WA-20-L Environment Plan

PROJECT / FACILITY	WA-20-L
REVIEW INTERVAL (MONTHS)	No Review Required
SAFETY CRITICAL DOCUMENT	NO

Rev	Owner	Reviewer/s *Managerial / Technical / Site*	Approver
	Environmental Operations lead	**Environmental Approvals and Compliance Lead**	**Asset Retirement Manager Decommissioning**
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Rev	Rev Date	Author / Editor	Amendment
A	16/10/21	RPS	For internal review
B	03/02/22	RPS	For internal review
0	22/02/22	RPS	Submitted to NOPSEMA

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Definitions

The following terms as used within this environment plan have definitions used in the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*:

Activity means a petroleum activity or a greenhouse gas 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.

Environment means:

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; and includes; and

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

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

Environmental management system includes the responsibilities, practices, processes and resources used to manage the environmental aspects of an 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 standards mentioned in an environment plan.

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

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

Environment plan means the document known as an environment plan that is submitted to the Regulator under regulation 9.

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:

c) a petroleum exploration permittee;

d) a petroleum retention lessee;

e) a petroleum production licensee;

f) a pipeline licensee;

g) an infrastructure licensee;

h) the registered holder of a petroleum access authority;

i) the registered holder of a petroleum special prospecting authority;

j) the holder of a petroleum scientific investigation consent.

Produced formation water means natural aqueous fluid recovered from a petroleum reservoir in association with the petroleum.

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

Regulator means:

a) in relation to a petroleum activity— National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA); or

b) in relation to a greenhouse gas storage activity—the responsible Commonwealth Minister.

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.

Titleholder means:

a) a greenhouse gas titleholder; or

b) a petroleum titleholder.

Abbreviations

Term	Definition
3D	three-dimensional
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHO	Australian Hydrographic Office
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
API	American Petroleum Institute
APPEA	The Australian Petroleum Production & Exploration Association
AUSREP	Australian Ship Reporting System
BIA	Biologically Important Area
CALM	catenary anchor leg mooring
CH_4	Methane
CM	Control Measure
CO_2	Carbon Dioxide
CSIA	Compound specific isotopic analyses
DAWE	Commonwealth Department of the Agriculture, Water and the Environment
DAWR	Department of Agriculture and Water
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	WA Department of Environment and Conservation (now DPaW and DER)
DEH	Department of Environment and Heritage (now DEWHA)
DER	Western Australia Department of Environment Regulation
DEW	Department of Environment and Water Resources (now DEWHA)
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (previously DEW, DEH)
DMIRS	Government of Western Australia Department of Mines, Industry Regulation and Safety
DMP	Western Australia Department of Mines and Petroleum
DoAWE	Department of Agriculture, Water and Environment
DoE	Department of the Environment (previously DSEWPaC)
DoEE	Department of the Environment and Energy
DOIR	WA Department of Industry and Resources
DOT	Western Australian Department of Transport
DP	Dynamic Positioning

Term	Definition
DPaW	Western Australia Department of Parks and Wildlife
DPIRD	Department of Primary Industry and Regional Development
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EHS	Environment, Health and Safety
EMBA	Environment that may be affected
ENVID	Environmental Hazard Identification
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
FPSO	Floating, Production, Storage and Offloading
GHG	Greenhouse gas
HSE	Health, Safety and Environment
HSEA	Health, Safety and Environment Advisor
IAPP	International Air Pollution Prevention
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
KEF	Key Environmental Feature
MDO	Marine Diesel Oil
MNES	matters of national environmental significance
MOC	Management of Change
MOPU	mobile offshore production unit
NATA	National Association of Testing Authorities
NatPlan	National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances
NEBA	Net Environmental Benefit Assessment
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
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

Term	Definition
OPGGS(E)R	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
P and A	Plugged and Abandoned
PLONOR	Pose Little or No Risk to the Environment
PMS	Planned Maintenance System
PMST	Protected Matters Search Tool
POB	Persons on Board
PSZ	Petroleum Safety Zone
PTS	Permanent threshold shift
JRCC	Joint Rescue Coordination Centre
ROV	Remotely Operated (underwater) Vehicle
RPS	RPS Australia West
Santos WA	Santos WA Northwest Pty Ltd
SDS	Safety Data Sheet
SQ	Sediment Quality
ST	Sidetrack
TBT	Tributyltin
TSS	Total Suspended Solids
TTS	Temporary threshold shift
UAV	Unmanned Aerial Vehicle
VLF	very low frequency
WA	Western Australia
WAF	Water-accommodated fraction
WAFIC	WA Fishing Industry Council
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
bbl	Barrels
°C	Degrees centigrade
cm	Centimetre (10 mm)
cm^2	Square centimetre
cm^3	Cubic centimetre
dB(A)	A-weighted sound pressure level in decibels
dB	Decibels
dB re 1µPa	Decibels re micro Pascals
Hr	Hour
kL	Kilolitre (1,000 litres)
km	Kilometre (1,000 m)
kHz	Kilohertz
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
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
t	Tonne
µg	Microgram
SPL	Sound pressure level
SEL	Sound exposure level

Term	Definition
PTS	Permanent threshold shift
TTS	Temporary threshold shift

1 Introduction

1.1 Environment plan summary

OPGGS(E)R 2009 Requirements
Regulation 11(3)
Within 10 days after receiving notice that the Regulator 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 the Regulator for public disclosure.
Regulation 11(4)
The summary: + must include the following material from the environment plan: + the location of the activity; + a description of the receiving environment; + a description of the activity; + details of environmental impacts and risks; + a summary of the control measures for the activity; + a summary of the arrangements for ongoing monitoring of the titleholder's environmental performance; + a summary of the response arrangements in the oil pollution emergency plan; + details of consultation already undertaken, and pans for ongoing consultation; + details of the titleholder's nominated liaison person for the activity; and + must be to the satisfaction of the Regulator.

The Environment Plan (EP) summary has been prepared from material provided in this EP. The summary consists of the following as required by Regulation 11(4) of the *Offshore Petroleum and Greenhouse Gas (environment) Regulations 2009* (OPGGS(E)R).

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	**Section 6** and **7**
The control measures for the activity	**Section 6** and **7**
The arrangements for ongoing monitoring of the titleholders environmental performance	**Section 8**
Response arrangements in the oil pollution emergency plan	WA-20-L Oil Pollution Emergency Plan (SO-91-BI-20020.01)

Environment Plan (EP) summary material requirement	Relevant section of EP containing EP Summary material
Consultation already undertaken and plans for ongoing consultation	**Section 4**
Details of the titleholders nominated liaison person for the activity	**Section 1.5.2**

1.2 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 seen petroleum exploration and production activity within it since 1968. Twenty production wells (including sidetracks) were drilled from a central location (the Legendre Hub) and were connected to the Ocean Legend Production Facility, a mobile offshore production unit (MOPU). Exploration and appraisal wells were drilled at a further eight surface locations (including sidetracks) within the permit. **Table 1-1** provides a summary of the wells drilled in WA-20-L.

The exploration and appraisal wells 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.

The 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. It was accepted by the regulator, the WA Department of Industry and Resources (DOIR) at that time.

Following the plugging and abandonment of the production wells, the Legendre facilities were decommissioned in accordance with the Legendre Field Decommissioning Environment Plan (LR-00-RI-063). This EP 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.

Activities included in the Legendre Field Decommissioning Environment Plan were:

- the towing of the Ocean Legend off permit (16 July 2011);
- the removal of subsea infrastructure with the exception of anti-scour mats that were re-positioned over the cut-off production conductors;
- concrete caps placed over the pad-eyes and shackles remaining from the catenary anchor leg mooring (CALM) buoy anchor piles; and
- a post-decommissioning remotely operated vehicle (ROV) survey within two years of completion of the removal activity.

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 post-decommissioning ROV survey was completed on 25 December 2013.

These 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."

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

Well name	Well Type	Latitude (GDA94)	Longitude (GDA94)	Spud date	Year plugged and abandoned
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-1H	Production	-19.703930	116.708692	21/01/2001	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
Legendre-4	Appraisal	-19.678905	116.732591	23/08/2005	2005
Taj-1	Exploration	-19.707319	116.739016	02/02/2006	2006

The two-year post decommissioning ROV survey in 2013 recorded gas seeping 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 seepage 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. In compliance with this, the seepage has been surveyed with ROV an additional three times (approximately every two years) since the seepage was first identified.

As a result of recent communications among the National Offshore Petroleum Titles Office (NOPTA), NOPSEMA and Santos, it was confirmed that an EP is required to cover the petroleum activities on permit WA-20-L, being the gas seepage and the presence of the Legendre-1 wellhead.

1.3 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 Environmental 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.

1.4 Environment plan validity

In accordance with Regulation 19, this EP remains valid from the date of NOPSEMA acceptance for a period of five years, or until NOPSEMA has accepted an end-of-activity notification under Regulation 25A, or until Santos revises this EP in the event a significant change to the activity or level of impact or risk occurs as required under Subregulation 17(10), 17(5), 17(6) and 17(7).

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.

1.5 Titleholder

OPGGS(E)R 2009 Requirements
Regulation 15. Details of titleholder and liaison person
15(1) The environment plan must include the following details for the titleholder: + name; + business address; + telephone number (if any); + fax number (if any); + email address (if any); + if the titleholder is a body corporate that has an ACN (within the meaning of the Corporations Act 2001)—ACN. 15(2) The environment plan must also include the following details for the titleholder's nominated liaison person: + name; + business address;

+ telephone number (if any); + fax number (if any); + email address (if any).

1.5.1 Details of the titleholder

In accordance with Regulation 15(1) of the OPGGS(E)R, the titleholder details are as follows:

Titleholder	ACN	Interest (%)	Address
Santos WA Northwest Pty Ltd	009 140 854	77.44	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
Santos Ltd	007 550 923	22.56	

1.5.2 Details for nominated liaison person

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

Name: D. MacInnes

Position: Environmental Approvals and Compliance Team Lead

Address: Level 7, 100 St Georges Terrace, Perth, Western Australia, 6000

Telephone number: (08) 6218 7100

Email address: offshore.environment.admin@santos.com

1.5.3 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.

Additional information regarding the Santos operations can be obtained from the Santos website at www.santos.com

1.6 Environmental management framework

OPGGS(E)R 2009 Requirements
Regulation 16(a). Other information in the environment plan
The environment plan must contain the following: + A statement of the titleholder's corporate environmental policy;

Regulation 13. Environmental assessment
Description of the activity 13(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.

1.6.1 Environmental management policy

The activities will be conducted in accordance with the Santos Environmental Management 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, 7 and **8** 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.

1.6.2 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.**

1.6.3 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.**

Unplanned events, such as unplanned hydrocarbon spills, may occur within State waters. All spill response activities will comply with legislative requirements established under relevant State and Commonwealth legislation. These are further detailed in **Appendix B.**

1.6.3.1 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 of the OPGGS Act places duties on titleholders in relation to the maintenance and removal of structures, equipment and property brought onto title. Specifically, 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”. The obligation to remove property may be agreed to by NOPSEMA through permissioning documents. 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.

Section 569 of the OPGGS Act places duties on titleholders in relation to the work practices within a title area. Specifically, 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.

1.6.3.2 Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is administered by the Commonwealth Department of the Agriculture, Water and the Environment (DAWE). 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.

In relation to EPs, NOPSEMA must be reasonably satisfied that the EP meets the criteria for acceptance under s10A of the OPGGS Environment Regulations. The criteria for acceptance apply to the management of all impacts and risks including those matters protected under Part 3 of the EPBC Act.

2 Activity description

OPGGS(E)R 2009 Requirements
Regulation 13(1)
Description of the activity 13(1) The environment plan must contain a comprehensive description of the activity including the following: (a) the location or locations of the activity; (b) general details of the construction and layout of any facility; (c) an outline of the operational details of the activity (for example, seismic surveys, exploration drilling or production) and proposed timetables; and (d) 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 the Regulator 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 Regulation 10A.

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**).

The two petroleum activities covered under this EP are:

+ the ongoing gas seepage in the form of small bubbles emanating from the seabed into the water column at the Legendre Hub, Legendre South-1 and Legendre South-3 locations (**Section 2.1**).
+ the presence of the Legendre-1 wellhead (**Section 2.2**), which has been in situ since the well was permanently plugged and abandoned in 1968.

Vessel-based surveillance, monitoring, inspection and research activities may be required in support of these two petroleum activities so for completeness have been described within this EP.

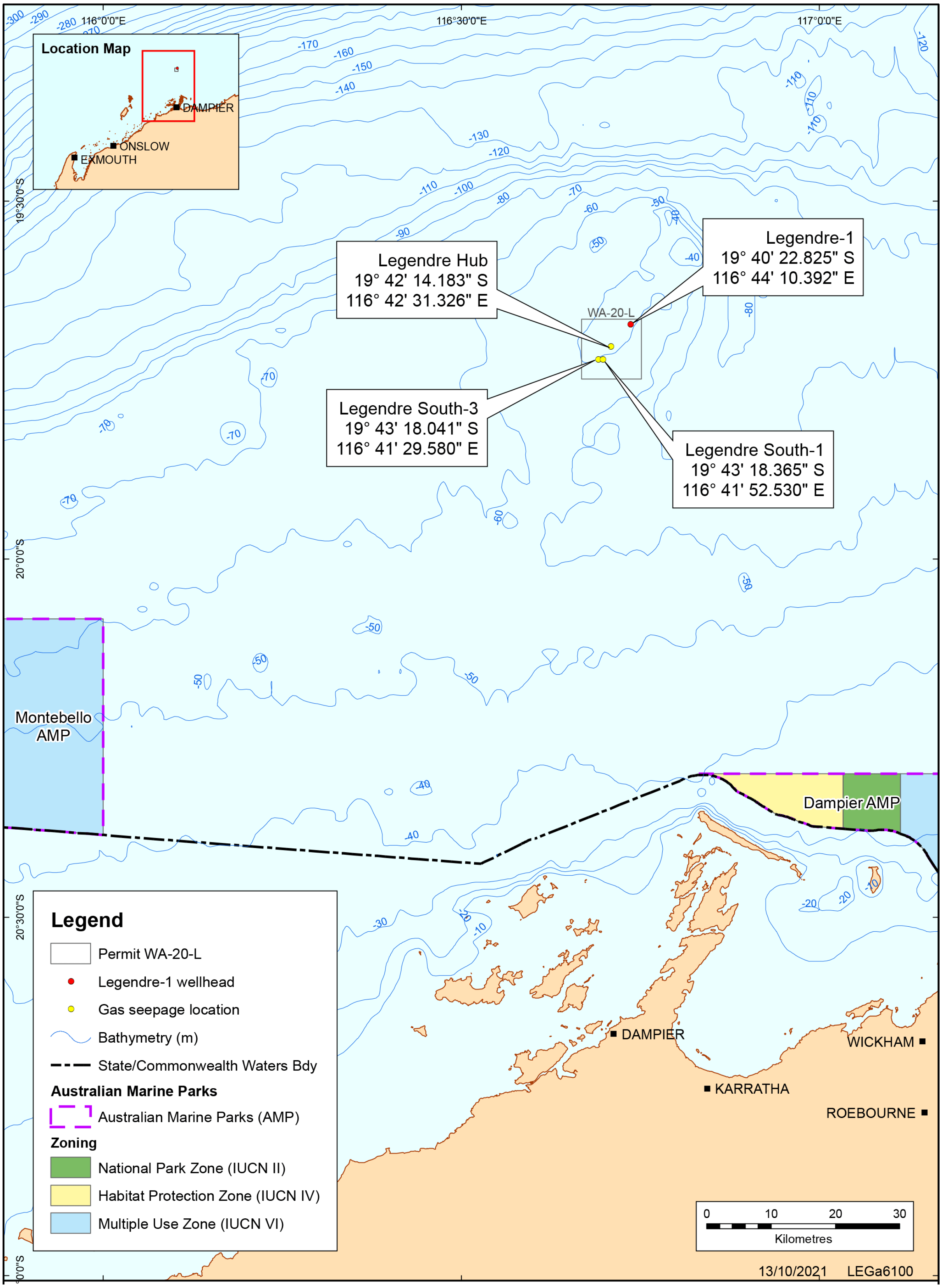

Figure 2-1: WA-20-L Location map

2.1 Gas seepage

Gas seepages from the seabed have been observed at three locations: the Legendre Hub, Legendre South-1 and Legendre South-3 (**Figure 2-1**). The water depth at these locations is 50 m, 54 m and 53 m respectively.

Gas seepage has been reported at Legendre Hub since 2013. Following the initial observation of gas seepage in 2013, further ROV surveys in 2016, 2019 and 2021 confirmed the seepage was ongoing. The ROV inspection in 2021, of all surface locations of wells in WA-20-L, confirmed that gas was seeping at the three locations above. Whilst various attempts at measurement of the seepage rate were made prior to 2021, these were considered to be qualitative and not useful for quantifying the seepage nor for making comparisons of seepage rates between years.

In 2021, gas seepage rates were estimated from bubble counts per unit time at the Legendre Hub, Legendre South-1 and Legendre South-3 locations (RPS 2021a). Characteristics of these seeps are provided in **Table 2-1**:.

Table 2-1: Characteristics of gas seepage from observations and measurements in 2021

Flow rate	Legendre Hub	Legendre South-1	Legendre South-3
Estimated number of bubble seeps	20	4	2
Bubble diameter at sea floor (mm)	1 – 10	1	5 - 10
Total seepage rate, combining all bubble seeps (mL/min) under seabed conditions	338.4	12.2	6.1
Site depth (m)	50.7	54.1	53.3
Site temperature at depth (°C)	27.2	29	27.2

Ongoing monitoring to further characterise the gas seepages will be undertaken throughout the duration of this EP as described in **Section 2.3**.

2.1.1 Gas source

Gas samples were collected during the 2021 survey from the Legendre Hub and Legendre South-1 surface locations (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). Gas chromatography (GC) and compound specific isotopic analyses (CSIA) of the gas from the two locations concluded that the two gases samples were very similar in molecular and isotopic composition, with approximately 85% methane content (RPS 2021a). 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 indicates that it is not migrating to the seabed over geological periods of time.

In 2020, Santos reviewed the plug and abandonment history of all wells in WA-20-L (Santos 2020), including the Legendre Hub wells and Legendre South-3, to confirm that the wells on title have been through a regulated abandonment process. The review compiled all regulator correspondence and as-built drawings and 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 which confirmed that this well also went through a regulated abandonment process and concluded that it was abandoned in accordance with the regulatory approved plug and abandonment program.

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.

2.1.2 Technical feasibility of intervention

During the 2011 Legendre plug and abandonment campaign, multiple permanent cement plugs were installed into the development well bores, and surface casing strings, conductors and wellheads were cut and removed from below the mud-line. 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.

Examples of this are shown below in **Figure 2-2** (Legendre North-1H, development well at Legendre Hub), and **Figure 2-3** (Legendre South-3, exploration well).

As can be seen from **Figure 2-2** and **Figure 2-3** it is not feasible to re-enter the abandoned wellbore due to:

+ 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
+ no safe “conduit” to re-enter the well because of 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.

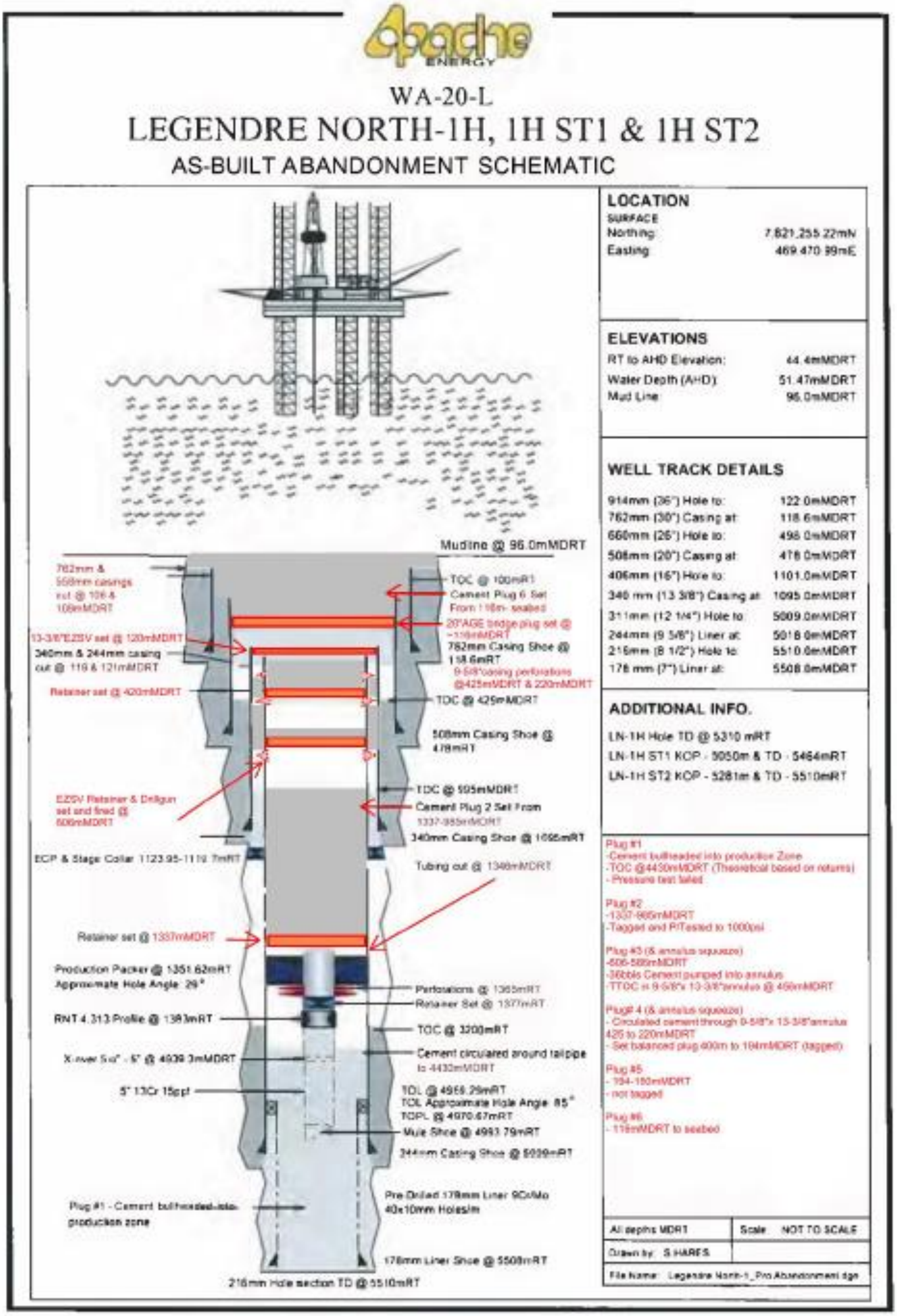

Figure 2-2: WA-20-L Example of plugged and abandoned wells at Legendre Hub location

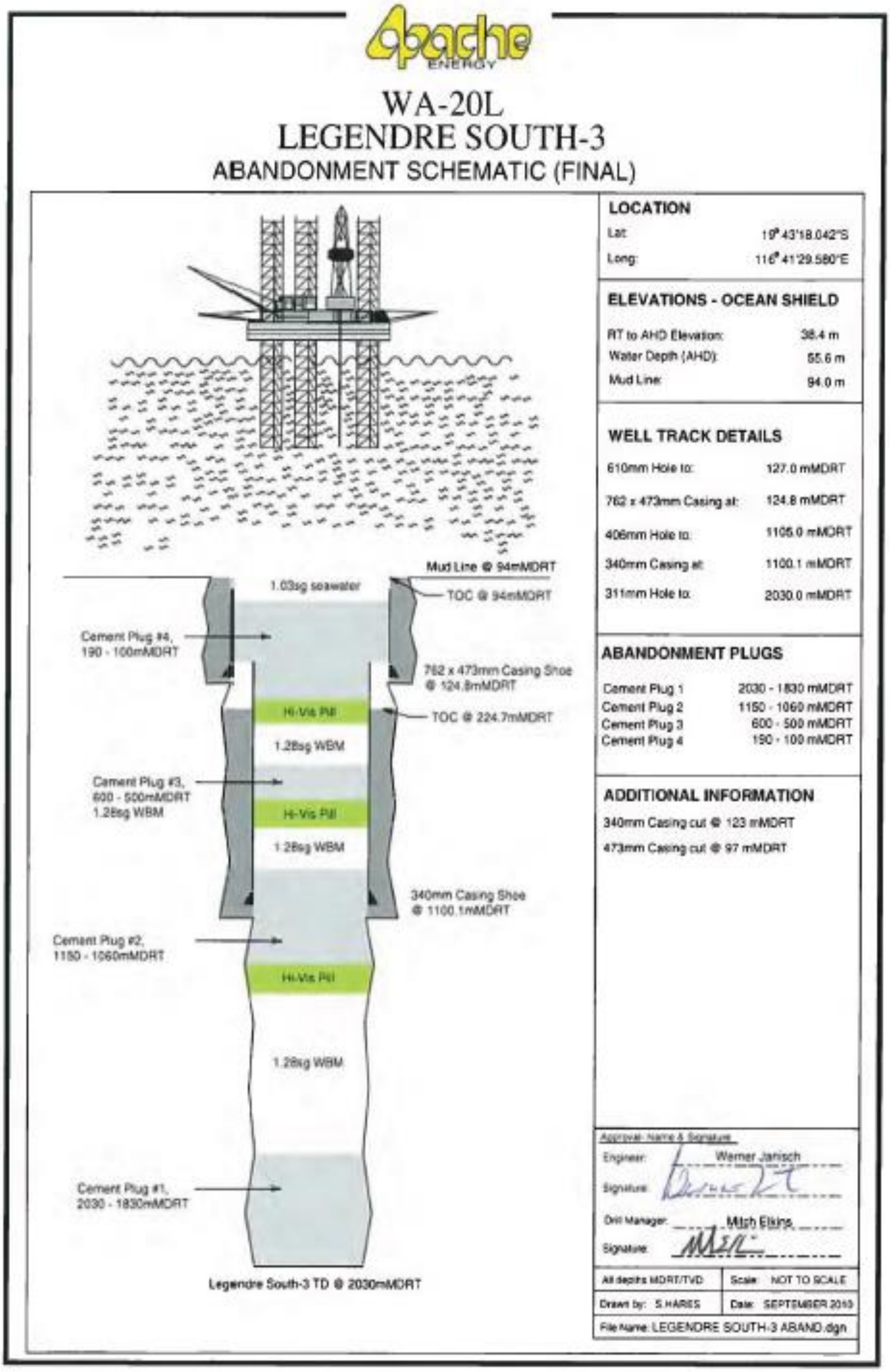

Figure 2-3: WA-20-L Example of plugged and abandoned wells

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 submitted plan 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. The wellhead was found and stands approximately 3.6 m high and 5 m wide (RPS 2021b).

2.2.1 Assessment of options

The removal of the Legendre-1 wellhead was considered in accordance with 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, 2018) and an assessment of options was carried out including the option for not removing the wellhead. **4**The assessment of options comprised the following:

a) a wellhead removal study (the study) which looked at options for how the wellhead could be removed;

b) A snagging risk study which looked at the impacts and risks posed by the wellhead remaining in situ; and

c) an environmental risk and impact assessment (ERIA) comparing the options of:

- removal of the wellhead, or
- leaving the wellhead in-situ.

The study is provided in full in **Appendix C.** A summary of the ERIA is provided in the sections below and **Table 2-3.**

2.2.2 Wellhead removal study

Santos commissioned an independent study to evaluate the technical feasibility of the removal of the Legendre-1 wellhead (**Appendix C**). The study assessed methods for removal via (i) internal cutting, which may remove the wellhead to below the mudline and (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 study used the 2021 ROV footage to assist in evaluating potential removal methods and risks.

2.2.2.1 Removal by internal cutting

The Legendre-1 wellhead could be removed by entering the well and cutting the well casing from inside the well using hydraulic cutters. The hydraulic cutter 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 as there is generally space to access this depth) 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.

The study found there is significant uncertainty in the feasibility of the methods, there are a number of risks associated with this type of removal, and there are high costs without guarantee of successful removal, as summarised below:

- the type of wellhead, high pressure housing and temporary abandonment cap type are unknown, making it unfeasible to prepare for internal access or pressure management operations. Identification of these components would require a separate vessel mobilisation in order to conduct marine growth cleaning and identification. It is noted that it may still not be possible to identify the components due to their age, having been installed in 1968.
- internal cutting requires use of heave compensated crane (or in-line compensator on the crane). This option has significant equipment requirements, e.g., 150 m^2 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 escalating costs is also high due to the unknown type and condition of the wellhead.

2.2.2.2 Removal by external cutting

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.

The study found there are a number of risks associated with removal above the mudline, summarised below:

- the wellhead has a temporary guide base (TGB) installed which prevents direct access to the wellhead conductor outside diameter for external diamond-wire saw mounting.
- the TGB has minimal clearance above the seabed, preventing access below the TGB for any external cutting to the wellhead without dredging seabed material from around the outside (i.e. an external cut will leave a stump protruding from mud-line). The extent of cement at seabed level below the TGB is unknown and it is likely a cement porch is present which would prevent dredging to enable a cut below the mud line.
- conventional diamond-wire saw (DWS) and Subsea ROV deployed DWS methods and tooling have significant technical issues likely to prevent them from being a suitable option for making the cut.
- Instead of the conventional DWS tooling, an in-line 155" Blakemere DWS could be installed around the TGB and could possibly effect a cut 100 mm above seabed. This tool presents the best external cut option. However, the tool is a proto-type design, has never been field tested, and 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 a proto-type tooling never before field tested. It would engender a moderate to high cost.

2.2.2.3 Wellhead removal study conclusions

The wellhead removal study concluded that both internal cutting and external cutting options are feasible, however there is a low chance of success for both options. The study included a budgetary cost estimate to conduct removal operations. Costs are estimated to be in the range of AUD 3 to 5 M assuming a “vessel of opportunity” could be used and that the operation was relatively trouble-free, which is unlikely given the age of the wellhead and the nature of the operation. The complexities and challenges listed in the sections above would likely result in the cost escalating through failed removal attempts.

2.2.3 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. 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 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 (AMCS 2021, 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. 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 (AMCS 2021). Further, the wellhead is within the Glomar Shoal, which is 'for the best part untrawlable ground' (AMCS 2021) and 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.

To determine the severity of damage in the unlikely event of a snag occurring, the study examined ROV imagery of the wellhead from the 2021 survey and 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 (AMCS 2021).

2.2.4 Environmental risk and impact assessment of options

As both the option to remove the wellhead or to leave it in place are considered feasible, the following was undertaken:

- an assessment of all environmental impacts and risks of each option using the Santos environmental assessment method described in **Section 4.1**, which 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 study EIRA 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**).

2.2.4.1 Activity and aspect descriptions

Leave wellhead in-situ

Leaving the Legendre-1 wellhead in-situ would involve no additional activity unless a further inspection of the wellhead is required.

Removal of wellhead

Regardless of the wellhead removal method, the activity would likely be carried out by a manned offshore support vessel (OSV) using dynamic positioning (DP). The number of personnel onboard (POB) is expected to be less than 50.

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

Due to the high level of corrosion observed on the wellhead, lifting the wellhead in one piece is not proposed. The 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 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) will be maintained around the vessel, as required under the OPGGS Act.

Additional support vessels, anchoring and refuelling at sea would not be required.

Due to the short duration of the activity no crew changes will be required, therefore helicopters are not considered in the scope of this activity except in an emergency response capacity.

It is estimated it would take a maximum of 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 2-2**.

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

Aspect	Wellhead removal	Leave in-situ
Planned events		
Presence of wellhead: wellhead degradation	✓ (in the event of removal above the mudline)	✓
Presence of wellhead: disturbance to other users	✓ (in the event of removal above the mudline)	✓
Seabed disturbance	✓	✘
Discharges from removal operation: cuttings	✓	✗
Discharges from removal operation: noise	✓	✗
Disturbance of artificial habitat	✓	✗

Aspect	Wellhead removal	Leave in-situ
Vessel presence: Disturbance to other users	✓	✗
Vessel presence: Planned operational atmospheric emissions	✓	✗
Vessel presence: Planned operational discharges	✓	✗
Vessel presence: anthropogenic noise	✓	✗
Vessel presence: anthropogenic light	✓	✗
Hydrocarbon spill response	✓	✗
Unplanned events		
Release of dropped objects	✓	✗
Vessel presence: Invasive marine species (IMS)	✓	✗
Hazardous liquid release	✓	✗
Vessel presence: hydrocarbon spill	✓	✗
Presence of wellhead: snagging	✓ (in the event of removal above the mudline)	✓

2.2.4.2 Outcomes of the assessment

Results by environmental aspect

Table 2-2 shows that the option of leaving the wellhead in situ delivers an equal or better environmental outcome for 14 of the 17 aspects considered as most of the environmental aspects are not relevant due to the lack of in-field activities if leaving the wellhead in situ. Three aspects are common to the wellhead removal (above the mudline) and wellhead in situ options, being impact from wellhead degradation, disturbance to other users and snagging risk. 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 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 (i.e., over hundreds of years). Snagged nets are at risk of ghost fishing and introduce safety and economic risk to commercial fishers. 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 with (**Section 2.2.3**). 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).

Table 2-3: and **Table 2-4** compare the environmental impacts and risks associated with the options of wellhead removal and of leaving the wellhead in-situ.

Overall assessment of better or equivalent environmental impact and acceptable outcome

Whilst the environmental consequence of either option is ranked as negligible for the identified impacts in common (contamination from material degradation and disturbance to other users), the removal option results in more localised environmental impacts as a direct result of the removal activity. The removal operations would cause localised seabed disturbance, generate metal cuttings, vessel emissions, displacement of other marine users and remove artificial habitat.

It is estimated that wellhead removal costs would be in the range of 4.9 M AUD. The complexities and challenges associated with wellhead removal would likely result in the activity length escalating through failed removal attempts, and thus 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. Vessel operations carry medium ranked risks of hydrocarbon spill, hydraulic fluid spill, and introduction of invasive marine species. 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.

Based on the outcome of the assessment of options for the Legendre-1 wellhead, presented in this Section, Santos proposes to leave the Legendre-1 wellhead in situ as it has been demonstrated to provide an equivalent or better environmental outcome than removing the wellhead.

Table 2-3: Wellhead options assessment of environmental outcomes – Planned events

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
Presence of wellhead: 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	Consequence Level: I - Negligible	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
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 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 (AMCS 2021). The minor avoidance behaviour of the wellhead may result in a Negligible increase in vessel fuel use and time.	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 (AMCS 2021). The minor avoidance of the wellhead may result in a Negligible increase in vessel fuel use and time.	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. 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.
	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	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.

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
	Consequence Level: I - Negligible	Consequence Level: N/A	
Removal operations: Discharges from cuttings	Release of cuttings/ filings of the wellhead during removal to the seabed and water column. 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.	None associated with option.	As there would be no discharges of cuttings/filings 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: 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	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
Removal operations: Disturbance of artificial 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). If the wellhead was removed above the mudline, a small area of hard substrate will remain that provides benthic habitat and associated demersal species.	None associated with option.	As there would be no disturbance of artificial habitats 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: 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 of wellhead Description and Potential Impact	Leave wellhead 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.	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
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) , however, permit area overlaps with the distribution provided in the National Conservation Values Atlas; + shearwater internesting 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	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Assessment Outcome
Removal operations: Anthropogenic light from vessels	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 and seabirds that can alter foraging and breeding activity in marine turtles, seabirds, fish and sharks.	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: Hydrocarbon spill response operations following a vessel collision	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 2-4 Wellhead options assessment of environmental outcomes – Unplanned events

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Comparative 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.		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	
Hazardous liquid releases	Accidental release of 100's 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	

Aspect	Removal of wellhead Description and Potential Impact	Leave wellhead in situ Description and Potential Impact	Comparative Assessment Outcome
Release of hydrocarbons	Release of MDO/MGO to the marine environment could occur between a passing 3rd party vessel and the OSV vessel 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 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.	
Presence of wellhead: snagging	None associated with the option of removal below mudline. 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 (AMCS 2021). The likelihood of interaction with the wellhead by commercial fishers is considered to be a - Remote.	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 (AMCS 2021). The likelihood of interaction with the wellhead by commercial fishers is considered to be a – Remote. There is no record of interaction with commercial fishers to date.	For either option the possibility of interaction with the wellhead by commercial fishers is considered to be a - Remote. There is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground (AMCS 2021). 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 a I - Negligible impact to other users.
	Risk level: Very low	Risk level: Very low	

2.3 Vessel-based support activities

Vessel-based surveillance, monitoring, inspection and research activities may be required in support of the petroleum activities described in **Sections 2.1** and **2.2**, so for completeness have been described and assessed within this EP. Vessel-based support activities may occur at any time within the period that this EP is in force. Vessel-based support activities may be performed during any season, may vary between two and 14 consecutive days within permit WA-20-L and may include 24-hour operations.

2.3.1 Vessels

Typically, a single vessel will be used to undertake the activity. 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 conservatively 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 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.

Aqueous 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 support activities are described below and include a range of standard methods for monitoring water, sediments and fauna in marine environments

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 also 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

Alternatively, 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

Discrete 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 establish 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 Fish sampling

Fish may be collected in commercial fish traps for ecotoxicological analyses. Fish traps will be deployed by hand or using a hydraulic winch, under licence from DPIRD.

2.3.2.7 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 that are 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. The gas collection funnel is marked with 100 ml, 200 ml, 300 ml, 400 ml, 500 ml, and 1000 ml volumes so that the volume of collected gas can be accurately determined. While the gas is being collected, the bubble sizes are also assessed and filmed by the ROV. The video time-code on the ROV footage can be used to calculate flow rates.

CSIRO are investigating the use of acoustic techniques to monitor flow rates of the gas seeps over longer periods of time rather than the points in time sampling available using the ROV/funnel technique described above.

3 Description of the environment

OPGGS(E)R 2009 Requirements
Regulation 13. Environmental Assessment
Description of the environment 13(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 regulation 4 includes its social, economic and cultural features. 13(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 within the meaning of the EPBC Act; + the national heritage values of a National Heritage place within the meaning of that Act; + the ecological character of a declared Ramsar wetland within the meaning of that Act; + the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act; + the presence of a listed migratory species within the meaning of that Act; + any values and sensitivities that exist in, or in relation to, part or all of: (i) a Commonwealth marine area within the meaning of that Act; or (ii) Commonwealth land within the meaning of that Act.

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 potential area impacted by planned activities includes the area immediately adjacent to each gas seepage location and the Legendre-1 wellhead site (**Figure 2-1**). 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 in the EMBA is provided in this chapter, with additional information provided in **Appendix F**.

3.1.1 Protected matters search tool reports

A desktop search of WA-20-L and the EMBA was undertaken using the Department of the Environment and Energy (DoEE) Protected Matters Search Tool (PMST) to identify MNES listed under the EPBC Act. The results of these searches, undertaken on 30 November 2020 and 22 September 2021 respectively, are provided in **Appendix E.**

On the first page of each PMST report, is a coarse graphic showing the area over which the search has been conducted. However, the granularity of this can make the output look different to the spatial area represented on figures within the EP.

The co-ordinates are also 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 of the gas seepage (**Section 7.5**), was undertaken to inform the EMBA. 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 7.5** for further information about 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 7.5** 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/m^2)	1	10	50
Shoreline accumulation (g/m^2)	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 Department of Agriculture, Water and Environment (DAWE) 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 regulation 13(1)(2) of the OPGGS(E)R) is available in **Appendix F**. 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 present within the EMBA 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 F.**

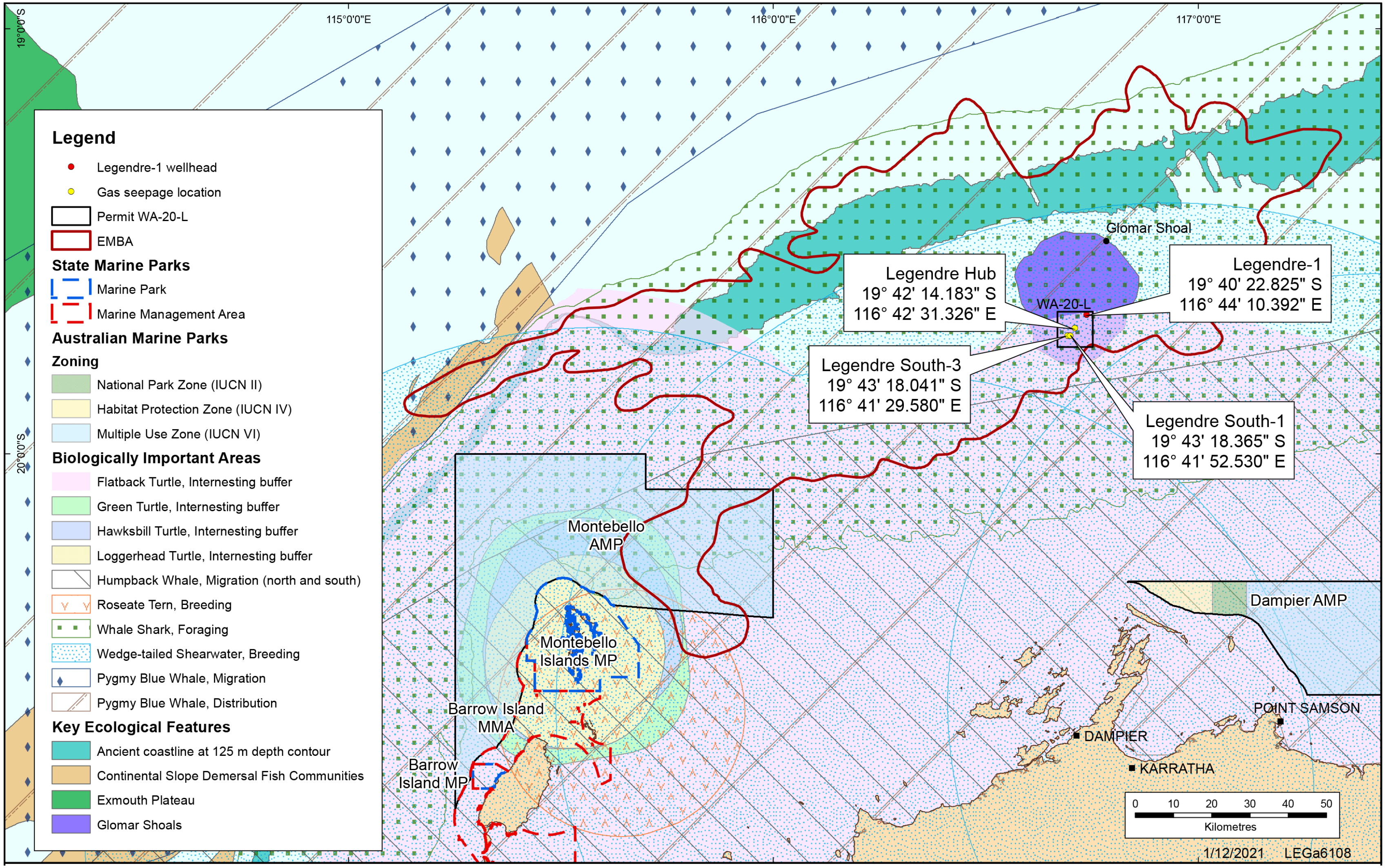

Figure 3-1:WA-20-L EMBA

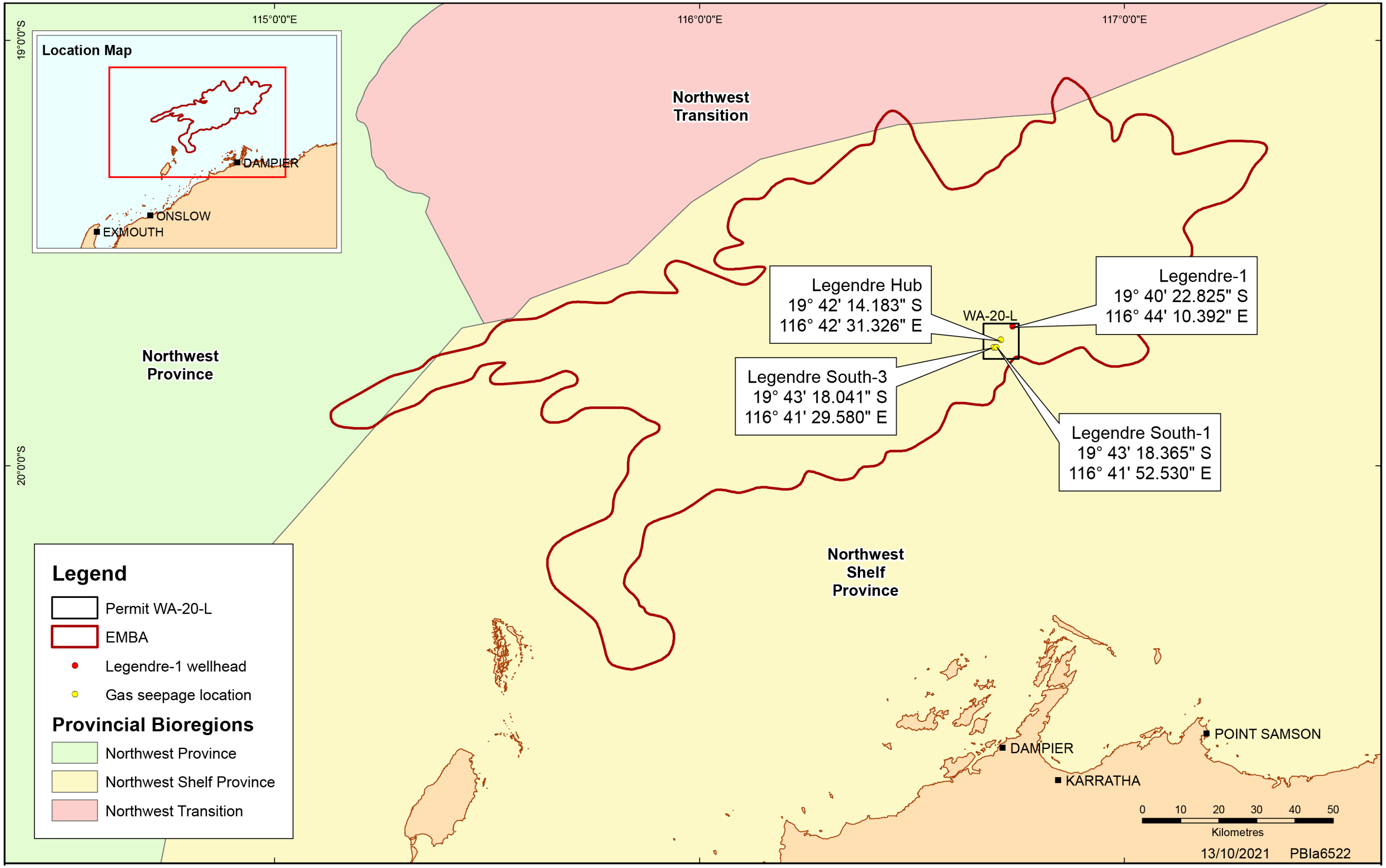

Figure 3-2: IMCRA 4.0 provincial bioregions within the EMBA and WA-20-L

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 North West Shelf (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).

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).

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.

3.3.5 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 menthane 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).

Methane seeps had been observed in the Legendre field and Santos commissioned RPS to conduct a sampling survey to characterise any gas seeps at all eight well locations in WA-20-L. RPS completed the surveys in March 2021 using a remotely operated vehicle (ROV), fitted with a methane sensor (sniffer) and gas collecting apparatus to characterise the seeps. A van Veen grab was used to collect sediment samples for contamination analysis. The survey confirmed the presence of gas seeps at the Legendre Hub as well as discovering minor gas bubble releases at Legendre South-1 and at Legendre South-3. Most of the gas seeps were located at and around the sites of an abandoned well, most commonly emerging from the tops of the concrete well caps and from under grouting concrete on the surrounding seabed.

Point estimates of methane concentration were measured directly over the identified WA-20-L seeps. 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 where there were several minor seeps. The point estimates were measured over at least 30 seconds. The flow rates of seeps which were too low to measure reliably were estimated visually by comparison with measured seeps. The gas flow rates across the seep sites ranged from approximately 6-338 mL/min, with majority of seepage from the Legendre Hub.

Gas samples were collected from the Legendre Hub and Legendre South-1 locations and analysed by the ChemCentre and a specialised laboratory in the United States. Methane contributed >85% of the molecular content of the gas samples.

Dissolved methane concentrations in seawater were measured at all locations using a hydrocarbon sensor. Methane concentrations were very low at all sites more than 10 m from the gas release locations. The measured concentrations at this distance from the source of the seeps were less than 20 ppm, which is at the lower end of the sensors range of detection. Concentrations measured at the seabed release site of the gas stream at Legendre South-1 were approximately 42-64 ppm at the base of the stream, and those taken at the seabed and 5 m above the seabed at Legendre Hub were approximately 112-391 ppm (RPS 2021a).

CSIA analysis performed on gas collected during the 2021 survey confirms the gas is thermogenic in origin and matches the reservoir hydrocarbons in the pool below, with no signs of biodegradation, indicating that the gas has migrated over a relatively short (geological) timeframe (RPS 2021a).

3.3.6 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).

Santos commissioned RPS to conduct a sediment sampling survey at the historic Legendre- 1 wellhead and at four of the well locations, including the Legendre Hub location with a confirmed gas seep. RPS completed the surveys in March 2021 using a van Veen grab to collect sediment samples for contamination analysis.

Sediments were sampled at four Legendre well locations, Legendre- 1, Legendre Hub, Legendre South-1, and Legendre South-3. 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 PSD curve and chemical geophysical 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).

3.3.7 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 remotely operated vehicle (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 KEF, described in **Appendix F**) 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 macroalage, 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). Five significant areas overlap WA-20-L: one key ecological feature (KEF) and four Biologically important areas (BIAs). An additional KEF and an Australian Marine Park is overlapped by the EMBA (**Table 3-2**). These areas are shown on **Figure 3-1**.

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

Value/ sensitivity	Name	Within WA-20-L	Within the EMBA	Distance to Wellhead	Distance to Gas release
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 Breeding, foraging	✓	✓	Overlaps	Overlaps
	Pygmy blue whale Distribution	✓	✓	Overlaps	Overlaps

Value/ sensitivity	Name	Within WA-20-L	Within the EMBA	Distance to Wellhead	Distance to Gas release
	Flatback turtle Internesting	✓	✓	Overlaps	Overlaps
	Green turtle internesting	✗	✓	119 km	112 km
	Hawksbill turtle internesting	✗	✓	124 km	117 km
	Humpback whale migration	✗	✓	17.5 km	13 km
	Pygmy blue whale migration	✗	✓	76 km	75 km
	Roseate tern breeding	✗	✓	123 km	116 km
	Loggerhead turtle Internesting	✗	✓	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 (North-west MPNMP) (Director of National Parks, 2018).

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

	Within WA-20-L	Within the EMBA
LTS	17	21
LMS	31	38
Total	48	59

Biologically Important Areas (BIAs) such as an aggregation, breeding, 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 F.** 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 F**.

Table 3-4: Environmental values and sensitivities within WA-20-L and the EMBA – threatened and migratory marine fauna

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events to Gas Seepage
			WA-20-L	EMBA		
Birds						
Calidris canutus	Red Knot	E	✓	✓	Conservation Advice *Calidris canutus* Red knot (TSSC 2016a)	Planned + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations Unplanned + Release of hydrocarbons
Numenius madagascariensis	Eastern Curlew	CE	✓	✓	Conservation Advice for *Numenius madagasca nereis* (DoE 2015a)	
Sternula nereis nereis	Australian Fairy Tern	V Migratory	✓	✓	Approved Conservation Advice for *Sternula nereis* nereis (DSEWPC 2011a)	
Anous stolidus	Common Noddy	Migratory	✓	✓	-	
Ardenna pacifica	Wedge-tailed shearwater	Migratory	✓	✓	-	
Calonectris leucomelas	Streaked Shearwater	Migratory	✓	✓	-	
Fregata ariel	Lesser Frigatebird	Migratory	✓	✓	-	
Fregata minor	Great Frigatebird	Migratory	✓	✓	-	
Sterna dougallii	Roseate tern	Migratory	✓	✓	-	
Calidris ferruginea	Curlew Sandpiper	CE	-	✓	Conservation Advice *Calidris ferruginea* curlew sandpiper. (DoE 2015)	
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).	

<table>
<tr><th rowspan="2">Scientific Name</th><th rowspan="2">Common Name</th><th rowspan="2">EPBC Act Status</th><th colspan="2">Presence</th><th rowspan="2">Conservation Advice or Recovery plan</th><th rowspan="2">Relevant events to Gas Seepage</th></tr>
<tr><th>WA-20-L</th><th>EMBA</th></tr>
<tr><td colspan="7">Sharks and Rays</td></tr>
<tr><td>Carcharias taurus (west coast population)</td><td>Grey Nurse Shark</td><td>V</td><td>✓</td><td>✓</td><td>Recovery plan for the Grey Nurse Shark (Carcharias taurus) (DoE 2014)</td><td rowspan="10"><u>Planned</u>
+ Introducing methane into the water column
+ Light emissions
+ Atmospheric emissions
+ Operational discharges
+ Spill response operations
+ Wellhead degradation
<u>Unplanned</u>
+ Release of hydrocarbons</td></tr>
<tr><td>Carcharodon carcharias</td><td>Great White Shark</td><td>V
Migratory</td><td>✓</td><td>✓</td><td>Recovery Plan for the White Shark (Carcharodon carcharias) (DSEWPC 2013)</td></tr>
<tr><td>Pristis zijsron</td><td>Green Sawfish</td><td>V
Migratory</td><td>✓</td><td>✓</td><td>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)</td></tr>
<tr><td>Rhincodon typus</td><td>Whale Shark</td><td>V
Migratory</td><td>✓</td><td>✓</td><td>Conservation Advice for Rhincodon typus (whale shark) (TSSC 2015a), Listing advice on Rhincodon typus (Whale shark) (TSSC 2001)</td></tr>
<tr><td>Carcharhinus longimanus</td><td>Oceanic Whitetip Shark</td><td>Migratory</td><td>✓</td><td>✓</td><td>-</td></tr>
<tr><td>Isurus oxyrinchus</td><td>Shortfin Mako</td><td>Migratory</td><td>✓</td><td>✓</td><td>Listing Advice Isurus oxyrinchus shortfin mako shark (TSSC 2014)</td></tr>
<tr><td>Isurus paucus</td><td>Longfin Mako</td><td>Migratory</td><td>✓</td><td>✓</td><td>-</td></tr>
<tr><td>Manta alfredi</td><td>Reef Manta</td><td>Migratory</td><td>✓</td><td>✓</td><td>-</td></tr>
<tr><td>Manta birostris</td><td>Giant Manta</td><td>Migratory</td><td>✓</td><td>✓</td><td>-</td></tr>
<tr><td>Anoxypristis cuspidate</td><td>Narrow Sawfish</td><td>Migratory</td><td>✓</td><td>✓</td><td>-</td></tr>
</table>

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events to Gas Seepage
			WA-20-L	EMBA		
Pristis clavata	Dwarf sawfish	V	-	✓	Approved Conservation Advice for *Pristis clavata* (Dwarf Sawfish). Department of the Environment, Water, Heritage and the Arts (2009)	
Marine turtles						
Caretta caretta	Loggerhead Turtle	E Migratory	✓	✓	Recovery Plan for Marine Turtles in Australia (DoEE 2017)	<u>Planned</u> + Introducing methane into the water column + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations + Wellhead degradation <u>Unplanned</u> + 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						
Aipysurus apraefrontalis	Short-nosed Seasnake	CE	✓	✓	Approved Conservation Advice on *Aipysurus apraefrontalis* (DSEWPC 2011)	<u>Planned</u> + Introducing methane into the water column + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations
Aipysurus foliosquama	Leaf-scaled Seasnake	CE	-	✓	Approved Conservation Advice for *Aipysurus foliosquama* (Leaf-scaled Sea Snake) (DSEWPaC 2011)	

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events to Gas Seepage
			WA-20-L	EMBA		
						+ Wellhead degradation Unplanned + Release of hydrocarbons
Mammals						
Balaenoptera borealis	Sei Whale	V Migratory	✓	✓	Conservation Advice for *Balaenoptera borealis* (sei whale) (TSSC 2015b)	Planned + Introducing methane into the water column + Light emissions + Atmospheric emissions + Operational discharges + Spill response operations + Wellhead degradation Unplanned + Release of hydrocarbons
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	V Migratory	✓	✓	Conservation Advice for *Megaptera novaeangliae* (humpback whale) (TSSC 2015d)	
Balaenoptera edeni	Bryde's Whale	Migratory	✓	✓	-	
Delphinus delphis	Common Dolphin	Migratory	✓	✓	-	
Grampus griseus	Risso's Dolphin	Migratory	✓	✓	-	
Orcinus orca	Killer Whale	Migratory	✓	✓	-	
Pseudorca crassidens	False Killer Whale	Migratory	✓	✓	-	

Scientific Name	Common Name	EPBC Act Status	Presence		Conservation Advice or Recovery plan	Relevant events to Gas Seepage
			WA-20-L	EMBA		
Stenella attenuata	Spotted Dolphin	Migratory	✓	✓	-	
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted Bottlenose Dolphin	Migratory	✓	✓	-	
Tursiops aduncus	Indian Ocean Bottlenose Dolphin	Migratory	✓	✓	-	
Tursiops truncatus s. str.	Bottlenose Dolphin	Migratory	✓		-	
Dugong dugon	Dugong	Migratory	-	✓	-	
Physeter macrocephalus	Sperm Whale	Migratory	-	✓	-	
Threatened species (EPBC Act Status): E = Endangered, V = Vulnerable, CE = Critically Endangered						

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**.

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
Commonwealth managed fisheries	Four Commonwealth fisheries have the licence to operate within WA-20-L and the EMBA. None of these actively fished in WA-20-L recently. Effort in the North West Slope Trawl Fishery has occurred historically within the EMBA.	✗	✓	N/A	Unplanned + Release of hydrocarbons
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.	✓	✓	Planned + 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.** + Gas seepage + Interaction with other marine users + Spill response operations Unplanned + Release of solid objects + Introduction of invasive marine species + Hazardous liquid releases	Unplanned + Release of hydrocarbons

Receptor	Description	WA-20-L Presence	EMBA Presence	Relevant events within permit area	Relevant events within the EMBA
Defence	There are no Defence restricted areas within WA-20-L or the EMBA. There is a Potential Depth Charge UXO - East of Montebello Islands however this is outside the EMBA area.	✘	✘	N/A	N/A
Tourism and recreation	No recreation or tourism is expected to occur within WA-20-L owing to the water depth and distance offshore. The southwestern extent of the EMBA reaches within 20 km of the Montebello Islands which offers recreational fishing, surfing and SCUBA diving.	✘	✓	N/A	Unplanned + Release of hydrocarbons
Petroleum industry	Debris from existing infrastructure is present within WA-20-L. Oil and gas facilities and permits are present within the EMBA, operated by other titleholders.	✘	✓	N/A	Unplanned + Release of 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.	✘	✓	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
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.	✘	✘	N/A	N/A

Receptor	Description	WA-20-L Presence	EMBA Presence	Relevant events within permit area	Relevant events within 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.				

3.6.1 Commercial fisheries

Commonwealth and State fisheries that have management areas overlapping with WA-20-L and the EMBA 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** and **Table 3-7.**

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.

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**.

Fisheries that have historical effort within WA-20-L are described in **Sections 3.6.1.1** to **3.6.1.4**.

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 permit area
					Permit Area	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	Scampi (*Metanephrops australienis,*	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	✗	✓	**No** -The management area of the NWSTF does not overlap the permit area.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within permit area
					Permit Area	EMBA	
Trawl Fishery (NWSTF)	*M boschmai*, *M velutinus*)			boundary of the NWSTF from north of the Montebello Islands to Scott Reef (DAWR, 2018).			

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 permit area
					Permit Area	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 PFTIMF, and trawl 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 3.6.1.1**).
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	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	✓	✓	**No** -WA-20-L overlaps with the management area of the MAMF; however, the proposed vessel-based work is not expected to overlap with the actual activities of this fishery due to the water depths.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within permit area
					Permit Area	EMBA	
		plants and live feed.		region, Perth, Geraldton, Exmouth and Dampier (Gaughan & Santoro 2021).			
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 extends from the 30 m isobath the AFZ (Gaughan & Santoro 2021).	✓	✓	**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, the proposed work is not expected to impact the activities of this fishery.
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 and the EMBA. 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 catch or fishing effort within WA-20-L.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within permit area
					Permit Area	EMBA	
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, the proposed work is not expected to overlap with the activities of the 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 the proposed work is not expected to overlap with the activities of the 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 trawl 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 Fishery (PFTIMF)	Red emperor, bluespotted emperor and Rankin cod and other demersal snappers, emperors and groupers.	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 effort within WA-20-L, relative to other areas within the fishery (refer to **Section 3.6.1.2**).

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within permit area
					Permit Area	EMBA	
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 proposed work is not expected to impact the activities of this fishery.
Western Australian North Coast	Sandbar (*Carcharhinus plumbeus*), hammer head	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	✓	✓	**No** - The fishery has not been active since 2008. Therefore, the proposed activity is not expected to impact the activities of this fishery.

Fishery	Target Species	Catch	Fishing Method	Area Description	Permitted to fish		Historical effort within permit area
					Permit Area	EMBA	
Shark Fisheries (WASF)	(*Sphyrnidae*), blacktip (C *melanopterus*) and lemon shark (*Negaprion brevirostris*).			between North-West Cape and 120°E and all waters south of latitude 18°S has been closed indefinitely (Gaughan & Santoro 2021).			
Western Australian Sea Cucumber Fishery	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, the proposed survey is not expected to overlap with the actual activities of 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 3-3**). 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 Ttrawl (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 3-4**). 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 3-4**). Fishing effort occurs relatively consistently across the entire year with no identified peak periods.

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 3-5**). 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 3-6**). 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.

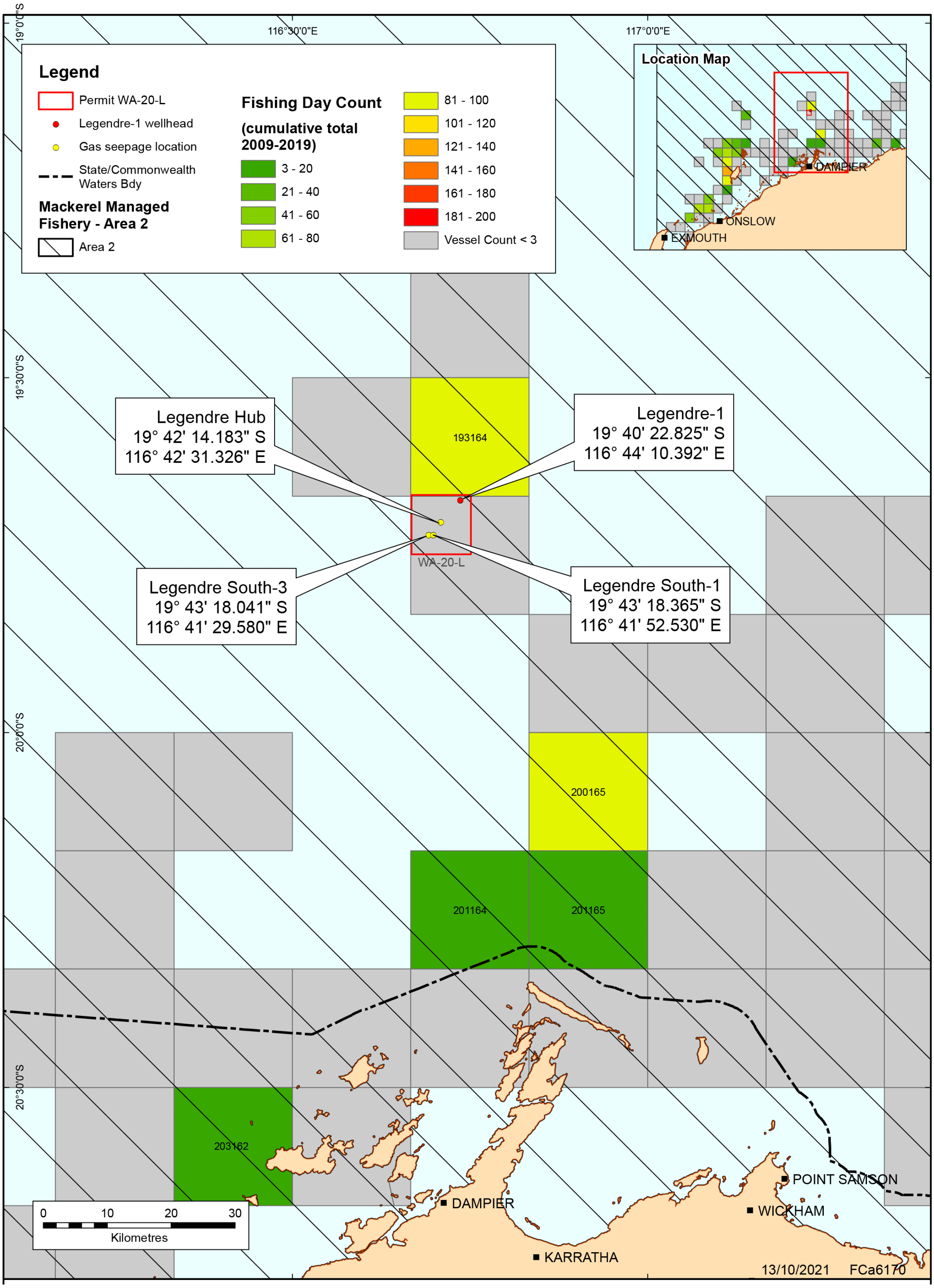

Figure 3-3: Mackerel Managed Fishery Fishing Day Count (2009-2019)

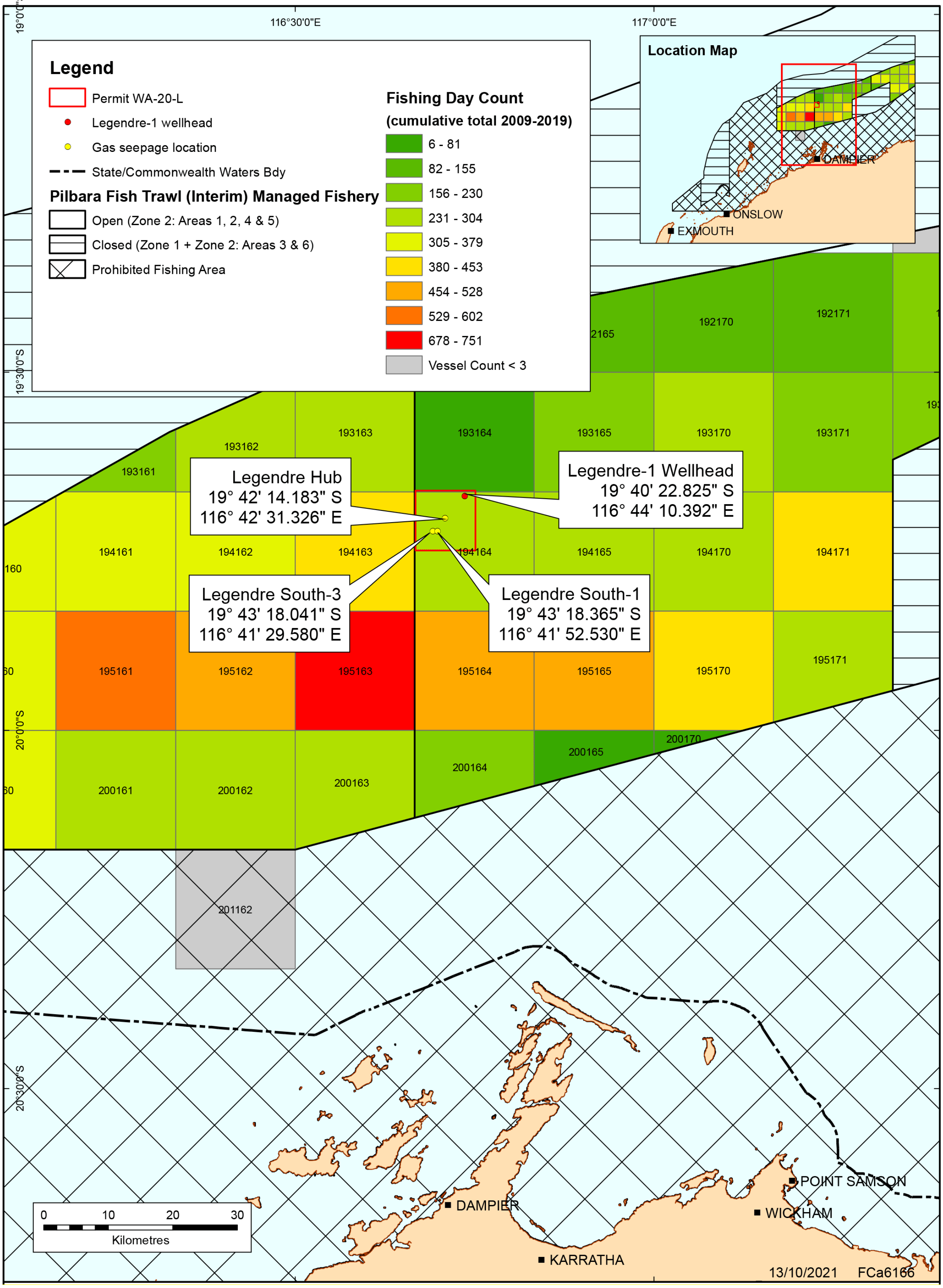

Figure 3-4: Pilbara Fish Trawl (Interim) Managed Fishery Fishing Day Count (2009-2019)

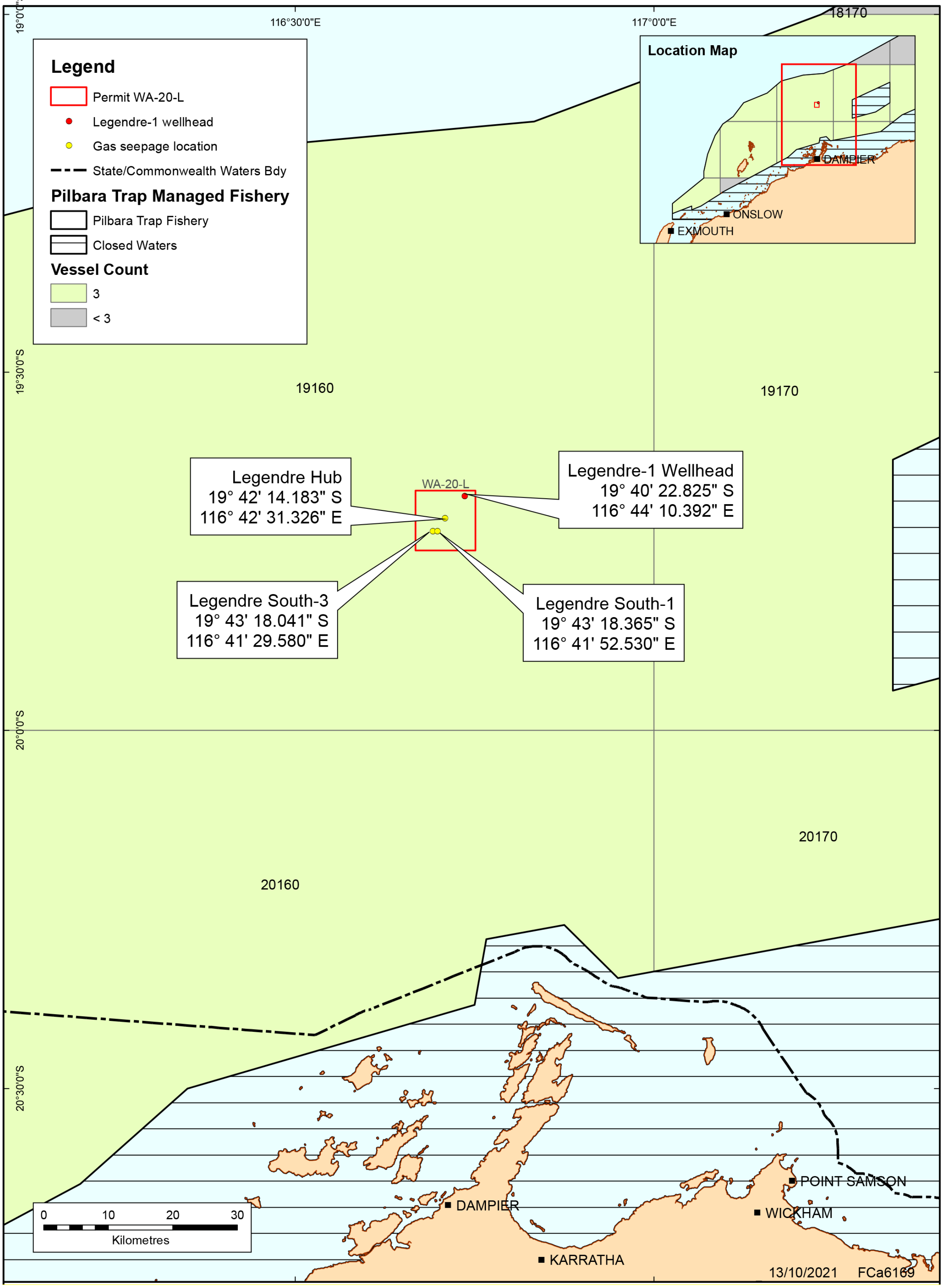

Figure 3-5: Pilbara Trap Managed Fishery Vessel Count (2009-2019)

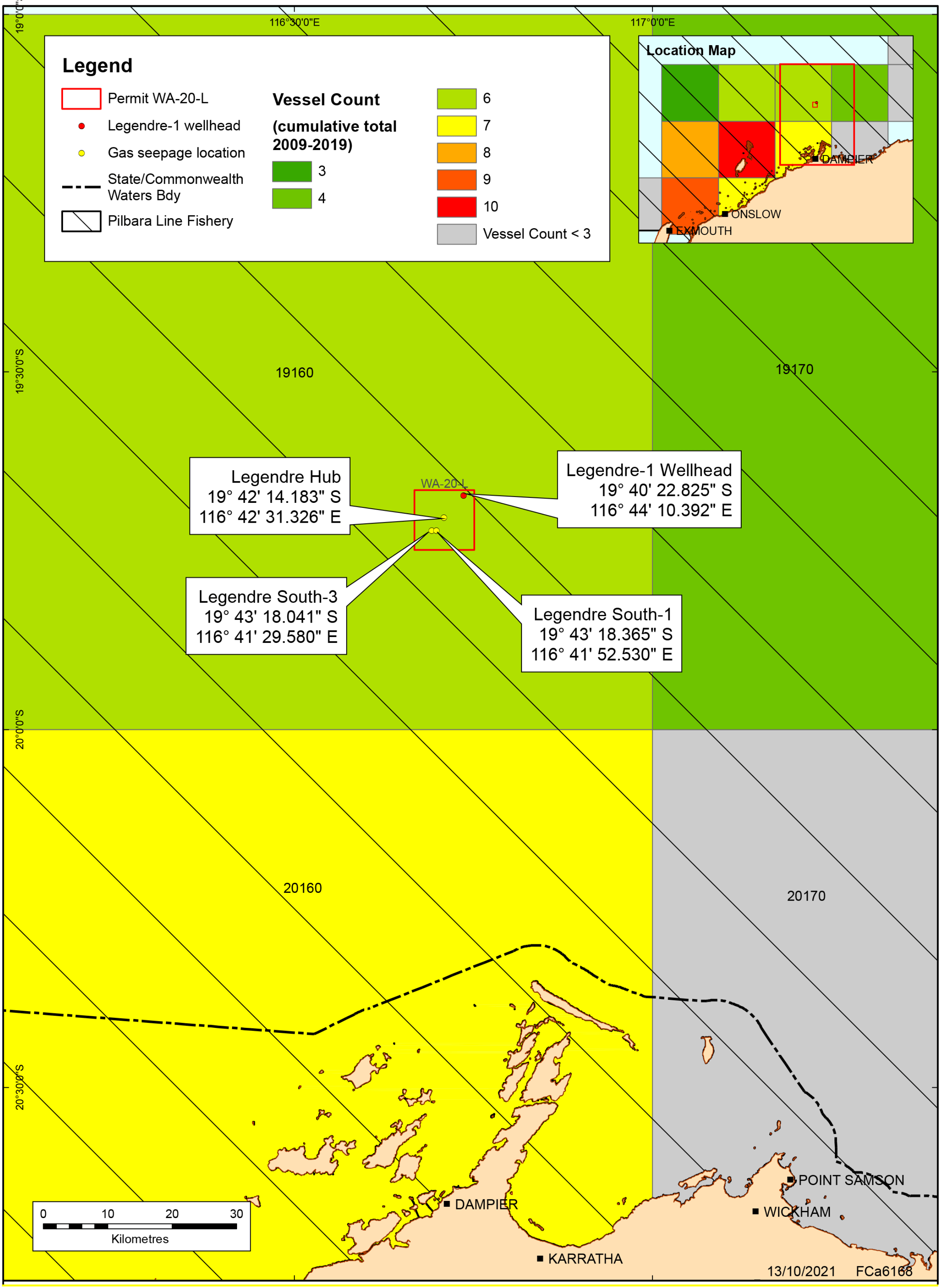

Figure 3-6: Pilbara Line Fishery Vessel Count (2009-2019)

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. The WA Department of Primary Industries and Regional Development (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 F provides a comprehensive description of species that may be present within WA-20-L.

3.6.2 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**).

The southwestern extent of the EMBA reaches within 20 km of the Montebello Islands which offers recreational fishing, surfing, snorkelling and SCUBA diving. Fishing and SCUBA charter companies operate at the islands from April to November.

3.6.3 Petroleum Industry

There are several exploration and production permits in the EMBA which allow exploration and production activities including platforms, floating production storage and offloading vessels, pipelines, drilling and potentially seismic activities (**Figure 3-8**). Vessels servicing oil and gas operations in the region may pass through WA-20-L and the EMBA en-route to facilities.

Previously, various petroleum exploration and production activities have been undertaken within WA-20-L (**Table 1-1**). Various infrastructure related to these activities remain within WA-20-L (**Table 3-8,** Figure 3-7). The substrate and infrastructure associated with the remaining wells in WA-20-L were surveyed using ROV in 2021 (RPS 2021b). **Table 3-8** summarises the remaining infrastructure.

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 pipe, shackles, rope, and concrete blocks).
Legendre Hub	Pavement.	The well location is covered by anti-scour mattresses.

Well name	Substrate	Remaining infrastructure
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	Large blocks of broken concrete raised above seabed.
Legendre South-1	Pavement/concrete	No visible well infrastructure.
Legendre South-3	Pavement/concrete	No visible well infrastructure.

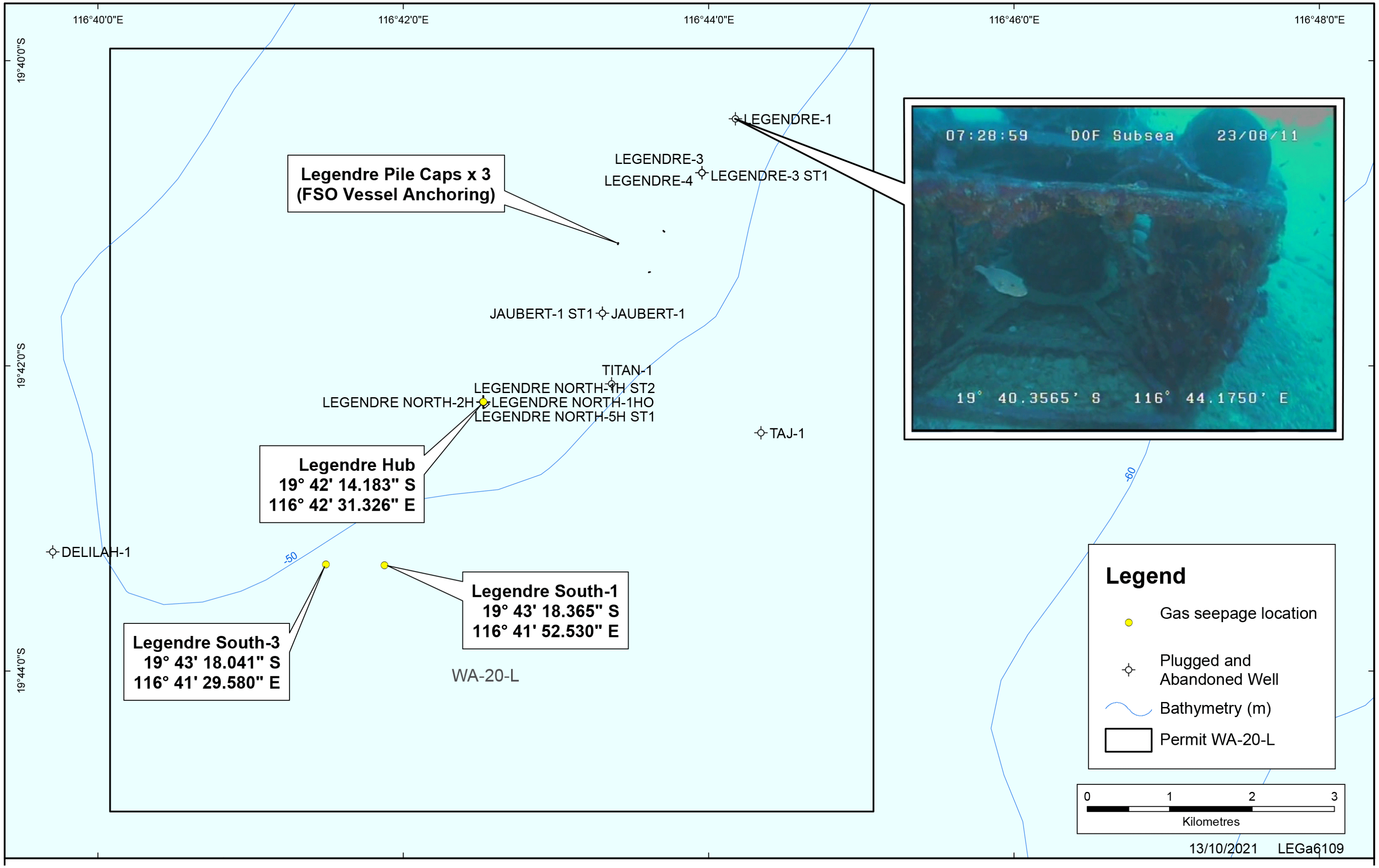

Figure 3-7: Petroleum infrastructure remaining in WA-20-L

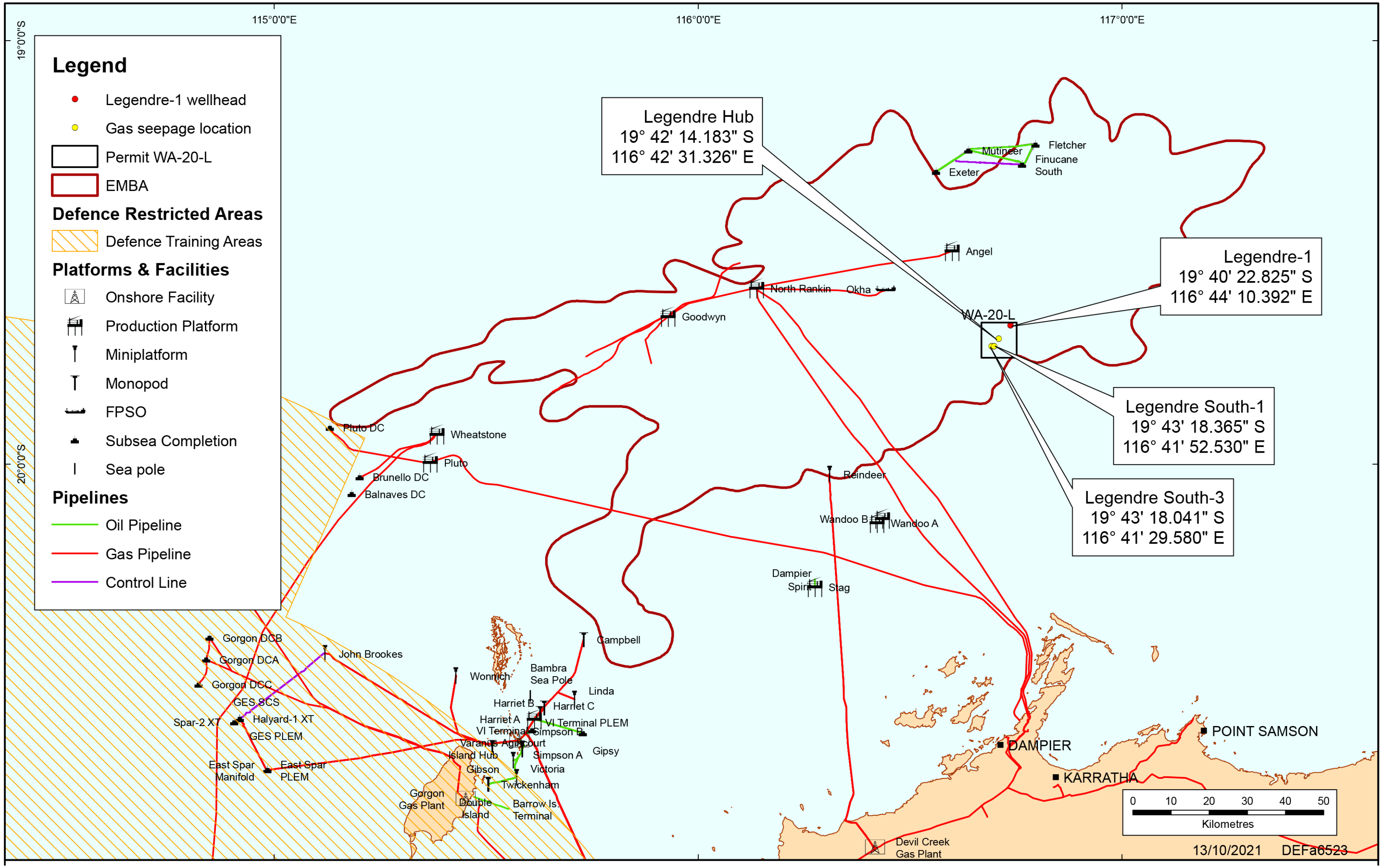

Figure 3-8: Petroleum infrastructure within the EMBA and Defence areas to the southwest of the EMBA

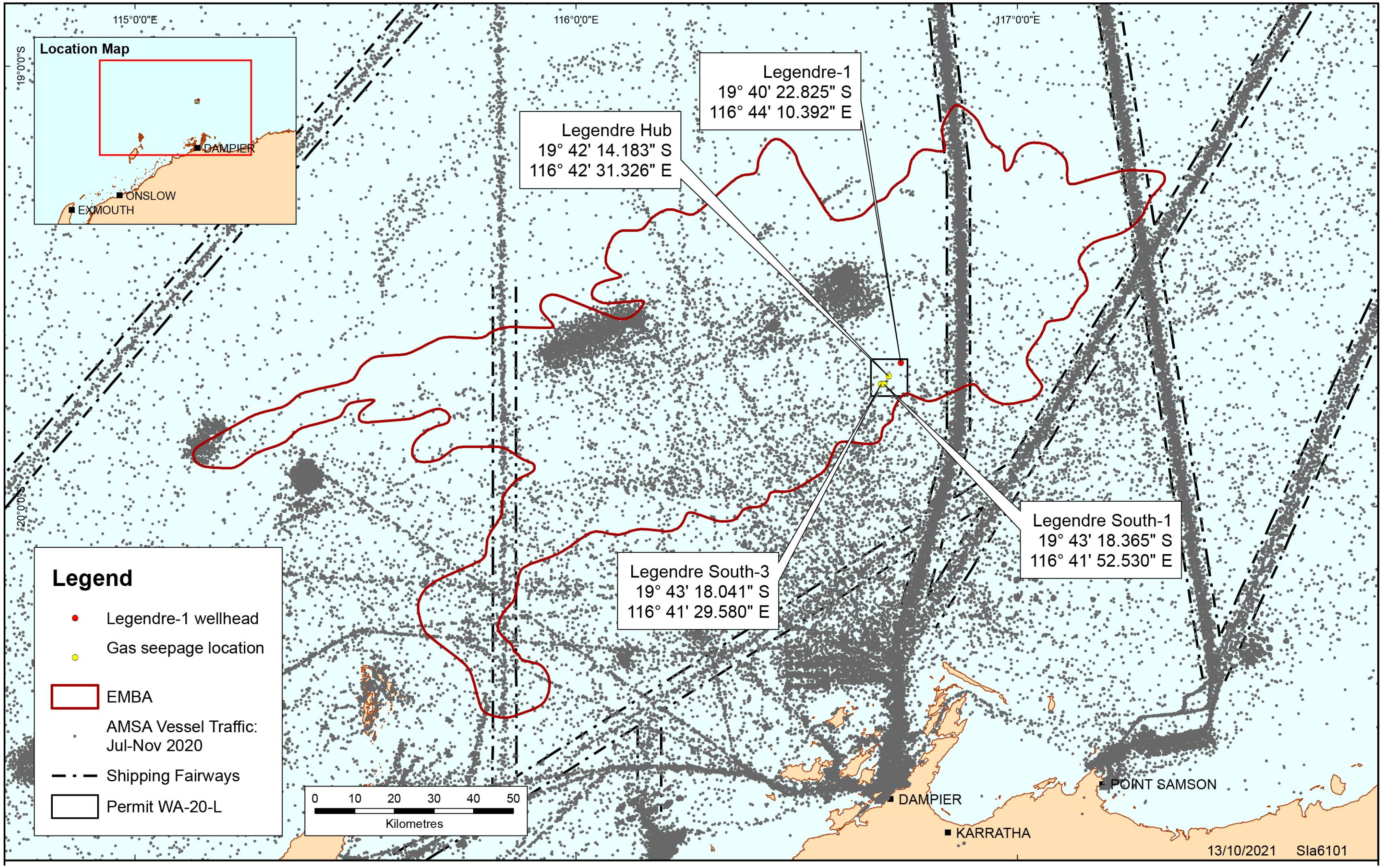

Figure 3-9: Shipping presence within and surrounding WA-20-L

3.6.4 Shipping

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 2020). AMSA shipping routes within and close to WA-20-L and the EMBA are shown in (**Figure 3-9**). 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.

4 Stakeholder consultation

OPGGS(E)R 2009 Requirements
Regulation 9AB
If the Regulator's provisional decision under Regulation 9AA is that the environment plan includes material apparently addressing all the provisions of Division 2.3 (Contents of an environment plan), the Regulator must publish on the Regulator'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.
Regulation 14(9)
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.
Regulation 16
The environment plan must contain the following: (c) report on all consultations between the operator and any relevant person, for Regulation 11A, 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 operator'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 Summary

Stakeholders in **Table 4-1** were informed of activities covered in this EP commencing in December 2021, principally via provision of a Legendre Field Decommissioning Environment Plan consultation package. The package was distributed to identified stakeholders, including maps showing WA-20-L relevant to specific stakeholder interests where relevant.

Santos also sent consultation reminders to those stakeholders expected to be most impacted by the proposed ongoing presence of the wellhead and the gas bubble seepage, these being relevant maritime safety authorities and licence holders in State commercial fisheries and their representative organisation given recorded catch in the past 10 years.

Santos' Quarterly Consultation Updates issued in February, April and July 2021 also contained reference to the Legendre field activities. The Quarterly Consultation Update is provided to a number of stakeholders identified in **Table 4-1**.

Based on Santos' experience with previous activities in the region and from stakeholder feedback and regulator discussions, the primary stakeholder issues of concern for this activity are:

- interaction with other marine users given the ongoing presence of the wellhead and the gas bubble seepage, including the potential for on-water interactions during periodic vessel-based monitoring activities (addressed in **Sections 0** and **6.2**).

Santos has considered all stakeholder responses and assessed the merits of all objections and claims about the potential impact of the proposed activity. The process adopted to assess these claims is outlined in **Section 4.4**. A summary of Santos' response statements to the objections and claims is provided in **Table 4-2** and any specific commitments made as a result of stakeholder consultation are listed in **Table 8-2** or **Table 8-4** if it is a notification requirement. Control measures and environmental performance standards for the proposed activity **(Table 8-2**)**.**

Santos considers that consultation with relevant stakeholders has been adequate to inform the development of this EP. Notwithstanding this, Santos recognises the importance of ongoing stakeholder consultation, and this is described in **Section 4.5.**

4.2 Stakeholder identification

Santos understands retaining a broad licence to operate depends on the development and maintenance of positive and constructive relationships with a comprehensive group of stakeholders in the community, government, non-government, other business sectors and other users of the marine environment. Fostering effective consultation between Santos and relevant stakeholders is an important part of this process.

Santos began the stakeholder identification process for this EP with a review of its stakeholder database, including stakeholders consulted for other recent activities in the area. The list of stakeholders was then reviewed and refined based on the extent of WA-20-L (refer to **Section 2**) and the relevance of the stakeholder according to Regulation 11A of the OPGGS (E) Regulations and NOPSEMA Bulletin #2 Clarifying statutory requirements and good practice consultation (November, 2019).

More specifically, stakeholders for this EP were identified through:

- regular review of legislation applicable to petroleum and marine activities;
- identification of marine user groups and interest groups active in the area (e.g., commercial fisheries, other oil and gas producers, merchant shipping);
- a review of the most recent DPIRD FishCube data as required;
- updated fishing licence holder contact details, from these identified fisheries, as provided by DPIRD;
- discussions with identified stakeholders to identify other potentially impacted persons; and
- active participation in industry bodies and collaborations (e.g., APPEA, AMOSC, National Energy Resources Australia).

Consideration was also given to potential future fishing in the permit by entitled commercial fishery licence holders based on water depth, target species and historic fishing catch, given the proposed ongoing presence of the wellhead and gas bubble seepage.

There are no adjacent titleholders, other than Santos WA Northwest Pty Ltd, which holds adjoining permit WA-48-R. The permit is also outside any Department of Defence practice or training areas.

Currently identified stakeholders and an assessment of their relevance under the OPGGS (E) Regulations for the purposes of consultation for this activity are listed in **Table 4-1**.

Table 4-1: Assessment of relevance of identified stakeholders for the proposed activity

Stakeholder	Relevant to Activity	Relevance/reason for engagement
Commonwealth Government Departments/Agencies		
Australian Border Force (Maritime Border Command)	Considered relevant persons under Regulation 11A(1) (a)	Maritime Border Command is Australia's lead civil maritime security authority and is ensuring Australia's maritime safety
Australian Fisheries Management Authority	Considered relevant persons under Regulation 11A(1) (a)	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. WA-20-L intersects Commonwealth-managed fisheries. While there has been no recent fishing effort in these fisheries, Santos has consulted AFMA given its interest in petroleum activities where licence holders are entitled to fish.
Australian Hydrographic Office (AHO)	Considered relevant persons under Regulation 11A(1) (a)	The AHO is the part of the Commonwealth Department of Defence responsible for maintaining and disseminating nautical charts, including the distribution of Notice to Mariners. WA-20-L is in Commonwealth waters.
Australian Maritime Safety Authority (AMSA) – maritime safety	Considered relevant persons under Regulation 11A(1) (a)	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. WA-20-L is in Commonwealth waters.
Australian Maritime Safety Authority (AMSA) – marine pollution	Considered relevant persons under Regulation 11A(1) (a)	AMSA is the statutory and control agency for marine pollution Commonwealth Waters. WA-20-L is in Commonwealth waters.
Department of Agriculture, Water and the Environment – Biosecurity (marine pests)	Considered relevant persons under Regulation 11A(1) (a)	The DAWE (marine pests) has primary policy and regulatory responsibility for managing biosecurity for incoming goods and conveyances, including biosecurity for marine pests. The Department is the relevant agency where an offshore activity has the potential to transfer marine pests between installations and mainland Australia. WA-20-L is in Commonwealth waters.
Department of Agriculture, Water and the Environment – Fisheries	Considered relevant persons under Regulation 11A(1) (a)	DAWE (fisheries) has primary policy responsibility for promoting the biological, economic and social sustainability of Australian fisheries. The Department is the relevant agency where the activity has the potential to negatively impact fishing operations and/or fishing habitats in Commonwealth waters. WA-20-L intersects Commonwealth-managed fisheries. While there has been no recent fishing effort in these fisheries, Santos has consulted DAWE given its interest in petroleum activities where licence holders are entitled to fish.
Department of Agriculture, Water and the Environment –	Considered relevant persons under Regulation 11A(1) (a)	DAWE (vessels and aircraft) has inspection and reporting requirements to ensure that all conveyances (vessels, installations and aircraft) arriving in Australian territory comply with international health regulations and that any

Stakeholder	Relevant to Activity	Relevance/reason for engagement
Biosecurity (vessels, aircraft and personnel)		biosecurity risk is managed. The department is the relevant agency where the titleholder's activity involves: + the movement of aircraft or vessels between Australia and offshore petroleum activities either inside or outside Australian territory + the exposure of an aircraft or vessel (which leaves Australian territory not subject to biosecurity control) to offshore petroleum activities.
Department of Industry Science, Energy and Resources (DISER)	Considered relevant persons under Regulation 11A(1) (a)	DISER is the department of the relevant Commonwealth Minister and is required to be consulted under subregulation 11A (1) of the Environment Regulations.
Director of National Parks (DNP)	Considered relevant persons under Regulation 11A(1) (a)	The DNP is the statutory authority responsible for administration, management and control of Commonwealth marine reserves (CMRs). The Director of National Parks 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.
State Government Departments/Agencies		
Department of Biodiversity, Conservation and Attractions (DBCA)	Considered relevant persons under Regulation 11A(1) (b)	DBCA is a relevant State agency responsible for the management of State marine parks and reserves and protected marine fauna and flora.
Department of Mines, Industry Regulation and Safety (DMIRS)	Considered relevant persons under Regulation 11A(1) (c)	DMIRS is the department of the relevant State Minister and is required to be consulted under subregulation 11A (1) of the Environment Regulations.
Department of Primary Industries and Regional Development	Considered relevant persons under Regulation 11A(1) (b)	DPIRD is responsible for managed West Australian State fisheries. WA-20-L intersects State-managed fisheries, of which the Pilbara Line Fishery, Pilbara Demersal Trap Managed Fishery and Pilbara Trawl Interim Managed Fishery have been active in WA-20-L.
Department of Transport (DoT)	Considered relevant persons under Regulation 11A(1) (b)	DoT is the control agency for marine pollution emergencies in State waters.
Industry Bodies		
Australian Petroleum Production & Exploration Association (APPEA)	Considered relevant persons under Regulation 11A(1) (e)	APPEA is the peak industry association for companies that explore for and produce oil and gas in Australia. APPEA has facilitated industry-wide discussion aimed at enhancing and strengthening Australia's offshore oil and gas decommissioning framework.

Stakeholder	Relevant to Activity	Relevance/reason for engagement
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	Considered relevant persons under Regulation 11A(1) (e)	ASBTIA represents the Australian southern bluefin tuna industry. ASBTIA is also listed on the AFMA website as a contact for petroleum operators to use when consultation with Commonwealth fishing operators is required. The permit intersects the Southern Bluefin Tuna Fishery. While there has been no recent fishing effort, Santos has consulted ASBTIA on behalf of licence holders who are entitled to fish in the permit.
Commonwealth Fisheries Association (CFA)	Considered relevant persons under Regulation 11A(1) (e)	The CFA was engaged as a representative body for Commonwealth fisheries, which is listed on the AFMA website as a contact for petroleum operators to use when consultation with fishing operators is required. The permit intersects the Southern Bluefin Tuna Fishery, Skipjack Tuna Fishery and the Western Tuna and Billfish Fishery. While there has been no recent fishing effort by licence holders in the permit, Santos has consulted CFA on behalf of licence holders who are entitled to fish in WA-20-L.
Marine Tourism WA (MTWA)	Considered relevant persons under Regulation 11A(1) (e)	MTWA represents the charter sector in WA. MTWA is identified as being able to assist in reaching its membership to inform them of activity timing should this be requested. While marine tourism is unlikely in the permit, Santos has consulted MTWA on behalf of member companies who are entitled to undertake activities in the permit.
Pearl Producers Association (PPA)	Considered relevant persons under Regulation 11A(1) (e)	The PPA is the peak representative organisation of The Australian South Sea Pearling Industry. PPA membership includes all *Pinctada maxima* pearl oyster licensees that operate within the Australian North-west Bioregion. While there is no recent fishing effort in the permit, Santos has consulted PPA based on previous request to be kept informed on Santos activities.
RecfishWest	Considered relevant persons under Regulation 11A(1) (e)	RecfishWest is the peak body representing recreational fishers in WA. RecfishWest is identified as being able to assist in reaching its membership to inform of activity timing should this be requested. While recreational fishing is unlikely in the permit, Santos has consulted RecfishWest on behalf of recreational fishers who are entitled to undertake activities in the permit.
Tuna Australia	Considered relevant persons under Regulation 11A(1) (e)	Represents statutory fishing right owners, licence holders, fish processors and sellers, and associate members of the Eastern and Western Tuna and Billfish fisheries. The permit intersects the Western Billfish and Tuna Fishery. While there has been no recent fishing effort, Santos has consulted Tuna Australia on behalf of licence holders who are entitled to fish in the permit.
Western Australian Fishing Industry Council	Considered relevant persons under Regulation 11A(1) (e)	WAFIC is the peak industry body representing the interests of the WA commercial fishing, pearling and aquaculture sector. The permit area intersects State-managed fisheries, of which the Pilbara Line, Pilbara Trap, Pilbara Trawl (Interim)

Stakeholder	Relevant to Activity	Relevance/reason for engagement
		Managed, and Mackerel (Area 2) fisheries have been active in the vicinity of the permit.
Commercial Fisheries – State Managed		
Mackerel Managed Fishery (Area 2)	Considered relevant persons under Regulation 11A(1) (d)	The permit intersects the fishery and DPIRD information indicates recent fishing in the vicinity of the permit (**Section 3.6.1)**. Licence holders in this fishery should be consulted.
Pilbara Line Fishery	Considered relevant persons under Regulation 11A(1) (d)	The permit intersects the fishery and DPIRD information indicates recent fishing in the vicinity of the permit (**Section 3.6.1)**. Licence holders in this fishery should be consulted.
Pilbara Demersal Trap Managed Fishery	Considered relevant persons under Regulation 11A(1) (d)	The permit intersects the fishery and DPIRD information indicates recent fishing in the vicinity of the permit **(Section 3.6.1)**. Licence holders in this fishery should be consulted.
Pilbara Fish Trawl Interim Managed Fishery	Considered relevant persons under Regulation 11A(1) (d)	The permit intersects the fishery and DPIRD information indicates recent fishing in the vicinity of the permit (**Section 3.6.1)**. Licence holders in this fishery should be consulted.
Other stakeholders		
King Bay Fishing Club	Considered relevant persons under Regulation 11A(1) (d)	King Bay Fishing Club has been identified as a relevant stakeholder based on feedback from RecfishWest that the club may have feedback on the activity from a local recreational fishing perspective.
Nickol Bay Fishing Club	Considered relevant persons under Regulation 11A(1) (d)	Nickol Bay Fishing Club has been identified as a relevant stakeholder based on feedback from RecfishWest that the club may have feedback on the activity from a local recreational fishing perspective.
Australian Marine Oil Spill Centre (AMOSC)	Considered relevant persons under Regulation 11A(1) (d)	AMOSC operates Australia's major oil spill response equipment stockpile on behalf of the Australian oil and gas industry.
Centre of Decommissioning Australia (CODA)	Considered relevant persons under Regulation 11A(1) (d)	CODA is a collaborative initiative between government and industry to support safe, efficient and environmentally sensitive decommissioning outcomes.

4.3 Stakeholder consultation

The approach to stakeholder consultation for this EP follows the process adopted by Santos for all its EPs, which includes:

+ clearly identifying and maintaining current lists of 'relevant' persons;
+ development of consultation materials commensurate with the proposed activities, identified risks/impacts and proposed management measures relevant to identified persons; and
+ clearly documenting and tracking notification commitments to relevant persons.

Stakeholders, wherever possible, were provided personal emails with information tailored to their functions, interests and activities, including outlining why they have been identified as a relevant stakeholder.

The consultation package contains details such as an activity summary, location map, coordinates, water depth, distance to key regional features, exclusion zone details and estimated timing and duration. This consultation package outlined potential risks and impacts together with a summary of proposed management control measures.

The intent of providing this level of information early in the consultation process is to facilitate each party proceeding with their business in a safe and efficient manner, and without loss or conflict, by minimising the extent of interruption by the activities on commercial fishing operators' activities to the lowest practicable level.

A summary of stakeholder consultation material for this EP is provided in **Table 4-2**.

Stakeholders were afforded at least four weeks to review consultation information. Santos accepted stakeholder feedback after this period, including feedback from additional stakeholders identified during the consultation process.

4.4 Assessment of stakeholder objections and claims

A summary of stakeholder consultation undertaken for this EP, including Santos' assessment of all stakeholder comments received, is outlined in **Table 4-2**.

Full transcripts between Santos and stakeholders are provided in the WA-20-L Environment Plan Sensitive Stakeholder Information Report as a confidential submission to NOPSEMA.

Santos adopted the following process to address objections and claims received during the consultation process:

1. Santos acknowledged receipt of all comments made by stakeholders.
2. Santos assessed the merits of all objections and claims made by stakeholders. This included assessing all reasonably available options for resolving or mitigating the degree to which a stakeholder's functions, interests or activities may be affected. Control measures were proposed and adopted where reasonably practicable.
3. Santos responded to all stakeholder objections and claims, and advised the stakeholder how each of their objections and claims would be addressed in the EP.

A similar process was applied to information provided and requests made by stakeholders not deemed to be an objection or claim.

Santos recognises the importance of ensuring a high degree of transparency in how a titleholder manages ongoing stakeholder consultation during the life of a five-year EP. As such, should additional stakeholder comments be received to those described in **Table 4-2**, Santos will assess the comments using the above process and update the EP to document the assessment of additional objections or claims.

In relation to stakeholder consultation Santos is of the opinion that Regulation 10A of the OPGGS(E) Regulations has been met.

Table 4-2: Consultation summary for the Activity

<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 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>
</table>

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="3">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.
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</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	portal to download digital data sets and maps. **[INFORMATION 001]** Santos responded to AMSA on 10 January 2021 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]** 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.	
	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
	[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**.	Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.
	[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**	Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.
	[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**	Santos responded to AMSA confirming the notifications requirements would be addressed in the EP.

<table>
<tr><th>Stakeholder</th><th colspan="2">Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))</th></tr>
<tr><td rowspan="4"></td><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 rowspan="3">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>
<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">Department of Agriculture, Water and the Environment (DAWE) – marine pests</td><td colspan="2">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 7.2.
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>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
Department of Agriculture, Water and the Environment (DAWE) – 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) – 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 7.2**. 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.	
	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 Industry Science, Energy and Resources (DISER)	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.	
	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.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))
Director of National Parks (DNP)	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]** o 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 o 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

<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">notification should include [REQUEST 004]:
o titleholder details
o time and location of the incident (including name of marine park likely to be effected)
o proposed response arrangements as per the Oil Pollution Emergency Plan (e.g. dispersant, containment, etc.)
o confirmation of providing access to relevant monitoring and evaluation reports when available; and
o contact details for the response coordinator.
o 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).
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></td><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></td><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></td><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></td><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 plan, taking account of any changes to measured environmental</td><td>Santos responded to DNP and acknowledged its request.</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	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 3.4**).	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 Section 7 of 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.
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**. This stakeholder also receives Santos' Quarterly Consultation Update for WA.	

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	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. 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.	

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	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).	
	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))
	[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).	Santos responded to DoT and acknowledged its request.
Industry Bodies		
Australian Petroleum Production & Exploration Association (APPEA)	APPEA was provided the consultation package via email on 6 December 2021. No formal response has been received from APPEA. 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 Southern Bluefin Tuna Industry Association (ASBTIA)	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.	
	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.
	CFA was provided the consultation package via email on 6 December 2021.	

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
Commonwealth Fisheries Association (CFA)	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.	
	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.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))
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]** + 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). This stakeholder also receives Santos’ Quarterly Consultation Update for WA.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	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))
	[INFORMATION 001] Santos acknowledged feedback from RecfishWest on the Legendre Decommissioning EP.	Santos responded to RecfishWest and noted the information provided.
	[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.	Santos responded to RecfishWest and noted the information provided.
	[INFORMATION 003] Santos acknowledged feedback from RecfishWest that recreational fishers frequent the area given the proximity to Glomar Shoals.	Santos responded to RecfishWest and noted the information provided.
	[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.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	[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.
	[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. 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.
Western Australian Fishing Industry Council (WAFIC)	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]** + 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.

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
	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. 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. + 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.

<table>
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<tr><td></td><td>[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.</td><td>[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:
o Most gas will be released to air at sea surface
o Gas is detectable only at meters from source in water column
o Rapid dispersion by tides and currents
o 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.</td></tr>
<tr><td></td><td>[CLAIM 001 AND 002] Santos acknowledged comments from WAFIC at the meeting of 2 February 2022 about potential reputational and market impacts from gas leaks and infrastructure/plastics left in the marine environment.</td><td>[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</td></tr>
</table>

Stakeholder	Stakeholder Consultation Summary (OPGGS(E) Regulation 16 (b)(i))	
		WAFIC to ensure research data collected was relevant to the fishing industry's needs.
Commercial fisheries – State Managed		
Mackerel Managed Fishery (Area 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.	
	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.
Pilbara Line Fishery	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.	
	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.
Pilbara Demersal Trap Managed Fishery	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.	

<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">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 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>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.</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">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>
<tr><td>[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.</td><td>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.</td></tr>
<tr><td rowspan="3">Nickol Bay Fishing Club</td><td colspan="2">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.</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="2">Australian Marine Oil Spill Centre (AMOSC)</td><td colspan="2">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.</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))	
	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.

4.5 Ongoing consultation

Stakeholder consultation for this activity will be ongoing and Santos will work with stakeholders before, during and after the activity. Should new stakeholders be identified (**Section 4.2**), they will be added to the stakeholder database and included in all future correspondence as required, including activity-specific notifications.

Santos, as a marine user, understands there will be the need to interact and communicate with other marine users to ensure mutual and individual stakeholder goals are met. Santos has identified the need for ongoing engagement with the fishing industry, as committed to in **Section 8.9**.

To this end, Santos commits to the following ongoing stakeholder consultation process:

1. Prior to commencement of the activity, Santos will notify all relevant stakeholders listed, or as revised, in **Table 8-4**. The notification will include information on activity timing, vessel movements and vessel details.
2. Upon completion of the activity, Santos will provide a cessation notification to the relevant stakeholders listed, or as revised, in **Table 8-4**. The final cessation notification will advise stakeholders that the activity has ended.
3. Santos' Quarterly Consultation Update (see **Section 4.6**) will include the Legendre field studies. Up to date knowledge of stakeholders will be managed as described **in Section 8.10.**

Where practicable and if available, Santos will endeavour to use the WAFIC consultation services to help distribute activity notifications to relevant commercial fishers.

In addition, Santos has through the consultation process for this EP committed to sharing the results of the monitoring program with the following stakeholders:

+ Director of National Parks;
+ RecfishWest; and
+ Western Australian Fishing Industry Council.

Santos will assess any additional stakeholder objections or claims in accordance with **Section 4.4**.

4.6 Quarterly consultation update

Activities covered under this EP will be included in Santos' Quarterly Consultation Update until they can be listed as a 'completed activity', with updates scheduled for approximately March, June, September and December annually.

The Quarterly Consultation Update is circulated to a broad group of Santos stakeholders, including many of the stakeholders identified in **Table 4-2**.

If stakeholders request additional information or raise concerns on any activity listed in a Quarterly Consultation Update, a dialogue with these stakeholders can continue during or post the preparation of an EP and will be recorded for future reference. Santos commits to respond and address any comments to the satisfaction of both parties and keep any consultation on file during and post acceptance of an EP.

Activities covered under this EP will be included in Santos' Quarterly Consultation Update until they can be listed as a 'completed activity', with updates scheduled for approximately March, June, September and December annually.

The Quarterly Consultation Update is circulated to a broad group of Santos stakeholders, including many of the stakeholders identified in **Table 4-2**.

If stakeholders request additional information or raise concerns on any activity listed in a Quarterly Consultation Update, a dialogue with these stakeholders can continue during or post the preparation of an EP and will be recorded for future reference. Santos commits to respond and address any comments to the satisfaction of both parties and keep any consultation on file during and post acceptance of an EP.

4.7 Addressing consultation feedback

Santos' Consultation Coordinator is available before, during and after the activity to ensure opportunities for stakeholders to provide feedback are available.

Santos will maintain records of all stakeholder consultation related this this EP and activity.

5 Environmental impact and risk assessment methodology

OPGGS(E)R 2009 Requirements
Regulation 13. Environmental assessment
Evaluation of environmental impacts and risks 13(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. 13(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.

Name	Definition
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.
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.

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

Name	Definition
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.
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).

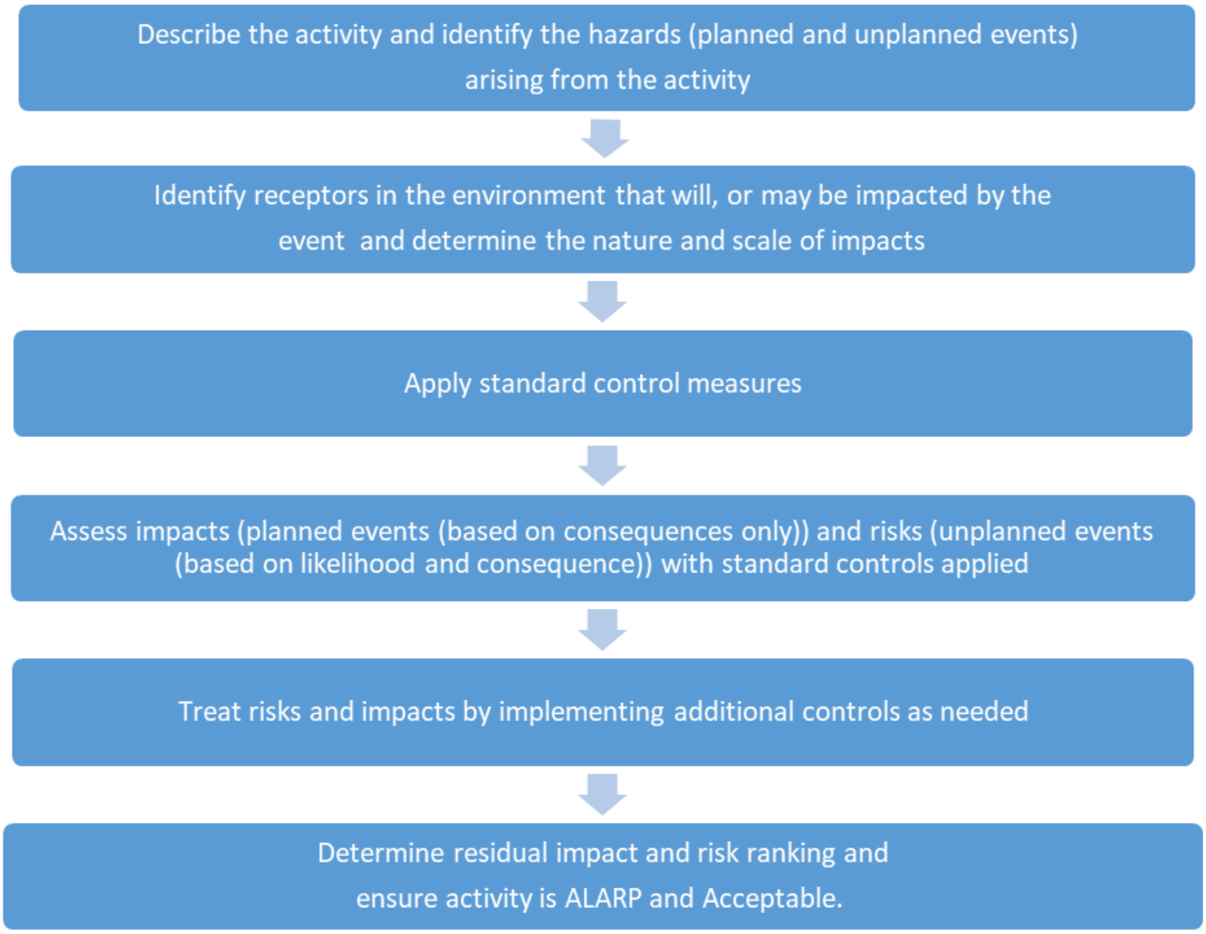

Figure 5-1: Environmental Impact and Risk Assessment Process

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 environment that may be affected (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 2009, 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 D)**.

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;
+ assessment and management of risks have addressed the principles of ecologically sustainable development;
+ 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.

6 Environmental assessment for planned events

OPGGS(E)R 2009 Requirements

Regulation 13(5)

The environment plan must include:

(a) details of the environmental impacts and risks for the activity;

(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.

Regulation 13(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.

Regulation 13(7)

The environment plan must:

(a) set environmental performance standards for the control measures identified under paragraph (5)(c);

(b) set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and

(c) include measurement criteria that the titleholder will use to determine whether each environmental performance outcome and environmental performance standard is being met.

Santos's environmental assessment identified eight potential sources of environmental impact associated with the petroleum activity of gas seepage including those derived from vessel-based support activities that may be carried out in response to the gas seepage. Two potential sources of environmental impact are associated with the petroleum activity of the wellhead remaining in situ.

Results of the environmental assessment are summarised in **Table 6-1** and

6.2	Interaction with other marine users – support vessel and wellhead 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

Table 6-2**.**

Table 6-1: Summary of the residual consequence associated with the gas seepage and vessel-based support activities

EP Section	Event	Residual consequence
6.1	Gas seepage	I - Negligible

EP Section	Event	Residual consequence
6.2	Interaction with other marine users – support vessel and wellhead 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

Table 6-2: Summary of the residual consequence associated with the wellhead remaining in situ

EP Section	Event	Residual consequence
6.9	Presence of wellhead: 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 methane to the sediment, benthic habitat at the seabed, water column and atmosphere from seepage of gas containing 85% methane
Extent	**Localised**: Within tens of meters of the seepage location
Duration	**Indefinite**: Ongoing gas seepage

6.1.2 Nature and scale of environmental impacts

Gas seepage has been observed at three locations on the seabed throughout WA-20-L: the Legendre Hub, at Legendre South-1 and at Legendre South-3 (**Figure 2-1).** See **Section 3.3.5** for characterisation of the gas seeps. Most of the gas seeps were located at or around the infrastructure at the abandoned well locations. There were two slow gas seeps at Legendre South-3, four slow seeps at Legendre South-1 and 20 slow seeps at the Legendre Hub. The gas seepages within WA-20-L contained ~85 % methane (RPS 2021a).

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). While all component gas released as natural gas mixtures may dissolve into the water column on rising from releases into deeper water (>200 m), a significant proportion of the gas within bubbles released in shallow water (< 100 m) can remain within the bubbles and be released into the atmosphere on reaching the sea surface (Olsen *et al.*, 2017, 2019, Gentz *et al.*, 2014).

During the field survey in WA-20-L in 2021, methane at the Legendre Hub site was detected at a maximum of 391 ppmv up to 5 m horizontally away from the approximately 20 seeps and detectable, but below the reliable detection limit of 20 ppmv, 20 m away from the gas seeps (**Section 3.3.5)**. The total flow 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 (**Section 3.3.5**).

At the Legendre South-1 site four gas seeps were present with a lower flow rate compared to the Legendre Hub site (total 12 mL/min, 1 mm bubble size) (**Section 3.3.5**). At the Legendre South-3 site there were two gas seeps present with a lower flow 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).

A literature review of methane behaviour in the water column, and a site-specific calculation of methane immediately above the seabed at the Legendre Hub was performed (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 6-1** 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 will be released into the atmosphere on reaching the surface. This is supported by the 2021 field studies where dissolved methane was not detected above ambient 10 m from the seep location (RPS 2021b).

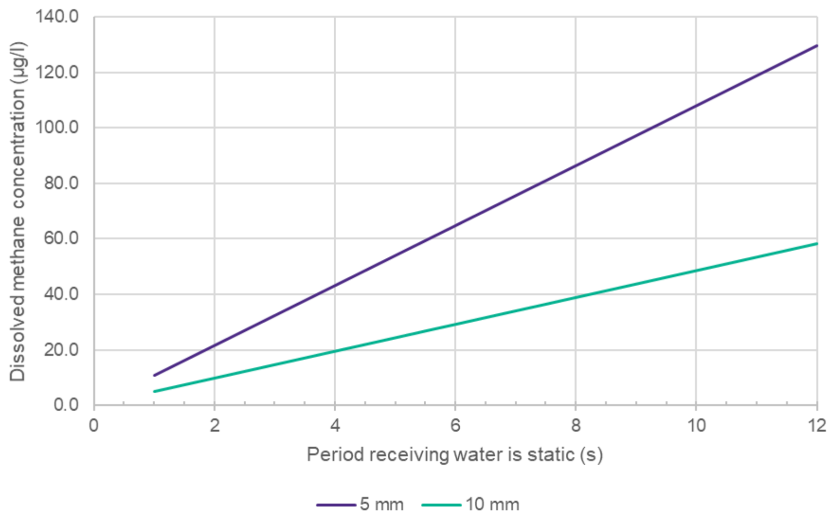

Figure 6-1: Comparison of potential accumulation of methane over time at Legendre Hub for bubble sizes at 5 mm and 10 mm assuming no exchange of water or methane in the 1 m above the seep source

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 3.3.3**). 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.

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 3.3.6; RPS 2021b). Results indicate that any contamination from the gas seepage is likely 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 effected 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).

Geoscience Australia (2021) document gas seep activity around Cornea on the northern Yampi Shelf (Jones et al., 2005; Rollet et al, 2006; Logan et al, 2010) and along the southern flank of the Ashmore Platform (Stalvies et al. 2017), Browse Basin. 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- (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.

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.

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 structure. 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, nor 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, and bluespotted emperor and Spanish mackerel. Available information and studies regarding toxicity of hydrocarbons to the marine environment focusses on the toxicity effects of crude oils on fishes and other biota. Studies on crude oil are not directly comparable to methane gas due to the difference in impact pathways of differing hydrocarbon states. Consequently, no data are available regarding toxicity impacts of dissolved and gaseous methane on marine fauna in warm, shallow water environments. 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.

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 (see **Section 4.4**). WAFIC further stated that gas leaks would have a direct impact on the commercial fishing industry's reputation and markets. As discussed above, biological level impacts to fish are not expected, with any exposure to dissolved or gaseous methane expected to be at non-toxic levels and temporary in nature. 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 and control measure

The EPO relating to this event is:

EPO-01: No long-term detectable 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 6-3**. EPS and measurement criteria for the adopted controls are presented in **Section 8.4.1.**

Table 6-3: Control Measures Evaluation for 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.**

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	Re-enter existing wells and intervene to reduce or stop gas seepage	Reducing or stopping the gas seep would reduce or prevent the release of methane into the water column and result in the environment being left in a condition close to what it was before the gas seep occurred.	As described in **Section 2.1.2**, it is not feasible to re-enter the existing wells.	**Reject –** Option not technically feasible.
CM-01	Gas seepage monitoring	Further measurement of flow rates of the gas seepages, water quality and sediment quality at Legendre Hub, Legendre South-1 and Legendre South-3.	Pre-monitoring, undertake a one off study by scientists to determine methodology and develop execution plan for measuring flow rates through time, estimated cost AUSD150,000. Each monitoring campaign would cost between AUSD 150,000 to 250,000.	**Adopt** - Measurements will provide input into an Adaptive Management Plan for the gas seeps (CM-06)

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-02	Well Integrity studies	Aim is to identify credible leak paths for Legendre Hub, Legendre South-1 and Legendre South-3 wells, undertake a global review to see if similar gas migration occurs elsewhere and conduct a remediation feasibility assessment considering technical merit, likelihood of success and cost.	Estimated cost for studies is AUSD200,000.	**Adopt –** Studies will provide input into an Adaptive Management Plan for the gas seeps (CM-06)
CM-03	Reservoir modelling	Use simple tank model to estimate range of forward-looking leak rates through time under different scenarios.	Estimated cost for modelling is AUSD50,000.	**Adopt** – Modelling will provide input into an Adaptive Management Plan for the gas seeps (CM-06)
CM-04	Fish ecotoxicology assessment	Ecotoxicology assessment of fishes to quantify impact on commercially targeted species.	Estimated cost for fish ecotoxicology assessment is AUSD 100,000, if combined with other vessel supported activities.	**Adopt** – Ecotoxicology assessment will provide input into an Adaptive Management Plan for the gas seeps (CM-06**)**
CM-05	Independent scientist review of impacts of gas seeps	Provides independent and subject matter expert assessment of environmental impacts of gas seeps from Legendre Hub, Legendre South-1 and Legendre South-3, based on a review of natural and other known gas seeps and information gained from CM-01, CM-02, CM-03, CM-04.	Estimated cost for independent scientist review of gas seeps is AUSD200,000.	**Adopt –** An independent review of marine gas seepage will provide input into an Adaptive Management Plan for the gas seeps (CM-06)

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-06	Adaptive Management Plan for the gas seeps (**Section 6.1.3.1**)	Implementation of Adaptive Management Plan reduces potential impacts of gas seeps to the marine environment and ensures criteria are met to maintain impacts to an acceptable and ALARP level.	Internal resources across multiple disciplines using Santos risk matrix and MOC process.	**Adopt** – Provides for management actions dependent on outcomes of ongoing impact and risk assessment.

6.1.3.1 Adaptive management plan

The Adaptive Management Plan addresses the ongoing management of gas seeps so that the requirements of acceptability (Regulation 10Ac) and ALARP (Regulation 10Ab) are met throughout the duration of the WA-20-L EP.

The findings from the implementation of the control measures (CM-01, CM-02, CM-03, CM-04, CM-05, **Table 6-3**) in 2022 will feed into an impact and risk assessment, as per the methodology in **Section 5**.

An environmental consequence ranking of Negligible or Minor will be considered acceptable and will require field monitoring of flow rates, water quality and sediment quality in Year 5 of the EP. A ranking of Negligible or Minor would be designated based on:

+ measured flow rates that are decreasing, not changing or fluctuating slightly
+ no detectable or minor localised contamination in sediment quality and water quality
+ projected forward rates from reservoir modelling under different scenarios do not indicate significant increase in flow rate
+ assessment by independent scientists as negligible to minor impact
+ stakeholder concerns regarding tainting of commercial fish is not supported by ecotoxicological studies.

An environmental consequence ranking of Moderate or above will be considered unacceptable and will require re-assessment of ALARP with regards to feasible intervention options (if any were identified in the well integrity studies) and continuation of field monitoring of flow rates, water quality, sediment quality and ecotoxicology and if required, execution of mitigative measures as soon as possible. A ranking of Moderate or above would be designated based on all of the below criteria being met:

+ measured flow rates that are significantly increasing
+ detectable contamination in sediment quality and water quality at reference sites >100 m away from gas seeps
+ projected forward rates from reservoir modelling under different scenarios indicate potential for a significant increase in flow rate
+ assessment by independent scientists as moderate impact or above

- stakeholder concerns regarding tainting of commercial fish are supported by ecotoxicological studies.

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 the relatively small area (tens of metres) that contains dissolved methane above background levels any exposure to marine fauna is expected to be temporary in nature. 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 into surficial sediments and the water column may result in local oxygen depletion. This may have resulted 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	Potential impacts to fishes from methane exposure may have effects on commercial fisheries. Biological level impacts to fish are not expected, with potential impacts being restricted to marketability of potentially tainted fishes. However, gas seepages have been occurring in WA-20-L since 2013 with no reported impact to commercial fisheries or fish marketability. WAFIC received no feedback from fishers on the gas seepage, however, it was agreed that Santos would include specific requirements or criteria used for marketing fish in the ecotoxicological fish study and results would be provided to WAFIC.
Overall worst-case consequence	I - Negligible

6.1.5 Demonstration of ALARP

The assessed residual consequence for this impact is I - Negligible. Re-entry of the abandoned well bore to reduce or stop gas seepage is not feasible due to the inability to tie-back and re-establish a structural connection and a pressure envelope with the well. There is no safe "conduit" to re-enter the well because multiple permanent cement plugs means 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.

Natural dry gas and oil seepages have been detected previously (Geoscience Australia, 2021) and low concentrations of methane in waters of the Browse Basin was 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).

A number of additional management controls including ongoing monitoring to further characterise the gas seepages, well integrity and reservoir modelling studies and an ecotoxicity study of commercial fish have been considered and adopted. Results of these studies will feed into an Adaptive Management Plan and should a change from a negligible impact to a moderate impact or above be found, then a re-assessment of ALARP will be carried out.

Stakeholder concerns regarding the 'clean and green' image of Western Australia' commercial fishery were raised during consultation. In response, Santos will undertake monitoring using suitably qualified scientists during 2022 to obtain 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. Santos will also implement an adaptive management plan which will allow ongoing evaluation of the finding of monitoring results and changes to the monitoring program.

Given the current environmental consequence of the gas seeps is ranked as I – Negligible and the Adaptive Management Plan will provide management actions should the environmental consequence escalate, it is therefore considered that the impact of the gas seeps is reduced to ALARP.

6.1.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – Maximum consequence of introducing 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 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 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?	WAFIC are satisfied with Santos commitment to include criteria commercial fishers require to support fish export in the fish ecotoxicology study.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

Santos has committed to additional field environmental monitoring and further studies in 2022. The information gained from this work will be fed into the Adaptive Management Plan ensuring that the gas seeps are managed to an acceptable and ALARP level.

6.2 Interaction with other marine users – support vessel and wellhead 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. Presence of Legendre-1 wellhead (3.6 m high x 5 m) resulting in displacement of trawl fishers until the wellhead has completely degraded (i.e., over hundreds of years).
Extent	**Localised** around the support vessel and wellhead.
Duration	**Temporary and intermittent** interaction with vessels when transiting WA-20-L. **Long term**: The potential effects of the presence of the wellhead may occur until equipment degrades (i.e. many decades).

6.2.2 Nature and scale of environmental 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**). The wellhead has remained in a fixed position since 1968 and is marked on AHO charts. Santos engaged a Subject Matter Expert, the Australian Maritime Council Search (AMCS), to undertake an assessment of the potential impacts of the wellhead on commercial fisheries. This included a review of fisheries that potentially operate near the wellhead and therefore may have to actively avoid the wellhead. The study examined the historical trawl fishing effort near the wellhead 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 (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 (AMCS 2021, Newman et al. 2020). WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of deviation required to trawl around the wellhead, 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 (AMCS 2021).

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 hazard 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 6-4**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-4: Control measures evaluation for interaction with other marine users

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-07	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.	**Adopted –** Benefits considered to outweigh negligible costs to Santos**.**
CM-08	Maritime notices	Ensures other marine users are aware of the presence of the vessel, and static data collection.	Costs associated with the personnel time in issuing notifications and closing out queries and responses.	**Adopted –** Benefits considered to outweigh negligible costs. Maritime requirement to issue marine notices.
CM-09	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.	**Adopted** – The safety benefits (and thus environmental benefits) outweigh the cost. Compliance with Marine Orders are a legislated requirement.
CM-10	Watchkeeping maintained on bridge	Reduce impacts to commercial fisheries by actively avoiding their activities and schooling fish in their vicinity.	Negligible costs.	**Adopted** – Benefits considered to outweigh costs.

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-11	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.	**Adopted** – Benefits considered to outweigh negligible costs to Santos.
CM-12	No recreational fishing from vessel	Reduce potential impacts to fisheries in the vicinity of the activity.	Negligible costs.	**Adopted** – 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.	**Rejected** – Not feasible.

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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 small size of the wellhead and fixed location, the benefits of removal are expected to be minimal. There is low historical fishing effort within the region of the wellhead as the bottom type is largely untrawlable ground (AMCS 2021).	It is estimated that wellhead removal costs would be in the range of 4.9 M AUD component and 3.6 M USD component. 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. A wellhead removal study concluded that r there is a low chance of success for wellhead removal.	**Reject –** As detailed in **Section 2.2,** wellhead removal would pose more environmental impacts and risks than it mitigated. As such, the cost to remove the wellhead is considered disproportionately high to the minimal environmental benefit of removal.
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.	**Rejected -** 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 evidenced through consultation.

Reference No	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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 6-5**.

Table 6-5: 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

Key receptors	Consequence Level
	(shipping) in the region. AMSA requires a high level of communication during the activity, therefore reducing the likelihood of interaction with other sea users. Given the wellhead is charted on navigational charts, it is not in an area actively trawled and it represents a very small percentage of the overall fishery, the current and potential future impact to commercial fish trawlers is considered I – Negligible. Therefore the expected consequence is (I - Negligible).
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.

WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of a deviation required around the wellhead 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 2.2.2**).

The potential impact of displacing other users, both from vessel-based activities and leaving the wellhead in-situ a have been assessed as I - Negligible. Given the impact is well understood, the negligible consequence and the proposed controls, impacts for marine user interaction 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 (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.
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?	WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of deviation required to move around the known position of the wellhead significant disruption to this fishery is not expected.

	No concerns raised regarding support vessel 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 wellhead has remained in a fixed position since 1968 and is marked on AHO charts. WAFIC and the licence holders within the PFITMF objected to the wellhead being left in situ, however given the small size of deviation required to move around the known position of the wellhead significant disruption to this fishery is not expected.

The presence of a support vessel and the wellhead 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 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**: 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 1600 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 8000 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, $15\log_{10}$ (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 2386 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 $10*\log_{10}$ (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.

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 (breeding, foraging), pygmy blue whale (distribution) 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 2.3.1**. 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, breeding or feeding areas for mammals lie in close proximity to WA-20-L, however, WA-20-L intersects with the pygmy blue whale distribution as provided by the National Conservation Values Atlas. The recovery plan for blue whales list noise interference as a potential threat. **Table 6-6** details receptor noise impact and behavioural thresholds for continuous noise for:

+ low-frequency cetaceans: which consists of baleen whales such as humpback whales; and
+ mid-frequency cetaceans: which consists of toothed whales except porpoises and river dolphins.

Table 6-6: Continuous noise: acoustic effects of continuous noise on marine mammals: unweighted SPL and SEL_{24h} 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 µPa²·s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)
Low-frequency	120	199	179
Mid-frequency		198	178

1. Sound pressure level.
2. Sound exposure 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 6-6**) for marine mammals from vessels are provided in **Table 6-7**.

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 6-7: Estimated distances to behavioural and physiological thresholds (as listed in Table 6-6) for marine 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**

Potential Receptor	Estimated Distance	Justification
Mid-Frequency cetaceans	Not predicted to occur	Not predicted to occur for vessels with a significantly greater power output (McPherson *et al.*, 2019)
TTS		
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, breeding 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 (Dow Piniack, 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 6-8**.

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 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 6-8** 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 6-8: Continuous noise: criteria for vessel noise exposure for turtles, adapted from Popper *et al.* (2014)

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

Note: 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 SEL_{cum} (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 6-9**) noise sources have been adopted.

Table 6-9: Continuous noise: criteria for noise exposure for fish, adapted from Popper *et al.* (2014)

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

Note: 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 6.3.3**.

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 in **Section 0**. 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 hazard 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 6-10** with EPSs and measurement criteria for the EPOs described in **Section 8**.

Table 6-10: CMs evaluation for noise emissions

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				
CM-13	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.	**Adopted** – Benefits in reducing impacts to marine fauna outweigh the costs incurred by Santos. Control drives compliance with EPBC Regulations (Part 8).
CM-14	Vessel planned maintenance system to vessel engines and machinery	Ensures equipment which generates noise is operating optimally and sound sources levels are appropriately verified	Costs are standard for routine PMS	**Adopted**- benefits in reducing noise impacts.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
		and within desired operating range.		
CM-10	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.	**Adopted** – 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.	**Rejected** –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.	**Rejected** – 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 Passive Acoustic Monitoring (PAM) operators, operational costs of increased shutdowns and potentially prolonging the	**Rejected** – Cost disproportionate to increase in environmental benefit given the low-level behavioural response expected. As Passive Acoustic Monitoring

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
			activity therefore increased impacts to the environment for example from anthropogenic light and routine vessel discharges.	(PAM) can only detect vocalising cetaceans, the limited ability of Passive Acoustic Monitoring (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 6-11**.

Table 6-11: 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 *Environment Protection and Biodiversity Conservation 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 **Section 6.3.3**. Therefore, the risks to marine fauna from noise associated with the project activities are considered to be ALARP.

6.3.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum consequence from underwater noise emissions is I 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.
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 VBA. 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.
+ Fish and zooplankton may be directly or indirectly attracted to lights.

According to the National Light Pollution Guidelines for Wildlife, a 20 km threshold provides a precautionary limit 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 be dependent upon 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 (Commonwealth of Australia, 2020).

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 breeding 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 hazard 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 6-12** with EPS and measurement criteria for the EPOs described in **Section 8**.

Table 6-12: Control measures evaluation for vessel light emissions

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-09	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 the activity including orientation of lighting to reduce light spill on the water wherever feasible without compromising navigation and safety requirements.	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
		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 schedule to suit multiple

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
				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 6-13**.

Table 6-13: 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 **Section 6.4.3**. 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.
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 Including Marine Turtles, Seabirds and Migratory Shorebirds (DoEE, 2020) + 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 (I). 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 (SOX), oxides of nitrogen (NOX) 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 CO_2); 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 hazard 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 6-14** with EPS and measurement criteria for the EPOs described in **Section 8**.

Table 6-14: Control measures evaluation for atmospheric emissions

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Controls				
CM-14	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.	**Adopted** – benefits of operating equipment within operational parameters will help maintain vessel fuel efficiency.
CM-15	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.	**Adopted** – environmental benefit outweighs the costs.
CM-16	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.	**Adopted** – under Marine Orders, the vessel must be compliant to operate in Australian waters.
CM-17	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.	**Adopted –** Benefit of ensuring no ozone- depleting substance release outweighs the minimal costs.

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
CM-18	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).	**Adopted** – 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).	**Rejected** – 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 the use of refrigeration. It is noted that ozone-depleting substances are rarely found on vessels.	**Rejected** – 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
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.	**Rejected** – 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.	**Rejected** – cost grossly disproportionate to low environmental benefit (impact rated I - Negligible).

6.5.4 Environment impact assessment

The impacts and consequence ranking for vessel light emissions are outlined in **Table 6-15**.

Table 6-15: 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.
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 (I) 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 equipment (for example, plankton nets, towed equipment) will result in some additional water turbidity.
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 environment 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 F**) are not considered to be impacted from seabed and benthic habitat disturbance and therefore are not discussed further.

6.6.3 Environmental performance outcomes and control measures

EPOs relating to this hazard 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 6-16**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-16: Control measures evaluation for seabed and benthic habitat disturbance

CM Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				
CM-19	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.	**Adopted** – 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 Reference	Control Measure	Environmental benefit	Potential cost/issues	Evaluation
CM-20	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.	**Adopted** – 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.	**Rejected** – 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.	**Rejected** – 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 6-17**.

Table 6-17: 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 (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.
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.
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 (I). 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. 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 hazard 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 6-18**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 6-18: Control measures evaluation for operational discharges

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard controls				
CM-21	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.	**Adopted** – Benefits of ensuring vessels are compliant with marine orders, outweigh minimal costs of personnel time, and it is a legislated requirement.
CM-22	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.	**Adopted** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-23	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.	**Adopted** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-24	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.	**Adopted** – 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-25	Chemical management procedure	Potential impacts to the environmental 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.	**Adopted –** Benefits of ensuring procedures are followed and measure implemented outweigh the costs.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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.	**Rejected** – 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.	**Rejected** - 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.	**Rejected** – Cost outweighs the benefit given the low impact expected from planned discharges.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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 cooling water and brine by avoiding requirement to discharge.	Increased fuel consumption and increased atmospheric emissions, associated with vessel transit to port 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 (e.g. incineration treatment on land).	**Rejected** - Cost associated with fuel and emissions disproportionate to risk and costs of discharging within approved conditions.

6.7.4 Environmental impact assessment

The impacts and consequence ranking for operational discharges are outlined in **Table 6-19**.

Table 6-19: 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.
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.
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 **Section 6.7.3**.

6.7.6 Acceptability evaluation

Is the consequence ranked as I or II?	Yes – maximum planned operational discharge consequence is rated I (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.
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 6-20**.

Table 6-20: Nature and scale of environmental impacts and risks for activities – 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** 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:	

<table>
<tr><td colspan="2">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.</td></tr>
<tr><td>Potential receptors:</td><td>Threatened, migratory, or local fauna
Physical environment or habitat
Protected areas</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td colspan="2">Operational discharges and waste:</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td>Potential receptors:</td><td>Threatened, migratory, or local fauna
Physical environment or habitat
Protected areas
Socio-economic receptors</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td colspan="2">Physical presence and disturbance:</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td>Potential receptors:</td><td>Threatened/Migratory Fauna
Physical Environment/habitat
Protected Areas</td></tr>
</table>

	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 – spill response operations

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 6-21**.

Table 6-21: Control measures evaluation for reducing potential impacts from spill response operations

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-26	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.	**Adopted –** Considered a standard spill response control.

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-27	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.	**Adopted –** Considered a standard spill response control.
Acoustic Disturbance				
CM-13	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.	**Adopted –** Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).
Light Emissions				
CM-10	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.	**Accepted** – Cost is considered acceptable for the benefit that may be realised from this control.
Atmospheric Emissions				
CM-16	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.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Disruption to Other Marine Users				

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-11	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.	**Adopted –** Considered a standard control for incident management.
Operational Discharges and waste				
CM-21	Vessel sewage system	Reduces potential for water quality impacts.	No cost/issue associated with this CM.	**Adopted –** Considered a standard spill response control (regulatory requirement).
CM-22	Oily mixtures system	Reduces potential for water quality impacts.	No cost/issue associated with this CM.	**Adopted –** Considered a standard spill response control (regulatory requirement).
CM-28	Compliance with controlled waste, unauthorised discharge and landfill regulations	Ensures correct handling and disposal of oily wastes.	No cost/issue associated with this CM.	**Adopted –** Considered a standard spill response control (regulatory requirement).
Physical presence and disturbance				
CM-29	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.	**Adopted –** Considered a standard spill response control.
CM-13	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.	**Adopted** – Ensures compliance with Part 8 of the EPBC Regulations 2000, which is considered a standard spill response control (regulatory requirement).

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
CM-30	Use of shallow draft vessels for nearshore operations	Reduce seabed disturbance.	Operational costs associated with operating shallow draft vessels for nearshore operations.	**Adopted –** Considered a standard control.

6.8.4 Environmental impact assessment

Key receptors	Consequence Level
Spill Response Operations – Light Emissions	
Threatened, migratory, or local fauna Physical environment or habitat Protected areas Socio-economic receptors	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)*. 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 Physical environment or habitat Protected areas Socio-economic receptors	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*.
Overall worst-case consequence level	I - I - Negligible
Spill Response Operations – Atmospheric Emissions	
Threatened, migratory, or local fauna Physical environment or habitat Protected areas Socio-economic receptors	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*.

Key receptors	Consequence Level
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 and of bathymetry and the establishment of demarcated areas for access and anchoring will reduce the level of impact to *I - Negligible*. 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. 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.*
Physical environment or habitat	
Protected areas	
Socio-economic receptors	
Overall worst-case consequence level	II - Minor
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

Key receptors	Consequence Level
Physical environment or habitat	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*.
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 a 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.
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 set out in **Table 3-4**. 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 Presence of wellhead: 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 many decades to degrade completely).

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 3.3.6**). 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). 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.

6.9.3 Environmental performance and control measure

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. As the potential impacts are considered to be acceptable and changes to the marine environment as a result of leaving the wellhead in situ are likely to be undetectable, environmental performance outcomes relating to environmental monitoring have not been included.

The control measures considered for this activity are shown in **Table 6-22**.

Table 6-22: Control Measures Evaluation for presence of wellhead: 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				
N/A	Removal of the wellhead	As detailed in **Section 2.2**, Removing the wellhead will result in the environment being left in a condition close to what it was before the well was drilled. However, given the small size (5 m wide by 3.6 m tall) and properties of the wellhead (inert material) the environmental benefits are expected to be Negligible.	It is estimated that wellhead removal costs would be in the range of 4.9 M AUD component and 3.6 M USD component. The removal operations would, amongst other environmental affects, cause localised seabed disturbance, generate metal cuttings, vessel emissions, displacement of other marine users and remove artificial habitat.	**Reject** – As detailed in **Section 2.2**, wellhead removal would pose more environmental impacts and risks than it mitigated. As such, the costs and health and safety risks to remove the wellhead are considered disproportionately high to the low environmental effects of leaving the wellhead in-situ.
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 expected to change for the remaining presence of the structure. Monitoring would not reduce the I - Negligible environmental impact of wellhead degradation	It is estimated that each monitoring campaign would cost between AUSD 100,000 to 200,000. 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 metals or metaloids were recorded in sediment samples at the wellhead site above the ANZG DGV. Monitoring would not reduce the environmental impact of

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				the wellhead degradation.

6.9.4 Environmental Impact Assessment

The impact and consequences ranking for wellhead degradation are outlined in **Table 6-23**.

Table 6-23: Impacts and consequence ranking – wellhead degradation

Receptor	Consequence Level
Threatened, migratory, or local fauna	Given the low toxicity of iron, the slow release rate 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 metaloids 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. 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 6.1.3)** 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.
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 – 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. 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)
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?	Yes – no stakeholder concerns raised with respect to the impacts of wellhead degradation.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

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.

7 Environmental assessment – Unplanned events

OPGGS(E)R 2009 Requirements
Regulation 13(5)
The environment plan must include: (d) details of the environmental impacts and risks for the activity; (e) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and (f) details of the control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level.
Regulation 13(6)
To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from: (c) all operations of the activity; and (d) potential emergency conditions, whether resulting from accident or any other reason.
Regulation 13(7)
The environment plan must: (d) set environmental performance standards for the control measures identified under paragraph (5)(c); (e) set out the environmental performance outcomes against which the performance of the titleholder in protecting the environment is to be measured; and (f) 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 risks associated with the activity. The results of the environmental assessment are summarised in **Table 7-1** and **Table 7-2**. A comprehensive risk and impact assessment for each of the unplanned events, 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 considered credible is a snag risk.

Table 7-1: Summary of the environmental risks associated with unplanned events of environmental monitoring of the gas seepage

EP Section	Unplanned event	Likelihood	Consequence	Residual risk level
0	Release of solid objects	I - Negligible	d - Occasional	Low
7.2	Introduction of invasive marine species	III - Moderate	a - Remote	Very Low
7.3	Marine fauna interaction	III - Moderate	b - Unlikely	Low
7.4	Hazardous liquid releases	I - Negligible	b - Unlikely	Very Low
7.6	Release of hydrocarbons	II - Minor	b - Unlikely	Very Low

Table 7-2: Summary of the environmental risks associated with unplanned events of the wellhead remaining in situ

EP Section	Unplanned event	Likelihood	Consequence	Residual risk level
7.7	Presence of wellhead: snagging			Very Low

7.1 Release of solid objects

7.1.1 Description of event

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.

7.1.2 Nature and scale of environmental impacts

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.

7.1.2.1 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.

7.1.2.2 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.

7.1.2.3 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.

7.1.3 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 7-3**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 7-3: Control measures evaluation for release of solid objects

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control Measures				
CM-23	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.	**Adopted** – Benefits of ensuring vessel is compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-19	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.	**Adopted** – Benefits of recovering dropped objects where safe and practicable to do so (unless the environmental consequences are I - Negligible) outweigh the costs.
CM-20	Dropped object prevention procedure	Impacts to environment are reduced by preventing dropped objects.	Personnel costs involved in implementing procedures and in incident reporting.	**Adopted** – Benefits of ensuring procedures are followed and measures implemented outweigh the costs of personnel time.
CM-14	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.	**Adopted** – 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 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.	**Rejected** – Not feasible to eliminate lifting in the field.

7.1.4 Environmental impact assessment

Description – Release of solid objects	
Receptors	Physical environment or habitats Threatened, migratory, or local fauna.
Consequence	I - Negligible

<u>Marine fauna – Cetaceans, marine turtles, seabirds, fish and sharks</u> 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.	
<u>Physical environment – Seabed disturbance</u> 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*

7.1.5 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.

7.1.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – 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 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).

7.2 Introduction of invasive marine species

7.2.1 Description of event

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).

7.2.2 Nature and scale of environmental impacts

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.

7.2.3 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

EPO-08: No introduction of marine pest species.

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 introduction of IMS

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard control measures				
CM-31	Implementation of the management controls in the Santos Invasive Marine Species Management Plan (IMSMP)	The risk of introducing IMS is reduced due to assessment procedure and management of ballast water.	Personnel costs involved in risk assessing vessels in accordance with the Invasive Marine Species Management 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.	**Adopted** – Minimal personnel costs and potential delays or costs to project are considered outweighed by the benefits of reducing the risk of IMS.
CM-32	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.	**Adopted** – 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.	**Rejected** – 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.	**Rejected** – not feasible.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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.	**Rejected** – 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.	**Rejected** – 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 policy on vessels.	Ballast water exchange required on the vessel for stability.	**Rejected** – On the basis that ballast water exchange is a safety-critical activity for marine operations.

7.2.4 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	

Description – Invasive Marine Species	
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*.

7.2.5 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.

7.2.6 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.

7.3 Marine fauna interaction

7.3.1 Description of event

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	During the Activity.

7.3.2 Nature and scale of environmental impacts

7.3.2.1 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 3.5**, 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 6.2**) rather than the physical presence. Such avoidance is likely to be temporary.

7.3.3 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 7-5**. EPSs and measurement criteria for the EPOs are described in **Section 8**.

Table 7-5: Control measures evaluation for marine fauna interaction

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control measures				
CM-13	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.	**Adopted** – 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 complies with the EPBC Regulations 2000.
CM-10	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.	**Adopted** – 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.	**Rejected** – 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.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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.	**Rejected** – 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.	**Rejected** – Risk of animals being encountered is too low to justify additional cost of MMO; in other words, cost is disproportionate to environmental benefit.
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.	**Rejected** – 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.

7.3.4 Environmental impact assessment

Key Receptors	Threatened/migratory fauna (marine mammals, marine reptiles, sharks and seabirds).
Consequence	III - Moderate

<u>Threatened, migratory and local fauna</u>

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

7.3.5 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 8-2**) 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.

7.3.6 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.

7.4 Hazardous liquid releases

7.4.1 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: o stern tube oil (non-hydrocarbon-based lube oil) from the vessel thruster/propeller stern tube (approximately <1 m³) o loss of primary containment (drums, tanks, IBCs, etc.) due to handling, storage and dropped objects (such as swinging load during lifting activities) o 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: o spills or leaking machinery accidentally discharged overboard in deck drainage water o overflow of the open and closed drainage systems o 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 m³).

	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.

7.4.2 Nature and scale of 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.

7.4.2.1 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.

7.4.2.2 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.

7.4.3 Environmental performance 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 7-6**, with EPSs and measurement criteria for the EPOs described in **Table 8-2**.

Table 7-6: Control measures evaluation for hazardous liquid releases

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
Standard Controls				
CM-14	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.	**Adopted** – Benefits of ensuring procedures are followed and equipment is compliant outweigh the minimal costs of personnel time.
CM-22	Vessel oily mixtures 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.	**Adopted** – Benefits of ensuring vessels are compliant outweigh the minimal costs of personnel time, and it is a legislated requirement.
CM-24	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 environment according to MARPOL Annex V.	Personnel costs of implementing. Potential additional cost and delays of deck cleaning product substitution.	**Adopted** – 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
CM-33	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.	**Adopted –** Benefits of ensuring procedures are followed and measures implemented and that the vessel is compliant outweighs the costs.
CM-34	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.	**Adopted –** Benefits of ensuring procedures are followed outweigh costs.
CM-26	General 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.	**Adopted –** Benefits of ensuring procedures are followed and measures implemented outweigh the costs.
CM-35	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.	**Adopted** – 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, cost and potential additional leak paths. Commercially available closed-loop systems typically use mineral-based fluids, which if released to the environment have a greater	**Rejected** - Cost disproportionately high compared to env benefit.

CM Reference	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
			impact than water-based fluids.	

7.4.4 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 7-12** and **Table 7-13**.	
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 unlikely.	
Residual Risk	The residual risk associated with this event is *Very Low*

7.4.5 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.

7.4.6 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – maximum minor hazard liquid release 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 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 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.

7.5 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).

7.5.1 Spill scenario selection

7.5.1.1 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.

7.5.2 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:

1. Oil floating at the water surface
2. Oil entrained in the water column as droplets
3. Soluble aromatic hydrocarbons dissolved in the water column
4. Oil contacting shorelines.

A hypothetical spill location at Legendre-1 was used in the model (see **Figure 2-1**). This was chosen as 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 7.6.3**).

7.5.3 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 7-7**.

Table 7-7: 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

7.5.4 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 7-8**, **Table 7-9**, and **Table 7-11**; 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 7-8: Floating hydrocarbons exposure values

Surface Oil Concentration (g/m^2)	Exposure Value	Description
1	Low	*Risk Evaluation* It is recognised that a lower floating oil concentration of 1 g/m^2 (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/m^2 (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/m^2 (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/m^2 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/m^2 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/m^2 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/m^2 (less than Bonn Agreement Code 4). Hence, 50 g/m^2 has been set as a guide for planning effective containment and recovery operations. Similarly, surface oil >50 g/m^2 (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 7-9: Shoreline hydrocarbon accumulation exposure values

Shoreline Accumulation (g/m^2)	Exposure Value	Description
10	Low	*Risk Evaluation* An accumulated concentration of oil above 10 g/m^2 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/m^2) 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/m^2 has been applied to impacts from shoreline accumulation of hydrocarbons. Response Planning A shoreline concentration of 100 g/m^2, 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/m^2 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 7-10: 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 7-11: 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 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.

7.5.5 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:

1. 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 2.3**.
2. Identify areas of high environmental value (HEV) within the EMBA (HEVs are described in **Section 7.5.5.2**).
3. Identify and then risk assess hotspots. Hotspots are effectively a subset of HEVs, and their determination is described in **Section 7.5.5.2**.
4. Identify priorities for protection (for consideration of spill response strategies in the OPEP).

7.5.5.1 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**.

7.5.5.2 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 breeding, 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.

7.5.5.3 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.

7.5.5.4 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 7-12**). 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 7-12** and the information is drawn upon within the hydrocarbon risk assessment. **Table 7-13** 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 7-12: Physical and chemical pathways for hydrocarbon exposure and potential impacts to receptors

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.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
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 weathering of the oil.	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. Reduced growth. Reduced hatchling success. Reduced reproductive output. Growth abnormalities. Behavioural disruption.

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
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 moderate threshold value.	N/A	N/A	

Receptor	Physical pathway	Potential impacts	Chemical pathway	Potential impacts
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 7-13: Nature and scale of hydrocarbon spills on environment and socio-economic receptors within the EMBA

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
Threatened, Migratory or local fauna		
Plankton (including zooplankton; fish and coral larvae)	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.	Plankton utilising the sea surface layer could be impacted by floating oil.
	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 7.5.4**) are predicted within 80 km of a spill. Floating oil concentrations above the moderate exposure threshold are predicted within 20 km of the spill.	
Marine mammals	Lethal or sub-lethal physical and toxic effects such as irritation of eyes/mouth and potential illness.	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.

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	**Surface hydrocarbons**
	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 (**Figure 3-1**). For further information about environmental impacts to marine mammals from hydrocarbon exposure and increased toxicity, refer to **Table 7-12**. 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).	
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 7-12**.	
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

<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 rowspan="2"></td><td></td><td>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.</td></tr>
<tr><td colspan="2">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 7-12.</td></tr>
<tr><td rowspan="2">Sharks, Rays and Fish</td><td>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 7-12.</td><td>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/m^2 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.</td></tr>
<tr><td colspan="2">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</td></tr>
</table>

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
	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 7-12**.	
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 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	

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
	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 (**Figure 3-9: Shipping presence within and surrounding)**. 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 Australians 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 Australians is expected to be low given that no native title claims, or registered cultural heritage sites within the EMBA. Interference with cultural heritage due to a hydrocarbon spill are expected to be I - Negligible.	
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 Commonwealth Heritage Areas	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.	
	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	

Receptor	Impacts of hydrocarbon spills	
	Entrained and dissolved aromatic hydrocarbons in the water column	Surface hydrocarbons
	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.	

7.6 Release of hydrocarbons

7.6.1 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*

7.6.2 Nature and scale of environmental impacts

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 7-12** and potential impacts to receptors found within the EMBA are further described in **Table 7-13**.

7.6.3 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 7.5.4** are presented in **Figure 7-1**.

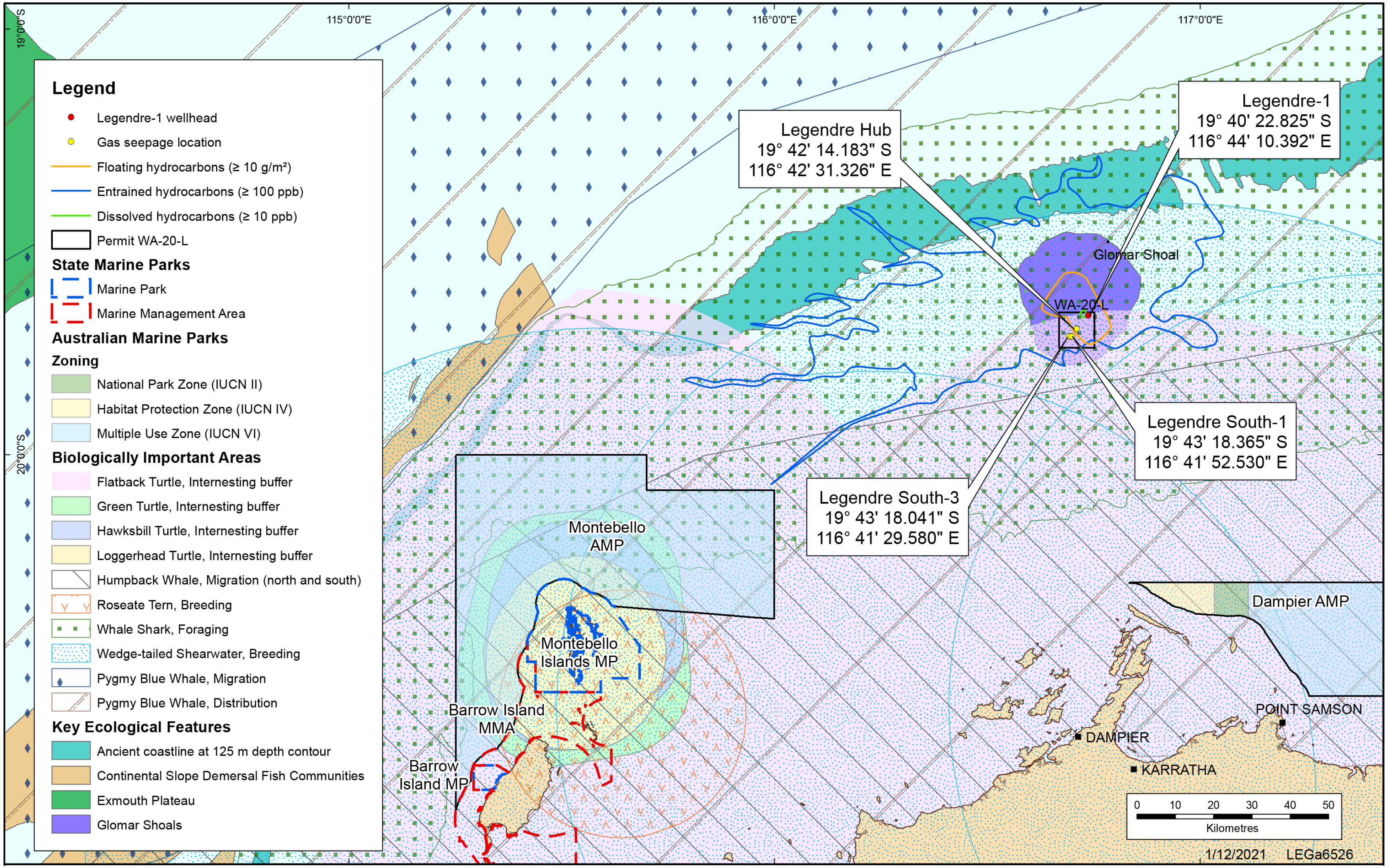

Figure 7-1: Areas contacted above moderate exposure values for a 35 m^3 MGO spill

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.

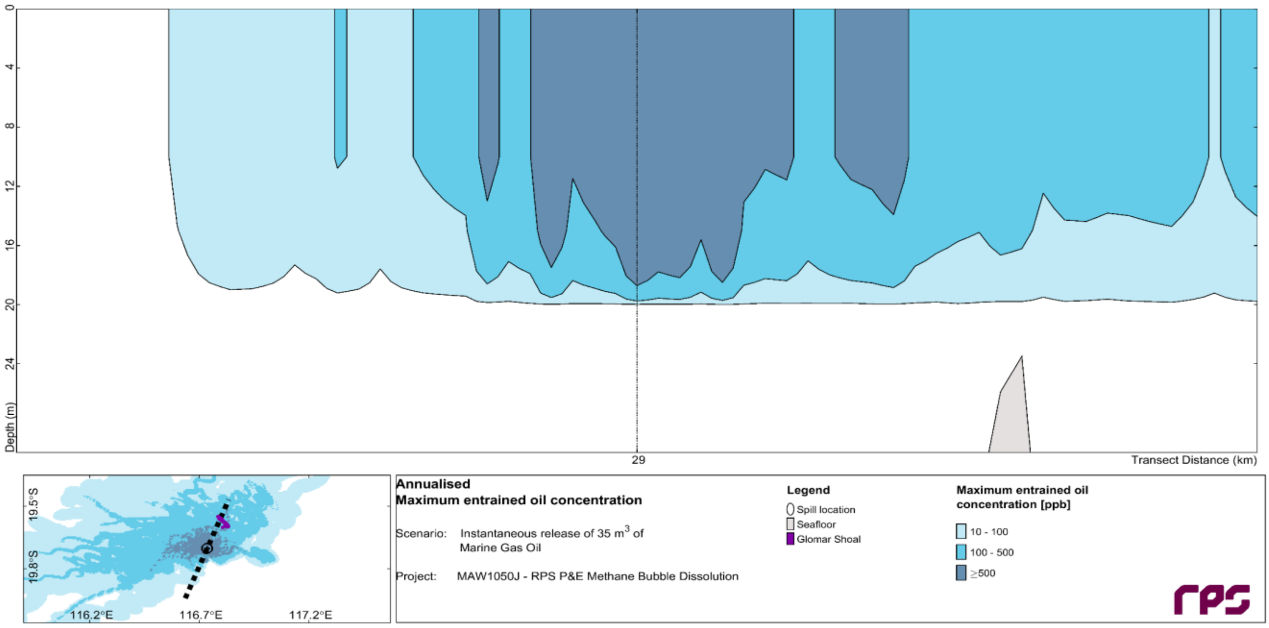

Figure 7-2: Maximum concentration of entrained oil (parts per billion) at depths along a transect drawn through the hypothetical spill site and intersecting with the shallowest point along Glomar Shoals (35 m^3 MGO spill)

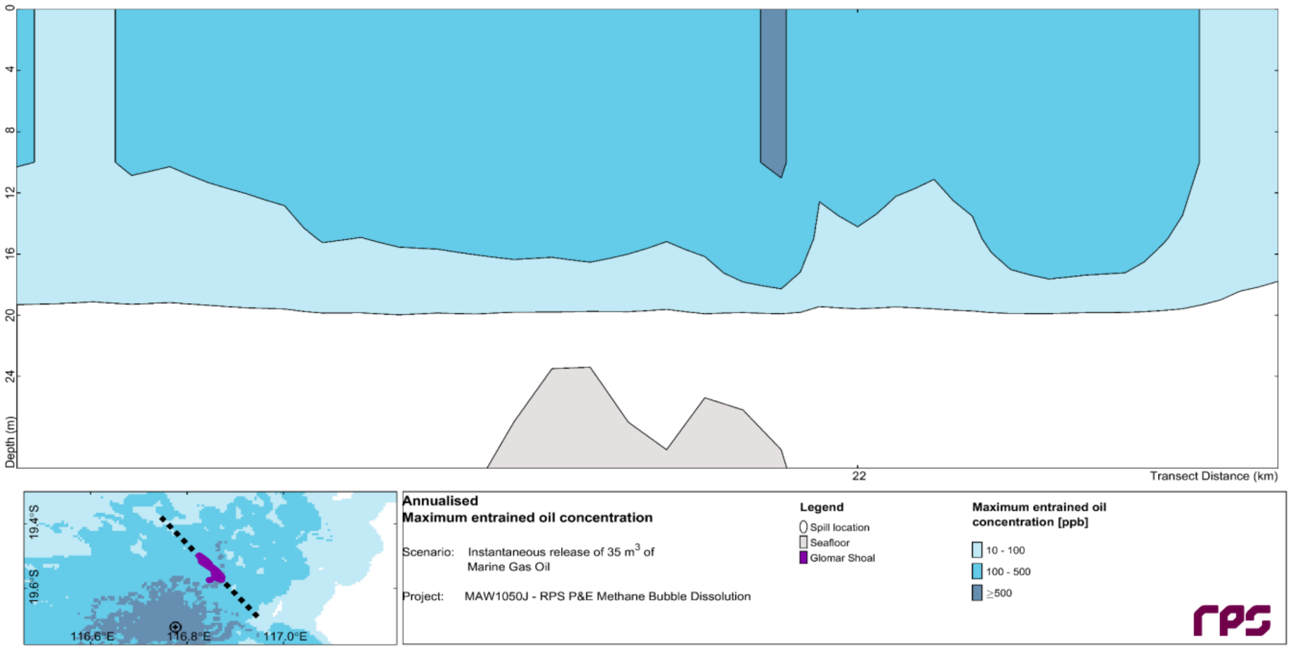

Figure 7-3: Maximum concentration of entrained oil (parts per billion) at depths along a transect drawn along the shallowest point along Glomar Shoals (35 m^3 MGO spill)

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.

7.6.4 Environmental performance outcomes and control measures

The EPO relating to this hazard is:

EPO-09: 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 7-14** and corresponding EPSs and measurement criteria are described in **Section 8.4**.

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 7-14: Control measures evaluation for release of hydrocarbons

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
Standard Control measures				
CM-09	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.	**Adopted** – Benefits considered to outweigh costs.
CM-10	Watchkeeping maintained on bridge	Minimises risk of collision through visual identification and avoidance of other vessels.	Negligible costs	**Adopted** – Benefits considered to outweigh costs.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
CM-33	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.	**Adopted** – Benefits considered to outweigh costs.
CM-36	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.	**Adopted** – 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	Marine assurance standard	Ensures vessels meet Marine assurance standards to reduce the likelihood of unplanned discharges.	Costs associated with personnel time in checking vessel.	**Adopted** – Benefits of ensuring procedures are followed and measures implemented and that the vessels are compliant, outweighs the costs. Regulatory requirement must be adopted.
CM-38	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.	**Adopted** – Benefits considered to outweigh costs.

CM Reference	Control measure	Environmental benefit	Potential cost/issues	Evaluation
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.	**Rejected** – 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.	**Rejected** – 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.

7.6.5 Environmental impact assessment

The below environmental impact assessment follows the risk assessment approach detailed in **Section 7.5.5**.

Two areas of high environmental value have been identified within the EMBA, the Montebello AMP and Glomar Shoals KEF (**Table 7-7**). The Glomar Shoals KEF is the only high environmental value area contacted by hydrocarbons greater than the moderate exposure values.

Table 7-15: 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 (Breeding BIA).

<table>
<tr><th colspan="2">Description</th></tr>
<tr><td>Key Receptors</td><td>Physical environment and habitats
Threatened, migratory fauna and local fauna
Protected Areas
Socio-economic</td></tr>
<tr><td>Consequence</td><td>II - Minor</td></tr>
<tr><td colspan="2">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 7-12, and potential impacts to receptors found within the EMBA are further described in Table 7-13.</td></tr>
<tr><td colspan="2"><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.</td></tr>
<tr><td colspan="2"><u>Threatened, migratory and local fauna</u>
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 7-12 and Table 7-13).
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 7-12 and Table 7-13.
Waters exposed to hydrocarbon levels greater than the moderate exposure levels overlap a breeding BIA for the Wedge-tailed shearwater. An unplanned release of MGO is not expected to interfere with their breeding activity,</td></tr>
</table>

Description
but could cause slight secondary effects through ingestion after preening or ingestion of oiled fish (as described in **Table 7-12** and **Table 7-13**). 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 7-12** and **Table 7-13**. 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 3-4**). 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.
<u>Protected areas</u> 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 7-12** and **Table 7-13**.
<u>Socio-economic receptors</u> 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 Unlikely (b).	
Residual Risk	The residual risk associated with this event is *Very Low*

7.6.6 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 7.6.4**) (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.

7.6.7 Acceptability evaluation

Is the risk ranked between Very Low to Medium?	Yes – residual risk is ranked as 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 advices 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 Low and ALARP. CMs will reduce the risk of impact from MDO spill to a level that is acceptable.

7.7 Presence of wellhead: snagging

7.7.1 Description of Event

Event	Presence of wellhead (3.6 m high x 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.

Extent	**Localised**: Approximately 1 km area around the wellhead (AMCS 2021).
Duration	**Long term:** The potential effects may occur until equipment degrades (i.e. many decades).

7.7.2 Nature and scale of environmental impacts

7.7.2.1 Socio-economic receptors

Commercial Fisheries

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

Santos engaged a Subject Matter Expert, the Australian Maritime Council Search (AMCS), to undertake an assessment of the potential impacts of the wellhead on commercial trawl fisheries. The review found that 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 vessels 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 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 AMCS concluded that the likelihood of interaction between a trawler and the wellhead is low. In the evet of a snag, some net and wires (bridle gear) would have to be left behind, with recovery of this gear unlikely (AMCS 2021). 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 (AMCS 2021).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 (AMCS 2021).

Petroleum Industry

The presence of the wellhead on the seabed may interfere with future petroleum activities (e.g. interfere with jack-up rig placement). However, due to the small footprint (approximately 5 m diameter) and known presence of the wellhead any such interference would be insignificant. 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.

7.7.3 Environmental performance and Control measure

The EPO relating to this event is:

EPO-10: Marine users are not adversely impacted by the presence of the wellhead.

The control measures considered for this activity are shown in **Table 7-16**. EPS and measurement criteria for the adopted controls are presented in **Section 8.3.**

Table 7-16: 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-39	Navigational charting of property.	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.	**Adopted** – 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

Control Measure Ref. No.	Control Measure	Environmental Benefit	Potential Cost/Issues	Evaluation
				appropriate marine charts.
Additional Control Measures				
CM-40	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.
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 AUSD 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. Consultation with trawl fisheries indicated that wellhead caps or cover does not remove the snag risk.	**Rejected –** 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. The height of the wellhead may need to be reduced to allow for the placement of a 'low profile' cover or cap.
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. The option of external cutting of the wellhead above the mud line would likely result in a	It is estimated that wellhead removal costs would be in the range of 4.9 M AUD component and 3.6 M USD component. 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.	**Reject –** As detailed in **Section 2.2,** wellhead removal would pose more environmental impacts and risks than it mitigated. 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
		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 (AMCS 2021).		
N/A	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.	**Reject -** The wellhead has been present since 1968 and as such any fisher that operates within the vicinity of it would be expected to be aware of its presence. Additional notification may lead to stakeholder fatigue and would not result in any additional environmental benefit. There have been no records of snagging on the wellhead for the duration of its presence.
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 AUSD 100,000 to 200,000. 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 monitoring would not reduce the I - Negligible impact of wellhead presence.

7.7.4 Environmental impact assessment

Description – Presence of wellhead: snagging	
Receptors	Socio-economic receptors
Consequence	I - Negligible

Socio-economic receptors

The independent assessment of the snag risk of the wellhead (see **Section 2.2.3**) 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

Description – Presence of wellhead: snagging	
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 (AMCS 2021). It is expected the loss of some net or wire would be a I – Negligible consequence.	
Likelihood	a - Remote
It is unlikely 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 Remote.	
Residual Risk	The residual risk associated with this event is *Very Low*

7.7.5 Demonstration of ALARP

The assessed residual consequence for this snagging is very low and cannot be reduced further. Additional control measures were considered (as detailed in **Section 7.7.3**) but rejected since the associated cost / effort was grossly disproportionate to any benefit.

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 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 this fishery is not expected.

It is considered therefore that the impact is ALARP.

7.7.6 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 recovery plans, threat abatement plans, conservation advice and Australian marine park zoning objectives)?	Yes – Santos has consulted with relevant decision-making government authorities and no concerns or objections have been raised.
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?	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. In the event of a snag occurring some damage or loss of equipment may occur.
Are performance standards such that the impact or risk is considered to be ALARP?	Yes – see ALARP above.

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.

8 Implementation strategy

OPGGS(E)R 2009 Requirements
Regulation 14(1)
The environment plan must contain an implementation strategy for the activity in accordance with this regulation.
Regulation 14(10)
The implementation strategy must comply with the Act, the regulations 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 2009 Requirements
Regulation 14(3)
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.

+ Stakeholder 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 EPS 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 long-term detectable 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	No introduction of marine pest species.
EPO-09	No loss of containment of hydrocarbon to the marine environment.
EPO-10	Marine users are not adversely impacted by the presence of the wellhead.

8.4.1 Control measures and environmental performance

OPGGS(E)R 2009 Requirements
Regulation 13(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. Those 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 activity

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	Performance Objective Reference	Section
Gas seepage monitoring	CM-01	A monitoring campaign of the gas seepage is undertaken in 2022 specifically to measure flow rates through time at gas seepages at Legendre Hub, Legendre South-1 and Legendre South-3. The methodology to be used to measure flow rates will be determined by scientists after an assessment of possible techniques and a detailed execution plan prepared for implementation in 2022. The monitoring campaign will include: + Installing devices on the seabed to measure gas flow rates through time + Methane measurements in the water column at gas seep sites and reference sites + Contaminant measurements in sediment at gas seep sites and reference sites.	CM-01-EPS-01	Records show gas seepage monitoring campaign is implemented.	EPO-01	0
Well Integrity Studies	CM-02	Following on from the evaluation in 2020 of P&A plans against reported P&A activity in WA-20-L, further studies are done in 2022 as follows: Part A – identify credible leak/gas migration pathways and assess effectiveness of barriers for the leak paths. For each well, develop a barrier summary to inform likelihood of the leak path and risk of escalation. Part B – conduct a review of gas migration from permanently abandoned wells (in mature and regulated oil and gas hub locations globally) and identify if any solutions to remediate were successful. Part C – remediation feasibility assessment – if possible solutions are identified from global review, assess application to WA-20-L wells including likelihood of success and costs.	CM-02-EPS-02	Records show studies were carried out in 2022.	EPO-01	6.1
Reservoir Modelling	CM-03	A simple tank model is used to estimate the range of forward-looking gas flow rates through time under different scenarios, informed by the well integrity studies.	CM-03-EPS-03	Records show studies were carried out in 2022.	EPO-01	6.1
Fish Ecotoxicology Assessment	CM-04	Ecotoxicological assessment of commercial species of fish in vicinity of gas seeps carried out in 2022. Criteria in assessment to include parameters provided by commercial fishing representatives such as WAFIC and DPIRD.	CM-04-EPS-04	Records show studies were carried out in 2022.	EPO-01	6.1
Independent scientist review of impacts of gas seeps	CM-05	Independent and subject matter expert review by scientists of information provided by CM-01, CM-02, CM-03 and CM-04 and evaluation of impact to marine environment.	CM-05-EPS-05	Records show independent review and evaluation carried out by expert scientists.	EPO-01	6.1
Adaptive Management Plan for gas seeps	CM-06	Adaptive Management Plan described in Section 6.1.3.1 is implemented following completion of control measures, CM-01, CM-02, CM-03, CM-04 and CM-05, in accordance with Santos impact and risk assessment procedure (EA-91-IG-00004).	CM-06-EPS-06	Records show Adaptive Management Plan is followed and if required, further actions are implemented in accordance with the plan.	EPO-01	6.1
Automatic Identification System (AIS) identification system on vessel	CM-07	Vessel has an Automatic Identification System (AIS) to aid in its detection at sea.	CM-07-EPS-01	Completed inspection report or statement of conformance supplied by vessel contractor	EPO-02	6.2
Maritime notices	CM-08	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-08-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-09	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-09-EPS-01	Vessel certification confirms compliance with applicable regulations	EPO-02 EPO-04	6.2 6.4 6.8

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	Performance Objective Reference	Section
Watchkeeping maintained on bridge	CM-10	Competent crew on the support vessel(s) shall maintain a constant bridge-watch.	CM-10-EPS-01	Completed operational report	EPO-02 EPO-03	6.2 6.3 7.3
Stakeholder consultation strategy	CM-11	Relevant persons consulted on the planned activity covered by this EP.	CM-10-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
		All correspondence with external stakeholders is recorded.	CM-10-EPS-02	Saved consultation records.	EPO-02	6.2
		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-10-EPS-03	Records show Santos' Consultation Coordinator is contactable before, during and after completion of the planned activity.	EPO-02	6.2
No recreational fishing from vessel	CM-12	Personnel are prohibited from recreational fishing activities on the vessel	CM-12-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-13	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-13-EPS-01	Log kept of marine fauna sightings when in WA-20-L.	EPO-03	6.3 7.3
Vessel planned maintenance system to vessel engines and machinery	CM-14	Engines, machinery and equipment are maintained in accordance with PMS.	CM-14-EPS-01	Condition and suitability survey of the vessel demonstrates compliance with PMS.	EPO-03 EPO-05 EPO-06	6.3 6.5 7.4
Fuel oil quality in accordance with MARPOL	CM-15	MARPOL-compliant fuel oil will be used during the activity.	CM-15-EPS-01	Fuel bunkering records.	EPO-05 EPO-06	6.5
International Air Pollution Prevention (IAPP) Certificate	CM-16	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-16-EPS-01	Current IAPP certificate.	EPO-05 EPO-06	6.5
Ozone-depleting substance (ODS) handling procedures	CM-17	ODS managed in accordance with Australian Marine Order 97 to reduce the risk of an accidental release of ODS to air.	CM-17-EPS-01	Completed ODS record book or recording system.	EPO-05 EPO-06	6.5
Waste incineration	CM-18	Waste incineration managed in accordance with MARPOL Annex VI, except incineration within the 500-m exclusion zone shall not occur.	CM-18-EPS-01	Completed waste record book or recording system.	EPO-05 EPO-06	6.5
Dropped object recovery	CM-19	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-19-EPS-01	Fate of dropped objects detailed in incident documents.	EPO-06 EPO-07	6.6 7.1
Dropped object prevention procedures	CM-20	Vessel lifting procedures include the following CMs to reduce the risk of objects entering the marine environment: + lifting equipment certification and inspection + lifting crew competencies + heavy lift procedures + preventative maintenance on cranes.	CM-20-EPS-01	Lifting equipment register. Permit to work records. Training records.	EPO-06 EPO-07	6.6 7.1

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	Performance Objective Reference	Section
Sewage treatment system	CM-21	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-21-EPS-01	Current ISPP certificate. Completed inspection checklist. Maintenance records.	EPO-05 EPO-06	6.7 6.8
Oily water treatment system	CM-22	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-22-EPS-01	Completed inspection checklist. Oil record book or log. Maintenance records. Current IOPP certificate.	EPO-05 EPO-06	6.7 6.8 7.4
Waste (garbage) management procedure	CM-23	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-23-EPS-01	Completed inspection checklist. Completed garbage disposal record book or recording system.	EPO-05 EPO-06	6.7 7.1
Deck cleaning product selection	CM-24	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-24-EPS-01	Safety data sheet (SDS) and product supplier supplementary data as required. Completed inspection checklist.	EPO-05 EPO-06	6.7 7.4
Chemical management procedure	CM-25	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-25-EPS-01	Completed inspection checklist	EPO-05 EPO-06	6.7 7.4
Competent Incident Management Team (IMT) and oil spill responder personnel	CM-26	Vessel crew are trained and competent, in accordance with Flag State regulations, to navigate vessels and reduce interaction with other marine users.	CM-26-EPS-01	Training records.	See OPEP	6.8
Use of competent vessel crew and personnel	CM-27	Vessel crew are trained and competent, in accordance with Flag State regulations, to navigate vessels and reduce interaction with other marine users.	CM-27-EPS-01	Training records.	See OPEP	6.8
Compliance with controlled waste, unauthorised discharge and landfill regulations	CM-28	Ensure operational NEBA considers waste management, to ensure environmental benefit outweighs the environmental impact of strategy implementation which may include secondary contamination	CM-28-EPS-01	NEBA Template.	See OPEP	6.8
Spill response activities selected on basis of a NEBA	CM-29	A NEBA is undertaken for every operational period.	CM-29-EPS-01	Incident Log contains NEBA	See OPEP	6.8
Use of shallow draft vessels for nearshore operations	CM-30	Shallow draft vessels are used for shoreline and nearshore operations unless directed otherwise by the designated Control Agency.	CM-30-EPS-01	Vessel specification documentation contained in IAP.	See OPEP	6.8

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	Performance Objective Reference	Section
Implementation of the management controls in the Santos Invasive Marine Species Management Plan (IMSMP)	CM-31	Vessels are managed to low risk in accordance with the Santos IMSMP (EA-00-RI-10172) prior to movement or 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.	CM-31-EPS-01	Completed risk assessment demonstrating vessel and equipment is low risk.	EPO-08	7.2
		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-31-EPS-02	Records show Ballast Water Management is implemented. Completed ballast water record book or log is maintained.		
Anti-foulant system	CM-32	Vessel anti-foulant system maintained in compliance with International Convention on the Control of Harmful Anti-fouling Systems on Ships	CM-32-EPS-01	Current International Anti-Fouling System Certificate.	EPO-08	7.2
Vessel spill response plans (SOPEP/SMPEP)	CM-33	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-33-EPS-01	Audit records. Inspection records.	EPO-06	7.4
Remotely operated vehicle inspection and maintenance procedures	CM-34	Preventive maintenance on ROV completed as scheduled to reduce the risk of hydraulic fluid releases to sea.	CM-34-EPS-01	Maintenance records.	EPO-06	7.4
		ROV pre-deployment inspection completed to reduce the risk of hydraulic fluid releases to sea.	CM-34-EPS-02	Completed pre-deployment inspection of hose integrity.		
Hazardous chemical management procedures	CM-35	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-35-EPS-01	Audit Records. Inspection Records.	EPO-06	7.4
Accepted oil pollution emergency plan (OPEP)	CM-36	In the event of a hydrocarbon spill to sea, the Santos OPEP requirements are implemented to mitigate environmental impacts.	CM-36-EPS-01	Completed incident documentation.	EPO-06	7.6
Marine assurance standard	CM-37	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-37-EPS-01	Completed inspection checklist and premobilisation documentation.	EPO-06	7.6

Control Measures	CM Reference	Environmental Performance Standard	EPS Reference No.	Measurement Criteria	Performance Objective Reference	Section
Pre-Activity commencement assurance check	CM-38	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-38-EPS-01	Completed Assurance Check form.	EPO-06	7.6
Navigational charting of wellhead	CM-39	The Legendre-1 wellhead is charted on Australian Hydrographic Service nautical charts.	CM-40-EPS-01	Australian Hydrographic Service nautical charts show that the wellhead is charted.	EPO-03	7.7
Stakeholder notification through industry representative body	CM-40	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-39-EPS-01	Australian Hydrographic Service nautical charts show that the wellhead is charted.	EPO-02	7.7

8.5 Leadership, accountability and responsibility

OPGGS(E)R 2009 Requirements
Regulation 14(4)
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, Santos' Manager – Offshore Drilling and Completions, is accountable for ensuring implementation, management and review of this EP.

The effective implementation of this EP requires collaboration and cooperation among Santos and its contractors. 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
Company Site Representative	Has responsibility for: + 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	Has overall responsibility for: + 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 + 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.
Santos HSE Manager	Has overall responsibility for: + ensuring incident preparedness and response arrangements meet Santos and regulatory requirements + approving the OPEP + providing ongoing resources to maintain compliance with the OPEP and other Santos incident response requirements.

Role	Responsibilities
Santos HSE Coordinator(s)	+ Ensures the EP is managed and reviewed: monitors conformance with EPOs and EPSs, and the implementation strategy in the EP. + Prepares, maintains and distributes the environmental compliance register. + Completes regular HSE reports, inspections and audits. + Completes HSE inductions and promotes general awareness. + Collates HSE data and records. + Contributes to HSE incident management and investigations. + Provides operational HSE oversight and advice. + Facilitates the development and implementation of MoC documents. + Provides incident reports, compliance reports and notifications to NOPSEMA. + Ensures stakeholder consultation and communication requirements have been fulfilled. + Ensures subcontractors are communicated the EP requirements.
HSE Team Lead – Security and Emergency Response	Has overall responsibility for: + 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 Oil Spill Response Advisor	Has overall responsibility for: + 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 2009 Requirements
Regulation 14(5)
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 and has appropriate training and competencies.

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; in other words, CMs CM-01 and CM-23
+ operating environment (for example, nearby protected marine areas)
+ activities with highest risk
+ EP commitments (for example, Table 8-2)
+ 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

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 2009 Requirements
Regulation 14(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 2009.

8.8 Incident reporting, investigation and follow-up

OPGGS(E)R 2009 Requirements
Regulation 14(2)
The implementation strategy must: + state when the titleholder will report to the Regulator in relation to the titleholder's environmental performance for the activity; and + provide that the interval between reports will not be more than 1 year. Note: Regulation 26C requires a titleholder to report on environmental performance in accordance with the timetable set out in the environment plan.
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.

All 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 Santos Incident Reporting and Investigation Procedure (QE-91-IF-00002) 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) Regulations:

+ 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 4.1**.

8.9 Reporting and notifications

OPGGSR 2009 Requirements
Regulation 14(2)
The implementation strategy must: + state when the titleholder will report to the Regulator in relation to the titleholder's environmental performance for the activity; and + provide that the interval between reports will not be more than 1 year.
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.

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				
OPGGS(E) Regulation 29 & 30 – Notifications NOPSEMA must be notified that the activity is to commence	Complete NOPSEMA's Regulation 29 Start or End of Activity Notification form prior to each environmental survey.	At least ten days before the activity commences.	Written	NOPSEMA
Before each environmental survey				
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
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

Initiation	Required Information	Timing	Type	Recipient
Consultation	Each environmental survey will be included in the Quarterly Consultation Update until the activity has ended.	Quarterly	Written	The Quarterly Consultation Update is circulated to a broad group of Santos stakeholders, including many of the stakeholders identified in **Section 4**
Department of Agriculture, Water and the Environment (DAWE) – Biosecurity (vessels, aircraft and personnel)	In addition to completing an IMS Risk Assessment in accordance with CM- 18, 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 DAWE biosecurity reporting obligations.	At least one month prior to each environmental survey commencement. MARS reporting at least 12 hours prior to arrival.	Written	DAWE Biosecurity (vessels, aircraft and personnel)

Initiation	Required Information	Timing	Type	Recipient
During the activity				
OPGGS(E) Regulation 26B – 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) Regulation 26C – 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) Regulation 16(c), 26 & 26A – Reportable Incident NOPSEMA must be notified of any reportable incidents For the purposes of Regulation 16(c), a reportable incident is defined as: an incident relating to the activity that has caused, or has the potential to cause,	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 + 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.	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 becoming aware of the reportable incident.	Oral	NOPSEMA
	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

Initiation	Required Information	Timing	Type	Recipient
moderate to significant environmental damage	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
DAWE Reporting Any harm or mortality to EPBC Act- listed threatened marine fauna Marine Fauna Sighting Data	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	DAWE
	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	DAWE

Initiation	Required Information	Timing	Type	Recipient
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 Any ship strike incident with cetaceans will also be reported to the National Ship Strike database	Ship strike report provided to the Australian Marine Mammal Centre: https://data.marinemammals.gov.au/report/shipstrike.	As soon as practicable.	Written	DAWE
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.			
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 AHO

Initiation	Required Information	Timing	Type	Recipient
End of each environmental survey				
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
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, including many of the stakeholders identified in **Section 4**

Initiation	Required Information	Timing	Type	Recipient
End of EP validity				
OPGGS(E) Regulation 29 – Notifications NOPSEMA must be notified that the activity is completed	Complete NOPSEMA's Regulation 29 Start or End of Activity Notification form.	Within ten days after end of the EP validity.	Written	NOPSEMA
OPGGS(E) Regulation 25A EP ends when titleholder notifies completion and the Regulator 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 Regulation 29 (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.

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
Chemicals (discharged to marine environment as per Section 6.6)	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 the associated OPEP, as well as 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 and OPEP 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 and OPEPs.

The MoC process considers Regulations 7, 8 and 17 of the OPGGS(E)R 2009 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.

New information will include results from monitoring campaigns conducted on the gas seepages in WA-20-L, as detailed in CM-01 and CM-02 (see **Section 8.4.1**). If a change in impacts or risks to the environment as a result of gas seepage is confirmed through monitoring, the MoC process will determine if any new control measures are required in order for the associated environmental impacts and risks to be demonstrated to be acceptable and ALARP.

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 (refer to CM-24) 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.

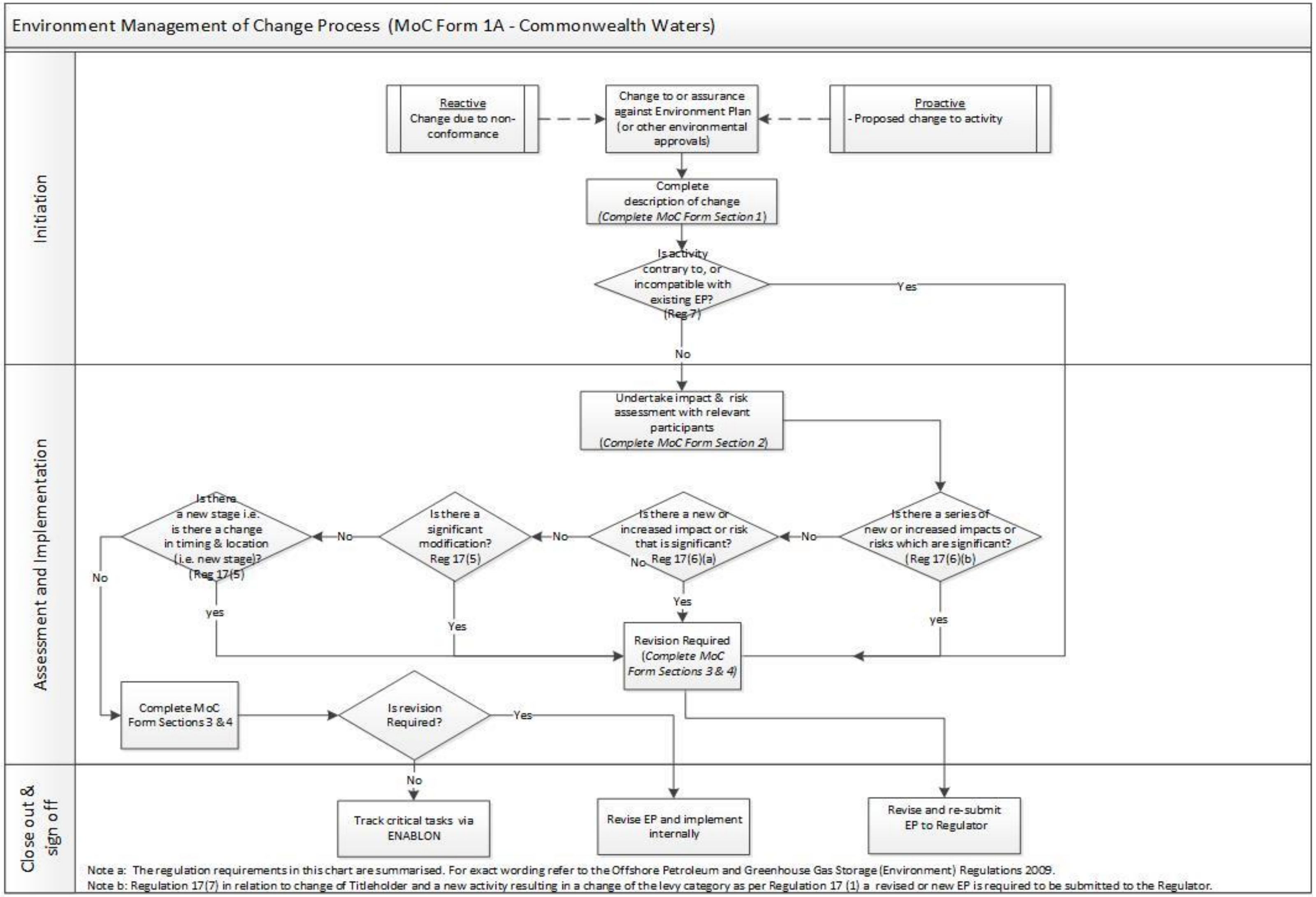

Figure 8-1: Environment management of change process (Commonwealth Waters)

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 given the nature of the 24/7 operations.

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
+ 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 APPEA (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 EMBA which includes completing a new EPBC Protected Matters Search, reviewing **Appendix B** 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.
+ 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 2009 Requirements
Regulation 14(6)
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 Standard (QE-91-ZF-100073).

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 or vessel-based) 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.
+ 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 or the OPEP are managed in accordance with the OPGGS(E)R and in a controlled manner.

9 References

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.

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.

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.

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.

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.

CSIRO (2005). RV Southern Surveyor. Voyage Summary SS 06/2005. CSIRO Division of Marine Research, Hobart. 19pp.

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. Avaiable 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

Department of Industry, Science, Energy and Resources (2018). Offshore Petroleum Decommissioning Guideline. Available online from: https://www.nopta.gov.au/_documents/guidelines/decommissioning-guideline.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.

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 (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). Availabe 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.

Dow 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.

DPIRD (2019a). Finfish Spawning Table for some Key Species – Updated 5 June 2019. Perth, Western Australia.

DSEWaC (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 (2012c). 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. (2012b). Species Group Report Card – Bony Fishes; 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.

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 modeling, 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.

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.

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.

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.

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.

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.

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.

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, Jornal 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.

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.

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.

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.

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

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.

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 (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

Urick, R.J. (1983). Principles of Underwater Sound. 3rd edition. McGraw-Hill, New York, London. 423 p.

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

Appendix A. SANTOS ENVIRONMENT, HEALTH AND SAFETY POLICY

Environment, Health & Safety

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:	Jodie Hatherly, General Counsel and VP Legal, Risk and Governance		
Approved by:	The Board	Version:	3

20 August 2019

Appendix B. RELEVANT INTERNATIONAL AGREEMENTS, CONVENTIONS AND COMMONWEALTH AND STATE LEGISLATION

International 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 2.2.4** 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	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;	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 2.2.4** 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
(IMO Resolution A.672(16))	+ The rate of deterioration of the material and it's 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 + 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 as 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*	**Sections 6 and 7**

International Agreements and Conventions	Summary	Relevant aspects of the activity	EP Section
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 and 7**

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.	Commonwealth – Australian Securities and Investments Commission	The titleholder has provided ACN details within the meaning of the Act.	**Section 1**
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	**Section 7**

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
			+ 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. + 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	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	Commonwealth – Department of Environment and Energy	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 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for Unplanned Events

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
Amendment Regulations 2006	Management Plans were also developed under this Act.			
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.	DAWE	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 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	AMSA	Several Marine Orders are enacted under this Act relating to offshore petroleum activities, including: + 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	Section 7 and Section 8 detail where the applicable requirements apply to the survey.

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
			+ Marine Order 58: Safe management of vessels.	
Offshore Petroleum and Greenhouse Gas Storage Act 2006 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009	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** – Risk Assessments for Planned Events

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	DAWE	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

Commonwealth Legislation	Summary	Administering Authority	Relevant aspects of the activity	EP Section
	installation to be removed, and/or to make good any damage to the seabed cause by that installation.			

Key WA State Legislation and Regulations

State Legislation	Summary	Administering Authority	Relevant to activity?	EP Sections
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 Parks and Wildlife (DPAW)	Yes, hydrocarbon spill scenarios impacts relating to potential impacts to listed species	**Section 6 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for Unplanned Events
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	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 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for Unplanned Events
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	Environmental Protection Authority	Yes, environment may receive exposure from a hydrocarbon spill	**Section 6 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for

State Legislation	Summary	Administering Authority	Relevant to activity?	EP Sections
	conservation, preservation, protection, enhancement and management of the environment.			Unplanned Events
Fish Resources Management Act 1994 Fish Resources Management Regulations 1995.	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 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	DPIRD	Yes. Vessels required to comply with the Act.	**Section 6 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for Unplanned Events
West Australian Maritime	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	West Australian Museum	Yes. maritime archaeological site in WA-20-L. Sites may receive exposure from a hydrocarbon spill.	**Section 6 –** Risk Assessments for Planned Events

State Legislation	Summary	Administering Authority	Relevant to activity?	EP Sections
Archaeology Act 1973	with exploration, early settlements, whaling and pearling camps and shipwreck survivor camps			**Section 7 –** Risk Assessments for Unplanned Events
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 –** Risk Assessments for Planned Events **Section 7 –** Risk Assessments for Unplanned Events

Appendix C. WELLHEAD REMOVAL TECHNICAL FEASABILITY STUDY

SANTOS

LEGACY SUBSEA WELLHEAD REMOVAL OPTIONS STUDY

Subsea Wellhead Removal Options Study

Document No. AEA-RPT-21-0209

13 July 2021

add energy

SUBSEA WELLHEAD REMOVAL OPTIONS STUDY

DATE:	DOCUMENT NO.	REVISION	PAGES:
13/02/2021	AEA-RPT-21-0209	0	28

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ABSTRACT:
Add Energy has been requested to perform a Subsea wellhead removal options Study.

KEYWORDS:
Subsea wellhead removal options study.

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1. STUDY SCOPE AND OBJECTIVES

Add Energy was engaged by Santos to conduct a scoping study on the options available for the removal of two legacy subsea wellhead that were P&A'd in the late 1960's and early 1970's.

- Scope of work to include;
    - OPTION 1 – Above mud-line (i.e. external cut) removal of legacy wellhead system
        - Diamond wire (or other method) external cutting (via ROV / divers etc.) and removal (stump left above mud-line)
    - OPTION 2 – Below mud-line (i.e. internal cut) removal of legacy wellhead system
        - Use of internal cutter powered either by ROV or via HPU and down-line (e.g. Baker "Terminator")
    - Marine growth cleaning and XT Cap Removal (hydraulic jack)
    - 13 5/8" x 9 5/8" internal cut and pull
    - 30" x 20" internal cut and pull
    - Wells – Legendre-1 (P&A'd in 1968); Tern-1 (P&A'd in 1971)
    - Each activity considered to be "stand-alone" (i.e. not linked to each other)

- Scope of this Legacy Wellhead Removal Study to include;
    - Review and summarise OPTION 1 and OPTION 2 methods for Legendre-1 and Tern-1 WHD 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)

- Deliverable
    - Technical and commercial report, outlining key conclusion and recommendation to better support scope outline above

2. EXECUTIVE SUMMARY

A review of industry field proven and new technology options for rig-less/vessel based severance and recovery of subsea wellheads was conducted with the aim to present Santos with the time/cost and operational risks and benefits for each of these options so that an optimal methodology can be selected for the removal of the Legendre-1 and Tern-1 legacy subsea wellheads based on the project specific requirements.

Whilst each of these wellhead removals will be considered separate projects both wells carry similar challenges and environments for the severance and recovery operations thus the options and risks outlined in this study should be considered to apply for both wells.

3. CONCLUSION

Based on the options reviewed during this study for the severance and recovery of the Tern-1 and Legendre-1 legacy wellheads, two options stood out as the most feasible given the project specific challenges of removing these particular wellheads and the key points for these options are summarised below.

Blakemere 155” External Diamond Wire Saw (DWS).

- This is the only external cutting option identified that does not require the removal of the guide bases or any dredging operations below the guide base thus eliminates these major risks to the time and cost of the project.
- Lowest cost option if acceptable to sever the wellhead just above the mudline.
- The DWS 155” is a newly designed tool and as yet not field proven thus presenting a potential risk to project time and cost however the tooling suite is substantially lower cost that the internal severance option thus could still provide a commercial advantage.
- Most cost-effective severance solution for single well wellhead severance campaign due to the relatively high mob/demob costs associated with the internal severance options.
- Tool designed for subsea cutting not wellhead specific thus modifications required for wellhead severance.
- Any wellbore pressure management operations would need to be conducted prior to severing the wellheads externally.

Sapura Well Services (TMT) AXE wellhead Severance Tool.

- This option provides the most flexibility for any combined operations requiring access to the wellbore.
- Facilitates wellhead severance below the mudline.
- High Mob/Demob costs for single well wellhead severance campaign.
- Extensive history in the region.
- Tooling designed specifically for wellhead severance.
- Local operator with capability to provide both wellhead severance and wellbore pressure management services combined. Potential cost savings if both services contracted.

4. RECOMMENDATIONS

- Based on the information and case studies reviewed in the scope of work, it is recommended that Santos further review the risks associated with the potential for trapped wellbore pressure given the age of the Tern-1 and Legenre-1 wells with a view to formally risk assessing the requirement for wellbore pressure management operations prior to severing and recovering the wellheads.
- It is recommended to further assess if a low-cost opportunity is available to clean the marine growth from each of the wellheads ahead of any wellhead severance campaign. Allowing more accurate information to be gathered on the wellhead corrosion status and lay out, T/A cap type and latching mechanism, further de-risking some of the other severance tooling options that require a competent HP housing upper profile to latch onto.
- Due to the high vessel mob/Demob costs the overall project costs for both of these wellhead severance and recovery projects could be substantially reduced by combining with other vessel-based operations in the adjacent areas.
- T/A cap jacking/removal tooling requirements for these projects would need to be identified/specified after marine growth cleaning of the wellheads to allow positive visual identification of the interfaces.
- Sacrificial removal of the T/A cap and wellhead upper profile could be considered as a contingent option for ensuring access to the wellbore is achieved in the event that the primary option of removing the T/A cap failed.

5. SUMMARY OF PROJECT SPECIFIC CHALLENGES

Legendre-1 status / assumptions

- The Legendre-1 wellhead is located in 53m water depth which is outside the max operating depth for air diving (max 50m) thus ROV operations should be considered as the only commercially viable option for wellhead recovery.
    - Note: SAT diving spreads circa AUD$350K p/day thus not feasible for single well standalone campaign)
- Wellhead has a Temporary guidebase (TGB) installed thus preventing direct access to the wellhead OD for external diamond wire saw mounting.
- Wellhead is of unknown type thus 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.
- HP housing TA cap type and latching mechanism unknown which presents a project risk for gaining access to the wellbore for any internal cutting or pressure management operations without prior marine growth cleaning and identification of the wellhead and T/A cap components.
- Extent of corrosion to the TA cap and wellhead housing is unknown. This presents a risk to any TA cap removal or wellhead interfacing operations. Once marine growth cleaning has been conducted allowing the potential for visual identification of the wellhead and TA cap components the ability to remove of the TA cap and interface with the HP housing upper profile may still not be possible.
- Wellbore/annulus pressure management. With the drilling and P&A of this well having been conducted circa 50 years ago there is a risk of finding migrated or static pressure in the wellbore and/or annuli and potential degradation of the existing down hole barriers that could present an environmental risk if severing the wellhead externally without accessing the wellbore to evaluate the current status.

- TGB appears to have minimal clearance above the seabed thus access below the TGB for any external cutting equipment requiring clear access to the wellhead/conductor OD would require dredging.
- Extent of cement 'porch' at seabed level below the TGB from surface 30" cement job is unknown thus the ability to dredge the seabed below the TGB could present a time and cost risk to the project for any external cutting option.

Tern-1 status / assumptions

- The Tern-1 wellhead is located in circa 90-100m water depth which is outside the max operating depth for air diving (max 50m) thus ROV operations should be considered the only commercially viable option for wellhead recovery.
    - Note: SAT diving spreads circa AUD$350K p/day thus not feasible for single well standalone campaign)
- The Tern-1 wellhead and Permanent guidebase (PGB) have extensive debris present. Fishing netting, ropes etc wrapped around the guideposts.
- Visibility in the area is limited due to depth and high currents thus presenting a time and cost risk to any technical ROV operations.
- Wellhead has a PGB installed thus preventing direct access to the wellhead for external diamond wire saw mounting.
- Wellhead is of unknown type thus 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.
- HP housing TA cap type and latching mechanism unknown which presents a project risk for gaining access to the wellbore for any internal cutting or pressure management operations.
- Extent of corrosion to the TA cap and wellhead housing is unknown. This presents a risk to any TA cap removal or wellhead interfacing operations. Once marine growth cleaning has been conducted allowing the potential for

visual identification of the wellhead and TA cap components the ability to remove of the TA cap and interface with the HP housing upper profile may still not be possible.

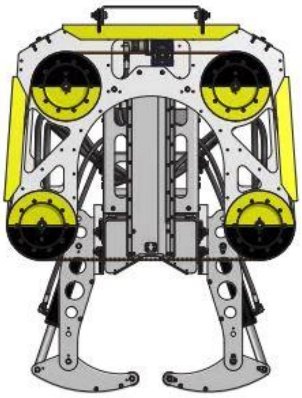
- Wellbore/annulus pressure management. With the installation and P&A of this well having been conducted circa 50 years ago there is a risk of migrated/static pressure in the wellbore and/or annuli or degradation of the existing down hole barriers that could present an environmental risk if severing the wellhead externally without accessing the wellbore to evaluate the current status.
- PGB appears to have minimal clearance above the seabed thus access below the TGB for any external cutting equipment would require dredging.
- Extent of cement 'porch' at seabed level below the PGB from surface 30" cement job is unknown thus the ability to dredge the seabed below the PGB could present a time and cost risk to the project for any external cutting option.

6. SUMMARY OF OPTIONS AND ASSOCIATED RISKS AND BENEFITS

There are numerous types of field proven subsea internal mechanical and water jet cutting and external diamond wire saw configurations and deployment options available on the market. The following options were considered for this study:

Option 1: External cutting by Diamond Wire Saw (DWS)

- In line or articulated crane deployed DWS (Aquaterra, Blakemere, Machtech)



DWS-30i Inline Saw	
Cutting Capacity	16 to 30 inches 406 to 762 mm
Operating Dimensions	86 x 65 x 40 inches 2184 x 1651 x 1016 mm
Shipping Dimensions	86 x 65 x 43 inches 2184 x 1651 x 1092 mm
Operating Weight	1050 lbs. 476 kg
Shipping Weight	1350 lbs. 612 kg

- Key Benefits
  - Compact design
  - Minimal deck space required for topside HPU (or ROV mounted HPU)
  - Can be deployed from an anchor handler type vessel with crane (low cost vessel) and working class ROV spread although heave compensated crane preferred.
  - Cut time for triple string cut (30” x 13 3/8” x 9 5/8”) circa 105 mins
  - This option can effect a cut below the mudline after dredging below the guidebase.
  - Low cost tooling rental rates (circa USD$1000 p/day)

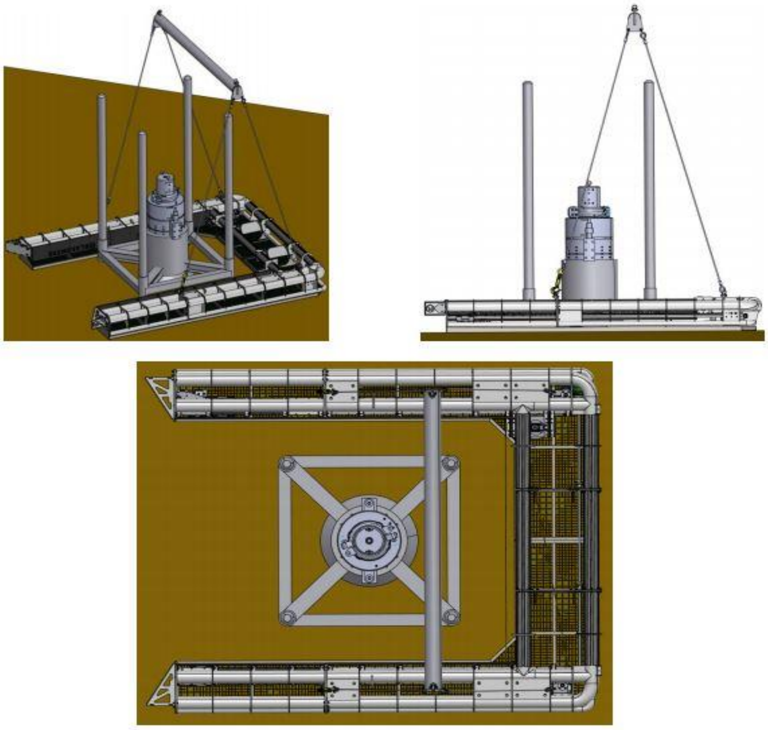
- Key challenges/disadvantages
  - These saws require access to the conductor OD for mounting which would require removal of the guidebase structures or alternatively excessive dredging to access the conductor below the guidebase. (circa 5mW x 3mD) High risk to project time and cost.
  - Crane deployment would not be practical below guidebase.
  - This option would still require accessing the wellbore for pressure management operations if required.
  - Both the DWS and the wellhead structure would require support from a crane during the cut.

- ## Inline ROV deployed DWS (Machtech, Oceaneering,TMT)

- Key Benefits
  - Compact design
  - Minimal deck space required for topside panel. (Hydraulic pressure supplied from ROV)
  - Can be deployed from an anchor handler type vessel with crane (low cost vessel) and working class ROV spread
  - Cut time for triple string cut (30” x 13 3/8” x 9 5/8”) circa 105 mins
  - This option can effect a cut below the mudline after dredging below the guidebase.
  - Relatively low cost tooling rental rates (circa USD$2000 p/day)

- Key challenges/disadvantages
  - These saws require access to the conductor for mounting which would require removal of the guidebase structures or alternatively excessive dredging to access the conductor below the guidebase. (circa 5mW x 3mD) High risk to project time and cost.
  - This option would still require accessing the wellbore for pressure management operations if required.

In line 155” crane deployed DWS (Blakemere)



- Key Benefits
  - This 155"DWS can be installed around the existing guidebase structures and installed on a mud mat on the seabed thus removing the requirement for dredging or removal of the guidebase structures.
  - A cut can be effected circa 100mm above the seabed thus leaving minimal stump. (tool designed to be able to be run inverted to get the cut closer to the seabed)
  - Relatively low cost equipment rental rates (circa AUD$4500 p/day +AUD$45K for mud mat and consumables)
  - Equipment available ex-Perth at 2-3 weeks lead time.
  - Can be deployed from an anchor handler spec vessel with ROV spread and non heave comp crane (low cost vessel option)(Heave comp crane preferred)
  - Cut time of circa 100-120mins.
  - Saw lift rigging can be disconnected on seabed and crane used to support wellhead structure during cutting operations.

- Key challenges/disadvantages
  - This option still requires access to the well bore for any pressure management operations required.
  - Bulky equipment to deploy from vessel.
  - Tool is new design and not field tested at the time of writing this report.

Option 2: Internal cutting by Mechanical or Abrasive Water Jet Cutting

- ### Terminator Mechanical cutting and wellhead retrieval tool (Baker Hughes)

- Key Benefits
  - Latches onto the wellhead upper profile during cutting operations to allow cutting and retrieval of the wellhead in one deployment.
  - Requires less deck space than abrasive water jet cutting systems. (Minimal topside equipment required on deck)
  - Requires access to the wellbore thus any pressure management can be conducted once the T/A cap is removed prior to severing the wellhead.
  - No Dredging required.
  - Cuts below mudline leaving no stump above the seabed.

- Key challenges/disadvantages
  - Requires confirmation of the type of upper wellhead profile and requires a serviceable upper wellhead profile to latch onto as the cutter torque is transmitted through the wellhead connector. The tool is reconfigurable for different wellhead profiles however given the uncertainty of the wellhead types on Tern-1 and Legendre-1 this would pose a key risk to the project without a pre-cleaning campaign to verify the wellhead condition and upper profile.
  - Circa 180 mins cut time for triple string cut.
  - Requires vessel with heave compensated crane. (or possibly use an inline compensator)

- ## Internal Multi-String Cutting Tool (IMCT) (Oceaneering)

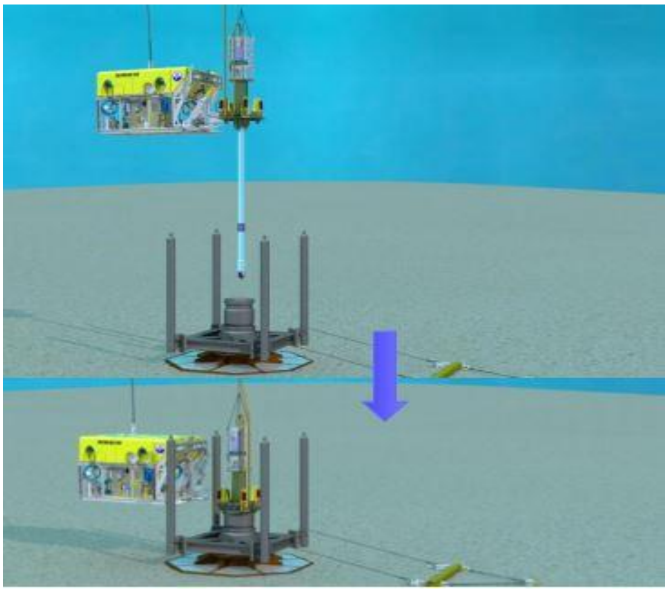
Internal Multi-String Cutting Tool (IMCT)

Subsea Wellhead Picker

- Key Benefits
  - When used in conjunction with the Subsea wellhead picker tool that latches onto the wellhead upper profile during cutting operations cutting and retrieval of the wellhead is capable in one deployment.
  - The IMCT can be utilised without the picking tool thus does not necessarily require a serviceable wellhead upper profile.
  - Requires access to the wellbore thus any pressure management can be conducted once the T/A cap is removed prior to severing the wellhead.
  - No dredging required.
  - Cuts below mudline leaving no stump above the seabed.

- Key challenges/disadvantages
  - Requires circa 100m2 of deck space for AWJC equipment. Equipment spread is circa 45T.
  - Requires removal of the TA cap and access to the wellbore. Time and cost risk if otherwise not required for wellbore pressure management.

- ## Sea Axe (Internal Abrasive Water Jet Cutting Tool) (TMT/Sapura energy Services)



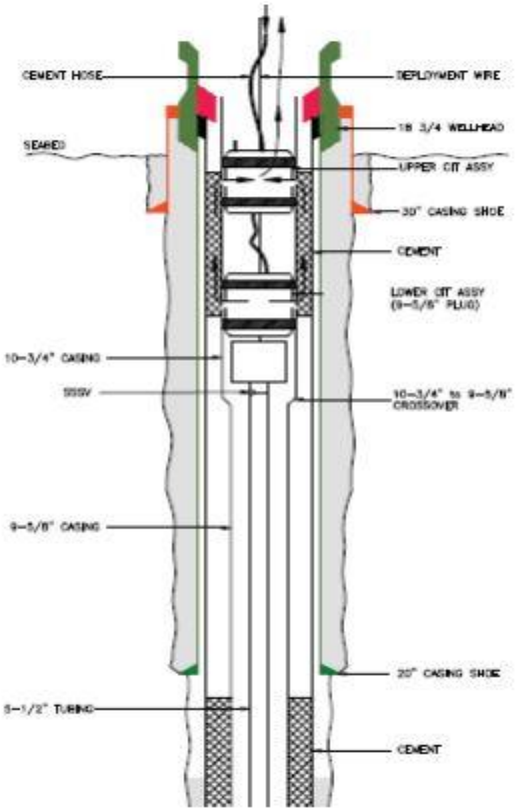
- Key Benefits
    - This tool uses a universal mounting system to latch onto any wellhead profile encountered. The wellhead latch fingers can be modified in field to accommodate any upper profile including a partially severed housing or LP housing.
    - This system would allow the top of the wellhead and TA cap to be cut off using an external DWS if required to gain access to the wellbore as no hub profile is required to latch the tool onto. Provides maximum flexibility for mounting the tool and gaining access to the wellbore.
    - Requires access to the wellbore thus any pressure management can be conducted once the T/A cap is removed prior to severing the wellhead.
    - No Dredging required.
    - Can be deployed from an anchor handler spec vessel with ROV spread and non heave compensated crane. (low cost vessel options)
    - Extensive track record in the region.
    - Tool is based in region.
    - Circa 3.5hours cut time once pumping has commenced.
    - Time saving over deployment of 155" external cutter once wellbore has been accessed.
    - Cuts below mudline leaving no stump above the seabed.

- Key challenges/disadvantages
    - Requires circa 125m2 of deck space for AWJC equipment. Equipment spread is circa 37T.
    - Requires removal of the TA cap and access to the wellbore. Time and cost risk if otherwise not required for wellbore pressure management.

7. WELLBORE PRESSURE MANAGEMENT

This option was not included as part of the initial scope delivery, but something to consider when assessing scope opportunities.

Sapura Energy Services (TMT) Cement Injection Tool (CIT)



SapuraKencana Well Services' Cement Injection Tool (CIT) is a combination, disposable, isolation, squeeze packer and casing perforating system. It enables the perforation of production casing, monitoring and control of annular pressure and, if required, re-cementation of the production casing annulus and placement of an abandonment plug in the casing itself. The tool has two main components including an upper and lower subassembly. Each subassembly is similar and comprises dual packers and perforating units. The subassemblies are interconnected by a lifting wire and hydraulic umbilical. A hydraulic umbilical connects the tool to surface controls, the length of which is determined by the plug requirement depth. Cement Injection Tool (CIT) Final well abandonment tool, combining perforating, pressure monitoring and the placement of cement plugs in annulus and production casing Any 15ksi hydraulic power unit or test pump can be utilised to function the tools. The CIT is run into the well to the required depth using a standard deck winch, hang-off tool and lifting wires (depth adjustment). The upper perforating subassembly is set then then activated, and annular pressure monitored. The lower perforating subassembly (±100m below the packer) is then set and activated and circulation established down the annulus and up a flow path through the lower and upper subassemblies, enabling a cement plug of ±100m to be placed in the annulus. The CIT units can then be removed from the well or left in hole as packers for placement of further cement plugs in the casing. Tools are designed for use in 9⅝" casing.

- Key Benefits
  - Eliminates requirement for explosives or wireline perforating systems
  - Disposable tool, reducing W.O.C time and total abandonment time Cost effective
  - Can be deployed from a vessel.
  - Does not require a wellhead connector to latch onto the HP housing thus provides flexibility for the Legendre-1 and Tern-1 legacy wellheads.
  - Establishes circulation path in un-cemented annulus
  - Extensive regional experience.

- Can be provided as part of the Sea Axe tooling spread from one vendor.

- Key challenges/disadvantages
    - Only ½”-1” downline for bull-heading wellbore.(if required) Limited flow rate.
    - Requires removal of the TA cap and access to the wellbore. Time and cost risk if otherwise not required for wellbore pressure management. Reduced time and cost risk compared to other internal cutting options due to the universal tooling mount thus allowing the TA cap to be cut off if required.

8. OFFSET WELL AND OPERATIONAL REVIEWS

Sapura Energy Well Services AXE – Wellhead severance system ›

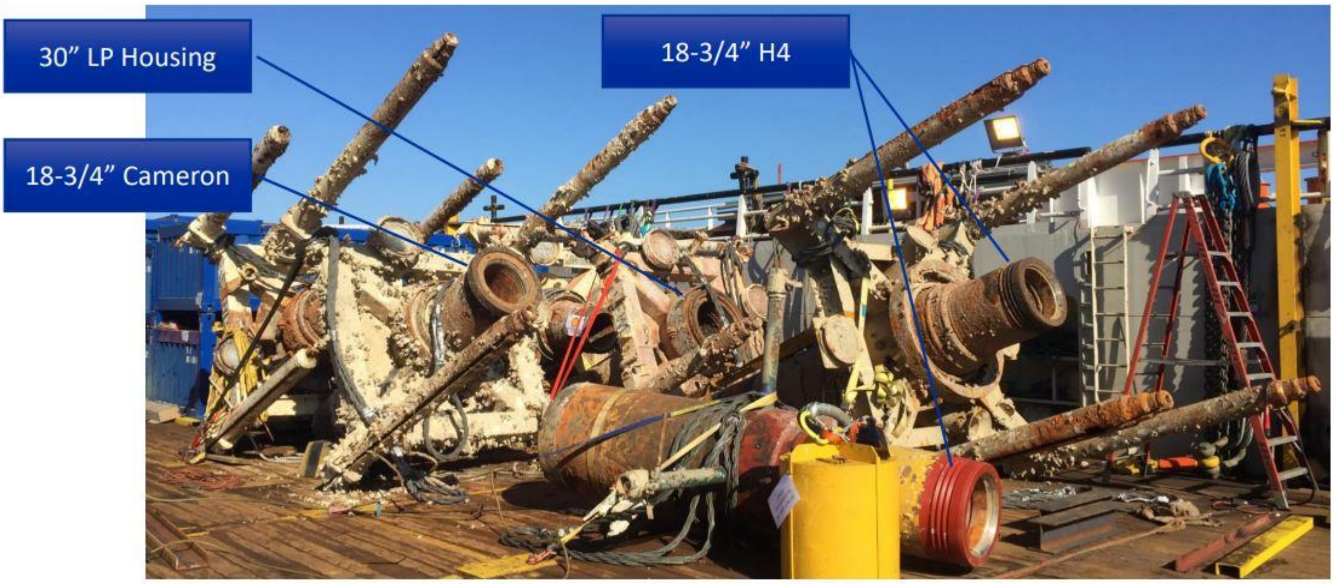
This option was not included as part of the initial scope delivery, but something to consider when assessing scope opportunities.

- Equipment Overview
  - High performance water abrasive severance system
  - Severance of 7 inch to 36 inch casings and wellhead in a single pass ›
  - Field proven system with over 80 subsea cuts completed to date ›
  - Patented proprietary design ›
  - 13,500psi / 1000 Bar system ›
  - Iron Silicate Abrasive media ›
  - Approx. 1600 kg/ abrasive per hour

- AXE projects within APME region›
  - Browse Basin – 7 subsea wellheads ›
  - North West Shelf – 9 subsea wellheads ›
  - Timor Sea - 30 subsea wellheads ›
  - Vietnam – 5 subsea wellheads ›
  - India – 9 pylon cuts ›
  - Deepest water depth – 266m › Current limit 350m, › Working towards 1100m

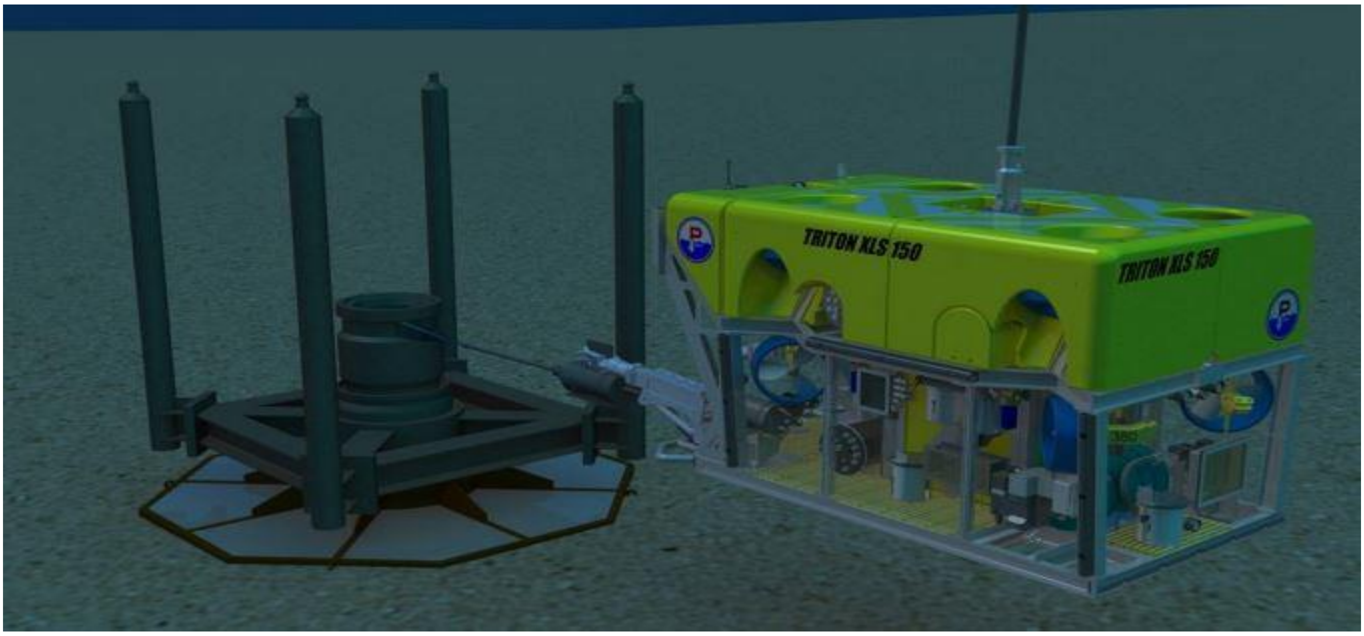
- Crux Wellhead Severances – Shell 2017
  - Location: Browse Basin, Australia
  - Vessel: SapuraKencana Constructor Offshore: June 2017
  - Water Depth: 125 to 266m
  - Scope: Well head severance and recovery of 7 exploration wellheads in various configurations.
  - Two of the wellheads had previous unsuccessful severance attempts, leaving damaged housing and partially severed casing.
  - SWS Developed a universal connector to land and latch onto wellheads of different sizes using the same tool. These included 18-3/4” Cameron Hub, 18-3/4” H4 and 30” LP housings
  - The SWS AXE Waterjet cutting system was used to successfully sever and recover all wellheads.

- Challis Jabiru Wellhead Severances – PTTEP 2012
  - Located in the North West Shelf, Western Australia
  - Severance of 17 production wellheads
  - Water Depth 120 metres
  - AXE System configured to run on the MODU rig “Ocean Patriot”
  - Multiple system rig up and rig downs due to deck space and scheduling during the P&A campaign.
  - Two of the wellheads had previous unsuccessful severance attempts, leaving damaged housing and partially severed casing.
  - All severance activities completed successfully on first pas of the AXE system

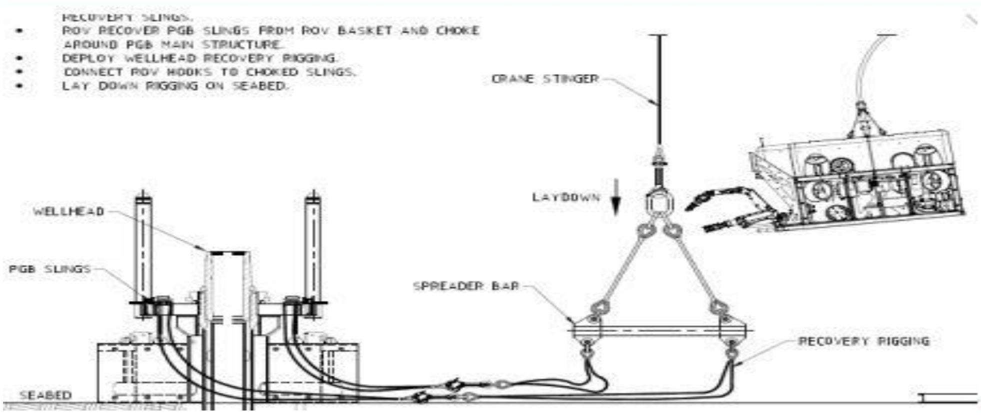


Axe Operational overview

- As-Found Survey ›
  - Marine growth inspection of wellhead ›
  - Stick-up depth measurement ›
  - TGB condition ›
  - PGB condition ›
  - Debris/anomalies
  - T/A cap removal

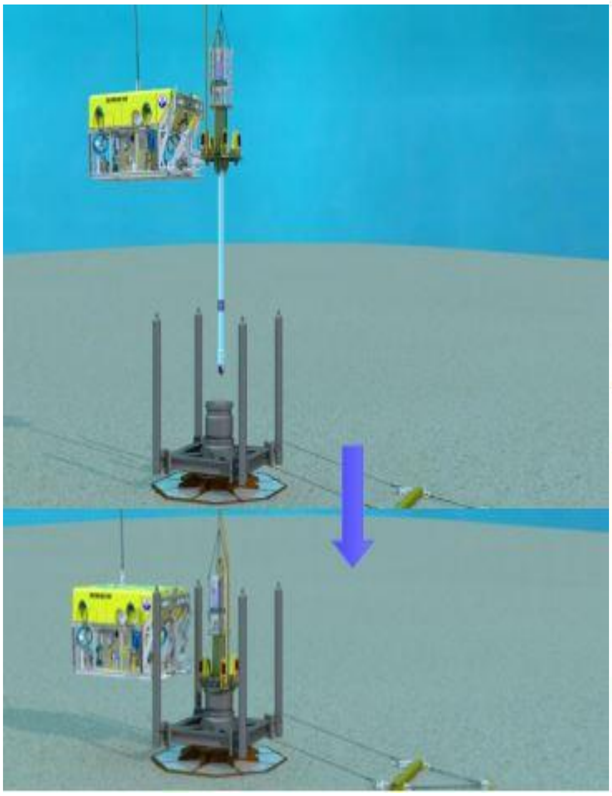


  - Install Wellhead Recovery Rigging

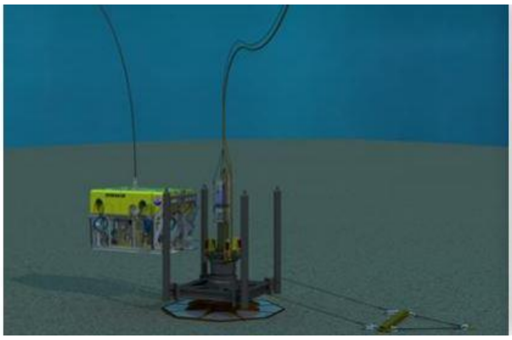


- Wellhead Severance Deployment
  - Prepare AXE for overboarding in required configuration for well
  - Upend AXE in transport frame

  - Lower AXE into well ›
  - ROV to engage AXE wellhead clamping mechanism ›
  - Establish & monitor umbilical management



- Wellhead Severance – Cutting
    - Commence surface supply of air & HP grit slurry ›
    - AXE rotation (i.e. cutting) controlled on surface (start / stop rotation) ›
    - Meanwhile activity – ROV installs recovery rigging ›
    - Complete cut -> shutdown AXE



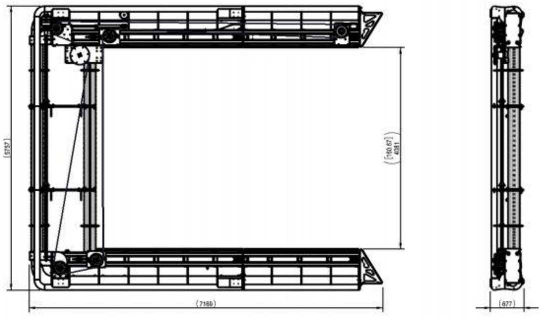
- Wellhead Severance – Recovery
    - Release AXE from wellhead and recover to deck (c/w umbilicals & clump weight) › Down-end onto transport frame › Complete AXE system maintenance › (e.g. flush system, nozzle change, valve redress)
    - Recover severed wellhead and TGB to deck and sea fasten.

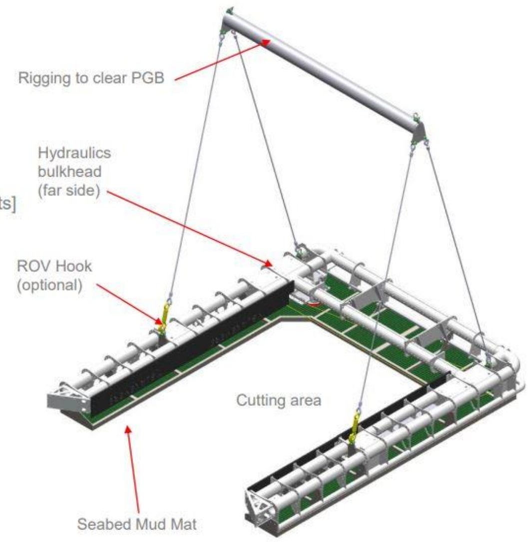
Blakemere DWS 155” External diamond wire Saw

- Equipment Overview
    - Designed to cut subsea structures of up to 155” in diameter
    - Bespoke mud mat to facilitate inverted mudline cutting
    - Bespoke lifting equipment including spreader bar
    - Surface spread including Offshore HPU, remote control system, Hose spooler.
    - Blakemere’s latest Diamond Wire Saw has incorporated a decade of experience and lessons learned into the one tool. This tool was designed specifically to cater for the requirements of upcoming domestic decommissioning scopes. The tool has a maximum cutting diameter of 155” (3,937mm) and can be configured to cut any size less than 155”, the only limitation being practicality. The tool’s smart control system optimizes cut speed and provides repeatable performance while also featuring a modular design to allow configuration for various cut sizes whilst also featuring integrated buoyancy chambers. The one-piece design does not have a moving head like conventional saws, reducing size and weight, changing the centre of gravity during operation. The additional benefit of the saw’s modular design allows the tools to easily be broken down to be stored and transported within shipping containers.

Figure 1 - DWS 155

- Capable of cutting profiles up to 155".
- Crane deployable for subsea operation
- Can be powered by surface HPU, via downline, or ROV hydraulics.
- Mudmat for operation while on seabed. Protects diamond wire & pulleys during operation.
- Cut height from seabed: 200 – 215 mm.
- Weight in-air: 4.8 Te; Weight in-water: 4.3 Te [including bespoke components]





Blakemere Subsea Severance Projects Within APME Region

YEAR	CLIENT	WORK SCOPE	LOCATION
2021	DOF Subsea	Phase 2 Mooring chain cutting. ROV operated DWS 0814.	Umoroa, New Zealand
2021	Sapura Energy	DWS 0814 cutting and plugging of 8" and 2" duplex spools for Minerva decom.	Australia, Bass Strait
2021	STR	Thevernard Island decommissioning of flexible flowlines with DWS 0814 and RFDC.	Australia, NW Shelf
2020	Fugro / Woodside	North Rankin A Caisson removal. ROV deployed DWS 3056. 50+ cuts.	Australia, NW Shelf
2020	Baker Hughes / ESSO	Whiting conductor removal. Surface operated DWS 1230.	Australia, Bass Strait
2020	DOF Subsea	Mooring chain cutting. ROV operated DWS 0814.	Umoroa, New Zealand
2019	Sapura Energy / Vermillion	CALM Buoy mooring chain replacement. DWS 0814.	Australia, NW Shelf
2019	BHP	Flexible flowline, mercury sample coupon cutting. DWS 1230.	Perth
2018	DOF Subsea	Enfield Decom. Riser and chain cutting.	Australia, NW Shelf
2018	Neptune Marine	PNG CALM Buoy decom	Papua New Guinea
2018	ICM	Concrete pile cutting	Australia, Fremantle Harbor
2018	Fugro	DWS contingency tool	New Zealand
2018	DOF Subsea	Pohokura 12" flowline decom	New Zealand
2018	iTech7	DWS 0814 Sole emergency pipeline repair.	Australia, Bass Strait
2017	Baker Hughes	DWS 1230 OMV Casing removal / Slot recovery	New Zealand
2016	Subsea 7	Cutting of flowlines and umbilical	Norway
2015	Aker Subsea	Cutting of 16" riser	Norway
2015	Technip	Contingency for cutting 16" casing	Norway
2015	Subsea 7	Cutting of 9", 10" and 15.5" flexible riser	Norway
2014	Helix Well Ops	Contingency cutting option for multi-string well conductor	UK, North Sea
2014	FugroTSM	Greater Western Flank IRM support	Australia, NW Shelf
2014	Allseas	Wheatstone Trunkline and Julimar Flowline Pipelay Contingency	Australia, NW Shelf
2014	Saipem	Ichthys 42" Pipelay Contingency	Australia, Darwin
2013	PTTEP	ROV operated cutting of 5" mooring chains	Australia, NW Shelf
2013	McDermott	2nd Phase Contingency for ROV operated cutting of 20" pipeline at 180msw	Australia, NW Shelf
2012	Subsea 7	Cutting of 20" flexible riser	Norway
2012	Technip	Saturation Diver assisted cutting of 18" water induction line at 90msw	UAE
2012	SMIT	Diver assisted cutting of 30" gas induction line at 60msw	UAE
2012	Technip	ROV operated cutting of 6" Production Spool at 520msw	Australia, NW Shelf

Note: The new model DWS 155" tool has not been field tested at the time of writing this report however is due to be deployed in July 2021 for the severance of the Sinbad & Campbell monopods for Santos.

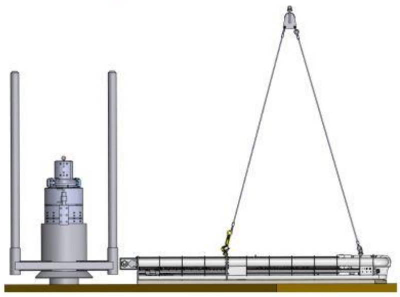
Blakemere DWS 155" Operational overview

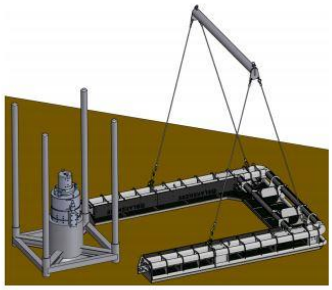
- As-Found Survey ›
    - Marine growth inspection of wellhead ›
    - Stick-up depth measurement ›
    - TGB condition ›
    - PGB condition ›
    - Debris/anomalies

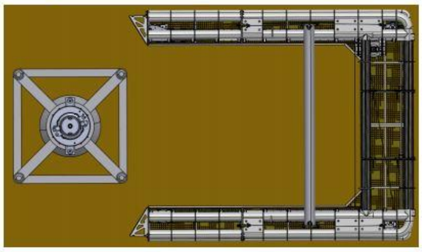
- Deployment

Deployment

- Pre-deployment checks completed on vessel back deck using Blakemere supplied HPU and control panel.
- Tool lifted via vessel crane using spreader bar.
- Optional ROV hooks can be used to aid in removing rigging once landed out subsea.
- Tool lowered to seabed near wellhead.



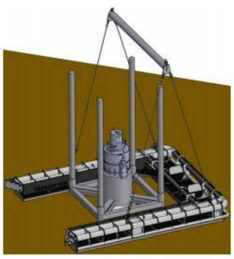


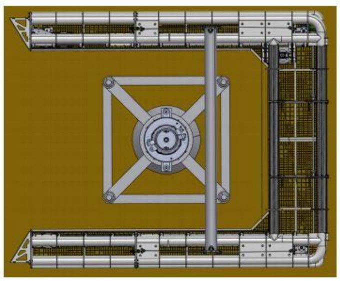


Wellhead Severance

Positioning and checks

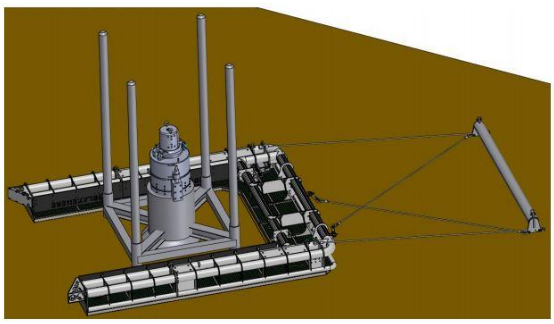
- Using vessel crane and ROVs, the tool is shifted into place around the PGB.
- Guidance features and protection plates on the tool assist in maneuvering the tool into place and protect components on the tool.
- Tool height and wire path is checked to confirm that the wire will pass underneath the main PGB structure to cut casing only.
- NOTE: The DWS 155 is capable of cutting completely through the PGB structure, if there is not a large enough gap underneath for the wire to travel. However, this will increase cut times. Dredging the area, if possible, may be a more cost-effective alternative.
- The weight of the tool is sufficient to maintain position, without the use of a clamp.





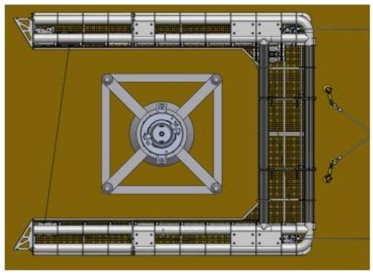
Rigging

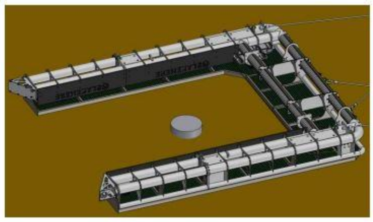
- The front ROV hooks shall be disconnected, and the spreader bar laid down. Monkey's fists and/or buoyancy balls can be used on certain rigging components to aid in recovery post cut.
- PGB lifting points shall be inspected for suitability and, if good, vessel crane shall be attached to lift the PGB post cut.
- If lifting points on PGB are not suitable for use then Blakemere can provide custom lifting arrangements for the PGB.

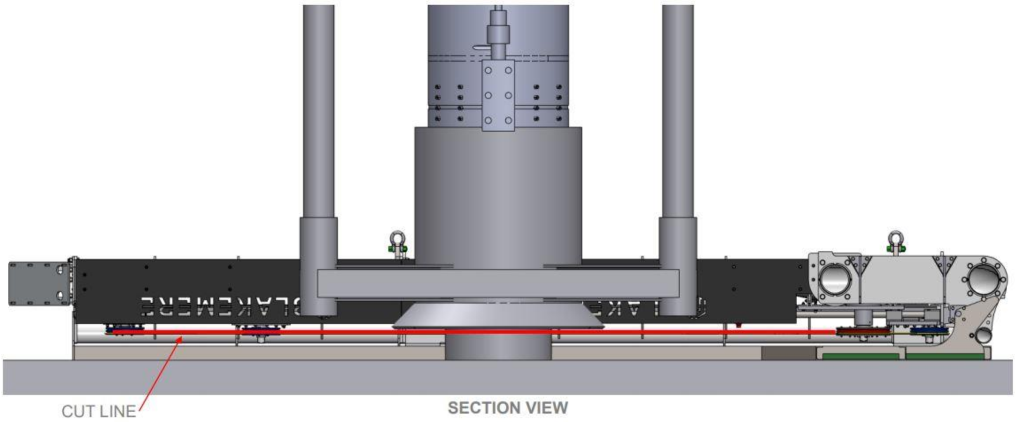


Cutting

- ROV shall connect to the tool via hotstab panel
- If possible, vessel crane shall provide an overpull on the PGB to prevent it from toppling during final stages of the cut.
- NOTE: compression on the wire is not a concern, attaching the vessel crane is to prevent the PGB from falling, rather than removing compression forces on the wire.
- ROV hydraulic supply drives the wire motor and the feed motor to complete the cut.
- Once the cut is complete, the PGB is removed via the vessel crane and the tool is recovered.

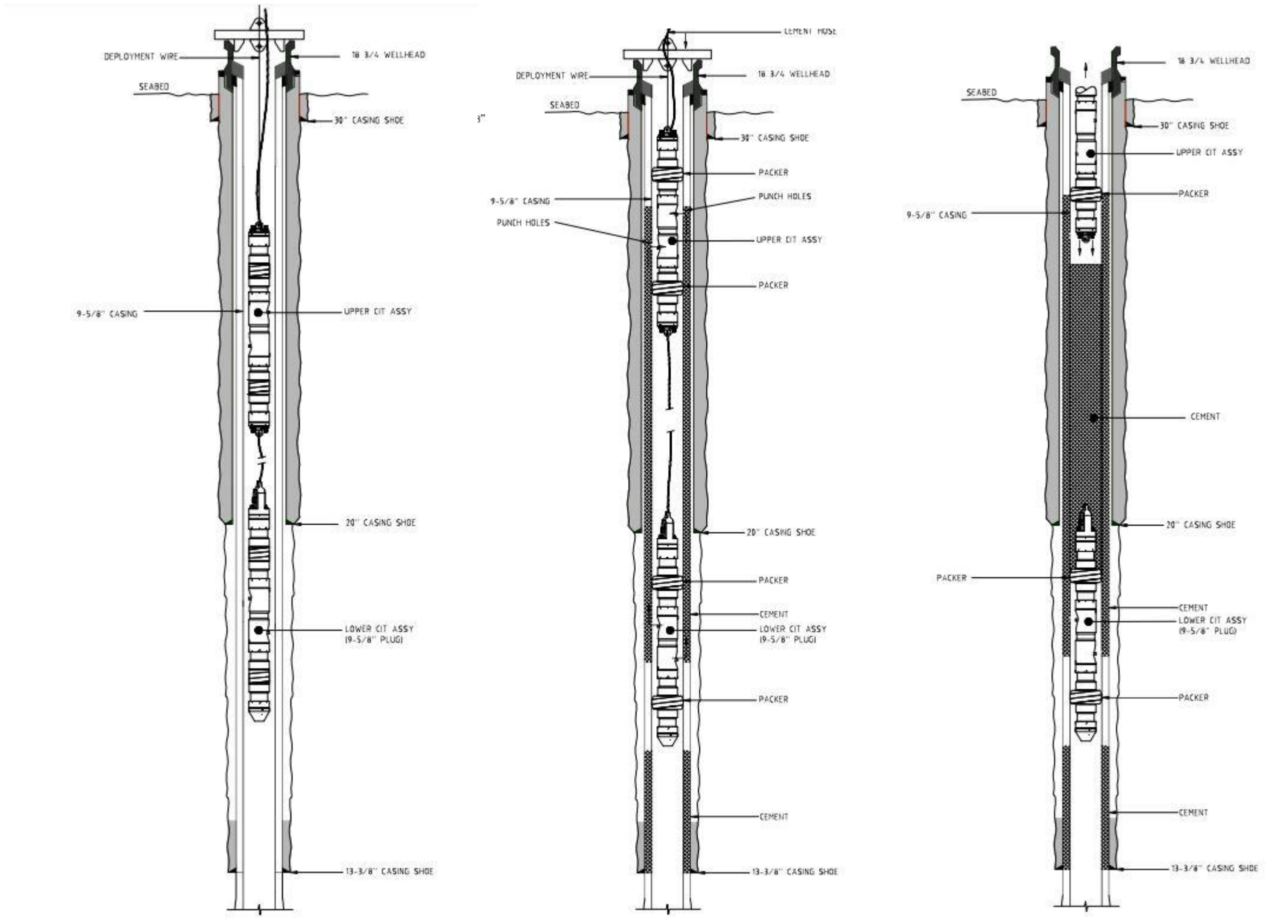






Sapura Energy Well Services Cement Injection Tool Operational overview

- Perform pre-deployment checks on the CIT.
- 2. Deploy CIT using deployment winch with assistance from suitable crane for deployment sheave support.
- 3. Guide CIT into Well Head.
- 4. Run CIT in hole; installing umbilical clamps every 10 metres.
- 5. Set packers from surface and pressure test between packers on both Upper and Lower CIT units.
- 6. Punch holes in 7 Inch Casing with the Lower CIT.
- 7. Bleed down annulus pressure.
- 8. Establish injection into 7” and 9-5/8” Annulus; Optional Scope a. Flush water into 7” and 9-5/8” Annulus down to Casing Shoe; b. Bullhead high viscosity pill down to 9-5/8” Casing Shoe.
- 9. Punch holes in the top 7” Casing with Upper CIT.
- 10. Flush circulation path in 7” and 9-5/8” Annulus with water.
- 11. Circulate cement into the 7” and 9-5/8” Annulus.
- 12. Disconnect from lower CIT.
- 13. Pump additional cement to achieve at least 100ft of cement above the lower CIT whilst pulling out of hole.
- 14. Recover Upper CIT to surface.



SWS CIT Project Experience Within APME Region

- **Exploration Wellheads Abandonment for Fina Exploration Minh Hai BV, 2008**
    - Located in the Gulf of Thailand offshore Vietnam.
    - Plug and abandon five wells Water depth 50 metres.
    - Set cement plugs in 9 5/8” to 13 3/8” annulus at 300m below wellhead.
    - Sever wellheads 3m below seabed.
    - 3 wells had 7 inch casing – severance 7 inch out to 30 inch First commercial use of SWS’ cement injection tool – CIT.
- **EKKN Abandonment of Subsea Production Wells ConocoPhillips, 2009 (Timor Sea)**
    - Located in the Elang Kakatua Field in the Timor Sea
    - Abandon 4 horizontal subsea trees and production wells.
    - Abandon 1 exploration wellhead.
    - Water Depth 100 metres
    - World first full abandonment of subsea wells from production status to wellhead removal performed from monohull work vessel without the use of riser or drillpipe.
    - Well kill and placement of downhole cement plugs performed through subsea tree. • Removal of early generation internal tree cap in open water.
    - Horizontal subsea tree removal, tubing severance and tubing hanger recovery.
    - Top hole casing perforation, placement of annular cement plugs and wellhead severance; all performed without explosives, riser or drillpipe.

9. TIME AND COST ESTIMATE

Wellhead Severance

The time and cost estimates below are based on per well costings for standalone campaigns for Legendre-1 and Tern-1 wells and do not include pre-planning and procedure writing which is assumed to be the same for all options.

Blakemere DWS 155" Option (5 day Vessel Based Ops)

Description	Cost type	Unit cost (AUD)	Days	Total (AUD)	Comments
DWS 155" unit rental	Day	3200	5	16000	
DWS 155" mob/Demob	Lump Sum	30000		30000	
Offshore HPU	Day	450	5	2250	
Control system	Day	250	5	1250	
Hydraulic Hose spooler	Day	600	5	3000	
Mud Mat	Lump sum	30000		30000	
Offshore Technicians (x2)	Day	4400	10	44000	
Equipment Transport	Lump Sum	20000		20000	
Vessel Hire (w/ROV spread & Personnel)	Day	90000	5	450000	
Vessel Mob/Demob	lump Sum	220000		220000	
Santos site Reps (x2)	Day	4000	10	40000	
				$856,500	

Sapura Well Services AXE Option (5 day Vessel Based Ops)

Description	Cost Type	Unit Cost (AUD)	Days	Total (AUD)	Comments
Project Management & Eng	Lump Sum	51200		51,200	
Equipment Prep & Mob/Demob w/Personnel	Lump Sum	450000		450,000	
Equipment rental	Day	12500	14	175,000	Min 14 days
Technicians (x6 for 24hour ops)	Day	10000	5	50,000	
Equipment Transport	Lump Sum	40000		40,000	
Vessel Hire (w/ROV Spread & personnel)	Day	90000	5	450,000	
Vessel Mob/Demob	Lump Sum	220000		220,000	
Santos Site Reps	Day	4000	10	40,000	
				$1,476,200	

Wellbore Pressure Management

The time and cost estimate below is based on per well costings for standalone campaigns for Legendre-1 and Tern-1 wells and do not include pre-planning and procedure writing which is assumed to be the same for all options.

There are various options for wellbore pressure management solutions such as BiSN Thermite activated alloy plugs and alternative casing punching options however further engineering reviews on the project specific requirements are required in order to commercially evaluate these. The below Sapura Well Services CIT option has been used as an example to provide indicative costing for a wellbore pressure management option and is based on this service being contracted in conjunction with one of the above wellhead severance options

Sapura Energy Services (TMT) Cement Injection Tool (CIT)

Description	Cost Type	Unit Cost (AUD)	Days	Total (AUD)	Comments
Project Management & Eng	Lump Sum	97,750		97,750	
Upper CIT Rental (1+1 spare)	Day	6,250	20	125,000	
Supply Lower CIT (1+1 spare)	Lump Sum	450,000		450,000	
Umbilical prep (Project specific)	Lump Sum	128,000		128,000	
Rental of Umbilical	Day	11,700	20	234,000	
Rental Power unit & Sheaves	Day	2,250	20	45,000	
CIT Technicians	Day	3,700	14	51,800	
Vessel additional days	Day	90,000	5	450,000	
Santos Site Reps (x2)	Day	4,000	5	20,000	
				1,601,550	

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Appendix D. 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.
	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.
	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;	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	Major, long term decline in threatened ecological community population size, diversity or function; Major reduction in area of threatened ecological community;	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.

[3] As defined by the Department of Agriculture, Water and Environment (DaWE)

[4] Benthic photosynthetic organisms such as seagrass, algae, hard corals and mangroves

[5] Fauna attached to the substrate including sponges, soft corals and crinoids.

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.***
		No introduction of disease likely to cause decline in threatened ecological community population size, diversity or function.		threatened ecological community population size, diversity or function.	Fragmentation of threatened ecological community; Introduce disease likely to cause long term decline in threatened ecological community population size, diversity or function.		
	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.

Appendix E. PMST RESULTS

Australian Government

Department of Agriculture, Water and the Environment

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.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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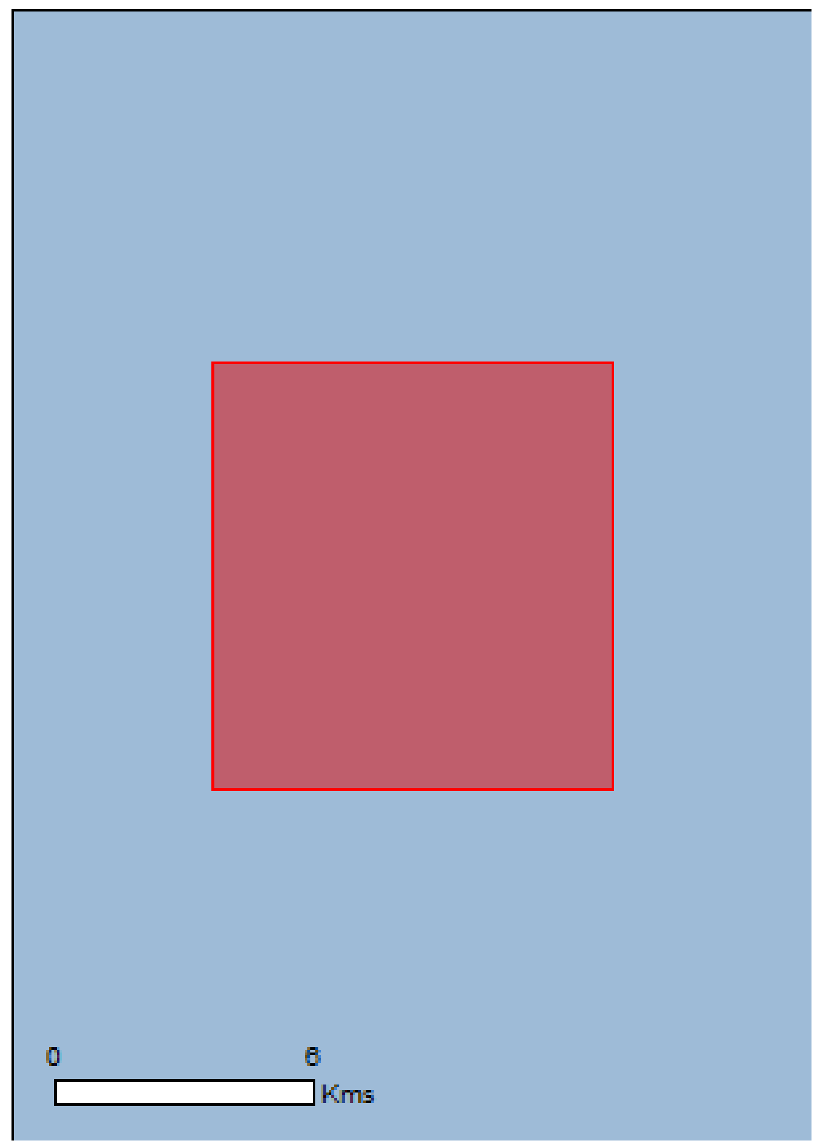

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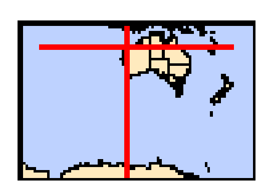

Summary

Matters of National Environmental 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:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	17
Listed Migratory Species:	31

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 http://www.environment.gov.au/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 Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	56
Whales and Other Cetaceans:	13
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

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 the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	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
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Mammals		
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
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species

Name	Status	Type of Presence
		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
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
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 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

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
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
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may 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

Name	Threatened	Type of Presence
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
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
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known 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 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
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

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	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
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		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
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
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Fish		

Name	Threatened	Type of Presence
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
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

Name	Threatened	Type of Presence
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
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
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		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
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		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 Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
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 Dophin, 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]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
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

Extra Information

Key Ecological Features (Marine) [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

Caveat
The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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 distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for 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 reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-19.74867 116.75131,-19.74867 116.66798,-19.66534 116.66798,-19.66534 116.75131,-19.74867 116.75131

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.

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Department of Agriculture, Water and the Environment

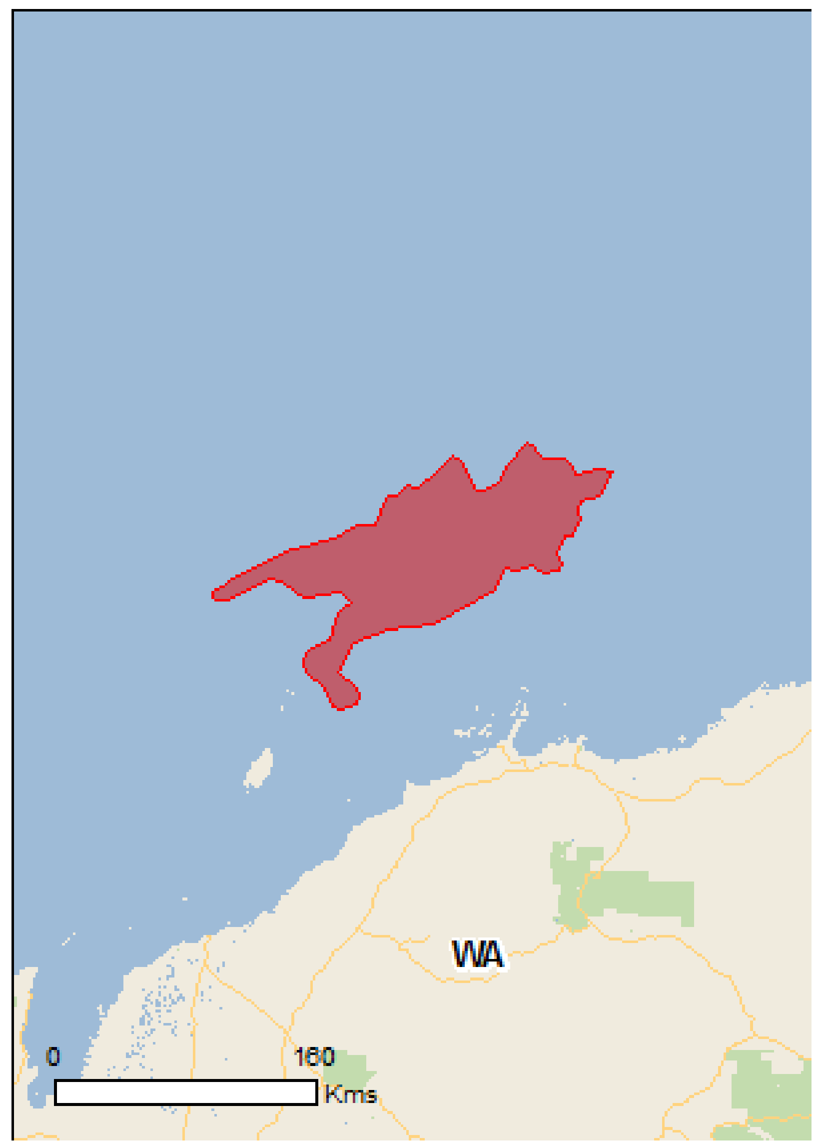
EPBC Act Protected Matters Report

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.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 22/09/21 12:31:00



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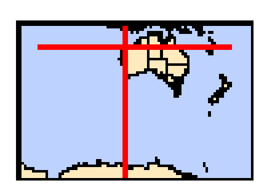
Coordinates

Buffer: 0.0Km



Summary

Matters of National Environmental 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:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	21
Listed Migratory Species:	38

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 http://www.environment.gov.au/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 Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	72
Whales and Other Cetaceans:	25
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	3

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 the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	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
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area

Name	Status	Type of Presence
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama 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 known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known 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 known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
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 clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to 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

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
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
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to 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 known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known 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
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known 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
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to 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
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		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 likely to 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]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	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
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	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
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
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	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
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
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 latispinosus Muiron Island Pipefish [66196]		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
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		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
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
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

Name	Threatened	Type of Presence
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
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		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
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
Mammals		
Dugong dugon Dugong [28]		Species or species habitat likely to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		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 likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Montebello	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [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
Ancient coastline at 125 m depth contour	North-west
Continental Slope Demersal Fish Communities	North-west
Glomar Shoals	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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 distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for 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 reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-19.3891 116.0824,-19.3719 116.1038,-19.3683 116.149,-19.3516 116.1621,-19.3231 116.2014,-19.3326 116.268,-19.2505 116.3667,-19.172 116.4369,-19.1625 116.4619,-19.1946 116.494,-19.3457 116.588,-19.3397 116.6356,-19.2969 116.7034,-19.2101 116.7582,-19.0887 116.8605,-19.1042 116.9033,-19.1827 116.9509,-19.172 117.0711,-19.216 117.1115,-19.266 117.127,-19.2303 117.259,-19.2481 117.3376,-19.3695 117.2686,-19.4052 117.1662,-19.4385 117.1413,-19.4992 117.165,-19.5729 117.1222,-19.5836 117.0699,-19.6729 117.0223,-19.724 117.0604,-19.7573 117.0461,-19.768 116.9568,-19.7252 116.9021,-19.7657 116.8046,-19.7478 116.7522,-19.8561 116.6856,-20.0334 116.3572,-20.056 116.2228,-20.0655 116.099,-20.1277 115.906,-20.2776 115.8251,-20.3609 115.9286,-20.4073 115.9417,-20.4489 115.928,-20.4822 115.843,-20.4668 115.7888,-20.3668 115.7537,-20.2835 115.6532,-20.2229 115.6395,-20.1782 115.6603,-20.1205 115.7805,-19.9808 115.8311,-19.9486 115.8531,-19.9207 115.8929,-19.8677 115.8364,-19.9016 115.6597,-19.8957 115.6395,-19.8094 115.5188,-19.7987 115.4587,-19.9123 115.2213,-19.9141 115.1541,-19.894 115.1354,-19.8732 115.134,-19.8506 115.1638,-19.7924 115.2693,-19.7472 115.3699,-19.6631 115.5368,-19.6173 115.6933,-19.5995 115.8158,-19.5302 115.9236,-19.5191 115.9407,-19.5198 116.0359,-19.3891 116.0824

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.

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Appendix F. VALUES AND SENSITIVITIES OF THE EXISTING 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
9	Joanna Edwards	Annette McGovern	Daniel Thompson
	JMEdwards	AMcG.	

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

Rev	Rev Date	Author / Editor	Amendment
A	13/0520/14	Oceanica	Technical review
B	13/05/2014	Oceanica	Editorial review
0	30/0720/14	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	09/07/21	Advisian	Issued for use

Contents

Santos

Figures

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Appendices

1. Introduction

Santos WA Energy Limited (Santos) is the titleholder of multiple petroleum titles for exploration, development and operational 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 (Submerged Lands) (Environment) Regulations 2012.*

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 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 combined EMBA.

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) provided by the WA Department of Agriculture, Water and the Environment (DAWE) (previously the Department of the Environment and Energy (DoEE) (in December 2020 and June 2021 and provided in **Appendix A**), as well as published scientific literature and studies, and other State and Territory protected species databases where applicable. Descriptions of all fauna 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 are completed using the exact coordinates that are utilised to produce the figures throughout Section 3 of the EP, 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.

On the first page of the PMST report, is a coarse graphic showing the area over which the search has been conducted. However, the granularity of this can make the output look different to the spatial area represented on figures.

The co-ordinates are also provided within the PMST report to allow for duplication of the searches 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.

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 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.

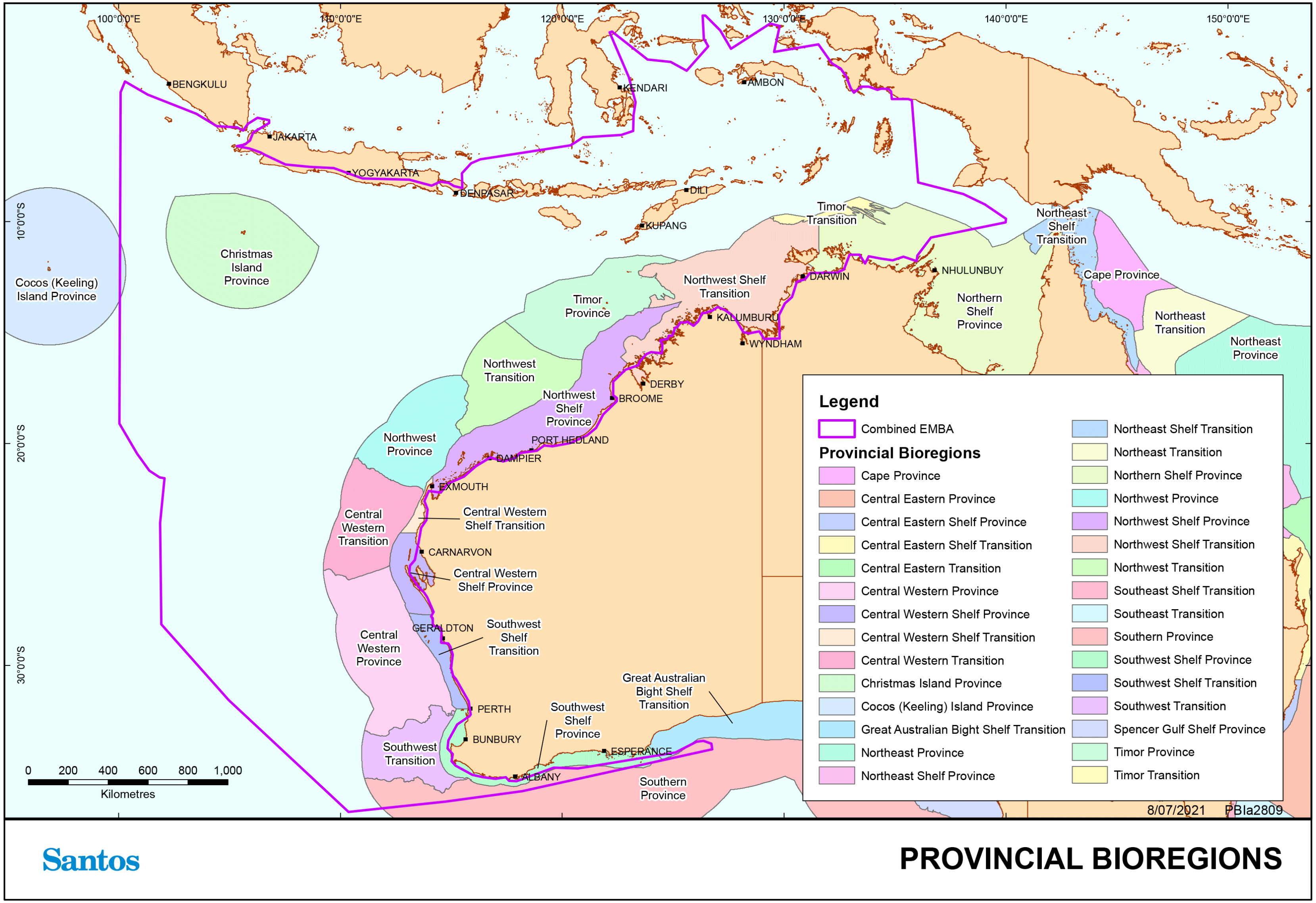


Figure 1-1: EMBA within IMCRA 4.0 Provincial Bioregion

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.

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 2.11). 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 km2) of continental rise on the Australian margin. The continental rise is located on the edge of the Perth Abyssal Plain (103 911 km2). 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 4000 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 9.8**).

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 3000 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**.

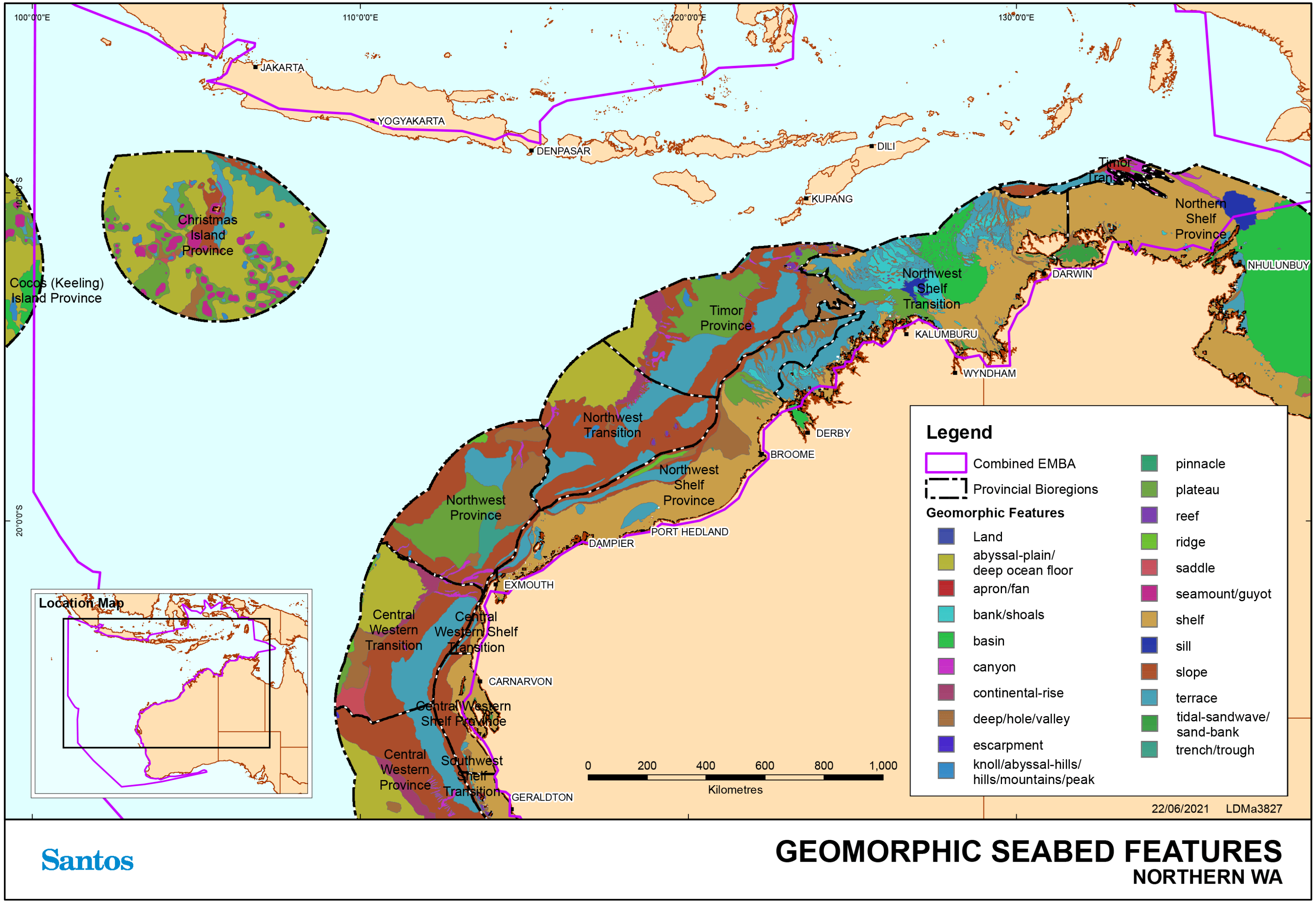


Figure 2-1: Geomorphic/seafloor features of Northern WA

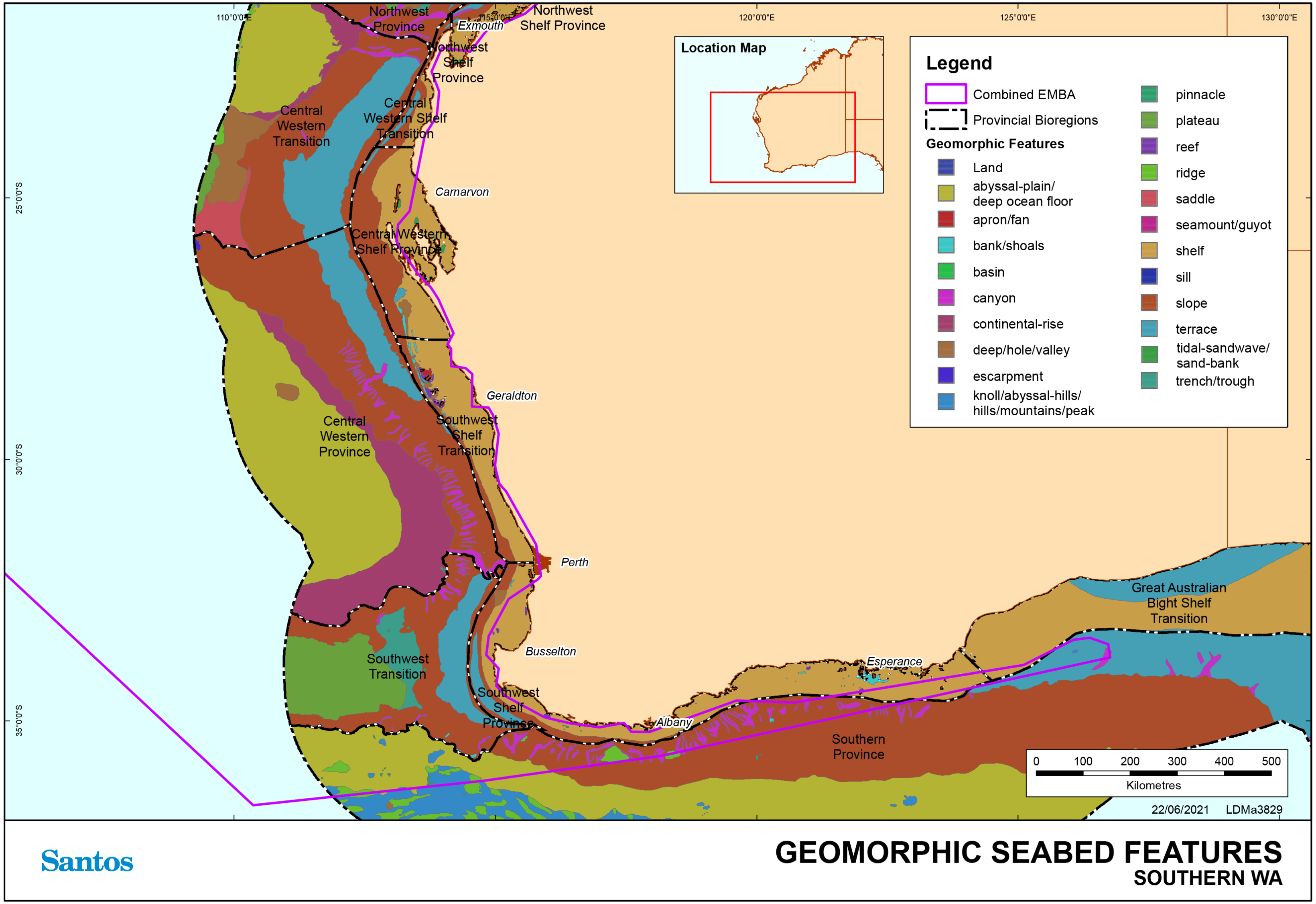


Figure 2-2: Geomorphic/seafloor features of Southern WA

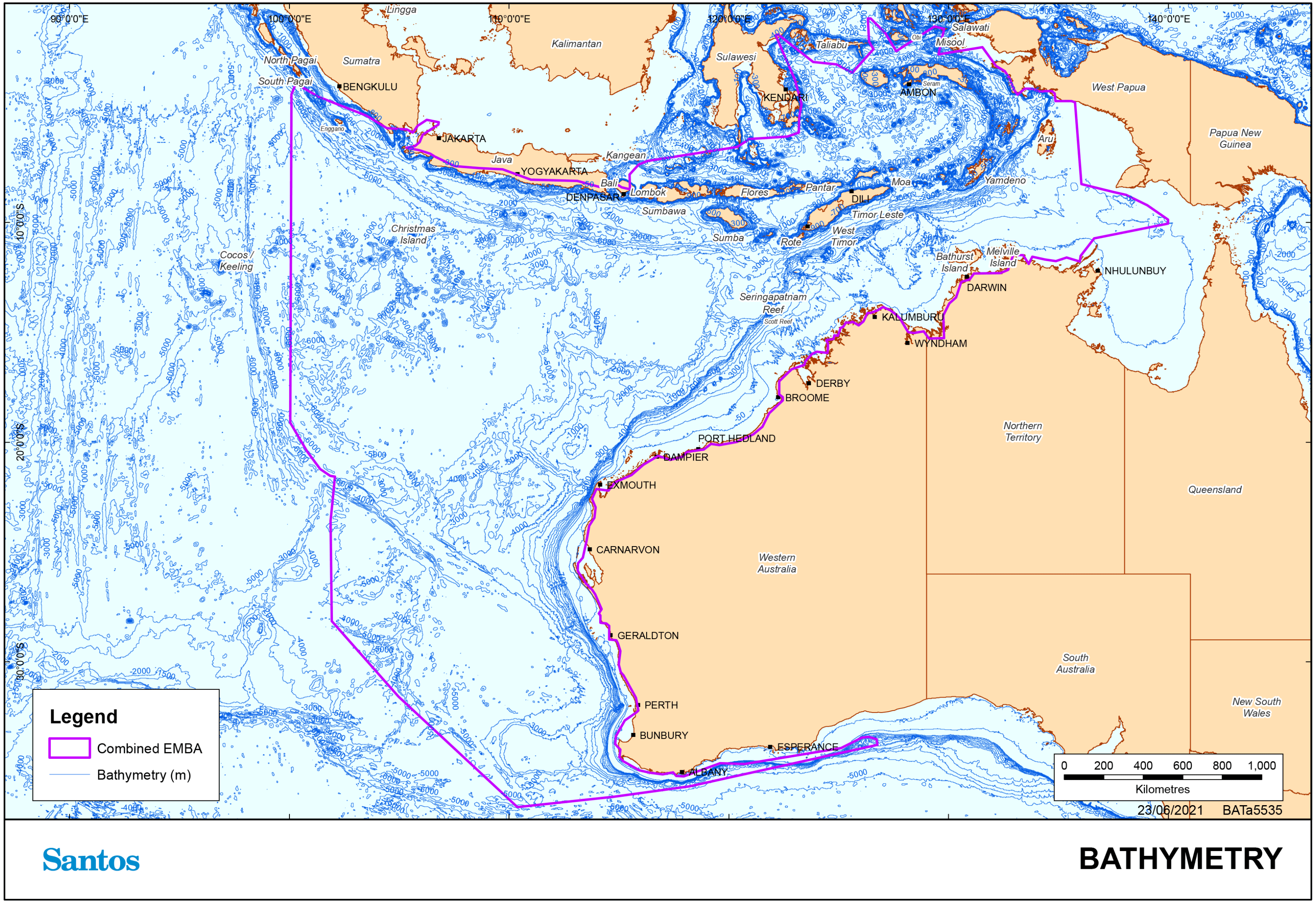


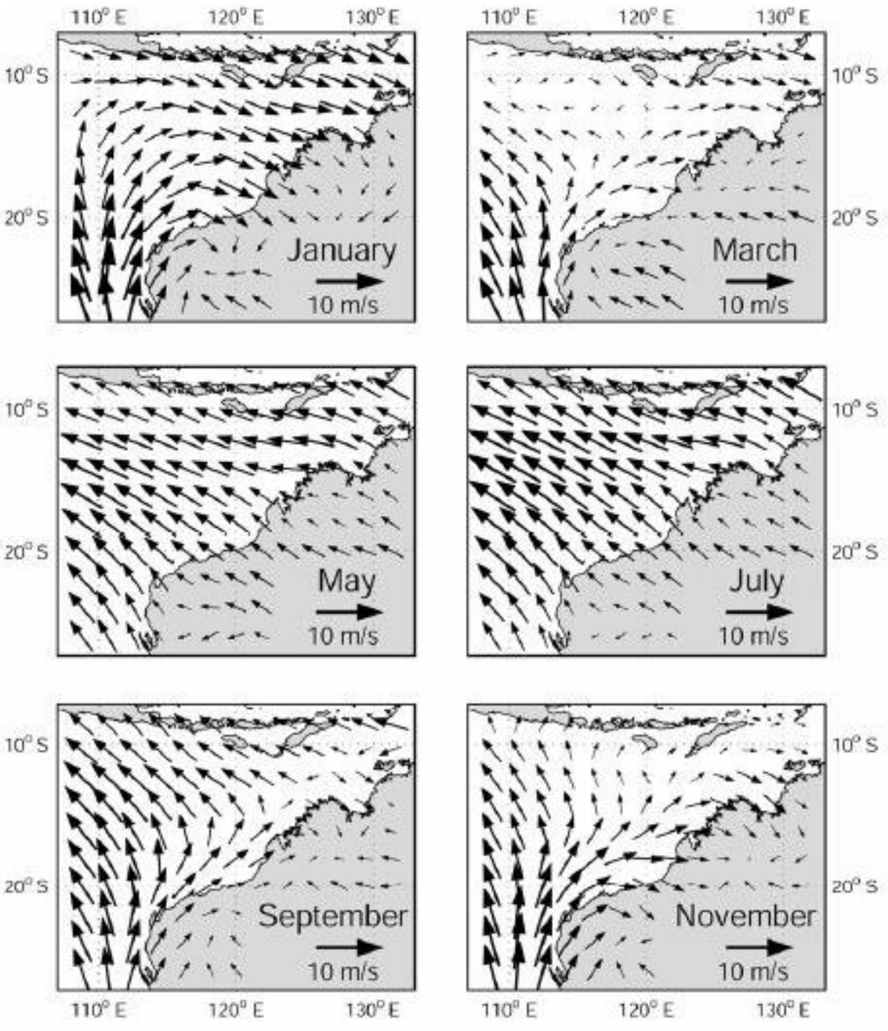
Figure 2-3: Bathymetry of the combined EMBA

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).

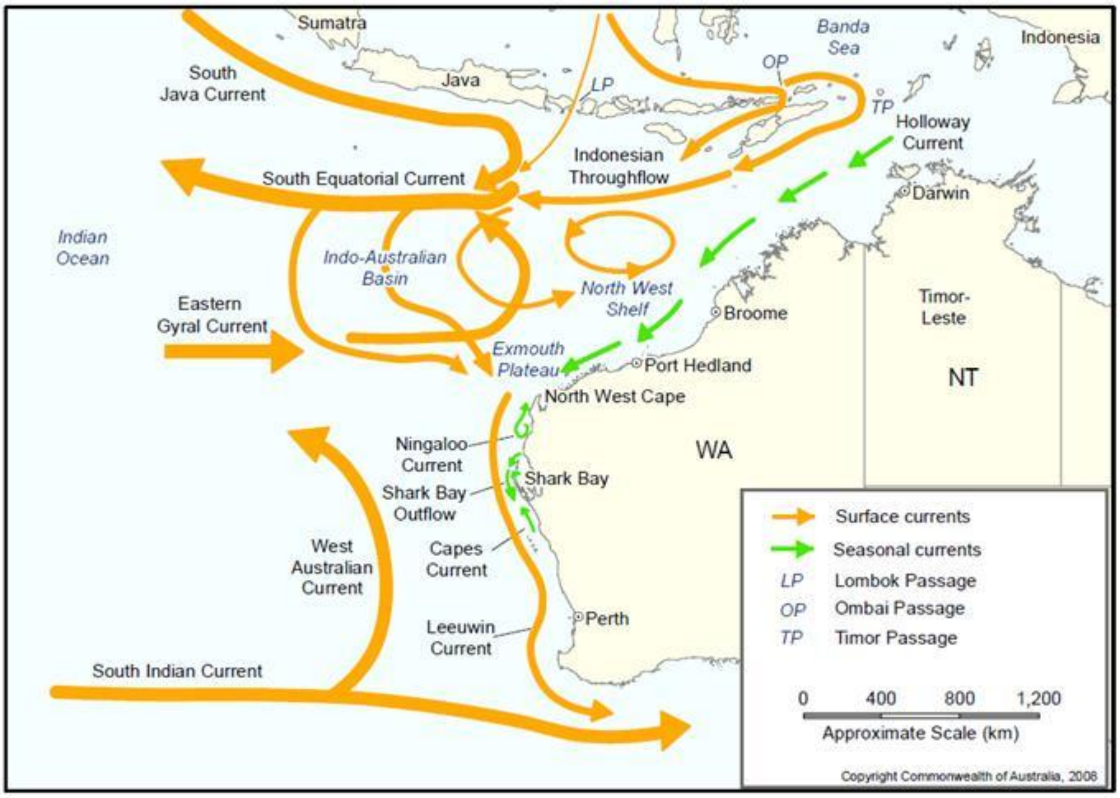


Figure 2-5: Surface currents in the Northern Territory and Western Australia

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 (Scott Reef; 1998), 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). 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.

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).

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).

Santos

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).

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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.

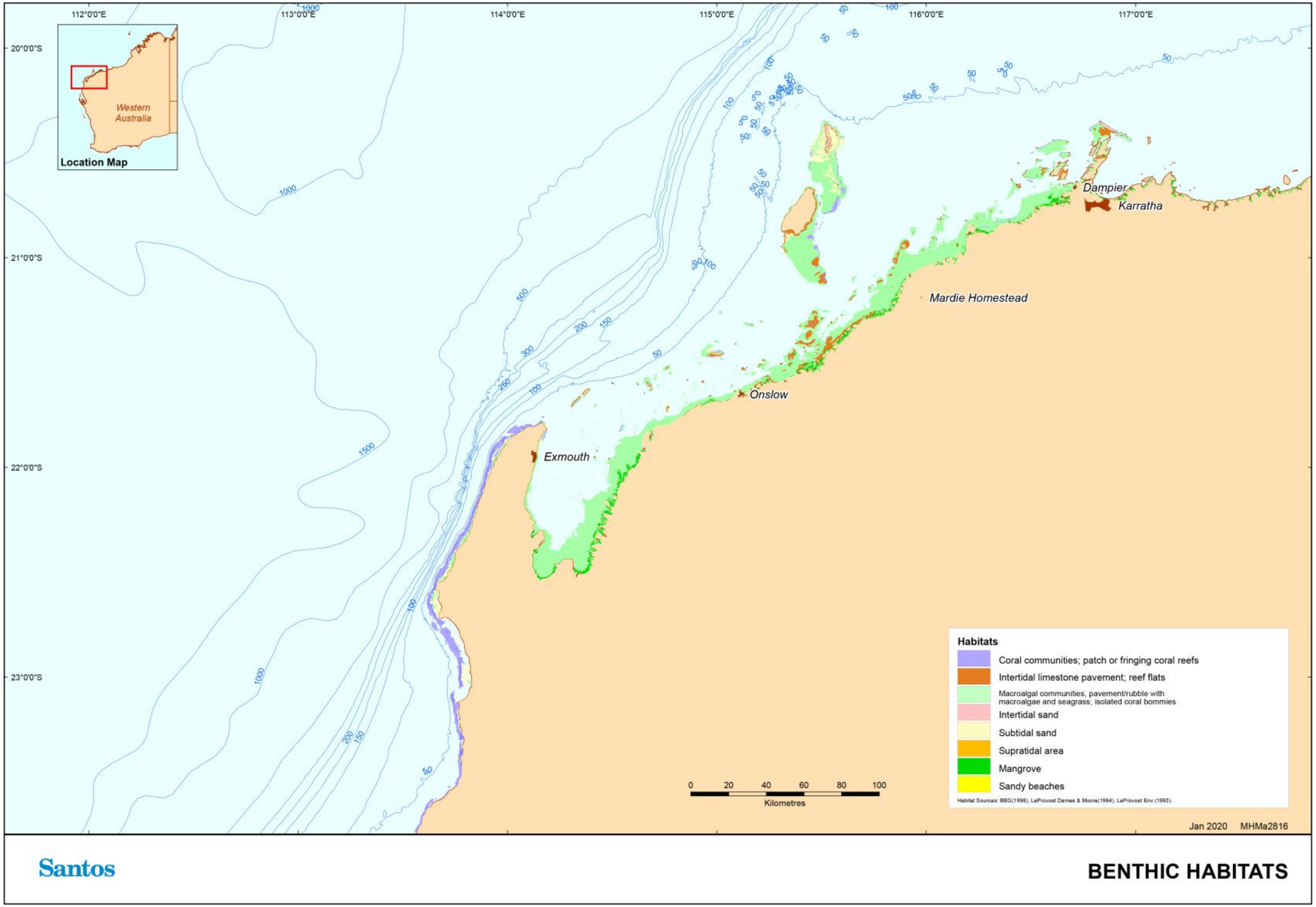

Figure 3-1: Benthic habitats from Coral Bay to Dampier

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 km2. 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 5m 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 Pendretti 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*		
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
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
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	Specially protected (species otherwise in need of special protection)	-	Listed nationally	Foraging, feeding or related behaviour known to occur within area.	Yes – Refer to **Table 5-3**
Northern 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 (*Pristis clavata)*	Vulnerable & 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 (*Pristis pristis*)	Vulnerable & Migratory	-	Priority 3	Vulnerable	Species or species habitat known to occur within area.	Yes – Refer to **Table 5-3**
Narrow sawfish (*Anoxypristis cuspidate*)	Migratory	-	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Green 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 (*Isurus oxyrinchus*)	Migratory	-	-	-	Species or species habitat likely to occur within area .	None - No BIA defined
Longfin mako (*Isurus paucus*)	Migratory	-	-	-	Species or species habitat likely to occur within area.	None - No BIA defined
Reef manta ray (*Manta alfredi*)	Migratory	-	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Giant manta ray (*Manta birostris*)	Migratory	-	-	-	Species or species habitat known to occur within area.	None - No BIA defined
Porbeagle (*Lamna nasus*)	Migratory	-	-	-	Species or species habitat may occur within area.	None - No BIA defined

In addition a review of conservation dependent species[2] identified five species of fish / sharks that may occur in the combined EMBA:

- Orange roughy (Hoplostethus atlanticus);
- Southern blue fin tuna (*Thunnus maccoyii*);
- Southern dogfish (Centrophorus zeehaani);
- School shark (*Galeorhinus galeus*); and
- Scalloped hammerhead (*Sphyrna lewini*).

[2] Conservation dependent species are listed species under the EPBC Act and are considered as part of the Commonwealth marine area.

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 south west 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).

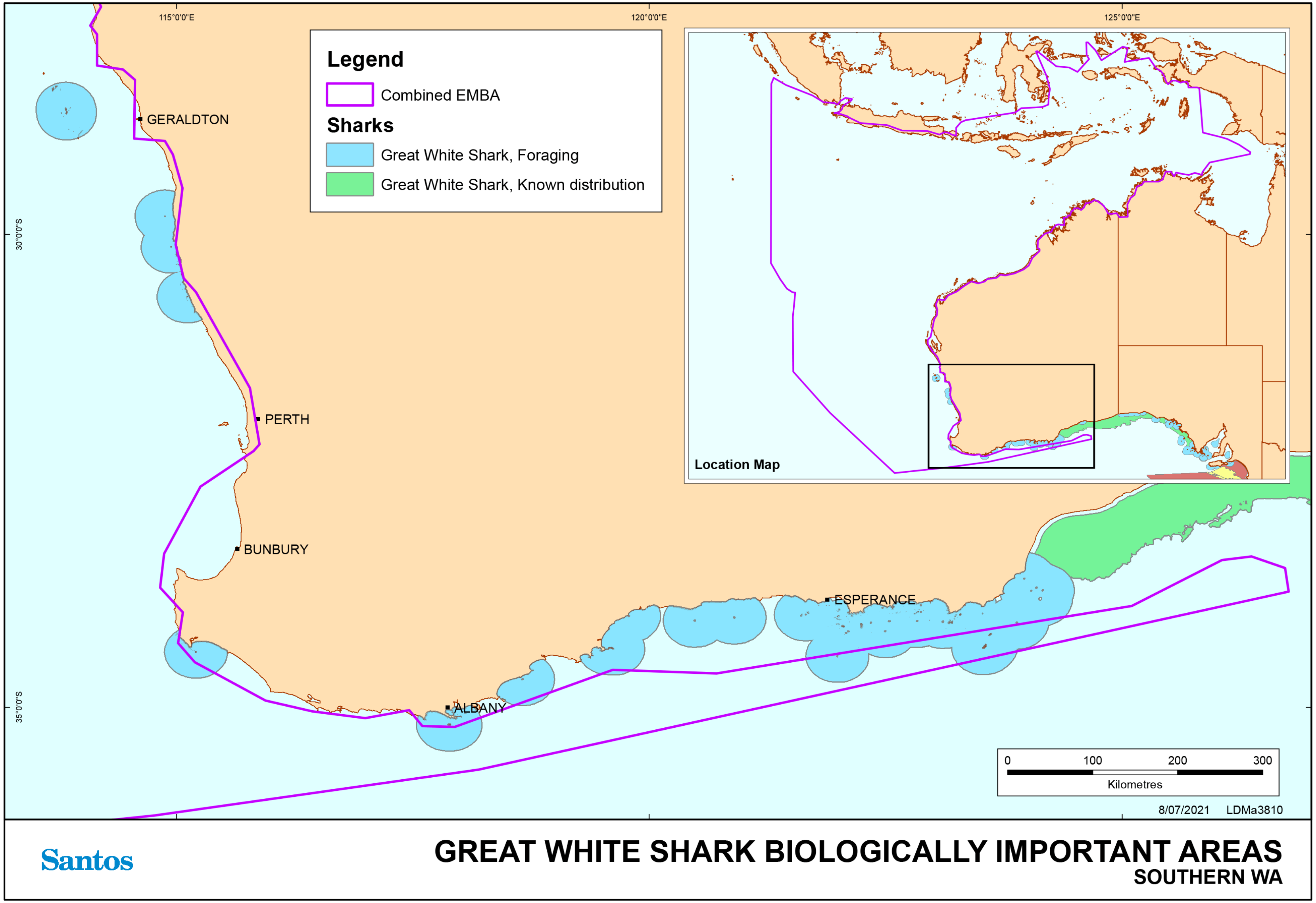

Figure 5-1: Biologically important area – great white shark

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). There is a general lack of knowledge on many aspects of whale shark biology, including definitive migration patterns. 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).

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 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.

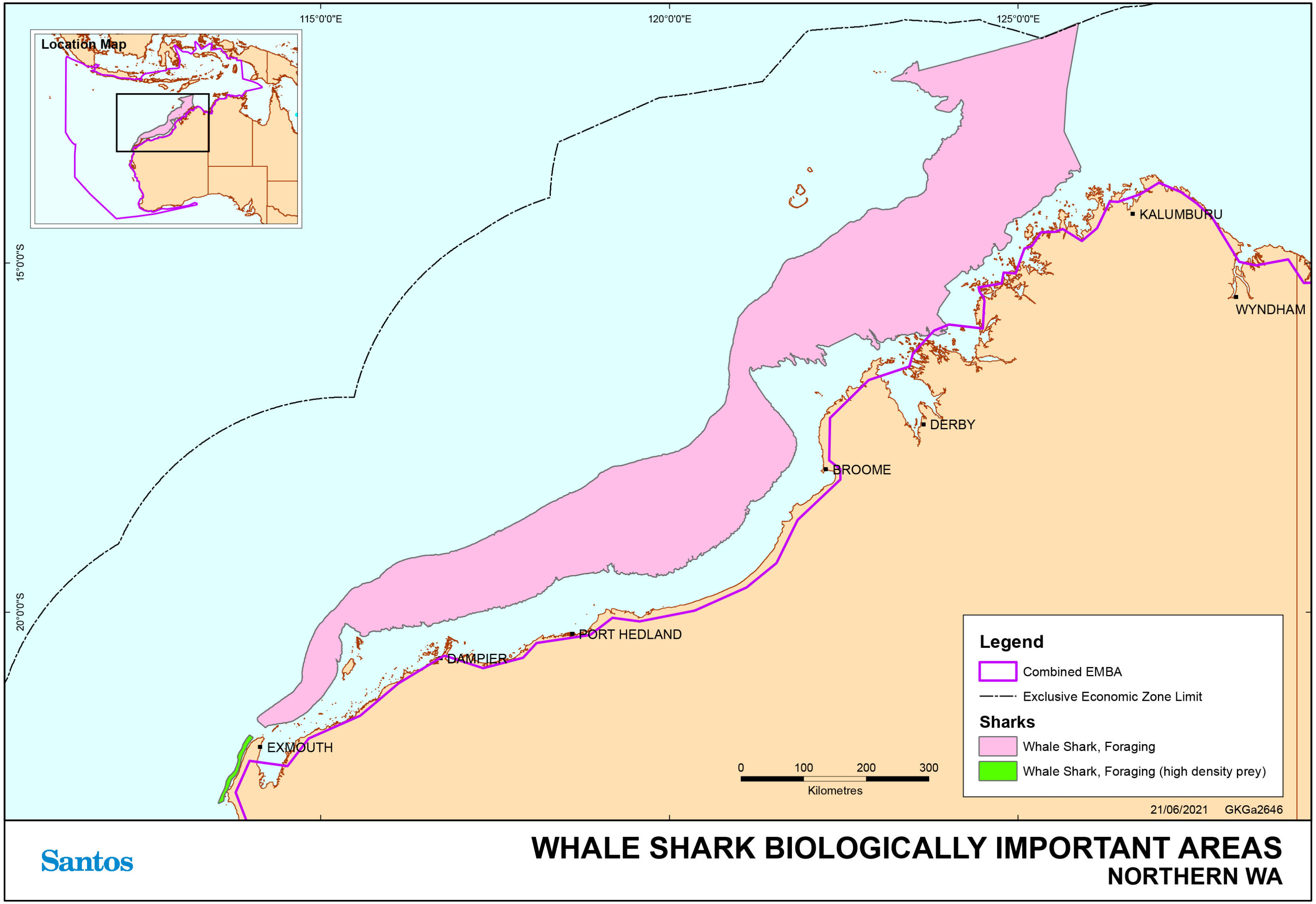

Figure 5-2: Biologically important area – whale shark

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**.

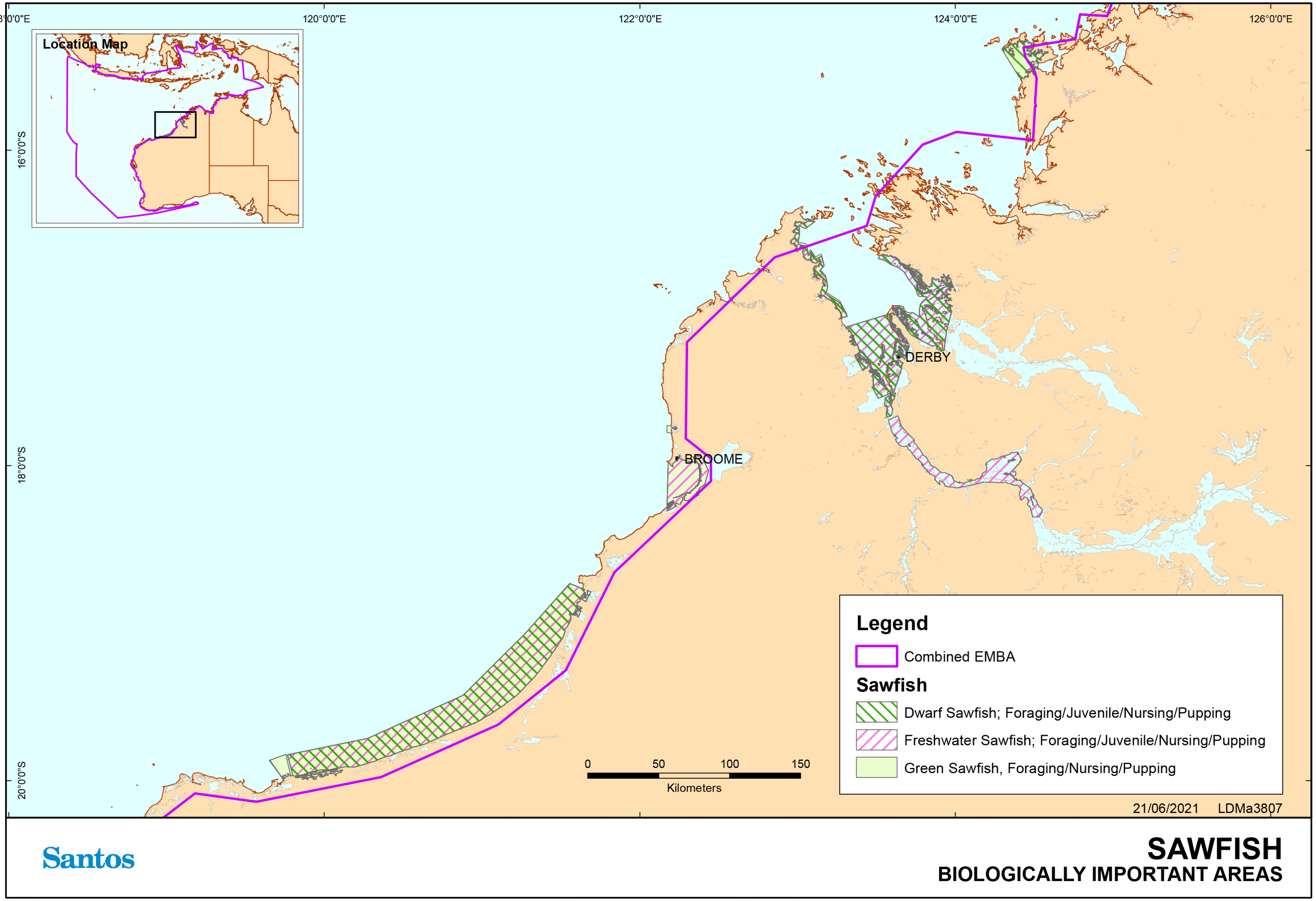

Figure 5-3: Biologically important areas – sawfish

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	Eighty Mile Beach Camden Sound - eastern shore Fitzroy River Mouth, May and Robinson River - tidal tributaries King Sound (inshore waters)

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
		Juvenile – King Sound, Fitzroy River and May Robinson River	
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)[3]. 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**
Short-nosed seasnake (*Aipysurus apraefrontalis*)	Critically Endangered	Critically Endangered	-	-	Species or species habitat known to	None - No BIA defined

[3] 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*		
					occur within area	
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	Specially protected species (other specially protected fauna)	-	-	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).

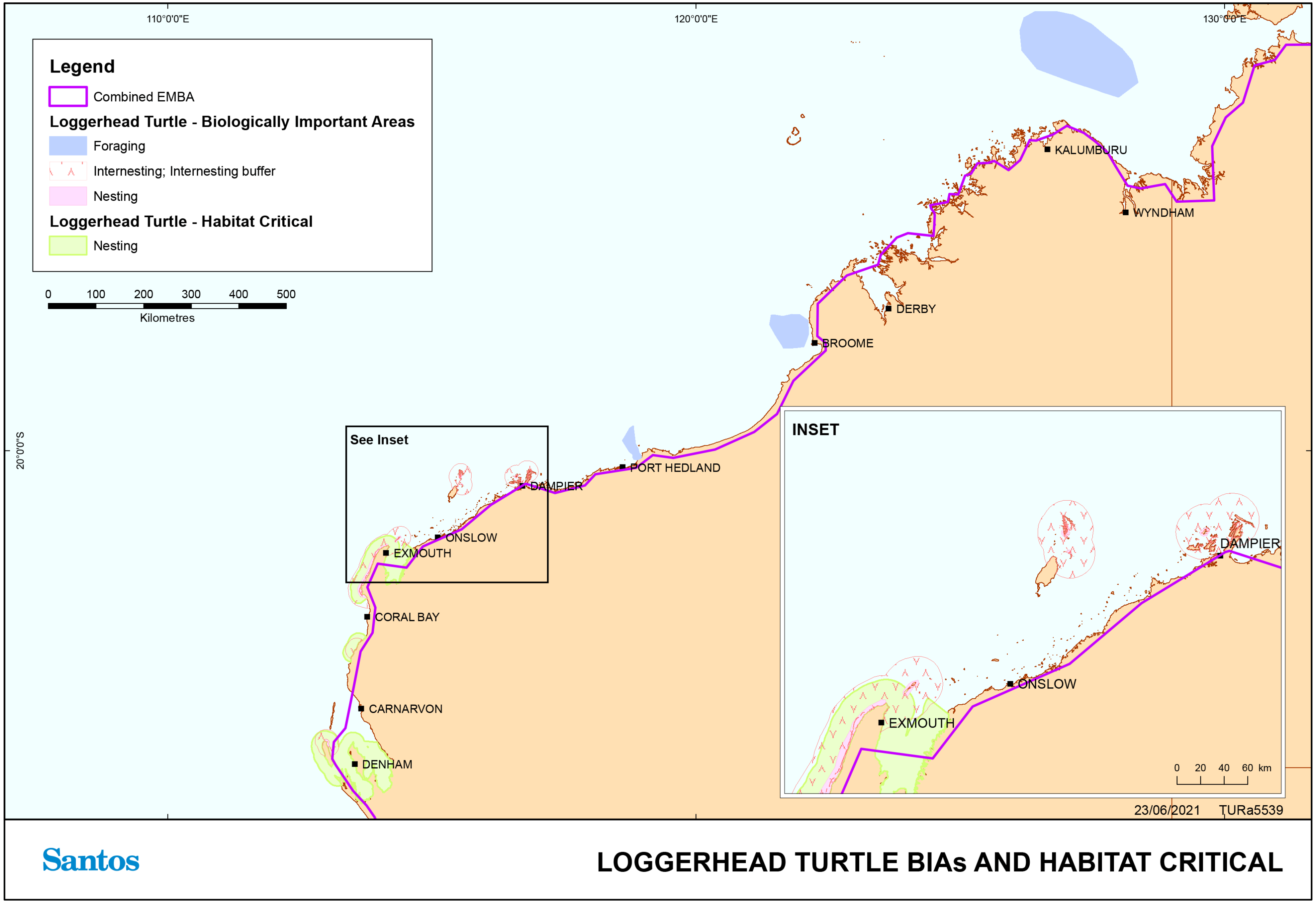

Figure 6-1: Biologically Important Areas and Habitat Critical – Loggerhead Turtle

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).

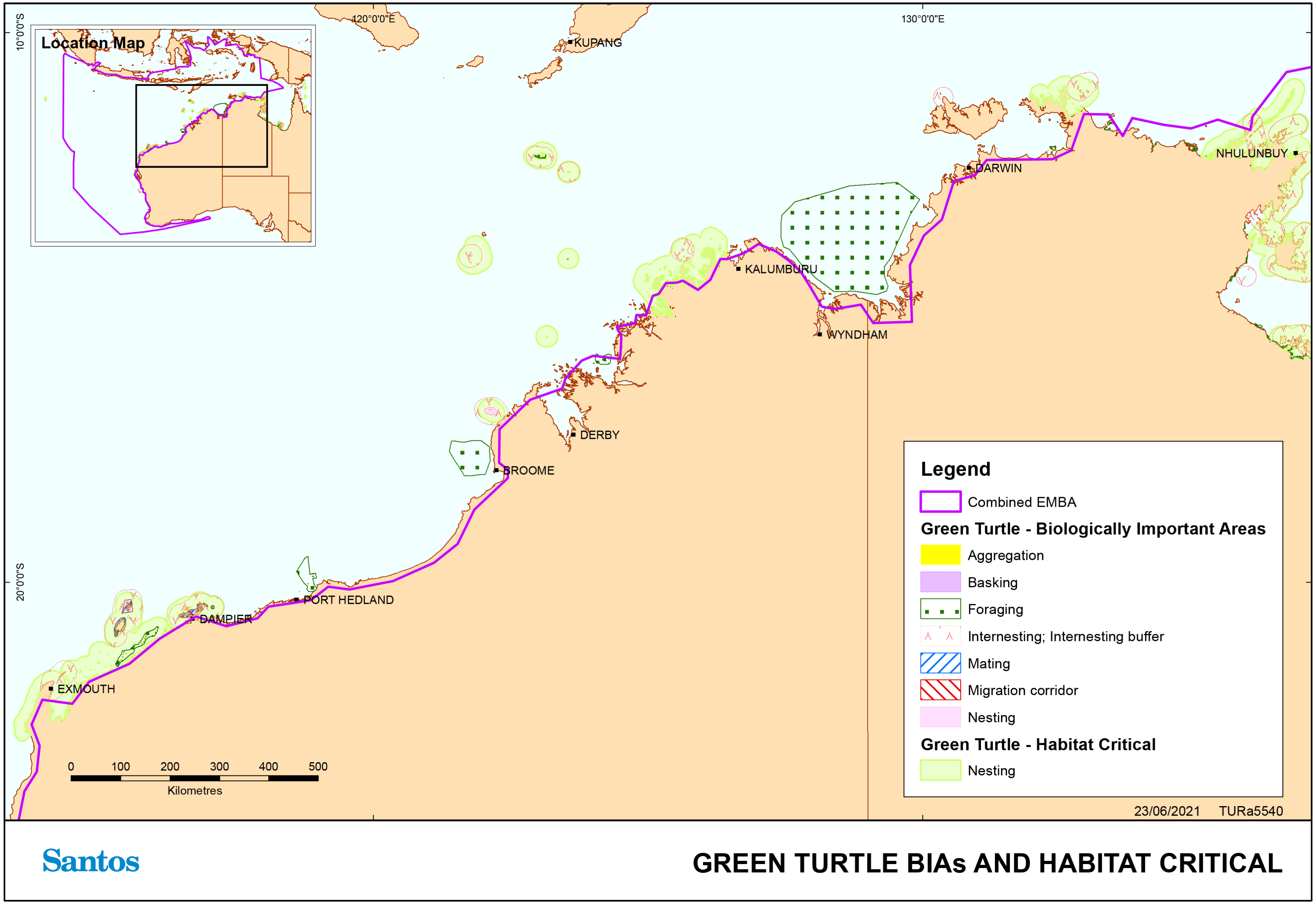

Figure 6-2: Biologically Important Areas and Habitat Critical – Green Turtle

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). 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.

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).

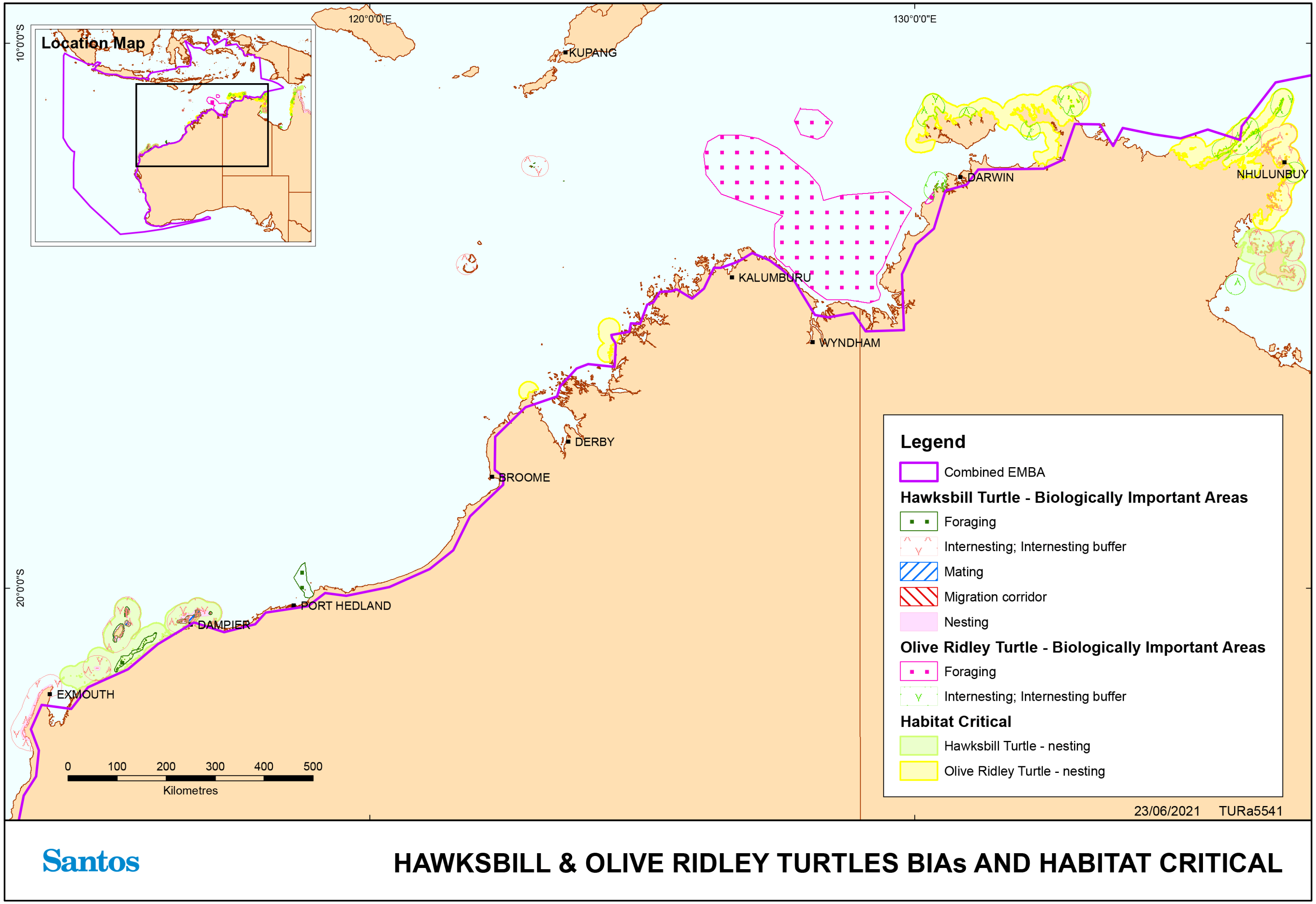

Figure 6-3: Biologically Important Areas and Habitat Critical – Hawksbill and Olive Ridley Turtle

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). 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).

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).

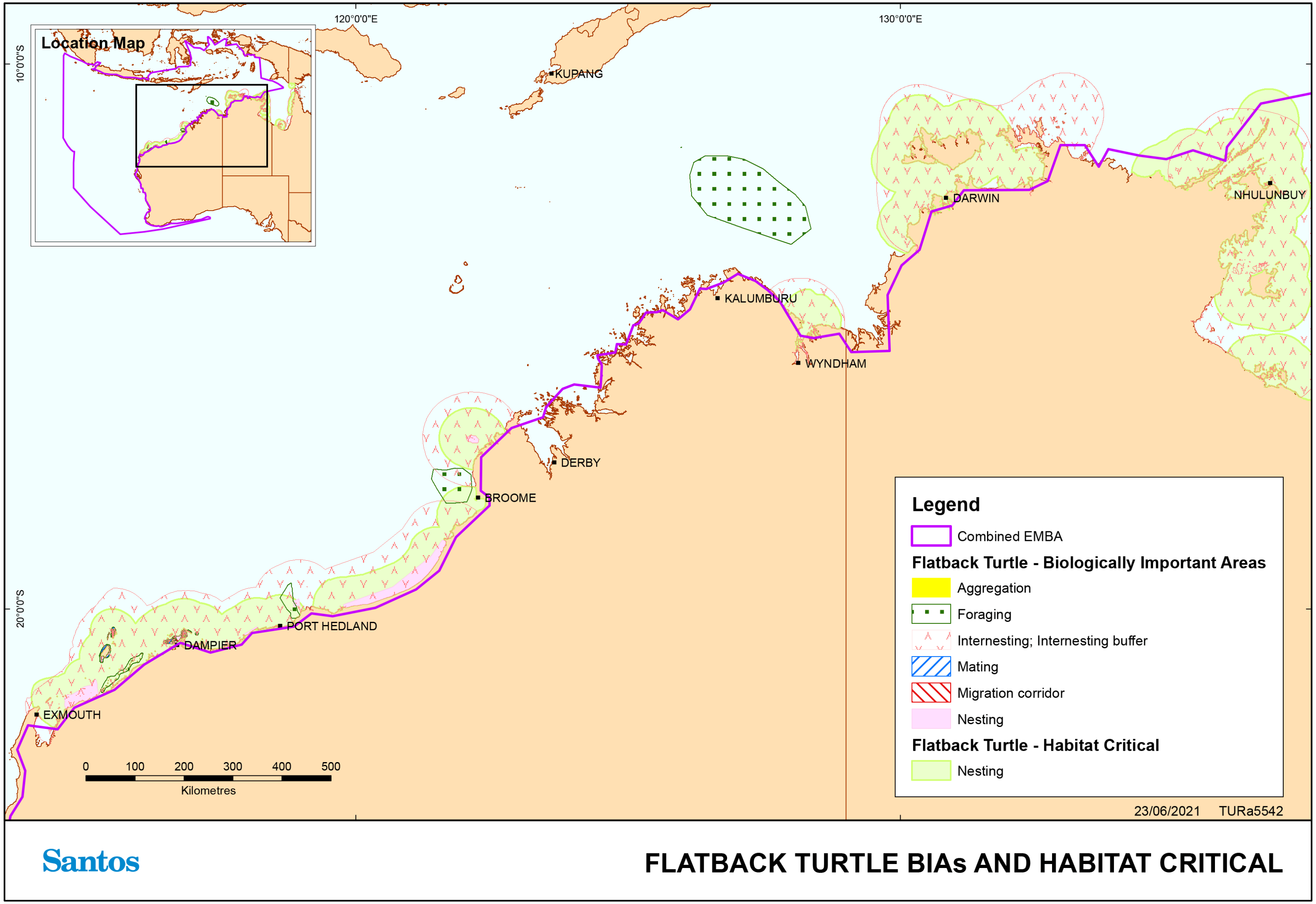

Figure 6-4: Biologically Important Areas and Habitat Critical – Flatback Turtle

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).

This species forages within the shallow benthic habitats of northern WA and the NT and is thought to feed primarily on gastropods and small crabs within the benthic, soft-bottomed communities of the continental shelf (Limpus 2009). 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.

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**[4].

[4] Further background information on BIA and identification of critical habitat in recovery plans is provided in **Section 5.4**.

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.

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 Montgomery Reef	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
			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)*	Vulnerable Migratory	Specially protected (special conservation interest)	-	-	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	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Bryde's whale *(Balaenoptera edeni)*	Migratory	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Pygmy right whale (*Caperea marginate)*	Migratory	-	-	-	Foraging, feeding or related behaviour 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		
Killer whale *(Orcinus orca)*	Migratory	-	-	-	Species or species habitat may occur within area	None - No BIA defined
Indo-Pacific humpback dolphin (*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	-	-	-	Species or species habitat known to occur within area	Yes – Refer to **Table 7-3**
Irrawaddy dolphin (Australian snubfin dolphin) *(Orcaella heinsohni)*	Migratory	-	P4	-	Species or species habitat known to occur within area	Yes – Refer to **Table 7-3**
Dusky dolphin (*Lagenorhynchus obscurus)*	Migratory	-	-	-	Species or species habitat likely to occur within area	None - No BIA defined
Australian sea lion (*Neophoca cinerea)*	Vulnerable	Vulnerable	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**
Dugong (*Dugong dugon)*	Migratory	Specially protected (species otherwise in need of special protection)	-	-	Breeding known to occur within area	Yes – Refer to **Table 7-3**

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7.1 Threatened and Migratory Species

7.1.1 Sei Whale

Sei whales have a worldwide, oceanic distribution, ranging from polar to tropical waters. 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 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). 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. 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.**

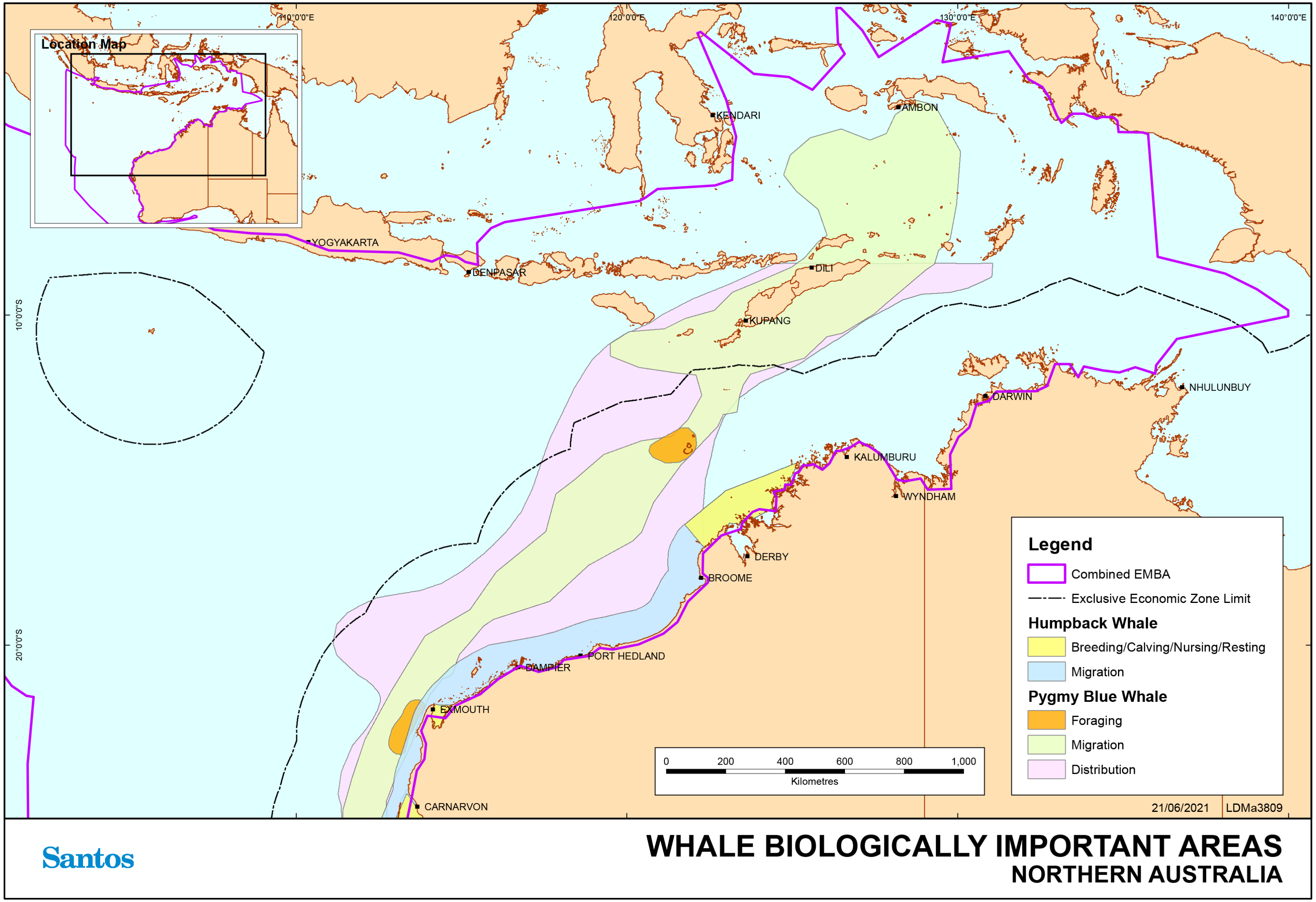

Figure 7-1: Biologically important areas – whales – Northern WA

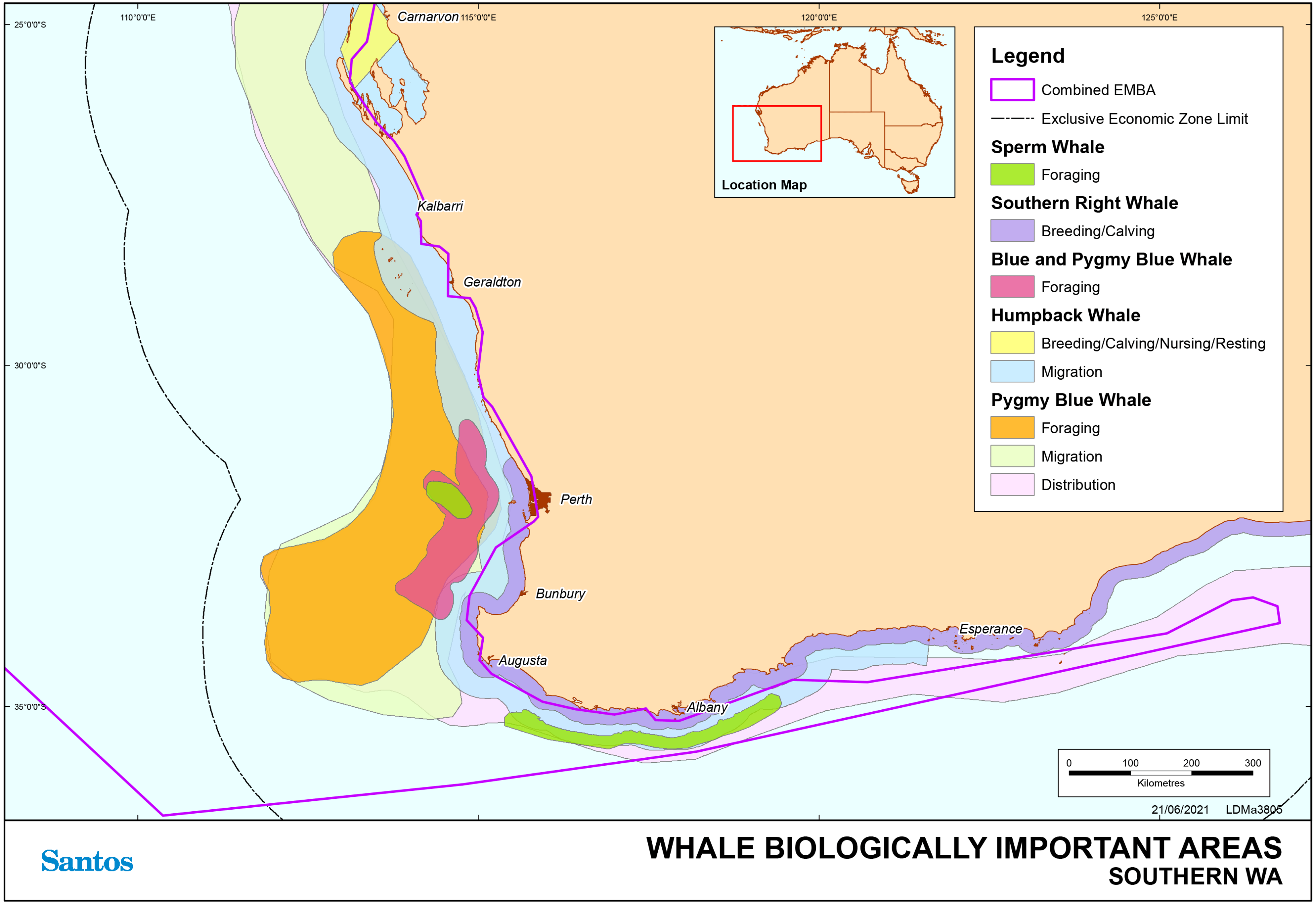

Figure 7-2: Biologically important areas – whales – Southern WA

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 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. 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 200 m) off continental shelves and sometimes near shelf edges, averaging 20 to 30 nautical miles offshore (Bannister *et al.* 1996). 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.

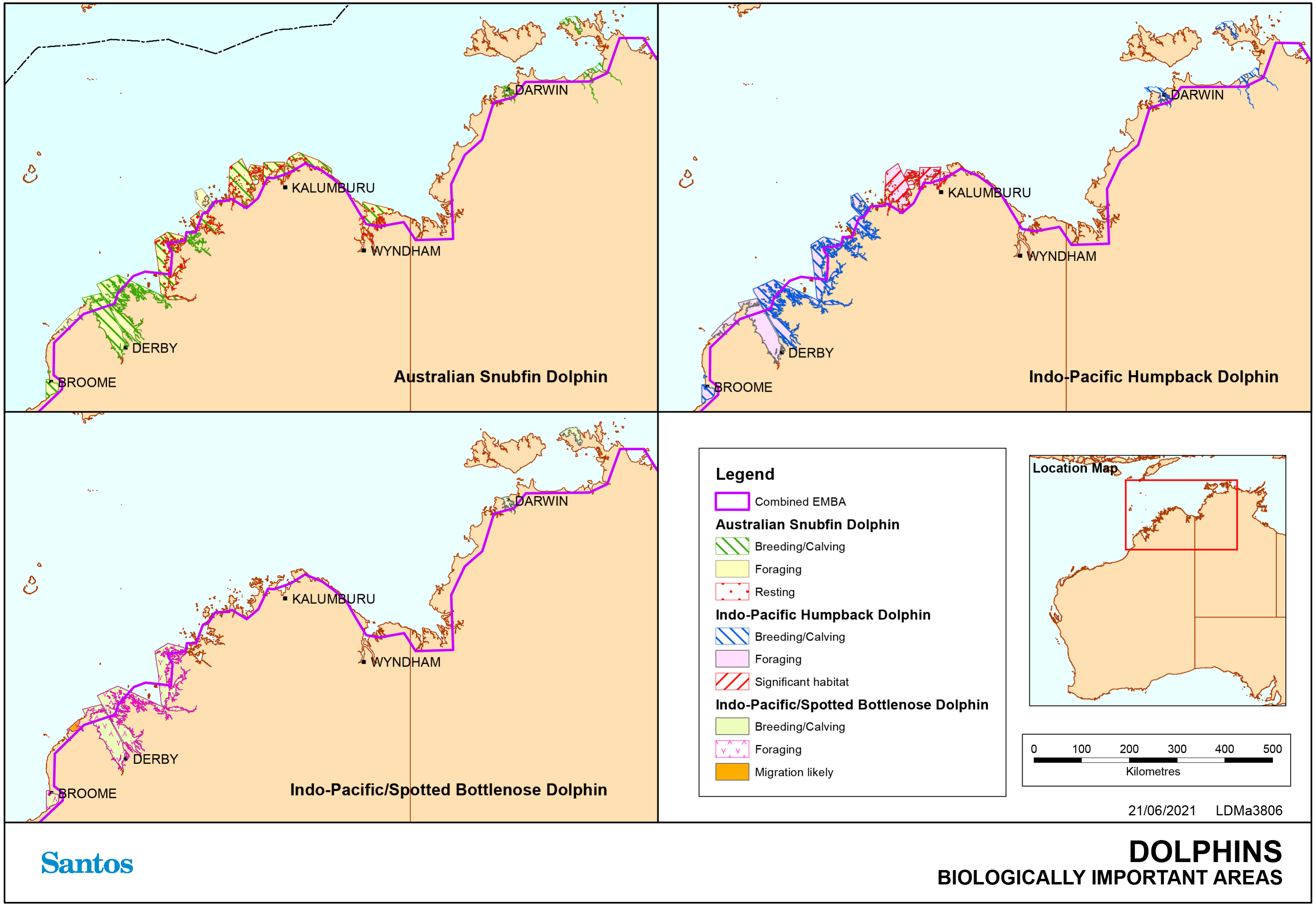

Figure 7-3: Biologically important areas – dolphins

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.**

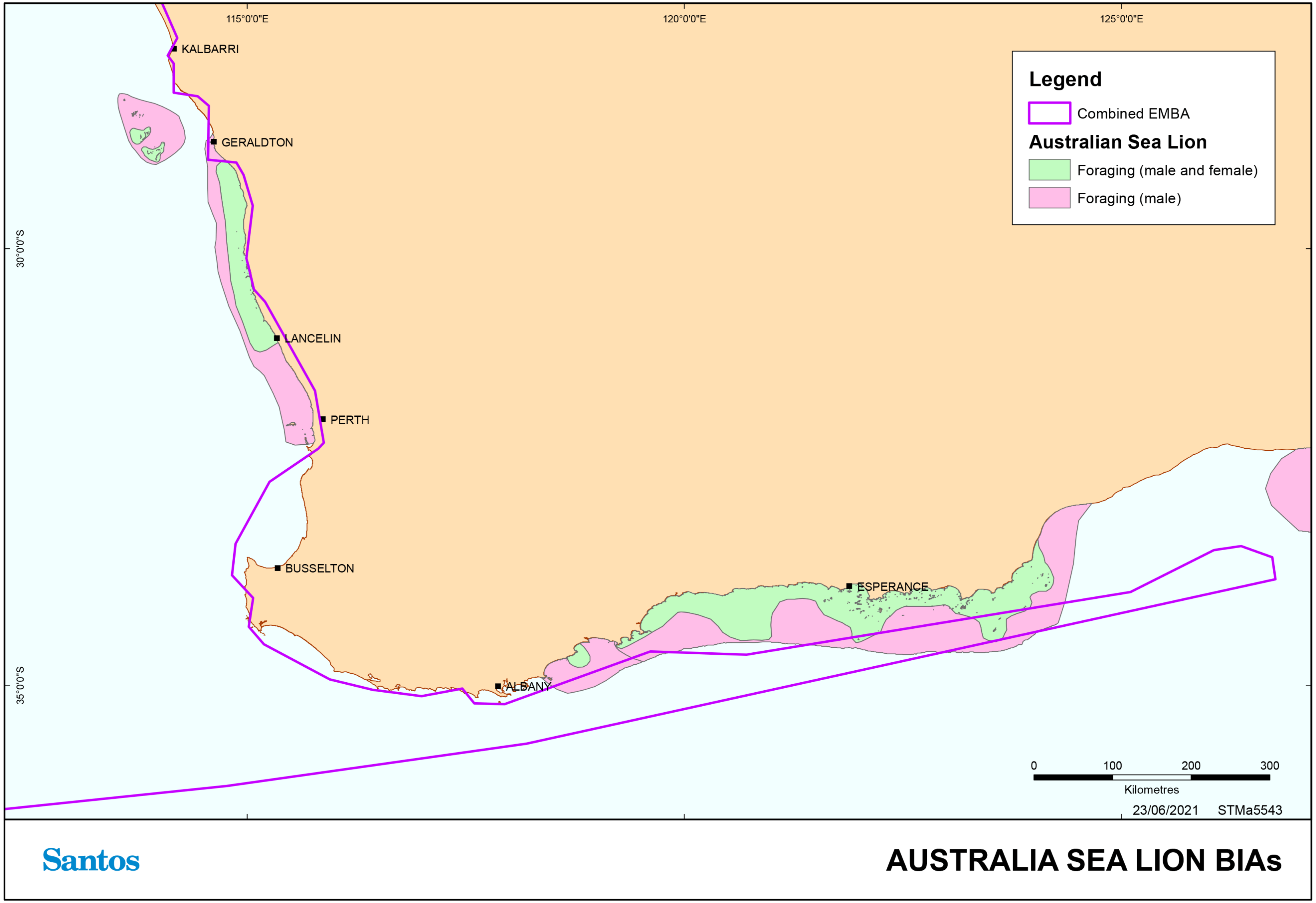

Figure 7-4: Biologically important areas – Australian sea lion

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.[5]

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[5] Identified as a relevant species through review of *Biodiversity Conservation Act 2016* listed species for marine species without an EBPC Act listing.

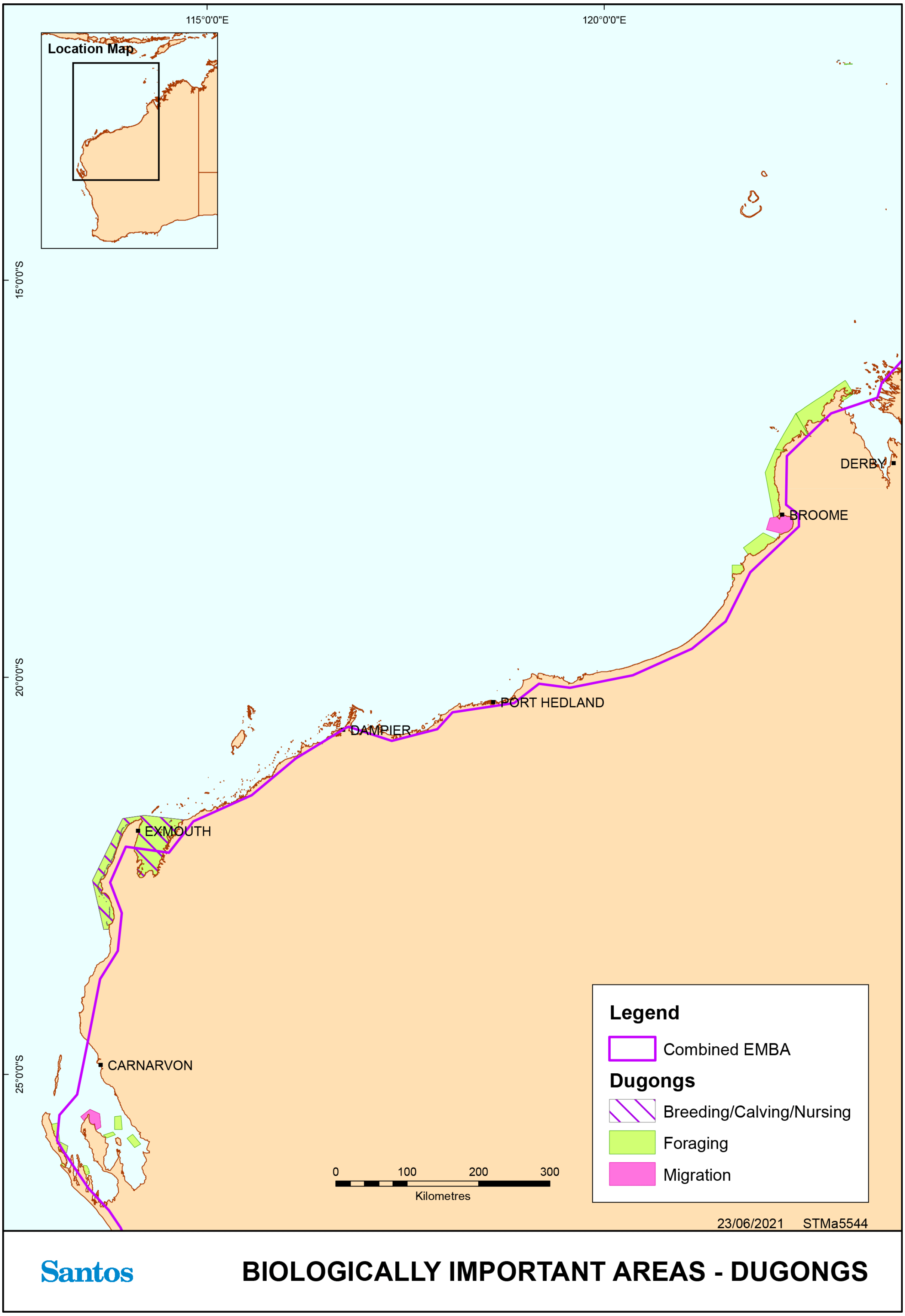

Figure 7-5: Biologically important areas – dugongs

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**[6].

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

[6] 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
			Scott Reef
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

Species	Scientific name	Aggregation area and use	BIAs within EMBA
			Willie Creek
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	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

Species	Scientific name	Aggregation area and use	BIAs within EMBA
		Breeding/calving/nursing – Exmouth and the Ningaloo coastline	Exmouth Gulf Kimberley coast, Dampier Peninsula 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 110 species, 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 8-6** and depicted in **Figure 8-1** and **Figure 8-2**.

Santos

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[7]	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 (*Numenius madagascariensis)*	Critically endangered, Migratory	Critically endangered	-	Vulnerable	Species or species habitat known to occur within area	None - No BIA defined

[7] 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*		
Australasian bittern (*Botaurus poiciloptilus)*	Endangered	Endangered	-	-	Species or species habitat known to occur within area	Yes – refer to **Table 8-6**
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 8-6**
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	-	-	-	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 may occur within area	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*		
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	Yes – refer to **Table 8-6**
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	Yes – refer to **Table 8-6**
Soft-plumaged petrel (*Pterodroma mollis)*	Vulnerable	-	-	-	Foraging, feeding or related behaviour known to occur within area	Yes – refer to **Table 8-6**
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	Yes – refer to **Table 8-6**

Species	Conservation Status				Likelihood of occurrence in EMBA	BIAs in EMBA
	EPBC Act 1999	BC Act 2016	Other WA Conservation Code	*TPWC Act 1976*		
Indian yellow-nosed albatross (*Thalassarche carteri)*	Vulnerable, Migratory	Endangered	-	-	Foraging, feeding or related behaviour may occur within area	Yes – refer to **Table 8-6**
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, Vulnerable	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 8-6**).

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 8-6**). 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 8-6**).

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.

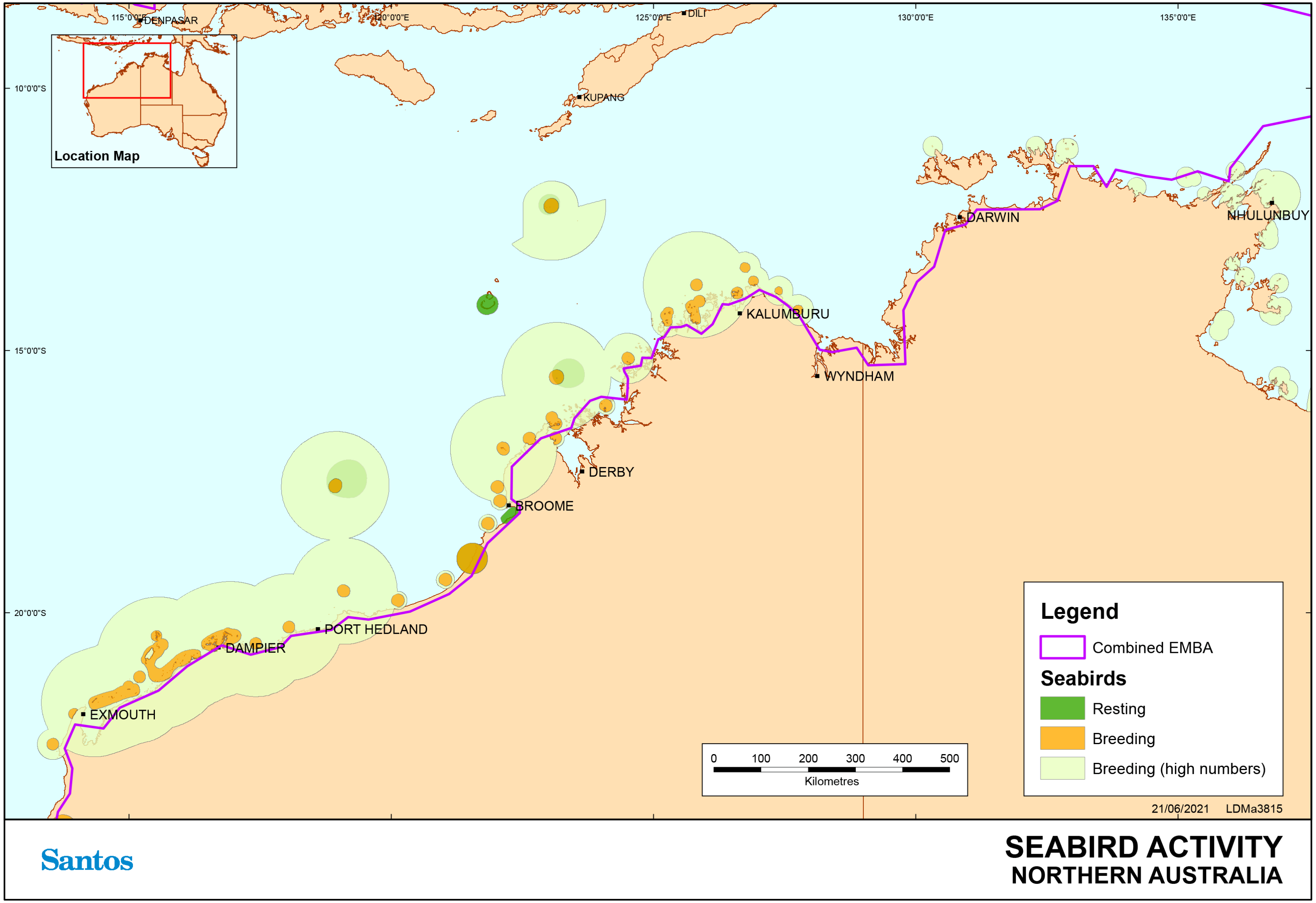

Figure 8-1: Biologically important areas – birds – Northern WA

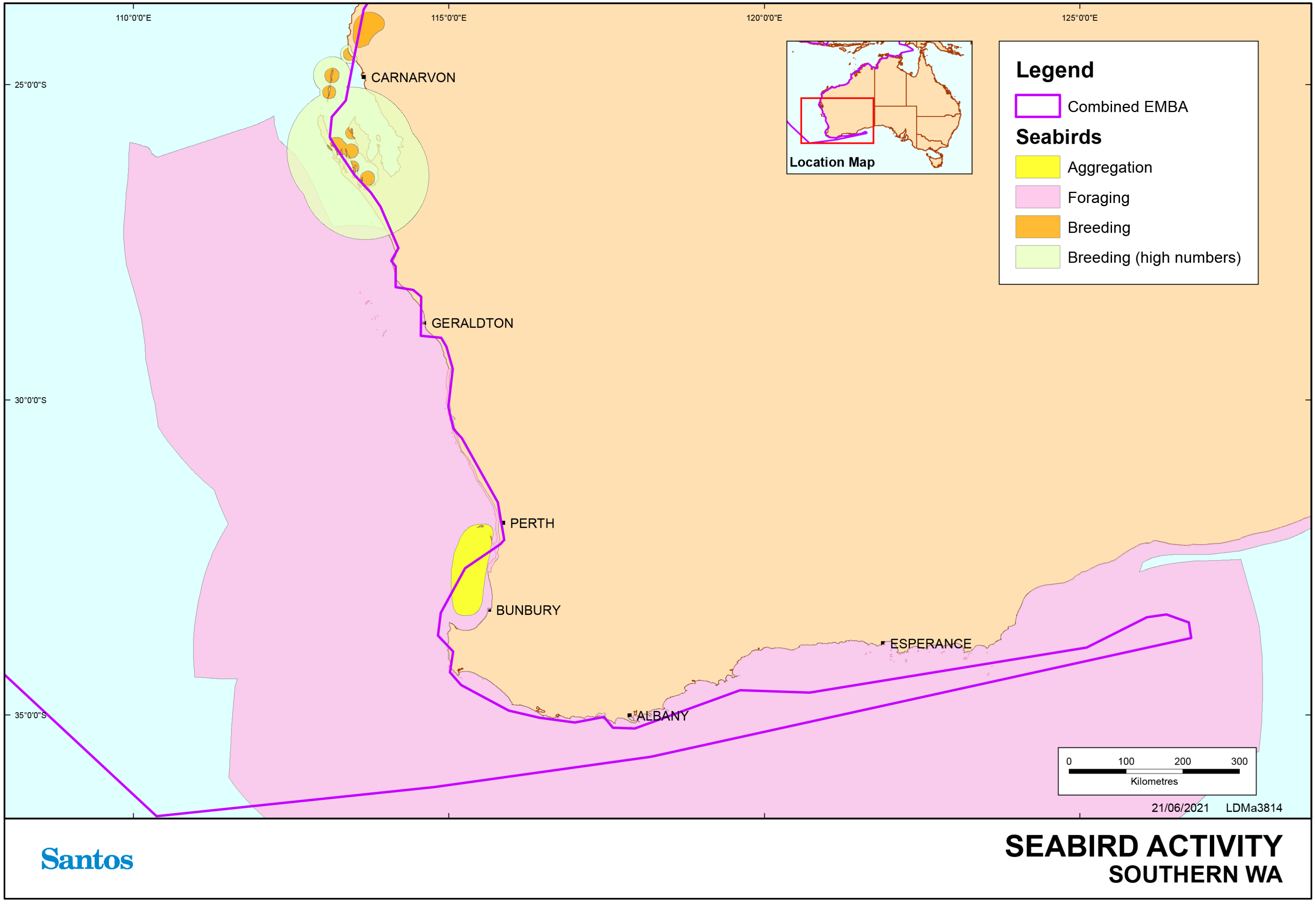

Figure 8-2: Biologically important areas – birds – Southern WA

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 51 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
Hydroprogne caspia	Caspian tern	Breeding known to occur within area

Species	Common Name	Likelihood of occurrence in EMBA
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
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

Species	Common Name	Likelihood of occurrence in EMBA
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

Feeding habitat	Feeding guild	Species
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.
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).
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

Migratory species	DoEE SPRAT information on distribution within the area of interest
	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. 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

Migratory species	DoEE SPRAT information on distribution within the area of interest
	+ Nuytsland Nature Reserve (409 individuals).
Grey-tailed tattler	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 60,000 birds); and + Roebuck Bay, WA (Approximately 8,500 birds).
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. Internationally important sites include Eighty Mile Beach with 440 individuals.
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.

Migratory species	DoEE SPRAT information on distribution within the area of interest
Red knot	The red knot large numbers are regularly recorded in north-west Australia, with 80 Mile Beach and Roebuck Bay being particular strongholds.
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); + 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).
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:

Migratory species	DoEE SPRAT information on distribution within the area of interest
	+ 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.
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).

8.4 Biologically Important Areas / Critical Habitat– Birds

Table 8-6 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**[8].

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 8-6: Critical habitat/ biologically important areas - birds

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
Abbott’s booby	*Papsula abbotti*	All known nesting trees and all forest vegetation within a 200m radius of known nesting trees for Abbott’s booby	Christmas Island
Australasian bittern	*Botaurus poiciloptilus*	All natural habitat (including constructed wetlands with suitable habitat)	Western coastal plain between Lancelin and Busselton Southern coastal region from Augusta to east of Albany
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

[8] 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
			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
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.
Christmas Island frigatebird	*Fregeta andrewsii*	All forest containing nesting and roosting sites, including currently known nesting and roosting colonies and any other smaller groups of nests and roosts	Christmas Island
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

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
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).
Red-footed Booby	*Sula sula*	Breeding, foraging - north west Kimberley and Ashmore reef	North west 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-	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

Species	Scientific name	Aggregation area and use	Specific geographic locations for species
		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
	Kakadu National Park
	Mary Floodplain System

Area type	Title
	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
	Ashmore Reef National Nature Reserve
	Garden Island

Area type	Title
	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 Rasmar 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[9]	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 [10]	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 [11]	-
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)	

[9] 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[9]	Management plan	Includes inter-tidal zone	Adjacent Marine Management Park (see Section 11)
Houtman Abrolhos Islands	Geraldton Sandplains	-	No - extends to the high water mark only.	Abrolhos Commonwealth Marine Park
Kalbarri	Geraldton Sandplains	Kalbarri National Park Management Plan (DPAW 2015)	Yes [11]	-
Namburg	Geraldton Sandplains	Namburg National Park Management Plan (1998)	Yes	-
Yalgorup	Swan Coastal Plain	Yalgorup National Park Management Plan (CALM 1995)	Yes [11]	-
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[11]	
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[11]	Walpole and Nornalup Inlets Marine Park
Waychinicup	Southern Jarrah Forest and Fitzgerald	Albany coast draft management plan 2016 (DPAW 2016)	Yes[11]	
West Cape Howe	Warren	Albany coast draft management plan 2016 (DPaW 2016)	Yes[11]	
D'Entrecasteaux	Warren	Shannon and D'Entrecasteaux National Parks Management Plan No. 71 (DEC 2012b)	Yes[11]	
Fitzgerald River	Fitzgerald	Fitzgerald River National Park Management Plan 1991 – 2001 No. 15 (CALM 1991)	Yes[11]	
Reserves of the Northern Territory (NT) – (see Figure 9-5)				
Djukbinj National Park	Darwin Coastal and Pine Creek	-	Yes[11]	-

National Park	IBRA bioregion[9]	Management plan	Includes inter-tidal zone	Adjacent Marine Management Park (see Section 11)
Garig Gunak Barlu National Park	Tiwi Cobourg	Cobourg Marine Park Plan of Management (PAWCNT, 2011)	Yes[11]	Cobourg Marine Park
Mary River National Park	Darwin Coastal	Mary River National Park Joint Management Plan March 2015 (PAWCNT, 2015)	Yes[11]	-
Keep River National Park	Victoria Bonaparte	-	Yes[11]	-
Charles Darwin National Park	Darwin Coastal	Charles Darwin National Park Plan of Management (NT government, nd)	Yes[11]	-

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 [10]	North Kimberley Marine Park
Pelican Island NR	-	1a			
Lesueur Island NR	A	1a			
Low Rocks NR	A	1a			
Browse Island NR	A	1a	-	Yes [11]	-
Scott Reef NR	-	1a	-	Yes [11]	-
Adele Island NR	A	1a	-	Yes [11]	-
Tanner Island NR	A	1a	-	Yes [11]	-
Lacepede Islands NR		1a	-	Yes [11]	-

[10] Inferred as adjacent marine park boundary is the high water mark and dual tenure cannot exist.

[11] 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 [11]	-
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 [11]	-
North Turtle Island NR	A	1a	-	Yes [11]	-
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[11]	Kimberly Marine Park
Unnamed NR		1a	-	Yes [11]	-
North Sandy Island NR	A	1a	-	Yes [11]	-
Montebello Islands CP	A	2	-	Partially [12]	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 [11]	-
Little Rocky Island NR	A	1a	-	Yes [11]	-
Airlie Island NR	-	1a	-	Yes [11]	-

[12] 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)
Thevenard Island Nature	-	1a	-	Yes [11]	-
Bessieres Island NR	A	1a	-	Yes [11]	-
Serrurier Island NR	-	1a	-	Yes [11]	-
Round Island NR	-	1a	-	Yes [11]	-
Locker Island NR	A	1a	-	Yes [11]	-
Rocky Island NR	-	1a	-	Yes [11]	-
Gnandaroo Island NR	A	1a	-	Yes [11]	-
Victor Island NR	-	1a	-	Yes [11]	-
Y Island NR	-	1a	-	Yes [11]	-
Tent Island NR	-	1a	-	Yes [11]	-
Burnside and Simpson Island NR	-	1a	-	Yes [11]	-
Whalebone Island NR		1a	-	Yes [11]	-
Whitmore, Roberts, Doole Islands & Sandalwood Landing NR	-	1a	-	Yes [11]	-
Muiron Islands NR	-	1a	Jarabi and Bundegi Coastal Parks and Muiron Islands (CALM 1999)	No [10]	Muiron Islands Marine Management Area
OneTree Point NR	A	1a	-	Yes [11]	
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 [11]	-
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 [11]	-
Beekeepers NR	-	1a	-	Yes [11]	-
Beagle Islands NR	A	1a	Turquoise Coast Nature Reserve Management Plan (CALM 2004). *Covers chain of approximately 40 protected islands lying between Lancelin and Dongara.*	Yes	-
Lipfert, Milligan, etc Islands NR	A	1a			-
Fisherman Islands NR	A	1a			Jurien Bay Marine Park: extends from Greenhead south to Wedge Island
Sandland Islands NR	A	1a			
Boullanger, Whitlock, Favourite, Tern and Osprey Islands NR	A	1a			
Escape Island NR	A	1a			
Essex Rocks NR	A	1a			

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
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 [11]	-
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[11]	-
Doubtful Islands NR	A	1a	-	Yes	Bremer Marine Park
Quarram NR	A	1a	-	Yes	South-west corner Marine Park
Chatham Island NR	A	1a	-	Yes	
Two Peoples Bay NR	A	4		Yes[11]	-

Reserve name and type	Reserve class	IUCN	Management Plan	Includes inter-tidal zone	Adjacent Marine Park (see Section 11)
Breaksea Island NR	A	1a	Albany coast draft management plan 2016 (DPAW 2016b)	Yes[11]	-
Bald Island NR	A	1a		Yes[11]	-
Eclipse Island NR	A	1a		Yes[11]	-
Michaelmas Island NR	A	1a		Yes[11]	-
Glasse Island NR	A	1a	-	Yes[11]	-
Arpenteur NR	-	1a	-	No	-
Figure 9-5					
Channel Point Coastal Reserve	-	5	-	Yes[11]	-
Casuarina Coastal Reserve	1 and 3	5	Casuarina Coastal Reserve Management Plan (PAWCNT, 2016)	Yes[11]	-
Shoal Bay Coastal Reserve	-	6	-	Yes[11]	-
Tree Point Conservation Area	-	5	-	Yes[11]	-

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.

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.

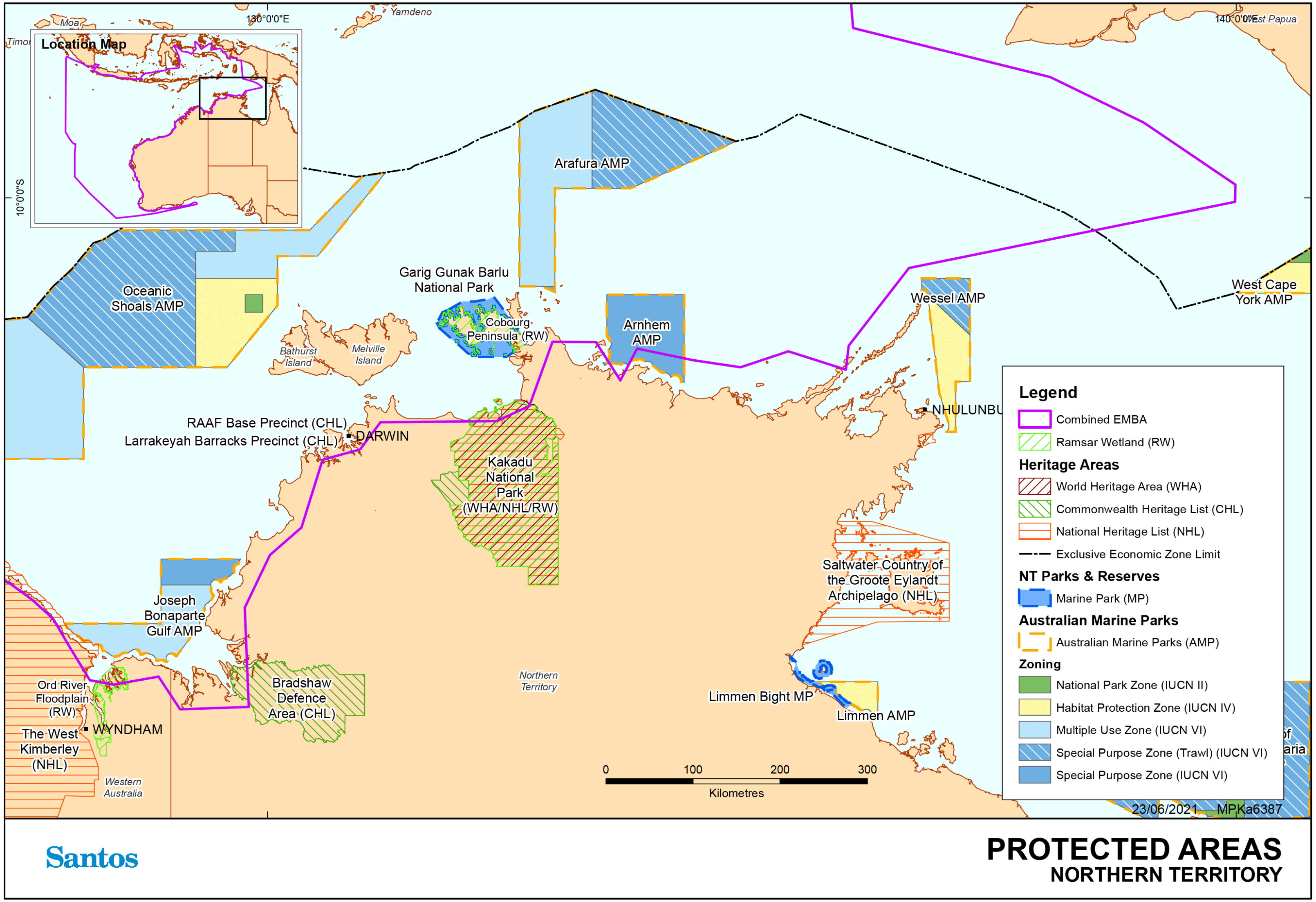

Figure 9-1: Protected areas in NT

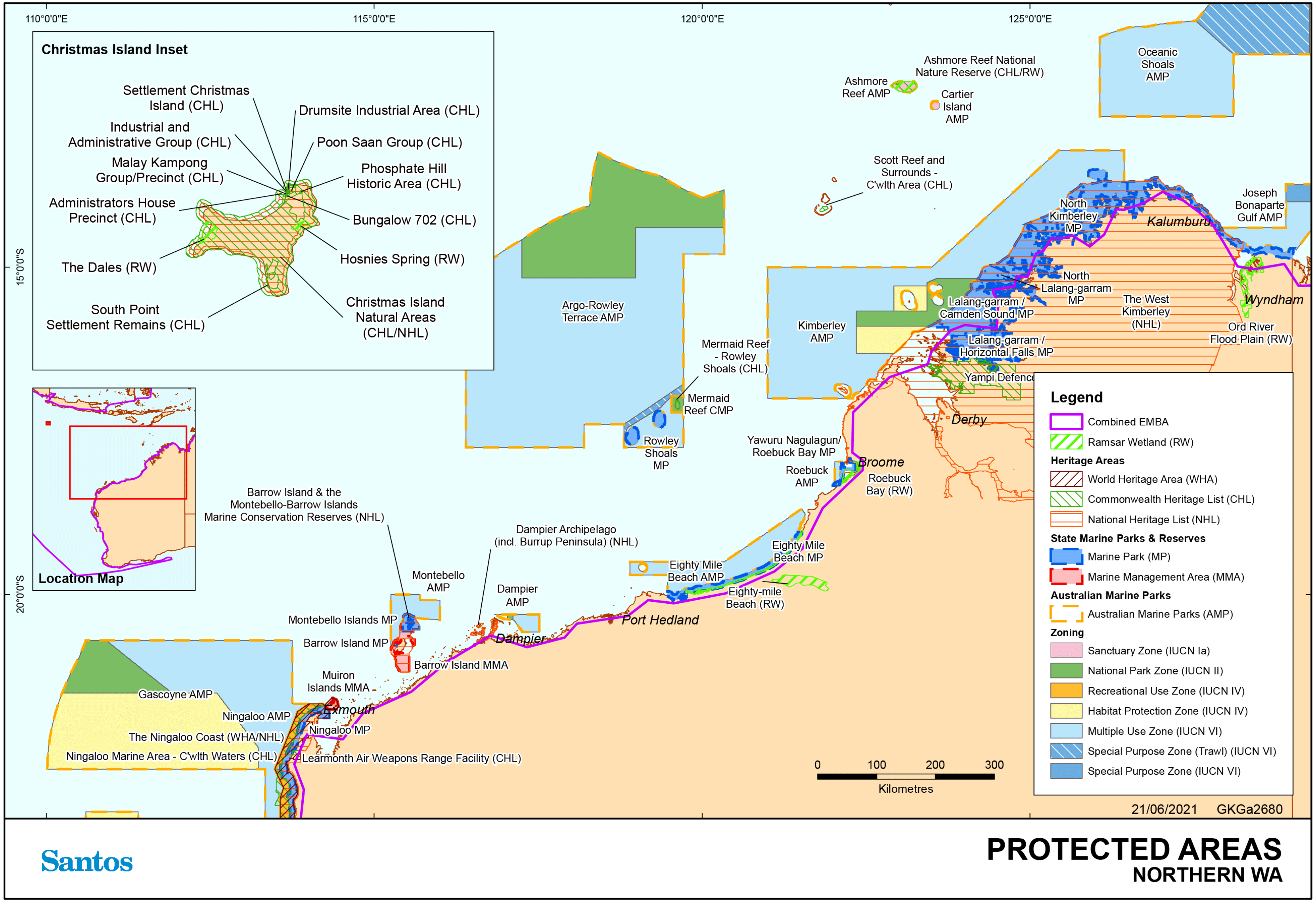

Figure 9-2: Protected areas in Northern WA

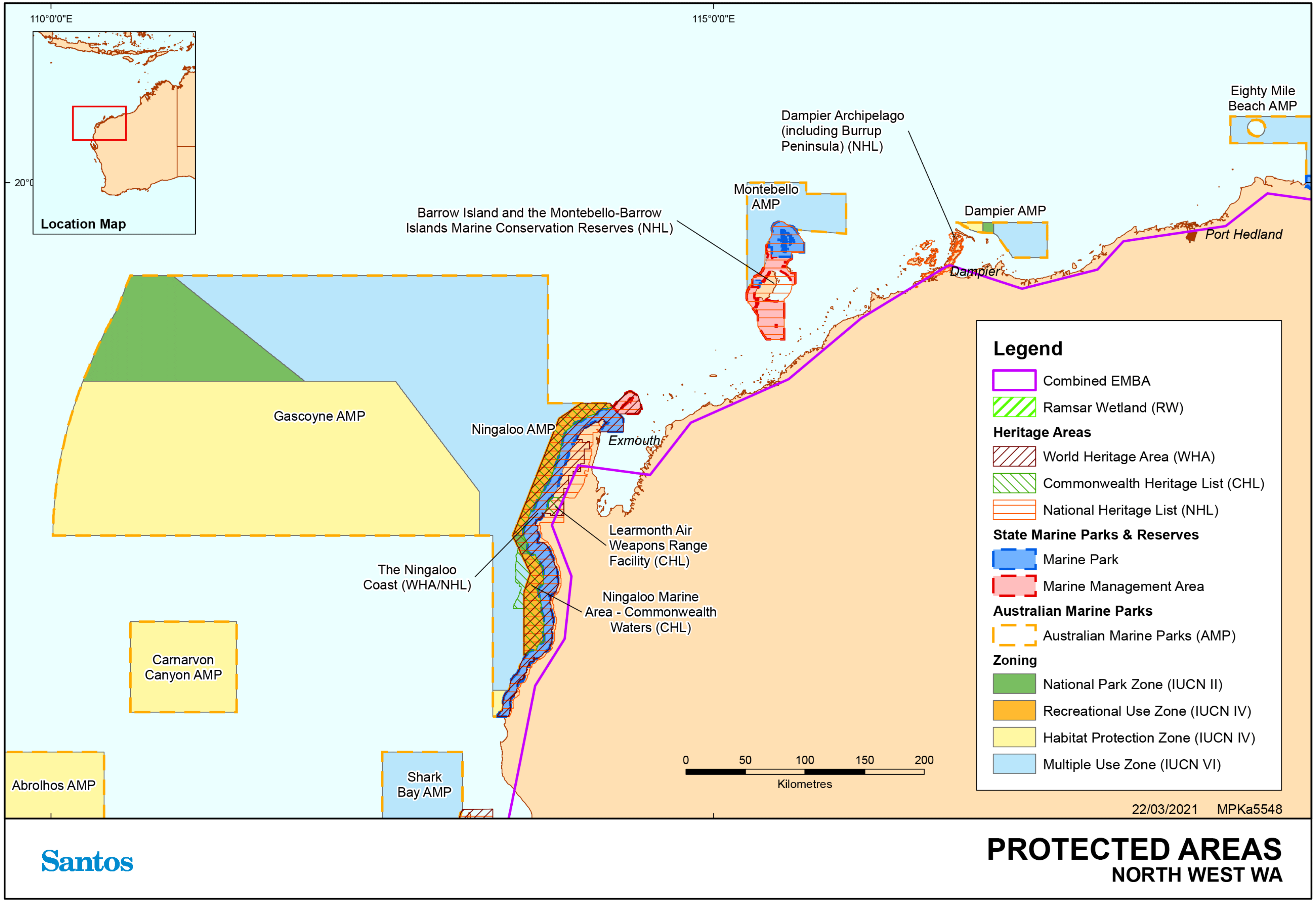

Figure 9-3: Protected areas in North West WA

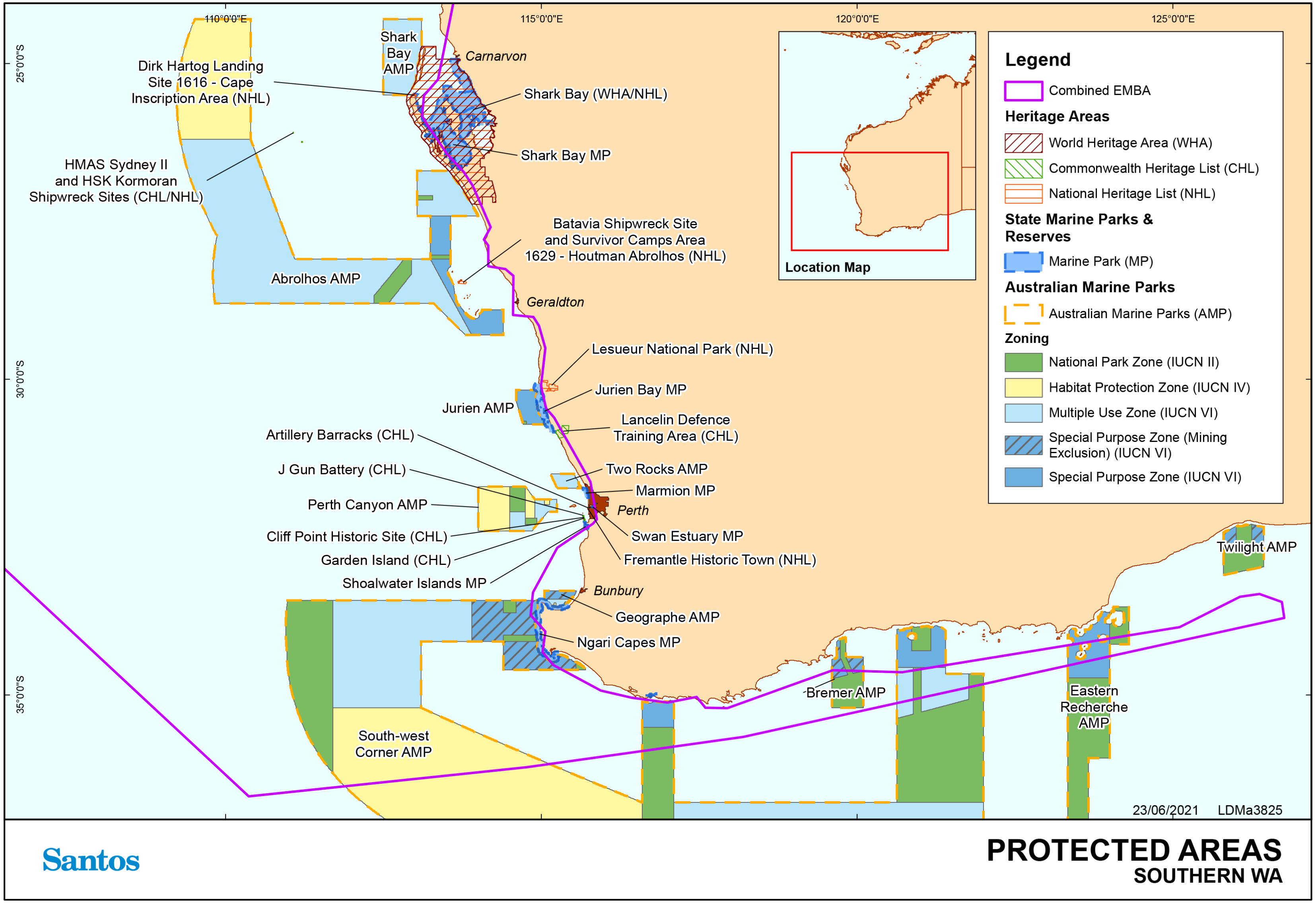

Figure 9-4: Protected areas in Southern WA

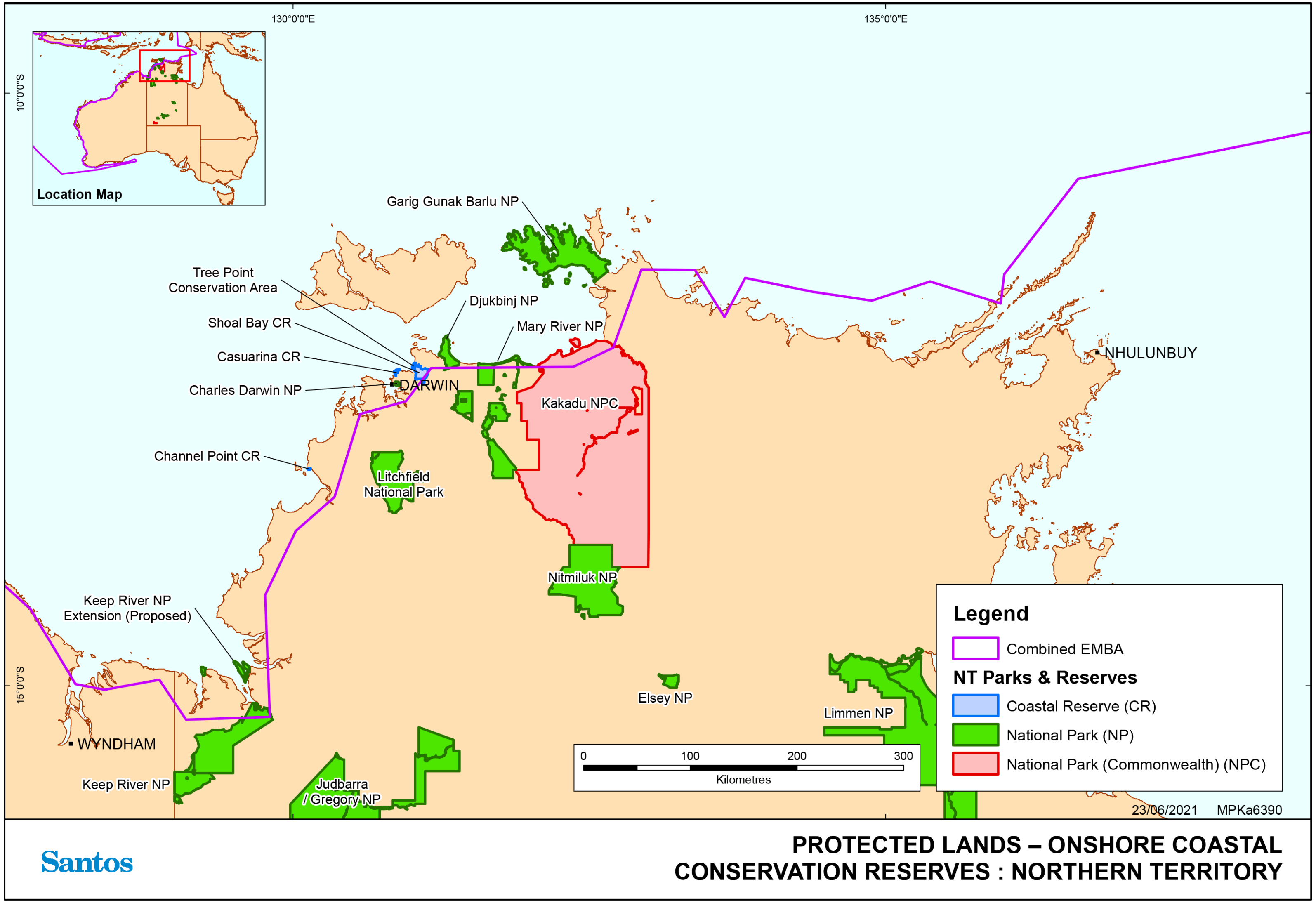

Figure 9-5: Protected Lands (CALM Act 1984) – terrestrial coastal reserves bounding marine waters in NT

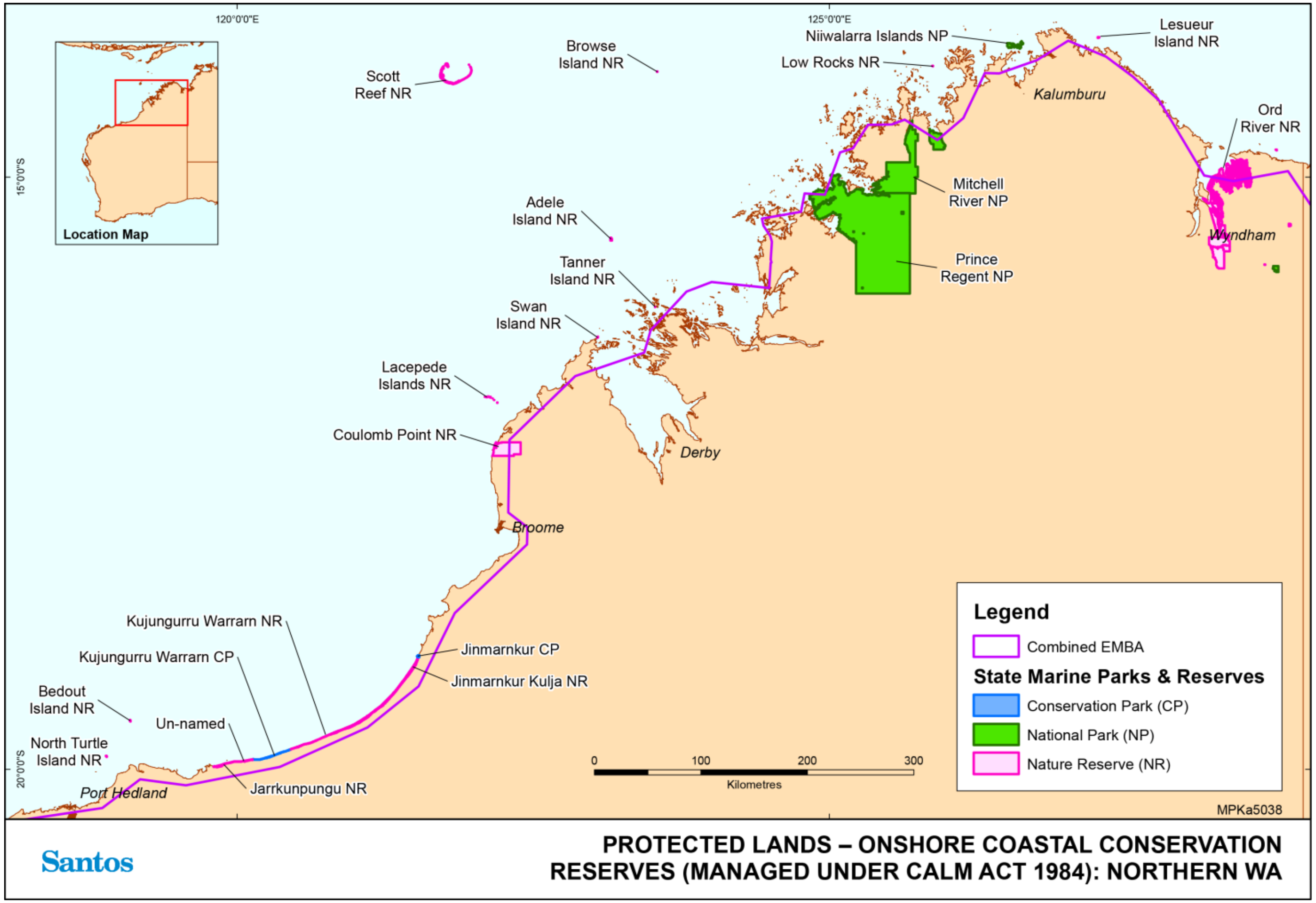

Figure 9-6: Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in northern WA[13]

[13] 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**).

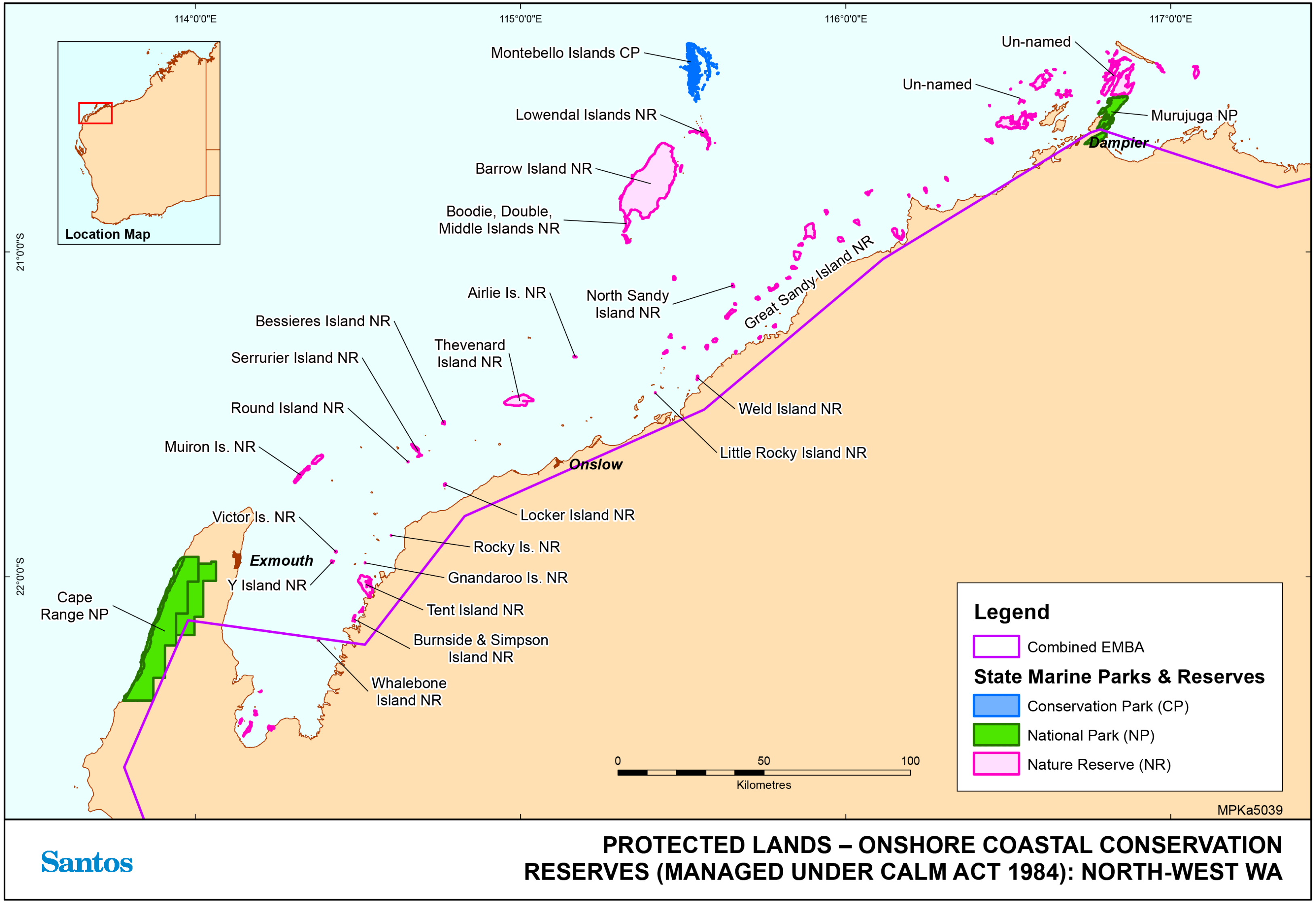

Figure 9-7: **Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in North-West WA**

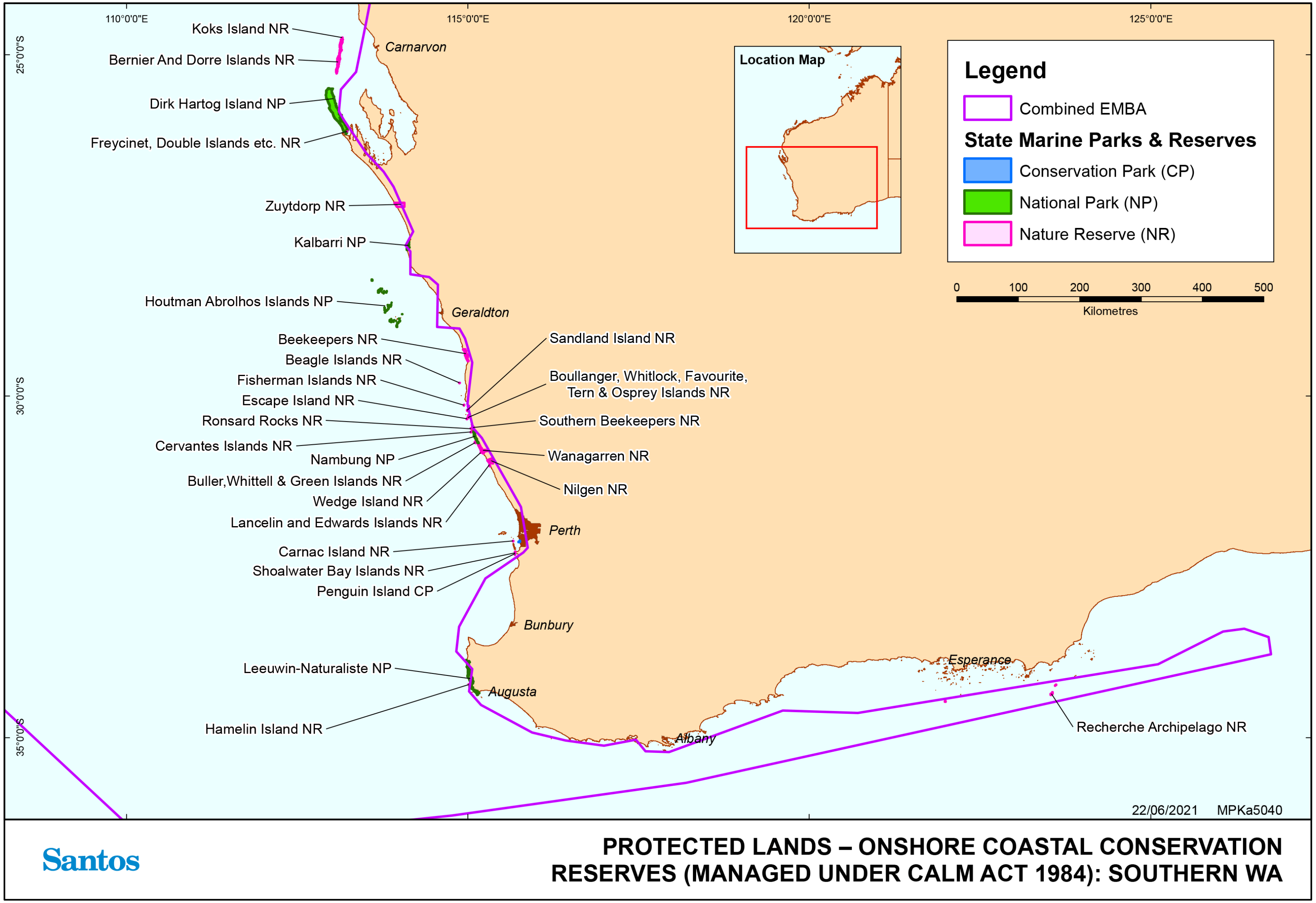

Figure 9-8: Protected Lands (CALM Act 1984) – terrestrial conservation reserves bounding marine waters in Southern WA[14]

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;
- 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.

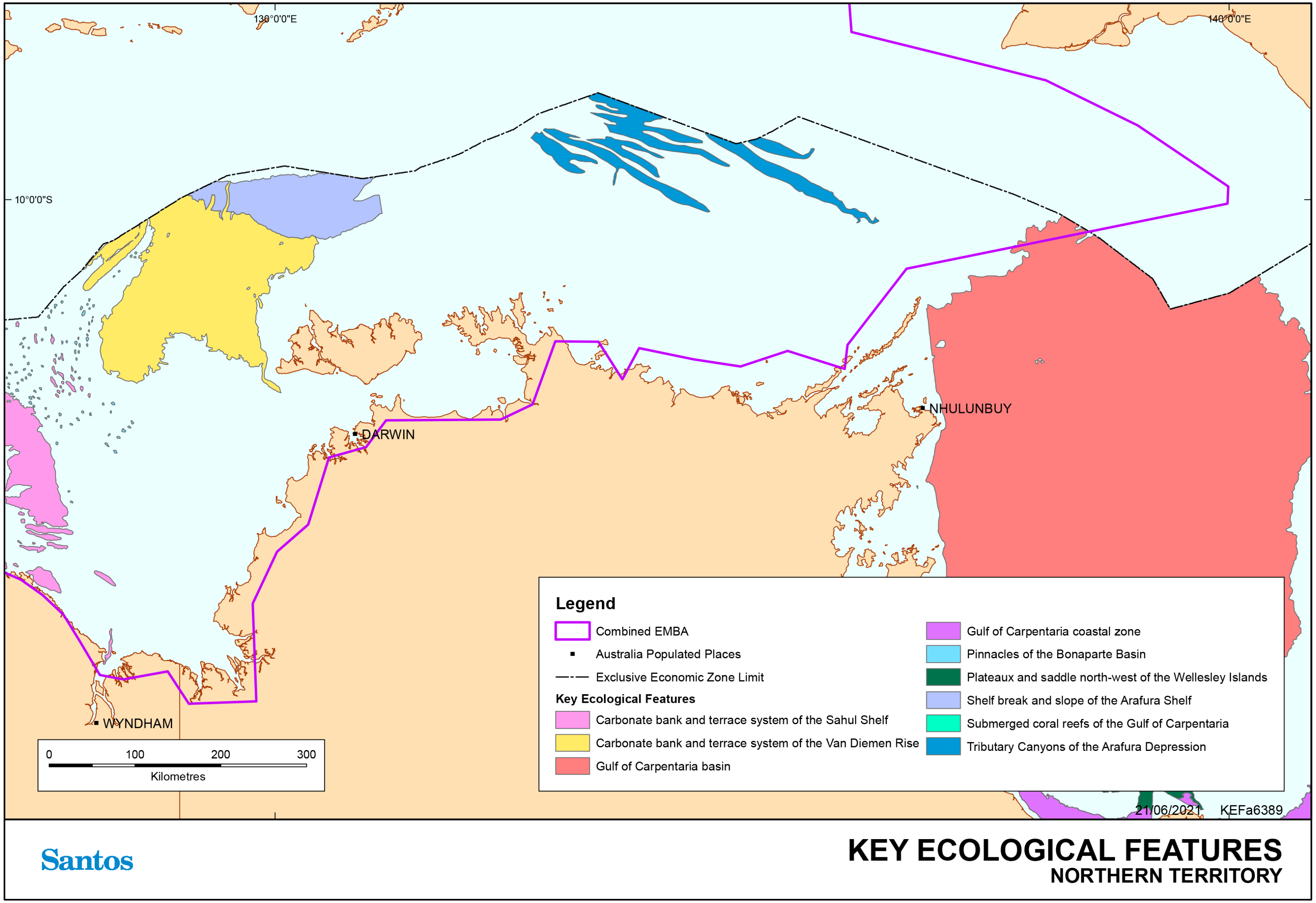

Figure 10-1: Key ecological features of NT

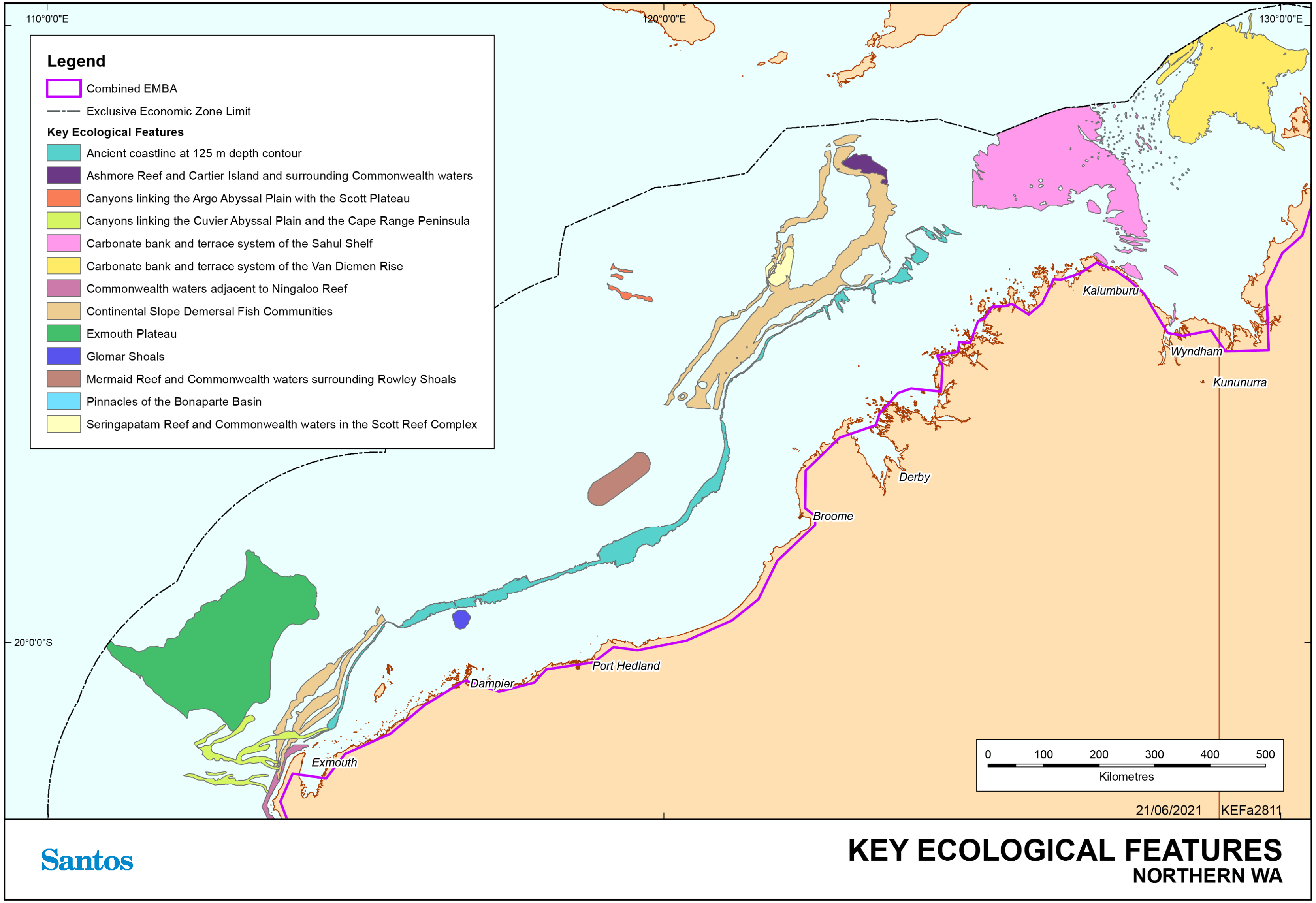

Figure 10-2: Key ecological features of Northern WA

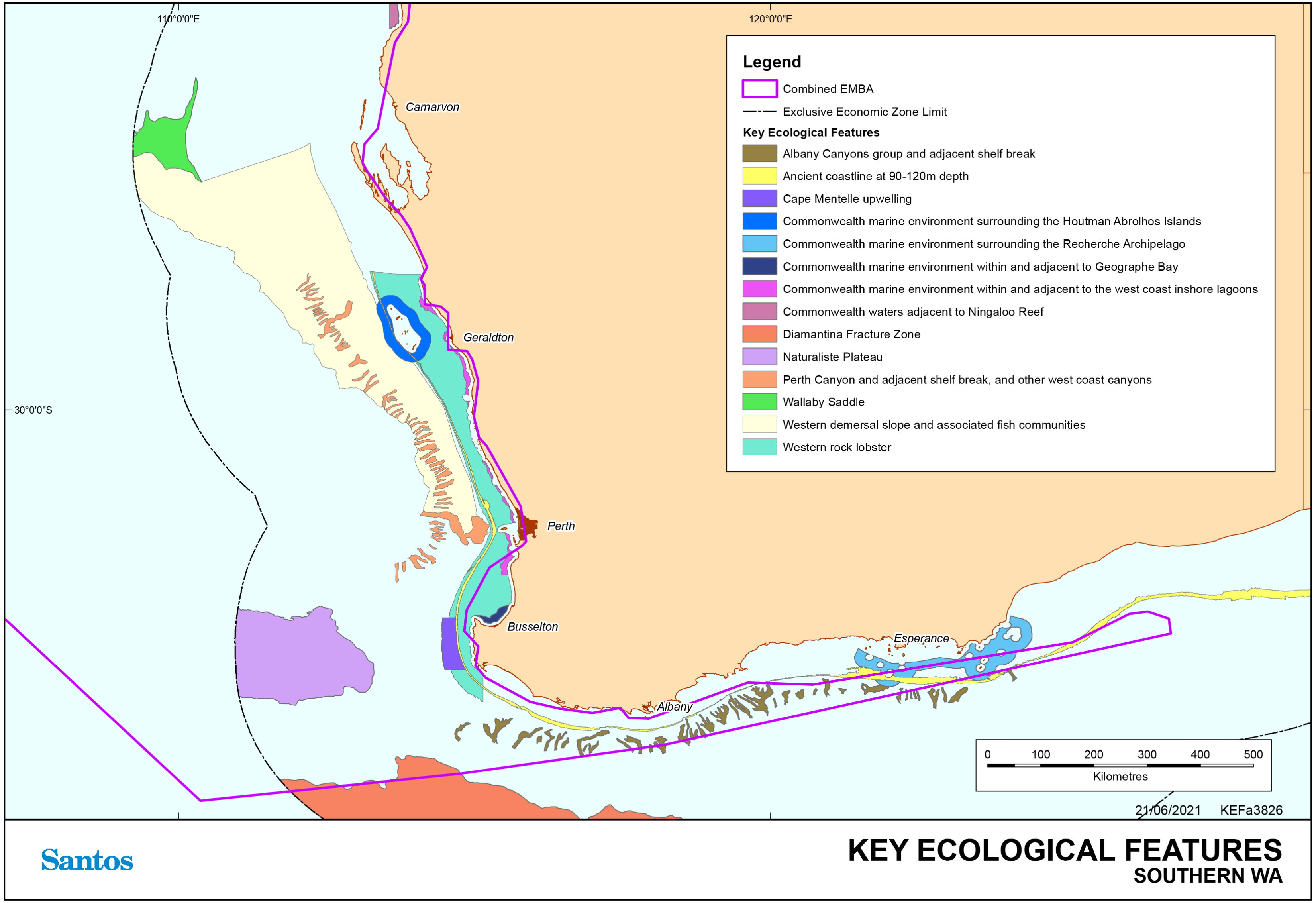

Figure 10-3: Key ecological features of Southern WA

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 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).

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 km² 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 km^2, 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 km^2 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).

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;	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
	+ Red-necked stint; + Red knot; + Ruddy turnstone; + Ruff (reeve); + Sanderling; + Sharp-tailed sandpiper; + Streaked shearwater; + Terek sandpiper; + Whimbrel; and + Wood sandpiper.		
	Christmas Island frigatebird	Conservation Advice for the Christmas Island frigatebird *Fregata andrewsi* (2020a) Recovery Plan for the Christmas Island Frigatebird (*Fregeta andrewsi*) (2004)	Introduction of a new disease
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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
	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)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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	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
	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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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	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
	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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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) Approved Conservation Advice for *Limosa lapponica baueri* (Bar-tailed godwit (western Alaskan)) (2016)	Habitat loss and habitat degradation
			Over-exploitation of shellfish
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	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
			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		Ongoing human disturbance

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		Approved Conservation Advice *for Numenius madagascariensis* (eastern curlew) (2015)	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
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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) National recovery plan for threatened albatrosses and giant petrels 2011-2016 (2011)	Fisheries bycatch
			Disease
			Competition for nesting habitat
			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

Santos

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	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
			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
Mammals	Sei whale		Climate and oceanographic variability and change

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
		Approved Conservation Advice for *Balaenoptera borealis* (sei whale) (2015)	Anthropogenic noise and acoustic disturbance
			Habitat degradation including pollution (increasing port expansion and coastal development)
			Pollution (persistent toxic pollutants)
			Vessel strike
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			Climate variability and change
			Noise interference
			Habitat modification
			Overharvesting of prey
	Humpback whale	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (2015)	Whaling
			Climate and Oceanographic Variability and Change
			Overharvesting of Prey
			Noise Interference
			Habitat degradation including coastal development and port expansion
			Entanglement
			Vessel disturbance and strike
	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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
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)
			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)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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)
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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)
			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)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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)
			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)

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
			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)
			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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	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
			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

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
		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
	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

Taxa	Common name	Recovery Plan / Conservation Advice	Threats
	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.

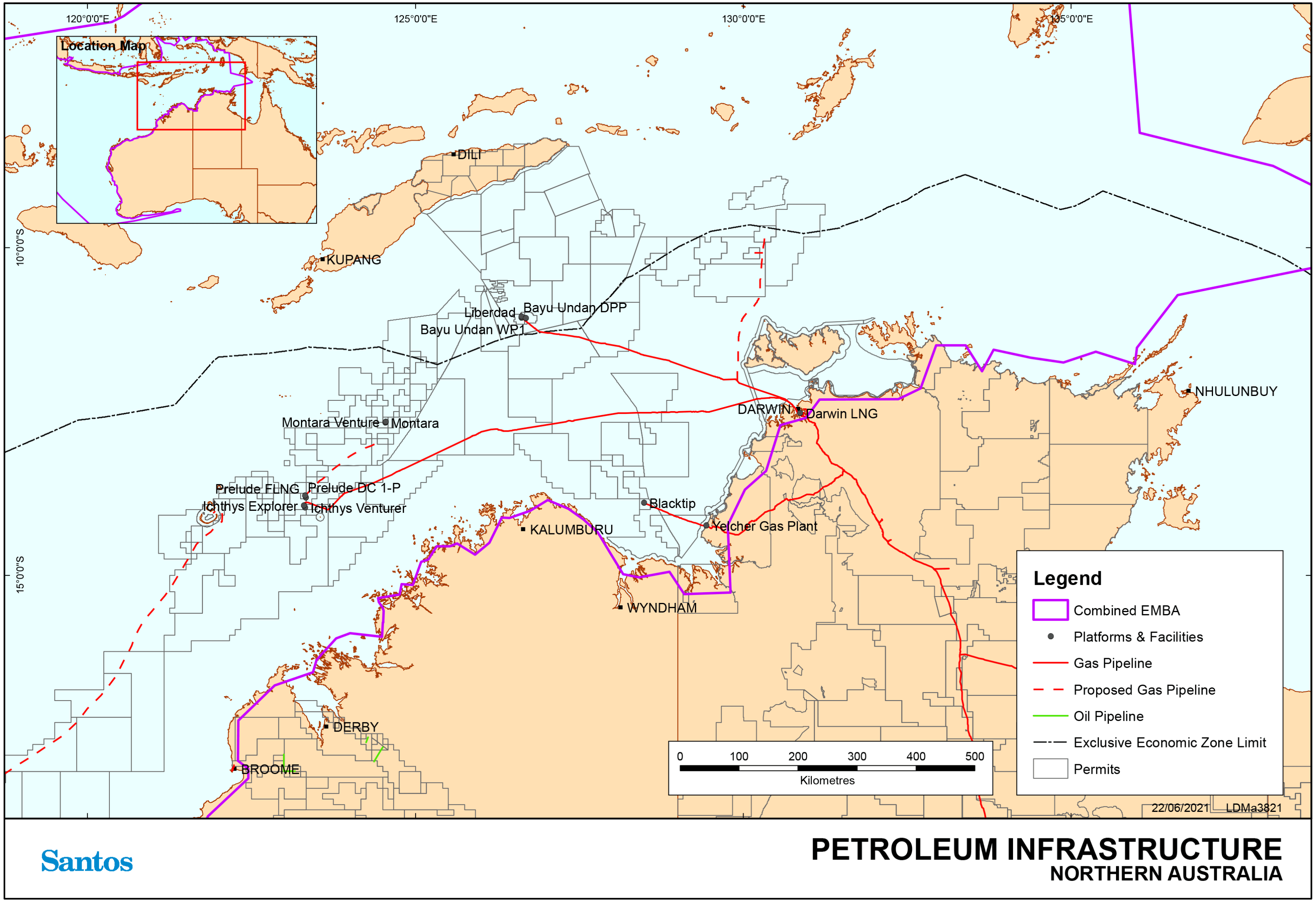

Figure 14-1: Existing petroleum infrastructure, permits and licences – Northern WA

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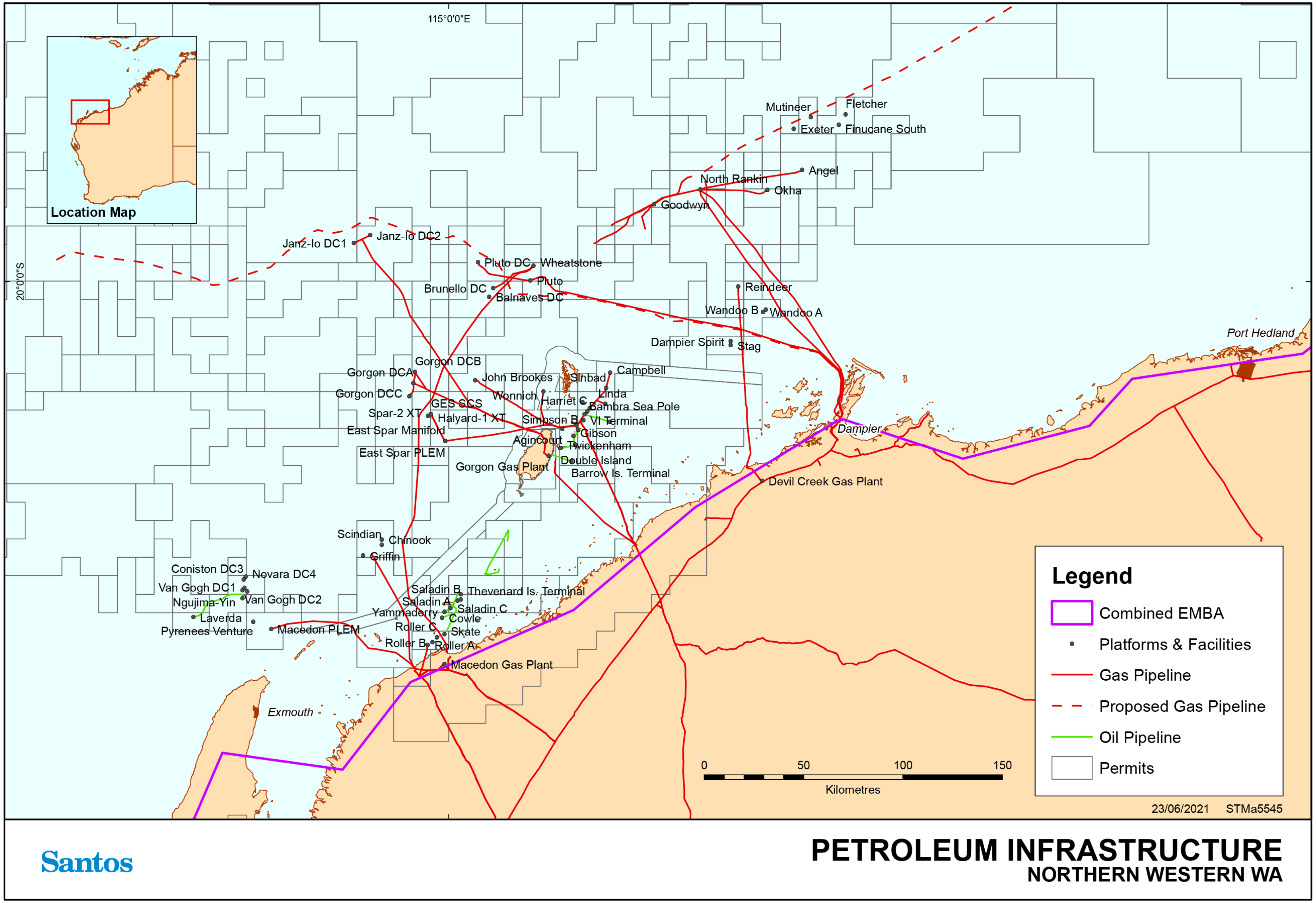

Figure 14-2: Existing petroleum infrastructure, permits and licences – Northern Western WA

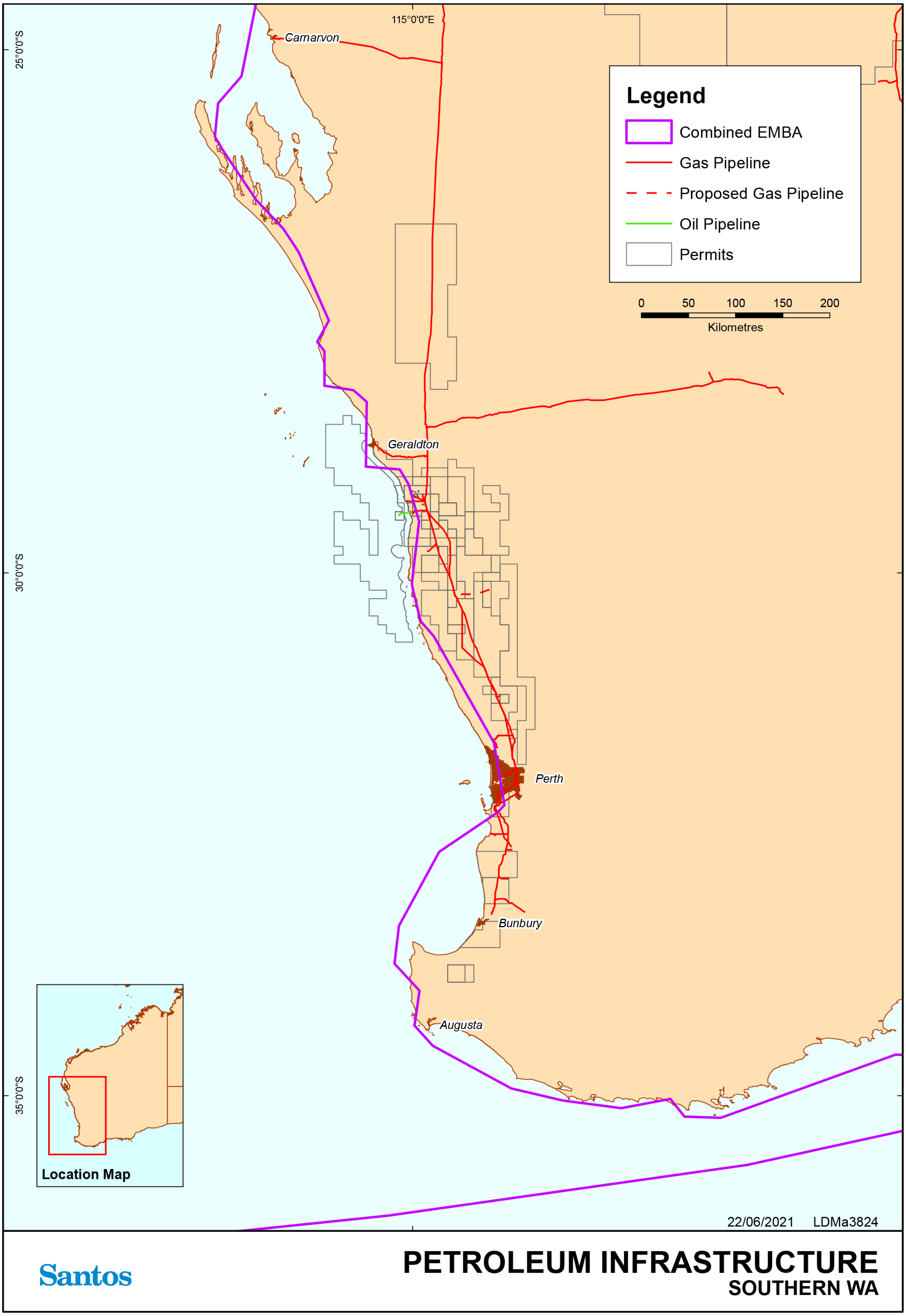

Figure 14-3: Existing petroleum infrastructure, permits and licences –Southern WA

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**.

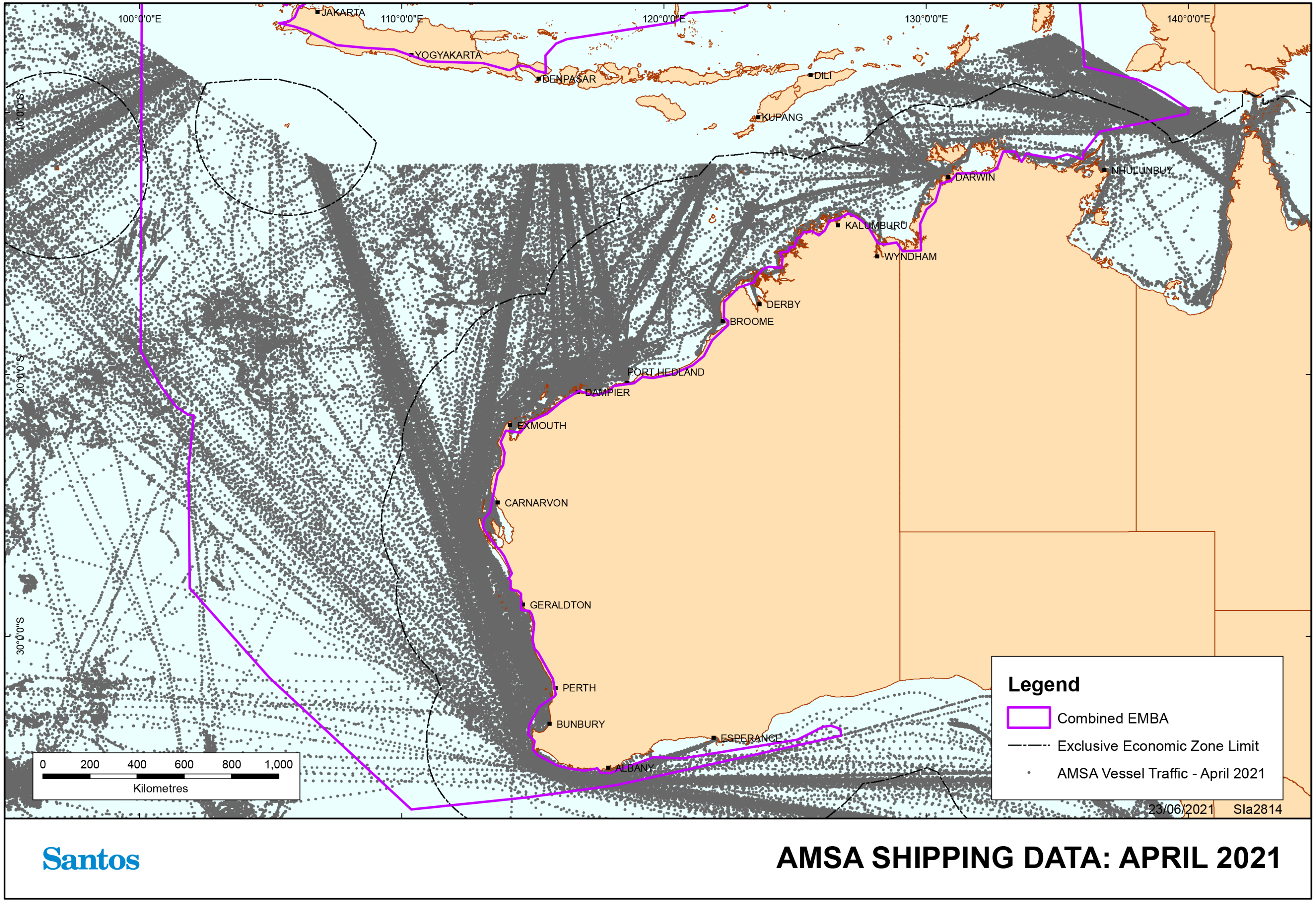

Figure 14-4:AMSA ship locations and shipping routes

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

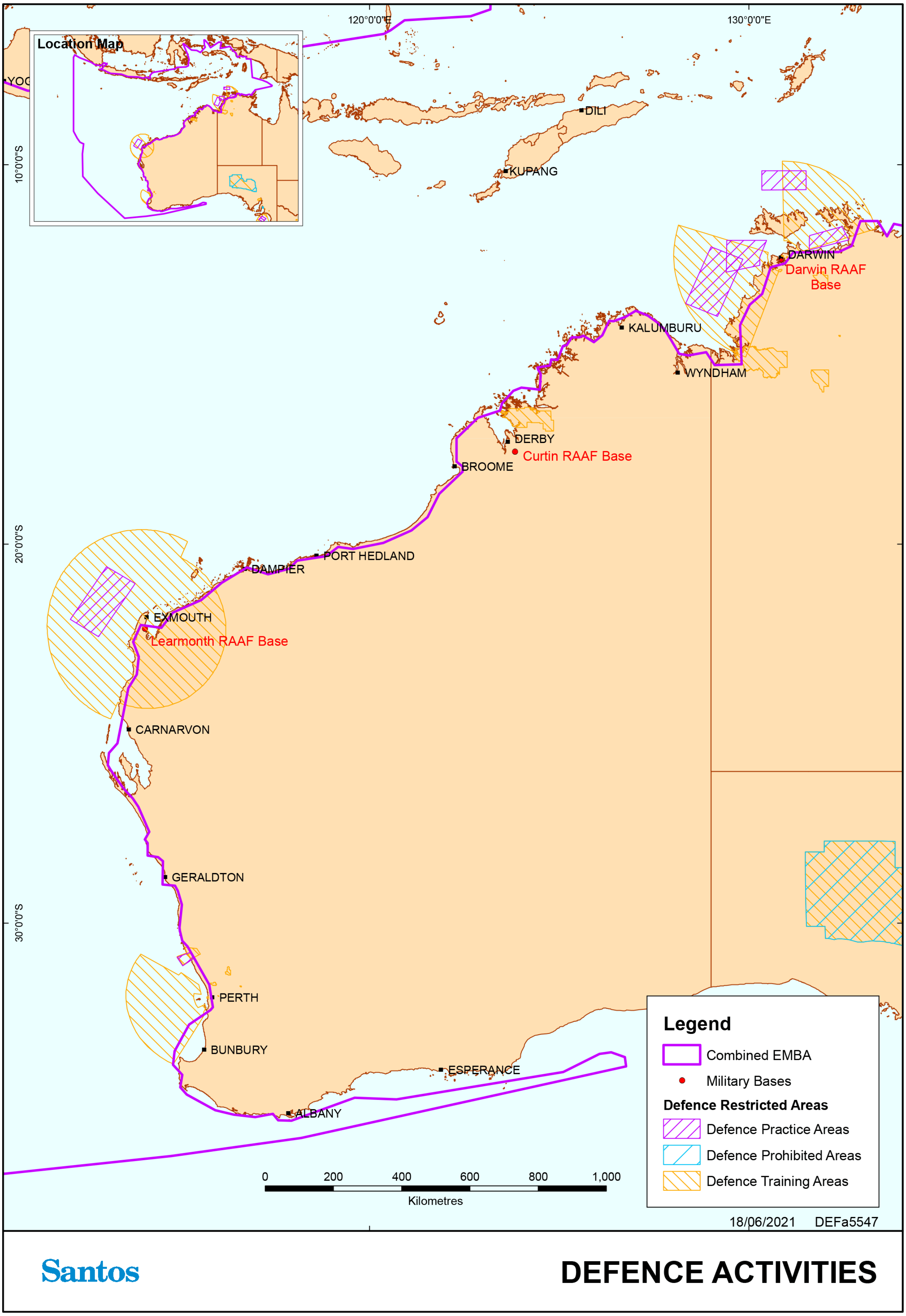

Figure 14-5: Defence activities

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.

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.

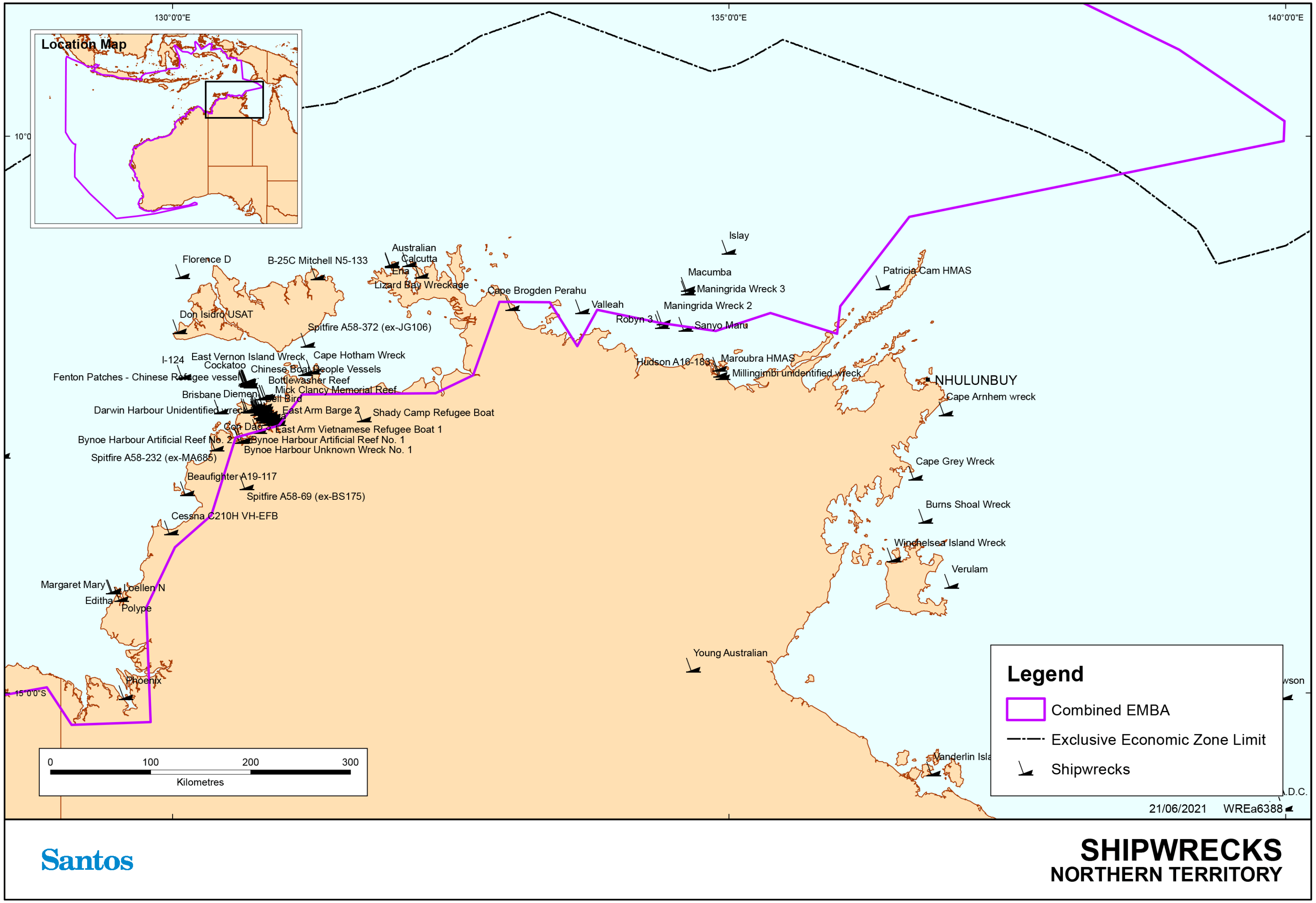

Figure 14-6: Shipwrecks –NT

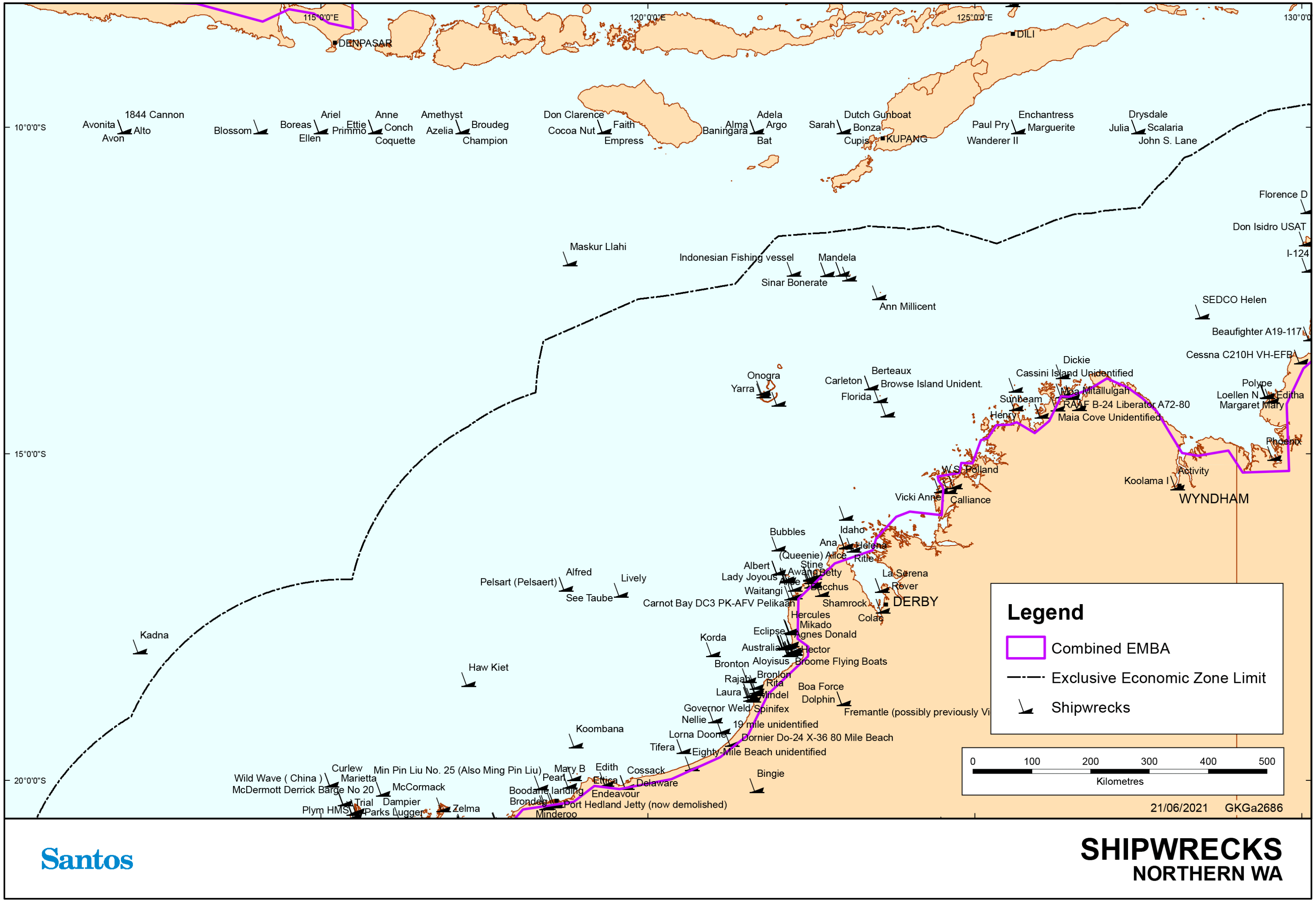

Figure 14-7: Shipwrecks – Northern WA

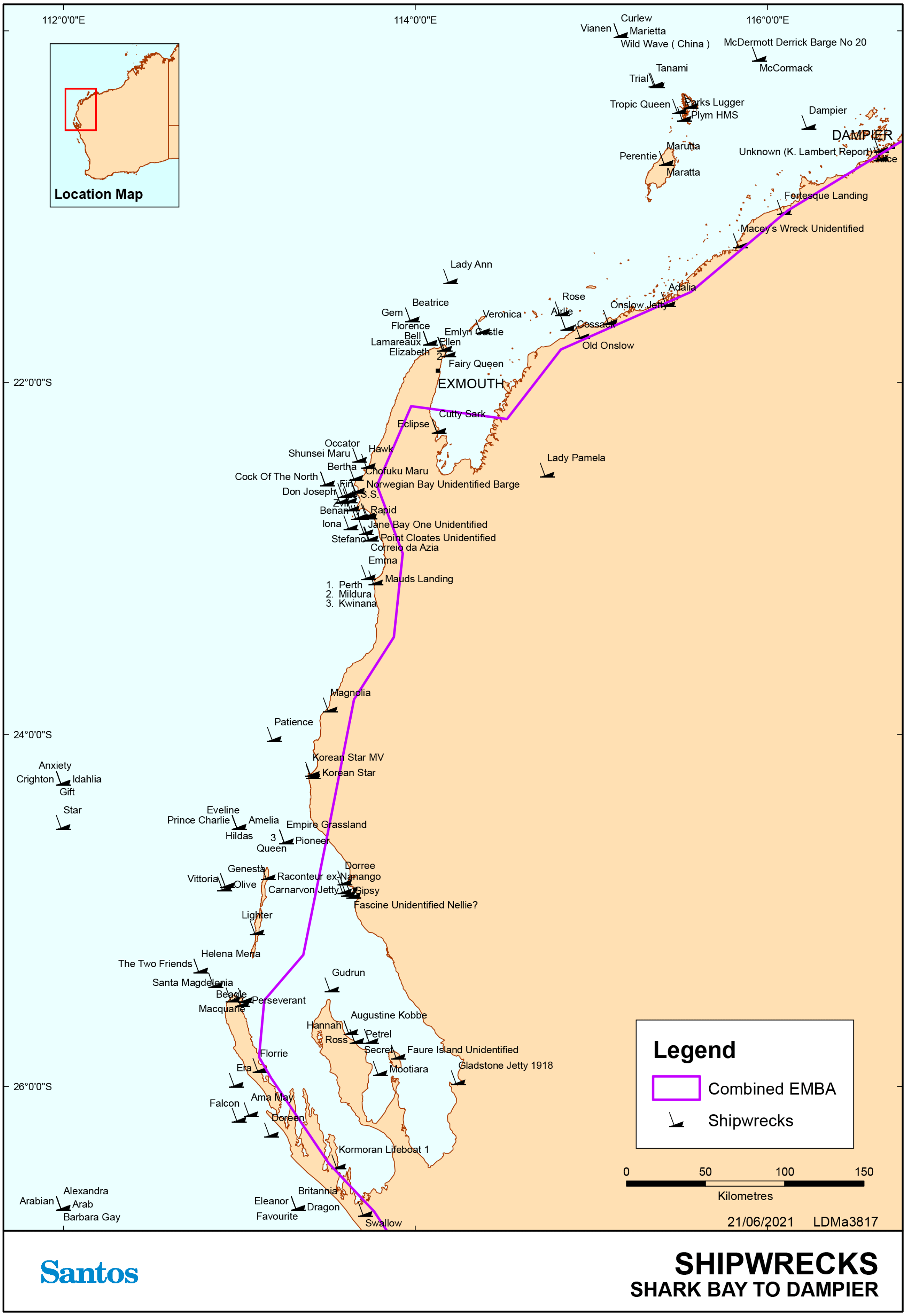

Figure 14-8: Shipwrecks – Shark Bay – Dampier

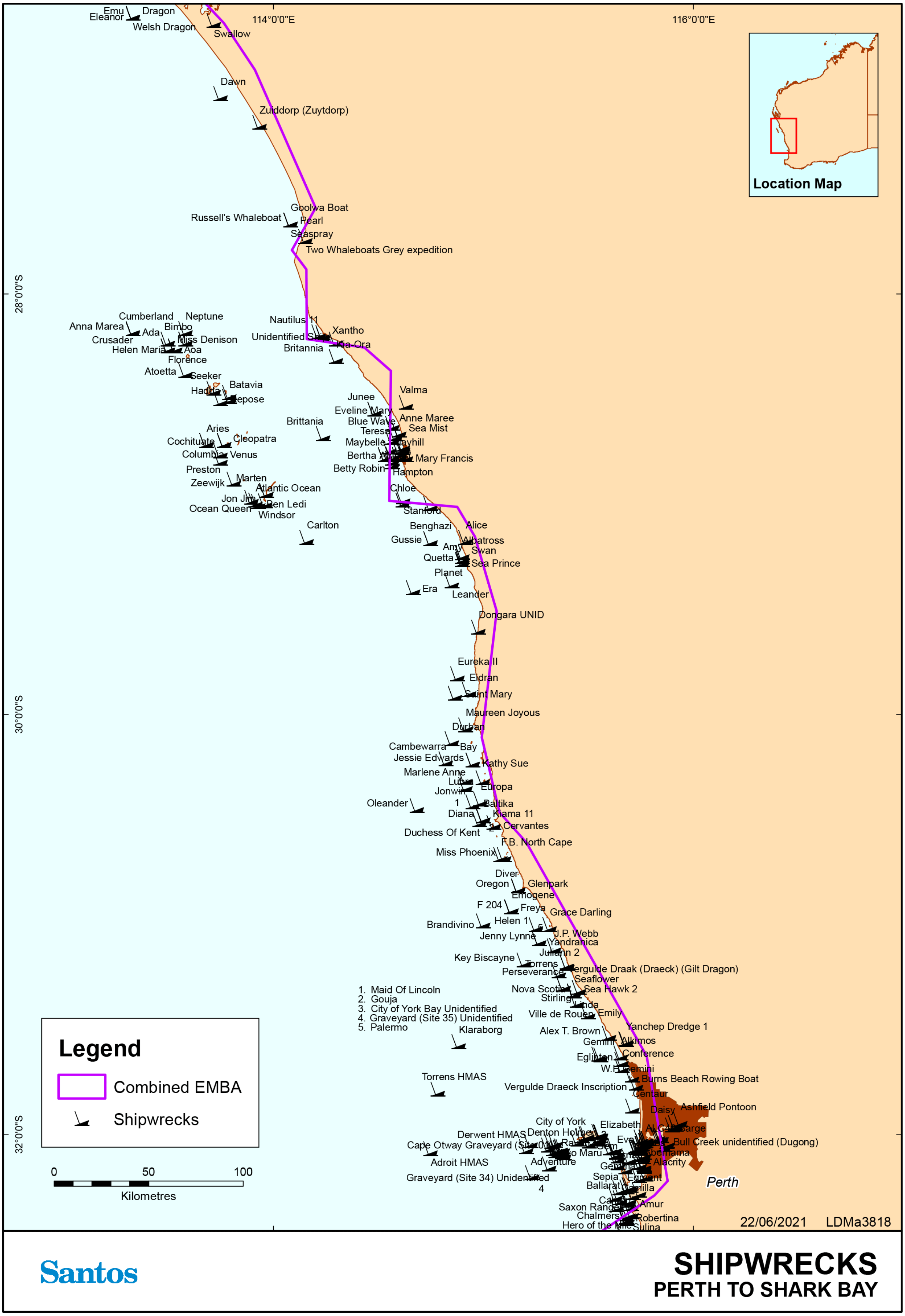

Figure 14-9: Shipwrecks – Perth – Shark Bay

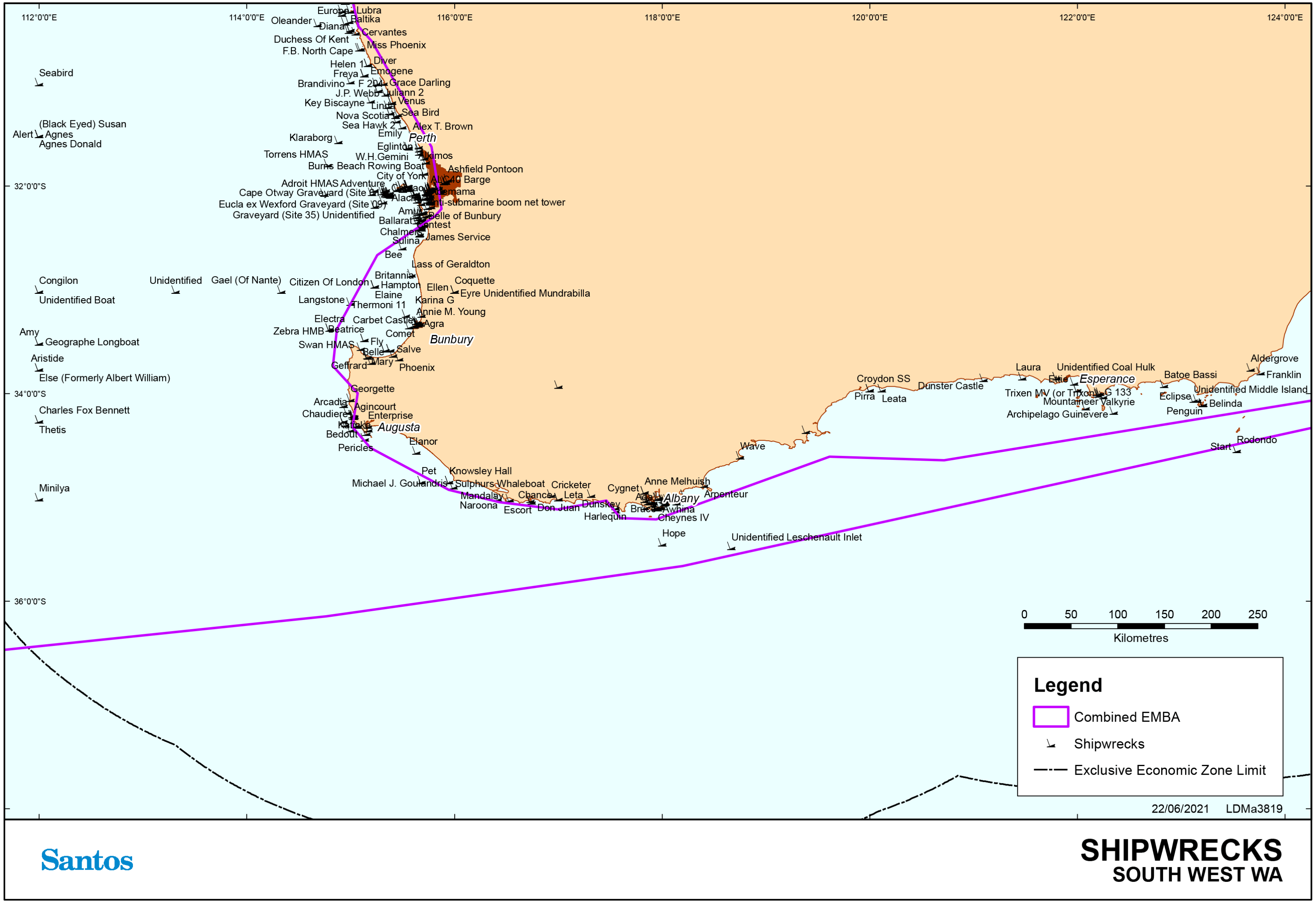

Figure 14-10: Shipwrecks – South West WA

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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[15]**;**
+ Northern Demersal Scalefish Managed Fishery (NDSF);
+ North Coast Traditional Trochus Fishery[15];
+ Pilbara Demersal Scalefish Fisheries[15]**;**
+ Pilbara Developing Crab Fishery[15]**;**
+ 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);
+ Western Australian Pearl Oyster Fishery – referred to as Pearl Oyster Managed Fishery in **Figure 14-12;**
+ Northern Shark Fisheries (closed[15]**)** including:

[15] Not shown in **Figure 14-12**

- Western Australian North Coast Shark Fishery[15]; and
- Joint Authority Northern Shark Fishery[15]
- North Coast Trochus Fishery[15]; and
- Pilbara Developing Crab Fishery[15].

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[15]**;**
- Shark Bay Crab Interim Managed Fishery; and
- Mackerel Fishery (Area 3 – Gascoyne/West Coast).

West Coast Bioregion

- Roe's Abalone[15]**;**
- 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[15]**;**
- Cockburn Sound Crab Managed Fishery[15]**;**
- Cockburn Sound Line and Pot Managed Fishery[15]**;**
- Cockburn Sound Mussel Managed Fishery[15]**;**

- Warnbro Sound Crab Managed Fishery (closed) [15]**;**
- West Coast Nearshore and Estuarine Finfish Fisheries, including:
- Cockburn Sound Fish Net Managed Fishery[15]**;**
- West Coast Beach Baited Managed Fishery[15]**;**
- South West Beach Seine Fishery[15]**;** and
- West Coast Estuarine Managed Fishery[15]**;**
- Temperate Demersal Gillnet and Demersal Longline Fisheries, including:
- West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (West Coast Bioregion) [15]**;**
- 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 [15]**;**
- Octopus Interim Managed Fishery [15]**;**
- West Coast Rock Lobster Managed Fishery; and
- West Coast Purse Seine Fishery [15]**.**

South Coast Bioregion

- Greenlip/Brownlip Abalone Fishery [15]**;**
- South Coast Crustacean Managed Fishery [15]**;**
- South Coast Deep-Sea Crab Fishery [15]**;**
- South Coast Estuarine Managed Fishery[15]**;**
- South Coast Open Access Netting Fishery [15]; and
- South West Coast Beach Net [15]**.**
- South Coast Salmon Managed Fishery;
- South Coast Trawl Fishery;
- South West Coast Salmon Managed Fishery [15]**;**
- 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 [15]**.**

Whole of State Fisheries

- Marine Aquarium Fish Managed Fishery (MAFMF);
- Specimen Shell Managed Fishery; and
- Hermit Crab Fishery (HCF) [15].

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 after recent funding to establish a South Coast Aquaculture Development Zone by DPIRD. An initial south coast aquaculture project aims to identify suitable areas for artificial farm structures to be constructed supporting shellfish production including abalone and edible oysters (Gaughan and Santoro 2020).

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.* 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. 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.

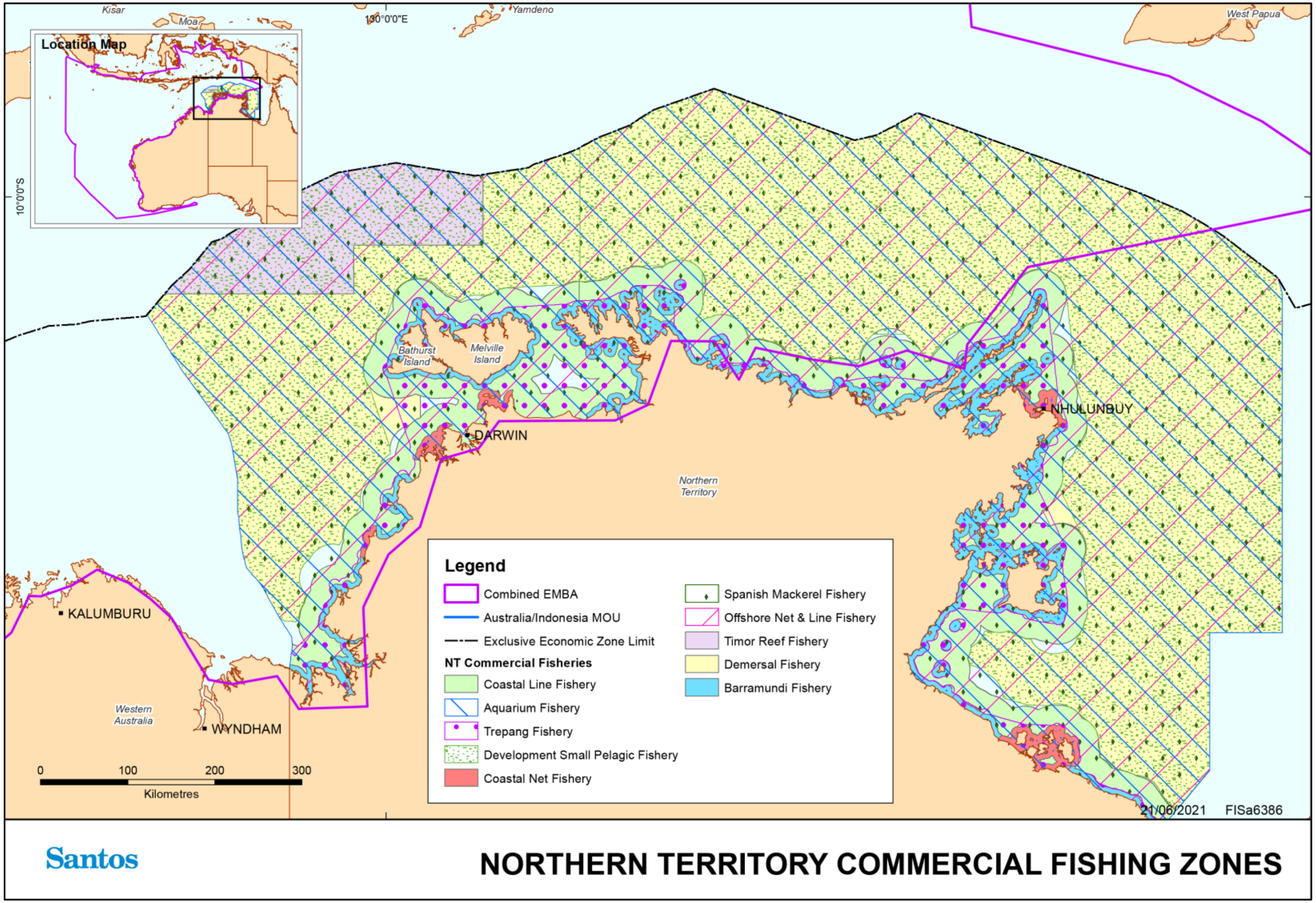

Figure 14-11:NT state commercial fishing zones

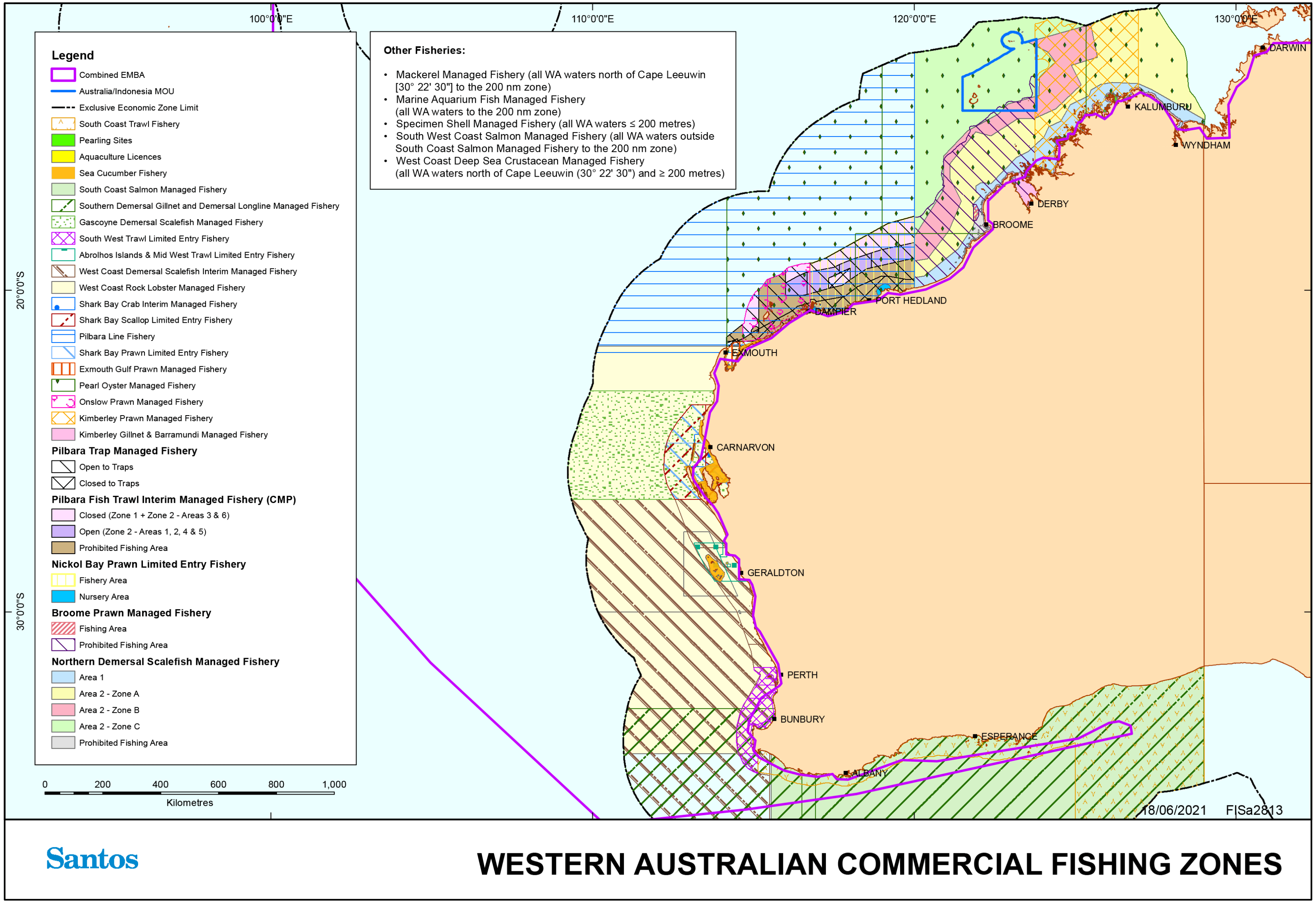

Figure 14-12: WA state commercial fishing zones

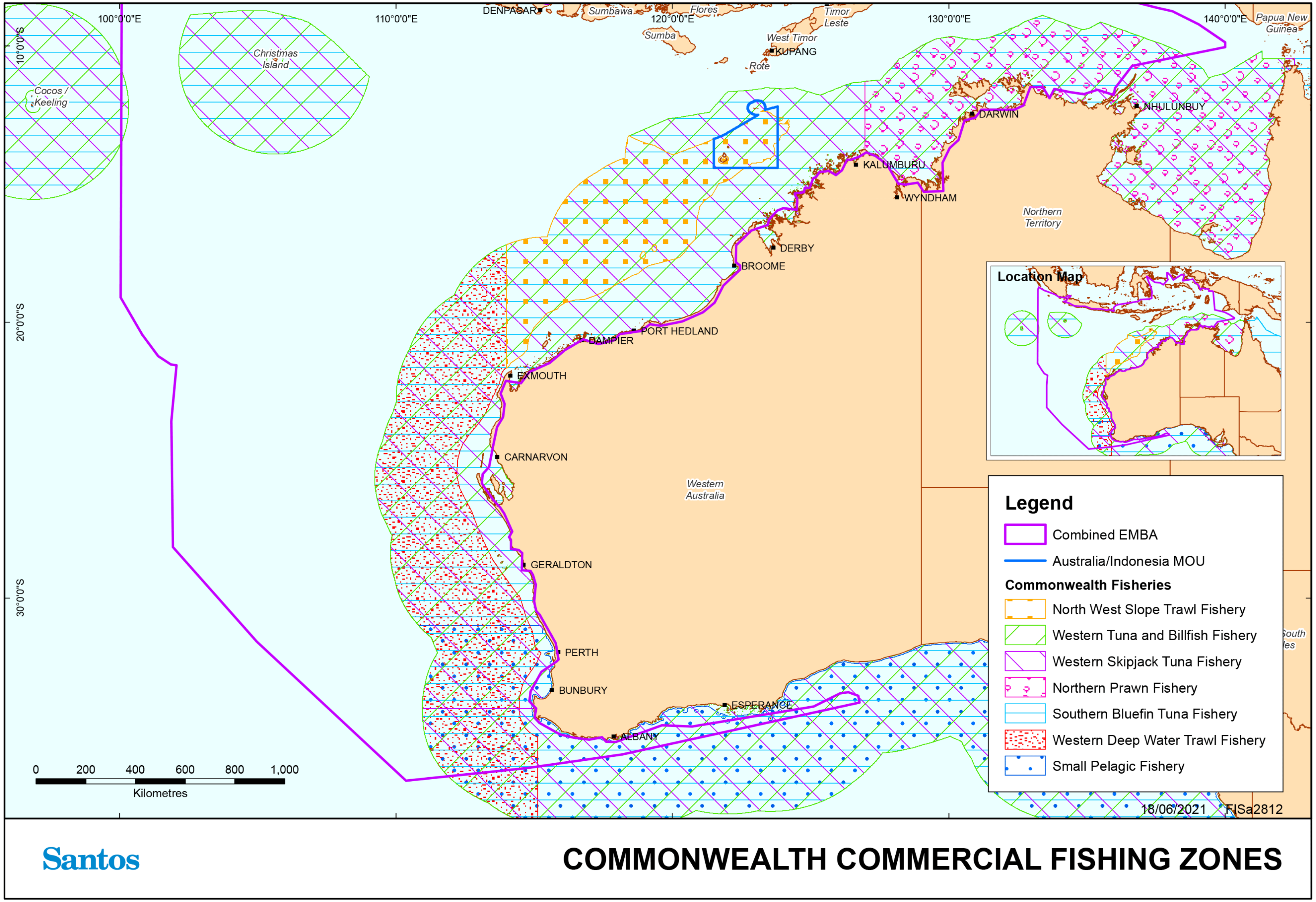

Figure 14-13: Commonwealth commercial fishing zones

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	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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			'iron' to prise the shellfish off rocks – both commercial and recreational divers employ this method.	greenlip/brownlip abalone is managed in three separate areas.
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*	2017/2018:	Line and pots	Fishery in development phase. Four main categories in WA waters. Octopus are

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
	in the northern parts of the fishery, and *O.maorum* in the southern and deeper sectors.	Commercial: 257 tonnes Recreational: 1 tonne	Trawl and trap (land Octopus as byproduct)	primarily caught in the Developing Octopus Interim 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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			Recreational fishers use drop nets or scoop nets, with diving for crabs becoming increasingly popular	recreational activity occurring in and around Nickol Bay.
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	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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
	(*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 snapper (*Argyrops spinifer*), Ruby snapper (*Etelis carbunculus*) and eightbar grouper (*Hyporthodus octofasciatus)*			isobath and seaward of a line generally following the 30 m isobath.
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	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
	endeavour prawns (*Metapenaeus* spp.) and coral prawns (various species).			
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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
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). 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.	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 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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
				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.
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*).	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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
	West Coast Offshore Demersals: Eightbar Grouper *Hyporthodus octofasciatus*, Hapuku *Polyprion oxygeneios*, Blue-eye Trevalla *Hyperoglyphe antarctica* and Ruby Snapper *Etelis carbunculus*.			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.
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*), sourthern 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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
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).
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).

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
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 legalised oysters by hand as they are seen.	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. 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				

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
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).
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.	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

Fishery	Target Species	Catch[1]	Fishing Method	Area Description
			Around 98% of Australia's SBT quota is taken by 5–10 purse seine vessels fishing for 13–25 kg southern bluefin tuna.	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, 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.

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.

Director of National Parks (DNP) 2012. Christmas Island National Park Management Plan 2014 – 2024.

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.

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

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

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 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.

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

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.

Pendretti 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.

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.

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

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.

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.

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

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.

16.6 Marine Reptiles

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

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.

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.

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

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 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.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.

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, Craig, Kowarski, Katie, Delarue, Julien, Whitt, Christopher, MacDonnell, Jeff, Martin, Bruce, 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.

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.

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].

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

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

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

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

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]

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.

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.

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)

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

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.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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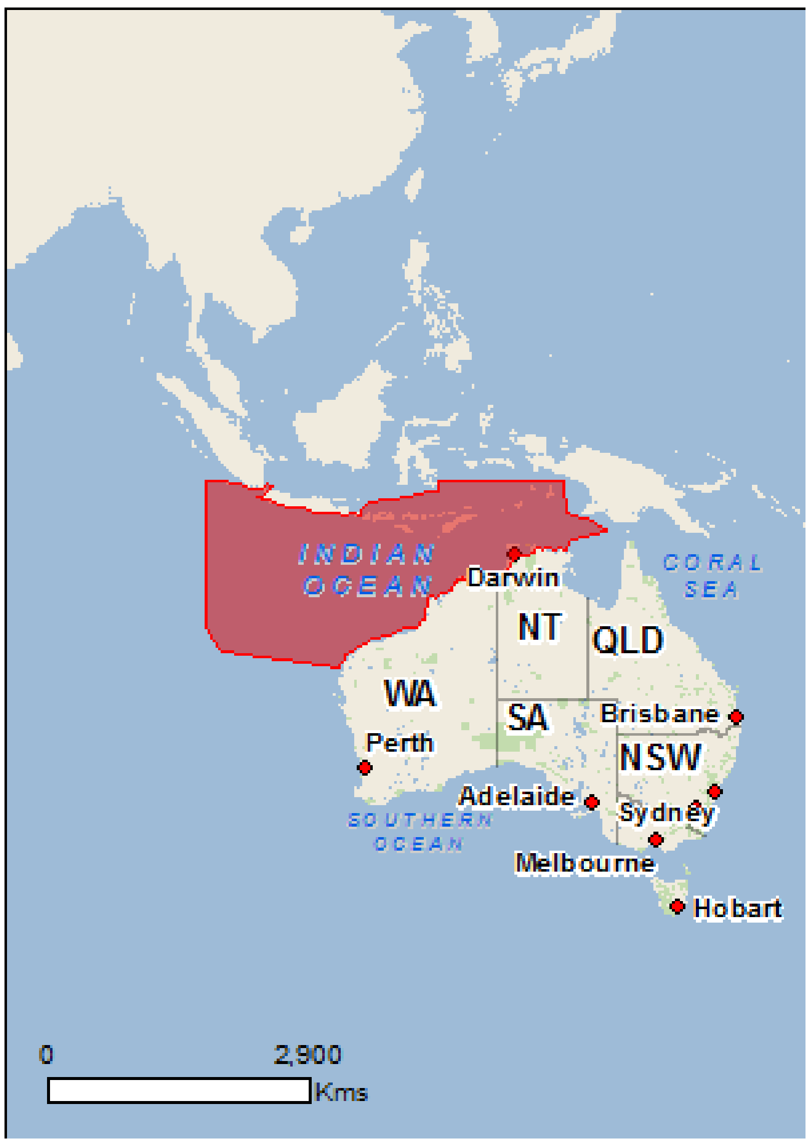

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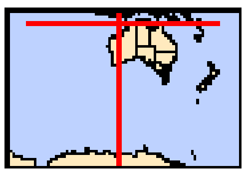

Summary

Matters of National Environmental 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:	2
National Heritage Places:	3
Wetlands of International Importance:	6
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	103
Listed Migratory Species:	92

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 http://www.environment.gov.au/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 Land:	33
Commonwealth Heritage Places:	23
Listed Marine Species:	164
Whales and Other Cetaceans:	32
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	2
Australian Marine Parks:	27

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	45
Regional Forest Agreements:	None
Invasive Species:	47
Nationally Important Wetlands:	17
Key Ecological Features (Marine)	17

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Kakadu National Park	NT	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Kakadu National Park	NT	Listed place
The Ningaloo Coast	WA	Listed place
The West Kimberley	WA	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Cobourg peninsula	Within Ramsar site
Hosnies spring	Within Ramsar site
Kakadu national park	Within Ramsar site
Ord river floodplain	Within Ramsar site
The dales	Within Ramsar site

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 the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North
North-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Accipiter hiogaster natalis		
Christmas Island Goshawk [82408]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Chalcophaps indica natalis Christmas Island Emerald Dove, Emerald Dove (Christmas Island) [67030]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Epthianura crocea tunneyi Alligator Rivers Yellow Chat, Yellow Chat (Alligator Rivers) [67089]	Endangered	Species or species habitat known to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Geophaps smithii smithii Partridge Pigeon (eastern) [64441]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Melanodryas cucullata melvillensis Tiwi Islands Hooded Robin, Hooded Robin (Tiwi	Critically Endangered	Species or species

Name	Status	Type of Presence
Islands) [67092]		habitat known to occur within area
Mirafra javanica melvillensis Horsfield's Bushlark (Tiwi Islands) [81011]	Vulnerable	Species or species habitat known to occur within area
Ninox natalis Christmas Island Hawk-Owl, Christmas Boobook [66671]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Pterodroma arminjoniana Round Island Petrel, Trinidade Petrel [89284]	Critically Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Turdus poliocephalus erythropleurus Christmas Island Thrush [67122]	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat known to occur within area
Tyto novaehollandiae melvillensis Tiwi Masked Owl, Tiwi Islands Masked Owl [26049]	Endangered	Species or species habitat known to occur within area
Fish		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Antechinus bellus Fawn Antechinus [344]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely

Name	Status	Type of Presence
		to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat known to occur within area
Crocidura trichura Christmas Island Shrew [86568]	Critically Endangered	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isoodon auratus auratus Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Breeding likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat known to occur within area
Mesembriomys gouldii melvillensis Black-footed Tree-rat (Melville Island) [87619]	Vulnerable	Species or species habitat known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Petrogale concinna canescens Nabarlek (Top End) [87606]	Endangered	Species or species habitat likely to occur within area
Petrogale concinna concinna Nabarlek (Victoria River District) [87605]	Critically Endangered	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Phascogale pirata Northern Brush-tailed Phascogale [82954]	Vulnerable	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat known to occur within area
Pteropus natalis Christmas Island Flying-fox, Christmas Island Fruit-bat [87611]	Critically Endangered	Roosting known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat known to occur within area
Sminthopsis butleri Butler's Dunnart [302]	Vulnerable	Species or species habitat known to occur within area
Trichosurus vulpecula arnhemensis Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat known to occur within area
Plants		
Asplenium listeri Christmas Island Spleenwort [65865]	Critically Endangered	Species or species habitat known to occur within area
Burmannia sp. Bathurst Island (R.Fensham 1021) [82017]	Endangered	Species or species habitat likely to occur within area
Hoya australis subsp. oramicola a vine [55436]	Vulnerable	Species or species habitat known to occur within area
Mitrella tiwiensis a vine [82029]	Vulnerable	Species or species habitat likely to occur within area
Pneumatopteris truncata fern [68812]	Critically Endangered	Species or species habitat known to occur within area
Stylidium ensatum a triggerplant [86366]	Endangered	Species or species habitat known to occur within area
Tectaria devexa [14767]	Endangered	Species or species habitat likely to occur within area
Typhonium jonesii a herb [62412]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Typhonium mirabile a herb [79227]	Endangered	Species or species habitat known to occur within area
Typhonium taylori a herb [65904]	Endangered	Species or species habitat likely to occur within area
Xylopia monosperma a shrub [82030]	Endangered	Species or species habitat known to occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat known to occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus egeriae Christmas Island Blue-tailed Skink, Blue-tailed Snake-eyed Skink [1526]	Critically Endangered	Species or species habitat likely to occur within area
Cryptoblepharus gurrmul Arafura Snake-eyed Skink [83106]	Endangered	Species or species habitat known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Cyrtodactylus sadleiri Christmas Island Giant Gecko [86865]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Lepidodactylus listeri Christmas Island Gecko, Lister's Gecko [1711]	Critically Endangered	Species or species habitat known to occur within area
Lucasium occultum Yellow-snouted Gecko, Yellow-snouted Ground Gecko [82993]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Ramphotyphlops exocoeti Christmas Island Blind Snake, Christmas Island Pink Blind Snake [1262]	Vulnerable	Species or species habitat likely to occur within area
Sharks		

Name	Status	Type of Presence
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Glyphis garricki		
Northern River Shark, New Guinea River Shark [82454]	Endangered	Breeding known to occur within area
Glyphis glyphis		
Speartooth Shark [82453]	Critically Endangered	Species or species habitat known to occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to 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

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Breeding known to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Ardenna pacifica		
Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata andrewsi		
Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia		
Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus		
Bridled Tern [82845]		Breeding known to occur within area

Name	Threatened	Type of Presence
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to 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 known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known 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
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to 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
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat known to occur within area
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat known to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis		
Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta		
Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius dubius		
Little Ringed Plover [896]		Roosting known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting known to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Australian Customs Service
Commonwealth Land - Australian Government Solicitor
Commonwealth Land - Christmas Island National Park
Commonwealth Land - Department of Administrative Services
Commonwealth Land - Department of Community Services & Health
Commonwealth Land - Department of Immigration Local Government & Ethnic Affairs
Commonwealth Land - Department of Transport & Regional Development
Commonwealth Land - Deputy Crown Solicitor
Commonwealth Land - Director of Property Services Defence Estate
Commonwealth Land - Kakadu National Park
Defence - AUSTRALIAN ARMY BAND - DARWIN
Defence - BERRIMAH ONE
Defence - BRADSHAW FIELD TRAINING AREA
Defence - DARWIN - AP10 RADAR SITE - LEE POINT
Defence - DARWIN - AP3 RECEIVING STATION - LEE POINT
Defence - DARWIN - TRANSMITTING STATION '11 MILE'
Defence - DARWIN RELOCATIONS CENTRE
Defence - DEFENCE FORCE CAREERS REFERENCE CENTRE
Defence - Esanda Builidng
Defence - HMAS COONAWARRA (Berrimah)
Defence - KOWANDI NORTH COMMUNICATION STATION
Defence - LARRAKEYAH BARRACKS
Defence - LEANYER BOMBING RANGE
Defence - MT GOODWIN RADAR SITE
Defence - Patrol Boat Base (DARWIN NAVAL BASE)
Defence - QUAIL ISLAND BOMBING RANGE
Defence - RAAF BASE DARWIN
Defence - ROBERTSON BARRACKS (Waler Barracks)
Defence - SHOAL BAY RECEIVING STATION
Defence - STOKES HILL OIL FUEL INSTALLATION
Defence - WINNELLIE ONE
Defence - WINNELLIE TWO

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Bradshaw Defence Area	NT	Listed place
Christmas Island Natural Areas	EXT	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Historic		
Administrators House Precinct	EXT	Listed place
Bungalow 702	EXT	Listed place
Drumsite Industrial Area	EXT	Listed place
Industrial and Administrative Group	EXT	Listed place
Larrakeyah Barracks Headquarters Building	NT	Listed place
Larrakeyah Barracks Precinct	NT	Listed place
Larrakeyah Barracks Sergeants Mess	NT	Listed place
Malay Kampong Group	EXT	Listed place
Malay Kampong Precinct	EXT	Listed place
Phosphate Hill Historic Area	EXT	Listed place
Poon Saan Group	EXT	Listed place
RAAF Base Commanding Officers Residence	NT	Listed place
RAAF Base Precinct	NT	Listed place
RAAF Base Tropical Housing Type 2	NT	Listed place
RAAF Base Tropical Housing Type 3	NT	Listed place

Name	State	Status
Settlement Christmas Island	EXT	Listed place
South Point Settlement Remains	EXT	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting known to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area

Name	Threatened	Type of Presence
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Roosting known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
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 latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Choeroichthys sculptus Sculptured Pipefish [66197]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		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
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Cosmocampus maxweberi Maxweber's Pipefish [66209]		Species or species habitat may occur within area
Doryrhamphus baldwini Redstripe Pipefish [66718]		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
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus macrorhynchus Whiskered Pipefish, Ornate Pipefish [66222]		Species or species habitat may occur within area
Halicampus mataafae Samoan Pipefish [66223]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
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 cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys parvicarinatus Short-keel Pipefish, Short-keeled Pipefish [66230]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippichthys spicifer Belly-barred Pipefish, Banded Freshwater Pipefish [66232]		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

Name	Threatened	Type of Presence
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		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
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
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Hydrophis pacificus Large-headed Seasnake, Pacific Seasnake [1112]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Parahydrophis mertoni Northern Mangrove Seasnake [1090]		Species or species habitat may occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area

Name	Status	Type of Presence
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Christmas Island	EXT	National Park (Commonwealth)
Kakadu	NT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label
Arafura	Multiple Use Zone (IUCN VI)
Arafura	Special Purpose Zone (IUCN VI)
Arafura	Special Purpose Zone (Trawl) (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Arnhem	Special Purpose Zone (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Cartier Island	Sanctuary Zone (IUCN Ia)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Oceanic Shoals	Habitat Protection Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	National Park Zone (IUCN II)
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Balanggarra	WA
Bardi Jawi	WA
Barrow Island	WA
Bedout Island	WA
Boodie, Double Middle Islands	WA
Browse Island	WA
Buffalo Creek	NT
Cape Range	WA
Casuarina	NT
Channel Point	NT
Charles Darwin	NT

Name	State
Dambimangari	WA
Djukbinj	NT
Garig Gunak Barlu	NT
George Brown Darwin	NT
Holmes Jungle	NT
Howard Springs	NT
Howard Springs	NT
Keep River	NT
Knuckey Lagoons	NT
Lawley River	WA
Lesueur Island	WA
Low Rocks	WA
Lowendal Islands	WA
Marri-Jabin (Thamurrurr - Stage 1)	NT
Marthakal	NT
Mary River	NT
Mijing	WA
Mitchell River	WA
Montebello Islands	WA
Niiwalarra Islands	WA
Ord River	WA
Pelican Island	WA
Shoal Bay	NT
Swan Island	WA
Tree Point Conservation Area	NT
Unnamed WA28968	WA
Unnamed WA40828	WA
Unnamed WA41080	WA
Unnamed WA41775	WA
Unnamed WA44672	WA
Unnamed WA44673	WA
Unnamed WA44677	WA
Uunguu	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Gallus gallus Red Junglefowl, Feral Chicken, Domestic Fowl [917]		Species or species habitat likely to occur within area
Lonchura oryzivora Java Sparrow [59586]		Species or species habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos javanicus Banteng, Bali Cattle [15]		Species or species habitat likely to occur within area
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus exulans Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Annona glabra Pond Apple, Pond-apple Tree, Alligator Apple, Bullock's Heart, Cherimoya, Monkey Apple, Bobwood, Corkwood [6311]		Species or species habitat may occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Mimosa pigra Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pennisetum polystachyon Mission Grass, Perennial Mission Grass, Missiongrass, Feathery Pennisetum, Feather Pennisetum, Thin Napier Grass, West Indian Pennisetum, Blue Buffel Grass [21194]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lepidodactylus lugubris Mourning Gecko [1712]		Species or species habitat likely to occur within area
Lycodon aulicus Wolf Snake, Common Wolf Snake, Asian Wolf Snake [83178]		Species or species habitat likely to occur within area
Lygosoma bowringii Christmas Island Grass-skink [1312]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
"The Dales", Christmas Island	EXT
Adelaide River Floodplain System	NT
Ashmore Reef	EXT
Cape Range Subterranean Waterways	WA
Cobourg Peninsula System	NT
Daly-Reynolds Floodplain-Estuary System	NT
Finniss Floodplain and Fog Bay Systems	NT
Hosine's Spring, Christmas Island	EXT
Kakadu National Park	NT
Legune Wetlands	NT
Mary Floodplain System	NT
Mermaid Reef	EXT
Moyle Floodplain and Hyland Bay System	NT
Murgenella-Cooper Floodplain System	NT
Ord Estuary System	WA
Port Darwin	NT
Shoal Bay - Micket Creek	NT

Key Ecological Features (Marine) [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
Carbonate bank and terrace system of the Van	North
Gulf of Carpentaria basin	North
Pinnacles of the Bonaparte Basin	North
Shelf break and slope of the Arafura Shelf	North
Tributary Canyons of the Arafura Depression	North
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Pinnacles of the Bonaparte Basin	North-west
Seringapatam Reef and Commonwealth waters in	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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 distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for 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 reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-7.36981 115.89261,-7.19135 116.29949,-6.55485 120.37194,-6.45848 120.55397,-6.19436 120.92517,-6.09044 122.66372,-5.91198 123.1872,-5.19516 123.20505,-5.0 123.30171,-5.0 135.75335,-8.24306 136.04424,-8.60962 137.51393,-8.75048 138.07868,-9.22161 139.04237,-9.86407 139.99177,-10.04253 139.98463,-10.72382 136.62178,-11.52618 135.99955,-11.77364 135.96981,-11.58685 135.37375,-11.74851 134.8812,-11.67712 134.38627,-11.55815 133.8152,-11.88652 133.63912,-11.48968 133.38979,-11.48677 132.93956,-12.14826 132.70162,-12.30784 132.365,-12.31736 131.16575,-12.59747 130.95403,-12.70638 130.56727,-13.40612 130.3488,-13.69213 130.02282,-14.23465 129.76584,-15.26257 129.80391,-15.28538 129.09681,-14.94928 128.87374,-15.03207 128.41037,-14.98497 128.16585,-14.62508 127.94872,-14.35212 127.78478,-14.14918 127.56355,-13.98357 127.33702,-13.84842 127.01722,-14.01273 126.7518,-14.12444 126.43663,-14.11902 126.31522,-14.49944 126.13206,-14.68485 125.91315,-14.51543 125.63714,-14.55422 125.52746,-14.55822 125.32684,-14.75504 125.19884,-14.81285 125.02928,-14.97063 124.91824,-15.02928 124.81225,-15.29304 124.7617,-15.34812 124.43249,-15.71938 124.51209,-15.84727 124.1046,-15.85025 123.58112,-16.31722 123.12308,-16.43833 122.97091,-16.30699 122.7639,-16.31841 122.51405,-16.58681 122.22566,-16.84665 122.02293,-18.11788 121.96844,-18.38967 121.84471,-18.49318 121.56274,-19.1856 121.16656,-19.32182 119.91259,-20.05946 118.11371,-20.23125 117.09824,-20.27051 116.58428,-20.6203 116.24164,-21.34484 115.08522,-21.58695 114.57006,-21.61586 114.38411,-21.70533 114.09667,-21.81336 113.98512,-21.90758 113.92516,-22.26736 113.89946,-22.41013 113.67246,-22.97204 113.32089,-21.53425 101.85645,-21.22968 101.3996,-20.44921 100.82852,-19.1072 100.04806,-5.0 100.09375,-5.0 101.31603,-5.13788 103.52417,-5.69943 104.43788,-5.75654 105.3516,-5.90168 105.61809,-5.59254 105.83277,-5.32348 106.26055,-5.43055 106.79236,-5.54834 106.78165,-5.99448 106.07852,-6.3514 105.92861,-6.52077 105.69911,-6.59054 105.32899,-6.71546 105.90363,-6.87964 106.41045,-6.99029 106.6139,-7.4293 107.52047,-7.52805 108.64596,-7.58515 109.71196,-8.04867 111.00163,-8.10578 113.10031,-8.38465 114.10801,-8.1943 114.5149,-8.25854 114.89323,-8.40488 115.12166,-8.48697 115.49286,-7.81953 115.47858,-7.36981 115.89261

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.

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Australian Government

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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.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

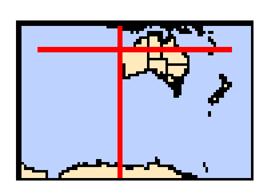
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 18/12/20 15:00:04

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2015

Coordinates

Buffer: 0.0Km



Summary

Matters of National Environmental 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:	4
National Heritage Places:	9
Wetlands of International Importance:	8
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	10
Listed Threatened Species:	175
Listed Migratory Species:	110

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 http://www.environment.gov.au/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 Land:	18
Commonwealth Heritage Places:	24
Listed Marine Species:	215
Whales and Other Cetaceans:	44
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	1
Australian Marine Parks:	44

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	144
Regional Forest Agreements:	1
Invasive Species:	65
Nationally Important Wetlands:	27
Key Ecological Features (Marine)	23

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Australian Convict Sites (Fremantle Prison Buffer Zone)	WA	Buffer zone
Australian Convict Sites (Fremantle Prison)	WA	Declared property
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
Lesueur National Park	WA	Listed place
Shark Bay, Western Australia	WA	Listed place
The Ningaloo Coast	WA	Listed place
The West Kimberley	WA	Listed place
Indigenous		
Dampier Archipelago (including Burrup Peninsula)	WA	Listed place
Historic		
Batavia Shipwreck Site and Survivor Camps Area 1629 - Houtman Abrolhos	WA	Listed place
Dirk Hartog Landing Site 1616 - Cape Inscription Area	WA	Listed place
Fremantle Prison (former)	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Becher point wetlands	Within 10km of Ramsar
Eighty-mile beach	Within Ramsar site
Forrestdale and thomsons lakes	Within Ramsar site
Hosnies spring	Within Ramsar site
Peel-yalgorup system	20 - 30km upstream
Roebuck bay	Within Ramsar site
The dales	Within Ramsar site

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 the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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.

Name	Status	Type of Presence
Aquatic Root Mat Community 3 in Caves of the	Endangered	Community known to

Name	Status	Type of Presence
Leeuwin Naturaliste Ridge		occur within area
Aquatic Root Mat Community 4 in Caves of the Leeuwin Naturaliste Ridge	Endangered	Community known to occur within area
Aquatic Root Mat Community in Caves of the Swan Coastal Plain	Endangered	Community known to occur within area
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area
Proteaceae Dominated Kwongkan Shrublands of the Southeast Coastal Floristic Province of Western Australia	Endangered	Community may occur within area
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community known to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond)	Endangered	Community known to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area

Listed Threatened Species

[Resource Information]

Name	Status	Type of Presence
Birds		
Accipiter hiogaster natalis		
Christmas Island Goshawk [82408]	Endangered	Species or species habitat known to occur within area
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calyptorhynchus banksii naso		
Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii		
Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Breeding known to occur within area
Calyptorhynchus latirostris		
Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding known to occur within area
Cereopsis novaehollandiae grisea		
Cape Barren Goose (south-western), Recherche Cape Barren Goose [25978]	Vulnerable	Species or species habitat likely to occur within area
Chalcophaps indica natalis		
Christmas Island Emerald Dove, Emerald Dove (Christmas Island) [67030]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus		
Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area

Name	Status	Type of Presence
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island),	Vulnerable	Species or species

Name	Status	Type of Presence
Dirk Hartog Black-and-White Fairy-wren [26004]		habitat likely to occur within area
Ninox natalis Christmas Island Hawk-Owl, Christmas Boobook [66671]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Turdus poliocephalus erythropleurus Christmas Island Thrush [67122]	Endangered	Species or species habitat likely to occur within area
Turnix varius scintillans Painted Button-quail (Houtman Abrolhos) [82451]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Crustaceans		
Cherax tenuimanus Hairy Marron, Margaret River Hairy Marron, Margaret River Marron [78931]	Critically Endangered	Species or species habitat may occur within area
Fish		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Nannatherina balstoni Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Insects		
Hesperocolletes douglasi Douglas' Broad-headed Bee, Rottnest Bee [66734]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat known to occur within area
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat likely to occur within area
Crocidura trichura Christmas Island Shrew [86568]	Critically Endangered	Species or species habitat likely to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area

Name	Status	Type of Presence
Isoodon auratus auratus Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus bernieri Rufous Hare-wallaby (Bernier Island) [66662]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus dorreae Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur within area
Lagostrophus fasciatus fasciatus Banded Hare-wallaby, Merrnine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Breeding known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Parantechinus apicalis Dibbler [313]	Endangered	Species or species habitat known to occur within area
Perameles bougainville bougainville Western Barred Bandicoot (Shark Bay) [66631]	Endangered	Species or species habitat known to occur within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat likely to occur within area
Pipistrellus murrayi Christmas Island Pipistrelle [64383]	Critically Endangered	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Pseudomys fieldi Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Pteropus natalis Christmas Island Flying-fox, Christmas Island Fruit-bat [87611]	Critically Endangered	Roosting known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat known to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Other		
Idiosoma nigrum Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat known to occur within area
Kumonga exleyi Cape Range Remipede [86875]	Vulnerable	Species or species habitat known to occur within area
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Androcalva bivillosa Straggling Androcalva [87807]	Critically Endangered	Species or species habitat likely to occur within area
Anigozanthos viridis subsp. terraspectans Dwarf Green Kangaroo Paw [3435]	Vulnerable	Species or species habitat likely to occur within area
Asplenium listeri Christmas Island Spleenwort [65865]	Critically Endangered	Species or species habitat known to occur within area
Banksia nivea subsp. uliginosa Swamp Honeypot [82766]	Endangered	Species or species habitat may occur within area
Banksia squarrosa subsp. argillacea Whicher Range Dryandra [82769]	Vulnerable	Species or species habitat may occur within area
Beyeria lepidopetala Small-petalled Beyeria, Short-petalled Beyeria [18362]	Endangered	Species or species habitat likely to occur within area
Caladenia barbarella Small Dragon Orchid, Common Dragon Orchid [68686]	Endangered	Species or species habitat may occur within area
Caladenia bryceana subsp. cracens Northern Dwarf Spider-orchid [64556]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Caladenia elegans Elegant Spider-orchid [56775]	Endangered	Species or species habitat known to occur within area
Caladenia excelsa Giant Spider-orchid [56717]	Endangered	Species or species habitat likely to occur within area
Caladenia hoffmanii Hoffman's Spider-orchid [56719]	Endangered	Species or species habitat known to occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Caladenia lodgeana Lodge's Spider-orchid [68664]	Critically Endangered	Species or species habitat likely to occur within area
Calectasia cyanea Blue Tinsel Lily [7669]	Critically Endangered	Species or species habitat likely to occur within area
Chorizema varium Limestone Pea [16981]	Endangered	Species or species habitat known to occur within area
Conostylis dielsii subsp. teres Irwin's Conostylis [3614]	Endangered	Species or species habitat may occur within area
Conostylis micrantha Small-flowered Conostylis [17635]	Endangered	Species or species habitat may occur within area
Diuris drummondii Tall Donkey Orchid [4365]	Vulnerable	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea concolor Kneeling Hammer-orchid [56777]	Vulnerable	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Drummondita ericoides Morseby Range Drummondita [9193]	Endangered	Species or species habitat may occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Eucalyptus beardiana Beard's Mallee [18933]	Vulnerable	Species or species habitat may occur within area
Eucalyptus cuprea Mallee Box [56773]	Endangered	Species or species habitat likely to occur within area
Gastrolobium papilio Butterfly-leaved Gastrolobium [78415]	Endangered	Species or species habitat may occur within area
Grevillea batrachioides Mt Lesueur Grevillea [21735]	Endangered	Species or species habitat may occur within area
Grevillea humifusa Spreading Grevillea [61182]	Endangered	Species or species habitat may occur within area
Hemiandra gardneri Red Snakebush [7945]	Endangered	Species or species habitat likely to occur within area
Isopogon uncinatus Albany Cone Bush, Hook-leaf Isopogon [20871]	Endangered	Species or species habitat likely to occur within area
Kennedia glabrata Northcliffe Kennedia [16452]	Vulnerable	Species or species habitat likely to occur within area
Lambertia echinata subsp. occidentalis Western Prickly Honeysuckle [64528]	Endangered	Species or species habitat may occur within area
Lechenaultia chlorantha Kalbarri Leschenaultia [16763]	Vulnerable	Species or species habitat likely to occur within area
Leucopogon marginatus Thick-margined Leucopogon [12527]	Endangered	Species or species habitat likely to occur within area
Leucopogon obtectus Hidden Beard-heath [19614]	Endangered	Species or species habitat may occur within area
Macarthuria keigheryi Keighery's Macarthuria [64930]	Endangered	Species or species habitat likely to occur within area
Marianthus paralius [83925]	Endangered	Species or species habitat known to occur within area
Melaleuca sp. Wanneroo (G.J. Keighery 16705) [89456]	Endangered	Species or species habitat known to occur within area
Paracaleana dixonii Sandplain Duck Orchid [86882]	Endangered	Species or species habitat known to occur within area
Pityrodia augustensis Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Pneumatopteris truncata fern [68812]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pterostylis sinuata Northampton Midget Greenhood, Western Swan Grrenhood [84991]	Endangered	Species or species habitat known to occur within area
Seringia exastia Fringed Fire-bush [88920]	Critically Endangered	Species or species habitat known to occur within area
Sphenotoma drummondii Mountain Paper-heath [21160]	Endangered	Species or species habitat may occur within area
Stachystemon nematophorus Three-flowered Stachystemon [81447]	Vulnerable	Species or species habitat may occur within area
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat may occur within area
Tectaria devexa [14767]	Endangered	Species or species habitat likely to occur within area
Tetratheca nephelioides [83217]	Critically Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area
Wurmbea tubulosa Long-flowered Nancy [12739]	Endangered	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Cryptoblepharus egeriae Christmas Island Blue-tailed Skink, Blue-tailed Snake-eyed Skink [1526]	Critically Endangered	Species or species habitat likely to occur within area
Ctenotus lancelini Lancelin Island Skink [1482]	Vulnerable	Species or species habitat known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Cyrtodactylus sadleiri Christmas Island Giant Gecko [86865]	Endangered	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-	Endangered	Species or species

Name	Status	Type of Presence
tailed Skink [64483]		habitat known to occur within area
Emoia nativitatis Christmas Island Forest Skink, Christmas Island Whiptail-skink [1400]	Critically Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lepidodactylus listeri Christmas Island Gecko, Lister's Gecko [1711]	Critically Endangered	Species or species habitat known to occur within area
Lerista nevinae Nevin's Slider [85296]	Endangered	Species or species habitat known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Liopholis pulchra longicauda Jurien Bay Skink, Jurien Bay Rock-skink [83162]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Ramphotyphlops exocoeti Christmas Island Blind Snake, Christmas Island Pink Blind Snake [1262]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Breeding likely to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Breeding known to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat may occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Ardenna tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area

Name	Threatened	Type of Presence
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Breeding known to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known 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
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat known to occur within area
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis		
Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba		
Sanderling [875]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Commonwealth Land - Christmas Island National Park
Defence - ARTILLERY BARRACKS - FREMANTLE
Defence - BROOME TRAINING DEPOT
Defence - CAMPBELL BARRACKS - SWANBOURNE
Defence - EAST FREMANTLE SMALL CRAFT BASE
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - HMAS STIRLING-ROCKINGHAM ;HMAS STIRLING - GARDEN ISLAND
Defence - IRWIN BARRACKS - KARRAKATTA
Defence - LANCELIN TRAINING AREA
Defence - LEARMONTH - AIR WEAPONS RANGE
Defence - LEARMONTH RADAR SITE - TWIN TANKS EXMOUTH
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - LEEUWIN BARRACKS - EAST FREMANTLE
Defence - PRESTON POINT TRAINING DEPOT
Defence - ROCKINGHAM - NAVY CPSO
Defence - SWANBOURNE RIFLE RANGE

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Christmas Island Natural Areas	EXT	Listed place
Garden Island	WA	Listed place
Lancelin Defence Training Area	WA	Listed place
Learmonth Air Weapons Range Facility	WA	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Historic		
Administrators House Precinct	EXT	Listed place
Army Magazine Buildings Irwin Barracks	WA	Listed place
Artillery Barracks	WA	Listed place
Bungalow 702	EXT	Listed place
Claremont Post Office	WA	Listed place

Name	State	Status
Cliff Point Historic Site	WA	Listed place
Drumsite Industrial Area	EXT	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
Industrial and Administrative Group	EXT	Listed place
J Gun Battery	WA	Listed place
Malay Kampong Group	EXT	Listed place
Malay Kampong Precinct	EXT	Listed place
Phosphate Hill Historic Area	EXT	Listed place
Poon Saan Group	EXT	Listed place
Settlement Christmas Island	EXT	Listed place
South Point Settlement Remains	EXT	Listed place

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Cereopsis novaehollandiae grisea Cape Barren Goose (south-western), Recherche Cape Barren Goose [25978]	Vulnerable	Species or species habitat likely to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Fregata andrewsi Christmas Island Frigatebird, Andrew's Frigatebird [1011]	Endangered	Breeding known to occur within area

Name	Threatened	Type of Presence
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat known to occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding likely to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma macroptera Great-winged Petrel [1035]		Breeding known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Puffinus assimilis Little Shearwater [59363]		Breeding known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Breeding known to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Puffinus huttoni Hutton's Shearwater [1025]		Foraging, feeding or related behaviour known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Puffinus tenuirostris Short-tailed Shearwater [1029]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Roosting known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or

Name	Threatened	Type of Presence
		related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
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 latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys sculptus Sculptured Pipefish [66197]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		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
Corythoichthys haematopterus Reef-top Pipefish [66201]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Cosmocampus maxweberi Maxweber's Pipefish [66209]		Species or species habitat may occur within area
Doryrhamphus baldwini Redstripe Pipefish [66718]		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
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		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 dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus macrorhynchus Whiskered Pipefish, Ornate Pipefish [66222]		Species or species habitat may occur within area
Halicampus mataafae Samoan Pipefish [66223]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
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
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippichthys spicifer Belly-barred Pipefish, Banded Freshwater Pipefish [66232]		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 breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		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
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		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
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		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

Name	Threatened	Type of Presence
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
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Breeding known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Name	Status	Type of Presence
Hyperoodon planifrons Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or

Name	Status	Type of Presence
		related behaviour known to occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tasmacetus shepherdi Shepherd's Beaked Whale, Tasman Beaked Whale [55]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Commonwealth ReservesTerrestrial [Resource Information]

Name	State	Type
Christmas Island	EXT	National Park (Commonwealth)

Australian Marine Parks [Resource Information]

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Bremer	National Park Zone (IUCN II)
Bremer	Special Purpose Zone (Mining
Carnarvon Canyon	Habitat Protection Zone (IUCN IV)
Cartier Island	Sanctuary Zone (IUCN Ia)
Dampier	Habitat Protection Zone (IUCN IV)
Dampier	Multiple Use Zone (IUCN VI)
Dampier	National Park Zone (IUCN II)
Eastern Recherche	National Park Zone (IUCN II)

Name	Label
Eastern Recherche	Special Purpose Zone (IUCN VI)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Jurien	National Park Zone (IUCN II)
Jurien	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Perth Canyon	Habitat Protection Zone (IUCN IV)
Perth Canyon	Multiple Use Zone (IUCN VI)
Perth Canyon	National Park Zone (IUCN II)
Roebuck	Multiple Use Zone (IUCN VI)
Shark Bay	Multiple Use Zone (IUCN VI)
South-west Corner	Habitat Protection Zone (IUCN IV)
South-west Corner	Multiple Use Zone (IUCN VI)
South-west Corner	National Park Zone (IUCN II)
South-west Corner	Special Purpose Zone (IUCN VI)
South-west Corner	Special Purpose Zone (Mining
Two Rocks	Multiple Use Zone (IUCN VI)
Two Rocks	National Park Zone (IUCN II)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Airlie Island	WA
Alfred Cove	WA
Bardi Jawi	WA
Barrow Island	WA
Bedout Island	WA
Beekeepers	WA
Bernier And Dorre Islands	WA
Bessieres Island	WA
Bold Park	WA
Boodie, Double Middle Islands	WA
Boullanger, Whitlock, Favourite, Tern And Osprey Islands	WA
Broome Bird Observatory	WA
Broome Wildlife Centre	WA
Browse Island	WA
Bundegi Coastal Park	WA
Burnside And Simpson Island	WA
Cape Range	WA
Carnac Island	WA
Coulomb Point	WA
Dambimangari	WA
Dambimangari	WA
Dirk Hartog Island	WA
Dongara	WA
Escape Island	WA
Freycinet, Double Islands etc	WA
Gnandaroo Island	WA
Hamelin Island	WA
Harry Waring Marsupial Reserve	WA
Jarrkunpungu	WA
Jinmarnkur	WA
Jinmarnkur Kulja	WA
Jurabi Coastal Park	WA
Kalbarri	WA

Name	State
Karajarri	WA
Keanes Point Reserve	WA
Kings Park	WA
Koks Island	WA
Kujungurru Warrarn	WA
Kujungurru Warrarn	WA
Lacepede Islands	WA
Lake Joondalup	WA
Lancelin And Edwards Islands	WA
Leda	WA
Leeuwin-Naturaliste	WA
Lesueur	WA
Little Rocky Island	WA
Locker Island	WA
Lowendal Islands	WA
Matilda Bay Reserve	WA
Montebello Islands	WA
Muiron Islands	WA
Murujuga	WA
NTWA Bushland covenant (0144)	WA
Nambung	WA
Nanga Station	WA
Neerabup	WA
Neerabup	WA
Nilgen	WA
North Sandy Island	WA
North Turtle Island	WA
Nyangumarta Warrarn	WA
Part Murchison house	WA
Penguin Island	WA
Port Gregory	WA
Prince Regent	WA
Recherche Archipelago	WA
Rottnest Island	WA
Round Island	WA
Serrurier Island	WA
Southern Beekeepers	WA
Swan Island	WA
Swan River	WA
Tamala Pastoral Lease (Part)	WA
Tanner Island	WA
Tent Island	WA
Thomsons Lake	WA
Unnamed WA21176	WA
Unnamed WA26400	WA
Unnamed WA28968	WA
Unnamed WA31906	WA
Unnamed WA34039	WA
Unnamed WA36907	WA
Unnamed WA36909	WA
Unnamed WA36910	WA
Unnamed WA36913	WA
Unnamed WA36915	WA
Unnamed WA37168	WA
Unnamed WA37338	WA
Unnamed WA37383	WA
Unnamed WA37500	WA
Unnamed WA39584	WA
Unnamed WA39752	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA40877	WA
Unnamed WA41080	WA
Unnamed WA41775	WA
Unnamed WA42469	WA
Unnamed WA43290	WA

Name	State
Unnamed WA43903	WA
Unnamed WA44414	WA
Unnamed WA44665	WA
Unnamed WA44667	WA
Unnamed WA44669	WA
Unnamed WA44672	WA
Unnamed WA44673	WA
Unnamed WA44682	WA
Unnamed WA44688	WA
Unnamed WA45772	WA
Unnamed WA45773	WA
Unnamed WA46926	WA
Unnamed WA46982	WA
Unnamed WA46983	WA
Unnamed WA46984	WA
Unnamed WA48291	WA
Unnamed WA48858	WA
Unnamed WA48968	WA
Unnamed WA49220	WA
Unnamed WA49561	WA
Unnamed WA49994	WA
Unnamed WA50067	WA
Unnamed WA51105	WA
Unnamed WA51162	WA
Unnamed WA51497	WA
Unnamed WA51583	WA
Unnamed WA51617	WA
Unnamed WA51658	WA
Unnamed WA51932	WA
Unnamed WA52237	WA
Unnamed WA52354	WA
Unnamed WA52366	WA
Unnamed WA53015	WA
Uunguu	WA
Victor Island	WA
Wanagarren	WA
Wandi	WA
Wedge Island	WA
Weld Island	WA
Woodvale	WA
Y Island	WA
Yanchep	WA
Yawuru	WA
Zuytdorp	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Gallus gallus Red Junglefowl, Feral Chicken, Domestic Fowl [917]		Species or species habitat likely to occur within area
Lonchura oryzivora Java Sparrow [59586]		Species or species habitat likely to occur within area
Meleagris gallopavo Wild Turkey [64380]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pavo cristatus Indian Peafowl, Peacock [919]		Species or species habitat likely to occur within area
Phasianus colchicus Common Pheasant [920]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat may occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus exulans Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Lycodon aulicus Wolf Snake, Common Wolf Snake, Asian Wolf Snake [83178]		Species or species habitat likely to occur within area
Lygosoma bowringii Christmas Island Grass-skink [1312]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
"The Dales", Christmas Island	EXT
Ashmore Reef	EXT
Booragoon Swamp	WA
Bunda-Bunda Mound Springs	WA
Bundera Sinkhole	WA
Cape Range Subterranean Waterways	WA
De Grey River	WA
Eighty Mile Beach System	WA
Exmouth Gulf East	WA
Gibbs Road Swamp System	WA
Herdsman Lake	WA
Hosine's Spring, Christmas Island	EXT
Joondalup Lake	WA
Karakin Lakes	WA
Lake MacLeod	WA
Lake Thetis	WA
Learmonth Air Weapons Range - Saline Coastal Flats	WA
Leslie (Port Hedland) Saltfields System	WA
Loch McNess System	WA
Mermaid Reef	EXT
Roebuck Bay	WA
Rottnest Island Lakes	WA
Shark Bay East	WA
Spectacles Swamp	WA
Swan-Canning Estuary	WA
Thomsons Lake	WA
Willie Creek Wetlands	WA

Key Ecological Features (Marine) [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
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Seringapatam Reef and Commonwealth waters in	North-west
Wallaby Saddle	North-west
Albany Canyons group and adjacent shelf break	South-west
Ancient coastline at 90-120m depth	South-west
Cape Mentelle upwelling	South-west
Commonwealth marine environment surrounding	South-west
Commonwealth marine environment surrounding	South-west
Commonwealth marine environment within and	South-west
Diamantina Fracture Zone	South-west
Naturaliste Plateau	South-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west
Western rock lobster	South-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, 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 distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for 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 reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-8.110051 120.376181,-8.413432 119.686137,-8.976808 119.872067,-8.857075 120.295123,-8.748104 120.365003,-8.944443 121.387017,-8.896056 121.73862,-8.77642 121.87834,-8.752625 122.125804,-8.691748 123.110175,-8.687346 123.482423,-9.75854 123.516666,-10.383148 123.263849,-10.567755 123.03086,-10.658619 122.803699,-10.808072 122.716331,-10.890417 122.798676,-10.786665 122.978512,-10.944817 123.205601,-10.818947 123.821447,-10.988525 125.037471,-11.913499 126.641108,-12.448877 127.200281,-13.147091 126.715455,-13.318401 126.494889,-14.227094 125.717017,-14.343262 125.111429,-14.575878 125.169519,-15.146948 124.962506,-15.13404 124.72429,-15.340607 124.400669,-15.498246 124.50395,-15.543968 124.516619,-15.936579 124.492348,-15.883041 124.006938,-15.964387 123.794187,-16.292067 123.493814,-16.479298 123.438507,-16.679321 122.85478,-17.217961 122.29943,-17.829879 122.291578,-17.954801 122.452192,-18.100415 122.450351,-18.679346 121.838291,-19.299554 121.531765,-19.644576 121.103462,-19.9777 120.359881,-20.133753 119.569602,-20.082028 119.18133,-20.326489 118.862903,-20.440596 118.092132,-20.654766 117.898254,-20.801688 117.32701,-20.62405 116.78223,-20.634023 116.752999,-21.023086 116.114577,-21.485594 115.564995,-21.81298 114.827666,-22.208356 114.521006,-22.133497 113.977382,-22.585628 113.781286,-22.971101 113.927623,-23.445803 113.877654,-23.801236 113.652646,-24.50168 113.514146,-25.252995 113.363645,-25.510993 113.142207,-25.833347 113.111916,-25.952346 113.179916,-26.437668 113.50771,-26.712407 113.765502,-26.934213 113.913108,-27.591313 114.201271,-27.792218 114.089596,-27.883892 114.157798,-28.214768 114.158935,-28.255736 114.432758,-28.365415 114.560728,-28.984599 114.552035,-29.012543 114.875396,-29.154795 114.96022,-29.509539 115.062795,-30.110359 114.992653,-30.197812 115.013206,-30.465331 115.0763,-30.60938 115.205131,-31.625489 115.777608,-32.220354 115.876139,-32.289384 115.812959,-32.667715 115.254594,-33.37603 114.869555,-33.736593 114.828494,-33.995457 115.066998,-34.32194 115.017795,-34.324079 115.017205,-34.522746 115.19192,-34.928478 115.943279,-35.044299 116.433171,-35.116634 116.994723,-35.031112 117.460781,-35.199211 117.598659,-35.210207 117.943954,-34.605829 119.612364,-34.641803 120.712898,-33.927965 125.103003,-33.445529 126.058654,-33.403888 126.367984,-33.52881 126.724904,-33.778653 126.760595,-35.660569 118.196677,-36.144352 114.765123,-36.602661 110.370604,-31.572685 104.971902,-28.146261 101.926192,-23.586421 101.882172,-16.27751 102.557939,-9.716324 103.455669,-8.002934 107.563135,-8.535209 111.991021,-8.455371 112.785888,-8.327118 112.865283,-8.464486 113.085367,-8.457829 113.730901,-8.559822 113.900249,-8.573748 114.394216,-8.822094 114.947409,-8.748677 115.119112,-8.858564 115.464227,-8.750721 115.752243,-8.830925 115.831405,-8.793232 115.941134,-8.910794 116.496366,-8.823057 116.584103,-8.94709 116.667788,-9.000602 116.92052,-9.0984 117.015989,-9.106275 117.556779,-8.987189 117.986975,-8.802474 118.393495,-8.802441 119.052454,-8.59679 119.258104,-8.339112 119.324791,-8.378125 119.467189,-7.878053 120.310745,-8.110051 120.376181

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.

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Appendix B: MNES Review Register

Table B-1: Review Register

Taxon	2021 Review (Rev 9 09/07/21)	Reason for Change	Sections Updated within this Document
Threatened Species			
Sharks	Speartooth shark *(Glyphis glyphis)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 5-1, Section 5.3, Section 5.3.5
Birds	Addition of *Territory Parks and Wildlife Conservation Act* 1976 conservation status	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 8-1, Section 8.2
Birds	Greater crested tern (*Thalasseus bergii)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 8-3
Birds	Little curlew (*Numenius minutus)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 8-3
Birds	Swinhoe's snipe (*Gallinago magala)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 8-3
Birds	Wandering Tattler (*Tringa glareola)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 8-3
Birds	Bar-tailed godwit	NT sites of international importance added	Table 8-5
Birds	Common greenshank	NT sites of international importance added	Table 8-5
Birds	Common sandpiper	NT sites of international importance added	Table 8-5
Birds	Fork-tailed swift	NT sites of international importance added	Table 8-5
Birds	Oriental pratincole	NT sites of international importance added	Table 8-5
Migratory Species-			
Reptiles	Salt-water crocodile *(Crocodylus porosus)*	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 6-1, Section 6.3

Taxon	2021 Review (Rev 9 09/07/21)	Reason for Change	Sections Updated within this Document
Provinces			
Provincial Bioregions	Timor Province	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 2.1
	Northwest Shelf Transition	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 2.1
	Timor Transition	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 2.1, 3.1, 3.3, 3.4, 4.1, 5.1
	Northern Shelf Province	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 2.1, 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 5.1
Protected Areas			
World Heritage Areas	Kakadu National Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.1.3
Wetlands of International Importance	Cobourg Peninsula	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.2.9
	Kakadu National Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.2.10
	Ord River Floodplain	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.2.11
Wetlands of National Importance	Adelaide River Floodplain System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.21

Taxon	2021 Review (Rev 9 09/07/21)	Reason for Change	Sections Updated within this Document
	Kakadu National Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.22
	Mary Floodplain System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.23
	Cobourg Peninsula System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.24
	Daly-Reynolds Floodplain-Estuary System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.25
	Finniss Floodplain and Fog Bay Systems	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.26
	Moyle Floodplain and Hyland Bay System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.27
	Murgenella-Cooper Floodplain System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.28
	Ord Estuary System	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.29
	Port Darwin	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.30
	Shoal Bay - Micket Creek	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, Section 9.3.31

Taxon	2021 Review (Rev 9 09/07/21)	Reason for Change	Sections Updated within this Document
National Heritage Place	Kakadu National Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, 9.4.10
Commonwealth Heritage Place	Bradshaw Defence Area	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-1, 9.5.10 Section 14.4
Coastal terrestrial Conservation Reserves	Five additional national parks included and four reserves	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 9-2 and 9-3
KEFs	Shelf Break and Slope of the Arafura Shelf	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 10.1.29
	Tributary Canyons of the Arafura Depression	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 10.1.30
Australian Marine Parks	Arafura Marine Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	12.4.2
	Arnhem Marine Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	12.4.3
	Joseph Bonaparte Marine Park	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	12.4.4
International Protected Areas	Additional international areas included	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 9.8
Social, Economic and Cultural Features			
Defence Activities	Bradshaw defence training area	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 14.4

Taxon	2021 Review (Rev 9 09/07/21)	Reason for Change	Sections Updated within this Document
Indigenous heritage	Tiwi Islands significant sites	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 14.6.1
Maritime heritage	Additional shipwrecks within EMBA, new figure provided	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 14.6.2
Fisheries	Additional NT fisheries	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Section 14.7.1 and 14.8
Legislation			
Conservation Status Legislation	Addition of *Territory Parks and Wildlife Conservation Act* 1976 conservation status to all species	Included with new PMST search for Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	Table 5-1, 6-1, 7-1, 8-1
Other edits			
-	Figures updated throughout to represent new EMBA	Included with revised EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	All figures in document
-	Text updated throughout to reflect new EMBA entering NT waters	Included with revised r Stairway EMBA based on Stairway TFN Rev 0 (SO-91-RZ-20027)	All text in document

Appendix G. CONSULTATION

[redacted]

From: Consultation, Santos
Sent: Monday, 6 December 2021 3:29 PM
To: [redacted]
Subject: SANTOS CONSULTATION | Legendre Decommissioning Environment Plan
Attachments: Legendre Consultation Information.pdf

Dear stakeholder

Santos is preparing an Environment Plan (EP) for the decommissioning of its interests in petroleum production licence WA-20-L in Commonwealth waters approximately 105 km north of Dampier.

Hydrocarbon production from the Legendre reservoir commenced in 1968 and ceased in 2011, with all production, appraisal and exploration wells permanently plugged in 2011 in accordance with requirements of the designated authority at the time.

The EP for this activity includes the presence of a wellhead at the Legendre-1 exploration appraisal well, which was not removed when the well was permanently plugged. The Legendre-1 well was drilled in 1968 and, given the age of the structure, there are considerable technical risks and challenges in removing the wellhead and it is proposed to leave this wellhead in-situ. The wellhead location is marked on nautical charts.

The EP also includes a vessel-based monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed at three locations within the Legendre permit. At each location, small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, have been observed in highly localised continuous or intermittent streams.

The information attached provides more detail on proposed activities, including a location map and a summary of risks, impacts and mitigation measures associated with leaving the wellhead on the seafloor and the gas bubble release.

Activity Summary

<table>
<tr><td>Activity Name</td><td colspan="4">WA-20-L Decommissioning Environment Plan</td></tr>
<tr><td>Activity Summary</td><td colspan="4">Santos is planning an Environment Plan to include:
• The presence of the Legendre-1 wellhead.
• A monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed.</td></tr>
<tr><td>Total Duration</td><td colspan="4">The wellhead will remain on the seabed and the gas bubble releases will be ongoing.</td></tr>
<tr><td>Permit Number</td><td colspan="4">WA-20-L</td></tr>
<tr><td rowspan="7">Location</td><td colspan="4">Approx. 105 km north of Karratha. Please see attached Consultation Information for location map.</td></tr>
<tr><td>Aspect</td><td>Latitude (GDA94)</td><td>Longitude (GDA94)</td><td>Water depth</td></tr>
<tr><td rowspan="4">WA-20-L extent</td><td>-19.74867</td><td>116.75131</td><td rowspan="4">49-53 m</td></tr>
<tr><td>-19.74867</td><td>116.66798</td></tr>
<tr><td>-19.66534</td><td>116.66798</td></tr>
<tr><td>-19.66534</td><td>116.75131</td></tr>
<tr><td>Gas bubble release site (Legendre Hub)</td><td>-19.68724</td><td>116.72624</td><td>52 m</td></tr>
</table>

	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
	Legendre-1 wellhead	-19.67300	116.73622	50 m
Exclusion Zone	A temporary 500 m petroleum safety zone (PSZ) will exist around the monitoring vessel when in the field.			

Providing feedback

The EP is being developed in accordance with the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and we are seeking your feedback on our proposed activities.

Please contact Santos by **10 January 2022** if you wish to comment on Santos' proposed activities or if you require additional information about the proposed activities.

The Environment Regulations require NOPSEMA to publish the environment plan submitted by the titleholder for assessment, and to publish the final accepted version of an environment plan. Environment plans are published in full, with the exception of sensitive information from the consultation process and transcripts of correspondence between stakeholders and the titleholder. This information is used by NOPSEMA during the assessment but is not published for wider review.

If you do not wish for your comments to be published in this environment plan, or wish to provide your comments anonymously, please make this known to Santos as soon as possible.

Regards

Santos

[redacted]
Stakeholder Adviser

As a service provider to

Santos Limited, Level 7, 100 St Georges Tce
Perth WA 6000
[redacted]

https://www.santos.com/

STAKEHOLDER CONSULTATION

Santos

WA-20-L

Decommissioning Environment Plan

Background

Santos holds the production licence for permit area WA-20-L, located in Commonwealth Waters approximately 105 km north of Dampier on the North West Shelf. Hydrocarbon production from the Legendre reservoir commenced in 1968 and ceased in 2011 and the 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.

Oil from the Legendre reservoir was produced from 2001 to 2011. The production operations comprised 20 production wells (including side-tracks) drilled from a central location and connected to a mobile offshore production unit (MOPU). In addition, exploration and appraisal wells were drilled at a further eight locations within the permit. In total, 30 wells were drilled within WA-20-L, the first being Legendre-1.

All production wells were plugged and abandoned in 2011. The subsea infrastructure associated with the oil production was removed in 2011 with the approved Environment Plan allowing for the following to remain on the seabed: anti-scour mats repositioned to cover the former conductor footprint and concrete caps placed over the pad-eyes and shackles of the remnant anchor piles associated with the CALM (Catenary Anchor Leg Mooring) buoy.

All appraisal and exploration wells have been confirmed as being plugged and abandoned in accordance with requirements of the designated authority at the time. The plugged and abandoned record for Legendre-1, a vertical exploration well drilled, plugged and abandoned in 1968, indicates that the wellhead was left in place.

Activity description

Santos is preparing the WA-20-L Decommissioning EP to cover:

- a monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed at three locations within the permit; and
- the presence of the Legendre-1 wellhead.

Locations are shown in Figure 1 and an overview is provided in **Table 1**.

The EP will be developed and implemented in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* for acceptance by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

To support the development of this EP, a site survey was conducted in Q1 2021 to visually survey the seabed at all exploration and appraisal well locations within the permit area and to sample and characterise the gas bubbles. Subsequent gas composition analysis confirmed that the gas is thermogenic and derived from the Legendre reservoir. The gas bubble releases were observed at three separate locations in proximity to the surface locations of permanently plugged and abandoned (P&A'd) wells. At each location, small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, were observed in highly localised continuous or intermittent streams.

The site survey in Q1 2021 confirmed the presence of the Legendre-1 wellhead sitting 3.6 m high and 5 m wide on the seabed, with no other wellheads present on the permit. Santos have undertaken a comprehensive feasibility assessment of removing the wellhead externally using proven and proto-type tooling as well as making the cut internally from within the wellhead. Given the age of the structure, there are considerable technical risks and challenges in executing the removal of the wellhead resulting in a lower certainty of success of removing the structure at or below the seafloor.

The impacts and risks under consideration in the EP for the gas bubble release and leaving the wellhead on the seabed are summarised in **Table 2**. The control measures to mitigate the key risks are described in **Table 3**.

Existing environment

The seabed in permit area WA-20-L is generally flat and featureless and water depth ranges from 49 m in the north-west to 53 m in the east.

WA-20-L overlaps the Glomar Shoals Key Ecological Feature and Biologically Important Areas (BIA) of four species listed under the *Environment Protection and Biodiversity Conservation Act 1999:* the pygmy blue whale distribution BIA, wedge-tailed shearwater breeding and foraging BIA, flatback turtle internesting BIA and whale shark foraging BIA. In total, 17 Listed Threatened species and 31 Listed Migratory species may occur within WA-20-L.

There are several State and Commonwealth managed commercial fisheries that are permitted to fish within WA-20-L. Marine users are not excluded from the area and the wellhead is marked on the Australian Hydrographic Service nautical charts. The anti-scour mats and concrete caps described previously are now considered part of the existing environment within which the EP activity will take place.

Figure 1: WA-20-L location map

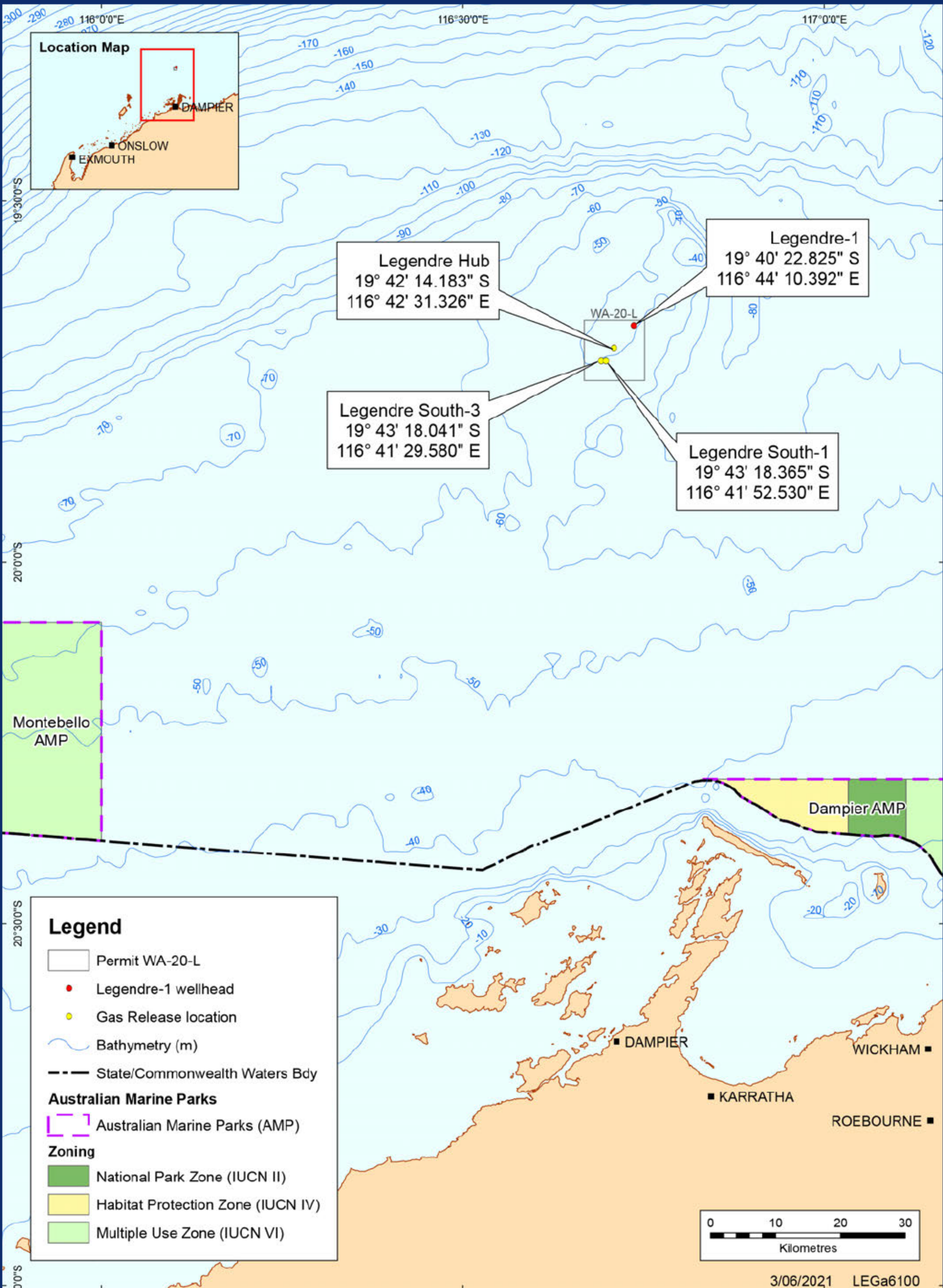

Table 1: Activity summary

ACTIVITY INFORMATION				
	Aspect	Latitude (GDA94)	Longitude (GDA94)	Water depth
Location	WA-20-L extent	-19.74867	116.75131	49-53 m
		-19.74867	116.66798	
		-19.66534	116.66798	
		-19.66534	116.75131	
	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
	Legendre-1 wellhead	-19.67300	116.73622	50 m
Timing and Duration	The gas bubble releases will be ongoing and the wellhead will remain on the seabed.			
Description of natural environment	Located within the NWS Province in the North-West Marine Bioregion. These regions are described in the Integrated Marine and Coastal Regionalisation (IMCRA) of Australia, version 4.0.			
Relevant fisheries	There are several State and Commonwealth managed commercial fisheries that are permitted to fish within WA-20-L. Marine users are not excluded from the area and the wellhead is marked on the Australian Hydrographic Service nautical charts.			
Worst case hydrocarbon spill scenario	All wells are plugged and abandoned. Therefore, there are no credible scenarios of hydrocarbon oil releases from exploration, appraisal and production wells. A worst-case diesel spill resulting from a vessel collision during vessel-based monitoring activities has been assessed in the EP.			

Table 2: Impacts and risks assessed in the WA-20-L decommissioning EP

IMPACTS AND RISKS			
	Legendre 1 Wellhead		Gas bubble release and monitoring
Aspect	Removal	Remain on seabed	
Impacts (planned events)			
Physical disturbance to seabed	Yes	No	Yes
Physical presence of wellhead	No	Yes	NA
Anthropogenic noise: e.g. vessels, wellhead removal	Yes	No	Yes
Anthropogenic light: e.g. vessels	Yes	No	Yes
Vessel emissions, discharges and waste generation	Yes	No	Yes
Gas release to marine environment	NA	NA	Yes
Risks (unplanned events)			
Physical presence of wellhead- consequences to other users	No	Yes	NA
Vessel presence: hydrocarbon spill	Yes	No	Yes
Vessel presence: IMS	Yes	No	Yes

(NA = not applicable)

Table 3: Measures in place or proposed to manage key environmental risks and impacts of the activity

POTENTIAL RISKS AND/OR IMPACTS	DISCUSSION	PROPOSED MANAGEMENT MEASURES
Physical presence of wellhead-consequences to other users	The risk of the physical presence of the Legendre-1 wellhead to other users is considered low as the wellhead is charted on Australian Hydrographic Service nautical charts so that marine users are aware of its location. Marine users will not be excluded from the area and the structure presents an isolated, small vertical feature in a relatively flat seabed that should be detectable by sonar used by trawling vessels. Any future users could reasonably be expected to become aware of the presence through reviewing marine charts. An independent assessment of snagging risk will be included within the EP. Removing the wellhead introduces environmental risks (e.g. vessel fuel oil spills) and displacement of users while the removal works are undertaken.	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.
Physical presence of wellhead-environmental consequences	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.	No control measures are considered necessary.
Gas release-environmental consequences	Very small amounts of methane gas dissolve into the surrounding water column as the bubbles rise to the sea surface. The dissolved methane would not be expected to contribute materially to water column toxicity. Negligible risk of impact is expected upon the values of the Glomar Shoals KEF and the EPBC Act listed species that may occur within WA-20-L, or other marine flora and fauna. No credible impact is expected from the gas release to the atmosphere on marine fauna or avifauna.	Monitoring and research programme.

Consultation

If you wish to provide feedback on this consultation advice, comment on the proposed activities captured by the WA-20-L Decommissioning EP, or if you require additional information, please contact Santos on the contact details below. Santos would appreciate your feedback by **10 January 2022**.

Santos
PO Box 5624, Perth, 6831
[redacted]
Email: Offshore.Consultation@Santos.com

[redacted]

From: Consultation, Santos
Sent: Monday, 6 December 2021 4:26 PM
Subject: SANTOS CONSULTATION | Legendre Decommissioning Environment Plan
Attachments: Legendre Consultation Information.pdf

Dear State Fishery Licence Holder

Santos is preparing an Environment Plan (EP) for the decommissioning of its interests in petroleum production licence WA-20-L in Commonwealth waters approximately 105 km north of Dampier.

The EP for this activity includes the presence of a wellhead at the Legendre-1 exploration appraisal well, which was not removed when the well was permanently plugged in 2011. The Legendre-1 well was drilled in 1968 and, given the age of the structure, there are considerable technical risks and challenges in removing the wellhead and it is proposed to leave this wellhead in-situ. The wellhead location is marked on nautical charts.

The EP also includes a vessel-based monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed at three locations within the Legendre permit. At each location, small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, have been observed in highly localised continuous or intermittent streams.

The information attached provides more detail on proposed activities, including a location map and a summary of risks, impacts and mitigation measures associated with leaving the wellhead on the seafloor and the gas bubble release.

Permit Location:	Approx. 105 km north of Dampier. Please see attached Consultation Information for location map.
Water Depth:	Approx. 49 m to 53 m (WA-20-L extent)
Activity Location:	The locations of the gas bubbles release and the Legendre-1 wellhead are included in the attached information sheet.
Timing and Duration:	The gas bubble releases will be ongoing and the wellhead will remain on the seabed.
Relevant Fisheries	The following State managed fisheries have been identified as relevant, based DPIRD FishCube data, fishing methods and water depth. Santos is engaging licence holders in these fisheries, the Department of Primary Industries and Regional Development, the Western Australian Fisheries Industry Council, the Pearl Producers Association, Recfishwest and Marine Tourism WA for activities proposed to be managed under this EP. • Pilbara Trap Fishery • Pilbara Fish Trawl (Interim) Managed Fishery • Pilbara Line Fishery • Western Australia Mackerel Fishery (Area 2)

Exclusion Zone:	Marine users are not excluded from the area. However, a temporary 500 m petroleum safety zone (PSZ) will exist around the monitoring vessel when in the field.

Providing feedback

The EP is being developed in accordance with the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and we are seeking your feedback on our proposed activities.

Please contact Santos by **10 January 2022** if you wish to comment on Santos' proposed activities or if you require additional information about the proposed activities.

The Environment Regulations require NOPSEMA to publish the environment plan submitted by the titleholder for assessment, and to publish the final accepted version of an environment plan. Environment plans are published in full, with the exception of sensitive information from the consultation process and transcripts of correspondence between stakeholders and the titleholder. This information is used by NOPSEMA during the assessment but is not published for wider review.

If you do not wish for your comments to be published in this environment plan, or wish to provide your comments anonymously, please make this known to Santos as soon as possible.

Regards

[redacted]

Santos

[redacted]
Stakeholder Adviser

As a service provider to

Santos Limited, Level 7, 100 St Georges Tce
Perth WA 6000
[redacted]

https://www.santos.com/

Santos

Santos Consultation

6 December 2021

Dear State Fishery Licence Holder

Santos is preparing an Environment Plan (EP) for the decommissioning of its interests in petroleum production licence WA-20-L in Commonwealth waters approximately 105 km north of Dampier.

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Exclusion Zone:	Marine users are not excluded from the area. However, a temporary 500 m petroleum safety zone (PSZ) will exist around the monitoring vessel when in the field.

Santos

Please be in contact via the phone or email details below if you have any questions on any of the activities outlined in the attached Consultation Information. Your feedback would be appreciated by **10 January 2022**.

Kind regards

[redacted]

Stakeholder Adviser

As a service provider to

Santos Limited,

Level 7 100 St Georges Tce, Perth WA 6000

[redacted]

e: offshore.consultation@Santos.com

[redacted]

From: Consultation, Santos
Sent: Friday, 31 December 2021 11:35 AM
Subject: FW: SANTOS CONSULTATION | Legendre Decommissioning Environment Plan
Attachments: Legendre Consultation Information.pdf

Dear State Fishery Licence Holder

Santos is sending this email by way of a reminder to commercial fishery licence holders as the closing period for feedback on proposed activities for the Legendre decommissioning Environment Plan closes on **10 January 2002**.

Santos is keen to provide opportunity for relevant stakeholders to provide feedback on proposed decommissioning activities, given the proposed ongoing presence of the Legendre-1 wellhead and the small gas bubbles seeping from the seabed at three locations within the Legendre permit.

Please get back to us if you need additional information.

Regards

[redacted]

[redacted]
Stakeholder Adviser

As a service provider to

Santos Limited, Level 7, 100 St Georges Tce
Perth WA 6000
[redacted]

https://www.santos.com/

From: Consultation, Santos
Sent: Monday, 6 December 2021 4:26 PM
Subject: SANTOS CONSULTATION | Legendre Decommissioning Environment Plan

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The EP also includes a vessel-based monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed at three locations within the Legendre permit. At each location, small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, have been observed in highly localised continuous or intermittent streams.

The information attached provides more detail on proposed activities, including a location map and a summary of risks, impacts and mitigation measures associated with leaving the wellhead on the seafloor and the gas bubble release.

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Relevant Fisheries	The following State managed fisheries have been identified as relevant, based DPIRD FishCube data, fishing methods and water depth. Santos is engaging licence holders in these fisheries, the Department of Primary Industries and Regional Development, the Western Australian Fisheries Industry Council, the Pearl Producers Association, Recfishwest and Marine Tourism WA for activities proposed to be managed under this EP. • Pilbara Trap Fishery • Pilbara Fish Trawl (Interim) Managed Fishery • Pilbara Line Fishery • Western Australia Mackerel Fishery (Area 2)
Exclusion Zone:	Marine users are not excluded from the area. However, a temporary 500 m petroleum safety zone (PSZ) will exist around the monitoring vessel when in the field.

Providing feedback

The EP is being developed in accordance with the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and we are seeking your feedback on our proposed activities.

Please contact Santos by **10 January 2022** if you wish to comment on Santos' proposed activities or if you require additional information about the proposed activities.

The Environment Regulations require NOPSEMA to publish the environment plan submitted by the titleholder for assessment, and to publish the final accepted version of an environment plan. Environment plans are published in full, with the exception of sensitive information from the consultation process and transcripts of correspondence between stakeholders and the titleholder. This information is used by NOPSEMA during the assessment but is not published for wider review.

If you do not wish for your comments to be published in this environment plan, or wish to provide your comments anonymously, please make this known to Santos as soon as possible.

Regards

[redacted]

[redacted]
Stakeholder Adviser

As a service provider to

Santos Limited, Level 7, 100 St Georges Tce
Perth WA 6000
[redacted]

https://www.santos.com/

Santos

Santos Consultation

31 December 2021

Dear State Fishery Licence Holder

Santos is sending this letter by way of a reminder to commercial fishery licence holders as the closing period for feedback on proposed activities for the Legendre decommissioning Environment Plan closes on **10 January 2002**.

As previously advised on 6 December 2021, Santos is preparing an Environment Plan (EP) for the decommissioning of its interests in petroleum production licence WA-20-L in Commonwealth waters approximately 105 km north of Dampier.

The EP for this activity includes the presence of a wellhead at the Legendre-1 exploration appraisal well, which was not removed when the well was permanently plugged in 2011. The Legendre-1 well was drilled in 1968 and, given the age of the structure, there are considerable technical risks and challenges in removing the wellhead and it is proposed to leave this wellhead in-situ. The wellhead location is marked on nautical charts.

The EP also includes a vessel-based monitoring and research programme to further assess the nature and potential impact of small gas bubbles seeping from the seabed at three locations within the Legendre permit. At each location, small gas bubbles, ranging in size from 1 to 10 mm diameter at the seafloor, have been observed in highly localised continuous or intermittent streams.

The information attached provides more detail on proposed activities, including a location map and a summary of risks, impacts and mitigation measures associated with leaving the wellhead on the seafloor and the gas bubble release.

Location:	Approx. 105 km north of Dampier. Please see attached Consultation Information for location map.
Water Depth:	Approx. 49 m to 53 m (WA-20-L extent)
Location:	The locations of the gas bubbles release and the Legendre-1 wellhead are included in the attached information sheet.
Timing and Duration:	The gas bubble releases will be ongoing and the wellhead will remain on the seabed.
Relevant Fisheries:	The following State managed fisheries have been identified as relevant, based DPIRD FishCube data, fishing methods and water depth. Santos is engaging licence holders in these fisheries, the Department of Primary Industries and Regional Development, the Western Australian Fisheries Industry Council, the Pearl Producers Association, Recfishwest and Marine Tourism WA for activities proposed to be managed under this EP. • Pilbara Trap Fishery • Pilbara Fish Trawl (Interim) Managed Fishery • Pilbara Line Fishery • Western Australia Mackerel Fishery (Area 2)

Exclusion Zone: Marine users are not excluded from the area. However, a temporary 500 m petroleum safety zone (PSZ) will exist around the monitoring vessel when in the field.

Please be in contact via the phone or email details below if you have any questions on any of the activities outlined in the attached Consultation Information. Your feedback would be appreciated by **10 January 2022**.

Kind regards

[redacted]

Stakeholder Adviser

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