they arise in the future.	
	Assessment of the merits of objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(ii))	Statement of response, or proposed response, to the objections, claims, information and requests (OPGGS(E) Regulation 16 (b)(iii))
	No assessment required.	No response required.

Appendix H: Consultation material

From:	Consultation, Santos
To:	[redacted]
Cc:	Consultation, Santos
Subject:	FOR DISCUSSION | Preliminary Consultation for Proposed Offshore Activities
Date:	Monday, 29 May 2023 2:58:04 PM
Attachments:	Santos Decommissioning EMBA Map.pdf image001.png Santos Drilling and PA EMBA Map.pdf

Dear [redacted]

Santos is contacting you as we are preparing to undertake consultation activities for a number of proposed activities in Commonwealth and WA State waters.

Based on a review of publicly available information, we have identified that [redacted] may have functions, interests or activities that may be affected by these proposed activities.

Preliminary consultation

Santos would like to meet with you to discuss whether the functions, interests or activities of [redacted] may be affected, including consideration of any values or sensitivities of importance.

If you consider that they may be affected by our proposed activities, we can then discuss consultation methods appropriate to [redacted] information needs and interests.

This engagement is a preliminary step ahead of consultation for each activity, which is planned to commence on **26 June 2023**. Consultation is required under Commonwealth and State environmental Regulations and a key part of preparing Environment Plans (EPs) for each activity. Regulator-accepted EPs are required before any petroleum activity can commence.

Proposed Activities Offshore WA

The table below provides a summary of proposed activities, some of which have been consulted on previously with environment plans (EPs) under Regulator assessment.

Environment Plan	Activity summary	EP status
Drilling + Plug and Abandonment Activities		
Spar-Halyard	+ Drilling of a development well (infill) to support ongoing production at the Varanus Island (VI) Hub. The well is approximately 114 km north of Onslow. Activity commencement is planned from Q1 2024	+ New activity for consultation
WA-63-L	+ Drilling of up to four exploration wells to support future production through the VI Hub Operations. Activity commencement is planned from Q1 2024. WA-63-L is approximately 107 km north of Onslow.	+ New activity for consultation
Simpson	+ Plug and abandonment activities of eight wells no longer required for production via the offshore Simpson facility. The wells are approximately 102 km west of Dampier. Activity commencement is planned from Q2 2024.	+ New activity for consultation
Gibson	+ Plug and abandonment activities of four wells no longer required for production via the offshore Gibson facility. The wells are approximately 113 km north east of	+ New activity for consultation

	Onslow. Activity is planned for Q2 2024.	
Mutineer Exeter Fletcher Finucane (MEFF)	+ Plug and abandonment activities for 12 wells no longer required for production. The MEFF wells are approximately 147 km north of Dampier. Activity is planned for Q2 2024.	+ Under assessment by Regulator
Decommissioning Activities		
Harriet Joint Venture (HJV) Decommissioning	+ Decommissioning of the HJV field, comprising removal of all platforms and substructures, as well as pipelines associated with the Simpson facility. The HJV field is approximately 117 km west of Dampier and 117 km north east of Onslow. Activity commencement planned is from Q1 2024.	+ New activity for consultation
MEFF Decommissioning	+ Decommissioning of the MEFF field, comprising partial removal of subsea infrastructure. The MEFF field is approximately 147 km north of Dampier. Activity commencement is anticipated from Q3 2024.	+ Under assessment by Regulator
Campbell Decommissioning	+ Removal of the platform and substructures of the Campbell facility, which is approximately 105 km west of Dampier. Activity commencement is planned from Q1 2024.	+ New activity for consultation
WA-20-L	+ Leave in-situ one plugged and abandoned wellhead, approximately 101 km north of Dampier. The WA-20-L petroleum permit is subject to an ongoing environmental monitoring for the duration of the EP to monitor for gas release.	+ Under assessment by Regulator
WA-1-P	+ Leave in situ three plugged and abandoned wellheads. Activity is ongoing following environment plan acceptance. The nearest well is approximately 85 km north-northwest of Dampier.	+ New activity for consultation

We have attached two maps – one for drilling and plug and abandonment activities and one for decommissioning activities.

These maps depict locations for proposed activities, as well as a consolidated Environment That May Be Affected (EMBA) for all proposed activities. The 'EMBA' represents the greatest spatial extent that could be affected by unplanned 'worst case' spill scenarios, noting that in the unlikely event of a spill not all environmental, social, economic and cultural aspects would be affected.

We have used these consolidated EMBAs to identify persons or organisations who may have functions, interests or activities that may be affected ('relevant persons') for all activities.

We have also developed consultation information sheets for each activity, which can be found on our web site to provide further details for you to understand if your functions, interests or activities may be affected. A QR Code linking to this site is also provided for convenience.

Additional resources

More information about how community members can participate in environmental approvals for activities proposed in Commonwealth waters has been published by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). This brochure sets out titleholders' responsibilities for consultation, as well as opportunities for relevant persons to provide guidance for consultation expectations.

Next steps

Please let us know whether:

- You need additional information to understand if you may be affected.
- You consider you may be relevant and would like to discuss consultation methods.
- You would like to provide feedback now on any of the above proposed activities.

If you have previously been consulted on Santos activities currently under assessment, you are welcome to provide additional feedback, which will be included in updates to respective EPs under assessment. If you have no further comment to make, then your previous feedback will be carried forward in the updated EP.

Importantly, we recognise that there may be some sensitivities about sharing culturally sensitive information so we will take your guidance on the best approach when undertaking consultation activities.

Please also us know if you would like any sensitive information you provide to remain private. If requested, Santos will ensure your information remains confidential between us and the regulator and will not be published or otherwise made publicly available. Santos will handle your information in accordance with our Offshore Western Australia Consultation Privacy Policy, which can be found here.

We look forward to hearing from you soon.

[redacted]

[redacted]

As a service provider to

Santos Limited, Level 7, 100 St Georges Tce
Perth WA 6000
[redacted]

https://www.santos.com/

Santos

WA-20-L Environment Plan

Information for Relevant Persons

Activity Overview

Santos is preparing for the final phase of decommissioning in production licence WA-20-L in Commonwealth waters, approximately 101 km north of Dampier, Western Australia (see **Figure 1**).

A number of decommissioning activities were undertaken in 2011 under approvals granted by the Regulator at that time, the Western Australian Department of Mines and Petroleum.

Santos now proposes to leave in situ the Legendre-1 wellhead. WA-20-L also contains small gas bubble seepages at three locations. No further decommissioning activities are planned.

Consultation & Feedback

All petroleum activities in Commonwealth waters must have an Environment Plan (EP) accepted by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) before any activities can take place.

Under Commonwealth Environmental Regulations, Santos is required to consult with relevant persons about proposed activities when preparing an EP. A relevant person includes authorities, persons or organisations whose functions, interests or activities may be affected by the proposed activity.

You might be a relevant person if, for example, you have spiritual or cultural connections to land and sea country in accordance with Indigenous tradition that might be affected by our activity, if you otherwise carry out recreational or commercial fishing, tourism or other activities that might be affected by our proposed activity, or if you are part of a local community that might be affected by our proposed activity.

If you consider you may be a relevant person, please contact us by **26 June 2022** to allow Santos time to initiate consultation with you, so you can tell us how you would like to be consulted throughout this process or if you need additional information.

Details on how to contact us are included in the **Providing Feedback** section of this information sheet.

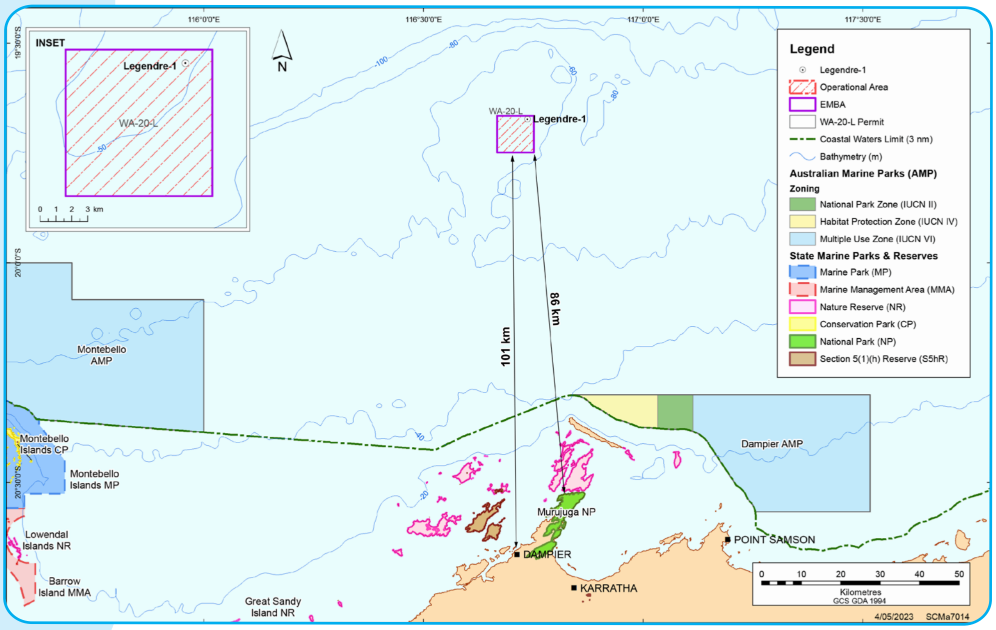


Figure 1. WA-20-L activity location

Activity Description

ACTIVITY DETAILS	
Location	The Operational Area is approximately 101 km north of Dampier.
Water depth	Approximately 49 m to approximately 54 m across.
Description of the Legendre-1 wellhead	The Legendre-1 wellhead is made predominantly of iron (98%) and sits approximately 3.6 m above the seabed.
Planned on-water decommissioning activities	Nil
Description of natural environment	The seabed in permit area WA-20-L is generally flat and featureless.
Petroleum production licence	WA-20-L

ACTIVITY COORDINATES

Aspect	Latitude (GDA94)	Longitude (GDA94)	Water depth
WA-20-L extent	19.74867	116.75131	49-53 m
	-19.74867	116.66798	
	-19.66534	116.66798	
	-19.66534	116.7513	
Legendre-1 wellhead	-19.67300	116.73622	50 m
Gas bubble release site (Legendre Hub)	-19.68724	116.72624	52 m
Gas bubble release site (Legendre South-1)	-19.72176	116.69792	54 m
Gas bubble release site (Legendre South-3)	-19.70394	116.70870	54 m

Figure 2. Legendre-1 wellhead.

About decommissioning activities (source NOPSEMA)

Decommissioning is a normal and inevitable stage in the lifetime of an offshore petroleum project that is planned and matured throughout the life of operations.

Decommissioning involves the timely, safe and environmentally responsible removal of, or otherwise satisfactorily dealing with, infrastructure from the offshore area that was previously used to support oil and gas operations.

Key aspects for consideration in planning decommissioning activities are:

+ **Navigation** – ensuring that property does not cause an unacceptable impact and risk to other marine users.
+ **Contamination** – consideration of any pollution or contamination resulting from the deterioration of property.
+ **Impact on marine environment** – consideration of impacts and risks from the activity to the marine environment.
+ **Stability** – consideration of movement of infrastructure.
+ **Technical Feasibility** – review of the technical feasibility of implementing the decommissioning activity.

The Australian Government base case for decommissioning is the complete removal of all infrastructure.

Options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and regulations, including well integrity and safety related matters, and other applicable laws.

More information about decommissioning can be found **here**.

Activity Purpose and Approvals

The Legendre reservoir was discovered in 1968 with the drilling of the Legendre-1 exploration well. The discovery was followed by appraisal drilling activities, with production commencing in 2001.

Oil from the Legendre reservoir was produced from 2001 to 2011, with operations comprising 20 production wells drilled from a central location and connected to a mobile offshore production unit (MOPU).

Production ceased in 2011, following which facilities were decommissioned in accordance with the Legendre Field Decommissioning Environment Plan (EP) approved by the regulator at that time, the WA Department of Mines and Petroleum.

All production wells were plugged and abandoned in 2011. The subsea infrastructure associated with the oil production was removed between 2011 and 2012, with the approved EP allowing for the following equipment to remain on the seabed:

+ Anti-scour mats repositioned to cover the former production conductors.
+ Six concrete caps placed over pad-eyes and shackles of the remnant anchor piles associated with the former facility mooring system.

Exploration and appraisal wells were drilled at a further eight locations within the permit. All appraisal and exploration wells have been confirmed as being plugged and abandoned in accordance with requirements of the designated authority at the time.

In total, 30 wells were drilled within WA-20-L, the first being the Legendre-1 exploration well, a vertical exploration well drilled, plugged, and abandoned in 1968, with records indicating that the wellhead was left in place.

Santos is proposing to leave the wellhead in situ given the age of the structure and the considerable technical risks and challenges in executing its removal wellhead.

A post-decommissioning site survey in 2013 confirmed the presence of gas bubbles seeping from under the anti-scour mats, which was reported to NOPSEMA. Santos undertook site surveys in 2019, 2021 and 2022, with the last survey identifying gas seepages at three separate locations in proximity to the surface locations of plugged and abandoned wells.

Small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, were observed at each location in highly localised continuous or intermittent streams.

Santos has assessed that the gas bubble seepage is not a risk to human safety, given the small gas volumes and low rates observed and considers the risk to the marine environment and impacts to fish, including commercial species, is very low to negligible.

Defining the Environment Area for Proposed Activities

Santos has undertaken an assessment to define the environmental, social, economic and cultural aspects that may be affected by proposed activities.

To do this we have considered the totality of the areas where activity impacts and risks may occur.

We call the widest extent of these areas the Environment that May Be Affected (EMBA). Typically, the outer boundary of the EMBA is defined by computer-based modelling for a worst-case hydrocarbon spill. As the Legendre-1 well has been plugged and abandoned and no on-water decommissioning activities are planned, there is no credible oil spill risk.

As such, Santos has nominally chosen for planning purposes the spatial extent of WA-20-L as being the EMBA, acknowledging the ongoing presence of the wellhead and the gas bubble (see **Figure 1**).

Environmental, Social, Economic and Cultural Features

We have undertaken a review of publicly available information to identify environmental, social, economic and cultural features that may be affected by activity impacts and risks, which are summarised in **Table 1**. These aspects will be risk-assessed within the EP on a case-by-case basis.

TABLE 1
ENVIRONMENTAL, SOCIAL, ECONOMIC AND CULTURAL FEATURES

	REGIONAL FEATURE	EMBA	INITIAL ASSESSMENT
Aboriginal Heritage	Registered Aboriginal heritage sites protected under the: + *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* + *WA Aboriginal Heritage Act 2021*	No	A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System was undertaken and indicated there are no registered cultural heritage sites within WA-20-L.
Cultural Heritage	Registered cultural sites under the: + *Underwater Cultural Heritage Act 2018*	No	A search of the Department of Agriculture, Water and the Environment Australasian Underwater Cultural Heritage Database was undertaken and indicated there are no registered shipwrecks within WA-20-L.
Defence	Designated defence activity areas	No	There are no Defence restricted areas within WA-20-L.
Fishing	Commercial fishing	Yes	A number of Commonwealth, and State fisheries overlap WA-20-L, of which four State fisheries are active.
	Indigenous, subsistence or customary fishing	No	Traditional Australian Indigenous fishing activities are generally concentrated within 3 nm of the Northern Territory / Western Australian coastline.
	Recreational and charter boat fishing	No	No interaction with recreational or charter boat fishers is anticipated given the remoteness of the Operational Area.
Oil and Gas Operations	Petroleum operations	No	Santos is Operator of WA-20-L.
Protected Areas (nearest Commonwealth and State marine parks)	Montebello Islands Marine Park	No	The Montebello Islands Marine Park is approximately 139 km to the wellhead, and 131 km to the area of gas release.
	Dampier Marine Park	No	The Dampier Marine Park is approximately 70 km to the wellhead, and 65 km to the area of gas release.
Shipping	Shipping fairway	No	No designated shipping fairways are within WA-20-L.
Telecommunications	Subsea telecommunications cables	No	No telecommunications cables are within WA-20-L.
Tourism	Tourism operations	No	No recreation or tourism is expected to occur within WA-20-L owing to the water depth and distance offshore.

Activity Impacts and Risk Management

We have summarised in **Table 2** the potential environmental impacts and associated management measures for the proposed activity. These aspects will be risk-assessed with the Environment Plan on a case-by-case basis.

TABLE 2
ACTIVITY IMPACT AND RISK MANAGEMENT

POTENTIAL ACTIVITY IMPACTS

Physical presence of wellhead

Description of potential impacts

The risk of the physical presence of the Legendre-1 wellhead to other users is considered low given that the wellhead's location is documented on nautical charts.

Santos engaged a subject matter expert, the Australian Maritime College (AMC), to undertake an assessment of the potential impacts of the wellhead on commercial trawl fisheries. In summary, the review found that there would be sufficient time and room for trawl fishers to manoeuvre to avoid the obstacle.

The AMC also confirmed that release measures could be undertaken at relatively low risk to vessel safety in the event of a hook up, though vessel risk would be increased if the hook up occurred in rough seas.

Compliance with the following key management measures

+ The wellhead is charted on Australian Hydrographic Service nautical charts so that marine users are aware of its location.

Marine users are not excluded from the area.

+ Santos will continue to engage with stakeholders in relation to its activities in the area.

Physical presence of wellhead - environmental consequences

Description of potential impacts

Indirect impacts may be limited to within 20 m of the structure. The value of the wellhead as artificial benthic habitat would continue until the wellhead has completely degraded.

Santos has assessed degradation of the wellhead for the EP. In summary, iron, the main constituent (~98%) of the wellhead and casing material, is not considered a significant contaminant in the marine environment and is only toxic to marine organisms at extremely high concentrations. Given the slow breakdown process of the products, toxic levels are not expected to occur any time in the future.

Compliance with the following key management measures

+ No control measures are considered necessary.

Gas release - environmental consequences

Description of potential impacts

Santos engaged CSIRO to undertake an extensive review of the potential environmental impacts and consequences to the marine environment from the gas bubble release and in the context of other known seeps in Australian marine waters. This review underpins the assessment of impacts and risks in the EP. Methane, the main constituent of the gas, is not toxic to marine life and will not accumulate in the tissues of fish that reside or traverse in close proximity to the gas bubbles.

Santos considers the risk to the marine environment and impacts to fish, including commercial species, is very low as:

+ Most gas will be released to air at sea surface.
+ Gas is only detectable within meters of the source in the water column.
+ Gas is rapidly dispersed by tides and currents.
+ Methane is non-toxic to marine biota.
+ Only benthic communities within meters will be exposed to the gas bubbles.

Compliance with the following key management measures

+ Santos engaged CSIRO to undertake a surveillance and monitoring plan to further quantify the occurrence, magnitude and temporal changes to the gas bubble seepage.
+ Monitoring data will provide input into the Adaptive Management Plan, detailed in the EP.

Consultation

Consultation provides Santos with an opportunity to receive feedback from authorities, persons and organisations whose functions, interests or activities may be affected by proposed petroleum activities.

This feedback helps us to refine or change the management measures we are planning to address potential activity impacts and risks. Santos' objective for proposed activities is to reduce environmental impacts and risks to a level that is as low as reasonably practicable (ALARP) and acceptable over the life of the activity.

Consultation also helps us to identify values and sensitivities where information is not publicly available, such as spiritual and cultural connection to land and sea country, as well as first-hand feedback on commercial and recreational fishing, tourism and local community activities and interests.

Providing feedback

If you consider you may be a relevant person, please contact us by **26 June 2023** to allow Santos time to initiate consultation with you in relation to the proposed activity and so you can tell us how you would like to be consulted throughout this process or if you need additional information.

Feedback provided by relevant persons will be considered in an update to the **WA-20-L Environment Plan** currently under assessment by NOPSEMA and through the life of the activity. Feedback from relevant persons will be included in the updated EP that is submitted to NOPSEMA for assessment.

Please let us know if you would like your personal/organisational details or any part of your feedback to remain private and we will ensure this remains confidential to NOPSEMA.

Santos

E: offshore.consultation@santos.com

T: 1800 267 600

www.santos.com/offshoreconsultation

From:	[redacted]
To:	
Cc:	
Subject:	FOR CONSULTATION | Proposed Carnarvon Basin Activities
Date:	Monday, 26 June 2023 9:22:32 PM
Attachments:	image002.png

Dear [redacted]

Santos is contacting you as again as preliminary consultation for proposed activities in the Carnarvon Basin has closed.

We are now asking for relevant persons to provide any feedback on the proposed activities outlined in the table below by **26 July 2023**.

More information on each proposed activity can be found via links provided below to activity fact sheets, which are published on our web site.

Environment Plan	Activity summary	EP status
Drilling + Plug and Abandonment Activities		
Spar-Halyard	Drilling of a development well (infill) to support ongoing production at the Varanus Island (VI) Hub. The well is approximately 114 km north of Onslow. Activity commencement is planned from Q1 2024.	New activity for consultation
Simpson	Plug and abandonment activities of eight wells no longer required for production via the offshore Simpson facility. The wells are approximately 102 km west of Dampier. Activity commencement is planned from Q2 2024.	New activity for consultation
Gibson	Plug and abandonment activities of four wells no longer required for production via the offshore Gibson facility. The wells are approximately 113 km north east of Onslow. Activity is planned for Q2 2024.	New activity for consultation
Mutineer Exeter Fletcher Finucane (MEFF)	Plug and abandonment activities for 12 wells no longer required for production. The MEFF wells are approximately 147 km north of Dampier. Activity is planned for Q2 2024.	Under assessment by Regulator
Decommissioning Activities		
Harriet Joint Venture (HJV) Decommissioning	Decommissioning of the HJV field, comprising removal of all platforms and substructures, as well as pipelines associated with the Simpson facility. The HJV field is approximately 117 km west of Dampier and 117 km north east of Onslow. Activity commencement planned is from Q1 2024.	New activity for consultation
MEFF Decommissioning	Decommissioning of the MEFF field, comprising partial removal of subsea infrastructure. The MEFF field is approximately 147 km north of Dampier. Activity commencement is anticipated from	Under assessment by Regulator

	Q3 2024.	
[Campbell Decommissioning](#)	Removal of the platform and substructures of the Campbell facility, which is approximately 105 km west of Dampier. Activity commencement is planned from Q1 2024.	New activity for consultation
[WA-20-L](#)	Leave in-situ one plugged and abandoned wellhead, approximately 101 km north of Dampier. The WA-20-L petroleum permit is subject to an ongoing environmental monitoring for the duration of the EP to monitor for gas release.	Under assessment by Regulator
[WA-1-P](#)	Leave in situ three plugged and abandoned wellheads. Activity is ongoing following environment plan acceptance. The nearest well is approximately 85 km north-northwest of Dampier.	New activity for consultation

Providing feedback

As part of consultation, we are asking for relevant persons to provide any feedback on proposed activities by **26 July 2023**.

If you have previously been consulted on Santos activities currently under assessment, you are welcome to provide additional feedback, which will be included in updates to respective EPs under assessment. If you have no further comment to make, then your previous feedback will be carried forward in the updated EP.

Please let us know if you would like any sensitive information you provide to remain private. If requested, Santos will ensure your information remains confidential between us and the regulator and will not be published or otherwise made publicly available. Santos will handle your information in accordance with our Offshore Western Australia Consultation Privacy Policy, which can be found here.

Activity notifications and emergency communications

Please let us know if you require notification prior to the start and upon activity completion.

We would also appreciate any preferred arrangements to support communications in the event of an emergency that may impact your functions, interests or activities.

Additional resources

More information about how community members can participate in environmental approvals for activities proposed in Commonwealth waters has been published in a brochure by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

Regards

[redacted]

[redacted]
Consultation Lead

As a service provider to

Santos

[redacted]

From: [redacted]
To:
Cc:
Subject: RE: FOR CONSULTATION | Proposed Carnarvon Basin Activities
Date: Wednesday, 19 July 2023 4:34:06 PM
Attachments: image001.png
image002.png

Dear [redacted]

Santos is sending you this reminder email as the feedback period for consultation on the activities outlined below closes on **Wednesday 26 July 2023**.

Consultation is required under Commonwealth and State Environmental Regulations and is a key part of preparing Environment Plans (EPs) for our proposed activities. Regulator-accepted EPs are required before any petroleum activity can commence.

Providing feedback

Please provide feedback at the earliest opportunity so we can assess your feedback and respond in a timely manner.

A summary of your feedback and our response will be included in the relevant Environment Plan, which will be submitted to the Regulator for assessment.

Please let us know if you would like any sensitive information you provide to remain private. If requested, Santos will ensure your information remains confidential between us and the Regulator and will not be published or otherwise made publicly available. Santos will handle your information in accordance with our Offshore Western Australia Consultation Privacy Policy, which can be found here.

You can provide feedback via return email or call us toll free on **1800 267 600**.

As previously advised, if you have already been consulted on Santos' activities currently under assessment, you are welcome to provide additional feedback, which will be included in updates to respective EPs under assessment. If you have no further comment to make, then your previous feedback will be carried forward in the updated EP.

Activity notifications and emergency communications

Please let us know if you require notification prior to the start and upon activity completion.

If you would like to be notified in the instance of an emergency situation that may impact your functions, interested or activities, please let us know.

Please visit our website if you would like to know more about our proposed activities.

Regards

Santos Consultation Team

Santos

t: +61 1800 267 600 | e: offshore.consultation@santos.com
Santos.com | Follow us on LinkedIn, Facebook and Twitter

Santos acknowledges the Traditional Owners and Custodians of the lands on which we operate. We pay our respects to their Elders past, present and emerging.

From: [redacted]
Sent: Thursday, June 29, 2023 8:32 PM
To: [redacted]
Cc: [redacted]
Subject: FOR CONSULTATION | Proposed Carnarvon Basin Activities

Dear [redacted]

Santos is contacting you as we are asking for relevant persons to provide any feedback on the proposed activities outlined in the table below.

More information on each proposed activity, some of which are under regulator assessment, can be found via links provided below to activity fact sheets, which are published on our web site.

Environment Plan	Activity summary	EP status
Drilling + Plug and Abandonment Activities		
Spar-Halyard	Drilling of a development well (infill) to support ongoing production at the Varanus Island (VI) Hub. The well is approximately 114 km north of Onslow. Activity commencement is planned from Q1 2024.	New activity for consultation
Simpson	Plug and abandonment activities of eight wells no longer required for production via the offshore Simpson facility. The wells are approximately 102 km west of Dampier. Activity commencement is planned from Q2 2024.	New activity for consultation
Gibson	Plug and abandonment activities of four wells no longer required for production via the offshore Gibson facility. The wells are approximately 113 km north east of Onslow. Activity is planned for Q2 2024.	New activity for consultation
Mutineer Exeter Fletcher Finucane (MEFF)	Plug and abandonment activities for 12 wells no longer required for production. The MEFF wells are approximately 147 km north of Dampier. Activity is planned for Q2	Under assessment by Regulator

	2024.	
Decommissioning Activities		
Harriet Joint Venture (HJV) Decommissioning	Decommissioning of the HJV field, comprising removal of all platforms and substructures, as well as pipelines associated with the Simpson facility. The HJV field is approximately 117 km west of Dampier and 117 km north east of Onslow. Activity commencement planned is from Q1 2024.	New activity for consultation
MEFF Decommissioning	Decommissioning of the MEFF field, comprising partial removal of subsea infrastructure. The MEFF field is approximately 147 km north of Dampier. Activity commencement is anticipated from Q3 2024.	Under assessment by Regulator
Campbell Decommissioning	Removal of the platform and substructures of the Campbell facility, which is approximately 105 km west of Dampier. Activity commencement is planned from Q1 2024.	New activity for consultation
WA-20-L	Leave in-situ one plugged and abandoned wellhead, approximately 101 km north of Dampier. The WA-20-L petroleum permit is subject to an ongoing environmental monitoring for the duration of the EP to monitor for	Under assessment by Regulator

	gas release.	
WA-1-P	Leave in situ three plugged and abandoned wellheads. Activity is ongoing following environment plan acceptance. The nearest well is approximately 85 km north-northwest of Dampier.	New activity for consultation

Providing feedback

As part of consultation, we are asking for relevant persons to provide any feedback on proposed activities by **26 July 2023**.

If you have previously been consulted on Santos' activities currently under assessment, you are welcome to provide additional feedback, which will be included in updates to respective EPs under assessment. If you have no further comment to make, then your previous feedback will be carried forward in the updated EP.

Please let us know if you would like any sensitive information you provide to remain private. If requested, Santos will ensure your information remains confidential between us and the regulator and will not be published or otherwise made publicly available. Santos will handle your information in accordance with our Offshore Western Australia Consultation Privacy Policy, which can be found here.

Activity notifications and emergency communications

Please let us know if you require notification prior to the start and upon activity completion.

We look forward to hearing from you.

Regards

Santos Consultation Team

Santos

t: +61 1800 267 600 | e: offshore.consultation@santos.com
Santos.com | Follow us on LinkedIn, Facebook and Twitter

Santos acknowledges the Traditional Owners and Custodians of the lands on which we operate. We pay our respects to their Elders past, present and emerging.

Santos

WA-20-L Environment Plan

Information for Relevant Persons

Activity Overview

Santos is preparing for the final phase of decommissioning in production licence WA-20-L in Commonwealth waters, approximately 101 km north of Dampier, Western Australia (see **Figure 1**).

A number of decommissioning activities were undertaken in 2011 under approvals granted by the Regulator at that time, the Western Australian Department of Mines and Petroleum.

Santos now proposes to leave in situ the Legendre-1 wellhead. WA-20-L also contains small gas bubble seepages at three locations. No further decommissioning activities are planned.

Consultation & Feedback

All petroleum activities in Commonwealth waters must have an Environment Plan (EP) accepted by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) before any activities can take place.

Under Commonwealth Environmental Regulations, Santos is required to consult with relevant persons about proposed activities when preparing an EP. A relevant person includes authorities, persons or organisations whose functions, interests or activities may be affected by the proposed activity.

You might be a relevant person if, for example, you have spiritual or cultural connections to land and sea country in accordance with Indigenous tradition that might be affected by our activity, if you otherwise carry out recreational or commercial fishing, tourism or other activities that might be affected by our proposed activity, or if you are part of a local community that might be affected by our proposed activity.

Santos is now consulting with relevant persons for activities proposed to be managed under the WA-20-L Environment Plan. If you consider you may be a relevant person, please contact us as soon as possible if you require any further information or if you think you are not on our consultation list.

We are asking for relevant persons to provide feedback by **26 July 2023**.

Details on how to contact us are included in the **Providing Feedback** section of this information sheet.

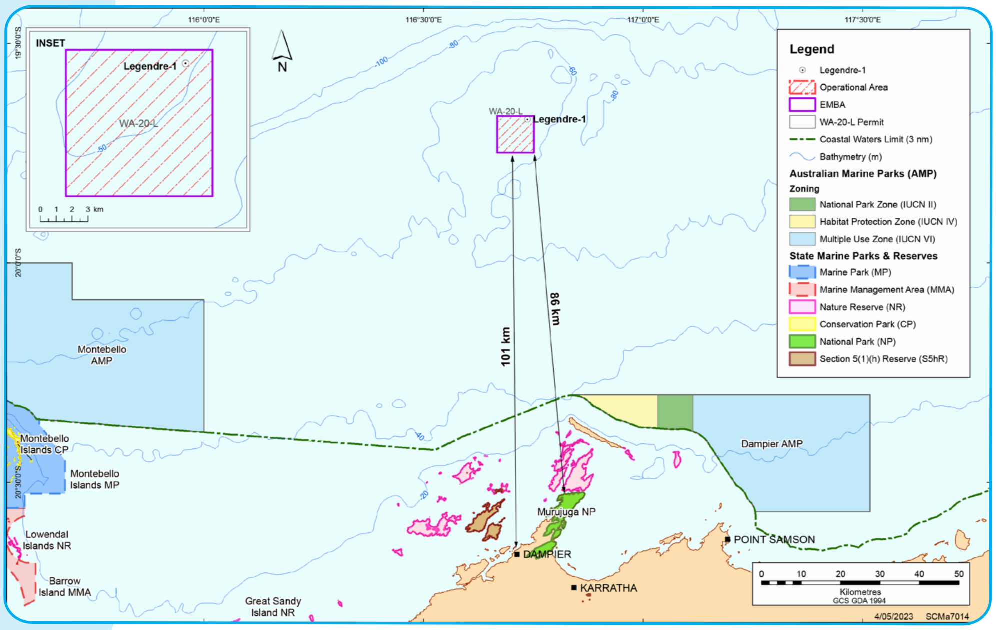


***Figure 1.** WA-20-L activity location*

Activity Description

ACTIVITY DETAILS	
Location	The Operational Area is approximately 101 km north of Dampier.
Water depth	Approximately 49 m to approximately 54 m across.
Description of the Legendre-1 wellhead	The Legendre-1 wellhead is made predominantly of iron (98%) and sits approximately 3.6 m above the seabed.
Planned on-water decommissioning activities	Nil
Description of natural environment	The seabed in permit area WA-20-L is generally flat and featureless.
Petroleum production licence	WA-20-L

ACTIVITY COORDINATES

Aspect	Latitude (GDA94)	Longitude (GDA94)	Water depth
WA-20-L extent	19.74867	116.75131	49-53 m
	-19.74867	116.66798	
	-19.66534	116.66798	
	-19.66534	116.7513	
Legendre-1 wellhead	-19.67300	116.73622	50 m
Gas bubble release site (Legendre Hub)	-19.68724	116.72624	52 m
Gas bubble release site (Legendre South-1)	-19.72176	116.69792	54 m
Gas bubble release site (Legendre South-3)	-19.70394	116.70870	54 m

Figure 2. Legendre-1 wellhead.

About decommissioning activities (source NOPSEMA)

Decommissioning is a normal and inevitable stage in the lifetime of an offshore petroleum project that is planned and matured throughout the life of operations.

Decommissioning involves the timely, safe and environmentally responsible removal of, or otherwise satisfactorily dealing with, infrastructure from the offshore area that was previously used to support oil and gas operations.

Key aspects for consideration in planning decommissioning activities are:

+ **Navigation** – ensuring that property does not cause an unacceptable impact and risk to other marine users.
+ **Contamination** – consideration of any pollution or contamination resulting from the deterioration of property.
+ **Impact on marine environment** – consideration of impacts and risks from the activity to the marine environment.
+ **Stability** – consideration of movement of infrastructure.
+ **Technical Feasibility** – review of the technical feasibility of implementing the decommissioning activity.

The Australian Government base case for decommissioning is the complete removal of all infrastructure.

Options other than complete removal may be considered, however the titleholder must demonstrate that the alternative decommissioning approach delivers equal or better environmental outcomes compared to complete removal and meets all applicable requirements under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and regulations, including well integrity and safety related matters, and other applicable laws.

More information about decommissioning can be found **here**.

Activity Purpose and Approvals

The Legendre reservoir was discovered in 1968 with the drilling of the Legendre-1 exploration well. The discovery was followed by appraisal drilling activities, with production commencing in 2001.

Oil from the Legendre reservoir was produced from 2001 to 2011, with operations comprising 20 production wells drilled from a central location and connected to a mobile offshore production unit (MOPU).

Production ceased in 2011, following which facilities were decommissioned in accordance with the Legendre Field Decommissioning Environment Plan (EP) approved by the regulator at that time, the WA Department of Mines and Petroleum.

All production wells were plugged and abandoned in 2011. The subsea infrastructure associated with the oil production was removed between 2011 and 2012, with the approved EP allowing for the following equipment to remain on the seabed:

+ Anti-scour mats repositioned to cover the former production conductors.
+ Six concrete caps placed over pad-eyes and shackles of the remnant anchor piles associated with the former facility mooring system.

Exploration and appraisal wells were drilled at a further eight locations within the permit. All appraisal and exploration wells have been confirmed as being plugged and abandoned in accordance with requirements of the designated authority at the time.

In total, 30 wells were drilled within WA-20-L, the first being the Legendre-1 exploration well, a vertical exploration well drilled, plugged, and abandoned in 1968, with records indicating that the wellhead was left in place.

Santos is proposing to leave the wellhead in situ given the age of the structure and the considerable technical risks and challenges in executing its removal wellhead.

A post-decommissioning site survey in 2013 confirmed the presence of gas bubbles seeping from under the anti-scour mats, which was reported to NOPSEMA. Santos undertook site surveys in 2019, 2021 and 2022, with the last survey identifying gas seepages at three separate locations in proximity to the surface locations of plugged and abandoned wells.

Small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, were observed at each location in highly localised continuous or intermittent streams.

Santos has assessed that the gas bubble seepage is not a risk to human safety, given the small gas volumes and low rates observed and considers the risk to the marine environment and impacts to fish, including commercial species, is very low to negligible.

Defining the Environment Area for Proposed Activities

Santos has undertaken an assessment to define the environmental, social, economic and cultural aspects that may be affected by proposed activities.

To do this we have considered the totality of the areas where activity impacts and risks may occur.

We call the widest extent of these areas the Environment that May Be Affected (EMBA). Typically, the outer boundary of the EMBA is defined by computer-based modelling for a worst-case hydrocarbon spill. As the Legendre-1 well has been plugged and abandoned and no on-water decommissioning activities are planned, there is no credible oil spill risk.

As such, Santos has nominally chosen for planning purposes the spatial extent of WA-20-L as being the EMBA, acknowledging the ongoing presence of the wellhead and the gas bubble (see **Figure 1**).

Environmental, Social, Economic and Cultural Features

We have undertaken a review of publicly available information to identify environmental, social, economic and cultural features that may be affected by activity impacts and risks, which are summarised in **Table 1**. These aspects will be risk-assessed within the EP on a case-by-case basis.

TABLE 1
ENVIRONMENTAL, SOCIAL, ECONOMIC AND CULTURAL FEATURES

	REGIONAL FEATURE	EMBA	INITIAL ASSESSMENT
Aboriginal Heritage	Registered Aboriginal heritage sites protected under the: + *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* + *WA Aboriginal Heritage Act 2021*	No	A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System was undertaken and indicated there are no registered cultural heritage sites within WA-20-L.
Cultural Heritage	Registered cultural sites under the: + *Underwater Cultural Heritage Act 2018*	No	A search of the Department of Agriculture, Water and the Environment Australasian Underwater Cultural Heritage Database was undertaken and indicated there are no registered shipwrecks within WA-20-L.
Defence	Designated defence activity areas	No	There are no Defence restricted areas within WA-20-L.
Fishing	Commercial fishing	Yes	A number of Commonwealth, and State fisheries overlap WA-20-L, of which four State fisheries are active.
	Indigenous, subsistence or customary fishing	No	Traditional Australian Indigenous fishing activities are generally concentrated within 3 nm of the Northern Territory / Western Australian coastline.
	Recreational and charter boat fishing	No	No interaction with recreational or charter boat fishers is anticipated given the remoteness of the Operational Area.
Oil and Gas Operations	Petroleum operations	No	Santos is Operator of WA-20-L.
Protected Areas (nearest Commonwealth and State marine parks)	Montebello Islands Marine Park	No	The Montebello Islands Marine Park is approximately 139 km to the wellhead, and 131 km to the area of gas release.
	Dampier Marine Park	No	The Dampier Marine Park is approximately 70 km to the wellhead, and 65 km to the area of gas release.
Shipping	Shipping fairway	No	No designated shipping fairways are within WA-20-L.
Telecommunications	Subsea telecommunications cables	No	No telecommunications cables are within WA-20-L.
Tourism	Tourism operations	No	No recreation or tourism is expected to occur within WA-20-L owing to the water depth and distance offshore.

Activity Impacts and Risk Management

We have summarised in **Table 2** the potential environmental impacts and associated management measures for the proposed activity. These aspects will be risk-assessed with the Environment Plan on a case-by-case basis.

TABLE 2
ACTIVITY IMPACT AND RISK MANAGEMENT

POTENTIAL ACTIVITY IMPACTS

Physical presence of wellhead

Description of potential impacts

The risk of the physical presence of the Legendre-1 wellhead to other users is considered low given that the wellhead's location is documented on nautical charts.

Santos engaged a subject matter expert, the Australian Maritime College (AMC), to undertake an assessment of the potential impacts of the wellhead on commercial trawl fisheries. In summary, the review found that there would be sufficient time and room for trawl fishers to manoeuvre to avoid the obstacle.

The AMC also confirmed that release measures could be undertaken at relatively low risk to vessel safety in the event of a hook up, though vessel risk would be increased if the hook up occurred in rough seas.

Compliance with the following key management measures

+ The wellhead is charted on Australian Hydrographic Service nautical charts so that marine users are aware of its location.

Marine users are not excluded from the area.

+ Santos will continue to engage with stakeholders in relation to its activities in the area.

Physical presence of wellhead - environmental consequences

Description of potential impacts

Indirect impacts may be limited to within 20 m of the structure. The value of the wellhead as artificial benthic habitat would continue until the wellhead has completely degraded.

Santos has assessed degradation of the wellhead for the EP. In summary, iron, the main constituent (~98%) of the wellhead and casing material, is not considered a significant contaminant in the marine environment and is only toxic to marine organisms at extremely high concentrations. Given the slow breakdown process of the products, toxic levels are not expected to occur any time in the future.

Compliance with the following key management measures

+ No control measures are considered necessary.

Gas release - environmental consequences

Description of potential impacts

Santos engaged CSIRO to undertake an extensive review of the potential environmental impacts and consequences to the marine environment from the gas bubble release and in the context of other known seeps in Australian marine waters. This review underpins the assessment of impacts and risks in the EP. Methane, the main constituent of the gas, is not toxic to marine life and will not accumulate in the tissues of fish that reside or traverse in close proximity to the gas bubbles.

Santos considers the risk to the marine environment and impacts to fish, including commercial species, is very low as:

+ Most gas will be released to air at sea surface.
+ Gas is only detectable within meters of the source in the water column.
+ Gas is rapidly dispersed by tides and currents.
+ Methane is non-toxic to marine biota.
+ Only benthic communities within meters will be exposed to the gas bubbles.

Compliance with the following key management measures

+ Santos engaged CSIRO to undertake a surveillance and monitoring plan to further quantify the occurrence, magnitude and temporal changes to the gas bubble seepage.
+ Monitoring data will provide input into the Adaptive Management Plan, detailed in the EP.

Consultation

Consultation provides Santos with an opportunity to receive feedback from authorities, persons and organisations whose functions, interests or activities may be affected by proposed petroleum activities.

This feedback helps us to refine or change the management measures we are planning to address potential activity impacts and risks. Santos' objective for proposed activities is to reduce environmental impacts and risks to a level that is as low as reasonably practicable (ALARP) and acceptable over the life of the activity.

Consultation also helps us to identify values and sensitivities where information is not publicly available, such as spiritual and cultural connection to land and sea country, as well as first-hand feedback on commercial and recreational fishing, tourism and local community activities and interests.

Providing feedback

If you consider you may be a relevant person, please contact us as soon as possible if you require any further information or if you think you are not on our consultation list.

We are asking for relevant persons to provide feedback by **26 July 2023**.

Feedback provided by relevant persons will be considered in an update to the **WA-20-L Environment Plan** currently under assessment by NOPSEMA and through the life of the activity. Feedback from relevant persons will be included in the updated EP that is submitted to NOPSEMA for assessment.

Please let us know if you would like your personal/organisational details or any part of your feedback to remain private and we will ensure this remains confidential to NOPSEMA.

Santos

E: offshore.consultation@santos.com

T: 1800 267 600

www.santos.com/offshoreconsultation

SEEKING RELEVANT PERSONS

Santos

CARNARVON BASIN DECOMMISSIONING ENVIRONMENT PLANS

Santos is seeking to identify and consult with relevant persons whose functions, interests or activities may be affected by our proposed decommissioning activities off Western Australia's north west coast.

Santos is planning several offshore decommissioning activities offshore Western Australia:

- **Harriet Joint Venture (HJV):** Decommissioning of the HJV field, comprising removal of all platforms and substructures, as well as pipelines associated with the Simpson facility. The HJV field is approximately 102 km west of Dampier and 105 km north east of Onslow. Activity commencement planned is from Q1 2024.
- **Mutineer Exeter Fletcher Finucane (MEFF):** Decommissioning of the MEFF field, comprising partial removal of subsea infrastructure. The MEFF field is approximately 147 km north of Dampier. Activity commencement is anticipated from Q4 2024.
- **Campbell:** Removal of the platform and substructures of the Campbell facility, which is approximately 105 km west of Dampier. Activity commencement is planned from Q1 2024.
- **WA-20-L:** Leave in-situ one plugged and abandoned wellhead, approximately 101 km north of Dampier. The WA-20-L petroleum permit is subject to an ongoing environmental monitoring for the duration of the EP to monitor for gas release.
- **WA-1-P:** Leave in situ three plugged and abandoned wellheads. The nearest well is approximately 85 km north-northwest of Dampier. Activity is ongoing following environment plan acceptance.

The environment that may be affected (EMBA) by proposed activities

Santos is assessing impacts and risks to the environment that may be affected (EMBA) by each of these activities, including on ecosystems (including people and communities), natural and physical resources, the qualities and characteristics of locations, places and areas and the heritage value of places. This will include assessment of the social, economic and cultural features of the environment.

The map below depicts activity locations and a consolidated EMBA for all proposed activities. The 'EMBA' represents the greatest spatial extent that could be affected by unplanned 'worst case' spill scenarios, noting that in the unlikely event of a spill not all environmental, social, economic and cultural aspects would be affected.

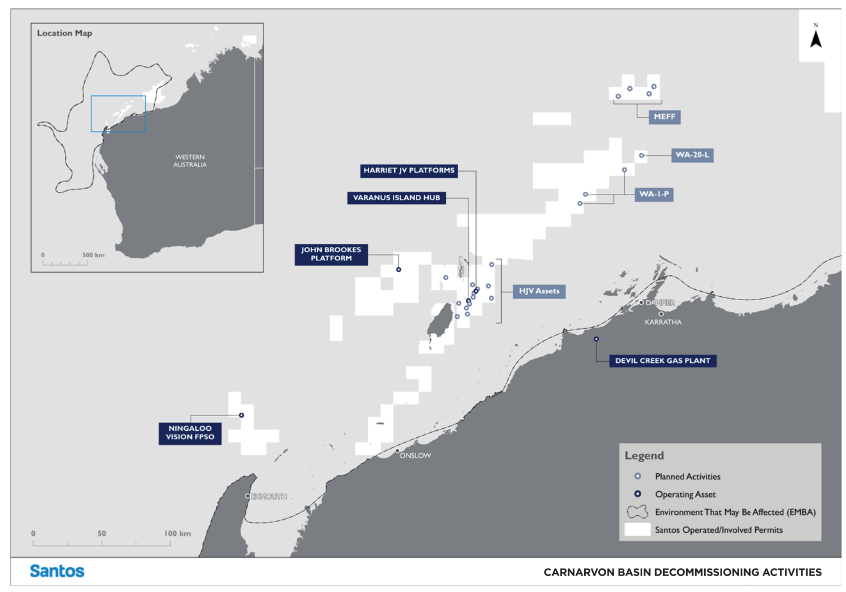
Santos is proposing to implement measures to reduce the impacts and risks of the activities. It is a requirement under relevant environmental legislation that these impacts and risks are reduced to as low as reasonably practicable and to an acceptable level.

Seeking Relevant Persons for Environment Plans

All petroleum activities must have an Environment Plan (EP) accepted by the respective Commonwealth, State or Territory Regulator before they can take place.

Santos is required to consult with relevant persons about those activities when preparing each EP.

A relevant person includes a person or an organisation whose functions, interests or activities may be affected by the proposed activity. Such functions, interests or activities may include those arising in relation to spiritual or cultural connections to land and sea country in accordance with Indigenous tradition; tourism; recreational and commercial fishing; other commercial or recreational activities and local communities that might be affected by our proposed activities (these are examples and not an exhaustive list).



Feedback from relevant persons is used to refine or change measures proposed to manage activity impacts and risks to a level that is as low as reasonably practicable and acceptable.

Consultation also helps us to identify environmental, social, economic and cultural values and sensitivities that may be affected, in addition to those identified by Santos based on our long-standing operating knowledge in these regions.

If you think your functions, interests or activities may be affected by any of these activities, you may be a relevant person with whom Santos must consult.

We welcome your feedback

We will use feedback from relevant persons to help us manage impacts and risks associated with these activities, ahead of submitting environment plans for each of our Carnarvon Basin activities activity to Commonwealth and State Regulators for assessment, depending on the location of activities. These Regulators are the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and the WA Department of Mines, Industry Regulation and Safety (DMIRS). Regulator acceptance of these environment plans is required before any petroleum activity can begin.

We have prepared consultation information sheets for each activity, which includes information about planned activities, identified environmental, social, economic and cultural aspects within each EMBA and how we propose to manage impacts and risks.

Contact us

If you consider you may be a relevant person, please contact us by **26 June 2023** to allow Santos to initiate consultation with you in relation to the proposed activity and so you can tell us how you would like to be consulted throughout this process.

Santos is committed to undertaking genuine and meaningful consultation. We want to provide information for people to make informed assessments of the possible consequences of the proposed activity on them.

Your feedback and input are important to us and input will be considered in the development of our environment plans for each activity.

Visit **www.santos.com/offshoreconsultation**, email **offshore.consultation@santos.com** or call **1800 267 600** for more information, to self-identify as relevant person or to provide feedback.

CARNARVON BASIN ENVIRONMENT PLAN CONSULTATION

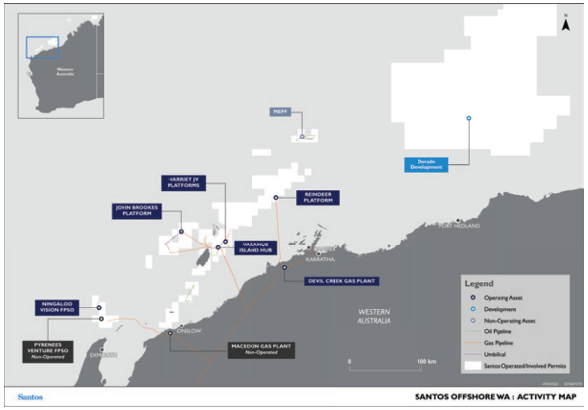
Santos

Santos is now consulting with relevant persons for Drilling, Plug and Abandonment and Decommissioning Environment Plans. Relevant persons are those whose functions, interests or activities may be affected by our proposed activities in the Carnarvon Basin off Western Australia's north west coast.

Proposed activities include:

+ **Spar-Halyard:** Drilling of a development well (infill) to support ongoing production at the Varanus Island (VI) Hub. The well is approximately 114 km north of Onslow. Activity commencement is planned from Q2 2024.
+ **Simpson:** Plug and abandonment activities of eight wells no longer required for production via the offshore Simpson facility. The wells are approximately 102 km west of Dampier. Activity commencement is planned from Q1 2024.
+ **Gibson:** Plug and abandonment activities of four wells no longer required for production via the offshore Gibson facility. The wells are approximately 113 km north east of Onslow. Activity is planned for Q1 2024.
+ **Mutineer Exeter Fletcher Finucane (MEFF):** Plug and abandonment activities for 12 wells no longer required for production. The MEFF wells are approximately 147 km north of Dampier. Activity is planned for first half of 2024.
+ **Harriet Joint Venture (HJV):** Decommissioning of the HJV field, comprising removal of all platforms and substructures, as well as pipelines associated with the Simpson facility. The HJV field is approximately 102 km west of Dampier and 105 km north east of Onslow. Activity commencement is planned from Q1 2024.
+ **MEFF:** Decommissioning of the MEFF field, comprising partial removal of subsea infrastructure. The MEFF field is approximately 147 km north of Dampier. Activity commencement is anticipated from Q4 2024.
+ **Campbell:** Removal of the platform and substructures of the Campbell facility, which is approximately 105 km west of Dampier. Activity commencement is planned from Q1 2024.
+ **WA-20-L:** Leave in-situ one plugged and abandoned wellhead, approximately 101 km north of Dampier. The WA-20-L petroleum permit is subject to an ongoing environmental monitoring for the duration of the environment plan to monitor for gas release.
+ **WA-1-P:** Leave in-situ three legacy plugged and abandoned wellheads. The nearest well is approximately 85 km north-north west of Dampier. Inspection activities will commence following environment plan acceptance.

The map below depicts activity locations for all proposed activities.



We welcome your feedback

We will use feedback from relevant persons to help us manage impacts and risks associated with these activities, ahead of submitting environment plans for each of our Carnarvon Basin activities activity to Commonwealth and State Regulators for assessment, depending on the location of activities.

For more information

More information, including information sheets for each activity, is available at **santos.com/offshoreconsultation**. These information sheets provide details on each proposed activity, the environment that may be affected, potential environmental impacts and risks, and proposed control measures to seek to reduce any impacts and risks to as low as reasonably practicable and an acceptable level.

If you consider you may be a relevant person, please contact us as soon as possible if you require any further information or if you think you are not on our consultation list.

We are asking for relevant persons to provide feedback by 26 July 2023.

CONTACT US

Visit:
santos.com/offshoreconsultation

Phone:
1800 267 600

Email:
offshore.consultation@santos.com

or scan the QR code

Santos

PRELIMINARY CONSULTATION – CARNARVON BASIN

Meeting with [redacted]

June 2023

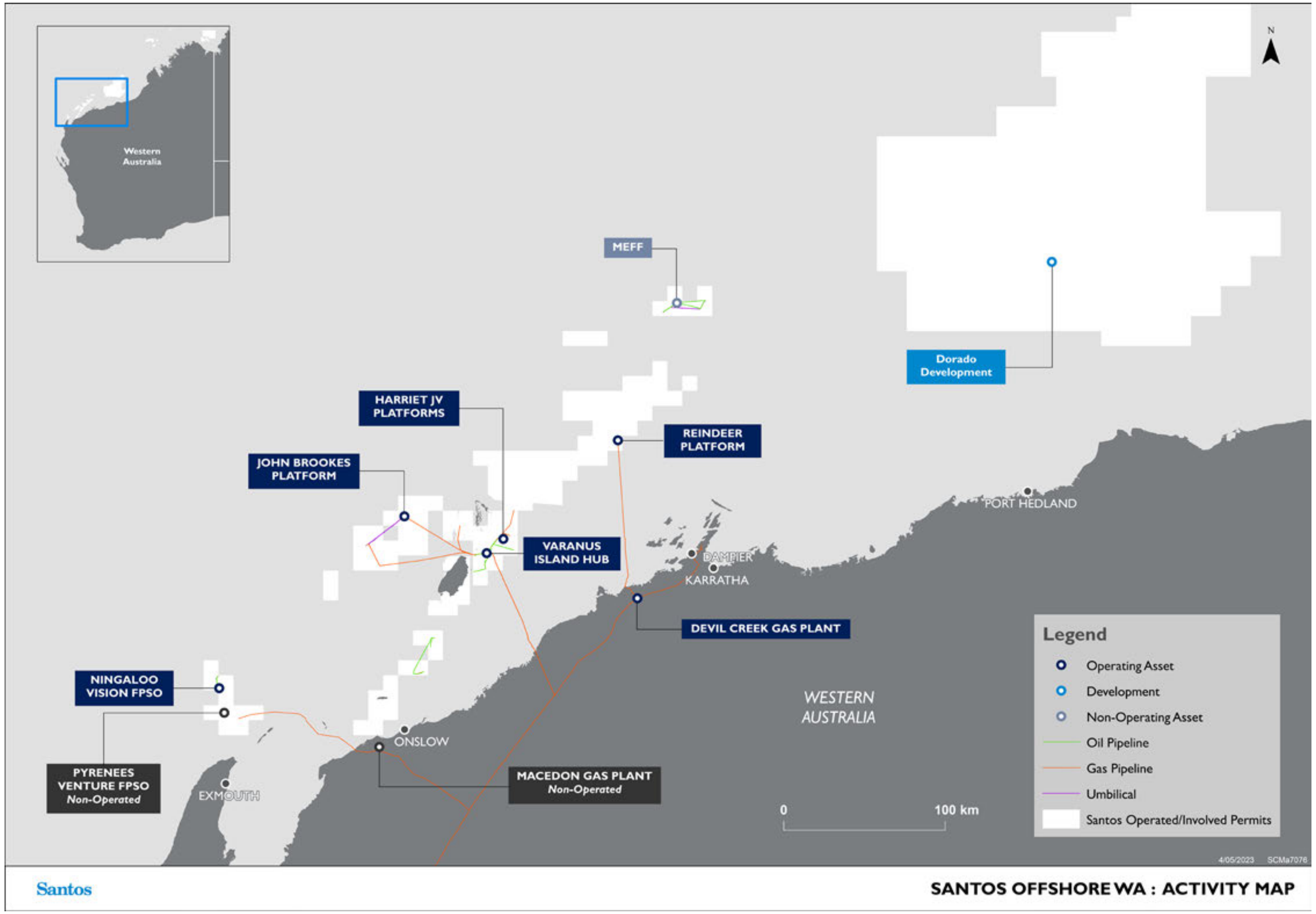
Agenda

- Meeting purpose
- Introductions
- About [redacted]
- About Santos
- Our consultation approach
- Proposed activities
- Consultation opportunities
- Questions and next steps

SECTION 1
ABOUT SANTOS

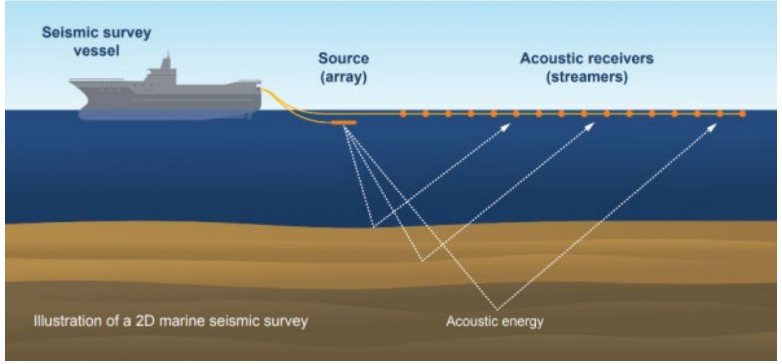
About Santos

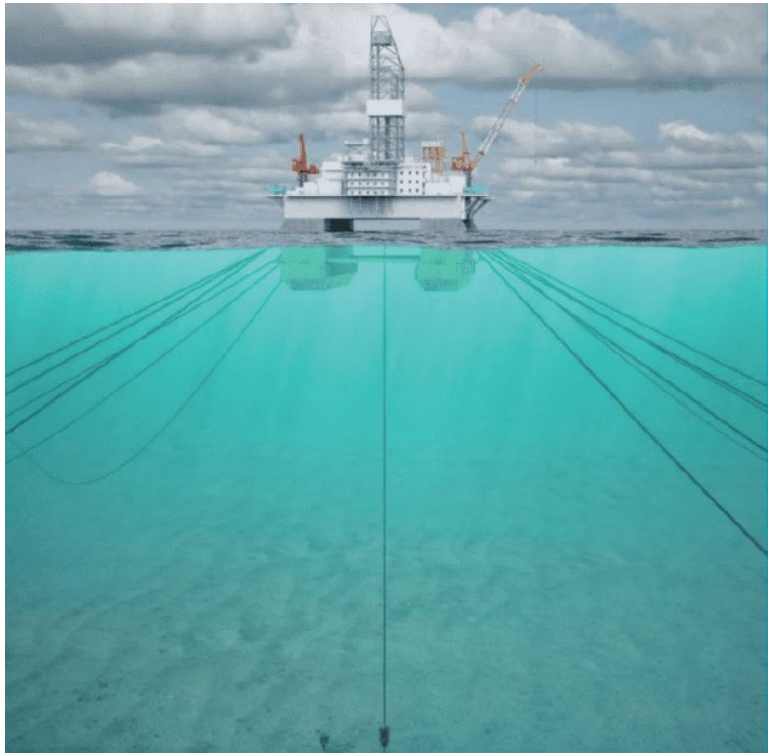
- Biggest producer of domestic gas in WA
- First offshore discovery, in the Carnarvon Basin, in the early 1980s
- WA products – gas, oil and condensate
- Interests in three of WA's major dedicated domestic gas plants
- Our business focus:
  - Safe, reliable operations
  - Minimise our social and environmental impacts
  - Near-field exploration opportunities
  - Progressive decommissioning of assets no longer required



About Oil and Gas Activities

Exploration → Appraisal → Development / Construction → Operations → Decommissioning



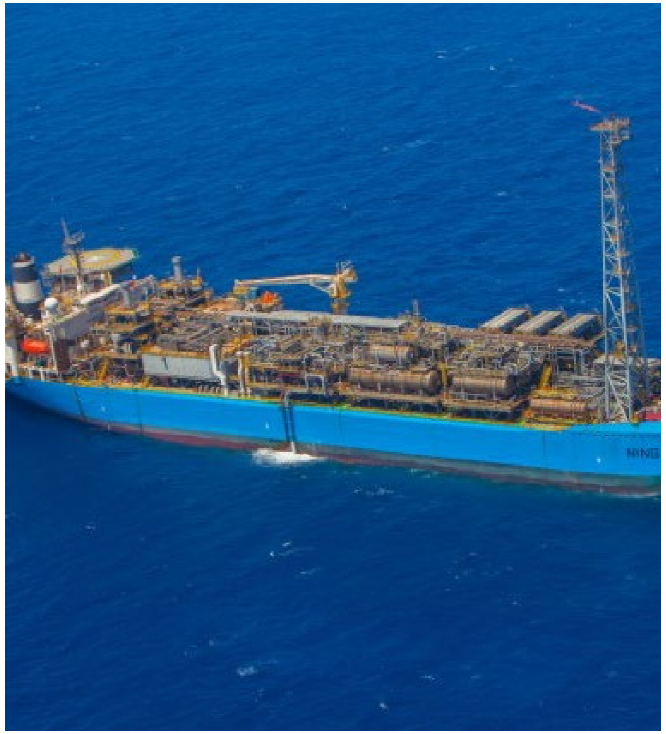


About Santos

Our WA operations

Devil Creek Gas Plant

Varanus Island Gas Plant

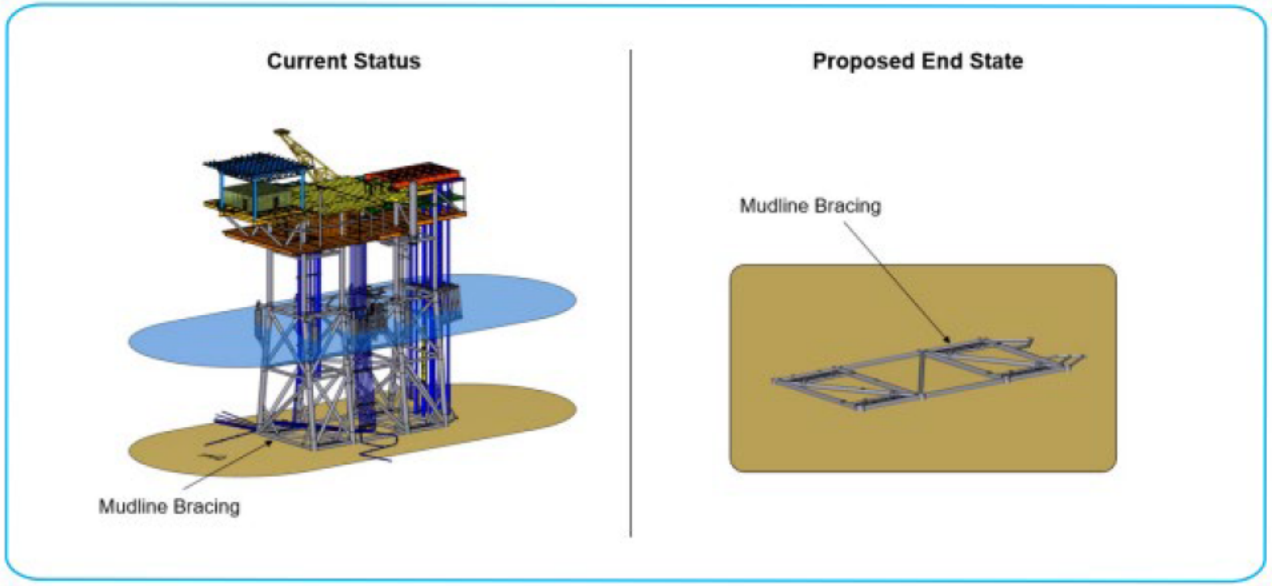


Ningaloo Vision FPSO

About Oil and Gas Activities

Legendre-1 wellhead

Campbell Platform



Harriet Bravo Platform

SECTION 2
OUR CONSULTATION APPROACH

Santos

Consultation – Regulatory Requirements

- **Commonwealth waters** – National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)
- **WA State waters** – Department of Mines, Industry Regulation and Safety (DMIRS)

"In the course of preparing an Environment Plan, a titleholder must consult with relevant persons in accordance with Division 2.2A, Regulation 11A…

"The purpose of consultation under regulation 11A of the Environment Regulations is to ensure that authorities, persons or organisations that are potentially affected by activities are consulted and their input considered in the development of environment plans."

Guideline - Consultation in the course of preparing an environment plan, NOPSEMA

NOPSEMA

"The implementation strategy must provide for appropriate consultation with relevant authorities and other relevant interested persons or organisations…

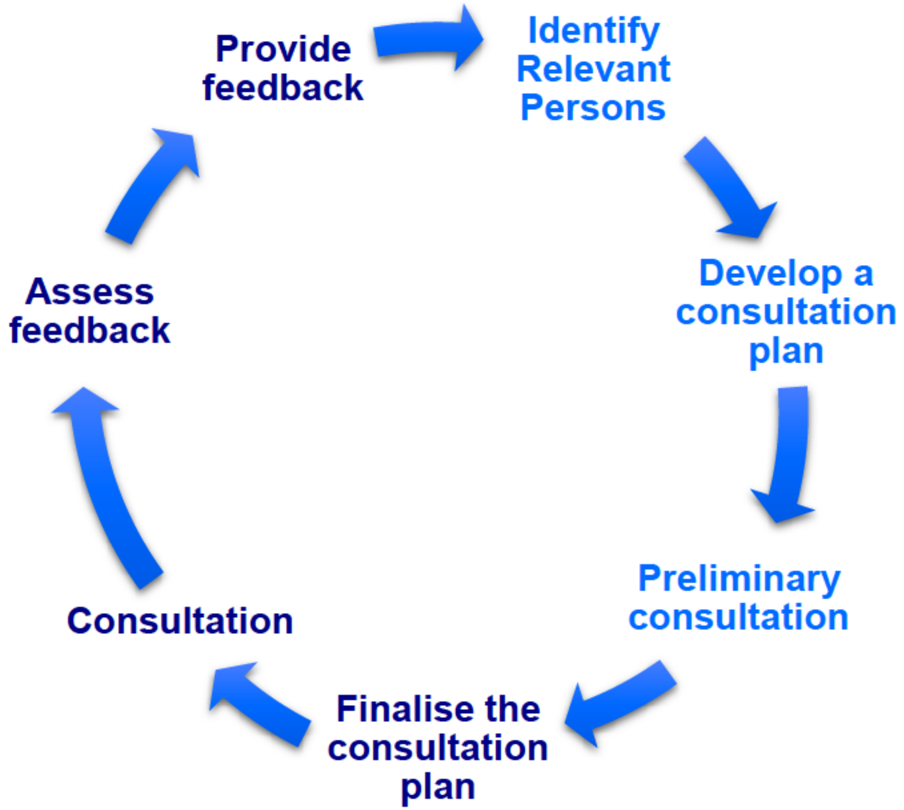
"The identification of potential stakeholders must take into consideration the activity type, location, environmental impacts and risks (planned activities and unplanned events) and relevant stakeholder interests or concerns."

Guideline for the Development of Petroleum, Geothermal and Pipeline Environment Plans in Western Australia, DMIRS

Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

Consultation – Santos Requirements

- Santos Management System
- Santos EP Consultation Methodology
  - Applied to Commonwealth and State jurisdictions
- Objective for all proposed activities is to **reduce environmental impacts and risks to a level that is ALARP and acceptable** over the life of the activity.
- Consultation feedback helps us to **refine or change proposed management measures** to address potential activity impacts and risks.
- Consultation also helps us to identify and understand environmental, social, economic and cultural features, values and sensitivities not available from publicly available sources.



Santos

Identifying Relevant Persons

We identify the functions, activities and interests of commercial fishers based on:

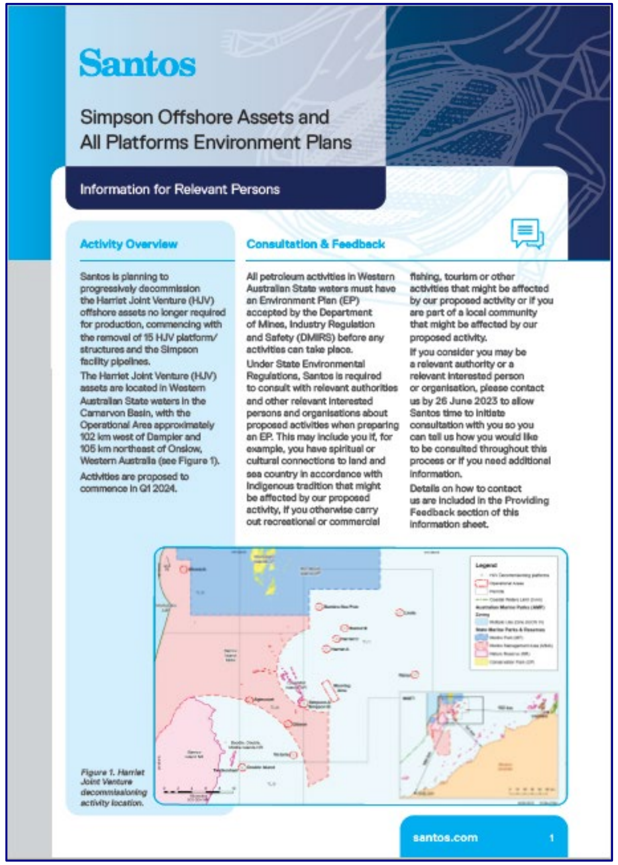
- EMBA intersect with Cwth and State Fisheries
- Review of government fishery publications (10-year history):
  - Fishery Status Reports (Cwth)
  - State of the Fisheries Reports (WA State)
- Review of other public information sources – eg studies, reports

Identification process is a starting point for conversations with potentially Relevant Persons ahead of formal consultation

Step 1	Identify and assess activity impacts and risks to define the Environment that May Be Affected (EMBA)
Step 2	Consider environmental, social, economic and cultural features that may be impacted
Step 3	Map categories of potentially Relevant Persons to environmental, social, economic and cultural features
Step 4	Research Relevant Person categories to identify authorities, persons and organisations whose functions, interests or activities may be affected

Identifying Relevant Persons

www.Santos.com/offshoreconsultation



Santos

Simpson Offshore Assets and All Platforms Environment Plans

Information for Relevant Persons

Activity Overview

Santos is planning to progressively decommission the Harriet Joint Venture (HJV) offshore assets no longer required for production, commencing with the removal of 15 HJV platform/structures and the Simpson facility pipelines.

The Harriet Joint Venture (HJV) assets are located in Western Australian State waters in the Carnarvon Basin, with the Operational Area approximately 102 km west of Dampier and 105 km northeast of Onslow, Western Australia (see Figure 1).

Activities are proposed to commence in Q1 2024.

Consultation & Feedback

All petroleum activities in Western Australian State waters must have an Environment Plan (EP) accepted by the Department of Mines, Industry Regulation and Safety (DMIRS) before any activities can take place.

Under State Environmental Regulations, Santos is required to consult with relevant authorities and other relevant interested persons and organisations about proposed activities when preparing an EP. This may include you if, for example, you have spiritual or cultural connections to land and sea country in accordance with Indigenous tradition that might be affected by our proposed activity, if you otherwise carry out recreational or commercial fishing, tourism or other activities that might be affected by our proposed activity or if you are part of a local community that might be affected by our proposed activity.

If you consider you may be a relevant authority or a relevant interested person or organisation, please contact us by 26 June 2023 to allow Santos time to initiate consultation with you so you can tell us how you would like to be consulted throughout this process or if you need additional information.

Details on how to contact us are included in the Providing Feedback section of this information sheet.

Figure 1. Harriet Joint Venture decommissioning activity location.

santos.com 1

SEEKING RELEVANT PERSONS

Santos

CARNARVON BASIN DRILLING AND PLUG AND ABANDONMENT ENVIRONMENT PLANS

Santos is seeking to identify and consult with relevant persons whose functions, interests or activities may be affected by our proposed activities off Western Australia's north west coast.

Santos is planning a number of drilling, and plug and abandonment, activities offshore Western Australia:

- **Spar-Halyard:** Drilling of a development well (infill) to support ongoing production at the Varanus Island (VI) Hub. The well is approximately 114 km north of Onslow. Activity commencement is planned from Q2 2024.
- **WA-63-L:** Drilling of up to four exploration wells to support future production through the VI Hub Operations. WA-63-L is approximately 107 km north of Onslow. Activity commencement is planned from Q1 2024.
- **Simpson:** Plug and abandonment activities of eight wells no longer required for production via the offshore Simpson facility. The wells are approximately 102 km west of Dampier. Activity commencement is planned from Q1 2024.
- **Gibson:** Plug and abandonment activities of four wells no longer required for production via the offshore Gibson facility. The wells are approximately 113 km north east of Onslow. Activity is planned for Q2 2024.
- **Mutineer Exeter Fletcher Finucane (MEFF):** Plug and abandonment activities for 12 wells no longer required for production. The MEFF wells are approximately 147 km north of Dampier. Activity is planned for the first half of Q2 2024.

The environment that may be affected (EMBA) by proposed activities

Santos is assessing impacts and risks to the environment that may be affected (EMBA) by each of these activities, including on ecosystems (including people and communities), natural and physical resources, the qualities and characteristics of locations, places and areas and the heritage value of places. This will include assessment of the social, economic and cultural features of the environment.

The map below depicts activity locations and a consolidated EMBA for all proposed activities. The 'EMBA' represents the greatest spatial extent that could be affected by unplanned 'worst case' spill scenarios, noting that in the unlikely event of a spill not all environmental, social, economic and cultural aspects would be affected.

Santos is proposing to implement measures to reduce the impacts and risks of the activities. It is a requirement under relevant environmental legislation that these impacts and risks are reduced to as low as reasonably practicable and to an acceptable level.

Seeking Relevant Persons for Environment Plans

In preparing its environment plans, Santos must consult with relevant persons for each of its proposed activities. A relevant person includes a person or an organisation whose functions, interests or activities may be affected by an activity proposed to be carried out under an environment plan. Such functions, interests or activities may include those arising in relation to spiritual or cultural connections to land and sea country in accordance with Indigenous tradition; tourism; recreational and commercial fishing; other commercial or recreational activities and local communities that might be affected by our proposed activities (these are examples and not an exhaustive list).

Santos is seeking to identify relevant persons for the purpose of preparing the environment plans for the drilling and plug and abandonment activities referred to above.

If you think your functions, interests or activities may be affected by any of these activities, you may be a relevant person with whom Santos must consult.

We welcome your feedback

We will use feedback from relevant persons to help us manage impacts and risks associated with these activities, ahead of submitting environment plans for each of our Carnarvon Basin activities activity to Commonwealth and State Regulators for assessment, depending on the location of activities. These Regulators are the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and the WA Department of Mines, Industry Regulation and Safety (DMIRS). Regulator acceptance of these environment plans is required before any petroleum activity can begin.

We have prepared consultation information sheets for each activity, which includes information about planned activities, identified environmental, social, economic and cultural aspects within each EMBA and how we propose to manage impacts and risks.

Contact us

If you consider you may be a relevant person, please contact us by **26 June 2023** to allow Santos to initiate consultation with you in relation to the proposed activity and so you can tell us how you would like to be consulted throughout this process.

Santos is committed to undertaking genuine and meaningful consultation. We want to provide information for people to make informed assessments of the possible consequences of the proposed activity on them.

Your feedback and input are important to us and input will be considered in the development of our environment plans for each activity.

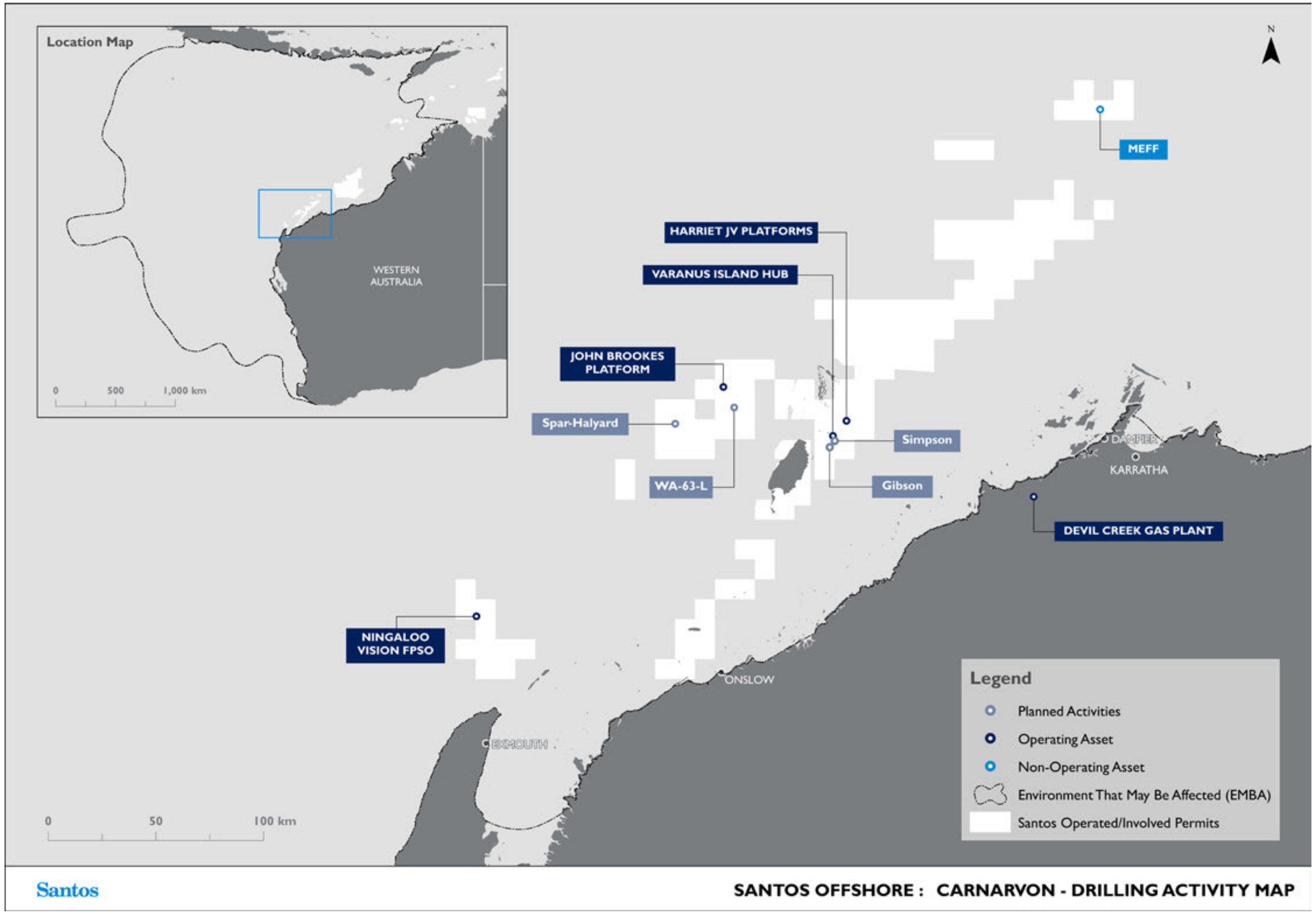
Visit www.santos.com/offshoreconsultation, email offshore.consultation@santos.com or call **1800 267 600** for more information, to self-identify as relevant person or to provide feedback.

Santos

SECTION 3
PROPOSED ACTIVITIES

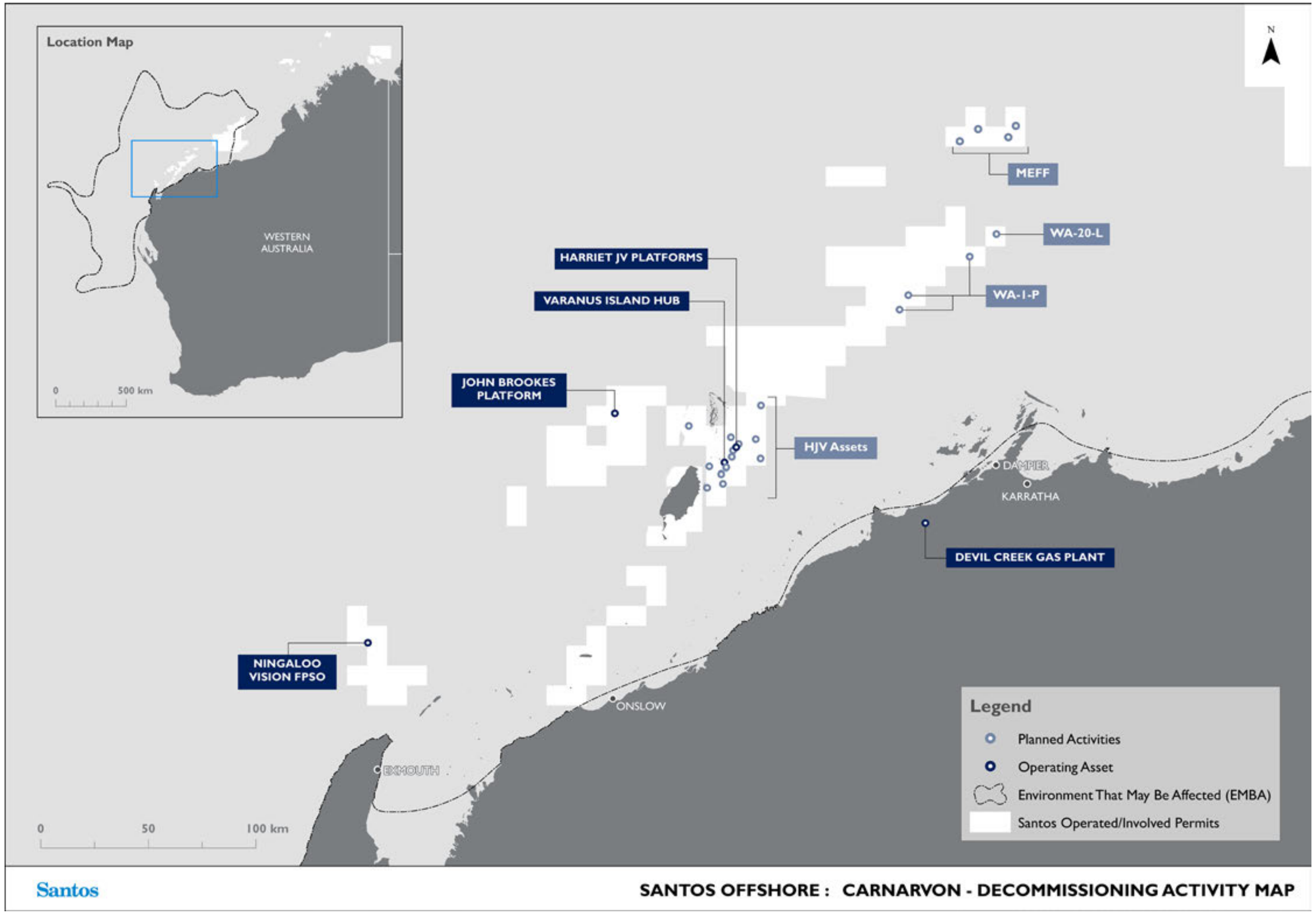
Drilling and Plug & Abandonment

- Spar Halyard – development well
- WA-63-L – up to four exploration wells
- Mutineer Exeter Fletcher Finucane (MEFF) – P&A 12 wells
- Harriet Joint Venture (HJV) – Simpson – P&A 8 wells
- HJV – Gibson – P&A 4 wells



Decommissioning

- MEFF – removal of most subsea equipment
- HJV – All platforms and Simpson pipelines
- HJV – Campbell – removal of platforms and substructures
- WA-1-P – leave in situ three wellheads
- WA-20-L – leave in situ one wellhead



SECTION 4 CONSULTATION OPPORTUNITIES

Santos

Consultation – planned activities and unplanned events

Santos is committed to co-designing consultation approaches that meet the information needs of Relevant Persons.

- **EP consultation**
  - Identification of Relevant Persons – entitlement to fish in EMBA vs active in Operational Area
  - Methods – emails, mail, one-on-one meetings, community drop-in sessions, technical fact sheet, activity summary fact sheets, posters and presentations, social media posts, video clips ….
  - Content – map, location, distance to shore, water depth …
- **Activity notifications**
  - Government, rep body and licence holder expectations – methods and content
- **Emergency communications**
  - Government, rep body and licence holder expectations – methods and content

Santos

Consultation approach – next steps

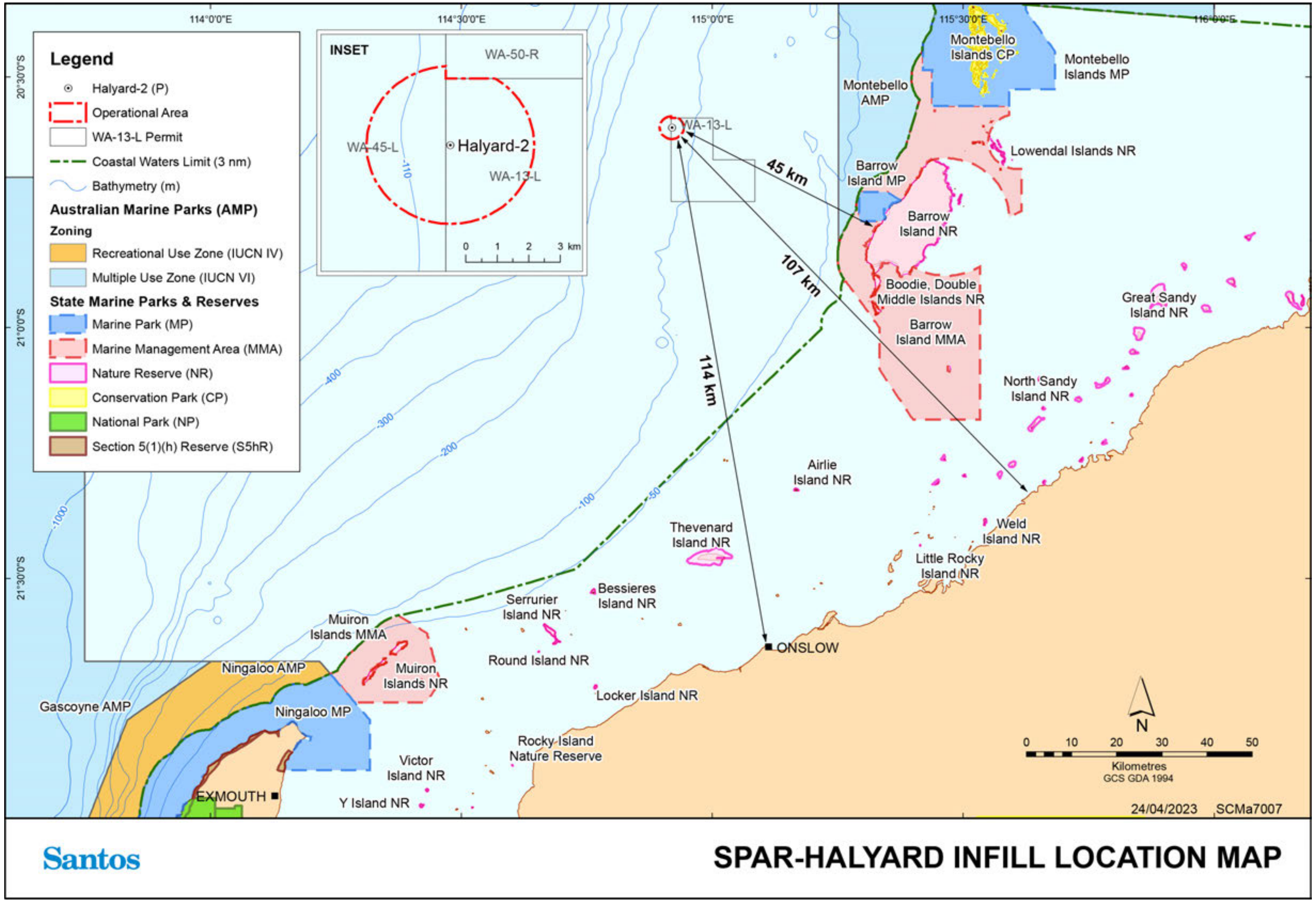
Santos is committed to co-designing consultation approaches that meet the information needs of Relevant Persons. Opportunities include:

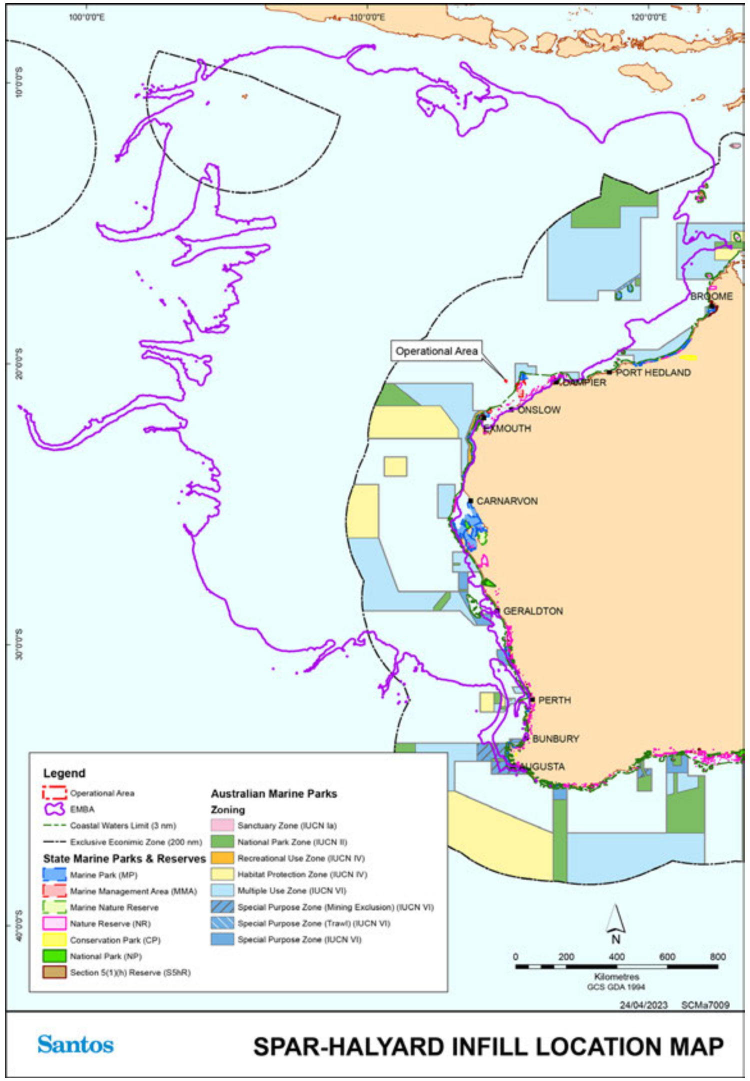
- Emails
- One-on-one meetings
- Community drop-in sessions
- Technical fact sheets
- Activity summary fact sheets
- Posters and presentations
- Social media posts
- Video clips
- Other opportunities

SECTION 5
QUESTIONS AND NEXT STEPS

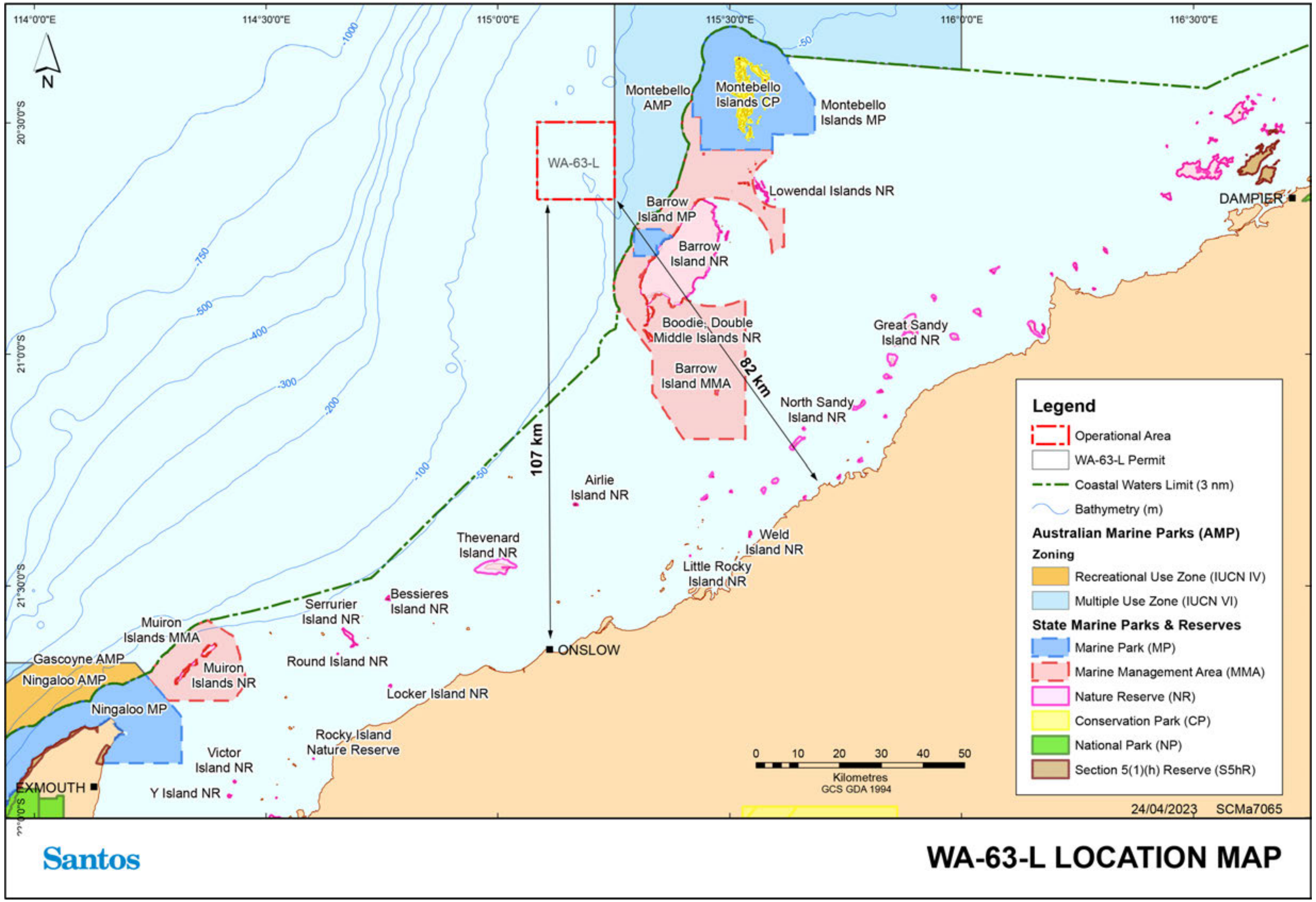
Santos

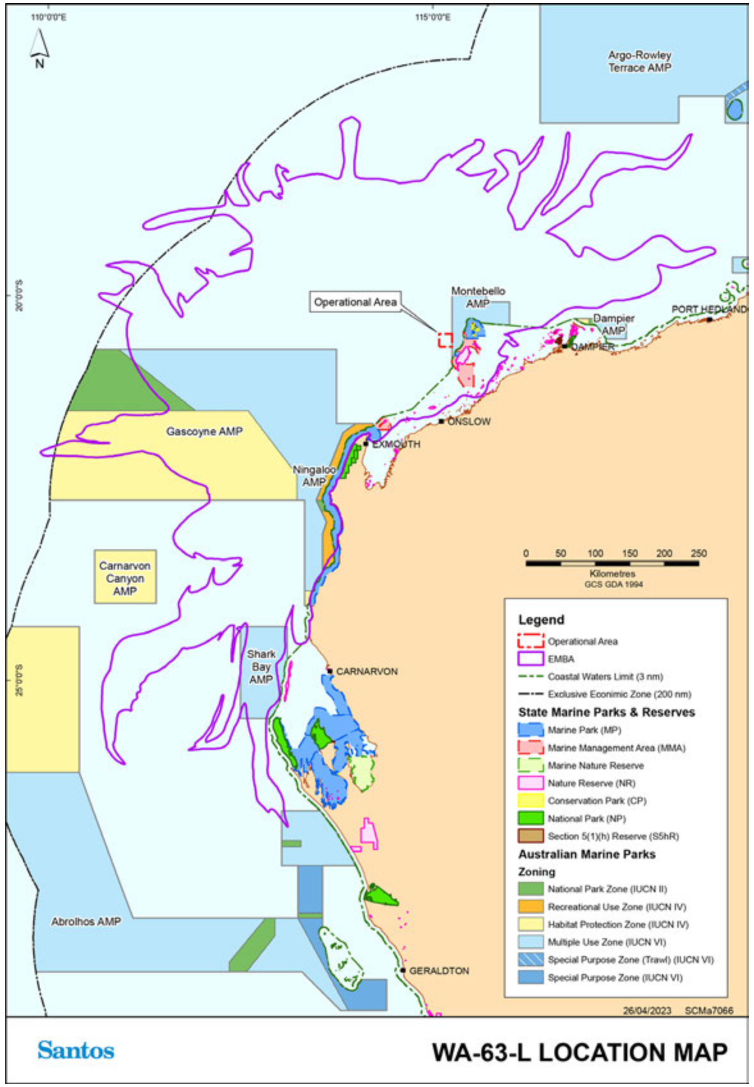
Spar Halyard



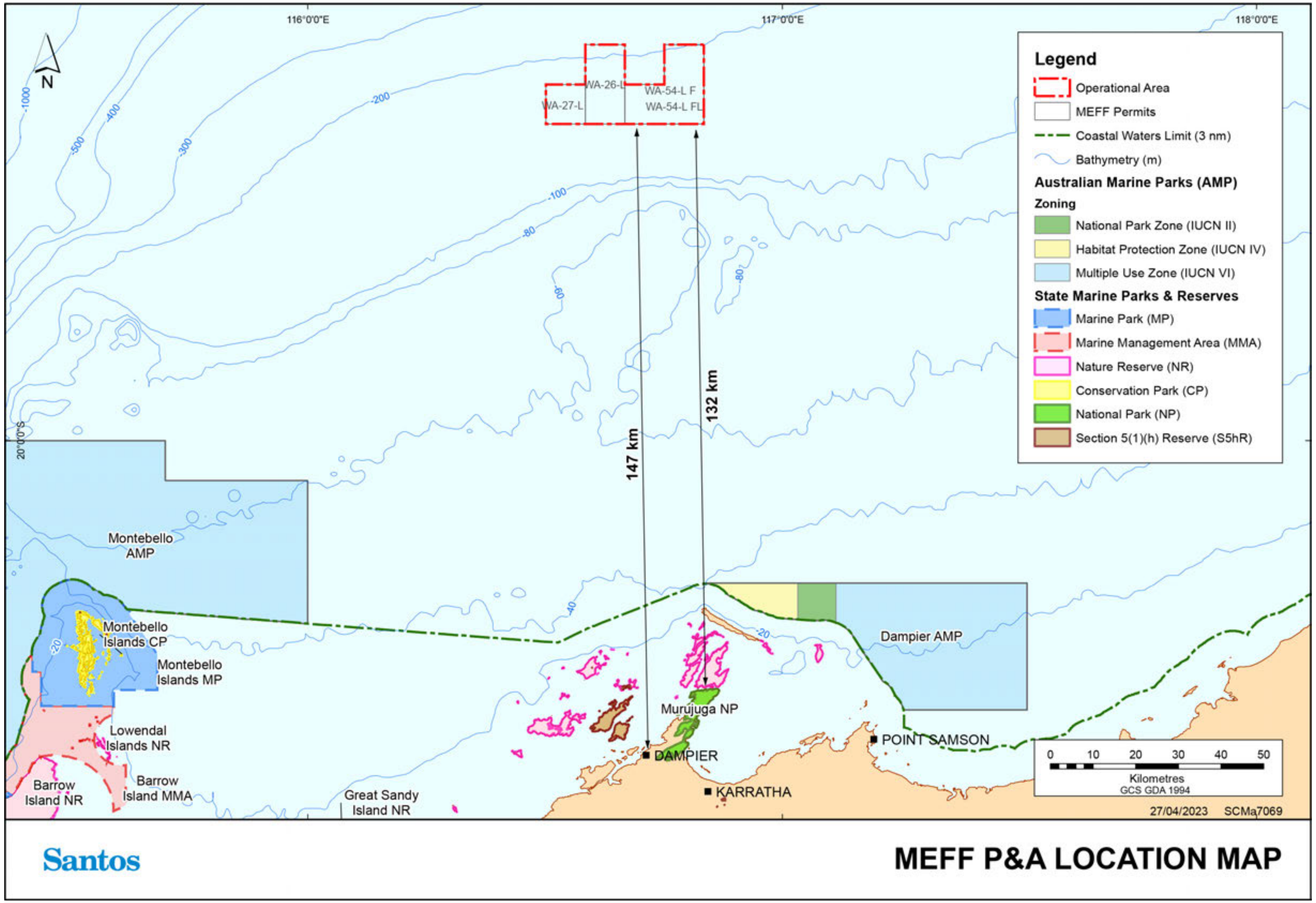


WA-63-L

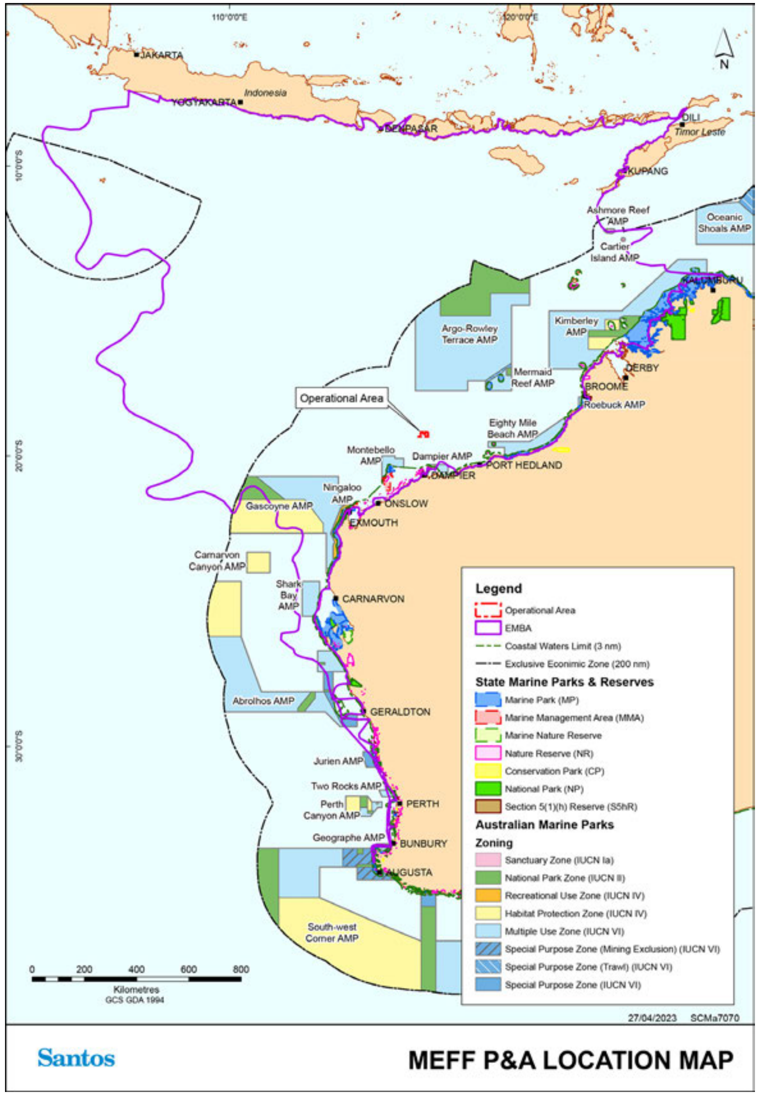

114°0'0"E
114°30'0"E
115°0'0"E
115°30'0"E
116°0'0"E
116°30'0"E
20°30'0"S
21°0'0"S
21°30'0"S
N
Montebello AMP
Montebello Islands CP
Montebello Islands MP
WA-63-L
Lowendal Islands NR
DAMPIER
Barrow Island MP
Barrow Island NR
Boodie, Double Middle Islands NR
Great Sandy Island NR
Barrow Island MMA
82 km
North Sandy Island NR
107 km
Airlie Island NR
Thevenard Island NR
Weld Island NR
Little Rocky Island NR
Bessieres Island NR
Serrurier Island NR
Muiron Islands MMA
Gascoyne AMP
Ningaloo AMP
Muiron Islands NR
Round Island NR
ONSLOW
Locker Island NR
Ningaloo MP
Rocky Island Nature Reserve
Victor Island NR
EXMOUTH
Y Island NR
-1000
-750
-500
-400
-300
-200
-100
-50
Legend
Operational Area
WA-63-L Permit
Coastal Waters Limit (3 nm)
Bathymetry (m)
Australian Marine Parks (AMP)
Zoning
Recreational Use Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
0 10 20 30 40 50
Kilometres
GCS GDA 1994
24/04/2023 SCMa7065
Santos
WA-63-L LOCATION MAP


110°0'0"E
115°0'0"E
20°0'0"S
25°0'0"S
N
Argo-Rowley Terrace AMP
Montebello AMP
Operational Area
Dampier AMP
PORT HEDLAND
DAMPIER
ONSLOW
EXMOUTH
Gascoyne AMP
Ningaloo AMP
Carnarvon Canyon AMP
Shark Bay AMP
CARNARVON
Abrolhos AMP
GERALDTON
0 50 100 150 200 250
Kilometres
GCS GDA 1994
Legend
Operational Area
EMBA
Coastal Waters Limit (3 nm)
Exclusive Economic Zone (200 nm)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Marine Nature Reserve
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Australian Marine Parks
Zoning
National Park Zone (IUCN II)
Recreational Use Zone (IUCN IV)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
Special Purpose Zone (Trawl) (IUCN VI)
Special Purpose Zone (IUCN VI)
26/04/2023 SCMa7066
Santos
WA-63-L LOCATION MAP

MEFF P&A

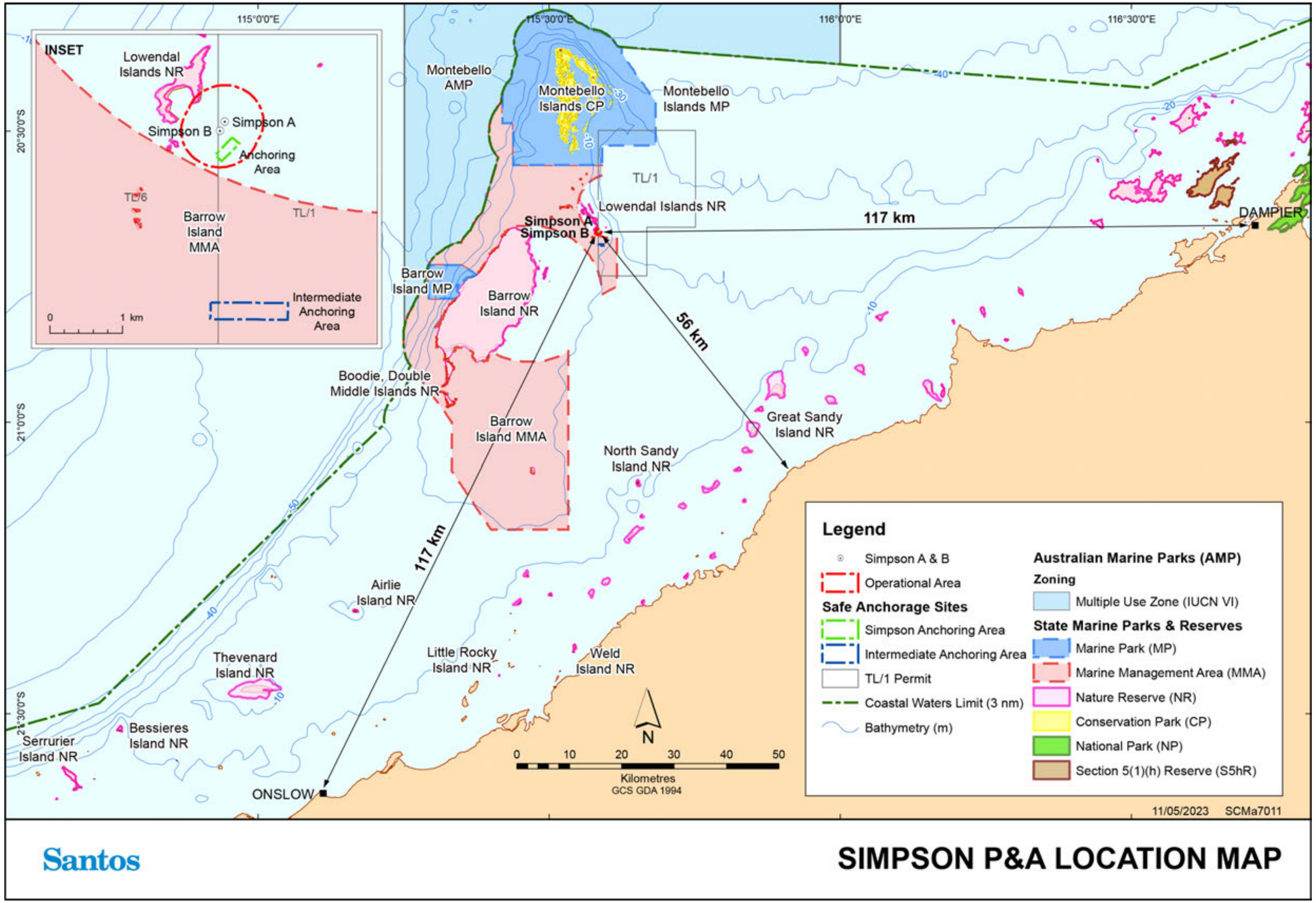


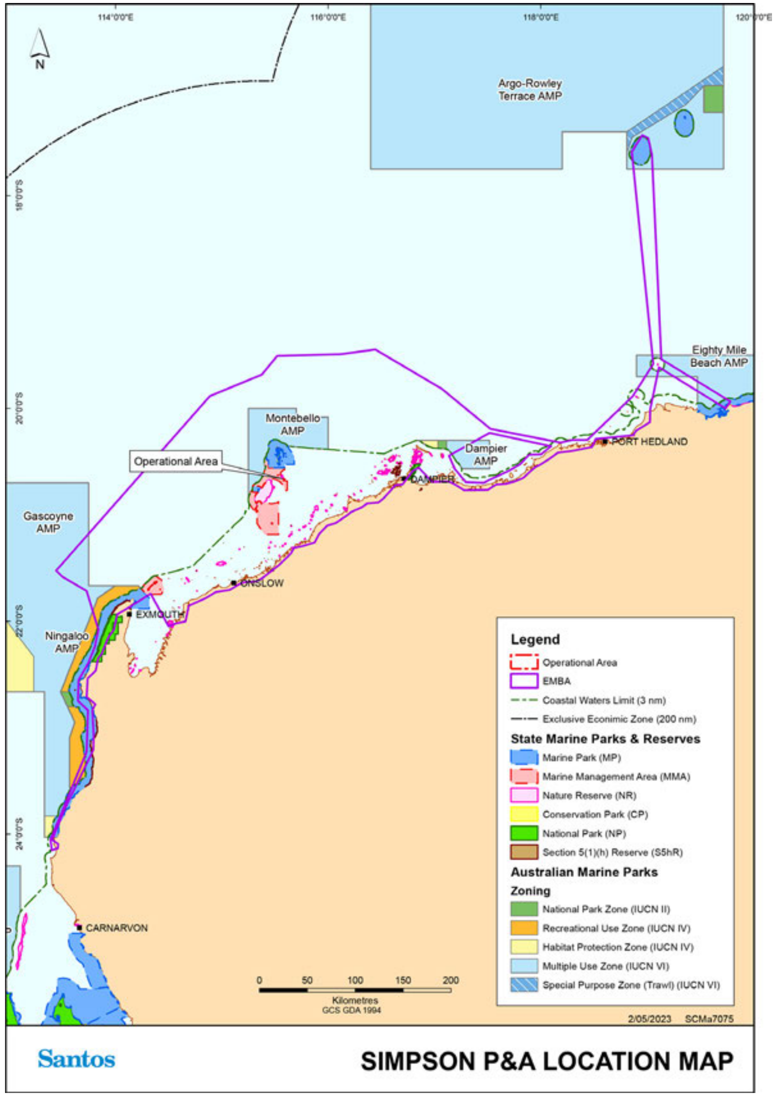
116°0'0"E
117°0'0"E
118°0'0"E
20°0'0"S
N
WA-26-L
WA-27-L
WA-54-L F
WA-54-L FL
147 km
132 km
-1000
-500
-400
-300
-200
-100
-80
-60
-40
-20
Legend
Operational Area
MEFF Permits
Coastal Waters Limit (3 nm)
Bathymetry (m)
Australian Marine Parks (AMP)
Zoning
National Park Zone (IUCN II)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Montebello AMP
Montebello Islands CP
Montebello Islands MP
Lowendal Islands NR
Barrow Island NR
Barrow Island MMA
Great Sandy Island NR
Murujuga NP
DAMPIER
KARRATHA
POINT SAMSON
Dampier AMP
0 10 20 30 40 50
Kilometres
GCS GDA 1994
27/04/2023 SCMa7069
Santos
MEFF P&A LOCATION MAP



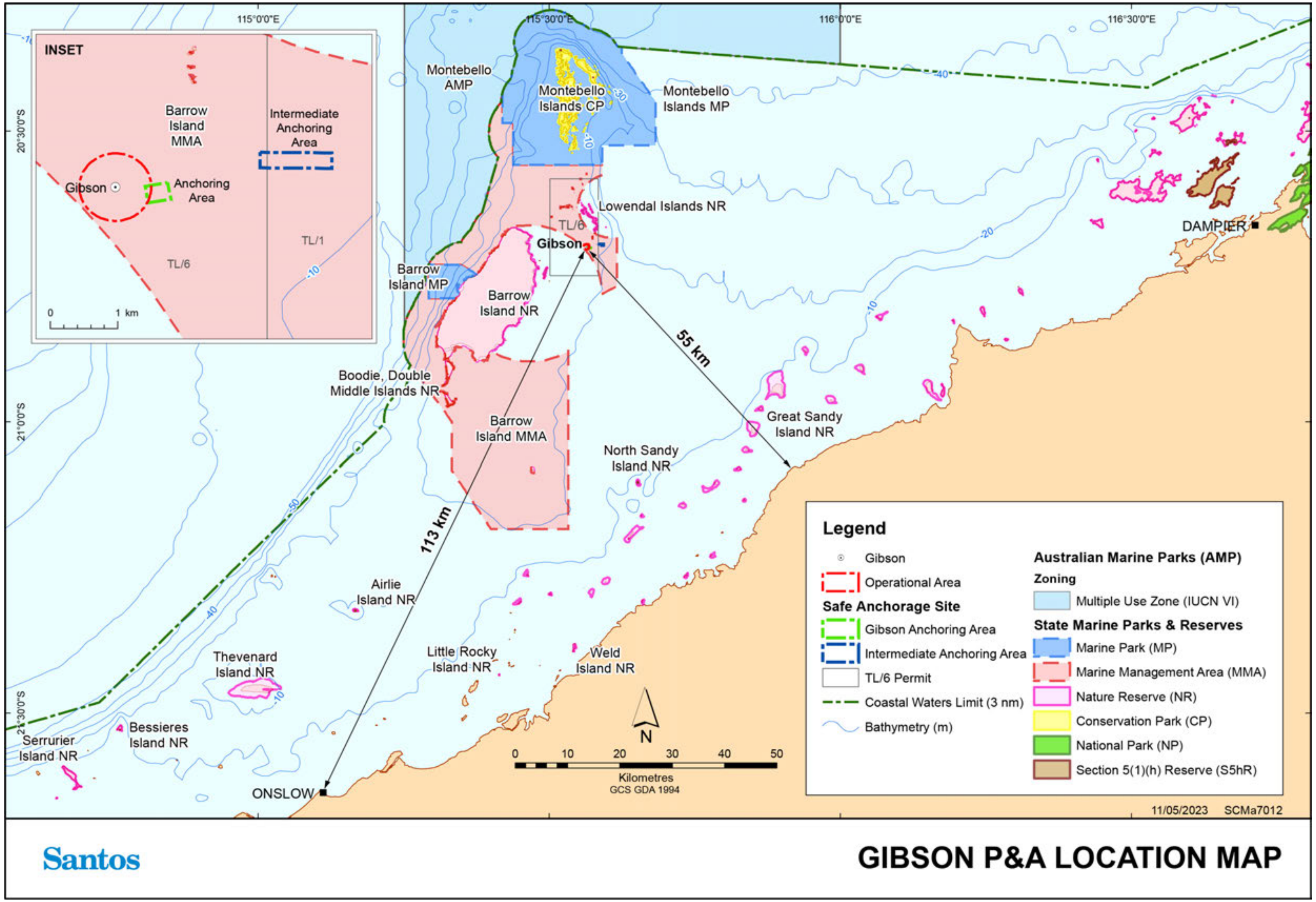
110°0'0"E
120°0'0"E
10°0'0"S
20°0'0"S
30°0'0"S
N
JAKARTA
Indonesia
YOGYAKARTA
DENPASAR
DILI
Timor Leste
KUPANG
Ashmore Reef AMP
Cartier Island AMP
Oceanic Shoals AMP
Argo-Rowley Terrace AMP
Kimberley AMP
Mermaid Reef AMP
DERBY
BROOME
Roebuck AMP
Operational Area
Eighty Mile Beach AMP
Montebello AMP
Dampier AMP
DAMPIER
PORT HEDLAND
Ningaloo AMP
ONSLOW
Gascoyne AMP
EXMOUTH
Carnarvon Canyon AMP
Shark Bay AMP
CARNARVON
Abrolhos AMP
GERALDTON
Jurien AMP
Two Rocks AMP
Perth Canyon AMP
PERTH
Geographe AMP
BUNBURY
AUGUSTA
South-west Corner AMP
Legend
Operational Area
EMBA
Coastal Waters Limit (3 nm)
Exclusive Economic Zone (200 nm)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Marine Nature Reserve
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Australian Marine Parks
Zoning
Sanctuary Zone (IUCN Ia)
National Park Zone (IUCN II)
Recreational Use Zone (IUCN IV)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
Special Purpose Zone (Mining Exclusion) (IUCN VI)
Special Purpose Zone (Trawl) (IUCN VI)
Special Purpose Zone (IUCN VI)
0 200 400 600 800
Kilometres
GCS GDA 1994
27/04/2023 SCMa7070
Santos
MEFF P&A LOCATION MAP

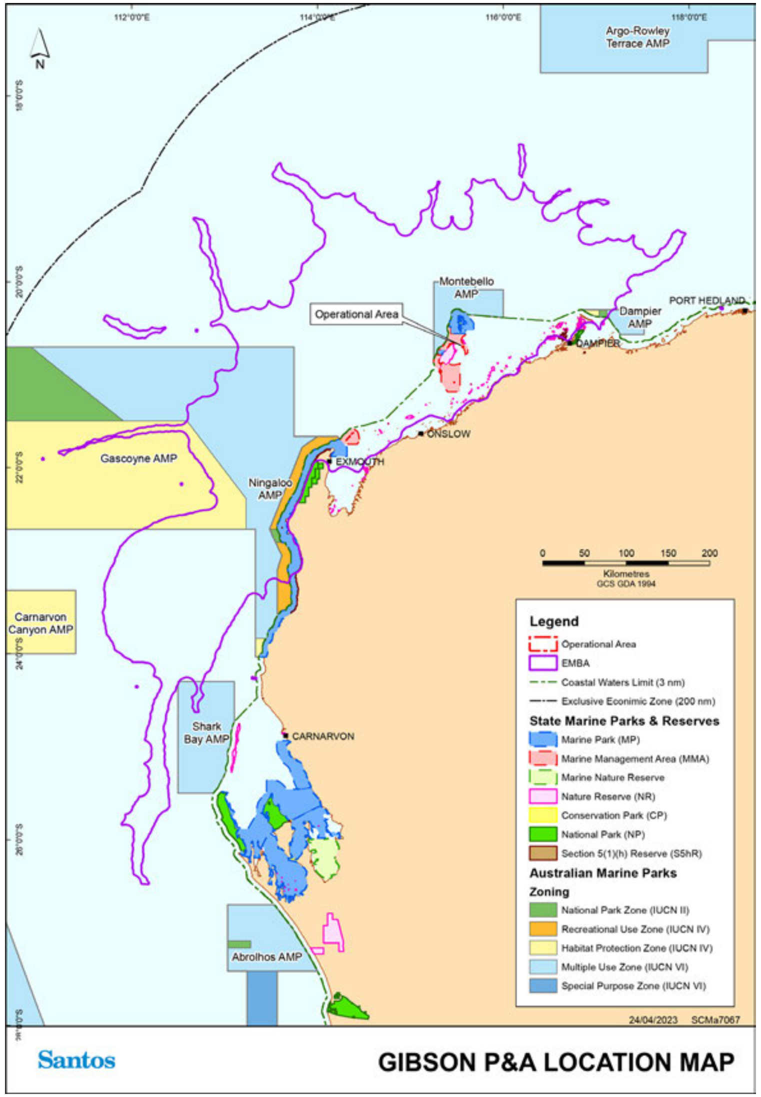
HJV – Simpson P&A



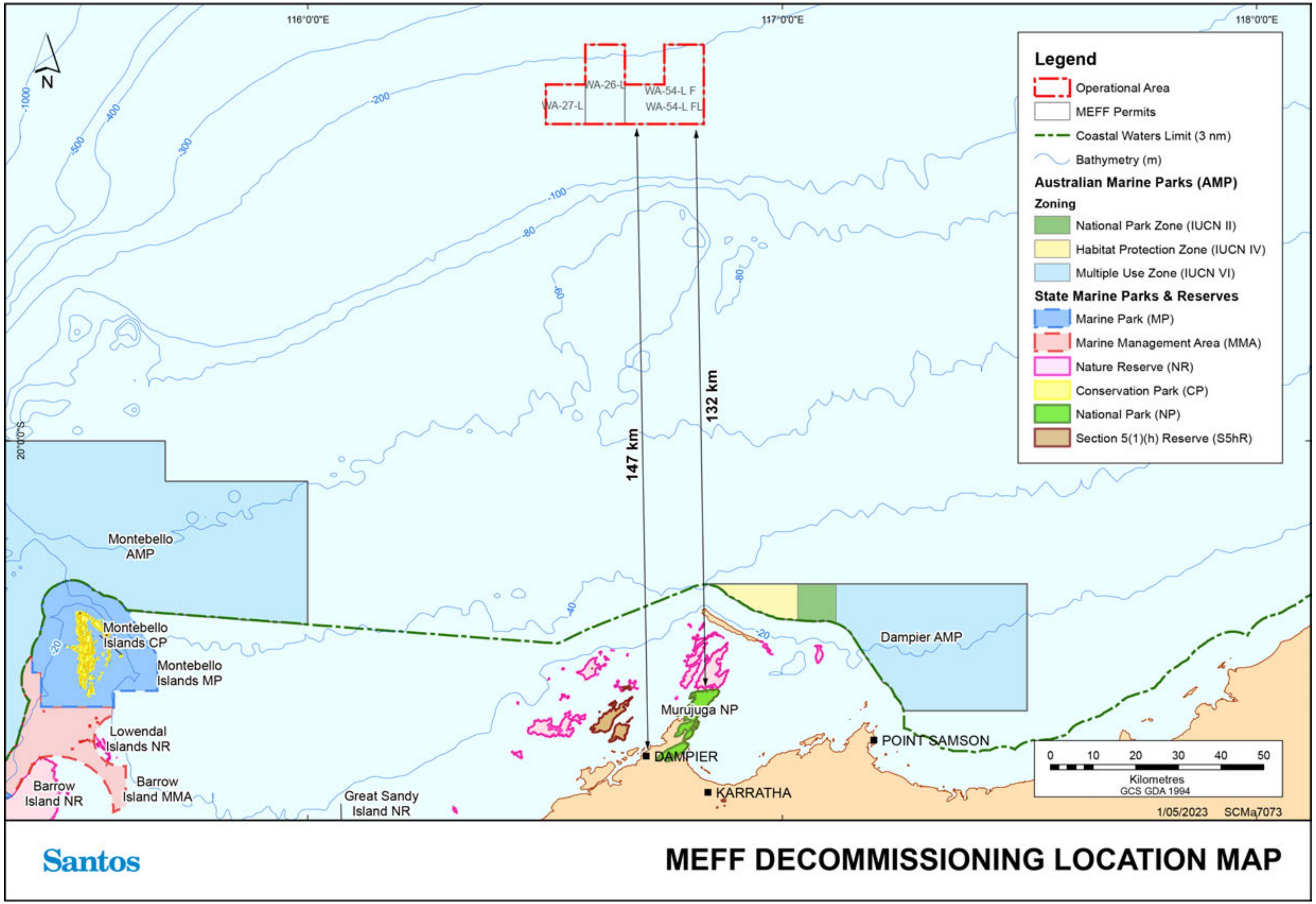


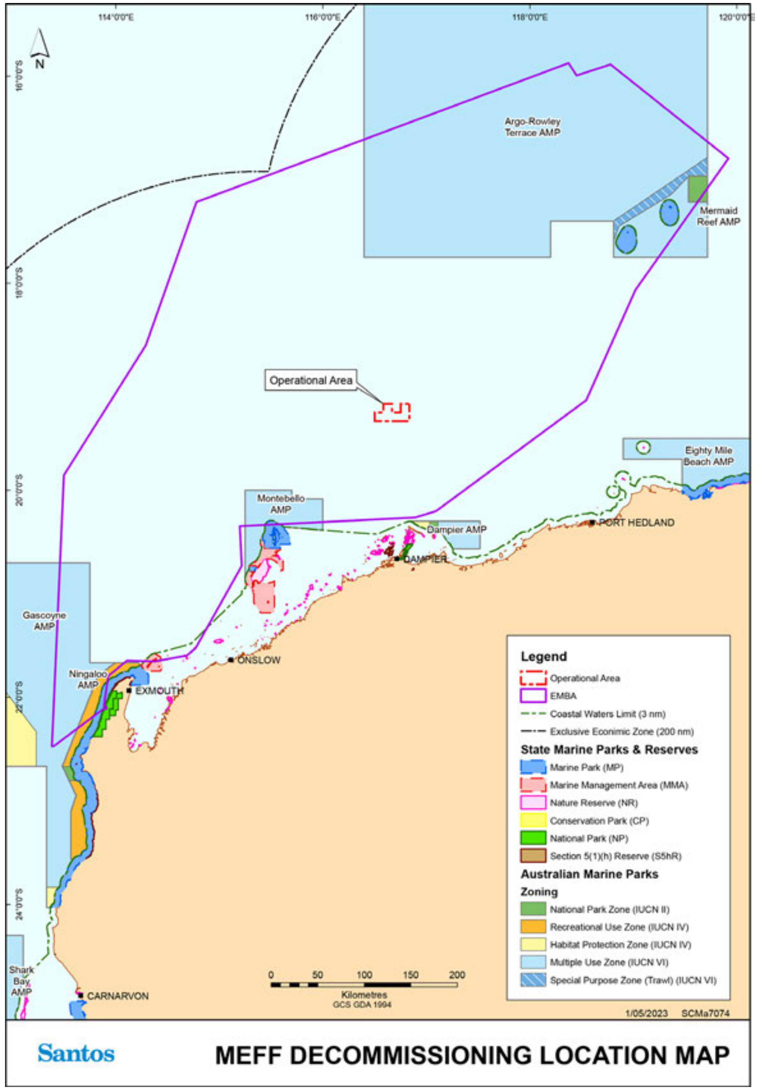
HJV – Gibson P&A



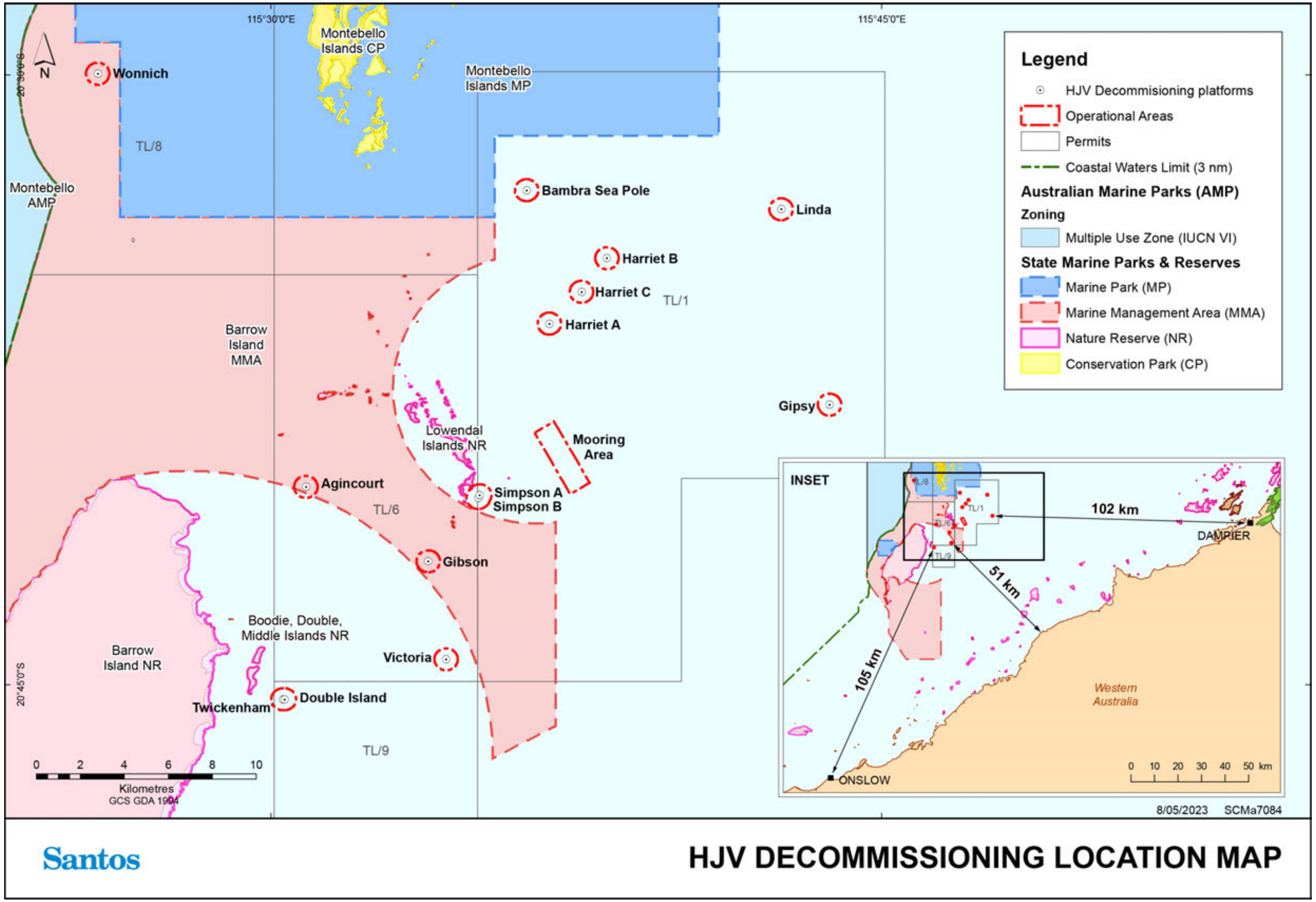


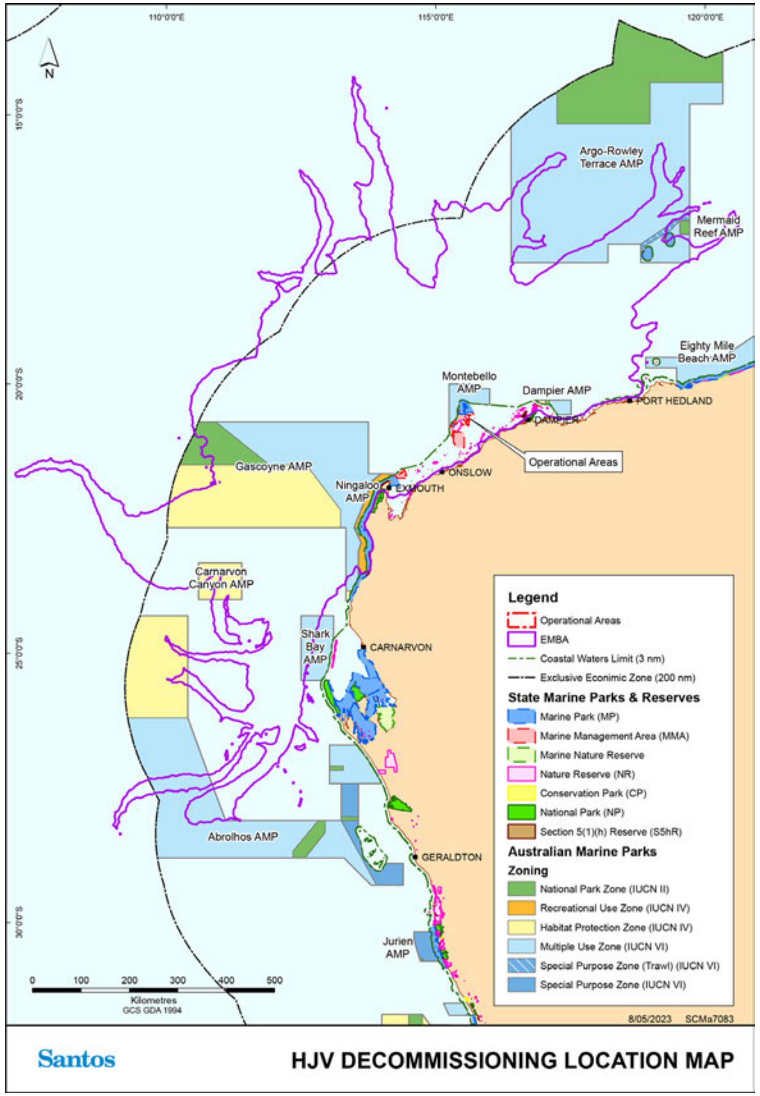
MEFF Decommissioning



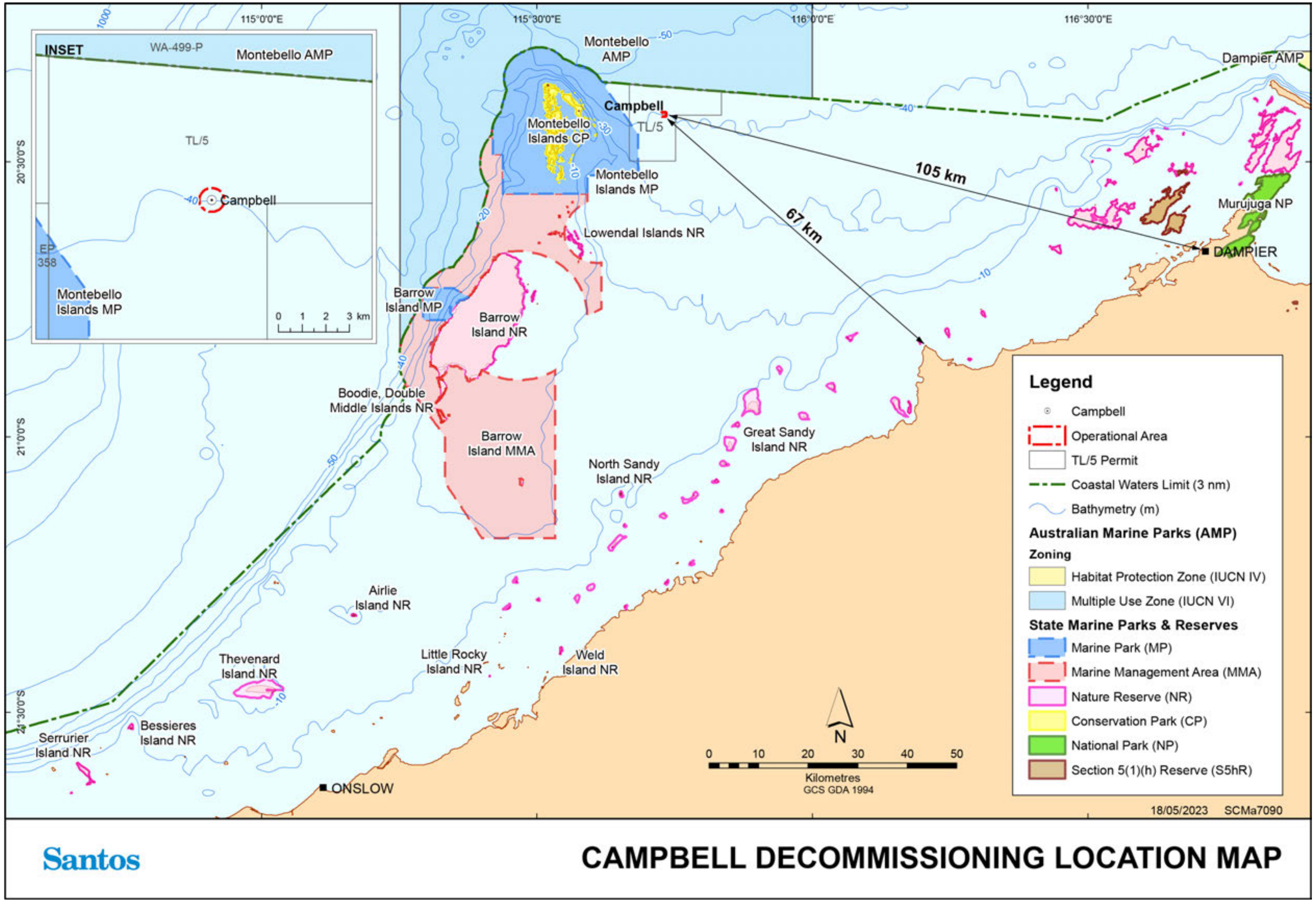


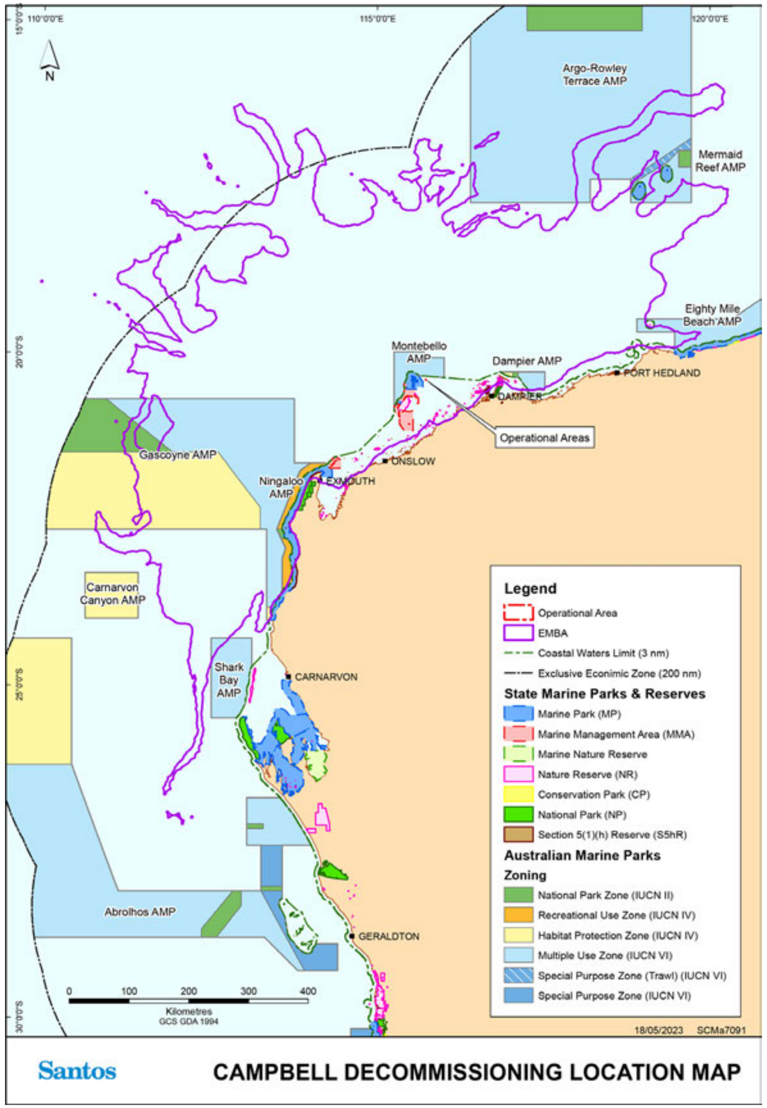
HJV Decommissioning



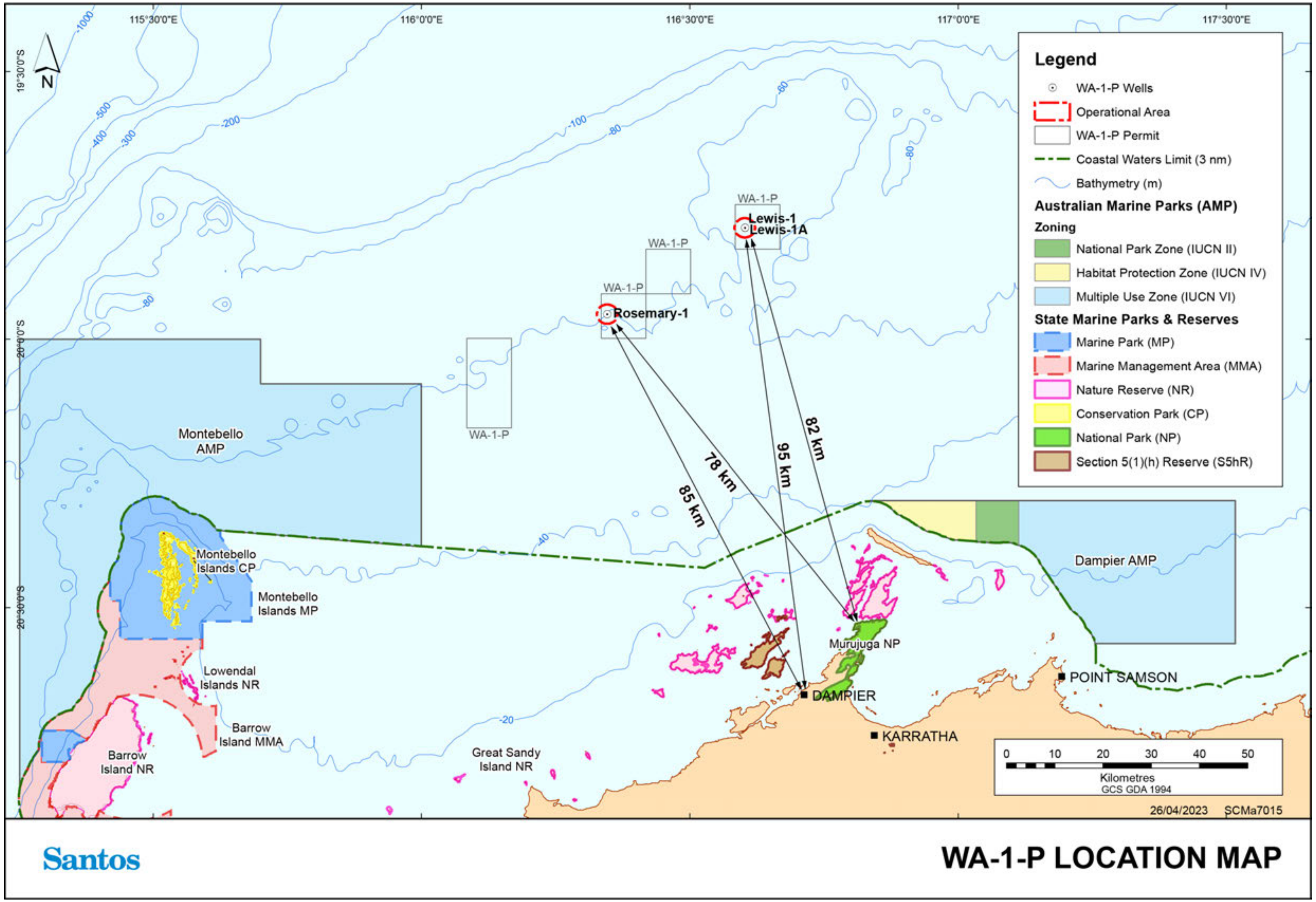


Campbell

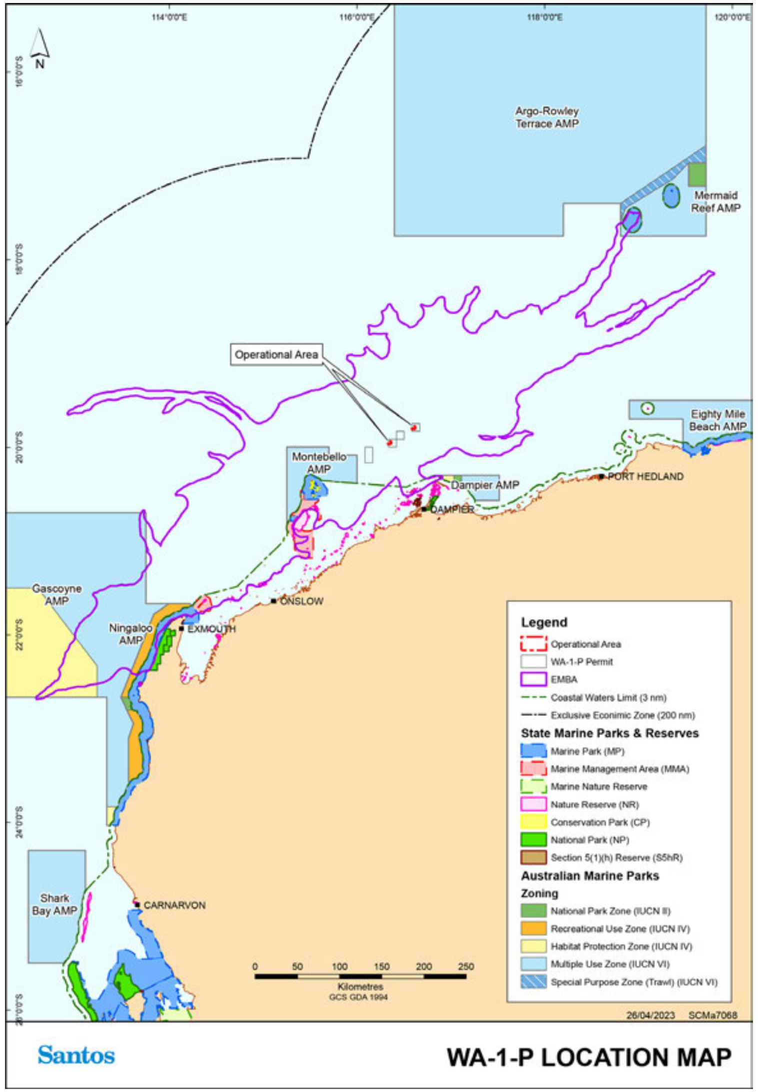

INSET
WA-499-P
Montebello AMP
TL/5
Campbell
EP 358
Montebello Islands MP
Montebello AMP
Dampier AMP
Campbell
TL/5
Montebello Islands CP
Montebello Islands MP
105 km
67 km
Murujuga NP
DAMPIER
Lowendal Islands NR
Barrow Island MP
Barrow Island NR
Boodie, Double Middle Islands NR
Barrow Island MMA
North Sandy Island NR
Great Sandy Island NR
Airlie Island NR
Thevenard Island NR
Little Rocky Island NR
Weld Island NR
Bessieres Island NR
Serrurier Island NR
ONSLOW
Kilometres
GCS GDA 1994
Legend
Campbell
Operational Area
TL/5 Permit
Coastal Waters Limit (3 nm)
Bathymetry (m)
Australian Marine Parks (AMP)
Zoning
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
18/05/2023 SCMa7090
Santos
CAMPBELL DECOMMISSIONING LOCATION MAP


Argo-Rowley Terrace AMP
Mermaid Reef AMP
Eighty Mile Beach AMP
Montebello AMP
Dampier AMP
PORT HEDLAND
DAMPIER
Operational Areas
ONSLOW
Gascoyne AMP
Ningaloo AMP
EXMOUTH
Carnarvon Canyon AMP
Shark Bay AMP
CARNARVON
Abrolhos AMP
GERALDTON
Legend
Operational Area
EMBA
Coastal Waters Limit (3 nm)
Exclusive Economic Zone (200 nm)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Marine Nature Reserve
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Australian Marine Parks
Zoning
National Park Zone (IUCN II)
Recreational Use Zone (IUCN IV)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
Special Purpose Zone (Trawl) (IUCN VI)
Special Purpose Zone (IUCN VI)
Kilometres
GCS GDA 1994
18/05/2023 SCMa7091
Santos
CAMPBELL DECOMMISSIONING LOCATION MAP

WA-1-P

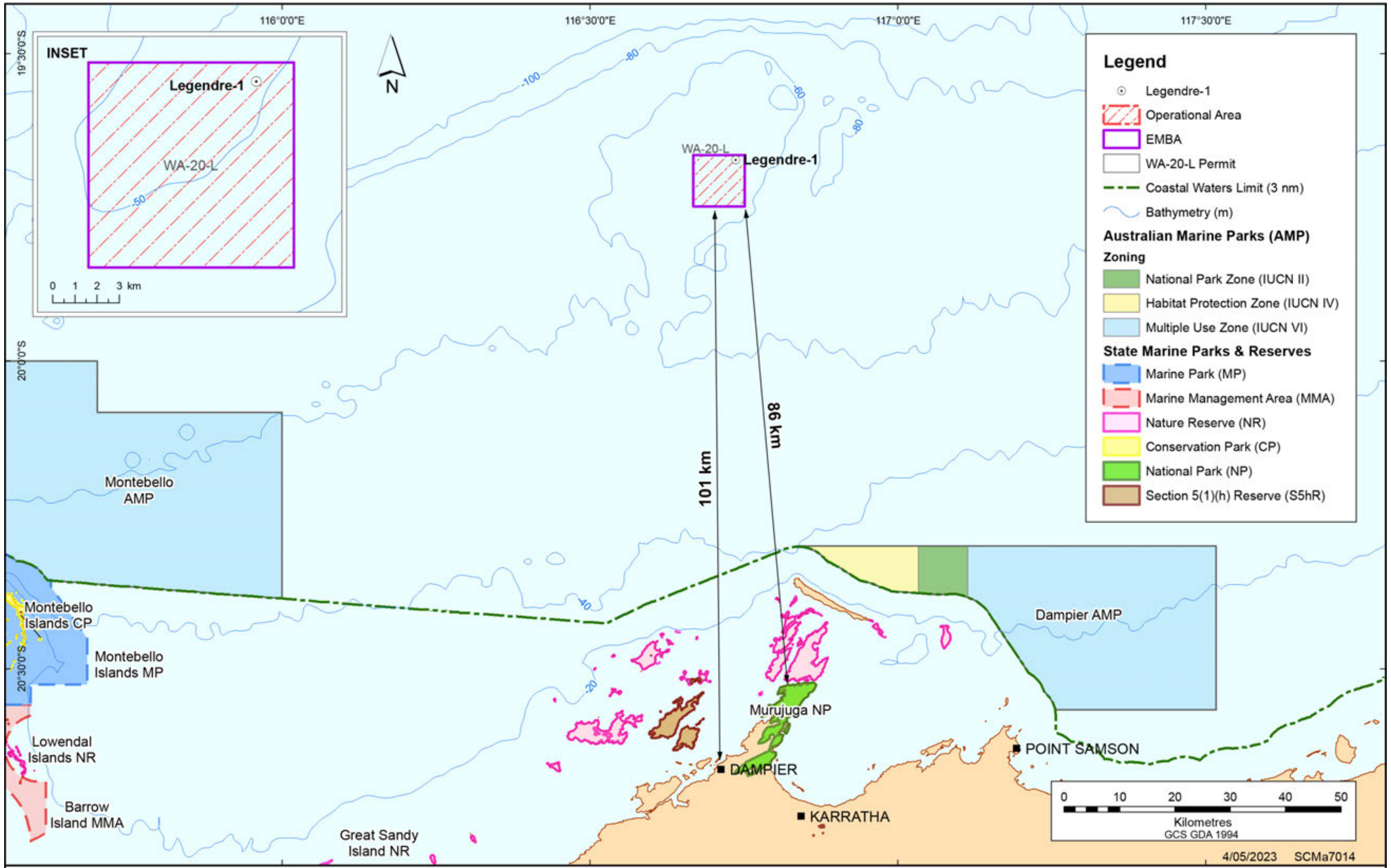


Legend
WA-1-P Wells
Operational Area
WA-1-P Permit
Coastal Waters Limit (3 nm)
Bathymetry (m)
Australian Marine Parks (AMP)
Zoning
National Park Zone (IUCN II)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Lewis-1
Lewis-1A
Rosemary-1
WA-1-P
85 km
78 km
95 km
82 km
Montebello AMP
Montebello Islands CP
Montebello Islands MP
Lowendal Islands NR
Barrow Island MMA
Barrow Island NR
Great Sandy Island NR
Murujuga NP
DAMPIER
KARRATHA
POINT SAMSON
Dampier AMP
Kilometres
GCS GDA 1994
26/04/2023 SCMa7015
Santos
WA-1-P LOCATION MAP



Argo-Rowley Terrace AMP
Mermaid Reef AMP
Operational Area
Eighty Mile Beach AMP
Montebello AMP
Dampier AMP
DAMPIER
PORT HEDLAND
Gascoyne AMP
Ningaloo AMP
EXMOUTH
ONSLOW
Shark Bay AMP
CARNARVON
Legend
Operational Area
WA-1-P Permit
EMBA
Coastal Waters Limit (3 nm)
Exclusive Economic Zone (200 nm)
State Marine Parks & Reserves
Marine Park (MP)
Marine Management Area (MMA)
Marine Nature Reserve
Nature Reserve (NR)
Conservation Park (CP)
National Park (NP)
Section 5(1)(h) Reserve (S5hR)
Australian Marine Parks
Zoning
National Park Zone (IUCN II)
Recreational Use Zone (IUCN IV)
Habitat Protection Zone (IUCN IV)
Multiple Use Zone (IUCN VI)
Special Purpose Zone (Trawl) (IUCN VI)
Kilometres
GCS GDA 1994
26/04/2023 SCMa7068
Santos
WA-1-P LOCATION MAP

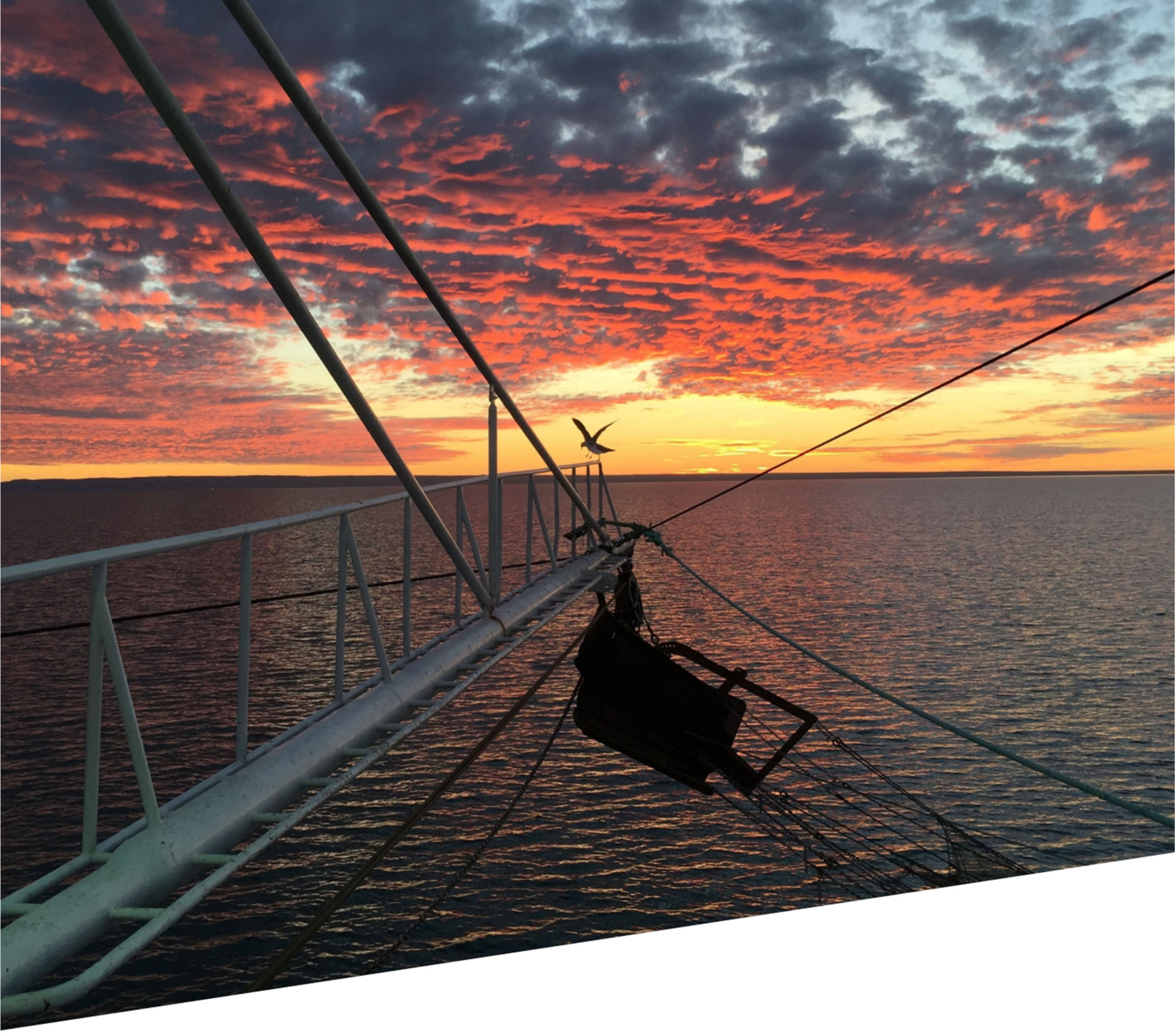
WA-20-L



Santos

LEGENDRE-1 WELL LOCATION MAP

Appendix I: Wellhead snagging risk study



REPORT

RISK INVESTIGATION – POTENTIAL IMPACT OF SANTOS LEGENDRE WELLHEAD ON COMMERCIAL FISHING OPERATIONS IN THE PILBARA DEMERSAL SCALEFISH FISHERIES

DR. JOHN WAKEFORD

OCTOBER 2021

AMCS AMC SEARCH

Training and Consultancy Division of the Australian Maritime College

Document Control Sheet

AMC Search Ltd Maritime Way Newnham Tasmania 7248 Australia Tel: +61 36324 9850 Locked Bag 1400, Launceston, Tasmania, 7250, Australia www.amcsearch.com.au	Reference Number:	5415621901
	Title:	Risk Investigation – Potential Impact of Santos Legendre Wellhead on Commercial Fishing Operations in the Pilbara Demersal Scalefish Fisheries
	AMC Search Client Manager	Nic Bender
	Client:	Santos
	Client Contact:	Joanna Edwards
	Client Reference:	Project No. 411012-00238
Project Summary:	Risk investigation to examine the impacts and risks of in-situ abandonment of Legendre Wellhead on commercial fishing operations.	

Revision Checking History

Revision Number	Date	Checked by	Issued by
0.1	August 26 2021	RP	JW
1	August 27 2021	NB	RP
2	October 11 2021	RP	NB

Distribution

Destination of Document	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Joanna Edwards, Santos Jo-Anne Blunn, Santos Brendan Dry, Santos Alison Byron, Advisian AMC Search File Library			X								

Third Party Disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by AMC Search at the instruction of, and for use by, our client named on this Document Control Sheet. It does not in any way constitute advice to any third party who is able to access it by any means. AMC Search excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report.

Contents

1. Executive Summary

Santos's Legendre Wellhead is located in a relatively productive commercial fishing area offshore of north west Australia, and in order to demonstrate to NOPSEMA that permanent abandonment of this wellhead in-situ represents an acceptably low impact and risk to these commercial fishers, AMC Search was contracted to provide risk assessment advice in several areas.

The investigation by AMC Search revealed that:

- The only commercial fishing group at risk from an interaction with the Legendre Wellhead were those engaged in fish trawling (four similar sized vessels – c.24m LOA, steel, displacement hull, purpose-built trawlers).
- These trawlers were very unlikely to have an interaction with the wellhead for the following reasons; the wellhead was located in an untrawlable area, the wellhead position was marked on charts (both Admiralty and vessel GPS plotter), and the capability of all vessels and crew to safely trawl around "marked" seabed obstacles was high.
- A low to moderate/high hazard-severity was associated with a trawler-wellhead interaction under normal operating conditions, depending on the entity being impacted upon.
  - The crew were unlikely to be harmed, unless they were caught at unawares in a vulnerable position, in which case a moderate impact (injury requiring hospitalisation) may result.
  - The fishing gear was likely to suffer moderate/high damage i.e., net torn, large holes/tears, and frameline breakage.
  - The trawler would only suffer minor damage i.e., scrape damage to surfaces from wires during gear recovery and was very unlikely to capsize.
  - The fishing income would suffer from catch loss and several hours to several days of downtime depending on the availability/location of a spare net.
- If a hookup occurred under unfavourable circumstances (e.g., rough seas, strong tide/current, whilst the vessel was turning), then the hazard severity for crew and vessel would increase. However, based on historical data in this fishery regarding fish trawler capsize events and harm to crew, together with the stability of these vessels under these extraordinary conditions/circumstances, it was unlikely to result in a vessel capsizing or a loss of life provided the skipper/crew follow recognised trawler hook-up safety procedures, which was a reasonable expectation given the trawling experience shared across the skippers in this fishery (10 - 30 years per skipper).

2. Background

Santos is proposing to permanently abandon the Legendre wellhead in-situ. To meet the requirements of the OPPGS(E)R, Santos must demonstrate that the impacts and risks of in-situ abandonment provide an equal or better environmental outcome than complete removal. In other words, the EP decommissioning plan must demonstrate that the impacts and risks posed to other users (specifically trawlers in the Pilbara Fish Trawl Fishery) are As Low As Reasonability Practicable (ALARP) and acceptable, in particular the snag risk posed by the wellhead.

3. Task

Santos is requesting advice from the Australian Maritime College as subject matter experts on the Australian fishing industry. As outline below, Santos is requesting advice in two stages, as well as input into two risk assessment workshops.

Stage 1 – Tern-1 Wellhead

Typical equipment and fishing methods

- Description of trawling nets used in the Northern Prawn Fishery (NPF)
- Description of fishing methods including size of typical turning circle when actively trawling used by the NPF (if possible).

Vessel technology

- Description of technology typically available to currently operating prawn trawlers to avoid navigation hazards, such as the Tern-1 wellhead.
- Description of the technology used by the NPF to avoid navigation hazards such as the Tern-1 wellhead (as they may not have Best Available Technology).
- Description of the minimum technology (if any) required by trawlers to avoid navigational hazards.
- Description of how trawlers manage updates from Australian Hydrographic Office (AHO) of navigation hazards – assume they are marked on their GPS system, confirm that they're not issued as paper charts or something that's not used.
- Advice on whether or not AHO navigation hazard charts are relied on/used by trawlers to avoid hazards such as the Tern-1 wellhead.
- Do they have any sensor or alarm signals that go off when they within a certain distance of navigational hazards
- Description of technology or equipment available onboard vessels to free snagged trawl nets.
- Discussion on risks to vessel stability posed by snagged trawl nets and what techniques are used by fisherman to maintain vessel stability.

Historic Trawl Vessel Incidents

- With reference to Australian Maritime Safety Authority (AMSA) and Australian Transport Safety Bureau (ATSB) databases as well as international incidents (such as Westhaven), provide a discussion on historic incidents and how relevant they are to the Tern-1 wellhead snag risk posed to current and future trawlers.

Risk Assessment

- Input, as a subject matter expert, into an (up to) two hour risk assessment workshop to assess the likelihood of a northern prawn trawling vessel:
    1. snagging trawl nets on the Tern-1 wellhead
    2. loosing gear as a result of snagging on the Tern-1 wellhead
    3. rolling a vessel as a result of snagging fishing nets on the Tern-1 wellhead

Stage 2 – Legendre Wellhead

- Tailor the advice provided in Stage 1 to Legendre wellhead (draft EP to be provided) and participate in a risk workshop. (Note: AMCS was subsequently notified that a workshop was not required for the Legendre WH – advice given 1 Aug 2021).

4. Advice provided by AMC Search

4.1 Legendre wellhead location and the affected commercial fisheries

The Legendre wellhead (WH) is located in a relatively productive fishing area offshore of north west Australia (refer Figs. 1 - 3). Historically this area was fished mainly by Taiwanese gillnetters and trawlers (Moran et al. 1988; Nowara & Newman 2001) before they were displaced by the creation of the Australian Fishing Zone (AFZ). The formation of several domestic fisheries followed, and today the main fishing activity is associated with what are known as the Pilbara Demersal Scalefish Fisheries (PDSF). The Spanish Mackerel fishery also extends through this area, although fishing intensity is relatively low and very close to the surface and therefore has nil risk of interacting with a well-head.

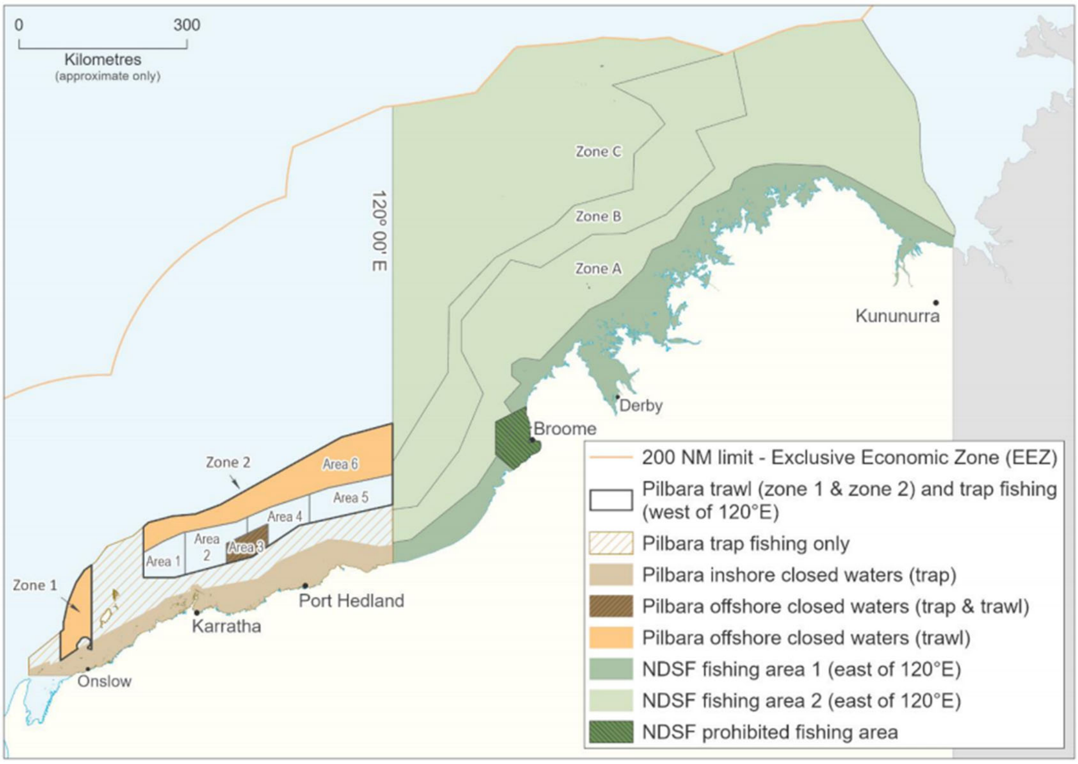


Figure 1. Demersal Scalefish fisheries of the North Coast Bioregion of Western Australia.
Note: Areas 1 to 6 are located in Zone 2 of the Pilbara subregion, and demersal trawling is only allowed in Areas 1, 2 4 and 5.
(Source: Status Reports of the Fisheries and Aquatic Resources of Western Australia 2019/20)

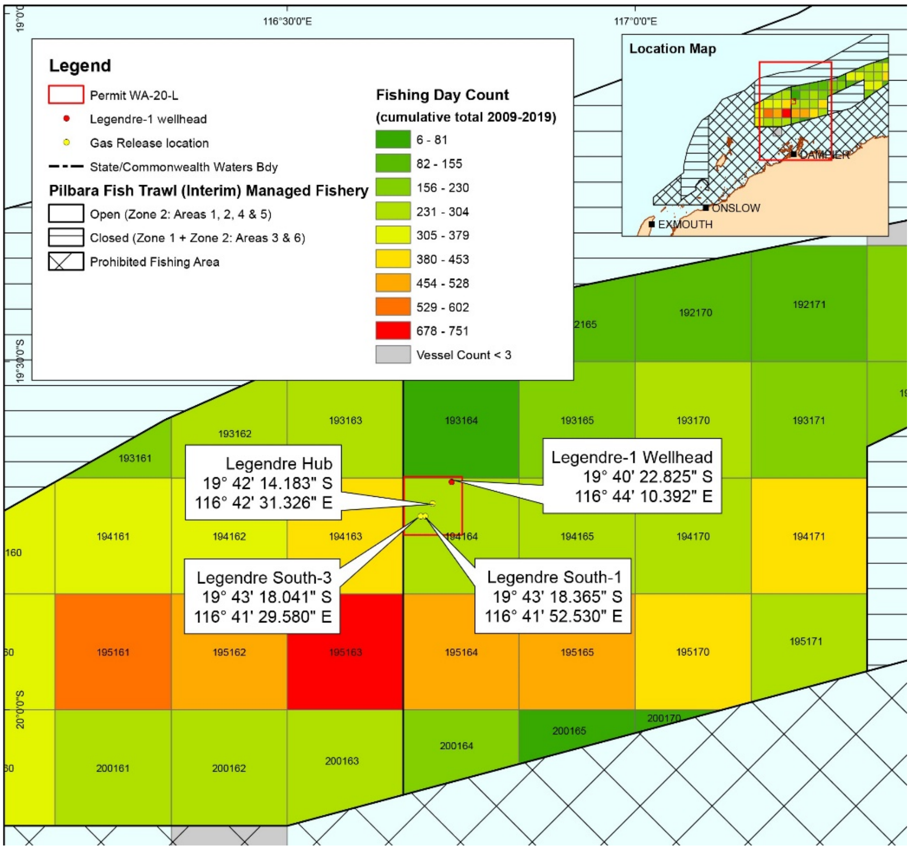


Figure 2. Trawling activity in the vicinity of the Legendre wellhead, which is located just east of the boundary between Fishing Area 1 and Area 2.
(Source: Santos)

Figure 3. Trawling activity in the vicinity of the Legendre wellhead. Note the wellhead position and exclusion zone is marked. Glomar shoal (central light blue patch bordered in black) is for the best part untrawlable ground. The red vertical line is the boundary between Fishing Area 1 and Area 2.
(Source: REDACTED)

Operators in the PDSF use three fishing methods, namely hook & line, trap, and demersal trawl (refer Fig. 4) to catch a wide range of demersal fish species. The former two methods are classified as passive fishing methods and rely on the fish coming to the gear for it to be caught, whereas the latter method is classified as an active fishing method and the gear approaches the fish for a capture event to occur. Static fishing methods are ideally suited for fishing around “structure”, and the gears used in the PDSF are no exception to the rule. Active fishing methods, such as trawling, may be susceptible to interactions with structure, depending on its physical nature and whether the gear has been designed for such interactions in mind. Wellheads and demersal fish trawl gear are generally incompatible and therefore in terms of commercial fisheries potentially affected by Santos’s Legendre wellhead, the Pilbara Fish Trawl Interim Managed Fishery (PFTIMF) as it is known, or Pilbara fish Trawl (PFT) for short, is the only one warranting further investigation.

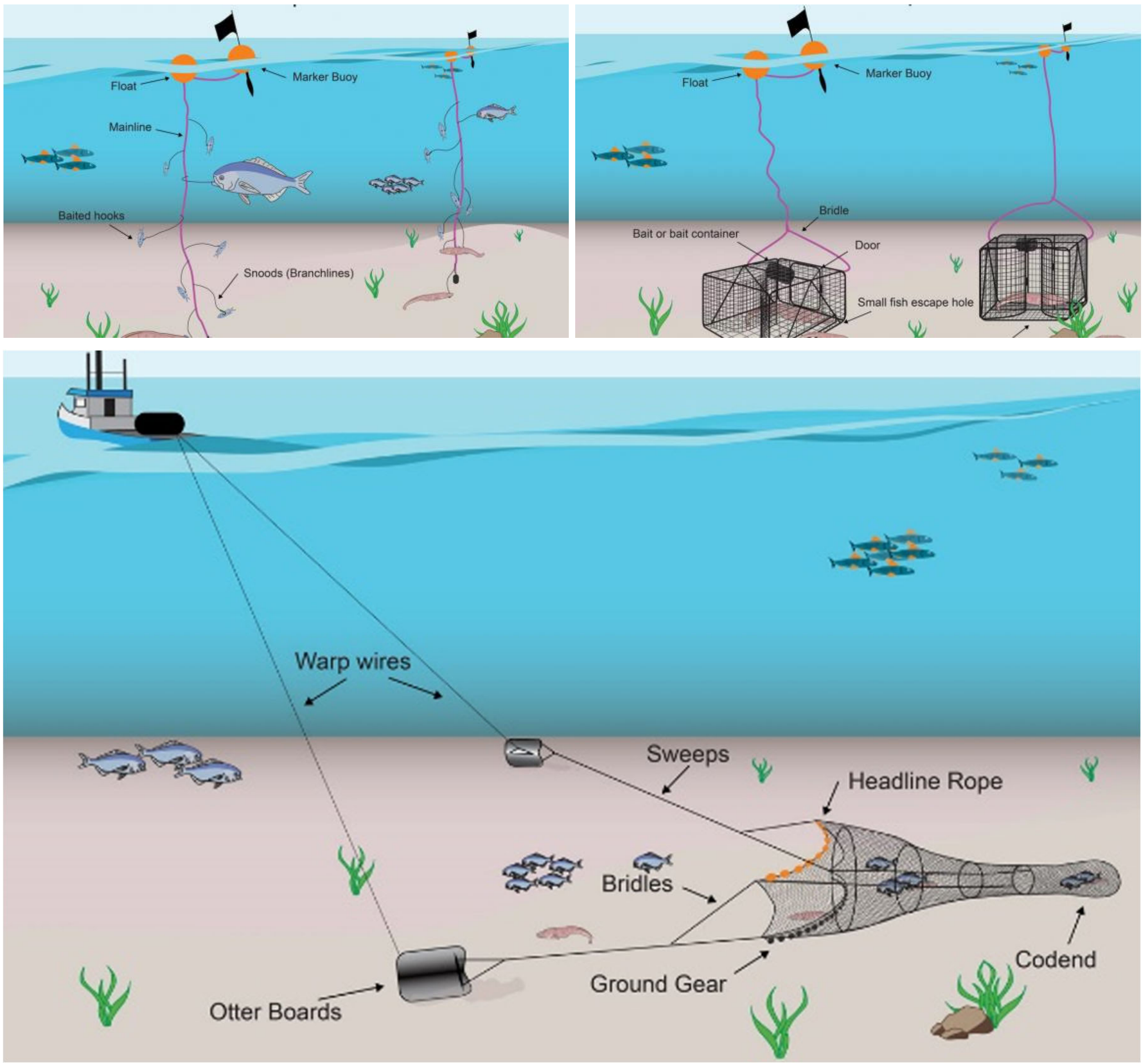


Figure 4. Hook and line (dropline) fishing (top left pic), trap fishing (top right pic), and demersal trawling (lower pic).
(Source: Australian Fisheries Management Authority, Canberra)

4.2 Relevant details on the Pilbara Fish Trawl (Interim) Managed Fishery

4.20 Fishery statistics

The PFT is accessible all year round, and operators typically fish 24 hours a day. Trip duration is normally between 5-10 days, with 15 to 23t of whole fish landed fresh (*i.e.,* unfrozen), usually in either Point Sampson (Karratha) or Exmouth, transported to Perth by refrigerated truck, and sold there (average price $5/kg so a 20t unload is worth approximately $100K). Annually fish production has been increasing in the last five years and is around 2,000 t (Newman et al 2020) and worth about $10m (based on an average price of $5/kg).

Fishing activity is constrained by fishing area (refer Fig. 1). Trawling is permitted in Areas 1, 2, 4, and 5, which equates to about 6900 nm^2 or 23,600 Km^2. The Legendre wellhead is located in Area 2, and with a 0.5 nm trawling exclusion zone, equates to about 0.00285 % of the available fishing area.

To distribute the fishing effort more uniformly across the fishery, a limited number of permits with a specific number of hours per area was implemented in 1997. This arrangement seems to be working well and is therefore unlikely to change in the foreseeable future.

The PFT is an "interim" managed fishery due to the need to continually monitor and assess the environmental impact trawling is having on the local environment i.e., the seabed habitat and Threatened, Endangered and Protected species (such as dolphin, turtle, and sawfish) located there. The review process is undertaken by the Department of Environment, with the WA Department of Primary Industry and Regional Development (WA DPIRD), fishing industry, and others, providing the necessary information to address certain conditions and allow a decision to subsequently be made regarding the continued usage of trawls in the fishery.

Some recent and favourable research regarding the trawling impact on habitat (Keesing et al (in press.)) and TEP species (Wakefield et al 2014; Wakefield et al 2016) will support the case for continuation of trawling in the PSF for a while yet.

4.21 Trawling effort in the PTIMF in close proximity to the Legendre wellhead

Trawlers operating in the PFT are essentially constrained to the 50 to 100m bathymetry, and even though the prescribed time allowances per Fishing Area serve to distribute that effort more evenly along the coast, there are factors such as:

- annual variation in fish distribution essentially caused by oceanographic and meteorological variation
- the presence of consistently productive trawlable hotspots
- area familiarity (which includes knowledge of potential hook-ups)
- operational considerations such as closeness to port, port accessibility, and port services,

which often cause the effort to become biased to one or two areas. Typically, Area 5 sees the least intense effort, while Areas 1 and 2 tend to be more intensely fished.

This historical bias in fishing effort indicates that the Legendre WH is in a high activity region of the fishery and is therefore very likely to have trawl gear working in the vicinity. Although Glomar Shoal where the wellhead is located is for the best part untrawlable ground (refer Fig. 3), so it is very unlikely to be approached by trawl gear.

4.22 Trawling effort trends including vessel numbers

As with a lot of Australia's fisheries, the PFT has also undergone major fishing effort reductions over the last three decades, and consequently the available permits that grant the holder a certain amount of fishing time (introduced in 1997) are fished each year by only three or four boats; a substantial reduction from the number of boats operating in the early 90's and beyond. Typically, the total time allocation across this fishery is not fished due to the preference for certain Areas (refer sect. 4.21 for more details).

The reduction in available fishing hours in the PFT following the implementation of the PFTIMF Management Plan 1997, together with reduction in vessel numbers, translates to less capacity in the fleet for exploratory fishing. In other words, the trend nowadays is for operators to go to known "trawl friendly" locations within a given Fishing Area that is producing good fish in that year. Some exploratory fishing remains (mainly the eastern end of Area 5) but that carries a degree of risk as this fishery does have some "trawl unfriendly" structure (i.e., small undercut limestone ledges partly covered by sediments). Note: the susceptibility of the trawl gear used in the PFT to this type of snag hazard is explained in section 4.29 and 4.30 below.

In summary, the PFT is a mature fishery with well-established fishing areas (one skipper refers to his fishing trips as "milk runs"), and the presence and location of long-standing trawl hazards such as the Legendre wellhead are known and avoided.

4.23 The PFT permit holders

The permit holders for the Pilbara Fish Trawl Fishery are based in Western Australia and listed below:

- MG Kailis Group (6 permits)
- Westmore Seafoods (5 permits)
- Kailis Brothers (2 permits)
- Iain Morrison (1 permit)

The first two companies are engaged in the actual fishing and usually have two vessels assigned to this task, although both vessels may not work in the fishery full-time. For example, MG Kailis utilises two trawlers, the FV Torbay (full-time) and the FV Portland Road (part-time). The latter works as a prawn trawler for the entire Exmouth Gulf Prawn Season (usually April – Nov), and then fishes in the PFT over summer on non-refit years. These four vessels are all very similar to one another.

4.24 The PFT fleet – FV Torbay

A prime example of a PFT trawler is FV Torbay, a 24.9m steel vessel, built as a prawn trawler in 1988 (Ocean Shipyards WA Pty Ltd), and subsequently converted over for fish trawling (refer Figs. 5 & 6). The structural and equipment modifications required to make the vessel more suitable for fish trawling included: closing in the main deck to create a cool fish handling room, adding several net drums on the raised deck, adding higher wire capacity winches below the main deck (i.e., internal), and adding a hopper with appropriate conveyor system and refrigerated sea water (RSW) tanks. Some additional wheelhouse electronics were added as well (refer sect. 4.43 for more details).

Figure 5. FV Torbay, an ex-prawn trawler converted for fish trawling in the PFT.
(Source: Fishing Untangled Pty Ltd.)

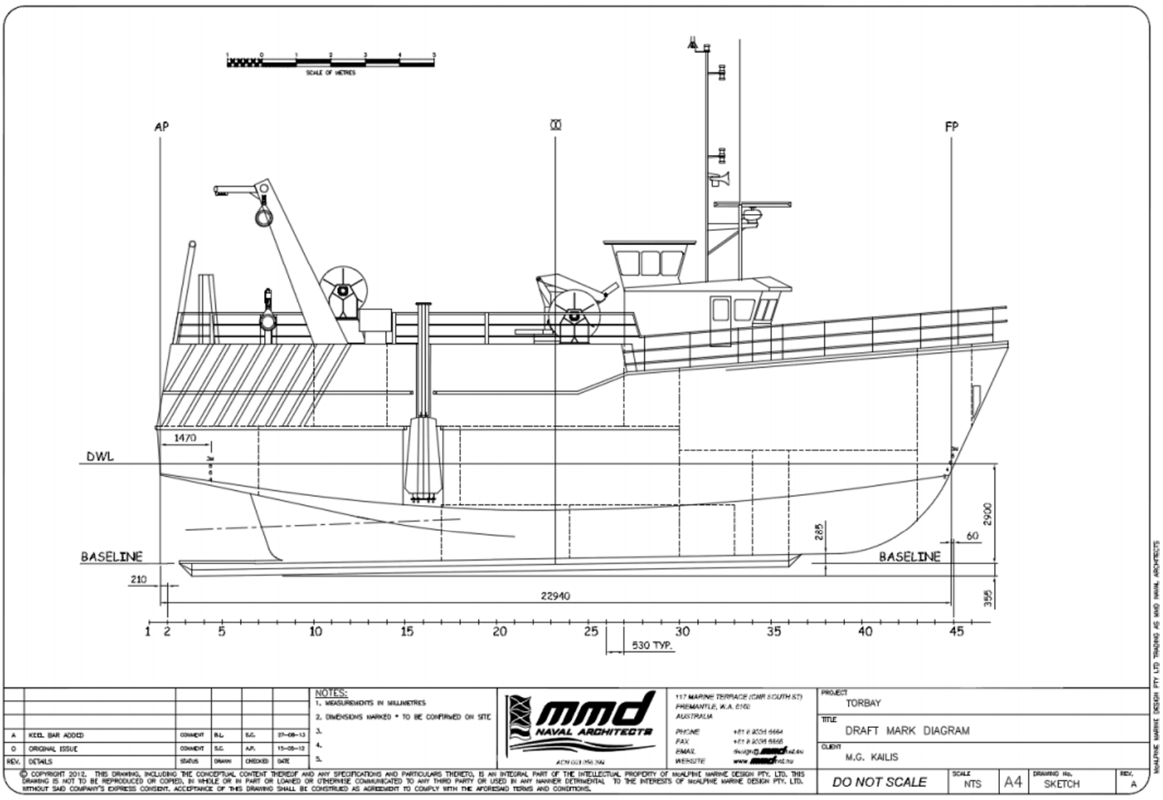


Figure 6. FV Torbay.
(Source: MMD Naval Architects - FV Torbay Stability Booklet)

4.25 The "dated" PFT fleet

The four trawlers operating in the PFT have been fishing for about three decades, so they are "dated" vessels (in terms of construction). However, even though these vessels are relatively old, their equipment and systems (i.e., propulsion, refrigeration, electrical, pumping, fuel, catch handing and processing, navigation) are continually being upgraded/altered in response to changes in fishery requirements/regulations, safety/survey regulations, fuel prices, and fish marketing opportunities etc.

Figure 7. FV Portland Road. A 24m steel trawler that works full-time as a prawn trawler, and opportunistically fishes part-time in the PFT.
(Source: Fishing Untangled Pty Ltd)

4.26 Differences between PFT trawlers

The four trawlers operating in the PFT are very similar in all of these areas:

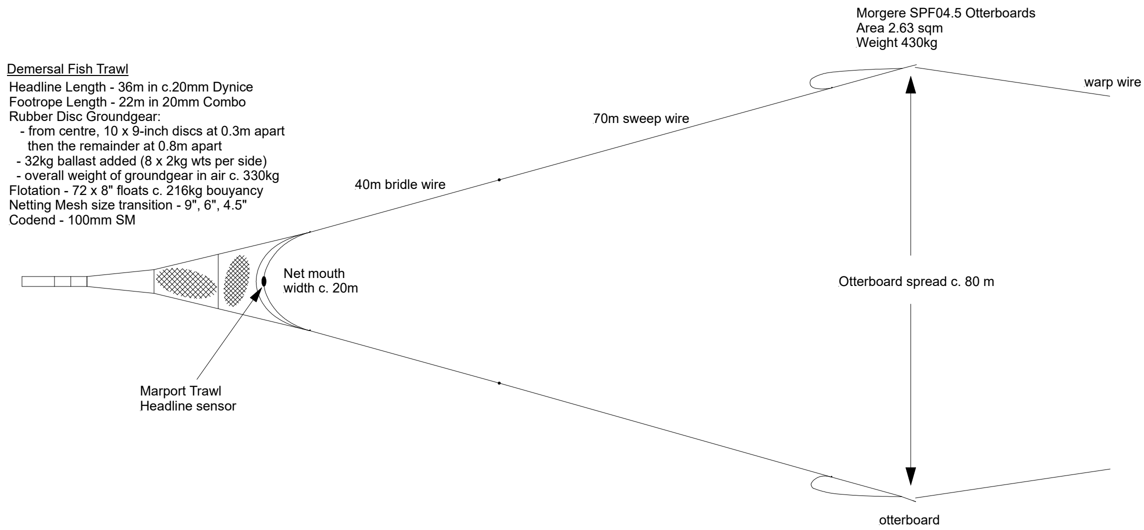
- vessel size
- wheelhouse navigational electronics
- vessel propulsion
- winch system
- vessel management system

Appearance wise though there are some differences, as the FV Portland Road has an open back deck, unlike the FV Torbay and Raconteur 2 for example.

Stability-wise there may also be subtle differences between these vessels due to differences in mass distribution and shape. These differences influence the magnitude and relative position of the centre of gravity and centre of buoyancy, which ultimately influence the vessel's stability i.e., its ability to right itself when acted upon by an external force that influences its orientation. All four vessels operating in this fishery have passed their stability checks as part of the AMSA survey process. These tests include and consider hookup events occurring when the vessel loading condition is sub-optimal.

4.27 Fish trawling gear description

The fish trawlers in the PFT all use very similar gear, with the nets supplied from the same net maker (Neptune Trawls). A typical configuration is depicted in Fig. 8. The purpose of each gear component is described below.



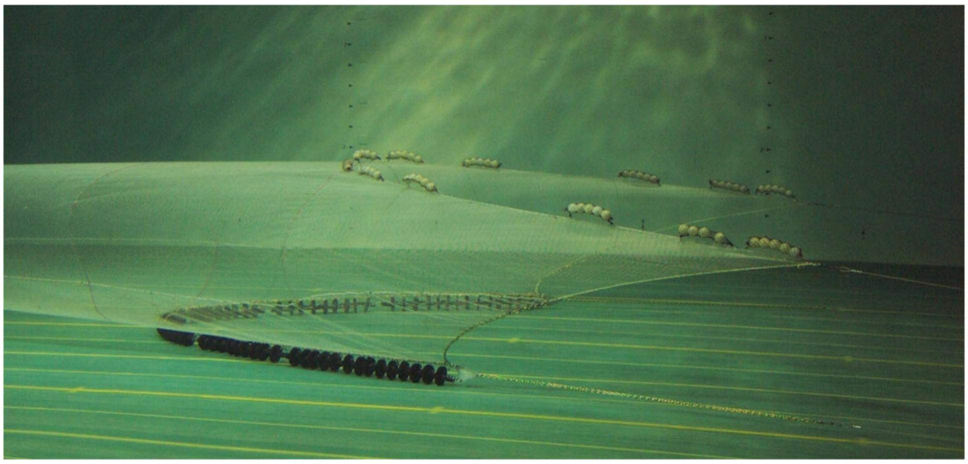


Figure 8. A plan view of a typical Pilbara fish trawl system (upper pic), and a side view (lower pic) of a 1/10th scale model being streamed in a flume tank (circulating water channel).
(Source: Fishing Untangled Pty Ltd.)

Otterboards: - produce a lateral spreading force to open the net up laterally, and to maintain this opening during the tow. They also provide a substantial amount of the ballast required to keep the trawl gear on the seabed during the tow.

Sweep wire: – a single length of wire that connects the otterboard to the wingtip of the trawl net via the bridle. It also serves to herd fish into the path of the net by dragging across the substrate at an angle and driving fish inwards. Good ground contact is essential for the herding process to be effective. Note: a skipper will gauge how good the contact has been during a tow by how polished this wire is when the gear is recovered; ideally it should have a chrome like appearance.

Bridle: – a forked (two leg) wire arrangement that connects the sweep wire to the upper and lower wingtips of the net. The lower bridle leg, being a continuation of the sweep wire, also serves to drive fish into the net mouth. The upper bridle leg also assists as well in a visual way. Similar to with the sweep, a well-polished lower bridle when the gear is recovered confirms that good ground contact was maintained during the tow.

Net: – a tapered cone of netting that serves to guide fish into the end part (codend) as it travels through the water. The net mouth is opened laterally (about 20m) by the otterboards, and vertically (3-4m) by the addition of floats along the upper frameline (headrope) connected to the leading edge of the netting. To keep the lower part of the net mouth near the seabed, but just clear of it to avoid damage, a series of circular rubber discs threaded onto a wire (referred to as the ground-gear) are connected at intervals along the lower frameline with shorts lengths of chain (refer Figs. 8 & 9). This rubber disc ground-gear provides the means to trawl over hard flattish seabed, and to ride over obstacles as well (up to a certain size) and allows a lot of unwanted small debris/organisms (e.g., starfish, shell, sponge, rubble) to pass under the net.

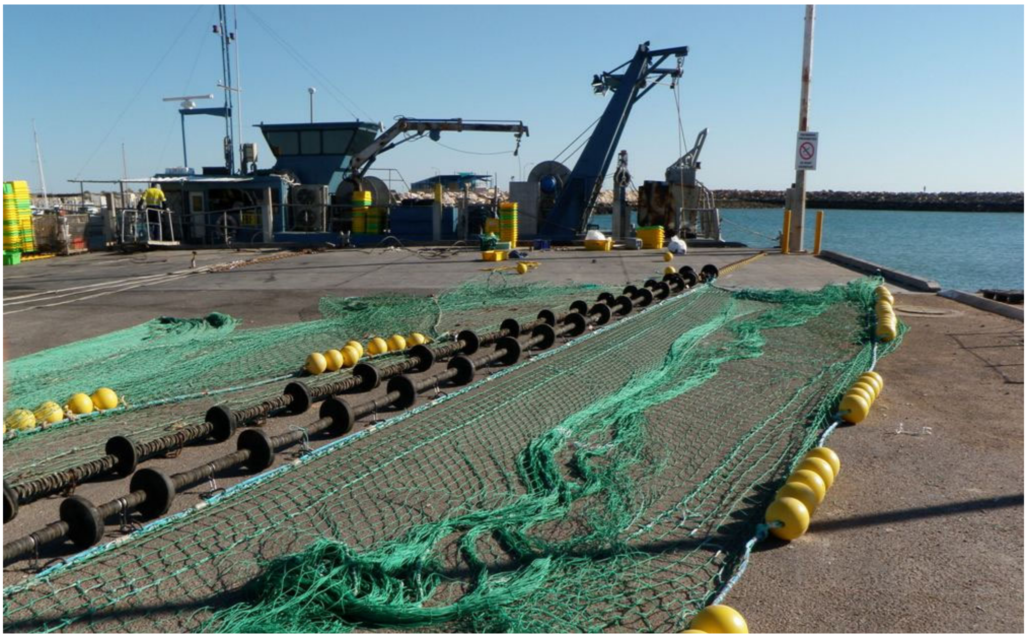


Figure 9. A PFT trawl net stretched out for repairs, showing 10-inch rubber disc ground-gear and clusters of 8-inch pneumatic floats attached to the lower (footrope) and upper (headrope) framelines respectively.
(Source: Fishing Untangled Pty Ltd.)

4.28 Fish trawling operational procedure

The time limit placed on trawling in each Area of the PFT means that operators entering a given Area will normally fish continuously i.e., trawl around the clock. Most of the tows on a trip will be about three hours in duration, although sprinkled amongst these are usually some shorter ones called “target shots” on fish marks (schools). The latter tows can be very productive and press the boats fish-handling capacity to the limit. Target shots may be done in a demersal or semi-pelagic trawling mode; the latter is when the otterboards and some portion of the sweep are not in ground contact.

Trawl speeds are usually between 3-4 knots (1.54-2.06 m/s), although due to tidal current being relatively strong in this region, the actual speed over ground may range between 1.5-5.5 knots (0.77-2.83 m/s) depending on whether it is an unfavourable or favourable current. As a rule, trawlers avoid towing with a side current acting as it affects the gear’s symmetry and has a detrimental effect on the catching efficiency.

4.29 Ground-gear configurations

The way that the ground-gear is configured on a fish trawl plays a big a part in what sized obstacles the net may pass over with negligible damage. Larger (diametric) discs provide more capacity to ride over larger obstacles, and the inclusion of cylindrical and spherical bobbins enhance things further again. Understandably, heavy duty ground-gear is expensive, makes the gear more difficult to handle, and causes excessive disturbance to the seabed habitat. For these reasons, trawler operators will, over time, gravitate to the smallest discs possible for the obstacles typically encountered.

Trawlers in the PFT primarily use 10-12 inch rubber discs and are not allowed to use discs larger than 350mm (c. 14-inch).

One misconception is that this ground-gear ploughs the seabed. In fact, the gear weighs about 330kg in air, but only about 110kg in water, and with the tension running through the ground wire whilst trawling, coupled with the uplift from the floats on the headline, the discs actually just skip lightly across the seabed. The goal being to just have enough contact to create some sand cloud and thus discourage fish from passing through the spaces under the footrope of the net. Some experienced skippers may even hang one or more lengths of rusty chain from the central region of the footrope as a means to check (by the polish on the last few links) that the discs are in fact contacting the seabed during the tow.

4.3 Trawl gear interaction with Legendre wellhead

4.30 Ground-gear/obstacle interactions

It is surprising what rubber disc gear will pass over in the way of obstacles on the seabed. Convex shapes protruding from the seabed up to 1m are not such a problem, whereas undercut objects are, since the relative size of object to that of the disc gear will largely govern whether the object is scooped into the net or overridden.

Making the net capable of riding over largish obstacles is only part of the challenge, and arguably the easier part, since it is the sweep and lower bridle wires dragging over the seabed that are more prone to getting caught on undercut fixed or heavy obstacles. With small to medium sized rocks, and most large sponges, the wire will pass underneath without too much difficulty. However, when the object is unable to shift i.e., an undercut ledge, bommie (more correctly bombora) or a wellhead, then the wire will run along the object, disrupting the gear symmetry, and eventually the half-bobbin located at the end of the bridle will interact with it (refer Fig. 10).

Figure 10. The lower wingtip of a PFT trawl net showing the rubber half bobbin (extreme left) that serves to protect the connection tackle and ”hard eyes” located at the terminal end of the ground-wire (upper wire), bolsch-line (middle blue combo rope) and footrope (lower wrapped combo rope) from interactions with seabed obstacles.

(Source: Fishing Untangled Pty Ltd)

What happens next can vary from the half-bobbin causing the wire/ground-gear to skip over the obstacle, to the lower bridle or connecting tackle failing/breaking and the obstacle passing by the outside of the net, to the lower bridle/ground-gear not breaking and the trawler decelerating and coming to a standstill (i.e., hooked-up).

4.31 Likely outcome of an interaction

The pictures taken of the Legendre wellhead (refer Fig. 11) show a strong semi-intact metal frame structure with relatively upright sides. It is very unlikely therefore that a demersal fish trawl coming into contact with this structure will ride over it. The most likely outcome is that the gear will come fast and some portion of it will have to be left behind once the vessel frees itself. Typically, in this depth of water (c.50m), a part of the net possibly with some wires connected, will be left behind on the snag. The reason for this is that the length of the sweep and bridle combined is 110m, which means when the gear comes fast on a snag, it is possible for the skipper to winch back over the gear and more often than not recover both otterboards with the net still snagged on the seabed. The sweep wires are then disconnected from the otterboards and transferred onto the net drum so that they can be wound on until taught. The rest of the procedure is discussed below in sections 4.50 - 2.

Figure 11. The Legendre Wellhead.
(Source: Santos & Intervention Engineering)

4.32 A fish trawl system and its spanwise limitation

A typical fish trawl system used in this fishery was described earlier (refer Sect. 4.27) and given an average otterboard span of 80m (refer Fig. 8) based on advice from P.Henderson (skipper FV Torbay). In reality this is always changing depending on water depth and other variables, such as the trawl speed, catch in the codend, wire to depth ratio used and how the otterboards are rigged and the orientation they adopt whilst trawling. An upper limit would be about 100m, and this would most likely be achieved in the deeper water.

Greater otterboards spreads would necessitate using longer sweeps and/or bridles (i.e., greater than 70 and 40m respectively). However, to constrain fishing effort in this fishery there are gear regulations that limit bridle and sweep wire to these lengths. So, in other words, on most occasions when trawlers in the PFT are working nearby to the Legendre wellhead, their gear will extend laterally about 40m either side of the vessel's centre line or path, unless a side current is acting and/or a turn is being made.

4.33 Swept area performance of a PFT system and the impact of a 0.5 nm exclusion zone

In a single day's trawling (based on 18 hours of bottom time), a PFT trawl system with an 80 m otterboard spread towed at a moderate speed (3.5 knots or 1.80 m/s) will cover:

$$span \times speed \times duration = 80 \times 1.80 \times (3600 \times 18) = 9{,}333{,}999\ m^2 \text{ or } 9.33\ km^2 \text{ or } 2.72\ nm^2$$

The total area available to trawling in the PFT (refer Table 1) amounts to 6900 nm^2, although due to bad bottom and unproductive area, the actual area trawled is much lower than this.

Based on these figures it would take a trawler 2535 days to trawl this 6900 nm^2 area if nil overlap occurred.

The circular area associated with a wellhead 0.5nm exclusion zone, equates to 0.196 nm^2(refer Table 1), which was just over 0.07 % of what a trawler covers in a day, and 0.00285 % of the total trawlable area in the PFT. In other words, the likelihood of an interaction between a trawler and the Legendre wellhead, even if its position was unknown, is very unlikely.

The displacement effect on trawlers not being able to trawl within 0.5 nm of the wellhead, was in the scheme of things a very small impact on trawling options. For example, even when the exclusion zone area (0.196 nm^2) was related to that of Area 2 (1800 nm^2), it still only equated to just under 0.011 % of that area, and even if the trawlable area of Area 2 was reduced to one half, we are still only talking about just under 0.022 %. In other words, a very insignificant proportion of the trawlable area.

Table 1. Area coverage analysis for 0.5 nm wellhead exclusion zone relative to daily area trawled by a single representative PFT trawler and certain Areas within the PFT.

Parameter	**Area**		
	m²	**Km²**	**nm²**
Single trawler swept area per day	9,333,999	9.33	2.72
Area 1			1300
Area 2			1800
Area 4			1500
Area 5			2300
Total trawlable area in PFT			6900
0.5nm wellhead exclusion zone			0.19635
number of days to trawl PFT once	2535		
Exclusion zone (0.5 nm) area as a percentage (%) of:			
daily swept area	0.0722 %		
PFT total trawlable area	0.00285 %		
Area 2	0.0109 %		
adjusted (50% trawlable) Area 2	0.0218 %		

In summary, the resultant findings from the analysis above were:

- Even if the position of the wellhead was not marked on the trawler's plotter, the likelihood of a fish trawl – Legendre wellhead interaction occurring was negligible, due to the vast expanse of the fishery and the relatively small area swept by the trawl gear each day.
- The presence of an 0.5 nm exclusion zone represented a very small percentage of the total area available to trawlers in the fishery (i.e., just under 0.003%, or 0.011% of Area 2).
- The wellhead exclusion zone was located in an area that is essentially untrawlable (high risk of gear damage/loss) using PFT trawl gear (refer Fig. 3).

And given that fish do migrate from closed fishing areas into open fishing areas, then the potential impact of a long-term exclusion zone on the catch income and profitability (via gear damage and associated downtime) of PFT trawlers was considered to be negligible.

4.34 Avoiding a trawl gear interaction with the Legendre WH – sharp turns

Sharp turns are generally avoided whilst trawling, since it may cause an otterboard to fall over and/or tangle the gear up. If the trawl gear is equipped with a trawl monitoring system, which provides the operator with key information on the net spread and otterboard orientation in almost real time (< 5 second delay), then sharper turns are always possible (refer Fig. 12).

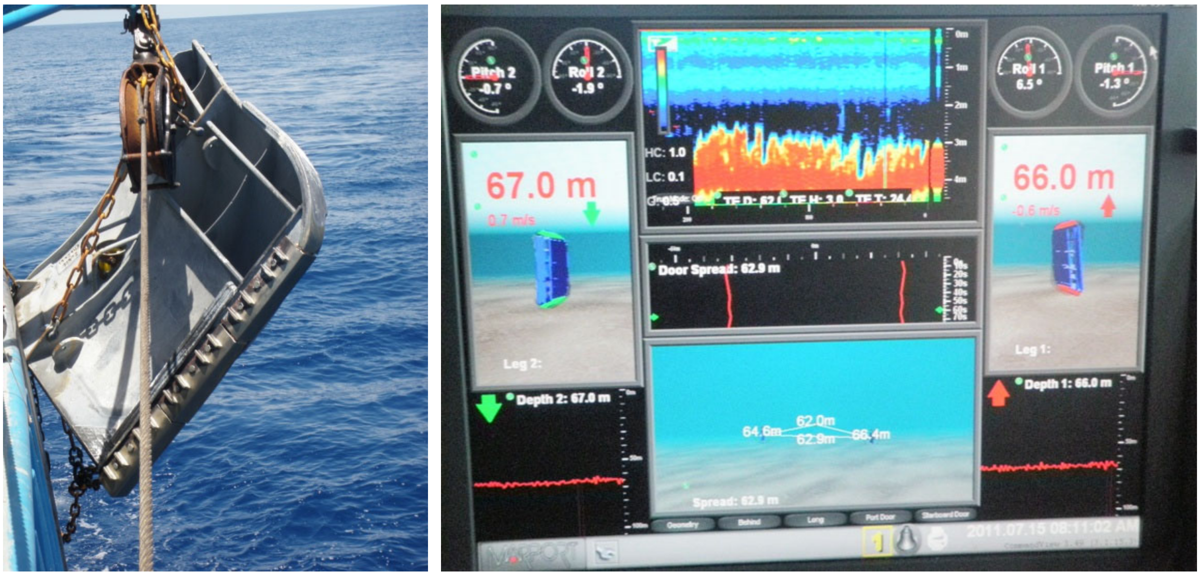


Figure 12. Marport board spread sensor (just visible; yellow in colour) inside a sensor pod on a Thyboron otterboard (left pic), and output data from the Marport Trawl Monitoring System otterboard sensors and headline sensor (right pic).
(Source: Fishing Untangled Pty Ltd.)

To avoid an obstacle detected on the echosounder (i.e., below, or abeam of the vessel) an operator need only do a 90 degree turn. In relation to the Legendre wellhead located in 50m of water, a trawler passing overhead would have the otterboards some 200m astern of the vessel (i.e., based on a wire to depth ratio of 4:1), which is ample distance to undertake a low-risk 90 degree turn and have the trawl gear pass on the inside of the wellhead, even if unfavourable seas and current are in effect. Noting that under these more challenging circumstances the trawler operator would most likely turn to the side that is easiest. However, if the operator is unfamiliar with the ground and its possible obstacles, then he/she may opt to play it safe and winch the gear up instead, since the echosounder is unable to warn the operator of obstacles in the path of the gear during a turn. This winch-up option may also be conveyed to the watch-keeper (crew-member) as the only option by the skipper when he/she is not at the helm.

4.4 Vessel technology for avoiding navigation hazards whilst trawling

4.40 Introduction

The following sections provide a description of the technology (wheelhouse electronics) available to fish trawlers to avoid navigation hazards whilst trawling, such as the Legendre wellhead. Firstly, a general description of the standard wheelhouse electronics is provided. This is then followed by the technology that would be utilised on a 'fully-equipped" vessel with nil budgetary constraints. Lastly, a comparison is made between the four trawlers operating in the PFT, namely the FV Ocean Raider, FV Raconteur, FV Torbay and FV Portland Road, and the "fully equipped" trawler, and the observed differences are discussed.

4.41 Wheelhouse electronics for trawling – Standard setup

Most modern fish trawlers will have at least the following wheelhouse electronics, such as:

- Global Positioning System (GPS)
- chart plotter
- radar

- Automatic Identification System (AIS)
- PC plus chart software (*e.g.* Max-Sea Time Zero)
- VHF/UHF radio
- Echosounder (single beam)

This equipment provides the trawler operator with all the information required to navigate safely around hazards on the seabed.

Radios can be used for communicating warnings/alerts to fishing vessels at short notice, including newly discovered hazards on the seabed that may cause a hook-up and/or gear damage and/or downtime.

The GPS plotter and *PC-based chart software* enable seabed obstacles to be marked accurately and quickly on detailed hydrographic charts, and by also displaying the vessel's position accurately, enable operators to safely navigate amongst these obstacles.

Echosounders and *sonar* give the vessel operator a means of detecting obstacles on the seabed, as well as add bathymetric and seabed hardness data to their charts.

PC-based chart software programmes such as Max-Sea Time Zero have enabled hydrographic charts to be overlayed with real-time output data from *GPS plotter*, *echosounder*, *radar* and more recently *AIS*. This integration capability has enhanced fishing vessel navigation significantly, and most trawlers nowadays run Max-Sea or similar products (Piscata, Sea Plot) for this reason.

Wheelhouse electronics with better capability have also become a lot more affordable over the last few decades, and consequently even small to medium sized coastal trawlers, now have an exceptionally good navigational capability, including navigating safely whilst trawling around marked obstacles such as wellheads.

4.42 Wheelhouse electronics for trawling – "Fully equipped"

The type of electronic equipment you may find on a "fully equipped" modern fish trawler with no expense spared is provided below:

Global Positioning System (GPS)

- 2x Certus Evo with BD992 (GPS, GLONASS, L-band and 30cm RTK), 2x Trimble GA830 - L1/L2/L5 plus L-band, pole mount, TNC Female Connector, 10m LMR400 Cable with connectors, UDP NMEA Multiplexer, Isolated DC-DC converter Retail
  [Price $57,970.42 inc GST]

Radar

FAR-2228-NXT-BB SOLID-STATE X-BAND BLACK BOX RADAR (DC Version) - Display not included
Comprising:

- PROCESSOR UNIT RPU-025-BE2S-S 1 unit
- SCANNER UNIT RSB-128-123NN 1 unit
- CABLE ASSEMBLY RW-00135-L30M 1 unit
- CONTROL UNIT RCU-014B-E-S 1 unit
- STANDARD SPARE PARTS AND INSTALLATION MATERIALS INCLUDED
- ANTENNA RADIATOR ASSEMBLY XN24CF

- HATTELAND 26T22MMDMA1-FOGA 26" Series X LCD Display 24VDC/230VAC Wide Screen LCD 1920 x 1200
  [Price $77,000.00 inc GST]

Automatic Identification System (AIS)

- FA-170 AIS c/w GVA-100 GPS/VHF Combined Antenna GVA-100, Distribution Box DB-1 for GVA-100
  [Price $10,131.25 inc GST]

Chart Plotter- PC plus chart software

- 2x VECOW Fanless MX TimeZero PC - Multiple Display Installations with isolated power supply
- TimeZero Professional Chart Plotting software V4 with PBG, WASSP interface, Single beam interface, Marport interface and Chart Included)
- 4x Industrial Network Switch's with isolated power supply
- 4x 24" Series X LCD Display Wide Screen FURUNO Hi Bright LCD 1920 x 1080 with desktop mount
  [Price $68,850.00 inc GST]

Communications

- 2x FM-8900S 25W VHF with colour 4.3" LCD, built-in DSC & CH70 Watch c/w HS-2003 and Antenna with 10m cable
- SAILOR Fleet One Terminal (includes ADU, BDU and 10m antenna cable), Handset
- SAILOR 6150 Non Solas Distress System with TT3027 Terminal; TT6194 Terminal Control Unit Standard accessories,
- CEL-FI GO TELSTRA MARINE PACK, ADHESIVE MOUNT and Extra Antenna with 10m cable
- TELTONIKA RUTX11 3G-4G CAT-6 ROUTER WITH WIFI / GPS / BLUETOOTH
  [Price $22,673.40 inc GST]

Communications 2

- Intellian V60E Antenna System 6W
- iDirect x7 Modem
- IP Signature 4 Dual Board Router
- TP Link – TL – SG1008MP 8 Port POE switch
- Eaton 5P1150iR – 1150va UPS (1U)
- Grandstream GXP 1620
- Jackson 6 outlet rack mount power supply
- SWS6606F 19" x 6RU x 600 mm deep server cabinet
- Consumables / patch leads
  [Price $30,250.00 inc GST]

Echosounder (single beam)

- Furuno FCV-1150 with two transducers. 200B-8B (200khz 2Kw) and 50BL-12HR (50Khz 2Kw)
  [Price $13,603.40 inc GST]

Multi-beam sounder

- WASSP F3X 4340F3X 9-32vDC 160kHz Wide Band multibeam sonar incl DRX46 processor & 160kHz transducer with 10M cable
  - Includes modules
    - Backscatter - Seabed classification / Bottom Hardness
    - Water Column Targets - visualisation of objects in the water column
    - SideScan Presentation

- Time Zero Software interface
- WASSP CDX Operating Softare - User Interface
- RTK Tides - automatic tidal correction using RTK GPS
- Advanced Key Pulse sofwtare license
- Interference Management Software (IMS) license

[Price $61,298.00 inc GST]

Sonar

- CH-600 85-215kHz 12.1" Display 24VDC, 8 inch soundome 400mm Travel w/out cable & shaft
[Price $41,019.00 inc GST]

Low light camera with the thermal image providing enhanced identification for safety

- M-Series M364C Thermal 640x512 30Hz 24° FoV & Colour Low Light HD Pan & Tilt Camera - JCU2 Kit (incl JCU, cover, PoE Injector, 8mtr Ethernet cable)
[Price $35,145.00 inc GST]

Trawl monitoring system

- M5 Mbar Receiver w/ accessories
- Marport MAC MINI (second generation-010219) w/ Accessory Rack, includes Scala software - FULL VERSION, USB-C Video interface, wireless trackball, power and interface cables, and PoE for 110/220 Vac
- Hydrophone Interconnect Junction box
- 2x NHT (active) Broadband - 30 to 60 Khz - 35 x 55 w/ 25 meters cable
- 1x NHT (passive) Broadband Hydrophone 35x55 w/ 25 meters cable
- 3x Steel Thru-Hull penetration
- A2 (XL) Trawl Explorer UDO echo w/ RPO, Depth, Temp, and Vbat includes target strength echogram/auto range
- A2 Door Sensor 144 KHz w/ RPO, Depth, Temp, and Vbat
- 2x 24" Series X LCD Display Wide Screen FURUNO Hi Bright LCD 1920 x 1080 with desktop mount
- 3x Basic II Fast Charger (110/220 Vac), single sensor

Price $149,512.83 inc GST

Autopilot

- NavPilot 711C Autopilot complete (less Heading Sensor)

Price $4,356.00 inc GST

Note: A full description of these products is provided in Annexure B.

Evidently the “fully equipped” fish trawler has in addition to the standard equipment:

- a multi-beam echosounder
- a trawl monitoring system (TMS) with 3D trawl positioning capability
- a sonar
- a current profiler (details not available)

Details and specifications for this high-end equipment are provided in Annexure A.

The benefits of having this extra wheelhouse electronic equipment are discussed below. Although it should be mentioned here that as a rule, high-end equipment provides much more functionality and much better quality output data. In some cases, this extra capability can translate to detecting a seabed obstacle in the path of the towed gear that would have otherwise gone undetected, or knowing where an obstacle lies relative to the towed gear astern of the vessel and avoiding coming fast.

4.43 Wheelhouse electronics – PFT trawlers

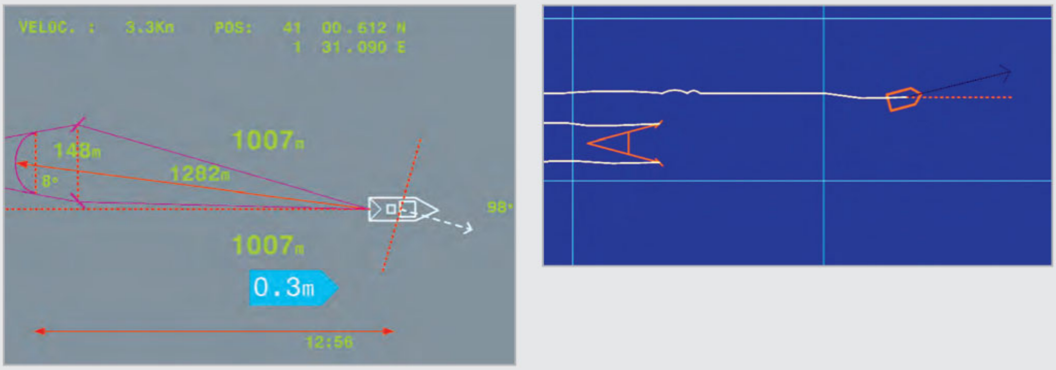
Trawlers in the PFT are not as well-equipped as the "fully equipped" example above, although they do come close in terms of having most of the equipment but not as sophisticated/high-end.

A review of the wheelhouse electronics present in the four vessels operating in the fishery, namely FV Ocean Raider, FV Raconteur, FV Torbay and FV Portland Road, revealed the following differences (refer Table 2).

Table 2. Wheelhouse electronics utilised by the four trawlers operating in the PFT to avoid interactions with seabed obstacles whilst trawling.

Item	**FV Ocean Raider**	**FV Raconteur**	**FV Torbay**	**FV Portland Road**
Echosounder (single-beam)	Yes High end (ES 80)	Yes High-end (ES 80)	Yes Mid range	Yes Mid-range
Echosounder (multi-beam)	Yes WASSP	No	Yes WASSP	No
Sonar	No	No	Yes Low end	Yes Low-med end
Trawl Monitoring System	No	Yes (Simrad)	Yes (Marport)	Yes (Marport)
3D Trawl Positioning	No	Yes	Partial	No
Satellite compass	Yes	Yes	Yes	Yes
Integrated GPS plotter, AIS, seabed mapping soft.	Yes	Yes	Yes	Yes

These w/electronic differences between the four PFT trawlers were partly due to the FV Portland Road and Raconteur 2 only working part-time in the PFT and having to also operate in other fisheries through the year with differing wheelhouse electronic requirements. For example, the FV Raconteur 2 spends some time trawling in deeper water (300 - 400m) hence the need for the Simrad Trawl monitoring system with proven 3D trawl positioning capability (refer Fig. 13). Although having such capability in the PFT with its strong currents is also advantageous in terms of knowing where the trawl gear is relative to the vessel, especially when navigating around marked or known obstacles.



In a bird's-eye view it looks like the trawl is on the port side and the warps are giving the same information when the skipper looks at them. In order to make a solid decision of where the trawl is, the skipper has to look at the COG and the heading of the vessel.

Placing the information on a chart plotter, the situation can be the opposite of what was initially thought. Here it is clear that the trawl is on the starboard side as a plotter records history and only plots COG.

Figure 13. Simrad ITI system showing a more accurate representation of the trawl net relative to the trawler once all the available data is plotted.
(Source: www.kongsberg.com/maritime/products/commercial-fisheries/cm_systems/iti)

In summary, all four trawlers operating in the PFT are very capable of trawling safely around marked obstacles such as the Legendre wellhead.

4.44 Wheelhouse electronics – Multi-beam echosounder obstacle detection

Multi-beam echo-sounders like the WASSP are expensive (c. $80K+ installed), however, they are becoming very popular on trawlers as they provide a much greater and effective swathe compared to single-beam transducers, enabling much smaller obstacles and fish to be detected much further afield laterally. This improvement comes about from the array of overlapping narrow beams transmitted laterally from the multi-faced transducer.

A single-beam transducer on the other hand operating under ideal conditions (calm seas, uniform seawater properties, clear flat seabed apart from the obstacle) would struggle to detect a 2m high object located further afield than 12m abeam (based on the object needing 0.5m of extra height above the seabed echo to be detected; in other words, a height of 1.5m in Fig. 14) of the vessel when trawling in 50m. Therefore, under ideal conditions a single-beam ES will only sweep 22% (i.e., footprint lateral width/overall gear span = 24/80 = 0.3 or 30%) of the trawl gear span, and under poor conditions, if the obstacle detection height fell to 1m, only 25% of the gear span is covered. The possibility therefore of a large obstacle passing by undetected and interacting with the trawl gear is relatively high, hence the attraction of the WASSP or a similar multi-beam system, or sonar for that matter.

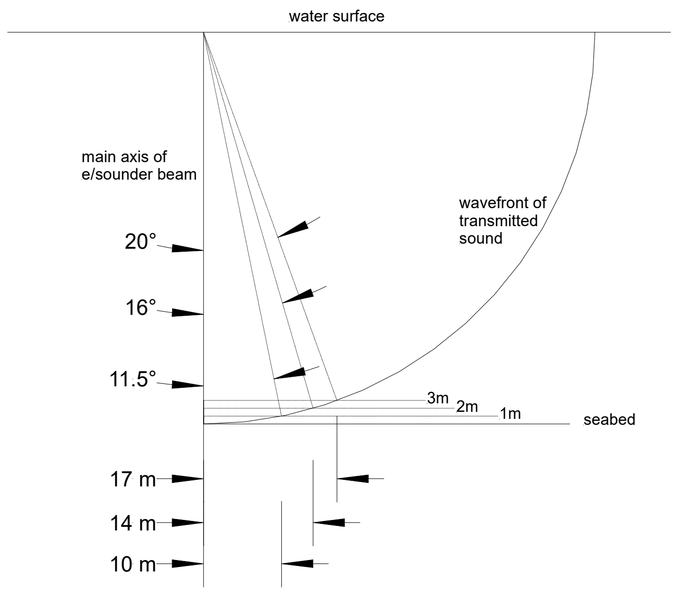


Figure 14. Lateral footprint dimensions and beam angles corresponding to three object heights (1, 2 and 3m) above the seabed for a transmitted echosounder beam in 50m of water.
(Source: Fishing Untangled Pty Ltd. johnwakeford@fishinguntangled.com.au)

Output data from the WASSP system can be used to enhance pre-existing charts with a much greater level of detail (resolution and hardness), (refer Fig. 15) making navigation around obstacles much safer. A WASSP system also enables the skipper to keep a watchful eye on his/her normal productive runs for any new obstacles subsequently appearing. Furthermore, unless a vessel has some sort of wheelhouse electronic equipment failure there is no reason why under ideal conditions (flat seabed, calm seas) a competent skipper/crewmember could not detect a large 2-3m high unmarked obstacle lying in the path of PFT trawl gear.

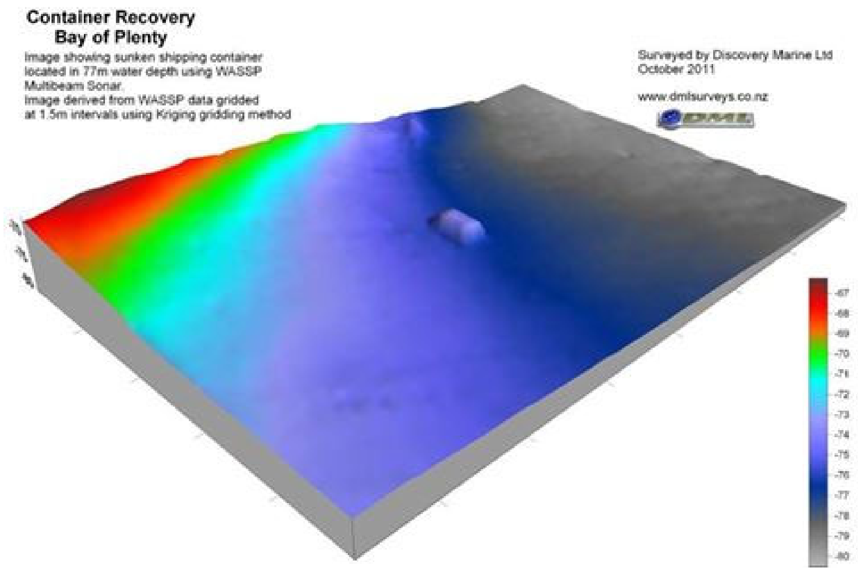


Figure 15. A seabed profile chart created using a WASSP system. Present in clear view is a sunken sea container lurking in wait for an unsuspecting trawler. Water depth 77m.
(Source: WASSP Multibeam website- https://wassp.com/)

4.45 Wheelhouse electronics – Sonar obstacle detection

Sonar systems also have a similar capability as the multi-beam sounder in terms of revealing obstacles abeam of the vessel, and also provide some insight as to what may lay ahead of the vessel as well. However, as a rule the resolution of the sonar image is not as good as the WASSP, unless a real top end sonar system (c. $300K) is used, noting that the sonar on the PFT trawlers is just above entry level. Vessel sonar is particular good for ascertaining seabed slope/shape, detecting patches of hard bottom, fish marks and larger obstacles, as well as monitoring the position of such targets relative to the moving vessel.

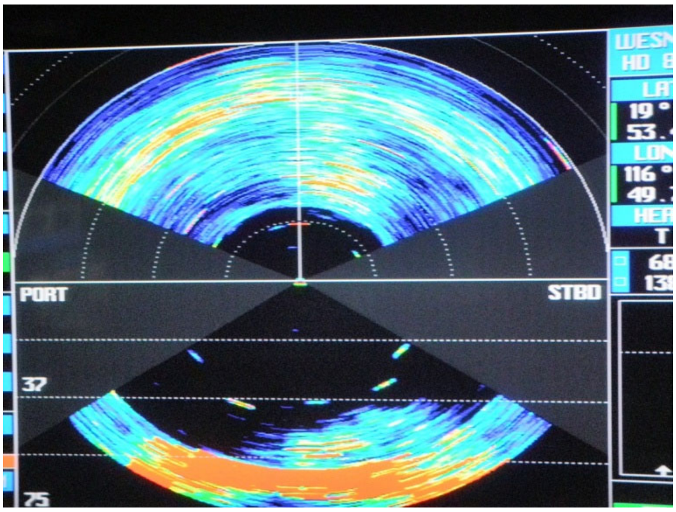


Figure 16. Sonar output from the Wesmar 8-inch unit on FV Torbay. Top of pic is showing the view ahead of the vessel, while the lower portion of the screen is displaying below and abeam of the vessel, with a fish mark off to starboard. Note the scale on the left showing the range from water's surface to 75m. Detecting a 1m high obstacle on the seabed with this system is therefore beyond its resolution.
(Source: Fishing Untangled Pty Ltd.)

4.46 Wheelhouse electronics – Trawl monitoring systems

As highlighted above in Table 2, a hydroacoustic trawl monitoring system was utilised on three of the four PFT trawlers. The benefits of having a TMS include: almost real-time updates on gear shape and orientation; gear position relative to the vessel (some brands); catch information; plus other useful information such as water temperature and water velocity (i.e. the strength of any side current acting across the trawl direction).

TMS's comprise of sensors that are placed at key points on the trawl gear; usually the otterboards and the upper part of the net (refer Fig. 17). One or more hydrophones mounted on the underside of the vessel hull then communicate with these sensors to enable useful data to be displayed on a monitor in the wheelhouse (note: some skippers may even have a 2nd monitor in their cabin for when they are not on watch) (refer Fig. 17). Over time, the vessel operator(s) become more aware of how much key trawl dimensions and the relative position of gear to vessel may change under different environmental/operational circumstances. This knowledge and data then serve to alert the operator to something going awry much sooner than if the traditional signals are relied upon, like the vessel slowing down or rudder coming on to counteract a turning moment imposed on the trawler by the trawl gear coming fast on a seabed obstruction.

There are five notable brands on the market; Marport, Netmind, Notus, Scanmar, and Simrad. Simrad are the most advanced when it comes to 3D trawl positioning capability (refer Fig. 13), followed by Marport; this capability is something that is very beneficial to have for navigating a trawl system safely around the many obstacles in this high tidal-current fishery.

A TMS is therefore a very effective early warning system for preventing a vessel from capsizing, as well as for averting gear damage/loss, and poor fishing performance due to debris build-up in the net etc. Approximate costs for the hardware and install are upwards of $80K, depending on the brand.

In summary, as with the WASSP system, a TMS represents an investment in more profitable and safer fishing, and the operators of trawlers in the PFT have evidently recognised this.

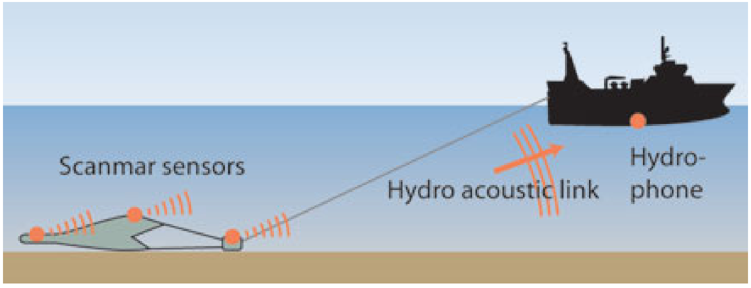


Figure 17. Components of a hydroacoustic trawl monitoring system (Scanmar type) (left pic.) and Marport headline sensor (right pic.)

(Source: Scanmar Catch Control and Sensors website https://www.scanmar.no & Fishing Untangled Pty Ltd. johnwakeford@fishinguntangled.com.au)

4.47 Hydrographic charts, marked obstacles and proximity alarms

PFT trawler operators would carry onboard a set of hydrographic charts (paper and electronic versions) covering the areas of operation, including the navigation route from home port to the fishing grounds. Generally speaking, the Admiralty Hydrographic Charts (AHO) are used primarily for navigation purposes, while the vessel's own chart creations are used once on the fishing grounds. That said, if the skipper decides to venture beyond traditionally fished areas, then the AHO charts will be utilised as a base foundation to work from.

So, in this process, marked seabed hazards such as wellheads will come to their attention, and they may then opt to customise the chart with their own hazard symbols and safe working distances (refer Fig. 3).

Most plotters nowadays have alarm functions for proximity to marked hazards, although by choice I suspect very few skippers utilise them whilst fishing. Possibly more so when they are steaming.

4.48 Chart updates via mariners' alerts

Chart updates via Mariner alert notifications are received via the boat's webmail service, which is usually run-on Inmarsat C or more recently a V-Sat option. Maintaining this communication link is vital for the following reason. All PFT trawlers must have what is known as a Vessel Monitoring System (VMS) installed to operate in this fishery, since it is required to monitor the usage of Fishing effort hours against their permits, amongst other things. The VMS runs via Inmarsat C, and should the connection or unit fail in any way, the vessel must cease fishing, report in to the compliance and monitoring section of WA Fisheries, and if the fault is not temporary, return immediately to port. So, in other words, whilst PFT trawlers are fishing, they must have an Inmarsat C connection (or similar) and will therefore always have the means to receive Mariner Alerts.

Typically, the Webmail will be checked at least daily. As to whether a new seabed obstacle notification sent via a Mariner Alert message ends up on the plotter is debatable, since this will be a function of how fastidious the skipper is with this type of activity, together with what other demands there are on his/her time. Understandably, there are intense periods during the fishing season whereby the skipper has to prioritise on an overwhelming number of tasks. Deferring reading of all the Mariner Alerts amongst a swag of other email messages is usually the outcome and may therefore result in some inadvertently being missed.

A better method to ensure the Legendre WH location resides on the electronic chart plotter of each PFT trawler is to provide this data to the industry representative body (WAFIC) for distribution via a form of registered mail/email, with a follow up-verification check and declaration by the skipper that it has been entered on the vessel's plotter.

4.5 Trawler hook-up considerations

4.50 Trawl gear hook-up forces

When a trawler comes fast on an unshifting seabed obstacle it can result in a considerable amount of force being applied to the structure and the vessel. Initially there is an impact force applied to the obstacle due to the collision, however, it is the force associated with the deceleration of the vessel and the subsequent pulling force that may be applied by the vessel operator whilst trying to free the snagged gear that are relatively large in comparison. The deceleration force associated with the vessel slowing is a function of how much give is in the trawl system by components collapsing laterally (sweep, bridle and net) and straightening (warp) and stretching (cable, rope, and netting). It should also be noted that when an interaction occurs between trawl gear and a seabed obstacle, the initial pull angle away from horizontal is relatively shallow and related to the wire to depth ratio used. For example, between W:D ratios of 3:1 to 4:1 the initial pull angle varies from 19.5 to 14.5°.

What occurs next will come down to the type of gear being used and the type of snag, plus environmental conditions, and other economic/financial factors. If the vessel comes too safely, often the snagged towing vessel will draw itself closer to the snag on the premise that the additional uplift will pull the gear free. Under certain circumstances (undercut obstacles like large rocks or vehicles) the vessel may opt to circle the snag and try pulling in a different direction. If these measures fail then the vessel will move progressively closer to directly overhead and use a combination of thrust, winch haul force, and vessel buoyancy to apply more of a load.

Understandably, this procedure heightens the risk level. However, if the breaking load of the fishing gear and connecting tackle is relatively low, then the gear will normally fail without jeopardising vessel stability to any great extent. Whereas with some trawlers, especially the smaller ones towing relatively large prawn trawl gear (with warp wires well outboard from the sides of the vessel), the risk of capsizing is very real.

Note: all four trawlers operating in the PFT are similar in design and around 24-25 m in length, and as explained earlier, in most hook-up situations, the otterboards are recovered, and the wire(s) connecting vessel to snagged gear is then run over the central part of the stern before applying extra tension, which from a vessel roll perspective is very safe. If one of the otterboards is snagged, then the rest of the gear is normally recovered by winching up wire on the other side, and then by using the sweep on one side and the warp on the other side, an even pull can be applied via the stern mounted trawl blocks; again, very stable from a roll perspective, and unlikely to capsize a vessel.

The only caveat with this is if the hook-up occurs in rough seas, in which case you would expect the skipper to exercise some caution, and if necessary, cut wire and return later to grapple the gear when it is calmer.

4.51 Trawl hook-up response procedure

AMSA have provided guidelines for Trawlers on how they should respond in a hook-up situation to minimise the risk to crew and vessel (AMSA Trawler Hook-up Guidelines) (refer Annexure B). Note that with PFT trawlers the recommendation to run the warp wire through a snatch block near the stern before cranking up the tension is not relevant as the trawl blocks already reside there, and moreover, the wire connecting vessel to snagged gear is usually transferred onto the net drum which is central and near the stern; i.e., as good as it gets.

As indicated in the guidelines, under certain circumstances it may be prudent for the vessel to cut the gear free (i.e., cut the wire(s)) to release the vessel, and then return later and use a grapple (similar to an anchor) to recover the gear. Grappling lost fishing gear usually involves towing a modified form of anchor across the seabed to reconnect the vessel to some part of the gear, and then applying a pulling force to drag it free of the snag. The pulling procedure followed is similar to what is adopted when the gear is snagged whilst fishing, with the difference being that the grapple is often pulled in the opposite direction to the tow-direction when the gear became snagged. Given that the grapple is usually connected to the end of the warp wire, this tends to govern the maximum tensile load that can be applied.

So, in summary, the minimum breaking load (MBL) of the connecting wire rope between vessel and fishing gear equates to the maximum applied pulling force, and from a worst case scenario perspective, this force may well be applied from directly overhead if pulling initially at shallower angles proves unsuccessful. The only additional equipment used in this freeing process may be a snatch block, and a grapple hook should it be needed; the former is carried onboard, whereas the latter may not be, although access to one is normally not far away (shared amongst several boats).

4.52 Trawl gear hook-up forces - Maximum loads and capsizing risk

PFT trawlers would run warps of 16-18mm wire (Searle 16 x 9 construction), sweeps in 16-18mm wire, and upper and lower bridle in 14 and 16mm (maybe 18mm) wire respectively (same construction). Note: when a PFT trawler shifts to directly overhead of a snag and cranks down to apply more load to free the snagged gear, it is the 16 or 18mm sweep wire that is connected to the winch, and importantly, below that (i.e., closer to the snagged gear) there are numerous other gear components with a lower MBL.

So understandably, that is where the breakage normally occurs. Details for the MBL of 16-18mm wire are provided in Annexure C and indicate that the trawler can apply up to 15-19 tF of tension during this freeing exercise, with most nets and net framelines breaking/tearing apart well before that (e.g., <6 tF). The risk to vessel stability during this exercise is therefore minimal, and the records (nil capsize incidences from hook-ups in this fishery for over three decades) support this notion. That said, breakages (gear failure) may occur on deck when the hooked-up gear is being recovered, and this may result in crew injury if due diligence has not been exercised or luck runs out.

4.53 Risks to vessel stability- Preventative measures

Whether a trawler capsizes in a hook-up situation is very much governed by the actions of the skipper/crew members when the interaction first takes place. Tell-tale signs such as rudder angle changing (if on autopilot), trawl spread decreasing with a concurrent disruption to otterboard orientation (if a TMS is used), and a slowing of the vessel, are early warning signs for a potential hook-up and should not be ignored. A timely reduction in engine/propeller revs is critical and possibly the single biggest factor governing what eventuates.

Another simple and effective way of preventing a vessel that hooks up from capsizing is to have a tension release mechanism on the trawl winch so that wire releases when the tension rises above a certain level. Mechanical brakes that allow slippage when a peak load occurs are one example. Active trawl winch systems that manipulate warp tension whilst trawling is another. For economic/financial reasons none of the PFT trawlers are equipped with an active winch system and use an insertable manual or automatic hard stopper/brake on each winch to prevent the drum from rotating and releasing wire once the hydraulics are disengaged and the vessel is trawling. This setup is simple but dangerous since it relies on the helmsman's awareness and reaction time when the gear hooks up to reduce the vessel's thrust and prevent the tensile load in the wire peaking and being imparted to the vessel.

To fit a modern tension release mechanism to an existing hydraulic winch configuration would cost about $30 - 50K, which includes installation (based on a Silecmar trawl winch control system). In some cases, depending on the winch set-up this may not be possible, or it may be cost prohibitive and cheaper just to buy a new complete winch system with the release feature installed - about $150K for the entire system, which covers hardware and installation.

4.54 Historical records on trawler hook-up incidents

According to several well-informed people (S. Little & G.Kessel – Vessel managers Westmore Seafoods, P.Henderson – Skipper PFT) associated with the PFT, there have not been any hook-up incidents that have ended up in tragedy in the last three decades. One of the reasons cited was that under most circumstances pulling on wire passing over the stern to free snagged gear does not jeopardise vessel stability to any great extent. In other words, if the hook-up situation is properly managed, tragedy can be averted.

As for outside of the PFT, in other Australian trawl fisheries, according to the AMSA records since July 2018, there has only been a single incident of a trawler capsizing, and this was a small prawn trawler operating in Qld (refer Annexure D). Note: a prawn trawler is more likely to capsize from a hook-up than a fish trawler, since the warps on prawn trawlers usually pass-through trawl blocks located outboard of the vessel sides, sometimes beyond 10m, and therefore they are very prone to roll and yaw moments when they come fast.

4.6 Risk Assessment Advice

4.60 Introduction

The purpose of this Risk Assessment was to investigate the likelihood of a PFT trawler:

1. snagging trawl nets on the Legendre wellhead
2. losing gear as a result of snagging on the Legendre wellhead
3. rolling a vessel as a result of snagging fishing nets on the Legendre wellhead

4.61 Risk Assessment Advice - Snagging trawl nets on the Legendre wellhead

Trawling can be hazardous, especially if the vessel must operate around potential hook-ups such as reef and other structure rising above the seabed, or in areas full of debris that can overfill the trawl such as large sponge, shell, and urchin, and make it unliftable, or in areas comprising of mud/silty/soft sediments that may ultimately do the same.

So, in the scheme of things, a well-head is only one more hazard amongst many facing PFT trawlers, and because its size, structure and location are known and fixed, unlike some of the other trawling hazards presented above, the possibility of an interaction is very low. For an interaction to occur, the operator would either have to be oblivious to its location, or know of its location, and make a poor judgement call while trawling nearby. This situation may arise for example when a crew-member, less qualified than the skipper or mate is on the helm.

4.62 Risk Assessment Advice - Overlap of fishing area with Legendre WH

Even though the Legendre wellhead is in a popular fishing area (Area 2) in the PFT, it was shown earlier that the wellhead was not only marked on a PFT trawler's plotter, but well-established trawl tracks in this region pass by at a safe distance (i.e., well beyond the 0.5 nm). It is also logical due to information sharing between trawlers in the same company, that the second trawler also has the same plotter output. Whether this is also the case for the other two trawlers cannot be confirmed at this stage, although based on the type of wheelhouse electronics present, and the long service of both skippers in this fishery, it is very likely.

4.63 Risk Assessment Advice - Losing gear because of snagging on the Legendre WH

Since the Legendre WH resides in about 50m of water, stands about 2-3m high and will not budge, the recovery of snagged fishing gear is very unlikely. Furthermore, if the operator manages to tear it free, some gear may still be lost and what is recovered will be damaged, possibly irreparably.

4.64 Risk Assessment Advice - Vessel capsizing after snagging net on the Legendre WH

Since the Legendre wellhead is unmovable, then indeed, if a net comes fast on it there will be a moderate deceleration force applied to the trawl gear and trawler. However, the distance of the gear astern of the vessel together with the trawl blocks being located at the stern (either side), suggest that this will not cause the vessel to capsize, just bring it to a standstill. Understandably, if the hookup occurs under unfavourable environmental circumstances and if poor decisions are made at critical times during the interaction (refer above) then the risk level will certainly rise. Although the history records of capsize incidences in the fishery would indicate, that even then, the situation can be managed relatively safely and is unlikely to end in tragedy.

4.65 Risk Assessment summary

The findings from the Risk Assessment are summarised below:

- The only commercial fishing group at risk from an interaction with the Legendre Wellhead were those engaged in fish trawling (four similar sized vessels – c.24m LOA, steel, displacement hull, purpose-built trawlers).
- These trawlers were very unlikely to have an interaction with the wellhead for the following reasons; the wellhead was located in an untrawlable area, the wellhead position was

marked on charts (both Admiralty and vessel GPS plotter), and the capability of all vessels and crew to safely trawl around "marked" seabed obstacles was high.

- A low to moderate/high hazard severity was associated with a trawler-wellhead interaction under normal operating conditions, depending on the entity being impacted upon.
  - The crew were unlikely to be harmed, unless they were caught at unawares in a vulnerable position, in which case a moderate impact (injury requiring hospitalisation) may result.
  - The fishing gear was likely to suffer moderate/high damage i.e., net torn, large holes/tears, and frameline breakage.
  - The trawler would only suffer minor damage i.e., scrape damage to surfaces from wires during gear recovery and was very unlikely to capsize.
  - The fishing income would suffer from catch loss and several hours to several days of downtime depending on the availability/location of a spare net.
- If the hook-up occurred under unfavourable circumstances (e.g., rough seas, strong tide/current, whilst the vessel was turning), then the hazard severity for crew and vessel would increase. However, based on historical data in this fishery regarding fish trawler capsize events and harm to crew, together with the stability of these vessels under these extraordinary conditions/circumstances, it was unlikely to result in a vessel capsizing or a loss of life provided the skipper/crew follow recognised trawler hook-up safety procedures, which was a reasonable expectation given the experience shared across the skippers in this fishery (up to 30 years).

5. References

Fridman, A.L. (1986). *Calculations for Fishing Gear Designs,* Fishing News Books Ltd, Farnham, Surrey, England ISBN 0-85238-141-7.

Mckenna, H.A., Hearle, J.W.S. & O'Hear, N. (2004). *Handbook of fibre rope technology*, Woodhead Publishing Ltd and CRC Press LLC, Cambridge, England.

Moran, M., Jenke, J., Burton, C., and Clark, D. (1988). The Western Australian trap and line fishery on the North West Shelf. FIRTA Report 86/28. WA Marine Research Laboratories, 79 pp.

Newman, S., Wakefield, C., Skepper, C., Boddington, D., and Steele, A. (2020). North Coast Demersal Resource Status Report 2020. In: Status Reports of the Fisheries and Aquatic Resources of Western Australia 2019/20: The State of the Fisheries eds. D.J. Gaughan and K. Santoro. Department of Primary Industries and Regional Development, Western Australia. pp. 154-165

Nowara, G.B. and Newman, S.J. (2001). A history of foreign fishing activities and fisheryindependent surveys of the demersal finfish resources in the Kimberley region of Western Australia. Fisheries Research Report No. 125. Department of Fisheries, Western Australia, 84 pp.

Wakefield, C. B., Santana-Garcon, J., Dorman, S.R., Blight, S., Denhan, A., Wakeford, J., Newman, S.J., and Molony, B.W. (2016). *Performance of modified exclusion devices varies for chondrichthyan, reptile and cetacean bycatch mitigation in fish trawls: assimilating subsurface interactions and potential for unaccounted mortality.* ICES Marine Science. 16 pp.

Wakefield, C. B., Blight, S., Dorman, S. R., Denham, A., Newman, S. J., Wakeford, J., Molony, B. W., Thomson, A. W., Syers, C. and O'Donoghue, S. (2014). *Independent observations of catches and subsurface mitigation efficiencies of modified trawl nets for endangered, threatened and protected megafauna bycatch in the Pilbara Fish Trawl Fishery*. Fisheries Research Report No. 244. Department of Fisheries, Western Australia. 40 pp.

6. Annexures

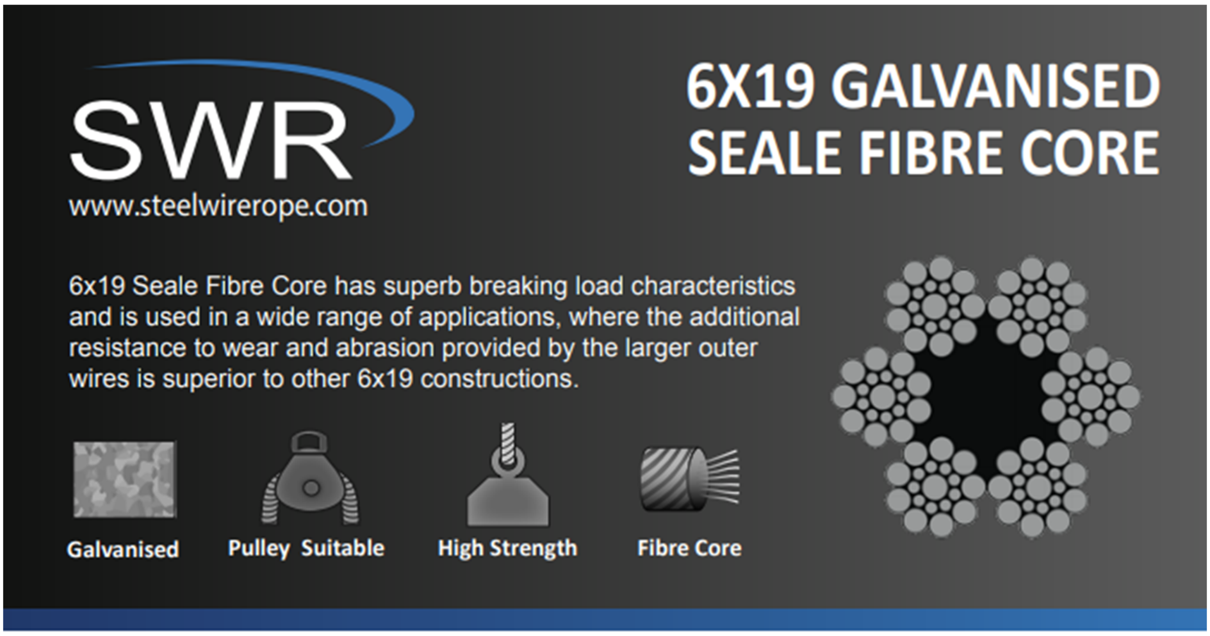
Annexure A – Details on the wheelhouse electronics of a "fully equipped" modern trawler

B1 - AIS
B2 - Camera
B3 - Chart plotter
B4 - Communications 1
B5 - Communications 2
B6 - Echosounder
B7 - GPS
B8 - Marport TMS
B9 - Radar
B10 - Sonar
B11 - WASSP

Annexure B – AMSA Hook-up Response for Trawlers

Hook-up response for trawlers (amsa.gov.au)

Annexure C – SWR Breaking Load Table for 6 x 19 Searle wire cable



Breaking Load Table

Nominal Diameter	Approximate Mass	Minimum breaking loads - 1770 Mpa		Minimum breaking loads - 1960 Mpa	
[mm]	[kg/m]	[kN]	[kg]	[kN]	[kg]
10	0.359	58.4	5,957	64.7	6,597
11	0.434	70.7	7,209	78.3	7,982
12	0.517	84.1	8,579	93.1	9,500
13	0.607	98.7	10,068	109.3	11,149
14	0.704	114.5	11,677	126.8	12,930
16	0.919	149.5	15,252	165.6	16,889
18	1.163	189.2	19,303	209.6	21,375
20	1.436	233.6	23,831	258.7	26,389
22	1.738	282.7	28,835	313.1	31,931
24	2.068	336.4	34,317	372.6	38,000
26	2.427	394.9	40,274	437.2	44,598
28	2.815	457.9	46,709	507.1	51,723
30	3.231	525.7	53,620	582.1	59,376
32	3.676	598.1	61,008	662.3	67,557
34	4.150	675.2	68,872	747.7	76,265
36	4.653	757.0	77,213	838.3	85,501
38	5.184	843.4	86,030	934.0	95,265
40	5.744	934.6	95,325	1034.9	105,557

Annexure D – AMSA trawler capsize records from July 2021 onwards

Australian Government
Australian Maritime Safety Authority

FREEDOM OF INFORMATION

18 August 2021

John Wakeford
Managing Director
Fishing Untangled

Our ref: 2021/9226

BY EMAIL ONLY: johnwakeford@fishinguntangled.com.au

Dear Mr Wakeford

RE: FREEDOM OF INFORMATION ACT 1982 APPLICATION – *Trawler Hook-ups data*

I refer to your request received by AMSA on 20 July 2021 in which you sought access to documents under the *Freedom of Information Act 1982* (the FOI Act). The request sought documents in relation to capsizing of trawlers. Specifically, your request sought:

> *"…data on how many prawn/shrimp trawlers operating in Australian waters have capsized as a result of hooking up on the seabed or and obstacle while trawling, or later when they have come to and are trying to free the snagged gear…"*

This letter sets out my decision on your request for access. I am an authorised decision-maker under section 23 of the FOI Act.

Timeframe for processing your request

Your request was received by AMSA on 20 July 2021. The statutory period for processing your request is 30 days. The timeframe for processing your request therefore expires on 21 August 2021.

Decision

Following the search and examination of records related to your request, AMSA has identified the following data relevant to your request. I have decided to release this information to you in full.

AMSA commenced full service delivery of the National System on 1 July 2018. Hence, Domestic Commercial Vessel's were required to report all marine incidents directly to AMSA from this date onwards.

A search of AMSA's incident database was conducted searching for marine incidents resulting in capsizing of Class 3 vessels (fishing vessels) since 1 July 2018. The search was then refined to keywords such as "trawl, trawler, hook up, seabed". One incident was identified to fall within the scope of your request.

Incident ID	Short Summary	Severity	Incident Date	Vessel	Location	Length
DCV2021-01057	Trawl gear fouled causing vessel to overturn, 1 person onboard, not injured.	Category 1 - Very Serious	13/04/2021	WIND AND SEA (445940)	QLD	8.6m

Relevant material

In reaching my decision I referred to the following:

- the terms of your request
- the documents relevant to the request
- the FOI Act
- the Privacy Act
- Guidelines published by the Office of the Information Commissioner under section 93A of the FOI Act
- advice from AMSA officers with responsibility for matters relating to the documents to which you sought access, and
- advice from the Agency's in-house legal team.

Contacts

If you have any queries about this notice, please do not hesitate to contact AMSA's FOI team at Freedomofinformation@amsa.gov.au.

Yours sincerely

Michelle Grech
MANAGER VESSEL OPERATIONS
OPERATIONS

Appendix J: Environmental consequence descriptors

Consequence Level		I	II	III	IV	V	VI
Acceptability		Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Severity Description		**Negligible** *No impact or negligible impact.*	**Minor** *Detectable but insignificant change to local population, industry or ecosystem factors. Localised effect*	**Moderate** *Significant impact to local population, industry or ecosystem factors.*	**Major** *Major long-term effect on local population, industry or ecosystem factors.*	**Severe** *Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.*	**Critical** *Irreversible impact to regional population, industry or ecosystem factors.*
Environmental Receptors	**Fauna** In particular, EPBC Act listed threatened/migratory fauna or WA Biodiversity Conservation Act 2016 specially protected fauna	Short term behavioural impacts only to small proportion of local population and not during critical lifecycle activity; No decrease in local population size; No reduction in area of occupancy of species; No loss/disruption of habitat critical to survival of a species; No disruption to the breeding cycle of any individual; No introduction of disease likely to cause a detectable population decline.	Detectable but insignificant decrease in local population size; Insignificant reduction in area of occupancy of species; Insignificant loss/disruption of habitat critical to survival of a species; Insignificant disruption to the breeding cycle of local population.	Significant decrease in local population size but no threat to overall population viability; Significant behavioural disruption to local population; Significant disruption to the breeding cycle of a local population; Significant reduction in area of occupancy of species; Significant loss of habitat critical to survival of a species; Modify, destroy, remove, isolate or decrease availability of quality of habitat to the extent that a significant decline in local population is likely; Introduce disease likely to cause a significant population decline.	Long term decrease in local population size and threat to local population viability; Major disruption to the breeding cycle of local population; Major reduction in area of occupancy of species; Fragmentation of existing population; Major loss of habitat critical to survival of a species; Modify, destroy, remove, isolate or decrease availability of quality of habitat to the extent that a long term decline in local population is likely; Introduce disease likely to cause a long term population decline.	Complete loss of local population; Complete loss of habitat critical to survival of local population; Wide spread (regional) decline in population size or habitat critical to regional population.	Complete loss of regional population; Complete loss of habitat critical to survival of regional population.
Environmental Receptors	**Physical Environment / Habitat** Includes: air quality; water quality; benthic habitat (biotic/abiotic), particularly habitats that are rare or unique; habitat that represents a Key Ecological Feature[3]; habitat within a protected area; habitats that include benthic primary producers[4] and/ or epi-fauna[5]	No or negligible reduction in physical environment / habitat area/function.	Detectable but localised and insignificant loss of area/function of physical environment / habitat. Rapid recovery evident within ~ 2 year (two season recovery)	Significant loss of area and/or function of local physical environment / habitat. Recovery over medium term (2–10 years)	Major, large-scale loss of area and/or function of physical environment / local habitat. Slow recovery over decades.	Extensive destruction of local physical environment / habitat with no recovery; Long term (decades) and wide spread loss of area or function of primary producers on a regional scale.	Complete destruction of regional physical environment / habitat with no recovery. Complete loss of area or function of primary producers on a regional scale.
Environmental Receptors	**Threatened ecological communities** (EPBC Act listed ecological communities)	No decline in threatened ecological community population size, diversity or function; No reduction in area of threatened ecological community; No introduction of disease likely to cause decline in threatened ecological community population size, diversity or function.	Detectable but insignificant decline in threatened ecological community population size, diversity or function; Insignificant reduction in area of threatened ecological community.	Significant decline in threatened ecological community population size, diversity or function; Significant reduction in area of threatened ecological community; Introduction of disease likely to cause significant decline in threatened ecological community population size, diversity or function.	Major, long term decline in threatened ecological community population size, diversity or function; Major reduction in area of threatened ecological community; Fragmentation of threatened ecological community; Introduce disease likely to cause long term decline in threatened ecological community population size, diversity or function.	Extensive, long term decline in threatened ecological community population size, diversity or function; Complete loss of threatened ecological community.	Complete loss of threatened ecological community with no recovery.

Consequence Level	I	II	III	IV	V	VI
Acceptability	Acceptable	Acceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Severity Description	**Negligible** *No impact or negligible impact.*	**Minor** *Detectable but insignificant change to local population, industry or ecosystem factors. Localised effect*	**Moderate** *Significant impact to local population, industry or ecosystem factors.*	**Major** *Major long-term effect on local population, industry or ecosystem factors.*	**Severe** *Complete loss of local population, industry or ecosystem factors AND/ OR extensive regional impacts with slow recovery.*	**Critical** *Irreversible impact to regional population, industry or ecosystem factors.*
Protected Areas Includes: World Heritage Properties; Ramsar wetlands; Commonwealth/ National Heritage Areas; Land/ Marine Conservation Reserves.	No or negligible impact on protected area values; No decline in species population within protected area; No or negligible alteration, modification, obscuring or diminishing of protected area values.*	Detectable but insignificant impact on one of more of protected area's values. Detectable but insignificant decline in species population within protected area. Detectable but insignificant alteration, modification, obscuring or diminishing of protected area values*	Significant impact on one of more of protected area's values; Significant decrease in population within protected area; Significant alteration, modification, obscuring or diminishing of protected area values.	Major long term effect on one of more of protected area's values Long term decrease in species population contained within protected area and threat to that population's viability Major alteration, modification, obscuring or diminishing of protected area values	Extensive loss of one or more of protected area's values; Extensive loss of species population contained within protected area.	Complete loss of one or more of protected area's values with no recovery; Complete loss of species population contained within protected area with no recovery.
Socio-economic receptors Includes: fisheries (commercial and recreational); tourism; oil and gas; defence; commercial shipping.	No or negligible loss of value of the local industry; No or negligible reduction in key natural features or populations supporting the activity.	Detectable but insignificant short-term loss of value of the local industry. Detectable but insignificant reduction in key natural features or population supporting the local activity.	Significant loss of value of the local industry; Significant medium term reduction of key natural features or populations supporting the local activity.	Major long-term loss of value of the local industry and threat to viability. Major reduction of key natural features or populations supporting the local activity.	Shutdown of local industry or widespread major damage to regional industry; Extensive loss of key natural features or populations supporting the local industry.	Permanent shutdown of local or regional industry; Permanent loss of key natural features or populations supporting the local or regional industry.

*Excluding World Heritage Areas.

Page intentionally left blank.