ENVIRONMENT PLAN

Eureka three-dimensional (3D) marine seismic survey

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Contents

Tables

Figures

Appendices

Appendix A : Pilot Energy Pty Ltd Environment Policy

Appendix B : Protected Matters Search Tool Report

Appendix C : Community Consultation and Engagement Plan

Appendix D : Consultation report

Appendix E : Oil pollution emergency plan

Appendix F : Operational and scientific monitoring plan

Appendix G : Underwater noise modelling

ACRONYMS AND ABBREVIATIONS

Name	Description
$	Dollars (Australian dollars unless specified otherwise)
%	Per cent
‘	Minutes
“	Seconds
°	Degrees
°C	Degrees Celsius
µg/l	Micrograms per litre
µPa	Micropascals
AA	Access Authority
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AGDD	Australian Government Department of Defence
AHO	Australian Hydrographic Office
AIMWTMF	Abrolhos Islands and Mid West Trawl Managed Fishery
ALA	Atlas of Living Australia
ALARP	As low as reasonably practicable
AMF	Abalone Managed Fishery
AMP	Australian Marine Park
AMSA	Australian Marine Safety Authority
APPEA	Australian Petroleum Production and Exploration Association
ASA	Active Source Area
ASX	Australian Securities Exchange
AUCHD	Australian Underwater Cultural Heritage Database
BACI	Before-After-Control-Impact
BIA	Biologically Important Area
BoM	Bureau of Meteorology
BRUVS	Baited Remote Underwater Video Systems
BTEX	Benzene, toluene, ethylbenzene and xylenes
CAES	Catch and Effort System
CCEP	Community Consultation and Engagement Plan
COLREGS	International Regulations for Preventing Collisions at Sea 1972
CONOPS	Concurrent Operations Plan
cP	Centipoise (unit of viscosity)
CPA	Closest point of approach
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CV	Curriculum Vitae
CWP	Central Western Province
CWC	Central West Coast
DAFF	Department of Agriculture, Fisheries and Forestry
DAWE	Department of Agriculture, Water and the Environment (formerly Department of Agriculture and Water Resources; superseded by DAFF and DCCEEW)
DAWR	Department of Agriculture and Water Resources (superseded by DAWE)
dB	Decibel

Name	Description
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEC	Department of Environment and Conservation
DEWHA	Department of the Environment, Water, Heritage and the Arts
DNP	Director of National Parks
DoD	Department of Defence
DoEE	Department of the Environment and Energy (superseded by DAWE)
DoF	Department of Fisheries (superseded by DPIRD)
DoT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
DWER	Department of Water and Environmental Regulation
E	East
ECR	Environmental Commitments Register
EEZ	Exclusive Economic Zone
EMBA	Environment that may be affected
ENSO	El Niño Southern Oscillation
EP	Environment Plan
EPA	Environmental planning area
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPO	Environmental performance outcome
EPS	Environmental performance standard
ERA	Ecological risk assessment
ERM	Environmental Resources Management
ESD	Ecologically sustainable development
FCA	Federal Court of Australia
FHPA	Fish Habitat Protection Area
FRMA	*Fish Resources Management Act 1994* (WA)
g/m^2	Grams per square metre (unit of surface or area density)
GHG	Greenhouse gas
GMEM	Gippsland Marine Environmental Monitoring
HF	High frequency
hrs	Hours
HSE	Health, Safety, and the Environment
Hz	Hertz
HWM	High water mark
IAGC	International Association of Geophysical Contractors
ILUA	Indigenous Land Use Agreement
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organization
IMS	Invasive marine species
IMT	Incident Management Team
IOGP	International Association of Oil and Gas Producers
ISPP	International Sewage Pollution Prevention
ISO	International Standards Organization
ITQ	Individually transferable quota
IUCN	International Union for the Conservation of Nature
JASCO	JASCO Applied Sciences

Name	Description
JRCC	Joint Rescue Coordination Centre (AMSA)
KEF	Key Ecological Feature
km	Kilometre
km^2	Square kilometres
KMAC	Kwelena Mambakort Aboriginal Corporation
km/h	Kilometres per hour
LC	Leeuwin Current
LF	Low frequency
LU	Leeuwin Undercurrent
m	Metre
M	Million
m/s	Metres per second
m2	Metres squared
m3	Metres cubed
MAFMF	Marine Aquarium Fish Managed Fishery
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MDO	Marine diesel oil
MEE	Maritime environmental emergencies
MEPC	Marine Environment Protection Committee
MFO	Marine fauna observer
MGO	Marine gas oil
mm	Millimetres
MMF	Mackerel Managed Fishery
MMOA	Marine Mammal Observer Association
MNES	Matters of National Environmental Significance
MOC	Management of Change
MOD	Maximum-over-depth
MPA	Marine Protected Area
MSS	Marine Seismic Survey
N	North
NATPLAN	National Plan for Maritime Environmental Emergencies
NCVA	National Conservation Values Atlas
nm	Nautical mile
NNTT	National Native Title Tribunal
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority (Commonwealth)
NOPTA	National Offshore Petroleum Titles Administrator (Commonwealth)
NSW	New South Wales
NT	Northern Territory
NT Act	*Native Title Act 1993*
OA	Operational Area
OAF	Open Access Fishery
OBN	Ocean bottom nodes
OCS	Offshore Constitutional Settlement 1995 (WA)
OGUK	Oil and Gas UK
OIMF	Octopus Interim Managed Fishery

Name	Description
OIW	Oil in Water
OPGGS	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS(E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
OSC	On-scene commander
OSM	Operational and Scientific Monitoring
OSMP	Operational and Scientific Monitoring Program
PAM	Passive acoustic monitoring
Pilot	Pilot Energy Pty Ltd
PEPR	Post-survey Environmental Performance Report
PERR	Post-survey Environmental Review Report
PK	Peak pressure levels
pm	Picometre
PMI	Potential mortality injury
PMST	Protected Matters Search Tool
POLREP	Oil Pollution Report
ppb	Parts per billion
PSU	Practical salinity unit
PSZ	Petroleum safety zone
PTS	Permanent threshold shift
QLD	Queensland
RATSIB	Representative Aboriginal, Torres Strait Islander body
RNTBC	Registered Native Title Bodies Corporate
RO	Reverse osmosis
RPS	RPS AAP Consulting Pty Ltd
RS	Rottnest Shelf
S	South
s	Seconds
SA	South Australia
SBT	Southern Bluefin Tuna
SBTF	Southern Bluefin Tuna Fishery
SCIPA	Sea Country Indigenous Protected Area
SDGDLMF	Southern Demersal Gillnet and Demersal Longline Managed Fishery
SEL	Sound exposure levels
SIMOPS	Simultaneous Operations Plan
SITREP	Situation Report
SNA	Safe Navigation Area
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPA	Special Prospecting Authority
SPF	Small Pelagic Fishery
SPL	Sound pressure level
SRD	Streamer recovery devices
SSMF	Specimen Shell Managed Fishery
SST	Sea surface temperature
SWCSMF	South West Coast Salmon Managed Fishery
SWMR	South-west Marine Region

Name	Description
SWNTA	South West Native Title Agreement
SWSP	Southwest Shelf Province
SWST	Southwest Shelf Transition
SWT	Southwest Transition
t	Tonnes
TAC	Total allowable catch
TACC	Total allowable commercial catch
TAS	Tasmania
TDGDLF	Temperate Demersal Gillnet and Demersal Longline Fisheries
TOFWC	Tour Operator Fishery West Coast
TSSC	Threatened Species Scientific Committee
TTS	Temporary threshold shift
UAV	Unmanned aerial vehicles
µm	Micrometre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UXO	Unexploded ordinance
VHF	Very high-frequency
VIC	Victoria
VOC	Volatile organic compounds
W	West
WA	Western Australia
WAC	Western Australian Current
WAFIC	Western Australian Fishing Industry Council
WCB	West Coast Bioregion
WCDGDLMF	West Coast Demersal Gillnet and Demersal Longline Managed Fishery
WCDS	West coast demersal scalefish
WCDSCMF	West Coast Deep Sea Crustacean Managed Fishery
WCDSIMF	West Coast Demersal Scalefish Interim Managed Fishery
WCNEFR	West Coast Nearshore and Estuarine Finfish Resource
WCPSMF	West Coast Purse Seine Managed Fishery
WCRLMF	West Coast Rock Lobster Managed Fishery
WDTF	Western Deepwater Trawl Fishery
WHP	World Heritage Property
WLAC	Wattandee Littlewell Aboriginal Corporation
WTBF	Western Tuna and Billfish Fishery
WRL	Western rock lobster
YAC	Yued Aboriginal Corporation
YMAC	Yamatji Marlpa Aboriginal Corporation
YSRC	Yamatji Southern Regional Corporation
WCNEFR	West Coast Nearshore and Estuarine Finfish Resource
WCPSMF	West Coast Purse Seine Managed Fishery
WCRLMF	West Coast Rock Lobster Managed Fishery
WDTF	Western Deepwater Trawl Fishery
WHP	World Heritage Property

1 INTRODUCTION

1.1 EP summary

This Environment Plan (EP) summary has been prepared from material provided in this EP. The summary consists of the following as required by section 35:

EP summary material requirement	Relevant section of EP containing EP summary material
The location of the activity	Section 3.1
A description of the receiving environment	Section 4
A description of the activity	Section 3.3
Details of the environmental impacts and risks	Sections 7 and 8
The control measures for the activity	Sections 7 and 8
The arrangements for ongoing monitoring of the titleholders environmental performance	Section 10
Response arrangements in the Oil Pollution Emergency Plan	Appendix E
Consultation undertaken	Section 5 and Appendix C and D
Details of the titleholders nominated liaison person for the activity	Section 1.3.1

1.2 Scope of this environment plan

Pilot Energy Pty Ltd (Pilot) is proposing to undertake the Eureka 3D marine seismic survey (hereafter referred to as the Eureka 3D MSS) in exploration permit area WA-481-P, Production Licence WA-31-L and an area of open acreage, which are located on the mid-west coast of Western Australia (WA), in the northern Perth Basin. The purpose of the Eureka 3D MSS is to collect 3D geophysical data about the underlying rock types to inform oil and gas exploration.

This EP has been prepared in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and associated Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (OPGGS (E) Regulations). It has also been prepared with reference to the Environment Plan Content Requirements Guidance Note (2020) produced by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.3 Proponent

Pilot is an Australian Securities Exchange listed oil and gas exploration and development company (ASX:PGY). Pilot holds a 21.25% interest in the producing Cliff Head Oil field and Cliff Head Infrastructure (WA-31-L), located in the nearshore North Perth Basin. Pilot also holds a 100% working interest in the exploration permit WA-481-P, which surrounds WA-31-L. Pilot is taking a lead role in the energy transition in WA and plans to leverage its existing and ongoing oil and gas operations and infrastructure to cornerstone the development of carbon management projects.

1.3.1 Titleholder and nominated liaison person

Pilot is currently the sole titleholder of Exploration Permit WA-481-P and holds a 100% working interest in the permit. Titleholder nominated liaison person details are provided in Table 1-1 in accordance with section 23 of the OPGGS (E) Regulations. 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, Pilot will notify NOPSEMA and provide the updated details (as described in Section 10 of this EP).

Any seismic data acquisition that occurs in the Production Licence of WA-31-L will be undertaken subject to an Access Authority (AA) granted by the National Offshore Petroleum Titles Administrator (NOPTA). Seismic acquisition occurring over open acreage will be undertaken subject to a Special Prospecting Authority (SPA) granted by NOPTA.

Table 1-1: Details of WA-481-P titleholder and nominated liaison person

Titleholder details	Liaison person details
Pilot Energy Pty Ltd ABN: 86 115 229 984	Mike Lonergan Business Address: Suite 301, 35 Spring Street Bondi Junction, NSW, 2022 Telephone number: +61 448 080 177 Email address mlonergan@pilotenergy.com.au

2 ENVIRONMENTAL REQUIREMENTS

The OPGGS Act provides the regulatory framework for all offshore petroleum exploration, production and greenhouse gas (GHG) activities in Commonwealth waters. The related OPGGS (E) Regulations require titleholders to undertake their petroleum activity in accordance with an EP accepted by NOPSEMA. This EP has been prepared to meet the requirements of the OPGGS (E) Regulations. This section provides information on the requirements that apply to the activity. Requirements include relevant laws, codes, standards, agreements, treaties, conventions or practices (in whole or part) that apply to the jurisdiction in which the activity will take place.

2.1 EPBC Act

The Eureka 3D MSS will take place within Commonwealth waters. Relevant requirements associated with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), related policies, guidelines, plans of management, recovery plans, threat abatement plans, and other relevant advice issued by the Department of Climate Change, Energy, the Environment and Water (DCCEEW; formerly the Department of Agriculture, Water and the Environment) are detailed in Section 4 in the applicable subsections, as part of the description of the existing environment.

2.1.1 Recovery plans and threat abatement plans

Under s139(1)(b) of the EPBC Act, the Environment Minister must not act inconsistently with recovery plans for a listed threatened species or ecological community or a threat abatement plan for a species or community protected under the Act. Similarly, under s268 of the EPBC Act: “A Commonwealth agency must not take any action that contravenes a recovery plan or a threat abatement plan.”

In respect to offshore petroleum activities in Commonwealth waters, these requirements are implemented by NOPSEMA via the commitments included in the Streamlining Program. Commitments relating to listed threatened species and ecological communities under the Act are included in the Program Report (Commonwealth of Australia, 2014).

A separate assessment is undertaken to demonstrate that the EP is not inconsistent with any relevant recovery plans or threat abatement plans. The steps in this process are:

- Identify relevant listed threatened species and ecological communities (Section 4.3).
- Identify relevant recovery plans and threat abatement plans (Section 9).
- List all objectives and (where relevant) the action areas of these plans and assess whether these objectives/action areas apply to government, the Titleholder, and the Activity (i.e. the Eureka 3D MSS) (Section 9).
- For those objectives/action areas applicable to the Activity, identify the relevant actions of each plan, and evaluate whether impacts and risks resulting from the Activity are clearly not inconsistent with that action (Section 9).

2.1.2 Australian Marine Parks

Under the EPBC Act, Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of National Parks (DNP) is responsible for managing AMPs (supported by Parks Australia) and is required to publish management plans for them. Other parts of the Australian Government must not perform functions or exercise powers relating to these parks that are inconsistent with management plans (s362 of the EPBC Act). Relevant AMPs are described in Section 4.4.1. The South-west Marine Parks Network Management Plan (DNP, 2018) describes the requirements for managing the marine parks that are relevant to this EP.

Specific zones within the AMPs have been allocated conservation objectives as stated below (International Union for Conservation of Nature (IUCN) Protected Area Category) based on the Australian IUCN reserve management principles outlined in Schedule 8 of the EPBC Regulations 2000:

- Special Purpose Zone (IUCN category VI) – managed to allow specific activities through special purpose management arrangements while conserving ecosystems, habitats and native species. The zone allows or prohibits specific activities
- Sanctuary Zone (IUCN category Ia) – managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible. The zone allows only authorised scientific research and monitoring
- National Park Zone (IUCN category II) – managed to protect and conserve ecosystems, habitats and native species in as natural a state as possible. The zone only allows non extractive activities unless authorised for research and monitoring
- Recreational Use Zone (IUCN category IV) – managed to allow recreational use, while conserving ecosystems, habitats and native species in as natural a state as possible. The zone allows for recreational fishing, but not commercial fishing
- Habitat Protection Zone (IUCN category IV) – managed to allow activities that do not harm or cause destruction to sea floor habitats, while conserving ecosystems, habitats and native species in as natural a state as possible
- Multiple Use Zone (IUCN category VI) – 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.

2.1.3 World heritage properties

Australian World Heritage management principles are prescribed in Schedule 5 of the EPBC Regulations 2000. No management principles are considered relevant to the scope of this EP given there is no potential impacts to any of these areas.

2.2 Summary of environmental requirements

Table 2-1 provides a summary of requirements that apply to the activity and are relevant to the activity's environmental management, while Table 2-2 summarises the international conventions and agreements of which Australia is a signatory that are relevant to the Eureka 3D MSS. Table 2-3 provides a summary of the relevant industry standards and guidelines considered for Eureka 3D MSS.

Table 2-1: Summary of requirements relevant to the activity

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
Australian Maritime Safety Authority Act 1990	Facilitates international cooperation and mutual assistance in preparing and responding to major oil spill incidents and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies.	Under this Act, any hydrocarbon spill to the marine environment, resulting from the survey must be reported. In Commonwealth waters the Australian Maritime Safety Authority (AMSA) is the Statutory Agency for vessels and must be notified of all incidents involving a vessel. Hydrocarbon spill risks are detailed in Section 8	AMSA
Biosecurity Act 2015 Biosecurity Regulations 2016	The objects of this Act are: 1. To provide for managing the following: a. Biosecurity risks b. The risk of contagion of a listed human disease c. The risk of listed human diseases entering Australian territory or a part of Australian territory, or emerging, establishing themselves or spreading in Australian territory or a part of Australian territory d. Risks related to ballast water e. Biosecurity emergencies and human biosecurity emergencies 2. To give effect to Australia's international rights and obligations, including under the International Health Regulations, the SPS Agreement and the Biodiversity Convention. 3. Biosecurity Amendment (Biofouling Management) Regulation 2023 served to amend the Biosecurity Regulation 2016 with the following insertion (after paragraph 48(2)(o)): a. Details of any inspections of the vessel for biofouling, cleaning of biofouling or treatment for biofouling undertaken before the vessel's arrival in Australian territory; b. Details of any inspections of the vessel for biofouling, cleaning of biofouling or treatment for biofouling intended while the vessel is in Australian territory; c. Practices included in any plan of biofouling management for the vessel that is currently in use; 4. Details of the voyage history of the vessel in the past 12 months.	The Biosecurity Act and regulations apply to 'Australian territory', which is the air space over and the coastal seas out to 12 nm from the coastline. Biosecurity risks associated with the survey are detailed in Section 8.	DAFF
Biosecurity Act 2015	Australian Ballast Water Management Requirements Version 8 (DAWE 2020)	Provides guidance on how vessel operators should manage ballast water when operating within Australian seas in order to comply with the Biosecurity Act. Section 8.3 details these requirements.	DAFF
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act aims to protect the environment, particularly matters of national environmental significance for which Australia has made international agreements. The EPBC Act streamlines national environmental assessment and approval processes and promotes	Petroleum activities are excluded from within the boundaries of a World Heritage Area (Sub regulation 10A(f)).	DCCEEW

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
	ecologically sustainable development and conservation of biodiversity. It also provides for a cooperative approach to the management of natural, cultural, social and economic aspects of ecosystems, communities and resources. Section 3A of the Act defines the principles of ecological sustainable development. The following principles are principles of ecologically sustainable development: a. Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations b. If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation c. The principle of inter-generational equity -- that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations d. The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making e. Improved valuation, pricing and incentive mechanisms should be promoted. Petroleum activities must be carried out in a manner consistent with the principles of ecological sustainable development set out in Section 3A of the EPBC Act. Determination of impact and risk Acceptability details that residual risks are ALARP, and the principles of ecologically sustainable development have been met (Section 5). Assessment of impacts and risks to Matters of National Environmental Significance (MNES) from the survey are described in Section 7 and 8.		
Environment Protection and Biodiversity Conservation Regulations 2000	Provides additional regulations regarding Matters of National Environmental Significance.	Part 8 of the Regulations details requirements for operating vessels and aircraft in relation to cetaceans. Section 7 details these requirements.	DCCEEW
EPBC Act Policy Statement 2.1 Interaction between offshore seismic exploration and whales	The policy statement encourages industry to minimise the likelihood of seismic activities causing injury or hearing impairment to whales in Australian waters. The aim of this Policy Statement is to: • Provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations. • Provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey	The policy statement provides guidance on undertaking seismic activities in Australian waters to limit potential impacts to whales. Section 7 details how the policy statement has been applied to this survey. The policy statement outlines sound exposure criteria for determining appropriate precaution zones and outlines recommended management procedures. Part A of the	

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
	sources to whales in biologically important habitat areas or during critical behaviours. • Provide guidance to both proponents of seismic surveys and operators conducting seismic surveys about their legal responsibilities under the EPBC Act (DEWHA, 2008c). • Part B of the policy statement outlines additional optional management procedures for consideration for seismic surveys in areas where there is a moderate to high likelihood of encountering whales.	policy statement outlines standard management procedures, which include: • Pre-start-up visual observations • Soft-start procedures • Start-up delay procedures • Operations and shut-down procedures • Night-time and low visibility procedures.	
Underwater Cultural Heritage (Consequential and Transitional Provisions) Act 2018	This Act protects historic wrecks (and associated relics) in Commonwealth waters that are more than 75 years old. Under this Act, historic shipwrecks are protected for their heritage values and maintained for recreational, scientific and educational purposes.	Anyone who finds the remains of a ship, or an article associated with a ship, needs to notify the relevant authorities, as soon as possible but ideally no later than after one week, and to give them information about what has been found and its location. Refer to Section 4.4.8 for information on historic shipwrecks in relation to the Eureka 3D MSS.	DCCEEW
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 73/78, COLREGS 1972) relating to maritime issues to which Australia is a signatory. The Act also has subordinate legislation contained in Regulations and Marine Orders.	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 • Marine Order 58: Safe management of vessels. Section 7 and Section 8 detail where the applicable requirements apply to the survey.	AMSA
Offshore Petroleum and Greenhouse Gas Storage Act 2006 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023	Addresses all licensing, health, safety, environmental and royalty issues for offshore petroleum exploration and development operations extending beyond the three nautical mile limit. Ensures that petroleum activities are undertaken in an ecologically sustainable manner and in accordance with an approved EP.	A titleholder must have an in-force EP prior to the commencement of any petroleum activity. This requirement is met by submission and acceptance of this EP. A significant modification, change or new stage of an existing activity that is not included in an in-force EP requires a revision of the EP to be submitted to NOPSEMA for acceptance. Titleholders are required to maintain financial assurance sufficient to give the titleholder carrying out the petroleum activity, the capacity to meet the costs, expenses and liabilities that may result in connection with carrying out the petroleum activity; doing any other thing for the purpose of the petroleum activity; or	NOPSEMA

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
		complying (or failing to comply) with a requirement under the OPGGS Act in relation to the petroleum activity. This requirement must be met by the titleholder before NOPSEMA can accept the EP.	
Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Act 2003 Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Regulations 2004	An Act to impose levies relating to the regulation of offshore petroleum activities and greenhouse gas storage activities.	Requires that EP levies be imposed on EP submissions, including revisions, where the activities to which the EP relates are authorised by one or more Commonwealth titles. This requirement applies once the EP is accepted.	NOPSEMA
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.	Provides for discharges and emissions from ships as per MARPOL Annex I, II, III, IV, V and VI. Several Marine Orders are enacted under this Act relevant to the activity, including: • Marine Order 91: Marine pollution prevention – oil • Marine Order 93: Marine pollution prevention – noxious liquid substances • Marine Order 94: Marine pollution prevention – packaged harmful substances • Marine Order 95: Marine pollution prevention – garbage • Marine Order 96: Marine pollution prevention – sewage • Marine Order 97: Marine pollution prevention – air pollution • Marine Order 98: Marine pollution prevention – anti-fouling systems. • Provides exemptions for the discharge of materials in response to marine pollution incidents. • Requires ships ≥400 gross tonnes to have pollution emergency plans. Section 7 details where the applicable requirements apply to the survey.	AMSA
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Is an offence to engage in negligent conduct that results in a harmful anti-fouling compound being applied to a ship. Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria.	If required, a ship must have a current anti-fouling certificate and must not use harmful antifouling compounds. Marine Order 98 Marine Pollution Prevention – anti-fouling systems is enacted under this Act.	AMSA

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
		Section 8 details where the applicable requirements apply to the survey.	
International Association of Geophysical Contractors (IAGC) Environment Manual for Worldwide Geophysical Operations (2013)	Provides the industry with useful information for conducting geophysical field operations in an environmentally sensitive manner.	Provide guidelines for best practice operations of seismic surveys to minimise environment impacts. Section 7 details applicable guidance.	IAGC
IAGC Mitigation Measures for Cetaceans during Geophysical Operations (February 2015)	Provides recommended mitigation measures for cetaceans during geophysical operations. IAGC recommends implementing the suggested controls (mentioned in the document) in the absence of regulations or guidelines.	Provide recommended mitigation measures for cetaceans during geophysical operations. Section 7 details applicable requirements.	IAGC
International Maritime Organization (IMO) Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) 2011	Provide a globally consistent approach to the management of biofouling. They were adopted by the Marine Environment Protection Committee (MEPC) in July 2011 and were the result of three years of consultation between IMO member states	Specific requirements are that vessels have a biofouling management plan and biofouling record book.	IMO
Australian Ballast Water Requirements, Version 8 (DAWE 2020)	Australian Ballast Water Management Requirements outline the mandatory ballast water management requirements to reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through ballast water from international vessels. These requirements are enforceable under the *Biosecurity Act 2015*.	Assists in the identification of potential risks to the project area and provides benchmarks to set Environmental Performance standards	DAFF
National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (2017)	The overarching goal of the strategy is to provide guidance on understanding and reducing the risk of vessel collisions and the impacts they may have on marine mega-fauna.	The strategy provides information and guidance on reducing vessel collisions with marine mega-fauna. Section 8 details applicable information and requirements.	DCCEEW

Table 2-2: Summary of relevant international conventions

Agreement	Scope (as relevant to this EP)	Relevance
1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972	Contributes to the international control and prevention of marine pollution by prohibiting the dumping of certain hazardous materials. Under the 1996 Protocol, dumping is prohibited, except for materials on an approved list.	No dumping of any wastes or other matter from survey activities with the exception of those listed in Annex 1 of the Protocol (which will be discharged in line with MARPOL requirements).
Bonn Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other harmful substances (Bonn Agreement)	The Bonn Agreement is the mechanism by which the North Sea states, and the European Union (the Contracting Parties), work together to help each other in combating pollution in the North Sea area from maritime disasters and chronic pollution from ships and offshore installations; and to carry out surveillance as an aid to detecting and combating pollution at sea.	The Bonn Agreement Oil Appearance Code may be used during spill response activities.
Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC 90)	This Convention establishes measures for dealing with marine oil pollution incidents nationally and in cooperation with other countries.	All vessels ≥400 gross tonnes will have a Shipboard Oil Pollution Emergency Plan (SOPEP) in place
International Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL 73/78)	This Convention covers prevention of pollution of the marine environment by ships from operational or accidental causes. It includes regulations aimed at preventing and minimising pollution from ships (accidental and routine).	Pollution from the survey activities will be managed in accordance with MARPOL requirements, as described in Sections 7 and 8.
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.	The survey will adhere to the requirements of COLREGS as implemented in Commonwealth waters through the *Navigation Act 2012* (refer to Section 8)..
International Convention for the Safety of Life at Sea, 1974 (SOLAS)	This convention outlines the minimum safety standards in the construction, equipment and operation of merchant ships.	The survey will adhere to the requirements of SOLAS as implemented in Commonwealth waters through the *Navigation Act 2012* (refer to Table 2-1).
International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001	The Convention prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.	The survey will adhere to the requirements of the convention as implemented through the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

Table 2-3: Summary of relevant industry standards and guidelines

Standard / guideline	Description
Australian and New Zealand guidelines for fresh and marine water quality (ANZECC/ARMCANZ 2000)	These guidelines provide a framework for water resource management and state specific water quality guidelines for environmental values, and the context within which they should be applied
The Australian Petroleum Production and Exploration Association (APPEA) Code of Environmental Practice (APPEA 2008)	Recognising the need to avoid or minimise and manage impacts to the environment, this code of environmental practice includes four basic recommendations to APPEA members undertaking activities Assess the risks to, and impacts on, the environment as an integral part of the planning process. Reduce the impact of operations on the environment, public health and safety to as low as reasonably practicable (ALARP) and to an acceptable level by using the best available technology and management practices. Consult with stakeholders regarding industry activities. Develop and maintain a corporate culture of environmental awareness and commitment that supports the necessary management practices and technology, and their continuous improvement.
NOPSEMA (2018) Information Paper IPI765 Acoustic Impact Evaluation and Management	The information paper provides advice to titleholders to assist with preparing EPs for marine seismic survey activities, and in particular the components of an EP that relate to detailing, evaluating and managing impacts from acoustic emissions.
WA Department of Fisheries (DoF) Guidance Statement on Undertaking Seismic Surveys in WA Waters	Identifies potential issues of concern associated with seismic surveys on fish and fish habitats, as defined under the Fish Resources Management Act 1994 (FRMA). It is aimed at giving proponents direction on general standards and protocols designed to avoid or mitigate the potential impacts of seismic surveys on fish. It is expected that proponents will incorporate these standards and protocols when planning and implementing seismic surveys.
WA DPIRD Fisheries Research Report No. 288 Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia (Webster et al. 2018)	The Fisheries Division of the WA DPIRD undertook an ecological risk assessment (ERA) of the potential effects of seismic surveys on marine finfish and invertebrates. The ERA assessed different categories of seismic source volume and the potential exposure of different types of finfish and invertebrates in different water depths. The ERA was undertaken at the level of individual adult finfish and invertebrate organisms closest to the seismic source and it was assumed that an individual organism remains stationary (i.e. does not flee) and is positioned directly in the path of the vessel, thus experiencing numerous pulses with varying degrees of intensity as the vessel approaches, passes overhead and moves further away. Therefore, the WA DPIRD ERA represents a highly conservative worst-case scenario that is not representative of real-life exposures in all cases, as it does not account for any avoidance response by mobile organisms. The WA DPIRD ERA identified that overall the greater the intensity of sound and shallower the water depth the greater the assigned risk. The organisms classified as most at risk from seismic impacts were immobile invertebrates (e.g. molluscs) while pelagic fish were rated as the least at risk. The 2D seismic exploration survey environmental impact and risk assessment in Section 7.1 of this EP has applied additional activity-specific and situation specific context to assess potential risks to individuals and populations. A guidance statement is currently being developed by the WA DPIRD Fisheries Division o
International Association of Oil and Gas Producers (IOGP) Recommended monitoring and mitigation measures for cetaceans during marine seismic survey geophysical operations (March 2017)	Provides recommendations on applying mitigation measures for cetaceans during geophysical operations. The measures outlined in this report are recommended for use during all marine seismic surveys that use compressed air source arrays, and are only intended for cetaceans (whales, dolphins and porpoises).
Marine Mammal Acoustic Technical Guidance (NMFS, Revision 2018)	The Technical guidance provides thresholds for onset of permanent threshold shift (PTS) and temporary threshold shifts (TTS) in marine mammal hearing for all underwater sound sources. It is intended to be used to better predict how a marine mammals hearing will respond to sound exposure.

Standard / guideline	Description
Effective planning strategies for managing environmental risk associated with geophysical and other imaging surveys (IUCN 2016)	This is a guideline to the responsible and effective planning of offshore geophysical surveys particularly with respect to marine mammals with the focus given to planning and implementing large-scale airgun surveys.
National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry (MPSC 2009)	A voluntary biofouling management guidance document developed under the National System for the Prevention and management of Marine Pest Incursions. Its purpose is to provide tools to operators to minimise the amount of biofouling accumulating on their vessels, infrastructure and submersible equipment and thereby to minimise the risk of spreading marine pests.

3 DESCRIPTION OF THE ACTIVITY

3.1 Survey location

The Eureka 3D MSS will take place within Commonwealth waters off the mid-west coast of WA, within the northern Perth Basin, in Exploration Permit Area WA-481-P, Production Licence WA-31-L and open acreage area (Figure 3-1).

For the purposes of this EP two areas have been defined for the survey based on the type of activities that will be undertaken and the discharge of seismic source. The following areas apply:

- Active source area (ASA)
- Operational area (OA).

The combinations of these two areas is referred to as the ‘survey area’. These areas are presented in Figure 3-1 and Figure 3-2 and a description of each area is provided below. Water depths in the survey area range from approximately 10–60 m.

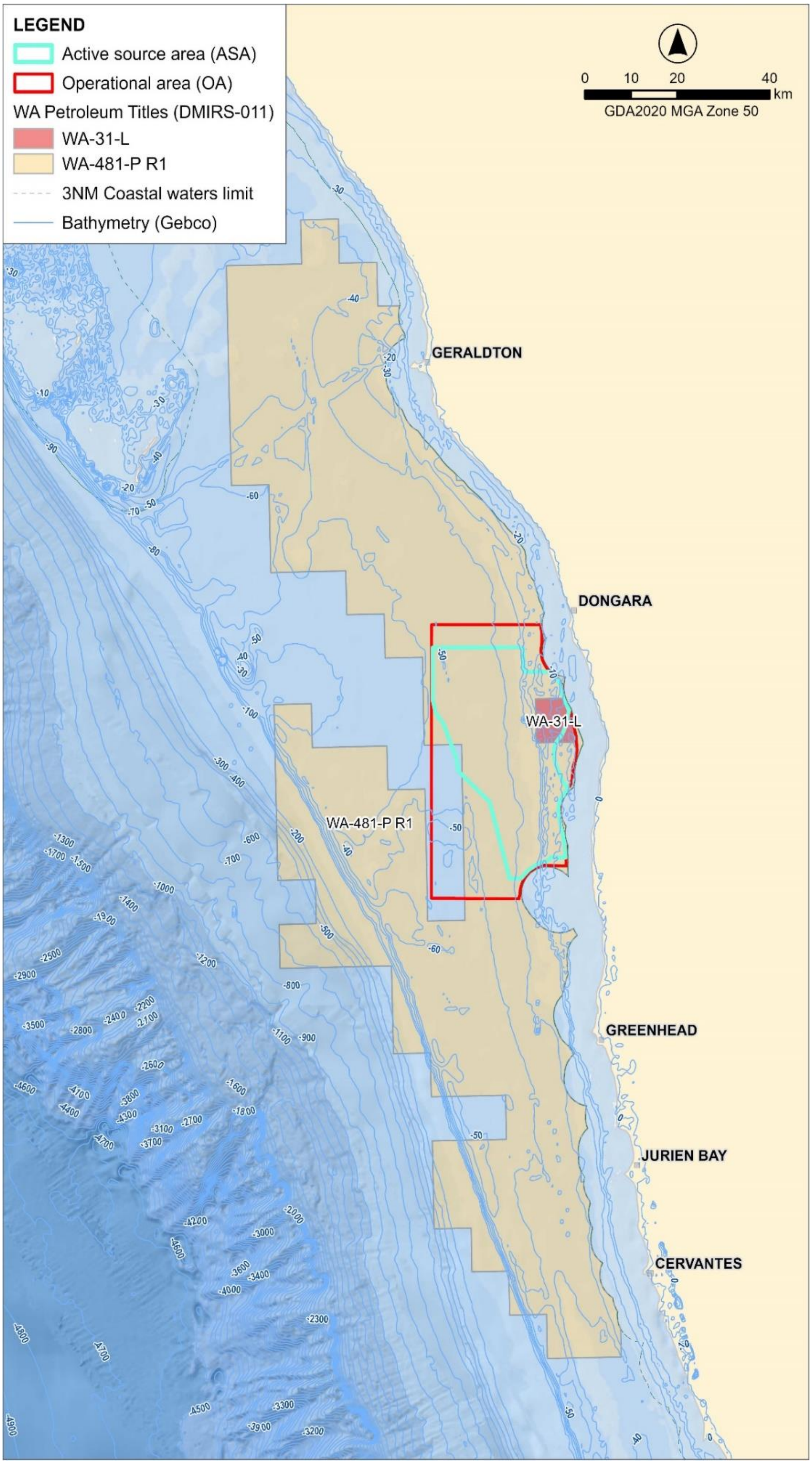

Figure 3-1: Eureka 3D MSS Active Source Area and Operational Area overlapping Petroleum Titles

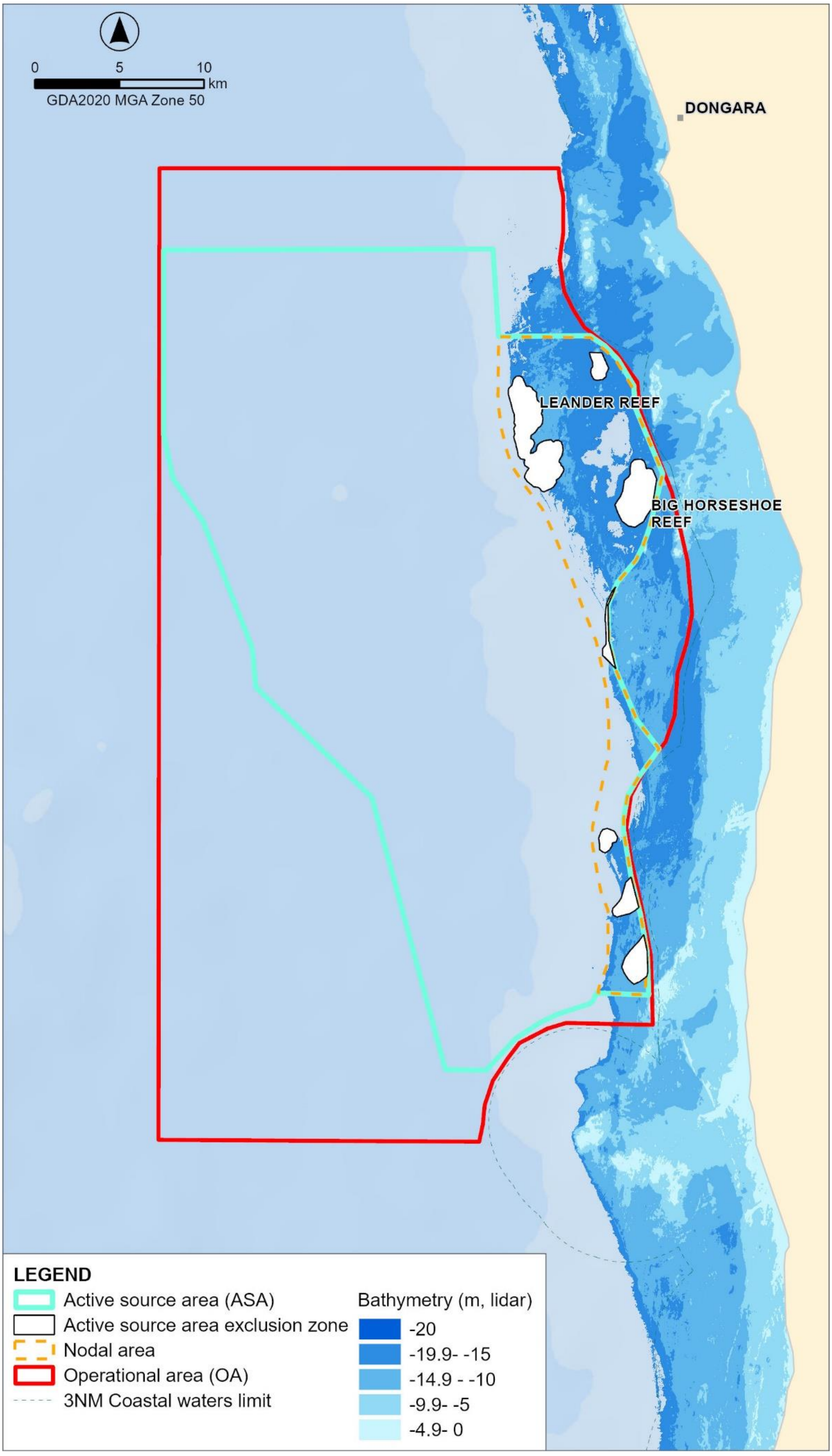

Figure 3-2: Eureka 3D MSS Active Source Area and Operational Area

3.1.1 Active source area

The ASA is defined as the maximum potential area within which seismic acoustic emissions may occur for the purpose of acquiring data. It includes vessel run-ins and run-outs, and soft starts where the seismic source is active. Seismic source testing (i.e. bubble tests) will also occur in the ASA. The seismic source will not be discharged outside of the Active Source Area or within any designated exclusion zones delineating shallow reefs as shown on Figure 3-2.

The active source area is further split into two areas; an offshore area where data will be acquired by a vessel towing the seismic source and streamers, and an inshore area (called the nodal area) where data will be acquired through the use of ocean bottom nodes in conjunction with a vessel towing the seismic source. Figure 3-2 demonstrates this with orange line bounding the approximate nodal area and the rest of the ASA is where streamer acquisition will occur. The actual extent of the towed streamer area will be defined following a full risk assessment with the chosen seismic contractor and will be adjusted accordingly. The streamer component of the survey will not be conducted in water depths of less than 15 m.

Within the nodal area there are also designated exclusion zones (Figure 3-2). These are areas that the seismic source will not be discharged due to proximity to known shallow reef areas, but ocean bottom nodes may still be placed. The reef exclusion areas have been defined through the usage of high resolution LiDar bathymetry data, selecting the significant spatial features and applying a 300 m exclusion zone to the extremities.

The extent of the ASA is approximately 946 km^2 with boundary coordinates provided in Table 3-1. The nodal area within the ASA is 119 km^2.

3.1.2 Operational area

The OA includes the ASA and an additional area for operations ancillary to achieving survey coverage. This includes vessel approach, vessel line turns, and necessary maintenance operations. There will be no discharge of the seismic source within the area of the OA that is located outside the ASA.

The extent of the OA is approximately 1,575 km^2 with boundary coordinates provided in Table 3-1.

Table 3-1: Operational and Active Source Area co-ordinates (GDA 94)

Operational area		Active source area	
Latitude	Longitude	Latitude	Longitude
-29.270842	114.606743	-29.7548	114.7702
-29.274973	114.849632	-29.6088	114.7284
-29.30962	114.851687	-29.5489	114.6592
-29.350656	114.856948	-29.5278	114.6573
-29.389779	114.895096	-29.4597	114.6288
-29.449083	114.915039	-29.4364	114.6111
-29.514094	114.92597	-29.4131	114.606
-29.568026	114.914272	-29.3145	114.6083
-29.596011	114.895846	-29.3174	114.8087
-29.627502	114.883474	-29.3641	114.8112
-29.696458	114.897106	-29.3646	114.8668
-29.733026	114.89746	-29.3919	114.893
-29.731198	114.844435	-29.4029	114.8934
-29.741452	114.815726	-29.439	114.9096
-29.761163	114.799096	-29.485	114.8922
-29.793673	114.790001	-29.4968	114.8806
-29.789274	114.593941	-29.5437	114.879
-29.270842	114.606743	-29.5857	114.9044
		-29.6228	114.8819
		-29.7171	114.8953

Operational area		Active source area	
Latitude	Longitude	Latitude	Longitude
		-29.7155	114.8635
		-29.7205	114.8605
		-29.7391	114.8133
		-29.7557	114.7951
		-29.7548	114.7702

3.2 Schedule

Pilot has identified 1 February 2025 to 31 March 2025, or the same period in 2026, as the survey window for acquisition of the Eureka 3D MSS. The survey timing has been based upon relevant person feedback and assessment of timing of biological, socio-economic and cultural sensitivities, and metocean constraints.

Acquisition will occur over 30 days within this window with an additional ten days allowing for downtime and survey infill, streamer and node deployment and streamer recovery. Downtime allows for inclement weather, avoiding interactions with other users and marine megafauna, and maintenance. The actual start date and year for the survey is subject to the availability of the survey vessels to conduct the survey, client data requirements, sea state conditions suitable for marine seismic acquisition, and granting of the required regulatory approvals and access authorities.

Seismic data will be acquired over a 24-hour period, with shutdowns for routine and reactive maintenance, repairs, transit and line turns and marine fauna and stakeholder avoidance. The exact start and end dates will be communicated to relevant persons in accordance with notification requirements described in Section 10.

3.3 Activity details

The core activity that forms the basis for this EP is the undertaking of the Eureka 3D MSS. Associated activities in support of the survey are likely to include use of support vessels as required, and crew changes within the Operational Area. Associated activities are described in this section as appropriate, with a focus on those considered relevant to the assessment of environmental impact and risk. Key details of the proposed seismic survey are summarised in Table 3-2 and described below.

The Eureka 3D MSS will be undertaken by a seismic survey vessel towing an underwater seismic source and up to a minimum of six streamers behind it. The seismic source will consist of an array of airguns of varying volumes (with a total volume of 2,495 cubic inches [in^3]). The survey vessel will tow the seismic source at 6m beneath the sea surface and will not be operated in depths of less than 10m. The total volume of the airgun array has been chosen based on the water depths within the survey area and depth of the target within the subsurface to ensure adequate seismic imaging. The airguns emit high pressure pulses of sound, with the primary energy directed downwards into the subsurface (not horizontally away from the source). The streamers and ocean bottom nodes contain underwater microphones (known as hydrophones) that record the sound waves reflected off the seabed and underlying rock formations. These data are later processed to provide information about the structure and composition of geological formations below the seabed.

The streamers will extend approximately 7 km behind the survey vessel and be spaced 100 m apart. The streamers will be towed at a depth of approximately 7 m below the surface in offshore areas outside of the nodal area. Tail buoys will be used to maintain position in the water and clearly indicate the streamer ends. The tail buoys will be fitted with turtle guards (or will be of a design that does not represent an entrapment risk to turtles and other marine fauna), lights and radar reflectors. Depth monitoring and control devices (birds) positioned along the streamers will be used to maintain the preferred tow depth. The streamers will be fitted with streamer recovery devices (SRDs), which are self-inflating and will return to the surface if the streamer sinks beyond a certain water depth.

Table 3-2: Key details of the Eureka 3D MSS

Parameter	Eureka 3D MSS
Survey area	
Permit area	WA-481-P
Other titleholders licence area that survey lines will enter (subject to Access Authority and Special Prospecting Authority)	WA-31-L and open acreage
Active Source Area	946 km^2
Node Survey Area	119 km^2
Operational Area	1575 km^2
Full fold area	750 km^2
Seismic activity	
Survey window	1 February 2025–31 March 2025, or 1 February 2026–31 March 2026
Duration of survey	30–40 days
Shotpoint Interval (Streamer)	12.5m shotpoint interval (approx. 5.4 sec) Sail lines will be approximately 300 m apart (dependant on # streamers)
Shotpoint Interval (Nodal)	100m shotpoint interval Sail lines will be approximately 50 m apart
Speed when traversing a sail line	4.5 knots
Orientation of sail lines	North – south
Seismic source	
Type	Airgun array
Size	2495 in^3
Pressure	2000 psi
Source levels (at 0–2,000 Hz)	255.2 dB re 1 μPa m (peak source pressure level)
Sound source tow depth	6m
Streamers	
Number	Six minimum
Streamer length	~6150 m
Distance from seismic vessel bow to tail buoy	~7000 m
Distance between streamers	100 m (dependent on number of streamers)
Streamer tow depth	~7 m (+/-2 m)
Vessels	
Seismic vessel	One vessel – specific vessel yet to be determined
Support vessels	Two support vessels (one supply and one chase) – specific vessels yet to be determined
Other vessel	1–2 additional smaller vessels may be required for laying ocean nodes
Refuelling	No refuelling will occur in Operational Area
Crew changes	Via support vessel as required

3.3.1 Seismic source operation with streamers

When acquiring data, the vessel will travel along a series of pre-determined lines within the ASA at approximately 4.5 knots (8 km/hour), discharging the seismic source at 12.5 m intervals (approximately every 5.4 seconds).

The Eureka 3D MSS is a typical 3D survey using methods and procedures similar to others conducted in Australian waters. No unique or unusual equipment or operations are proposed. The survey will be conducted 24 hours a day. Survey and equipment parameters are provided in Table 3-2. Pilot will consider options for the optimal technology based on what contractors have available at the time of survey to allow for technical advances, within the scope of the parameters provided for in this EP.

The seismic survey vessel will typically acquire the data along a series of adjacent and parallel lines in a “racetrack”-like pattern. At the end of the first line in a racetrack sequence, the vessel will turn in a wide arc to position for another parallel line in the opposite direction, offset several kilometres from the previous line. The vessel will then turn again to position to return in the opposite direction along the third parallel line in the sequence. The distance between sail lines will be approximately 300 m based on a six streamer vessel.

The survey area will be split into two areas, a western and eastern portion. The western portion will be completed first, followed by the eastern portion (Figure 3-3). The vessel will sail lines that are typically in a north–south orientation. The time required to complete each sail line is dependent on vessel speed and currents.

During line run-outs, the seismic source will typically be operated at full volume for the equivalent of half a streamer length (approximately 3 km) before the source is shut down and the survey vessel commences the next line turn. Following completion of the line turn, the vessel will complete a run-in towards the ASA, which involves sailing in a straight line to allow the streamers to straighten prior to commencing acquisition. At the ASA boundary soft-start procedures will commence for a minimum of duration of 30 minutes (approximately 4 km). Soft-starts begin with the operation of the single smallest source element in the array and gradual ramp-up to include additional source elements until the seismic source is operated at full volume for the commencement of the acquisition line within the ASA.

The seismic source may also be operated for short durations in a controlled manner elsewhere in the ASA, for the purpose of source maintenance and testing. These activities are infrequent and typically involve short intermittent controlled discharges of individual source elements (i.e. single gun/cluster or single source array) for durations in the order of a short number of testing shots. Since this testing only involves a single gun or a small cluster of guns, the noise propagated from the source during this activity must logically be less than the whole array. Therefore, any impacts from noise emissions will not be greater than that predicted in the impact assessment.

Operation of the seismic source in all cases will be in accordance with control measures and performance standards specified in this EP.

3.3.2 Infill

When acquiring 3D marine seismic data, surface currents may shift the streamers away from their nominal positions. This shift, called feathering, can lead to holes in the data coverage. Holes in data coverage can also occur when the airgun array is turned off due to technical or logistical reasons (e.g. technical problems or marine fauna interactions). These holes are typically filled by steering the vessel closer to the previous sail-line or by acquiring additional sail-lines along the holes. These extra sail-lines are known as infill. Infill can be a large part of the time and cost for a marine seismic survey. Without infill activity, seismic surveys would be incomplete, the data compromised, and contract requirements not fulfilled.

It is not possible to estimate what the amount of feather (and resulting coverage) will be. The western section of the ASA (blue lines on Figure 3-3) will be acquired and then infilled. Then the vessel will travel to the eastern section (red lines on Figure 3-3) and complete acquisition and then undertake any required infill.

With proper infill management, unnecessary infill lines may be reduced or avoided. The on-board navigator steers the seismic vessel for coverage to minimise the amount of infill. Additionally, steerable streamers and fan-mode techniques for the streamer spread are used to minimise infill requirements. In the nodal area the static placement of the receivers allows greater control over the source/receiver interaction which results in a much lower likelihood of requiring infill, though it may occur.

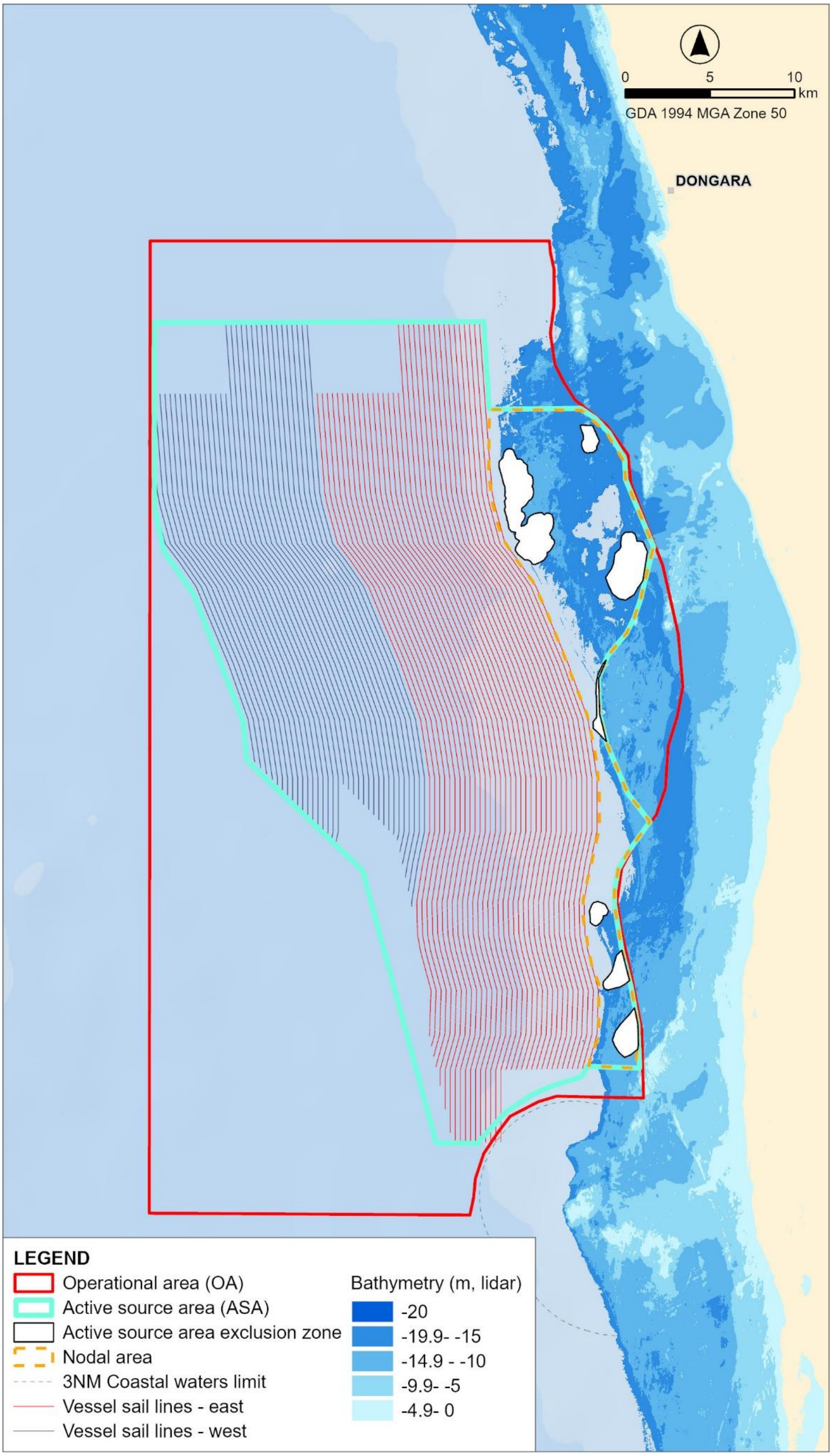

Figure 3-3: Sail lines in the east and west and nodal area showing exclusion zones

3.3.3 Ocean bottom nodes

The shallow waters within the survey area present a potential technical and safety challenge for the survey vessel towing a large streamer array. These sections, referred to as the nodal area (Fig 3-2 and 3-3), will be acquired using Ocean Bottom Node (OBN) technology rather than towed streamers.

These devices are small and light (ranging from 3–12 kg, with dimensions between 200–400 mm × 200–400 mm and an approximate height of 100 mm – dependant on manufacture) and have flexible placement and retrieval options including autonomous vehicles, nodes on a rope (NOAR) and commercial divers. The final design of the nodal survey is dependent on the seismic contractor awarded the activity as it relates to the number of nodes available and the deployment method proposed in order to acquire the survey in the most efficient and timely manner. However it is expected that they will be placed in grids of 250 m × 250 m, which would result in the deployment of approximately 2,500 nodes across the entire nodal area. This results in a source density of approximately 200/sqkm. Pilot will consider (where operational requirements allow) the option of using a smaller seismic source (<2,500 in^3) for acquisition in the shallow waters where nodes may be used. The nodes would be placed at the start of the survey and collected at the end of the survey timeframe.

No nodes will be deployed within the 500 m radius petroleum safety zone (PSZ) around the Cliff Head development wellhead platform.

Once the nodes have been deployed, a seismic source vessel will tow the source along source lines 50 m apart, with the source firing at 100 m intervals along each line. Where there are the source exclusion zones, the source vessel will deviate around these zones, with the source points being offset laterally. Given the cumulative nature of the noise emitted there will be a 24hr restriction on each subsequent pass that goes within a 200m distance of the exclusion zone boundary.

Timing for acquisition of this area will be based on the Vessel Masters assessment and may occur before, during or after streamer acquisition.

Dependent on the assessment of the Vessel Contractor, with regards to the safe acquisition of the towed streamer component of the survey, and the conditions at the time of survey, this nodal area may increase in size. The increase would be limited to sections of the western boundary of the nodal area.

3.3.4 Simultaneous surveys

It is unlikely that seismic surveys will operate simultaneously in the region as there are limited titleholders nearby to the survey area and the high cost of mobilising a survey vessel means that titleholders are driven to share a vessel sequentially rather than to operate individual vessels simultaneously. As of the date of submission no EPs have been submitted for surveys within proximity to the OA.

In addition, the goals of a survey can be compromised by simultaneous operations (SIMOPS). The sound generated from one survey will interfere with the seismic data acquisition of the other survey, limiting the value of the acquired data for interpretation.

3.3.5 Vessels

3.3.5.1 Seismic vessel

A purpose-built survey vessel will be used for the Eureka 3D MSS and will carry up to approximately 70 people. The specific vessel for the survey has yet to be determined.

The seismic vessel and towed arrays, comprising the acoustic source array and streamer array (including the streamer header buoys, starboard and port deflectors or baravanes, streamers and tail buoys) are surrounded by a Safe Navigation Area (SNA). The SNA will extend to three nautical miles (nm) around the seismic vessel and towed equipment. The support/chase vessel will be used to ensure third party vessels are prevented from entering the SNA.

Potable water, primarily for accommodation and associated domestic areas, will be generated on the seismic and support/chase vessels using a reverse osmosis (RO) system. This process will produce brine, which is diluted and discharged at the sea surface in accordance with controls detailed in Section 7.5. The project vessels will also discharge deck drainage from open drainage areas, bilge water from closed drainage areas, putrescible waste and treated sewage and grey water. Any hazardous and non-hazardous waste will be appropriately stored and transported to shore for disposal.

3.3.5.2 Support vessels

A minimum of two support vessels will be engaged for the Eureka 3D MSS. These comprise:

- One chase vessel accompanying the seismic vessel to assist with managing potential interactions with other marine users
- One supply vessel responsible for resupply and other support functions
- Additional vessels may be required for laying ocean nodes.

There will be no refuelling of the survey vessel in the OA.

Crew changes are expected to be undertaken by a supply vessel approximately every 4–6 weeks so are unlikely to occur during the survey period, except in mitigating circumstances.

4 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

This section describes the environmental and socio-economic values and sensitivities within the existing environment of the Operational Area and wider environment that may be affected (EMBA) by the proposed activity (see Figure 4-1). The EMBA is a conservative approximation of the furthest extent that could be affected in any credible impact scenario. In this case, the EMBA represents an unplanned release of marine gas oil (MGO). The EMBA was derived from oil spill modelling for an instantaneous release of 320 m^3 at the south-east point of the OA. It is important to note that the EMBA covers a much larger area than the area that is likely to be affected during any one single spill event. The modelling was run for a variety of weather and metocean conditions (100 simulations in total). Other nearby sensitivities that were considered potentially relevant to the EP are also described in this section. The information contained in this section has been used to inform the assessment of impacts and risks in Section 7 and Section 8. For further detail on the modelling refer to Section 8.6.

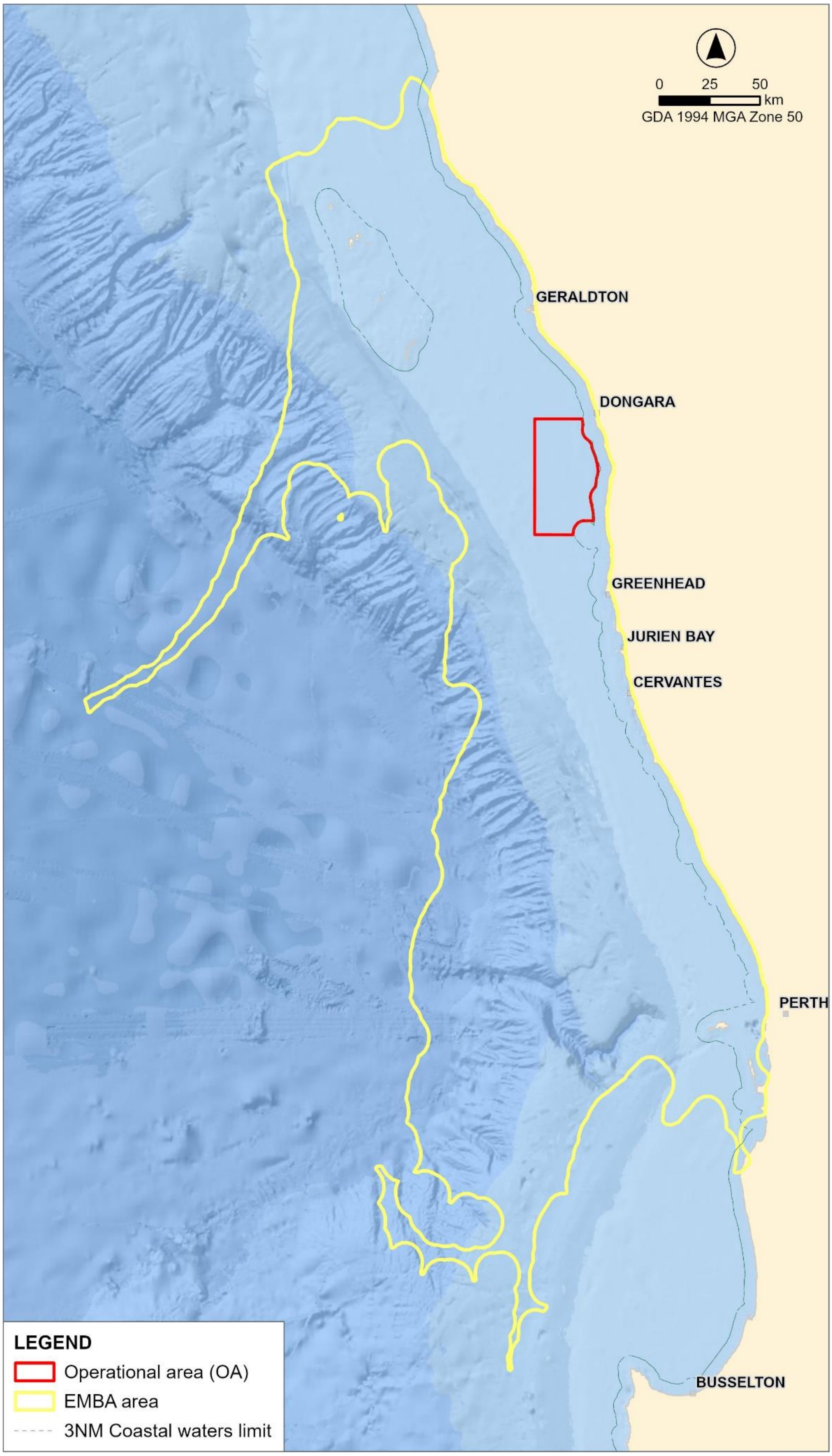

Figure 4-1: Operational area and EMBA for the Eureka 3D MSS

4.1.1 Regional context –South-west Marine Region

The OA is located in the South-west Marine Region (SWMR), described in 2008 by the former Department of the Environment, Water, Heritage and the Arts (DEWHA) (now the Department of Agriculture, Fisheries and Forestry; DAFF) during the introduction of Integrated Marine and Coastal Regionalisation of Australia (IMCRA) bioregional planning. Under these plans, the Australian marine environment was categorised into six broad marine bioregions (Figure 4-2). The Marine Bioregional Plans describe the marine environment and conservation values of each marine region, as well as set out broad biodiversity objectives, identify regional priorities and outline strategies and actions to address these priorities (DSEWPC 2012a).

The SWMR comprises Commonwealth waters from the eastern end of Kangaroo Island, South Australia (SA) to Shark Bay, WA. The SWMR spans approximately 1.3 million square kilometres (km^2) and is characterised by the following aspects (DSEWPC 2012a; DEWR 2007):

- Contains subtropical to temperate waters, with complex oceanographic patterns primarily driven by the Leeuwin Current and its interactions with other currents
- Narrow continental shelf on the west coast and a wide continental shelf in the Great Australian Bight
- Exposure of the continental shelf to high wave energy throughout the region
- Islands and reefs in both subtropical (e.g. Houtman Abrolhos Islands) and temperate waters (e.g. Recherche Archipelago)
- Low levels of nutrients and biomass in the ocean and most of the coastal waters
- Diverse marine communities composed of species of temperate origin, which mix with tropical and subtropical species
- Containing globally significant levels of biodiversity and endemism
- Containing threatened and migratory species listed under the EPBC Act, including cetaceans, pinnipeds, marine reptiles, seabirds, seahorses and pipefish, and sharks
- Containing biologically important areas (BIAs), in which EPBC Act listed species carry out critical life functions, such as reproduction, feeding, migration or resting
- Low levels of terrigenous inputs, particularly in the southern part of the region, contributing to low levels of productivity.

Within the SWMR, marine habitats are further categorised into seven provincial bioregions. The OA is located within the Southwest Shelf Transition (SWST), and the EMBA overlaps with part of the Central Western Province (CWP), Southwest Transition (SWT), and the Southwest Shelf Province (SWSP) (Figure 4-3) These four provincial bioregions are described below.

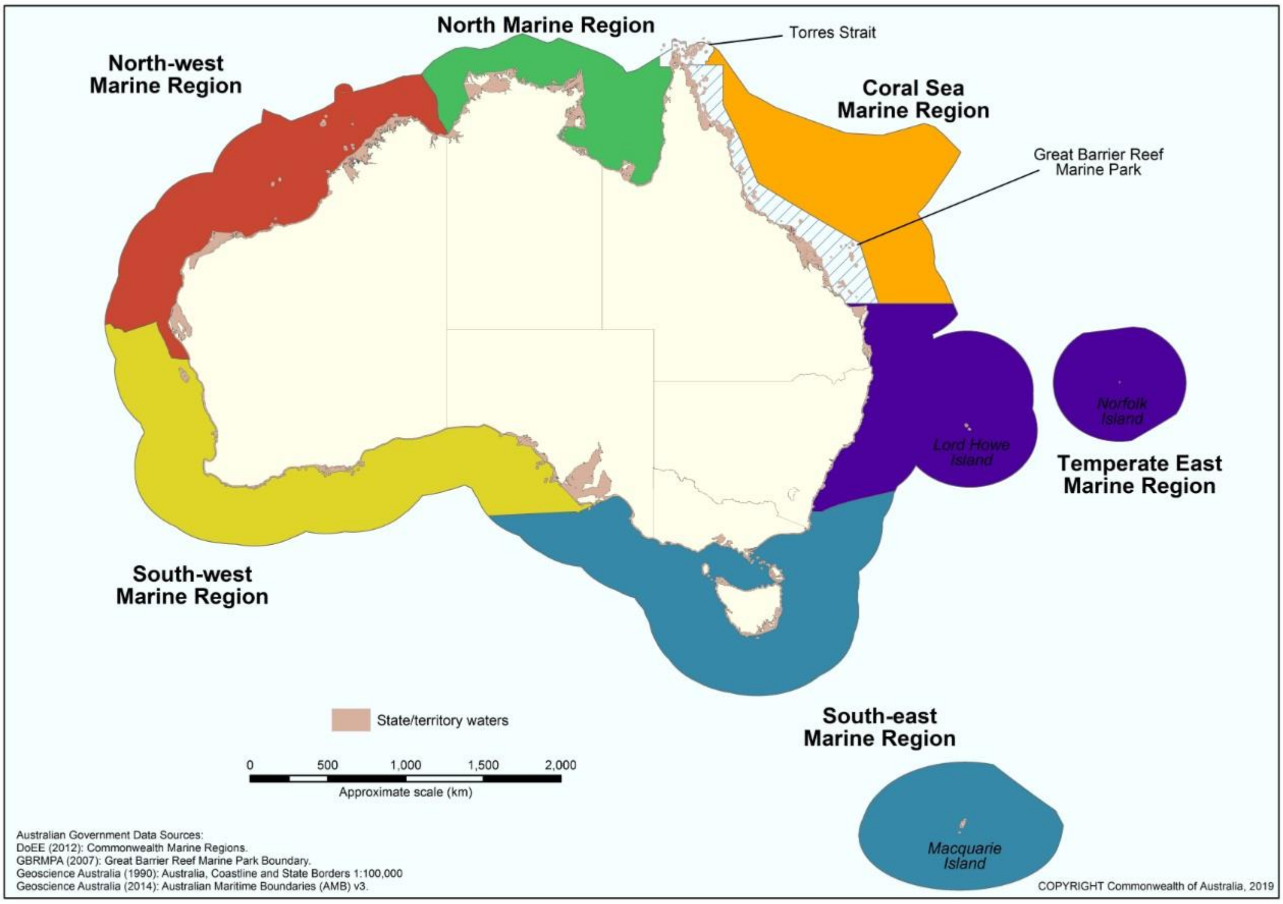

Figure 4-2: Marine bioregions of Australia (Source: DCCEEW 2019a)

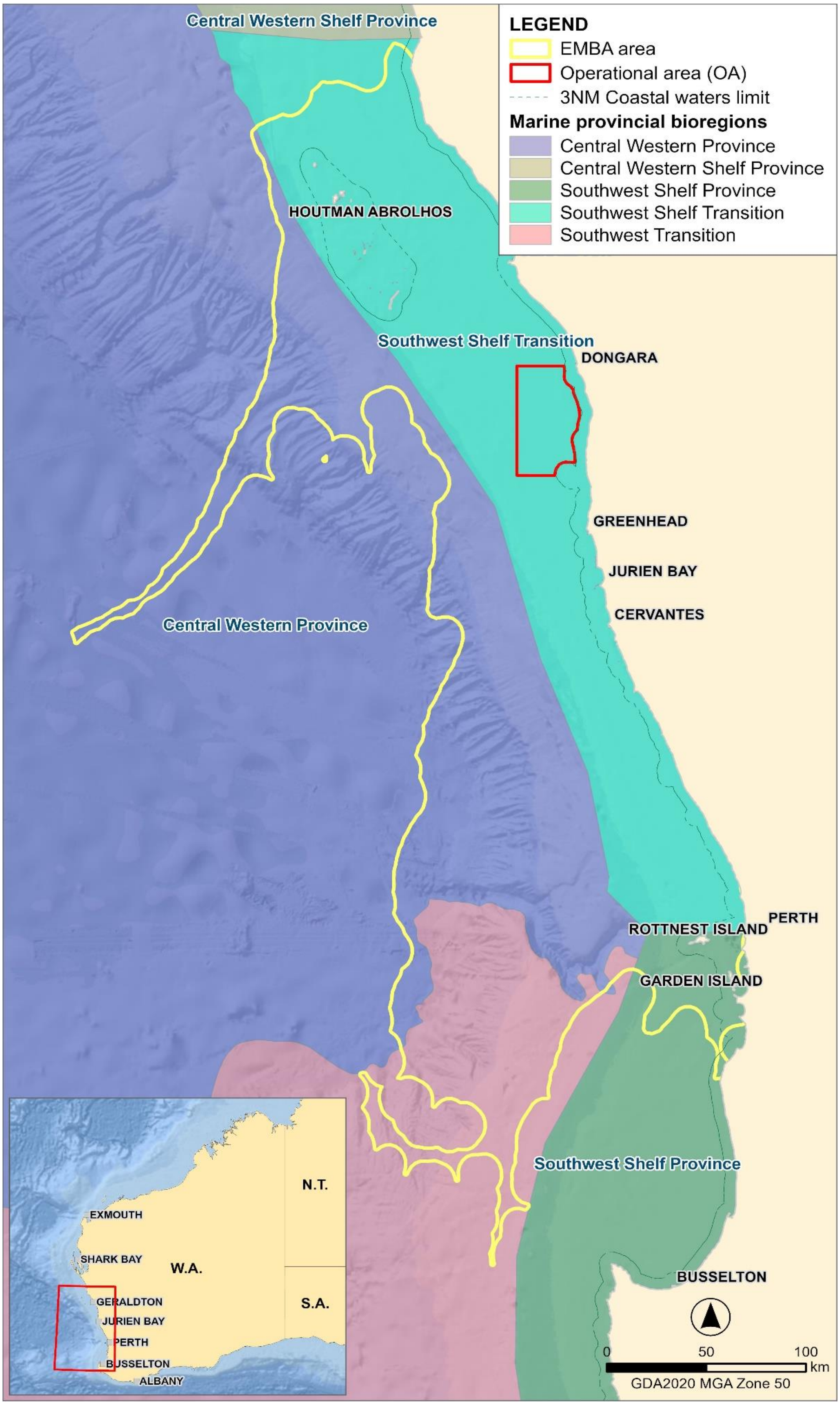

Figure 4-3: Provincial bioregions (IMCRA v4.0) (source: North West Atlas/DCCEEW 2023)

4.1.1.1 Southwest Shelf transition

The OA is located within the Southwest Shelf Transition (SWST), which covers approximately 33,000 km^2 in nearshore areas of the continental shelf between Perth and Kalbarri (Figure 4-3). The narrow continental shelf ranges from approximately 40 to 80 km in width, with a depth of 10–200 m and is physically complex, containing narrow ridges, depressions, and smooth plains (DEWHA 2008b). Important topographical features on the shelf include the Abrolhos Islands, Beagle Islands, Rottnest Island, Garden Island, Cockburn Sound, and the inshore lagoons that run parallel to the coastline (DEWR 2007). The SWST is influenced by the Leeuwin Current (LC) as it pushes sub-tropical water southward along the western edge of the bioregion. The area is a complex transition zone, representing the northern limit of warm temperate species, and the southern limit of sub-tropical and tropical species. For example, the Houtman Abrolhos Islands off Geraldton are renowned for their coral reefs and unique mix of temperate and tropical species (DEWHA 2008b). The region is commercially important to both the petroleum and commercial fishing industries, as well as Defence.

4.1.1.2 Central Western Province

The EMBA overlaps with part of the Central Western Province (CWP), which covers approximately 27,000 km^2 extending offshore from the SWST to the limit of the Australian Exclusive Economic Zone (EEZ) (Figure 4-3). The CWP is characterised by a narrow continental slope, canyons, and the most extensive area (~52,000 km^2) of continental rise in all of Australia’s marine regions (DEWHA 2008b). Large eddies approximately 200–300 m in diameter are a significant feature in the bioregion. Eddies detach from the LC and spin anti-clockwise, transporting shallow water plankton communities offshore to deeper waters, which can enhance productivity in surface waters (DEWHA 2008b). The CWP contains the Perth Canyon, the largest submarine canyon in Australia, which marks a distinct change in the distribution of marine organisms and the southern boundary for many tropical and sub-tropical species (DEWHA 2008b). Demersal fish communities on the continental slope have relatively high biodiversity and include at least 31 endemic species (DEHWA 2008b). The region is commercially important for fishing, shipping, and defence training.

4.1.1.3 Southwest Transition

The EMBA overlaps with part of the Southwest Transition (SWT), which covers approximately 110,000 km^2 extending from the Southwest Shelf Province (SWSP) out to the Australian EEZ (Figure 4-3). The SWT is centred on the Naturaliste Plateau, a 90,000 km^2 submerged continental fragment that rises from water depths of >5000 m to 2000 m and is surrounded by deep ocean floor. This bioregion represents a significantly different environment from the surrounding seabed and adjacent provinces (DEWHA 2008b). Depths in the bioregion range from 48 m to ~6000 m and contain all biome types, resulting in a great diversity of epifauna (DEWHA 2008b). The region is commercially important for fishing, shipping, and defence training.

4.1.1.4 Southwest Shelf Province

The EMBA overlaps with part of the Southwest Shelf Province (SWSP), which covers approximately 61,000 km^2 extending offshore to the SWT (Figure 4-3). It includes the coastal waters and continental shelf of south-west WA. The continental shelf is narrow, with small offshore inlets, high-energy swells, and rocky headlands (DEWHA 2008b). The SWSP contains the second deepest seabed habitat in all IMCRA shelf bioregions and is the only bioregion to contain three classes of geomorphic units (DEWHA 2008b). The SWSP is strongly influenced by the LC, which runs southward along the entirety of the bioregion. This bioregion hosts a large rage of temperate species, with some tropical influence, and large seagrass meadows (DEWHA 2008b). The region is commercially important for fishing, shipping, and Defence training.

4.2 Physical environment

4.2.1 Climate

4.2.1.1 Seasonal patterns

The climate of the SWMR is dry subtropical, exhibiting a short and hot summer season from December to March and a cooler winter season between May and September (BoM 2022a). The region is characterised by winter dominant rainfall and windy conditions experienced year-round, which strengthen in the summer months.

The region is also influenced by the El Niño Southern Oscillation (ENSO), an irregular periodic variation in winds and sea surface temperatures over the tropical Pacific Ocean that is associated with climate anomalies in the tropics and subtropics (McClatchie et al. 2006).

4.2.1.2 Air temperature and rainfall

The region experiences a Mediterranean climate, characterised by distinct seasonal patterns of hot, dry summers (November to February) and mild, wet winters (May to August; BoM 2022a). The highest air temperatures in the region occur in January and February, while the lowest temperatures occur in July and August. Rainfall typically occurs during the winter wet season, with the highest rainfall recorded in June and July. Rainfall during the summer period is typically low.

Air temperatures measured at Geraldton airport (approximately 55 km north of the OA) from 2011–2022 are summarised in Table 4-1 and indicate a maximum mean monthly air temperature of 33.0 °C in January, with an annual mean of 27.0 °C. The minimum mean monthly air temperature is 9.0 °C in August, with an annual mean of 13.8 °C (BoM 2022a). Rainfall measured in Geraldton town (approximately 55 km north of the OA) from 1877 to 2022 shows maximum and minimum mean monthly precipitation of 109.8 mm in June and 3.6 mm in December, with a mean total annual precipitation of 445.3 mm (BoM 2022a).

Table 4-1: Mean daily maximum and minimum air temperatures for each month (2011–2022) and mean monthly precipitation (1877–2022) recorded at Geraldton

Month	Mean daily maximum (\°C)*	Mean daily minimum (°C)*	Mean monthly precipitation (mm)†
January	33	19.2	6.1
February	32.8	19.6	9
March	31.9	18.5	13.6
April	28.8	15.6	23.6
May	25.1	12.3	66.7
June	22	10.3	109.8
July	20.6	9.5	88.3
August	21.1	9	64.5
September	23.3	9.2	29.8
October	25.7	11.6	17.7
November	28.4	14.4	8.1
December	31.4	17	3.6

* Recorded at Geraldton airport (source: BoM 2022a)

†Recorded at Geraldton town

4.2.1.3 Wind

Anticyclonic high-pressure systems, as well as periodic tropic and extratropical cyclones and seasonal sea breezes characterise the wind patterns off the WA coast. The seasonal movement of high-pressure systems from ~38°S in summer (generating mainly offshore winds) to ~30°S in winter (producing mainly onshore winds) creates a progressive phase-shift in the seasonal wind pattern (Gentilli 1971; 1972; Pattiaratchi &

Woo 2009). Around the OA winds vary seasonally, with generally strong and persistent southerlies during the summer months and weaker, more variable winds in winter (Figure 4-4). The wind roses indicate predominantly southerly winds between February and March, with average wind speeds of 7.5 m/s and peak speeds of 18.5 m/s.

In addition to seasonal wind trends, there is a consistent sea breeze system characterised by offshore winds from an easterly direction in the morning, switching to obliquely onshore winds from a south-south-west direction in the afternoon. The cycle is often defined by an abrupt increase in wind speed and shift in wind direction (Masselink & Pattiaratchi 2001).

Winds in the region are also highly influenced by meteorological processes, such as the passage of cold fronts during winter and storms in the southern Indian Ocean. Dissipating tropical cyclones may track down from the northwest coast infrequently during late summer and can have significant impacts on the coastline, causing extreme winds, storms surge, and storm waves (Eliot & Pattiaratchi 2010).

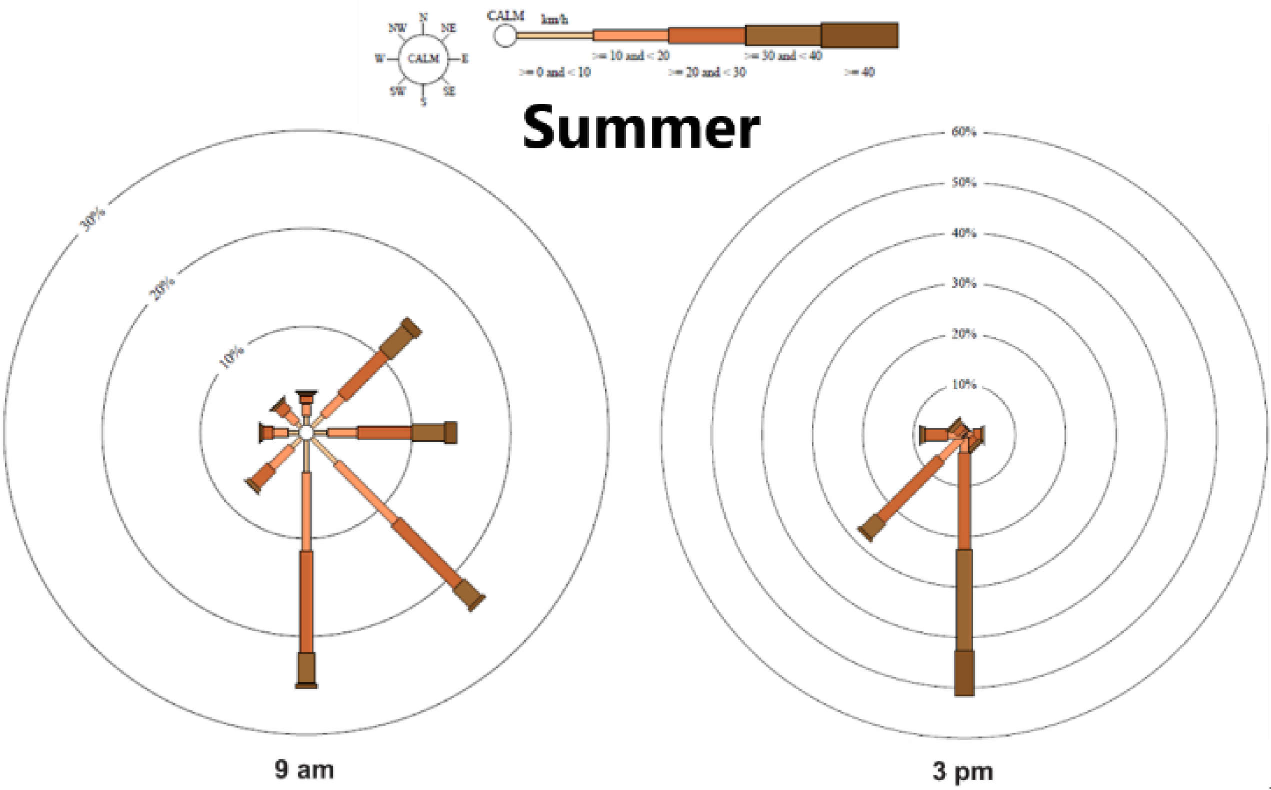

Figure 4-4: Wind roses for Geraldton, showing direction (%) vs wind speeds (km/h) at 9.00 am and 3.00 pm in summer 1941–2014 (source: BoM 2022b)

4.2.2 Oceanography

4.2.2.1 Tides

The SWST has a mixed, primarily diurnal, and partly semi-diurnal tidal regime. Tides off the WA coast generally increase in magnitude from south to north, with seasonal variation in tidal range as the annual cycle of diurnal tides peaks near the solstices in June and December (BoM 2023a; Eliot 2018).

Tides recorded at Port Denison (6 km north-west of the OA) are mainly diurnal and microtidal, with an average tidal range of approximately <1 m (BoM 2023a). Similarly, Geraldton (approximately 55 km north of the OA) tides are typically diurnal and microtidal. In the wider EMBA, Fremantle (approximately 260 km south-east of the OA) also experiences mainly diurnal microtidal conditions, with an average tidal range of approximately 0.7 m (DoT 2023) and surge and mean sea level fluctuations of comparable amplitude to the tide (BoM 2023a; Eliot 2018).

Due to the small range, tides in the SWST are influenced by the inter-annual variability of mean sea level and global long-term sea level rise, as well as meteorological processes including winds and cyclonic events that may override tidal patterns and contribute to greater sea level changes, such as storm tides (Eliot 2018).

4.2.2.2 Waves

The SWMR has high wave energy on the continental shelf around the whole region (DSEWPC 2012a). The offshore wave climate in the SWST is characterised by persistent moderate energy swell from the south to south-west, together with a variable local wind wave climate (Lemm et al. 1999; Masselink & Pattiaratchi 2001). Sea breezes have a strong influence on the offshore wave conditions during summer, therefore swell is from the south to south-west with predominantly low period (less than eight second [s]) waves in the range of 1–2 m (Lemm et al. 1999). In winter, north-westerly to south-westerly storm waves occur, characterised by high period (more than 8 s) swell and waves in the range of 1.5–2.5 m that show significant inter-annual variation (Lemm et al. 1999; Masselink & Pattiaratchi 2001). As such, there is a distinctive shift in the offshore wave regime from moderate, locally generated seas in summer to greater, distantly generated swell in winter. Persistent background swell above 0.5 m occurs year-round from the Indian and Southern oceans (Lemm et al. 1999).

Closer to the shore, the swell is frequently attenuated by up to 90% as waves propagate across the continental shelf through several offshore reef systems and islands, contributing to smaller wave heights (Sanderson et al. 2000; Hegge 1994). As such, the nearshore wave climate is more protected from longer waves in the prevailing south-westerly swell (Hegge 1994; Lemm et al. 1999; Masselink & Pattiaratchi 2001). Wave heights are approximately 30–70% of offshore outside the reef system depending on the location, and typically increase northward due to a reduction of reefs, ridges, and islands (Masselink & Pattiaratchi 2001). For example, in the Perth metropolitan area in the south of the SWST, mean significant wave heights in the summer and winter are approximately 1.5 m and 2.5 m, respectively (Masselink & Pattiaratchi 2001).

Waves are also highly influenced by meteorological processes including winds and cyclonic events. In WA, continental shelf waves are generated by the passage of tropical cyclones in the northern part of the state and may propagate for thousands of kilometres influencing local wave climates in the SWST (Eliot & Pattiaratchi 2010).

4.2.2.3 Oceanic temperature

Current data available from the National Oceanic and Atmospheric Administration (NOAA) shows the mean annual sea surface temperature (SST) in the OA and EMBA is approximately 21–23 °C (Boyer et al. 2018a). SST typically peaks in January–February and is lowest in July–August (BoM 2023b; IMOS 2023).

Oceanic temperatures in the SWST transition between warmer waters of the tropics (at the northern limit) and cooler waters of the mid latitudes (at the southern limit), with seasonal and depth variations related to the currents in the region. Oceanic temperatures vary in cycles: inter-annual (longer-term), annual (seasonal), short-term (multi-day weather related) and diurnal (daily).

Historically, oceanic temperatures recorded in the region were approximately 19–24 °C in summer and 16–21 °C in winter, with a mean annual temperature range (i.e. winter minimum to summer maximum) of 3–7 °C (Pearce et al. 1999). The along-shore temperature gradient was approximately 0.4 °C per degree of latitude. The short-term cycle had a typical range of 1–2 °C, while the mean diurnal temperature range was approximately 0.2 °C (deep offshore waters) to 1.7 °C (inshore waters during mid-summer; Pearce et al. 1999).

At the Abrolhos Islands (approximately 60 km north-west of the OA), the Leeuwin Current (LC) maintains warmer temperatures over winter, effectively dampening atmospheric influences and restricting the annual variation to approximately 20–24 °C (Pearce et al. 1999; Phillips & Huisman 2009). Conversely, the shallow coastal waters of Dongara (approximately 6 km east of the OA) are more directly influenced by atmospheric conditions, with mean monthly temperatures ranging between 17.5 °C in July and 23.9 °C in February (based on data from 1990 to 1994), in phase with coastal air temperatures (Pearce et al. 1999; Phillips & Huisman 2009).

Climate change has caused a warming trend (approximately 0.02 °C year) in SSTs in the south-eastern Indian Ocean, and warmer than average temperatures persist off the WA coast (BoM 2023c). SSTs along the WA coast have also shown strong seasonal and inter-annual variability over recent decades, with increases/decreases in mean monthly SST by up to 2 °C in interannual cycles between 1993 and 2018, mainly associated with ENSO events (Pattiaratchi & Hetzel 2020). During La Niña events, a strong LC transports warm water southwards, whereas during El Niño events, the LC is weaker with generally lower water temperatures (Chen et al. 2019). This variability greatly influences coastal ecosystems, for example, the 2011 La Niña event, created a severe marine heatwave along the WA coast (Pearce & Feng 2013).

4.2.2.4 Currents

The primary current in the SWST is the LC system, which includes three main currents: the LC, the Leeuwin Undercurrent (LU), and the shelf current systems consisting of the Capes and Ningaloo currents (Pattiaratchi & Woo 2009). The LC is a shallow (<300 m), narrow band (<100 km wide) of warm, lower salinity, nutrient depleted water of tropical origin that flows southward along the western perimeter of the region from Exmouth to Cape Leeuwin and into the Great Australian Bight (Pattiaratchi & Woo 2009) (Figure 4-5). The LC flows year-round with seasonal variability, typically strengthening in autumn–winter and weakening in summer when winds blow from the south (Cresswell & Domingues 2009; Pattiaratchi & Woo, 2009). The strength of the LC is also driven by ENSO events, strengthening during La Niña and weakening during El Niño periods (DEWR 2007; Pattiaratchi & Woo, 2009).

The LC strongly affects the ecology of the region by supressing the upwelling of cooler, nutrient-rich waters while generating localised eddies through the interaction with seabed topography and offshore waters of different densities (Pattiaratchi & Woo 2009; DEWHA 2008b). Eddies form at the shelf break and eventually separate from the current and drift westward (McClatchie et al. 2006). Eddies generate cross-shelf currents that connect the continental shelf and deeper waters, providing nutrients on the continental shelf that enhance biological productivity (DEWHA 2008b). LC eddies have been observed off Shark Bay, the western edge of the Abrolhos Islands, south-west of Jurien Bay, the Perth Canyon, south-west of the Capes region, south of Albany and south of Esperance (DEWR 2007) (Figure 4-5).

The LC also plays a key role in the distribution of species in the region. The warm water transported southward has extended the distribution of tropical and subtropical species to areas further south than would otherwise occur. Additionally, the LC and the deeper Flinders Current form a ‘conveyor belt’ system that is likely used for large-scale movements by migratory species (DEWR 2007). The LC system interacts with the other main currents in the region: the LU, the Western Australian Current (WAC), and the coastal Ningaloo, Capes and Cresswell currents (McClatchie et al. 2006) (Figure 4-5). The LU is a deeper, subsurface current that flows northward beneath the LC over the continental slope, while the WAC is a shallow, northward flowing surface current farther offshore from the LC (Pattiaratchi & Woo 2009; DEHWA 2008b) (Figure 4-6).

The coastal currents are driven by wind and subsequently exhibit considerable seasonal variability and influence on the biological communities in the region (Pattiaratchi & Woo 2009). The Capes current is an inner shelf current that originates in the Capes region and flows northward in the summer months to the Abrolhos Islands. The current transports cool and saline water, together with the larvae of temperate species, contributing to the upwelling of cold water on the continental shelf by displacing the LC further offshore (Pattiaratchi & Woo 2009; DEHWA 2008b).

Typical seasonal current distributions in the OA are shown in Figure 4-7.

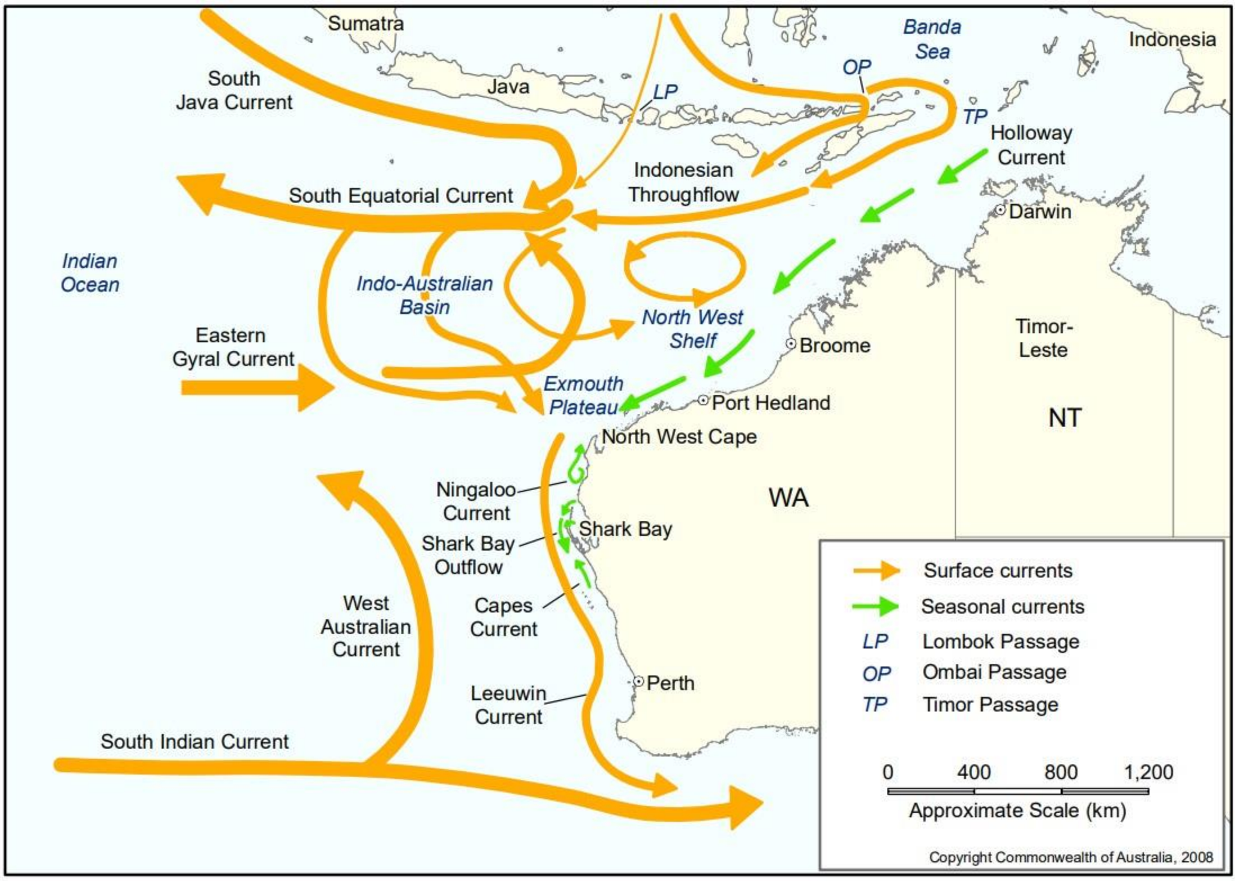

Figure 4-5: Surface currents in Western Australian waters. Source: DEWHA (2007)

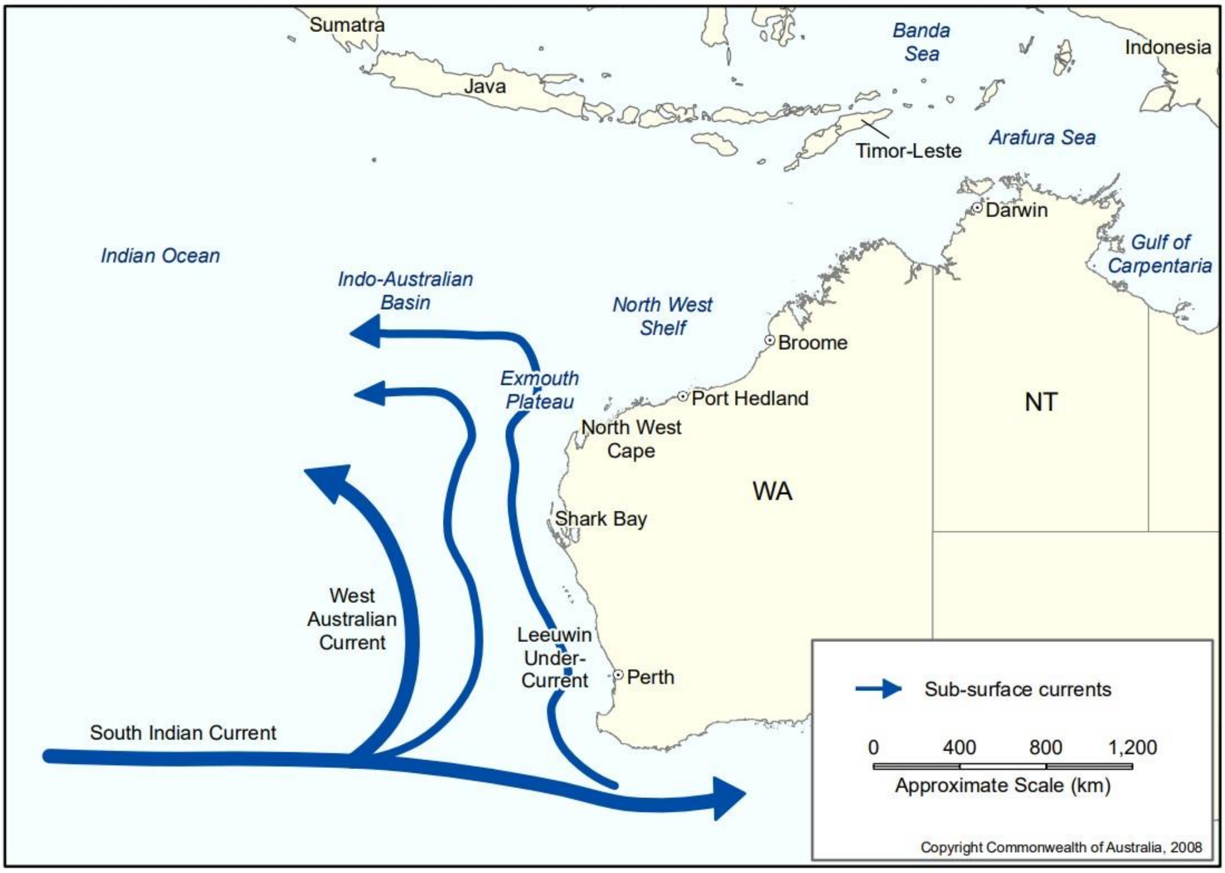

Figure 4-6: Subsurface currents in WA waters (Source: DEWHA 2007)

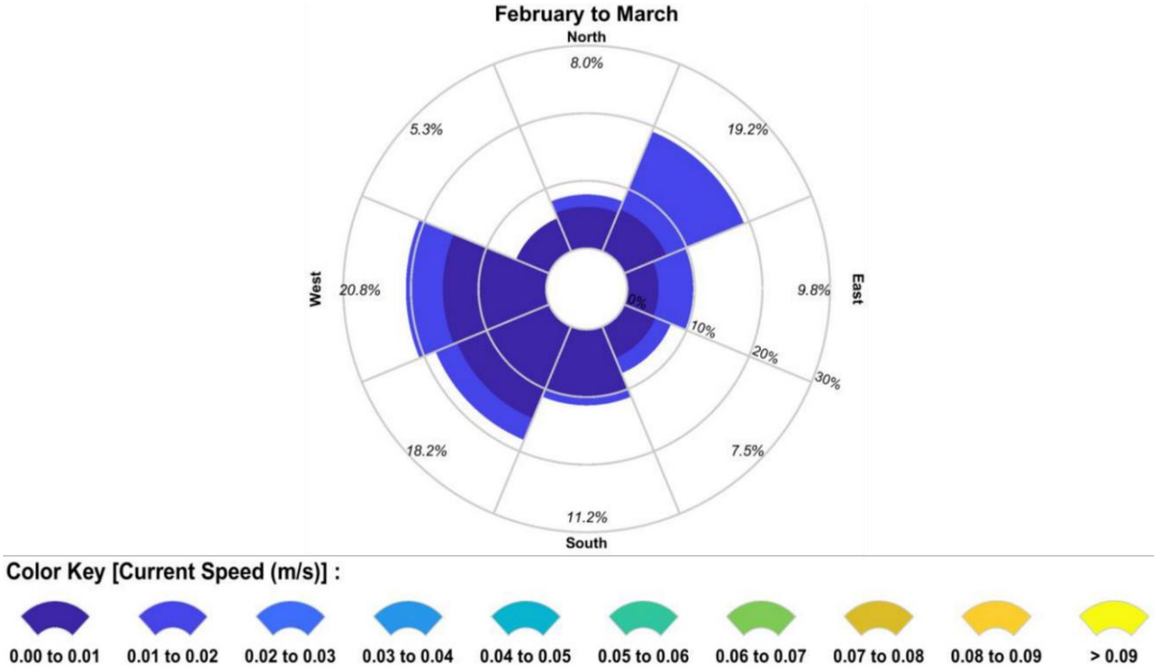

Figure 4-7: Typical seasonal current distributions (2006 – 2015, inclusive) in the OA. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record (Source: RPS 2023)

4.2.2.5 Salinity

Current data available from NOAA and BoM shows annual surface salinity in the OA and EMBA is approximately 35–36 practical salinity units (PSU) (Boyer et al. 2018b; BoM 2023b). Historically, salinity recorded in the region was also approximately 35–36 PSU (McClatchie et al. 2006; Pattiaratchi & Woo 2009; Chen et al. 2019).

Salinity off the WA coast transitions between warmer, lower salinity waters near the tropics to cooler, higher salinity waters off south-western Australia (McClatchie et al. 2006), with seasonal and interannual variability associated with the LC and ENSO events. The LC brings lower salinity water of tropical origin southward through the SWST and is typically stronger in the autumn–winter, reducing local salinity (Chen et al. 2019; Pattiaratchi & Woo 2009). ENSO events drive interannual variability, for example, higher salinity was recorded during the El Niño event in 2010, with a corresponding decrease in salinity during the strong La Niña event in 2011 (Chen et al. 2019).

WA also experiences high evaporation rates during the summer months, especially in the northern region, resulting in more saline and dense shallow coastal waters. This creates a cross-shelf gradient with deeper waters, i.e. salinity is more uniform in the surface waters offshore (Chen et al. 2019).

4.2.2.6 Water quality

Waters in the SWMR are characterised by low levels of biological productivity and nutrients (DEWR 2007; DEWHA 2008b). The LC is the primary driver of water quality off the WA coast, bringing nutrient depleted water of tropical origin southward while suppressing the upwelling of nutrient-rich waters of the northward WAC along the continental shelf (Pearce 1991; Pattiaratchi & Woo 2009). The LC typically weakens during summer, facilitating more upwelling of nutrient-rich waters along the continental shelf (Cresswell & Domingues 2009; Pattiaratchi & Woo, 2009). The LC also increases biological productivity around localised eddies that generate cross-shelf currents connecting the continental shelf and deeper waters, providing nutrients on the continental shelf (DEWHA 2008b).

The SWMR is also characterised by the absence of high-flowing river systems and consequently a limited amount of terrigenous (originating from the land) nutrient inputs, which greatly influences the ecology of the region (DEWR 2007; DEWHA 2008b). The suppression of large-scale upwelling by the LC together with limited nutrient inputs from the land maintains the relatively nutrient-poor conditions in the region compared to other marine environments. The low river discharge and generally low biological productivity also results in low turbidity (suspended sediments), making the waters of the region relatively clear (DEWR 2007; DEWHA 2008b). This allows light to penetrate to benthic communities at greater depths and provides for light-dependent species and associated communities to be found deeper than elsewhere (up to 120 m in some parts of the SWMR; DEWR 2007; DEWHA 2008b).

In nearshore areas, turbidity also varies due to periodic storm run-off and wind generated waves (Pearce et al. 2003). For example, major sediment transport associated with tropical cyclones in the northern part of WA may influence turbidity on a regional scale (Brewer et al. 2007).

4.2.3 Bathymetry and geomorphology

The bathymetry in the OA and EMBA is primarily characterised by flat seabed and parallel ridges along the continental shelf. Water depths in the OA range from approximately 10 m on the eastern perimeter to approximately 75 m in the south-west corner, with most of the OA between 25 and 50 m deep (Figure 3-2). The wider EMBA gradually slopes from the coastline towards the shelf edge and is approximately 10–200 m deep (Figure 3-2). Prominent features in the EMBA include the reefs, submerged banks/shoals, deep holes, and valley features surrounding the Abrolhos Islands 60–80 km offshore, as well as fringing coastal reefs and intertidal areas along the coastline (Figure 4-8). During consultation information was provided to indicate that some reef areas may at times be shallower than 10m.

The continental shelf between Geraldton and Cape Leeuwin is named the Rottnest Shelf (RS), which ranges from approximately 40 to 80 km wide, with a depth of 10–200 m. Important features on the RS include the Abrolhos Islands, Beagle Islands, Rottnest Island, Garden Island, Cockburn Sound, and inshore lagoons that run parallel to the coastline (DEWR 2007). The RS includes a steep shoreface (<30 m deep), a flat inner shelf plain (30–50 m deep), a linear ridge complex (~40 m deep) and an outer shelf sloping to the shelf edge (~200 m deep) (McClatchie et al. 2006). Parallel limestone ridges and depressions 5–10 km offshore stand 10–20 m above the sea floor creating an extensive area of shallow water on the shelf, which is indicative of the geomorphology of the OA (DEWR 2007). The edge of the RS contains a series of broken offshore ridges that extend to the northern limits of the SWST, where they emerge to support the carbonate reef growth of the Abrolhos Islands (DEWHA 2008b). The RS supports sandy seabed, limestone pavement, patch reef, emergent reef, and seagrasses, providing shallow water habitats for many marine communities (DEWR 2007).

The escarpment at the RS boundary marks the ancient sub-aerially exposed land surface and coastline (beach and dune deposits), known as the ancient coastline. The ancient coastline between 90 and 120 m depth is designated as a Key Ecological Feature (KEF) and runs through the western perimeter of the EMBA (Section 4.3.5, Figure 4-9). This area provides hard substrate and may support greater diversity and species richness relative to surrounding areas of soft sediment (DSEWPC 2012a).

Beyond the RS lies an extensive continental slope incised by terraces and submarine canyons, a well-developed continental rise, and an extensive area of abyssal plain/deep ocean floor (McClatchie et al. 2006; Richardson et al. 2005). The continental slope includes the Perth Canyon, which is the largest and most significant on the Australian margin, and a designated KEF (Section 4.3.5).

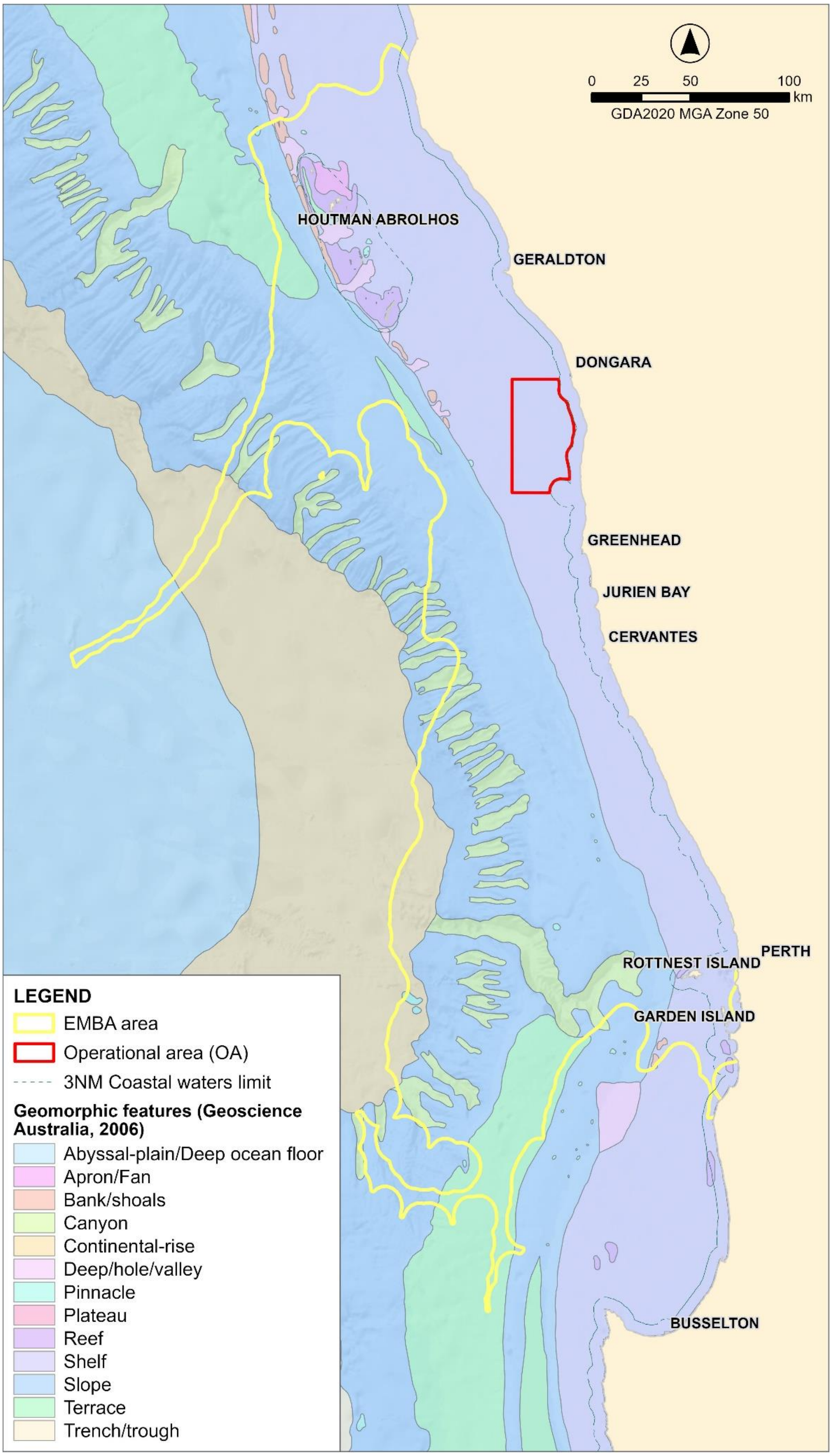

Figure 4-8: Geomorphic features of the OA and EMBA

4.2.4 Sedimentology

Sediments in the OA and EMBA are broadly characterised by calcareous gravel, sand, and silt. This type of substrate is known to support relatively little seabed structure or sessile epibenthos. Habitats closer to the shore are categorised as sand and reef, with some small areas of exposed reef and macroalgae meadow.

In the SWST, surface sediments primarily contain cool-water carbonate facies on the shelf and warm-water tropical carbonate facies on the reef platforms (Richardson et al. 2005). Shelf sediments contain the skeletal remains of bryozoans, molluscs, foraminifers, and coralline algae, and typically occur as discontinuous sheets over rocky or algal substrates (Richardson et al. 2005). On the reef platforms, scattered zooxanthellate coral fragments reflect warm-water sediment types (Richardson et al. 2005).

Oceanographic processes drive sediment transport in the region. Off the coast of south-west WA, sediments are mobilised in up to 100 m water depth and are generally transported off the shelf (Richardson et al. 2005). The micro tides in SWST play a relatively minor role in sediment transport on the shelf (Richardson et al. 2005).

4.3 Biological environment

4.3.1 Plankton communities

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.

Spatial distribution of phytoplankton and zooplankton is irregular, both vertically and horizontally and temporally. 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.

Plankton within the OA are expected to reflect the conditions of the SWMR on-shelf areas. A large-scale study of plankton dynamics across the northern areas of the SWMR found distinct phytoplankton and zooplankton assemblages from on-shelf and offshore areas (Koslow et al. 2006). Surface waters of the south-western shelf have low nutrient availability, with phytoplankton occurring in higher concentrations near areas where upwelling of deeper, nutrient-rich water occurs (Koslow et al. 2006). The most common plankton in the offshore waters of the south-west Australian shelf are diatoms (single-cell algae with cell walls made of silica); however, the LC also supplies a high proportion of tropical phytoplankton to the area (Koslow et al. 2006). Significant predictable eddy fields occur near the OA, such as offshore of the Abrolhos Islands and south-west of Jurien Bay (Pattiaratchi 2007). These eddies provide mesoscale upwelling, providing nutrients to the local region and increasing plankton productivity. Occasional blooms may occur in the OA, increasing productivity in the region. However, typically the area will consist of warm, nutrient-poor waters (Pattiaratchi 2007).

4.3.2 Benthic habitats and communities

The distribution of benthic communities in the SWMR depends on the water depth, substrate, sediment characteristics, and the availability of food. The OA lies within the Central West Coast (CWC) IMCRA meso-scale region. The CWC is characterised by a relatively narrow continental shelf with diverse moderate energy coastal landforms (IMCRA 1997). The area is typically characterised by temperate species; however, due to warm currents is also characterised by many tropical and sub-tropical species (Fletcher et al. 2011). The sediments within the CWC are expected to be broadly characterised by calcareous gravel, sand, and silt. This type of substrate is known to support relatively little seabed structure or sessile epibenthos. The area is likely sparsely covered by sessile filter-feeding organisms (e.g. gorgonians, sponges, ascidians, and bryozoans) and mobile invertebrates such as echinoderms, prawns, and detritus-feeding crabs (DEWHA 2008b). Habitat closer to the shore is categorised as sand and reef, with some small areas of exposed reef and macroalgae meadow. These areas have greater biodiversity and complexity.

Figure 4-8 shows several banks and shoals located within the EMBA that may support diverse benthic assemblages. Previous benthic surveys commissioned by Roc Oil in 2004–2007 for the Cliff Head Development (Figure 7-4) found five key benthic habitats in the area:

- Sand sea floor habitat:
  - Sub-tidal areas with thick layer of sand over limestone pavement
  - Low epibiota, small patches of macroalgae/ephemeral seagrasses
- Limestone pavement habitat:
  - Red and brown macroalgae dominated habitat
  - Low epibiota, some presence of sessile fauna filter feeders (sponges, ascidians, soft corals) and sparse hard corals
- Patch reef habitat:
  - High profile structures, rising one to four metres above sea floor
  - Tropical and subtropical hard coral species as well as macroalgae and sessile filter feeders (sponges, soft coral)
- Emergent reef habitat:
  - Rich in epibiota diversity
  - High abundance of sponges and ascidians, macroalgae and encrusting corals
  - Approximately 37 genera of coral present at Abrolhos Islands reefs (within the EMBA)
- Seagrass/macroalgae habitat:
  - Fourteen species of seagrass present in region, covering sea floor and limestone pavement habitats
  - Only present in fringe shallow areas of the OA and EMBA.

It is expected that the OA and EMBA would support similar epibenthos as those found in the Cliff Head benthic surveys due to shared bioregions and comparable benthic habitat, sediments, and geomorphic features. The EMBA also contains KEFs that support a range of benthic habitats and communities. Benthic habitats associated with KEFs within the OA and/or EMBA are described in Section 4.3.5.

4.3.2.1 Corals

Corals in WA span over 12,000 km of coastline, ranging from tropical to temperate waters, and from coastal reefs to offshore atolls. Coral communities off the west coast are characterised by widely contrasting environments, with high biodiversity and species richness, partly due to the biogeographic overlap of tropical and temperate species (DEWHA 2008b).

Coral diversity typically decreases with increasing latitude (Gilmour et al. 2016). Low latitude reefs in the Kimberley have the highest species diversity and the greatest differences in community composition between oceanic and coastal reefs (Gilmour et al. 2016). The sub-tropical reefs of the Abrolhos Islands are the most southern extensive coral community along the west coast, comprising 184 known coral species (McClatchie et al. 2006). The southward flowing LC moderates winter temperatures and assists the transport of coral larvae, extending the distribution of tropical and subtropical species to areas further south than would otherwise occur. To the south of the Abrolhos Islands, abundant corals mainly occur around offshore islands, with corals at inshore sites occurring in isolated patches (DEWHA 2008b). Smaller localised pockets do occur as far south as Cape Naturaliste (DEWHA 2008b).

The primary differences in community composition across WA are the greater abundance of Acroporidae and massive *Porites* on offshore reefs and tropical reefs north of the Abrolhos Islands, with *Faviidae*, Pocilloporidae, *Turbinaria* and/or *Pavona* more abundant among inshore reefs and those south of the Abrolhos Islands (Gilmour et al. 2016).

WA also has a diverse range of coral reproduction patterns, which vary with coral community composition, modes of reproduction and the cycles of gametogenesis for coral species (Gilmour et al. 2016). The dominant mode of coral reproduction is broadcast spawning; however, the spawning period and the degree of synchrony varies between tropical and temperate regions. The primary period of coral spawning in WA, including in the mid-west and around the Abrolhos Islands is in autumn, often culminating in the mass spawning of many species and colonies during March and/or April (Gilmour et al. 2016). In the temperate south-west, where corals are near their geographical limit, coral spawning occurs around summer and autumn between approximately January and May (Gilmour et al. 2016).

4.3.3 Fish assemblages

Fish communities in the SWMR are diverse, with over 900 species occupying a variety of habitats (DSEWPC 2012a). The SWST supports a gradient of fish communities that extends from the tropical ecosystems of Shark Bay, south along the continental shelf to the temperate ecosystems at Rottnest Island (DEWHA 2008b). Fish assemblages are shaped by depth and habitat, as well as currents such as the LC, which extends the distribution of many tropical and sub-tropical species south down the west coast. Consequently, the EMBA represents the northern limit of many warm temperate fish species, and the southern limit of many sub-tropical and tropical species. For example, the coral reefs around the Abrolhos Islands support a diverse and unique mix of temperate and tropical species (DEWHA 2008b).

The fish assemblages in the OA and/or EMBA are primarily characterised by temperate and subtropical fishes, including many species endemic to the west coast (McClatchie et al. 2006) and several that are targeted by commercial and recreational fishers. On the continental shelf, the variety of benthic habitats support diverse demersal fish assemblages. Key inshore (20–250 m) demersal species include the commercially important WA dhufish (*Glaucosoma hebraicum*), pink snapper (*Pagrus auratus*), baldchin groper (*Choerodon rubescens*) and red-throat emperor (*Lethrinus miniatus*), as well as blue groper (*Achoerodus gouldii*) and the endemic breaksea cod (*Epinephelides armatus*). The Abrolhos region supports approximately 400 known species of demersal fish (DEWHA 2008b) and marks the southern limit in WA for some widespread Indo-Pacific tropical finfish species, such as goldband snapper (*Pristipomoides multidens*). Tropical reef fish species such as those found at the Abrolhos Islands are unlikely to occur in the OA. Key nearshore (<20 m) demersal or benthopelagic (living and feeding near the bottom as well as in midwaters or near the surface) species include the commercially important sea mullet (*Mugil cephalus*) and yellowfin whiting (*Sillago schomburgkii*) (Newman et al. 2023; McClatchie et al. 2006). Key offshore (>250 m) demersal species include the commercially important hapuku (*Polyprion oxygeneios*), blue-eye trevalla (*Hyperoglyphe antarctica*) and eightbar grouper (*Hyporthodus octofasciatus*) (Newman et al. 2023). Other demersal fishes such as apogonids/cardinalfishes (Family Apogonidae), leatherjackets (Family Monacanthidae) and flatheads (Family Platycephalidae) may also occur in the EMBA.

Some demersal species are site-attached or habitat dependent, and do not move away from their home reef, seagrass bed or sand patch. Other species occupy a wide range across several habitats throughout their life cycle (McClatchie et al. 2006). The inshore lagoons in the EMBA are important for the recruitment of commercially and recreationally important species (and it is assumed many other fish species; DEWR 2007). Many juvenile demersal species use inshore, seagrass or sandy/muddy bay habitats for feeding and protection, before migrating offshore as adults to reefs or other habitats (e.g. pink snapper; McClatchie et al. 2006; DEWR 2007).

Key pelagic fishes that occur in the EMBA include mackerels (e.g. Spanish mackerel; *Scomberomorus commerson*), large carangids (e.g. samson fish; *Seriola hippos*), tunas (e.g. southern bluefin tuna; *Thunnus maccoyii*) and billfishes. These large predatory species are typically highly mobile, although they may be associated with specific habitats or bathymetric features. Due to their typical depth and range, oceanic species such as southern bluefin tuna are unlikely to occur in the OA. Schools of migratory fish that visit the inshore/nearshore areas of the EMBA include tailor (*Pomatomus saltatrix*; pelagic-oceanic) and WA salmon (*Arripis truttacea*; pelagic-netric; Newman et al. 2023; DEWHA 2008b). These mid-sized predators feed on small pelagic fish and invertebrates found throughout the inshore lagoons, and in turn are preyed upon by larger predators such as snapper, samson fish, Spanish mackerel, and sharks (DEWHA 2008b). Smaller pelagic fishes in the EMBA include Australian herring (*Arripis georgiana*; pelagic-netric), southern garfish (*Hyporhamphus melanochir*; pelagic-neritic), pilchards (family *Clupeidae*; mostly pelagic-neritic), and whitebait (*Hyperlophus vittatus*; pelagic-neritic, brackish, amphidromous; Newman et al. 2023; McClatchie et al. 2006). Smaller pelagic species are typically pelagic-netric (occupying shallow pelagic zone over the continental shelf) and may also occupy brackish habitats. Small pelagic fishes are key fish communities in the SWMR, providing a critical link between primary production and higher predators and are an important prey item for a diverse range of species (DEWHA 2008b).

Fish spawning may occur year-round, although some species are known to have distinct seasonal spawning periods (Table 4-3). Most finfish species undergo a planktonic larval phase.

The EPBC Act Protected Matters Search Tool (PMST) was used to identify listed species under the EPBC Act that may occur within the OA and/or EMBA (report in Appendix B). The PMST identified three species listed as threatened under the EPBC Act that may occur in the OA and/or EMBA (Table 4-4). A description of the identified threatened fishes is provided in Table 4-2, including their distribution, migratory movements, preferred habitat, and likely presence within the EMBA. Balston's pygmy perch (*Nannatherina balstoni*) is a freshwater species identified by the PMST. Balston's pygmy perch complete their life cycle in freshwater environments (Bray & Gomon 2023; Froese & Pauly 2023); therefore, this species is not included in Table 4-2 and Table 4-4.

The PMST (Appendix B) also identified 18 pipefish species, three pipehorse species, three seahorse species and two seadragon species listed as Marine under the EPBC Act that may occur in the OA and/or EMBA. Listed marine species are not considered threatened under the EPBC Act. The majority of the listed syngnathids (pipefish, pipehorses, seahorses, and seadragons) occupy nearshore and inner shelf habitats that occur in the OA and/or EMBA, typically among seagrasses, mangroves, coral reefs, macroalgae dominated reefs, and sand or rubble (Bray & Gomon 2023; Froese & Pauly 2023; McClatchie et al. 2006). Where depth ranges are known, only two of the 26 listed species are typically recorded in water depths greater than 50 m (Bray & Gomon 2023; Froese & Pauly 2023). Consequently, the listed species may occur in the shallow inshore habitats of the OA and/or EMBA.

Table 4-2: Listed threatened fishes potentially occurring within the EMBA

Common name	Habitat, distribution, and seasonality	Presence in EMBA
Southern bluefin tuna	**Habitat and distribution** Southern bluefin tuna (SBT; *Thunnus maccoyii*) are a large, fast-swimming pelagic-oceanic species, with a depth range of approximately 0–2743 m and a usual depth range of 0–500 m (Bray & Gomon 2023; Froese & Pauly 2023). SBT are circumglobal in temperate and cold temperate waters of the southern hemisphere, ranging across the Pacific, Indian, southern and south-eastern Atlantic oceans, mostly between 30°S and 50°S (Bray & Gomon 2023). In Australian waters, they occur from New South Wales (NSW) through to north-west Australia, although are rare in the central and western Bass Strait along the south coast (Bray & Gomon 2023). Adults are opportunistic predators and mostly feed on pelagic fishes, as well as crustaceans and squid (Bray & Gomon 2023; Froese & Pauly 2023). They are highly valued in global markets and typically the most expensive fresh seafood in the world (Bray & Gomon 2023). Juveniles are generally associated with coastal and continental shelf waters such as in the OA and EMBA, while adults typically inhabit pelagic-oceanic waters and are unlikely to occur closer to the shore. During the southbound migration, the species may occur in the EMBA, but their presence would be sporadic and brief as they continue their southerly migration. **Seasonality** SBT are oceanodromous (live and migrate within oceans) and highly migratory (Froese & Pauly 2023). During breeding between September and April, large fish migrate long distances from their southern feeding areas to their only known spawning ground between northern WA and Java, Indonesia (Bray & Gomon 2023). Individuals then migrate down the WA coast during their first year, before heading west into the Indian Ocean or east into the Great Australian Bight (Bray & Gomon 2023). The eggs and larvae move south from the spawning grounds off Java, and juveniles are often seen south of Perth during their first year. By two to three years of age, juveniles are seen in surface waters off southern Australia, and in the Tasman Sea (Bray & Gomon 2023).	May occur
Orange roughy	**Habitat and distribution** Orange roughy (*Hoplostethus atlanticus*) are a benthopelagic (living and feeding near the bottom as well as in midwaters or near the surface) species that inhabits the deep ocean, with a depth range of approximately 180–1809 m and a usual depth range of 400–900 m (Froese & Pauly 2023). Orange roughy are widespread and are found around southern and south-eastern Australia and New Zealand, in the western Pacific Ocean, the Atlantic Ocean, and in the eastern Pacific Ocean off Chile. In Australian waters, they occur from central NSW, through to south-western Australia, including Tasmania (Bray & Gomon 2023). Orange roughy typically aggregate over steep continental slopes, ocean ridges and seamounts, where they feed on crustaceans and fish (Froese & Pauly 2023). They are slow growing, late to mature, and one of the longest-lived fish species known (Froese & Pauly 2023). Orange roughy may occur in the EMBA; however, their presence in the OA is unlikely as their typical depth range exceeds the maximum depth of the OA. **Seasonality** Orange roughy are oceanodromous, typically migrating between spawning and different feeding areas (Froese & Pauly 2023). They are synchronous annual spawners, forming dense spawning aggregations around seamounts, ridges, canyons, and plateaus. Several stocks may exist at distinct seasonal spawning sites (Bray & Gomon 2023; Froese & Pauly 2023).	May occur

4.3.4 Commercially targeted fish stocks

The SWMR supports commercial fisheries that target a variety of demersal and pelagic fish species. The WA Department of Primary Industries and Regional Development (DPIRD) provided data on the distribution and spawning of fish species that are indicative of fish stocks targeted by fisheries in the OA and EMBA. These species are known as key indicator species and are used in the management of commercial fish stocks. Indicator species are selected from a suite of commercially targeted fishes (based on their vulnerability, management importance and sustainability risk) to represent the status of the overall resource. The status of a suite (e.g. demersal finfish) is evaluated based on the risk status of several indicator species, which represent the more vulnerable species within that suite (Newman et al. 2023).

Table 4-3 summarises the distribution, habitat, depth range and spawning period of indicator species that are relevant to the OA and EMBA. Refer to Section 4.4.2 for more information on commercial fisheries in the OA and EMBA.

Table 4-3: Key inshore and offshore commercial indicator fish species relevant to the OA and EMBA

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
WA dhufish (*Glaucosoma hebraicum*)	WA dhufish are a demersal, non-migratory species endemic to western and southwestern Australia, from Shark Bay to Esperance (Lewis et al. 2012; Bray & Gomon 2023; Froese & Pauly 2023). Adults are generally sedentary and inhabit low to high profile reefs, rocky outcrops, ledges, and hard/flat seabeds, typically 20–50 m deep (Lewis et al. 2012; Bray & Gomon 2023; Froese & Pauly 2023). Juveniles inhabit predominantly sandy areas of low to medium profile reef with mixed macroalgae, sponge and seagrass, as well as seagrass beds in sandy areas (Lewis et al. 2012; Bray & Gomon 2023; Froese & Pauly 2023). Juveniles typically occur in shallower waters 2–48 m deep (Lewis et al. 2012).	WA dhufish are genetically homogeneous in WA, representing a single biological stock (Berry et al. 2012; Fairclough et al. 2013; Smallwood et al. 2013).	Adults 3–200 m (Fairclough & Fisher 2023). Juveniles 2–48 m (Lewis et al. 2012).	WA dhufish are gonochoristic broadcast spawners, releasing floating, pelagic eggs into the water column (Froese & Pauly 2023; Smallwood et al. 2013). Eggs and larvae are dispersed by currents and may travel long distances, contributing to variability in dhufish recruitment (addition of young fish to the overall fish population) to different parts of the coast (Berry et al. 2012; DPIRD 2023a). Spawning occurs throughout their range, typically in shallower waters over isolated reef outcrops and weed-covered sandy areas (DPIRD 2023a). Older and larger female dhufish release more eggs per spawning season, making them important for overall dhufish stocks (DPIRD 2023a). Adults are generally sedentary and there is little evidence of movement once they recruit to an area as juveniles (Fairclough et al. 2013). Stock status Inadequate (Newman et al. 2023).	October to May. Peak December to March (Fairclough & Fisher 2023; Hesp et al. 2002; Berry et al. 2012).	Given their distribution, habitat, and principal depth ranges, adult and juvenile WA dhufish are likely to occur in the OA and/or EMBA. The proposed acquisition window (February–March) overlaps with two months of the eight-month WA dhufish spawning period (Table 4-11).
Pink snapper (*Pagrus auratus,* also known as *Chrysophrys auratus*)	Pink snapper are widely distributed throughout the western Indo-Pacific, including in coastal waters off southern Australia and northern New Zealand (Bray & Gomon 2023; DPIRD 2023b). In WA, they occur in warm temperate to sub-tropical waters from north of Karratha to the Great Australian Bight (Bray and Gomon 2023; DPIRD 2023b; Smallwood et al. 2013). Adults are primarily demersal and inhabit rocky reefs, muddy and sandy areas typically 20–200 m deep, moving to more protected waters for spawning (Bray & Gomon 2023; DPIRD 2023b). Adults can	Pink snapper generally shows low genetic differentiation and high connectivity across WA (Bertram et al. 2022), representing a consistent biological stock. Genetic differentiation typically occurs only at large spatial scales (several hundred km) in Australia; however, it has been recorded at smaller scales in areas of the mid-west (e.g. Shark Bay) and south-east (Fairclough et al. 2013; Bertram et al. 2022).	1–200 m (Fairclough & Fisher 2023)	Pink snapper are gonochoristic serial spawners. Adults migrate to inshore waters for spawning, forming aggregations in known regions off the WA coast, typically in waters less than 50 m deep (Froese & Pauly 2023; Smallwood et al. 2013). In the north, individuals aggregate at inshore reefs around Shark Bay between autumn and spring (May–November), while further south, aggregations form in Cockburn Sound, Owen Anchorage and Warnbro Sound between mid-spring and early summer (October–December) as water temperatures increase (Moran et al. 2003; Lenanton et al. 2009; DPIRD 2023b; Froese & Pauly 2023). Adults that aggregate to spawn in certain	May to November in the Mid-west/Kalbarri. Peak June to August (Fairclough & Fisher 2023).	Given their distribution, habitat, and principal depth range, pink snapper are likely to occur in the OA and/or EMBA. The proposed acquisition window (February–March) does not overlap with the pink snapper spawning period (Table 4-11).

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
	show strong site fidelity to a range of habitats (Bray & Gomon 2023; Froese & Pauly 2023). Juveniles and small adults typically occur in shallower habitats such as bays, inlets and estuaries, often over muddy and seagrass areas (Bray & Gomon 2023).			areas (e.g. Cockburn Sound) may return to that location each year (DPIRD 2023b). Pelagic eggs and larvae produced at the two aggregation sites are kept there by localised currents. This helps keep the offspring in a protected environment, which juveniles use as a nursery (DPIRD 2023b). Stock status Inadequate (Newman et al. 2023).		
Red-throat emperor (*Lethrinus miniatus*)	Red-throat emperor primarily occur in the western Pacific. In Australia, they occur from the central coast of WA to the central coast of NSW, with a discontinuous distribution across northern Australia (Bray & Gomon 2023; Froese & Pauly 2023). The Montebello Islands are the northern-most range in WA for red-throat emperor (van Herwerden et al. 2009). Adults are primarily demersal and non-migratory, inhabiting coral reefs, sandy and rubble areas during the day, before moving to sandy areas to forage at night (Bray & Gomon 2023; Froese & Pauly 2023). Juveniles inhabit shallower, inshore seagrass and mangrove habitats, moving into deeper water as they age (Bray & Gomon 2023; Froese & Pauly 2023).	There are two separate biological stocks of red-throat emperor in western and eastern Australian waters (van Herwerden et al. 2009). Genetic diversity is lower in the west coast population, and higher in the east coast population (van Herwerden et al. 2009). East and west coast populations are managed as separate stocks due to the level of genetic subdivision.	5–50 m (Fairclough & Fisher 2023)	Red-throat emperor are serial spawning, protogynous hermaphrodites that first function as females before changing sex during their life cycle to become males (Froese & Pauly 2023). Spawning occurs throughout their range but may occur at different times in different populations. Regional variation also occurs in reproductive parameters such as size and age at sex change (Williams et al. 2006). Eggs and larvae are pelagic. Stock status Undefined.	October to February. Peak December to February (Fairclough & Fisher 2023).	Given their distribution, habitat and principal depth range, red–throat emperor are likely to occur in the OA and/or EMBA. The proposed acquisition window (February–March) overlaps with one month of the three-month peak red-throat emperor spawning period.
Baldchin groper (*Choerodon rubescens*)	Baldchin groper are a demersal species endemic to the west coast of WA, from Coral Bay to Geographe Bay (Bray & Gomon 2023; Froese & Pauly 2023). They are most abundant at the Abrolhos Islands, although are becoming increasingly common further south (Bray & Gomon 2023; DPIRD 2023c).	Baldchin groper are genetically homogeneous over all or most of WA, comprising a single biological stock (Fairclough et al. 2011; Gardner et al. 2015).	20–100 m	Baldchin groper are serial spawning, monandric protogynous hermaphrodites that first function as females before changing sex during their life cycle to become males (Smallwood et al. 2013; Bray & Gomon 2023; DPIRD 2023c). They usually mature as females at approximately 2–3 years of age and 27 cm long. They produce eggs for several years, before changing sex to male at approximately 8–12 years of age and 48–	August to January. Peak October to December (Fairclough & Fisher 2023)	Given their distribution, habitat, and principal depth range, baldchin groper are likely to occur in the OA and/or EMBA. The proposed acquisition window (February–March) does not overlap with

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
	Adults are generally sedentary and inhabit coral, rocky, and weedy reefs, while juveniles typically inhabit shallower, weedy areas near reefs (Bray & Gomon 2023; Froese & Pauly 2023).			55 cm long (Bray & Gomon 2023; DPIRD 2023c). Spawning occurs near or in benthic reef habitats and at all depths throughout their distribution (Wise et al. 2007; Smallwood et al. 2013). Adults may form large spawning aggregations of up to 100 fish. Spawning at the Abrolhos Islands occurs from early spring to mid-summer (Bray & Gomon 2023; DPIRD 2023c). Eggs and larvae are pelagic (Smallwood et al. 2013). Baldchin groper are relatively sedentary, and movement is confined to small spatial scales. Adults typically occupy the same areas where they were recruited (Fairclough et al. 2011). Stock status Inadequate (Newman et al. 2023).		the baldchin groper spawning period.
Hapuku (*Polyprion oxygeneios*)	Hapuku are a demersal species widespread in temperate oceans of the southern hemisphere (Wakefield et al. 2010; Bray & Gomon 2023). In Australia, they occur in deep (>100 m), continental shelf waters from NSW to south-west WA and Rottnest Island (Wakefield et al. 2010; Smallwood et al. 2013; Bray & Gomon 2023). Adults inhabit deep reefs, canyons and seamounts on the mid-continental shelf to upper slope (Wakefield et al. 2010; Bray & Gomon 2023). Juveniles are pelagic and primarily inhabit surface waters in association with drifting seaweed or floating objects (Smallwood et al. 2013; Bray & Gomon 2023; Froese & Pauly 2023).	The biological stock structure of hapuku throughout Australian waters is unknown. While there may be separate stocks in different geographic regions, the long pelagic juvenile phase of *Polyprion* spp. suggests widespread geographic connectivity and pan-oceanic mixing between southern hemisphere populations (Ball et al. 2000; Wakefield et al. 2010).	115–500 m	Hapuku is gonochoristic (separate males and females) and spawns during the Australian winter following a pre-spawning migration (Wakefield et al. 2010; Bray & Gomon 2023; Froese and Pauly 2023). Eggs and larvae are pelagic (Smallwood et al. 2013). *Polyprion* spp. have an extended pelagic juvenile stage of up to four years in oceanic waters (Ball et al. 2000; Wakefield et al. 2010). Juvenile hapuku in this phase reach sizes up to 670 mm total length (Wakefield et al. 2010). Stock status Sustainable (Newman et al. 2023).	June to September. Peak July to August (Fairclough & Fisher 2023).	Given their distribution, habitat, and principal depth range, hapuku are likely to occur in the EMBA. However, as their principal depth range is greater than the maximum depth of the OA, hapuku are unlikely to occur in the OA. The proposed acquisition window (February–March) does not overlap with the hapuku spawning period.
Blue-eye trevalla	Blue-eye trevalla are widespread in oceans of the southern hemisphere	Recent studies have identified four adult blue-eye	250–650 m	Blue-eye trevalla are serial spawners. Females reach reproductive maturity at 11–	November to May	Given their distribution, habitat,

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
(*Hyperoglyphe antarctica*)	(Bray & Gomon 2023). They are widely distributed southern temperate Australia and extend to sub-tropical latitudes in WA and southern Queensland (QLD) (Williams et al. 2017). Adults are benthopelagic and inhabit deep reefs, seamounts, ridges, and steep features on the upper continental slope, remaining close to the seabed during the day and moving up in the water column at night (Williams et al. 2017; Bray & Gomon 2023; Froese & Pauly 2023). Juveniles inhabit near-surface waters for the first two years of their life, sometimes in association with floating debris (Bray & Gomon 2023; Froese & Pauly 2023).	trevalla stock areas in Australia west, south, east and seamounts-Lord Howe (Williams et al. 2017). Each of these areas represents a discrete adult sub-population without extensive migration between them. However, there is broad-scale connectivity between regional populations of blue-eye trevalla during their pelagic early life phase, and some of the adult subpopulations act as larger 'sinks' than others, i.e. benefiting more from recruitment derived from 'upstream' spawning areas (Williams et al. 2017).		12 years of age, and males at 8–9 years of age (Bray & Gomon 2023). Spawning occurs in summer and autumn as adults aggregate in shallower waters from central NSW to north-eastern Tasmania (Smallwood et al. 2013; Bray & Gomon 2023). Females produce approximately 2–11 million eggs per spawning season, releasing them in several batches (Bray & Gomon 2023; Froese & Pauly 2023). Eggs and larvae are pelagic (Smallwood et al. 2013). Stock status Sustainable (Newman et al. 203).	(Fairclough & Fisher 2023).	and principal depth range, blue-eye trevalla are likely to occur in the EMBA. However, as their principal depth range is greater than the maximum depth of the OA, blue-eye trevalla are unlikely to occur in the OA. The proposed acquisition window (February–March) overlaps with two months of the blue-eye trevalla seven-month spawning period.
Eightbar grouper (*Hyporthodus octofasciatus*)	Eightbar grouper are a deep-water demersal species distributed throughout the western and central Indo-Pacific (Wakefield et al. 2013a; Bray & Gomon 2023). In Australia, they occur in tropical and temperate waters on the outer continental shelf from WA, across northern Australia to QLD. They are widely distributed throughout WA off the north, west and south coasts, and typically inhabit offshore atolls and deeper, rocky reefs (Wakefield et al. 2013a; Bray & Gomon 2023).	The biological stock structure and population connectivity of eightbar grouper is unknown in Australian waters (Wakefield et al. 2013a). They have a continuous distribution throughout WA but do not reproduce in temperate waters south of ~30°S (Wakefield et al. 2013a), suggesting connectivity and recruitment from the northern tropical region.	105–480 m	Eightbar grouper are monandric protogynous hermaphrodites that first function as females before changing sex during their life cycle to become males (Wakefield et al. 2013a). Spawning occurs from late spring to summer in north-western Australia (Wakefield et al. 2013a). Eggs and larvae are pelagic (Smallwood et al. 2013). There is no evidence of eightbar grouper reproduction or males being observed south of ~30°S. While population connectivity is unknown, the spawning omission in temperate waters suggests recruitment from the northern tropical region (Wakefield et al. 2013a). Stock status Sustainable (Newman et al. 2023).	October–February. Peak November–January (Fairclough & Fisher 2023).	Given their distribution, habitat, and principal depth range, eightbar grouper are likely to occur in the EMBA. However, as their principal depth range is greater than the maximum depth of the OA, eightbar grouper are unlikely to occur in the OA. The proposed acquisition window (February–March) overlaps with one month of the eightbar grouper five-month spawning period.

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
Bass groper (*Polyprion americanus*)	Bass grouper are a deep-water demersal species with a global, discontinuous distribution in temperate and sub-tropical waters. In the south-western Pacific, they occur in southern Australia and New Zealand, including south-western Australia to Rottnest Island in WA (Smallwood et al. 2013; Bray & Gomon 2023). Adults inhabit deep continental and oceanic island slopes, as well as rocky reefs, caves, and shipwrecks (Wakefield et al. 2013b; Bray & Gomon 2023; Froese & Pauly 2023). Juveniles are pelagic and may associate with floating objects (Bray & Gomon 2023; Froese & Pauly 2023).	There are separate northern and southern hemisphere biological stocks of bass grouper (Ball et al. 2000). Life history characteristics of *Polyprion* spp. suggest widespread geographic connectivity and mixing throughout southern stocks due to their long pelagic juvenile phase (Ball et al. 2000; Wakefield et al. 2013b). However, southern stocks may be differentiated in certain geographic areas, e.g. temperature profiles and current patterns throughout the southern oceans may prevent significant gene flow between the south and eastern Pacific (Ball et al. 2000).	50–1000 m	Bass grouper is gonochoristic and spawns during the Australian winter (Bray and Gomon 2023). The eggs, larvae and juveniles are pelagic. *Polyprion* spp. have an extended pelagic juvenile stage of up to four years in oceanic waters (Ball et al. 2000; Wakefield et al. 2013b). Stock status Sustainable (Newman et al. 2023).	March–June (Fairclough & Fisher 2023).	Given their distribution, habitat, and principal depth range, bass groper are likely to occur in the EMBA. However, as their principal depth range is greater than the maximum depth of the OA, bass groper are unlikely to occur in the OA. The proposed acquisition window (February–March) overlaps with one month of the bass groper four-month spawning period.

4.3.5 Key Ecological Features

Key Ecological Features (KEFs) are the parts of the marine ecosystem that are considered important for a region's biodiversity or ecosystem function and integrity (DCCEEW n.d.). KEFs have been identified by the Australian Government based on advice from scientists regarding the ecological processes and characteristics of the area. KEFs are not Matters of National Environmental Significance (MNES) and have no legal status. However, they may be considered as components of the Commonwealth marine area.

Two KEFs occur within the OA: Commonwealth marine environment within and adjacent to the west coast inshore lagoons; and Western rock lobster. Four additional KEFs occur within the EMBA: Ancient coastline at 90–120 m depth; Commonwealth marine environment surrounding the Houtman Abrolhos Islands; Perth Canyon and adjacent shelf break, and other west coast canyons; and western demersal slope and associated fish communities (Figure 4-9). These KEFs are described below.

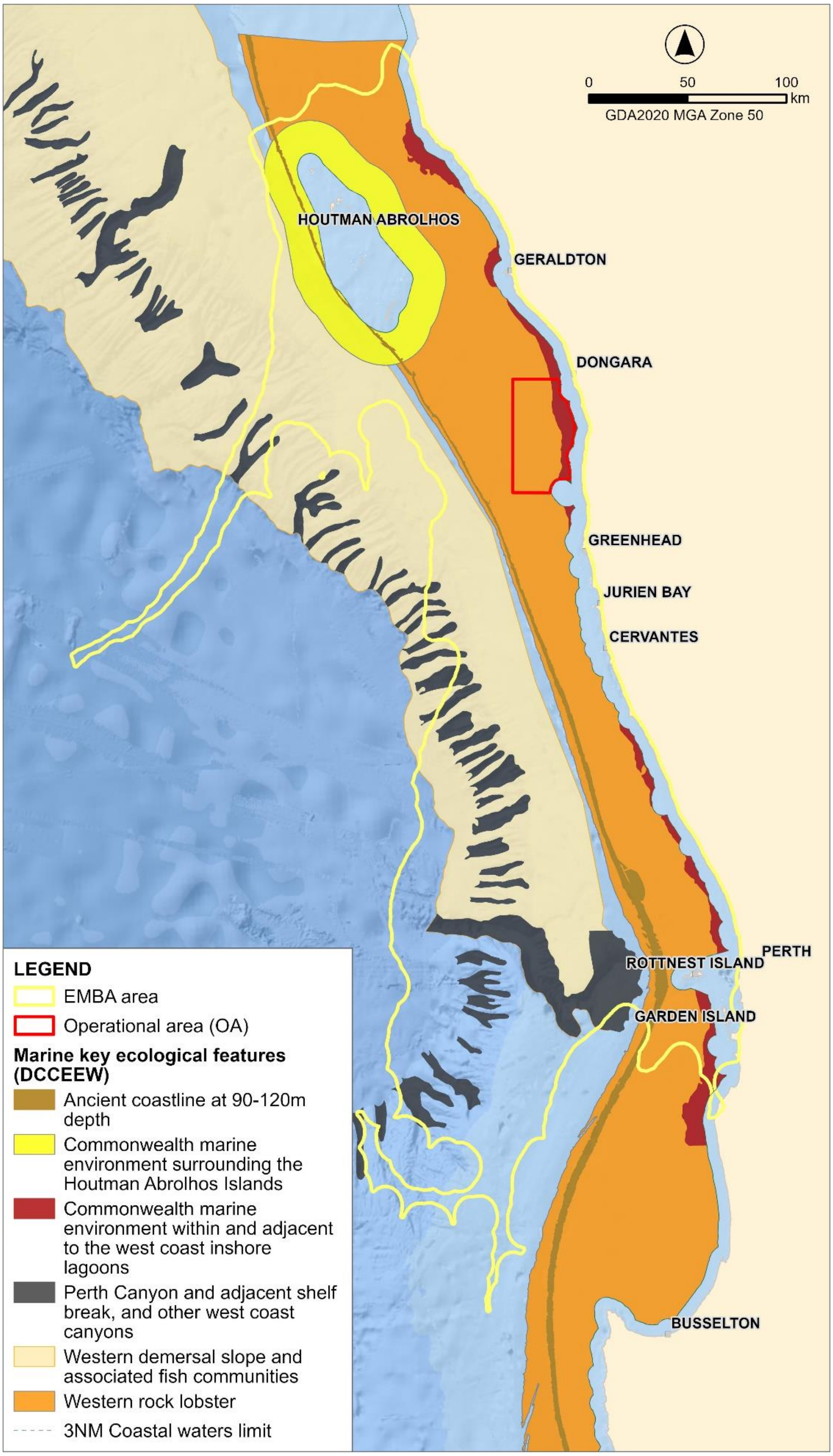

Figure 4-9: KEFs overlapping the OA and EMBA

4.3.5.1 Commonwealth marine environment within and adjacent to the west coast inshore lagoons

The Commonwealth marine environment within and adjacent to the west coast inshore lagoons is a chain of inshore lagoons extending along the WA coast (from Mandurah to Kalbarri) that were formed by limestone reef ridges approximately 0 to 30 m deep (DSEWPC 2012b). Both the OA and EMBA overlap the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF (Figure 4-9).

The lagoons support habitat that is regionally and nationally important for high benthic productivity and aggregations of marine life (DSEWPC 2012b). The lagoons contain a unique community of marine species, due to an influx of warm water and propagules from tropical and subtropical regions carried by the LC. Macroalgae (e.g. extensive beds of *Ecklonia* spp.) and seagrass are the main sources of production, together with groundwater enrichment that may also supply nutrients to the lagoons (Dambacher et al. 2009). The seagrass provides critical habitat for many marine species, with epiphytes attached to the seagrass providing the main sources of food within the lagoons.

The unique mix of tropical, subtropical, and temperate flora and fauna mean the lagoons are associated with high diversity and endemism (McClatchie et al. 2006). The seagrass habitats provide valuable feeding grounds for protected species such as green and leatherback turtles and are important nursery areas for many recreational and commercial fish species, including western rock lobster, dhufish, pink snapper, breaksea cod, baldchin and blue gropers, abalone, and many other reef species (DSEWPC 2012b). Schools of migratory fish also rely on these lagoons, including herring, garfish, tailor, and Australian salmon. The inshore lagoons are important for the recruitment of commercially and recreationally important species (and it is assumed many other fish species; DEWR 2007). Many juvenile demersal species use inshore, seagrass or sandy/muddy bay habitats for feeding and protection, before migrating offshore as adults to reefs or other habitats (e.g. pink snapper; McClatchie et al. 2006, DEWR 2007).

4.3.5.2 Western rock lobster

Within the SWMR, western rock lobsters (WRL; *Panulirus cygnus*) can be found north of Cape Leeuwin to a depth of 150 m (DSEWPC 2012a). Both the OA and EMBA overlap the Western rock lobster KEF (Figure 4-9).

WRL are the dominant large benthic invertebrate in the SWMR. The species plays an important trophic role, as both predator and prey, and is a highly valued recreational and commercial fishing target. The lobster significantly reduces the densities of a diverse variety of invertebrate prey (e.g. epifaunal gastropods), and is a key prey for many species, particularly during the post-larval puerulus phase (MacArthur et al. 2007). Spawning and egg hatching occurs at depths below 40 m in spring–summer, whereafter the phyllosoma get transported offshore into the Indian Ocean via the LC (Figure 4-10). The phyllosoma life stage lasts 9 to 11 months, spreading the species' larvae throughout the south-eastern Indian Ocean, aggregating at depths 50 to 120 m (Hayes et al. 2008). Late phyllosoma larvae metamorphose into a post-larval puerulus beyond the edge of the continental shelf, after which they swim towards shallow inshore reefs. The lobsters stay in these reefs for three to four years, before migrating out to deeper waters to spawn, completing their life cycle (MacArthur et al. 2007).

While inhabiting the inshore reefs, the lobsters are valuable prey for a large range of species, including octopus, cuttlefish, baldchin groper, blue groper, dhufish, pink snapper, wirrah cod, breaksea cod and Australian sea lions (ASLs) (Hayes et al. 2008). Due to the vulnerability and high biomass of lobster, the species is a critical trophic pathway for many inshore species. WRL are also directly targeted by commercial and recreational fishers. Further information on the commercial fishing of WRL is provided in Section 4.4.2.

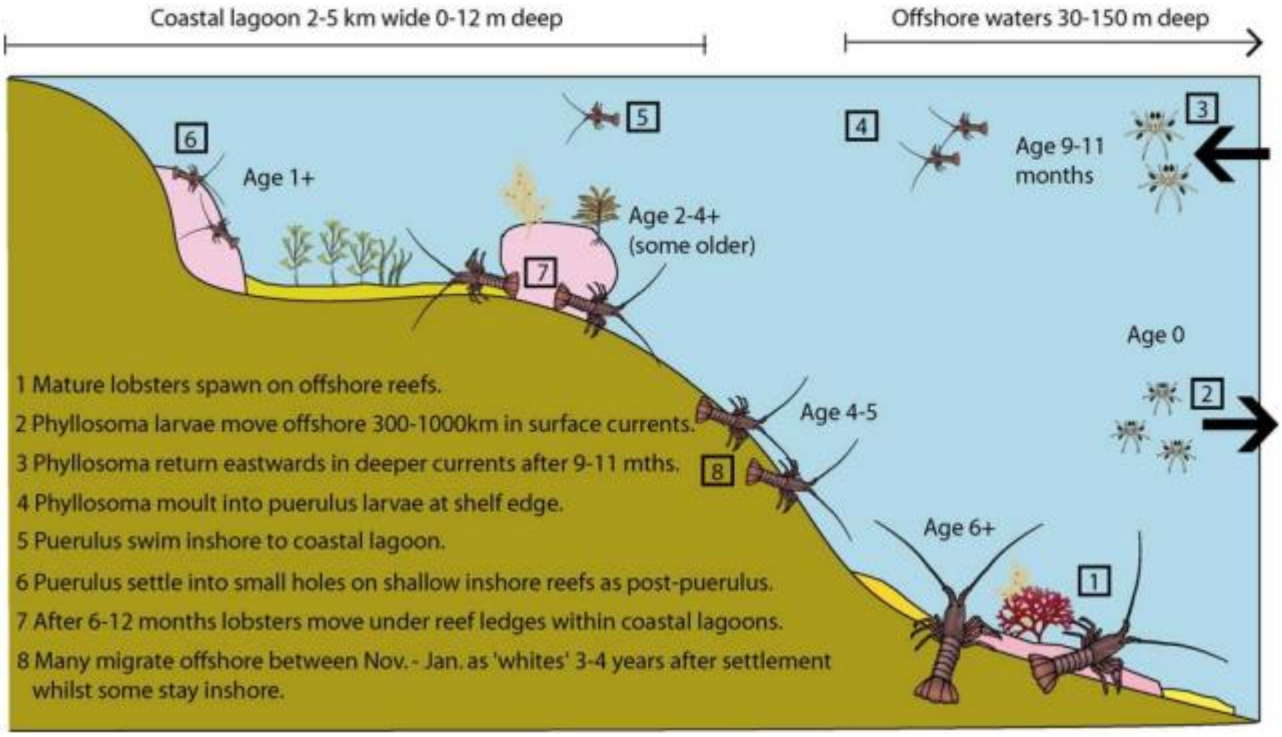

Figure 4-10: Western rock lobster life cycle (source: parksaustralia.gov.au)

4.3.5.3 Ancient coastline at 90–120 m depth

The Ancient coastline between 90 m and 120 m depth KEF contains terraces, escarpments, and steps, reflecting the gradual increase in sea level across the shelf that occurred during the Holocene (DSEWPC 2012a). The south-west corner of the OA is located ~30 km north-east of the ancient coastline, whilst the EMBA overlaps this feature (Figure 4-9).

The ancient coastline is thought to provide areas of hard substrate that contribute to enhanced productivity, biodiversity, and aggregations of marine life (DSEWPC 2012a). The hard substrate may contribute to greater benthic diversity and species richness relative to the surrounding soft sediment habitat, and may include sponges, crinoids, molluscs, echinoderms, and other benthic invertebrates (DSEWPC 2012a). The topographic complexity of these escarpments may also provide a relatively nutrient-rich environment for sessile communities (DSEWPC 2012a).

While little published information is currently available, the hard substrates of the ancient coastline represent distinct benthic habitats for associated mesophotic (approximately 30–150 m depth) demersal fish species (DEWHA 2008b), which may exhibit some level of site fidelity. These habitats may also support some demersal fish species travelling across the continental shelf to the upper continental slope (DSEWPC 2012a), as well as pelagic species that may aggregate in the region. For example, research into fish communities that inhabit the ancient coastline region in the north-west of WA showed that depth, sea floor complexity, and habitat type explained patterns in the richness and abundance of fish assemblages, which were greater in shallower depths featuring benthic biota and pockets of complex substrate (Currey-Randall et al. 2021). Commercially important demersal indicator species (see Section 4.3.4) with principal depth ranges that include 90–120 m are WA dhufish, pink snapper, baldchin groper, hapuku, eightbar groper, and bass groper (Bray & Gomon 2023; Fairclough & Fisher 2023; Froese & Pauly 2023).

4.3.5.4 Commonwealth marine environment surrounding the Houtman Abrolhos Islands

The Houtman Abrolhos Islands are located ~60 km offshore from the WA coast and comprise 122 islands and reefs at the edge of the continental shelf between 28°15’ S and 29°S (DSEWPC 2012a). The north-west corner of the OA is located ~70 km south-east of the Abrolhos, while the EMBA overlaps this feature (Figure 4-9).

The Commonwealth marine environment surrounding the Houtman Abrolhos Islands KEF has conservation value as an area of high biodiversity and endemism in benthic and pelagic habitats and provides important nesting/breeding habitat for many seabird and mammal species (DSEWPC 2012a).

The Abrolhos region supports the highest-latitude coral reefs in the Indian Ocean, as warm water transported southward by the LC extends the distribution of tropical and subtropical species to areas further south than would otherwise occur. The reefs support fauna species typical of the oceanic coral reef communities of the Indo-West Pacific (DEC 2007), including approximately 400 species of demersal fish, 492 species of molluscs, 110 species of sponges, 172 species of echinoderms and 234 species of benthic algae (DEWHA 2008b; Wells & McDonald 2010).

The Abrolhos region marks the northern limit in WA of many warm temperate fish species, as well as the southern limit for some widespread Indo-Pacific tropical finfish species, such as goldband snapper. The islands also represent the northernmost breeding site of ASLs and an important resting area for migrating humpback whales (DSEWPC 2012a).

The major benthic habitats of the Abrolhos include intertidal and subtidal reefs that support a diverse range of benthic communities, including many tropical and sub-tropical species of coral, macroalgae and sessile filter feeders that are not found elsewhere in the CWC (Smale et al. 2012). The Houtman Canyon, like the Perth Canyon, supports many endemic deep-sea species of hard coral, motile feeder feeders and sessile filter feeders, with significantly greater diversity compared to the surrounding soft sediments (Smale et al. 2012).

The Abrolhos Marine Park is described in Section 4.4.1.

4.3.5.5 Perth Canyon and adjacent shelf break, and other west coast canyons

The Perth Canyon and adjacent shelf break, and other west coast canyons KEF includes the Perth, Geographe, Busselton, Pelsaert, Geraldton, Wallaby, Houtman and Murchison canyons (Figure 4-9). The OA is located ~220 km north of the Perth Canyon, whilst the EMBA overlaps this feature.

The Perth Canyon is the largest known undersea canyon in Australian waters and is recognised as a unique sea floor feature with ecological properties of regional significance (DSEWPC 2012a). Deep ocean currents rise to the surface, creating nutrient-rich, cold-water upwelling zones that increase local productivity and attract aggregations of marine life (DSEWPC 2012a). These habitats support small fish, crustaceans, molluscs, and varying epibiota, together with deep-diving mammals (primarily pygmy blue whales) and large predatory fish (Pattiaratchi 2007). The canyons also transport shelf material into the deep ocean and are an important link between continental shelf and deepwater habitats.

Benthic communities in the Perth canyon include endemic, prehistoric deep-sea corals along the 200–700 m bathyal depths (Trotter et al. 2019), as well as localised concentrations of endemic epibiota between 680–1800 m deep, such as sponges, molluscs, echinoderms, crustaceans, brachiopods, and worms (Trotter et al. 2019). The canyon contains far greater biodiversity and endemic species compared to the nearby soft sediment habitats. The Perth Canyon Marine Park is described in Section 4.4.1.

4.3.5.6 Western demersal slope and associated fish communities

The Western demersal slope and associated fish communities KEF extends from the edge of the shelf to the limit of the Australian EEZ, between Perth and the northern boundary of the SWMR (DSEWPC 2012a). The south-west corner of the OA is located ~30 km north-east of the shelf, whilst the EMBA overlaps this feature (Figure 4-9).

The demersal slope and associated fish communities of the CWP are recognised as a KEF for their high levels of biodiversity and endemism when compared to other more intensively sampled oceanic regions of the world (DSEWPC 2012a). Species diversity is attributed to the overlap of Indo-west Pacific and temperate Australasian fauna (Williams et al. 2001). Scientists have described 480 species of demersal fish that inhabit the slope of the CWP, 31 of which are considered endemic to the bioregion (DSEWPC 2012a).

Demersal fish assemblages occurring at depths greater than 400 m are characterised by relatively small benthic species such as grenadiers, dogfish, and cucumber fish (DSEWPC 2012a). 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 (Williams et al. 2001, DCCEEW n.d).

4.3.6 Threatened and migratory species

The EPBC Act Protected Matters Search Tool (PMST) was used to identify species listed under the EPBC Act that may occur within the OA and EMBA (report in Appendix B). The results of the search inform the assessment of planned events in Section 7 as well as unplanned events in Section 8. It should be noted that the EPBC Protected Matters database is a general database that conservatively identifies areas in which protected species have the potential to occur.

A total of 50 EPBC Act listed species were identified as potentially occurring within the OA, consisting of eight mammals, four marine reptiles, 11 sharks and rays, and 27 marine birds. Of those listed, 31 are considered Threatened species under the EPBC Act (Table 4-4).

An additional 47 EPBC Act listed species were identified as potentially occurring within the EMBA, consisting of four mammals, two sharks and 41 marine birds. Of these, 17 are considered Threatened species under the EPBC Act (Table 4-4).

One Migratory terrestrial species (grey wagtail; *Motacilla cinerea*) and one freshwater fish species (Balston's pygmy perch; *Nannatherina balstoni*) were identified in the EPBC search as occurring within the EMBA and have been excluded from further assessment due to the lack of a credible impact scenario.

The full list of species identified from the PMST is provided in the EPBC Act PMST report (Appendix B). The below table contains species that are deemed likely to occur in the OA and/or EMBA, based on the PMST search and background research. All species below are listed as Marine under the EPBC Act.

Table 4-4: EPBC Act Threatened and migratory marine species listed potentially occurring within the OA and EMBA

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Marine mammals					
Neophoca cinerea	Australian sea lion	Endangered	X	✓	✓
Eubalaena australis	Southern right whale	Endangered	✓	✓	✓
Balaenoptera musculus	Blue whale	Endangered	✓	✓	✓
Balaenoptera physalus	Fin whale	Vulnerable	✓	✓	✓
Balaenoptera borealis	Sei whale	Vulnerable	✓	✓	✓
Orcinus orca	Killer whale, Orca	N/A	✓	✓	✓
Balaenoptera edeni	Bryde's whale	N/A	✓	✓	✓
Megaptera novaeangliae	Humpback whale	N/A	✓	✓	✓
Caperea marginata	Pygmy right whale	N/A	✓	X	✓
Physeter macrocephalus	Sperm whale	N/A	✓	X	✓
Balaenoptera bonaerensis	Antarctic minke whale, Dark-shoulder minke whale	N/A	✓	X	✓
Lagenorhynchus obscurus	Dusky dolphin	N/A	✓	X	✓
Marine reptiles					
Caretta caretta	Loggerhead turtle	Endangered	✓	✓	✓
Chelonia mydas	Green turtle	Vulnerable	✓	✓	✓
Dermochelys coriacea	Leatherback turtle	Endangered	✓	✓	✓
Natator depressus	Flatback turtle	Vulnerable	✓	✓	✓
Sharks and rays					
Sphyrna lewini	Scalloped hammerhead	Conservation Dependent	X	✓	✓
Rhincodon typus	Whale shark	Vulnerable	✓	✓	✓
Carcharodon carcharias	White shark, Great white shark	Vulnerable	✓	✓	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Carcharias taurus	Grey nurse shark (west coast population)	Vulnerable	X	✓	✓
Pristis pristis	Freshwater sawfish	Vulnerable	✓	✓	✓
Carcharhinus longimanus	Oceanic whitetip shark	N/A	✓	✓	✓
Mobula birostris	Giant manta ray	N/A	✓	✓	✓
Isurus oxyrinchus	Shortfin mako, Mako shark	N/A	✓	✓	✓
Mobula alfredi	Reef manta ray, coastal manta ray	N/A	✓	✓	✓
Isurus paucus	Longfin mako	N/A	✓	✓	✓
Lamna nasus	Porbeagle, Mackerel shark	N/A	✓	✓	✓
Centrophorus zeehaani	Southern dogfish	Conservation Dependent	X	X	✓
Galeorhinus galeus	School shark	Conservation Dependent	X	X	✓
Fish					
Thunnus maccoyii	Southern bluefin tuna	Conservation Dependent	✓	X	✓
Hoplostethus atlanticus	Orange roughy	Conservation Dependent	X	X	✓
Avifauna					
Numenius madagascariensis	Far eastern curlew	Critically Endangered	✓	X	✓
Limosa lapponica menzbieri	Bar-tailed godwit	Critically Endangered	✓	X	✓
Calidris ferruginea	Curlew sandpiper	Critically Endangered	✓	X	✓
Macronectes giganteus	Southern giant-petrel	Endangered	✓	X	✓
Calidris canutus	Red knot	Endangered	✓	X	✓
Diomedea amsterdamensis	Amsterdam albatross	Endangered	✓	X	✓
Thalassarche cauta	Shy albatross	Endangered	✓	X	✓
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	X	✓	✓
Sternula nereis nereis	Australian fairy tern	Vulnerable	X	✓	✓
Diomedea exulans	Wandering albatross	Vulnerable	✓	X	✓
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	X	✓	✓
Thalassarche melanophris	Black-browed albatross	Vulnerable	✓	X	✓
Diomedea epomophora	Southern royal albatross	Vulnerable	✓	X	✓
Macronectes halli	Northern giant petrel	Vulnerable	✓	✓	✓
Thalassarche impavida	Campbell albatross	Vulnerable	✓	X	✓
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	✓	✓	✓
Thalassarche steadi	White-capped albatross	Vulnerable	✓	X	✓
Onychoprion anaethetus	Bridled tern	N/A	✓	✓	✓
Sterna dougallii	Roseate tern	N/A	✓	✓	✓
Actitis hypoleucos	Common sandpiper	N/A	✓	X	✓
Ardenna carneipes	Flesh-footed shearwater	N/A	✓	✓	✓
Calidris melanotos	Pectoral sandpiper	N/A	✓	X	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Anous stolidus	Common noddy	N/A	✓	✓	✓
Calidris acuminata	Sharp-tailed sandpiper	N/A	✓	X	✓
Hydroprogne caspia	Caspian tern	N/A	✓	✓	✓
Apus pacificus	Pacific swift	N/A	✓	✓	✓
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit	N/A	✓	X	✓
Calidris tenuirostris	Great knot	Critically Endangered	✓	X	✓
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	✓	X	✓
Halobaena caerulea	Blue petrel	Vulnerable	✓	X	✓
Charadrius leschenaultii	Greater sand plover, large sand plover	Vulnerable	✓	X	✓
Pachyptila turtur subantarctica	Fairy prion (southern)	Vulnerable	X	X	✓
Pluvialis squatarola	Grey plover	N/A	✓	X	✓
Calidris ruficollis	Red-necked stint	N/A	✓	X	✓
Ardenna grisea	Sooty shearwater	N/A	✓	X	✓
Phaethon rubricauda	Red-tailed tropicbird	N/A	✓	X	✓
Calidris alba	Sanderling	N/A	✓	X	✓
Pandion haliaetus	Osprey	N/A	✓	X	✓
Arenaria interpres	Ruddy turnstone	N/A	✓	X	✓
Pluvialis fulva	Pacific golden plover	N/A	✓	X	✓
Tringa brevipes	Grey-tailed tattler	N/A	✓	X	✓
Limosa limosa	Black-tailed godwit	N/A	✓	X	✓
Charadrius bicinctus	Double-banded plover	N/A	✓	X	✓
Phalaropus lobatus	Red-necked phalarope	N/A	✓	X	✓
Sternula albifrons	Little tern	N/A	✓	X	✓
Thalasseus bergii	Greater crested tern	N/A	✓	X	✓
Ardenna pacifica	Wedge-tailed shearwater	N/A	✓	X	✓
Xenus cinereus	Terek sandpiper	N/A	✓	X	✓
Tringa totanus	Common redshank	N/A	✓	X	✓
Tringa nebularia	Common greenshank	N/A	✓	X	✓
Tringa stagnatilis	Marsh sandpiper	N/A	✓	X	✓
Numenius minutus	Little curlew	N/A	✓	X	✓
Numenius phaeopus	Whimbrel	N/A	✓	X	✓
Phalaropus lobatus	Red-necked phalarope	N/A	✓	X	✓
Sternula albifrons	Little tern	N/A	✓	X	✓
Thalasseus bergii	Greater crested tern	N/A	✓	X	✓
Ardenna pacifica	Wedge-tailed shearwater	N/A	✓	X	✓
Xenus cinereus	Terek sandpiper	N/A	✓	X	✓
Tringa totanus	Common redshank	N/A	✓	X	✓
Tringa nebularia	Common greenshank	N/A	✓	X	✓
Tringa stagnatilis	Marsh sandpiper	N/A	✓	X	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Numenius minutus	Little curlew	N/A	✓	X	✓
Numenius phaeopus	Whimbrel	N/A	✓	X	✓

4.3.6.1 Listed threatened species recovery plans and conservation advice

Species 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 (DoEE, n.d.). Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of a listed species or ecological community (DoEE, n.d.). Table 4-5 lists the applicable recovery plans and/or conservation advice for EPBC Act-listed species within the OA and EMBA, as identified by the PMST search. Any relevant requirements applicable to the activity will be considered as part of the Environmental Risk Assessment (Section 7 and Section 8).

Table 4-5: Recovery plans and conservation advice for EPBC Act-listed species occurring within the operational area and EMBA

Species	Recovery plan / conservation advice	Key threats identified in the plan/ advice	Actions relevant to the Eureka 3D MSS	Environmental risk assessment section
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (Commonwealth of Australia 2018)	Marine-based sources of debris.	Contribute to long-term prevention of marine debris, through waste management and resource recovery. Limit the amount of single use plastic material lost to the environment in Australia.	Section 8.5
Mammals				
Sei whale	Conservation advice *Balaenoptera borealis* sei whale (TSSC, 2015a).	Anthropogenic noise and acoustic disturbance. Vessel strike.	Assessing and addressing anthropogenic noise. Minimising vessel collisions.	Section 7.1 Section 7.2 Section 8.2
Blue whale	Conservation management plan for the blue whale A recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2015–2025 (Commonwealth of Australia, 2015a).	Noise interference. Vessel disturbance.	Assessing and addressing anthropogenic noise. Minimising vessel collisions.	Section 7.1 Section 7.2 Section 8.2
Fin whale	Conservation advice *Balaenoptera physalus* fin whale (TSSC, 2015b).	Anthropogenic noise and acoustic disturbance. Vessel strike.	Assessing and addressing anthropogenic noise. Minimising vessel collisions.	Section 7.1 Section 7.2 Section 8.2
Australian sea lion	Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*; DSEWPC 2013a)	Anthropogenic noise and acoustic disturbance. Vessel strike. Oil spill.	Assessing and addressing anthropogenic noise. Minimising vessel collisions.	Section 7.1 Section 7.2 Section 8.2 Section 8.6
Southern right whale	Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a)	Anthropogenic noise and acoustic disturbance. Vessel strike.	Assessing and addressing anthropogenic noise. Minimising vessel collisions.	Section 7.1 Section 7.2 Section 8.2
Reptiles				
Loggerhead turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia, 2017)	Threats to the WA stock include: Light pollution. Vessel disturbance (strike) – rated as 'almost certain' likelihood of occurrence, minor consequence. Noise interference (acute) – rated as a 'likely' likelihood of occurrence, minor consequence. An "almost certain" rating means the event is expected to occur every year. A "minor" rating means	Minimise light pollution No specific actions for vessel disturbance are identified by the plan. The Australian Government has developed a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (2017) to	Section 7.1 Section 7.2 Section 7.4 Section 8.2

Species	Recovery plan / conservation advice	Key threats identified in the plan/ advice	Actions relevant to the Eureka 3D MSS	Environmental risk assessment section
		that individuals are affected, but there is no effect at stock level.	provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna. A precautionary approach to acute noise exposure should be applied to seismic surveys.	
Green turtle	Recovery plan for marine turtles in Australia (DoEE, 2017)	Threats to the WA stock include: Light pollution. Vessel disturbance (strike) – rated as a 'likely'* likelihood of occurrence, minor consequence. Noise interference (acute and chronic) – rated as 'unknown' likelihood of occurrence, minor consequence. *A "likely" rating means the event is expected to occur at least once every five years. No specific actions for vessel disturbance are identified by the plan. The Australian Government has developed a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (2017) to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Minimise light pollution A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1 Section 7.2 Section 7.4 Section 8.2
Flatback turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Threats to the Pilbara stock include: Light pollution. Vessel disturbance (strike) – rated as an 'almost certain' likelihood of occurrence, minor consequence. Noise interference (acute) – rated as a 'likely' likelihood of occurrence, minor consequence. No specific actions for vessel disturbance are identified by the plan. The Australian Government has developed a National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (2017) to provide guidance on reducing the risk of vessel collisions and the impacts they may have on marine fauna.	Minimise light pollution A precautionary approach to acute noise exposure should be applied to seismic surveys.	Section 7.1 Section 7.2 Section 7.4 Section 8.2
Leatherback turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017)	Vessel disturbance	Minimising vessel collisions.	Section 8.2

Species	Recovery plan / conservation advice	Key threats identified in the plan/ advice	Actions relevant to the Eureka 3D MSS	Environmental risk assessment section
	Approved conservation advice for *Dermochelys coriacea* (leatherback turtle) (DEWHA 2008c)			
Sharks and rays				
Great white shark	Recovery plan for the great white shark (*Carcharodon carcharias*) (DSEWPaC 2013)	No threats identified that are applicable to this EP.	N/A	N/A
Whale shark	Conservation advice *Rhincodon typus* whale shark (TSSC 2015c)	Vessel disturbance	Minimising vessel collisions.	Section 8.2
Freshwater sawfish	Approved Conservation Advice for *Pristis pristis* (largetooth sawfish) (DoE, 2014a) Sawfish and River Shark Multispecies Recovery Plan (Commonwealth of Australia 2015b)	No threats identified that are applicable to this EP	N/A	N/A
Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (DoE 2014b)	No threats identified that are applicable to this EP	N/A	N/A
Seabirds				
Red knot	Conservation advice *Calidris canutus* red knot (TSSC 2016a)	Habitat degradation (oil pollution). Human disturbance (general).	Manage disturbance at important sites when red knots are present.	Section 7.1 Section 7.5 Section 8.6 Section 8.7
Curlew sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (DoE 2015a)	Habitat degradation (oil pollution). Human disturbance (general).	Manage disturbance at important sites when curlew sandpipers are present.	Section 7.1 Section 7.4 Section 8.6 Section 8.7
Far eastern curlew	Conservation advice *Numenius madagascariensis* eastern curlew (DCCEEW, 2023)	Habitat degradation (oil pollution). Human disturbance (general).	Manage disturbance at important sites when eastern curlews are present.	Section 7.1 Section 7.4 Section 8.6 Section 8.7
Common sandpiper, red knot, pectoral sandpiper, sharp-tailed sandpiper, greater sand plover	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia 2015)	Habitat degradation (oil pollution).	Ensure all areas important to migratory shorebirds in Australia continue to be considered in development assessment processes.	Section 8.6 Section 8.7

Species	Recovery plan / conservation advice	Key threats identified in the plan/ advice	Actions relevant to the Eureka 3D MSS	Environmental risk assessment section
Abbott's booby	Conservation Advice *Papasula abbotti* Abbott's booby (TSSC 2015d)	No threats identified that are applicable to this EP.	N/A	N/A
Greater sand plover	Conservation Advice *Charadrius leschenaultii* greater sand plover (TSSC, 2016b)	Habitat degradation (oil pollution). Human disturbance (general).	Manage disturbance at important sites when greater sand plovers are present.	Section 7.1 Section 7.4 Section 8.6 Section 8.7
Albatrosses and petrels	National Recovery Plan for albatrosses and petrels (DCCEEW 2022b)	Habitat degradation (oil pollution). Human disturbance (general).	Manage disturbance at important sites when greater sand plovers are present	Section 7.1 Section 7.4 Section 8.6 Section 8.7

4.3.6.2 Biologically important areas

Biologically Important Areas (BIAs) are regions where a particular species is known or likely to display important behaviours such as breeding, foraging, nesting, or migration (DoEE n.d.). BIAs provide information to help inform regulatory and management decisions. Table 4-6 identifies the BIAs associated with Threatened and Migratory species potentially occurring within the OA and EMBA, as identified during the PMST search conducted on 3 March 2023 (Appendix B). Further information on BIAs is provided in the individual species descriptions below (Section 4.3.7 and Section 4.3.10).

Table 4-6: Listed Threatened and Migratory species' BIAs within the OA and EMBA

Species	BIA	Distance from OA	Overlaps EMBA
Humpback whale	Migration (north and south)	Overlaps	✓
Pygmy blue whale	Migration	<1 km	✓
	Known Foraging	Overlaps	✓
Southern right whale	Seasonal calving (calving buffer)	185 km	✓
	Migration	<1 km	✓
Sperm whale	Foraging	215 km	✓
Australian sea lion	Foraging	Overlaps	✓
White shark	Foraging	Overlaps	✓
Common noddy	Foraging	40 km	✓
Australian lesser noddy	Foraging (provisioning young)	55 km	✓
Flesh-footed shearwater	Aggregation	250 km	✓
Wedge-tailed shearwater	Foraging (in high numbers)	Overlaps	✓
Little penguin	Foraging (provisioning young)	250 km	✓
Caspian tern	Foraging	Overlaps	✓
Pacific gull	Foraging (in high numbers)	Overlaps	✓
Bridled tern	Foraging (in high numbers)	Overlaps	✓
Sooty tern	Foraging	16 km	✓
White-faced storm petrel	Foraging (in high numbers)	Overlaps	✓
Great winged petrel	Foraging (provisioning young)	400 km	✓
Soft-plumaged petrel	Foraging (in high numbers)	22 km	✓
Little shearwater	Foraging (in high numbers)	Overlaps	✓
Roseate tern	Foraging	Overlaps	✓
Australian fairy tern	Foraging (in high numbers)	Overlaps	✓

4.3.7 Marine mammals

Several species of marine mammals are known to occur in the region and have wide distributions that are associated with feeding and migration patterns linked to reproductive cycles. There are at least 38 marine mammal species known to occur regularly in the SWMR, including at least 27 whale species, 11 species of dolphin and two species of pinnipeds (McClatchie et al. 2006; DEWHA 2008a).

Four Threatened and Migratory, seven Migratory and one Threatened marine mammal species were identified by a search of the EPBC Act Protected Matters Database as potentially occurring in the OA and/or EMBA, consisting of nine whales, two dolphins and one pinniped (Table 4-7).

Cetacean species, such as the pygmy blue whale (*Balaenoptera musculus brevicauda*), southern right whale (*Eubalaena australis*) and humpback whale (*Megaptera novaeangliae*), are known to transit between Southern Ocean feeding grounds and tropical water breeding grounds. However, some mammal species (e.g. the ASL; *Neophoca cinerea*) are resident in the region throughout the year (DEWHA 2008a). The

SWMR is an important foraging and breeding region for Australian sea lions, with 99% of the population occurring within the SWMR (McClatchie et al. 2006). ASLs are also present in the OA; including the foraging areas for WA's largest breeding colony at Beagle Island (DSEWPC 2013a, Gales et al. 1994).

The long-nosed fur seal (*Arctocephalus forsteri*) was not identified as occurring in the OA or EMBA in the searches of the Protected Matters Database; however, there are observations of haul outs of long-nosed fur seals at the Beagle Islands, 10 km south of the OA (Campbell et al. 2014).

A description of the identified Threatened and/or Migratory marine mammals, including their distribution, migratory movements, preferred habitat, and likely presence within the OA and EMBA is provided in Table 4-7.

Five marine mammal species have BIAs within the OA and/or EMBA, as follows:

- The humpback whale migration, breeding, and calving BIA extend along the length of the WA coast, to its northernmost extent offshore of the Kimberley. The migration BIA overlaps the OA (Figure 4-13).
- Pygmy blue whale migration and known foraging area BIAs pass along the shelf edge at depths between 500 m and 1,000 m. The OA overlaps with the known foraging BIA (Figure 4-11), whilst the EMBA overlaps the migration BIA (Figure 4-12).
- The southern right whale migration BIA, which extends all the way up the west coast of WA as far north as Ningaloo Reef, is located just inshore of the OA (Figure 4-13) and overlaps the EMBA. The nearest reproductive BIA is 185 km away.
- The sperm whale foraging BIA is located approximately 215 km south of the OA but overlaps the EMBA
- ASL foraging BIAs extend along the west coast of Australia, south of Geraldton down to Perth. The OA and EMBA overlap both foraging BIAs (Figure 4-14). As central placed foragers, ASLs forage year-round in the OA. There is a defined breeding BIA for ASLs on the Beagle Islands, located ~10 km south of the southern boundary of the OA.

The distribution range of the pygmy blue whale is described as cosmopolitan in the conservation management plan (CMP) for blue whales and has been designated as extending from the shorelines of WA to beyond the continental slope, shown as a layer in the National Conservation Values Atlas (NCVA). Studies investigating the seasonal presence of the pygmy blue whale in the south-east Indian Ocean have identified a seasonal migration of the animals from the southern coast of WA at Cape Leeuwin (McCauley et al. 2018, Thums et al. 2022) to as far north as Indonesian waters (Double et al. 2014; Thums et al. 2022). The northern migration of the pygmy blue whales – Augusta to Derby, WA, occurs between April and July (peak periods in May and June), with a return southbound migration from October to January (peak periods in November and December) (McCauley & Jenner 2010, McCauley & Duncan 2011, Double et al. 2012, 2014, Thums et al. 2022). The animals migrate as solitary individuals or in small groups along the continental slope, typically at depths between 500 m and 1000 m on the way to the Banda and Molucca seas near Indonesia, where calving is thought to occur (Double et al. 2014). A recent study by Thums et al. (2022) tracked the northern and southern migratory movements of 22 satellite tagged pygmy blue whales along the WA coastline from Bremer Bay to Scott Reef and on to Indonesian waters. The tracking data indicated extensive use of the continental slope by the animals as they migrated, rather than the shelf (Thums et al. 2022). Three areas of high pygmy blue whale occupancy were identified: The Perth Canyon, the Montebello Islands, and waters off Timor-Leste (Thums et al. 2022). Further, based on these tracking data of pygmy blue whales, Thums et al. (2022) designated important animal usage areas such as foraging and resting in regions along their migratory corridor. Figure 4-11 and Figure 4-12 display the overlap of the OA with the pygmy blue whale most important foraging areas and migratory paths in the region, as calculated by Thums et al. (2022) from the overlap between three metrics of pygmy blue whale spatial use.

The southern right whale occurs off the coast of Australia, with two subpopulations identified: a south-western population of ~2200 animals and a south-eastern population of ~300 animals (Bannister 2017). The south-western population occupies WA and SA waters, predominantly in southern regions from Cape Leeuwin, WA (Bannister 2010) to Fowlers Bay, SA (Charlton et al. 2019). Recently, the DCCEEW has extended the BIAs for the species in the NCVA, outlining migration and reproduction zones as far north as Exmouth Gulf, WA.

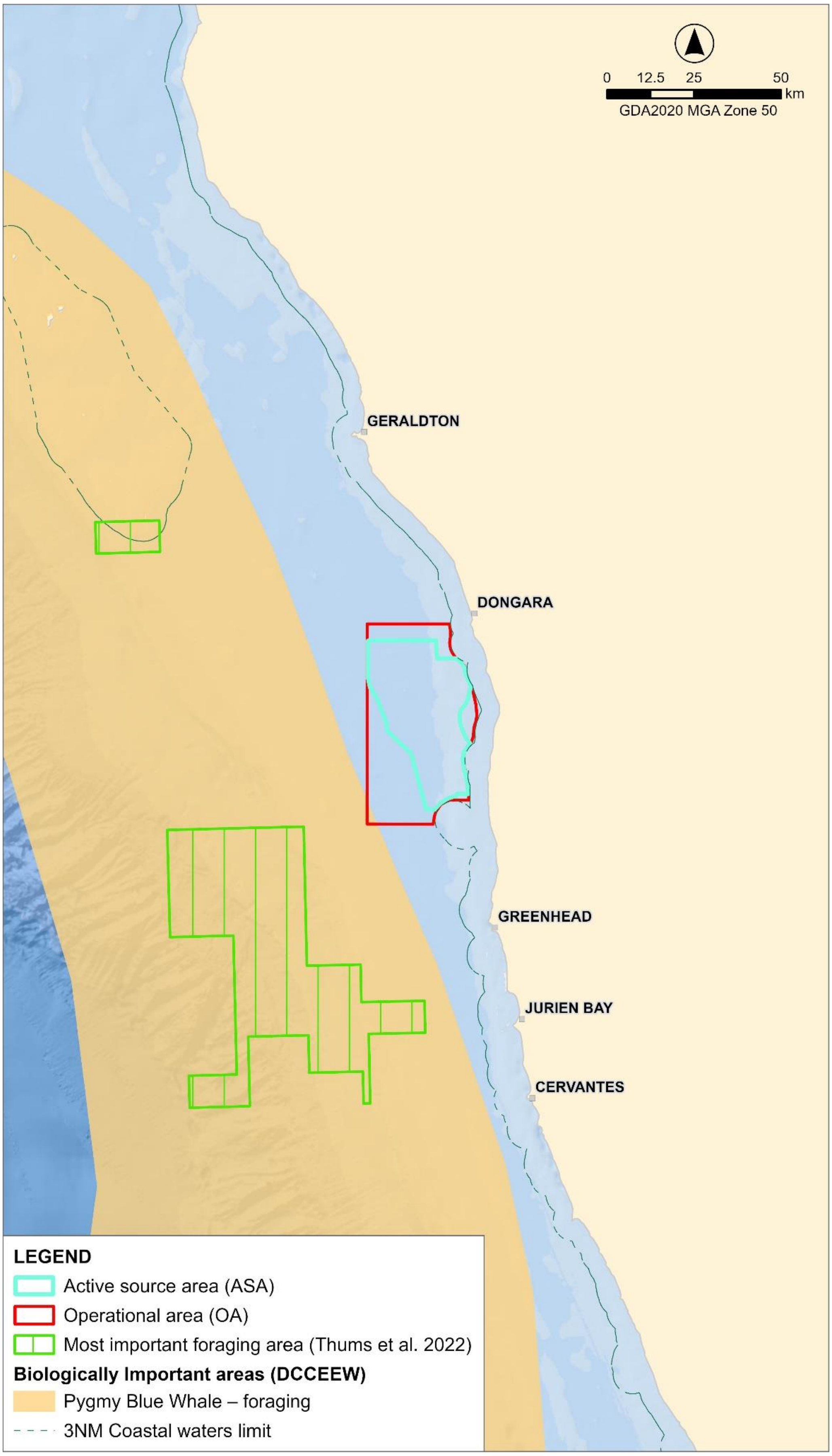

Figure 4-11: Pygmy blue whale known foraging BIA and most important foraging area, as detailed in Thums et al. (2022)

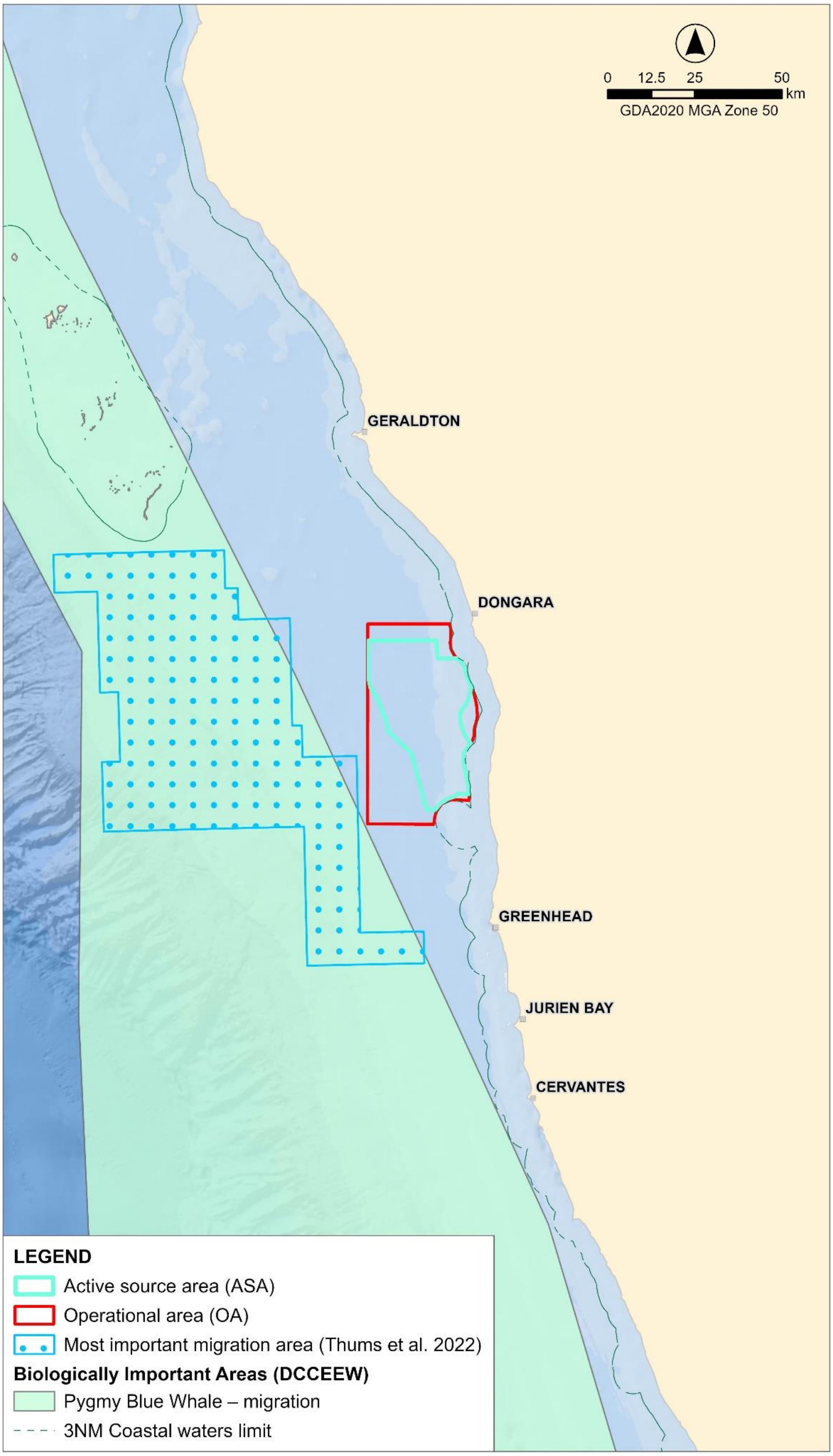

Figure 4-12: Pygmy blue whale migration BIA and the most important migration path, as detailed in Thums et al. (2022)

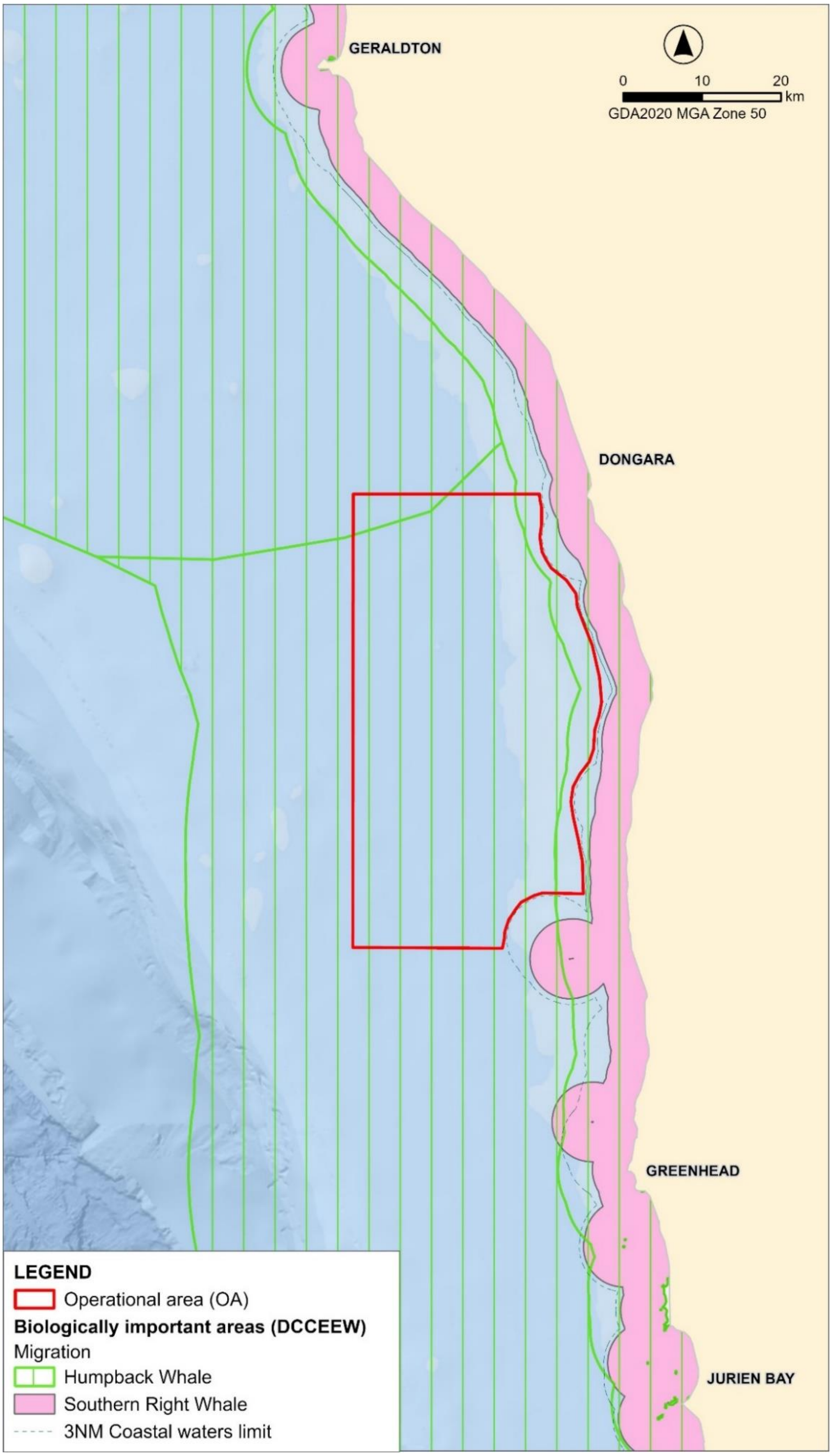

Figure 4-13: Humpback and southern right whale migration BIAs

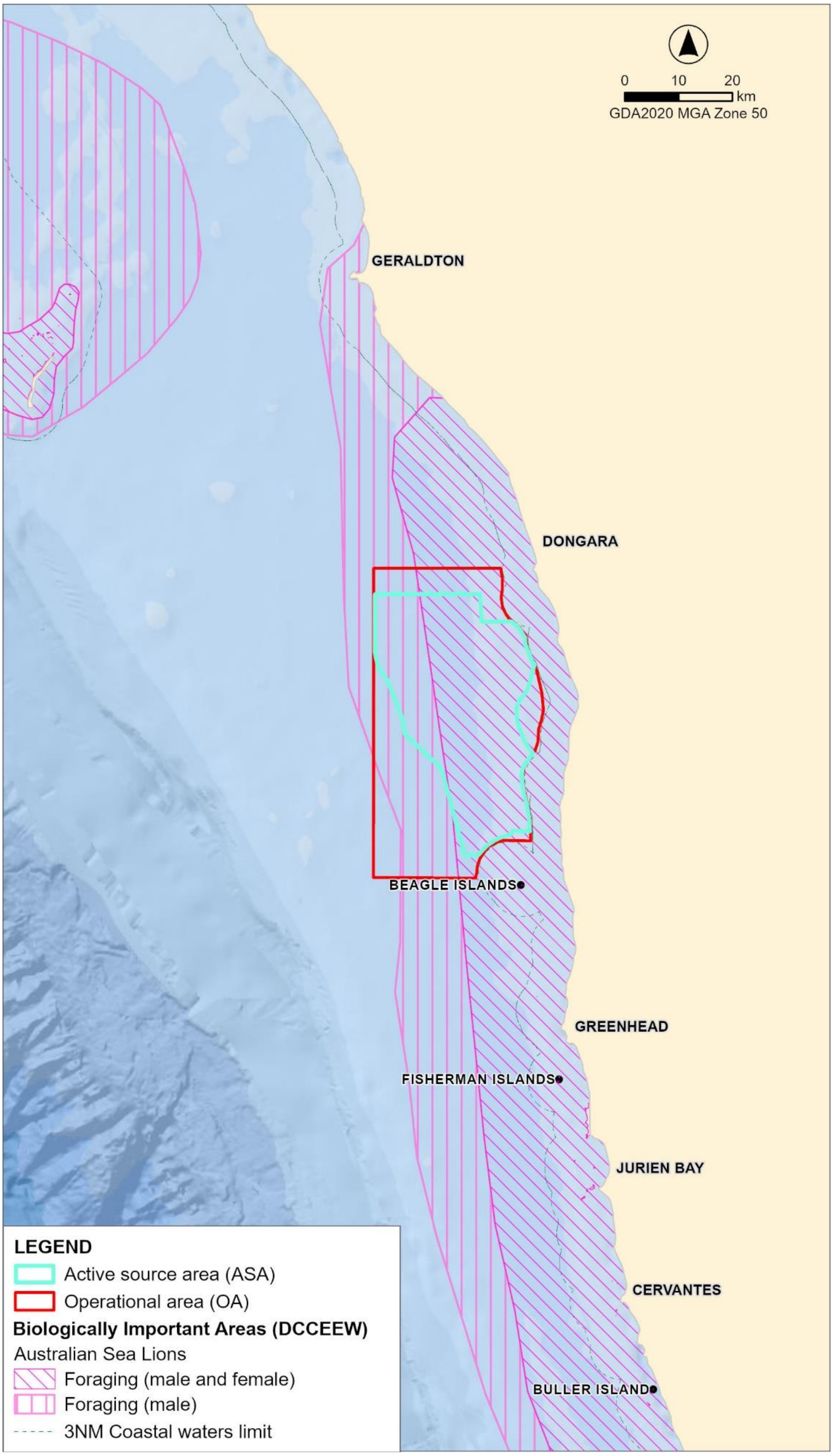

Figure 4-14: Australian sea lion foraging BIA

Table 4-7: Threatened and Migratory mammals potentially occurring within the OA and EMBA

Common name	Habitat, distribution and seasonality	Presence
Marine mammals potentially occurring within the OA		
Blue whale	**Habitat and distribution**	Known
	Two subspecies of blue whale are found in the southern hemisphere The pygmy blue whale (*Balaenoptera musculus brevicauda*) and the Antarctic blue whale (*B. m. intermedia*). During the southern hemisphere summer, Antarctic blue whales are usually found south of 60°S, while pygmy blue whales are usually found north of 55°S (DoEE 2019). The pygmy blue whale has a worldwide oceanic distribution and are regularly sighted in Australian waters. Whilst the species prefer deep waters (500 – 1,000 m), whale sightings in Australia are usually related to migration purposes or opportunistic feeding. The pygmy blue whale has BIAs for migration and foraging along the WA coastline. The OA and EMBA overlap the migration and foraging BIAs. Satellite tracking of pygmy blue whales undergoing their northern migration indicates whales generally follow known migration paths, along the WA coast (Double et al. 2012, 2014; Thums et al. 2022).	
	Seasonality	
	The annual northbound migration past Perth Canyon and Geraldton has been detected between April and July (peak May-June), with the return southbound migration from October to January (peak November and early December; McCauley and Jenner 2010; McCauley and Duncan 2011; Double et al. 2012, 2014; Thums et al. 2022).	
Humpback whale	**Habitat and distribution**	Known
	Humpback whales occur globally and throughout Australian waters with their distribution being influenced by migratory pathways and aggregation areas for resting, breeding, and calving (DoEE 2019). There are two genetically distinct west and east coast populations of humpback whales in Australia (DoEE 2019). The southbound migration corridor tends to be within the 200 m isobath (Jenner et al. 2001). The humpback whale migration (north and south) BIA overlaps the OA and EMBA.	
	Seasonality	
	The annual peak northbound migration along the Jurien Bay to Carnarvon migration route occurs between June and July, while the southbound migration peak occurs between September and October (Jenner et al. 2001). The west coast population of the humpback whale is thought to be increasing in size by about 9% per year (TSSC 2015e); estimates conducted suggest that in 2008 the population migrating up the WA coast was at 21,750 individuals (Hedley et al. 2011).	
Bryde's whale	**Habitat and distribution**	May occur
	Bryde's whales are distributed throughout oceanic and inshore, tropical, and warm temperate waters between 40˚N and 40˚S year-round. They have been recorded off all states of Australia, except for the Northern Territory (NT) (DoEE 2019).	
	Seasonality	
	The inshore form of the Bryde's whale is typically limited to the 200 m depth contour and breeds and calves year-round, whilst the offshore form is found in deeper waters (500 to 1000 m) and breeds and calves over several months during winter (Best et al. 1984; Kato 2002). The nearest known area of aggregation is Ningaloo Reef (over 600 km away; DoEE 2019) There is currently no evidence of large-scale movements of the inshore form of the Bryde's whale. However, the offshore form may migrate seasonally, heading towards warmer tropical waters during the winter months. There is limited data on migration, mating, breeding, and calving patterns for Bryde's whales, and no specific feeding or breeding grounds have been discovered off Australia.	

Common name	Habitat, distribution and seasonality	Presence
Fin whale	**Habitat and distribution**	Likely
	Fin whales occur from polar to tropical waters, but rarely in inshore waters (DoEE 2019). Fin whales are widely distributed in both hemispheres between latitudes 20–75°S (Mackintosh 1965). This species is common in temperate waters, the Arctic Ocean and Southern Ocean. Fin whales feed intensively in high latitudes and may feed in lower latitudes to some extent depending upon prey availability and locality. Fin whales feed on planktonic crustacea, fish, and cephalopods (crustaceans). The Australian Antarctic waters are important feeding grounds for fin whales. Sightings of fin whales feeding in the Bonney Upwelling area indicate that this area is also a potentially important feeding ground. There is no known mating or calving areas for fin whales in Australian waters. Fin whales are killed by ship strike more than any other whale, which may be linked to surface feeding (DoEE 2019).	
	Seasonality	
	Fin whales are seasonally present in eastern Antarctic waters from February to June, before migrating to lower-latitude Australian waters (Aulich et al. 2022). In Australian waters, fin whales have a seasonal, migratory presence from May to October on both the east and west coasts (Aulich et al. 2022). Peak presence of the animals has been observed from June to August in the Perth Canyon, WA, approximately 200 km south of the OA (Aulich et al. 2019, 2022).	
Sei whale	**Habitat and distribution**	Likely
	Sei whales are considered a cosmopolitan species, ranging from polar to tropical waters, but tend to be found more offshore than other species of large whales. They show well defined migratory movements between polar, temperate, and tropical waters (Mackintosh 1965). Migratory movements are essentially north–south with little longitudinal dispersion. Sei whales have been infrequently recorded in Australian waters (Bannister et al. 1996). The similarity in appearance of sei whales and Bryde's whales has resulted in confusion about distributional limits and frequency of occurrence.	
	Seasonality	
	This species is known to breed in tropical and subtropical waters, while Australian Antarctic waters are important feeding grounds for sei whales, as are temperate, cool waters (Horwood 1987). Sei whales have the same general pattern of migration as most other baleen whales, although it is timed a little later and they do not go to such high latitudes (Gambell 1968).	
Southern right whale	**Habitat and distribution**	Likely
	The southern right whale is found predominately along the southern coastline of Australia, from Sydney to Perth, though some sightings have occurred as far north as Exmouth (Bannister 2020). Distribution is presumed to be between about 32°S and 65°S, with the main feeding areas thought to occur between 40°S and 55°S (Bannister et al. 1996). Most feeding areas are assumed to be in deeper offshore waters. Recently, the DCCEEW have extended the BIAs for the species, outlining migration and reproduction zones as far north as Exmouth Gulf, WA. The migration BIA, which extends all the way up the west coast of WA as far north as Ningaloo Reef, is located just inshore of the OA. The seasonal calving and calving buffer BIAs overlap the EMBA and are located ~215 km south of the OA.	
	Seasonality	
	Southern right whales migrate to more temperate coastal waters to calve from May to November (Watson et al. 2021). The closest calving area to the study area is approximately 500 km away in Flinders Bay; however, occasional sightings and strandings have been observed further north (refer Atlas of Living Australia [ALA] database). The defined migratory period for the southern right whale within the migration BIA up the west coast of WA is April to October (refer to NCVA).	

Common name	Habitat, distribution and seasonality	Presence
Orca, killer whale	**Habitat and distribution**	May occur
	The orca is found in all the world's oceans, from the Arctic and Antarctic regions to tropical seas (Ford et al. 2005). The species has been recorded in all the coastal waters of Australia, with concentrations reported in Tasmania, and common sightings in SA and Victoria (DoEE 2019).	
	Seasonality	
	The preferred habitat of the species includes oceanic, pelagic, and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters. They may be more common in cold, deep waters, but off Australia, orcas are most often seen along the continental slope and on the shelf, particularly near seal colonies. Orcas have regularly been observed within the Australian territorial waters along the ice edge in summer. No areas of significance and no determined migration routes have been identified for this species within waters off WA (DoEE 2019). Mating is known to occur all year round, whilst the calving season spans several months.	
Australian sea lion	**Habitat and distribution**	Known
	Australian sea lions (ASL's) have a breeding distribution from the Abrolhos Islands in WA to the Pages Islands in SA. Population numbers and distribution has significantly reduced due to human pressures such as hunting and coastal development (McClatchie et al. 2006). Breeding predominantly occurs in SA, with only ~17% occurring in WA. Foraging BIAs for the species overlap the OA and EMBA. There is a defined breeding BIA for ASLs on the Beagle Islands, located ~10 km south of the southern boundary of the OA. Beagle Island is the largest breeding colony in Western Australia, contributing 40-60 pups per breeding cycle. The foraging BIA for males, and males and females, overlaps the EMBA and OA.	
	Seasonality	
	ASLs are the only seal that has an asynchronous non-annual breeding cycle, with breeding cycles ranging from 16 to 20 months and pupping occurring at different times throughout the SWMR (McClatchie et al. 2006). Discussion with DBCA has advised that based on current knowledge of the breeding patterns at Beagle Island there may be overlap with the timing of the survey and ASL breeding. Foraging occurs year-round within the OA and EMBA (DSEWPC 20133, Campbell & Holley 2007).	
Mammals potentially occurring within the EMBA		
Antarctic minke whale	**Habitat and distribution**	Likely
	The distribution of Antarctic minke whales along the west coast of Australia is currently unknown, however, it is likely that they do not migrate as far north as dwarf minke whales (to 11°S; DoEE 2019). The southern distribution of Antarctic minke whales extends down to approximately 65°S in the Australian Antarctic Territory (DoEE 2019). It is possible that Antarctic minke whales may transit through the OA; however, no BIAs have been identified in the region and it is not likely that the area is used for feeding, breeding, or resting.	
	Seasonality	
	There is insufficient data to prescribe migration times and routes for Antarctic minke whales; however, most sightings in WA waters occur from December to March, indicating this may be their migration period (Sobtzick 2010; DoEE 2019).	

Common name	Habitat, distribution and seasonality	Presence
Sperm whale	**Habitat and distribution**	Known
	Sperm whales are abundant from polar waters to the equator and typically found in deep temperate and tropical offshore waters (greater than 600 m) or closer to the shore in water depths greater than 200 m (DoEE 2019). Sperm whales tend to be found where the seabed rises steeply from great depth and are probably associated with concentrations of major food in areas of upwelling (Bannister et al. 1996). There is limited information on their distribution in Australian waters, although they have been recorded off the coast of all Australian states, where they occur in groups of up to 50 individuals (DoEE 2019). The foraging BIA for sperm whales overlaps with the EMBA and is located ~215 km south of the OA.	
	Seasonality	
	In the Southern hemisphere, migrations occur from July to March, peaking in September and December. Calves may be born in tropical and temperate waters and are mainly born between November and March.	
Dusky dolphin	**Habitat and distribution**	Likely
	Dusky dolphins have only been reported 13 times since 1828 along southern Australia from WA to Tasmania (Gill et al. 2000). They are observed along the southern hemisphere in temperate and sub-Antarctic waters and are not known to migrate; however, some have been observed in deep waters (Ross 2006). The species has been observed to stay in shallower waters in winter and move out to deeper waters in summer (Gill et al. 2000).	
	Seasonality	
	There is limited information on the movement patterns of dusky dolphins in Australia. Globally, mating has been observed in summer, with calving occurring in the next summer (Ross 2006). The species is not known to migrate.	
Pygmy right whale	**Habitat and distribution**	Likely
	In Australia, pygmy right whales are distributed between 32°S and 47°S, spread along southern Australia from Geraldton in WA to Forster in NSW, though are not spread uniformly (Kemper 2002). The species is observed more often in eastern Australia. The species is typically found in areas of upwelling (Kemper 2013).	
	Seasonality	
	The breeding cycle of pygmy right whales is unknown; however, some reports have assumed a calving seasonally between May and January (Pavey 1992; Kemper 2002). There is no evidence of large-scale migration for the species (Kemper 2002).	

4.3.8 Sharks and rays

The SWMR supports high species richness of shark, sawfish and rays stemming from the diversity of marine environments. There are approximately 500 shark and sawfish species globally, with 95 species found within the SWMR (i.e. 19% of the world's shark species; McClatchie et al. 2006).

Three Threatened and Migratory, six Migratory and four Threatened/Conservation Dependent shark and ray species were identified in the PMST search as potentially occurring in the OA and EMBA (Table 4-4).

A description of the identified threatened and/or migratory sharks, sawfish and rays is provided in Table 4-8, including their distribution, migratory movements, preferred habitat, and likely presence within the OA and EMBA.

One BIA for the shark and ray species described in Table 4-4 has been identified as overlapping the OA and EMBA: the white shark foraging BIA, which extends northwards along the 200 m isobath (Figure 4-15).

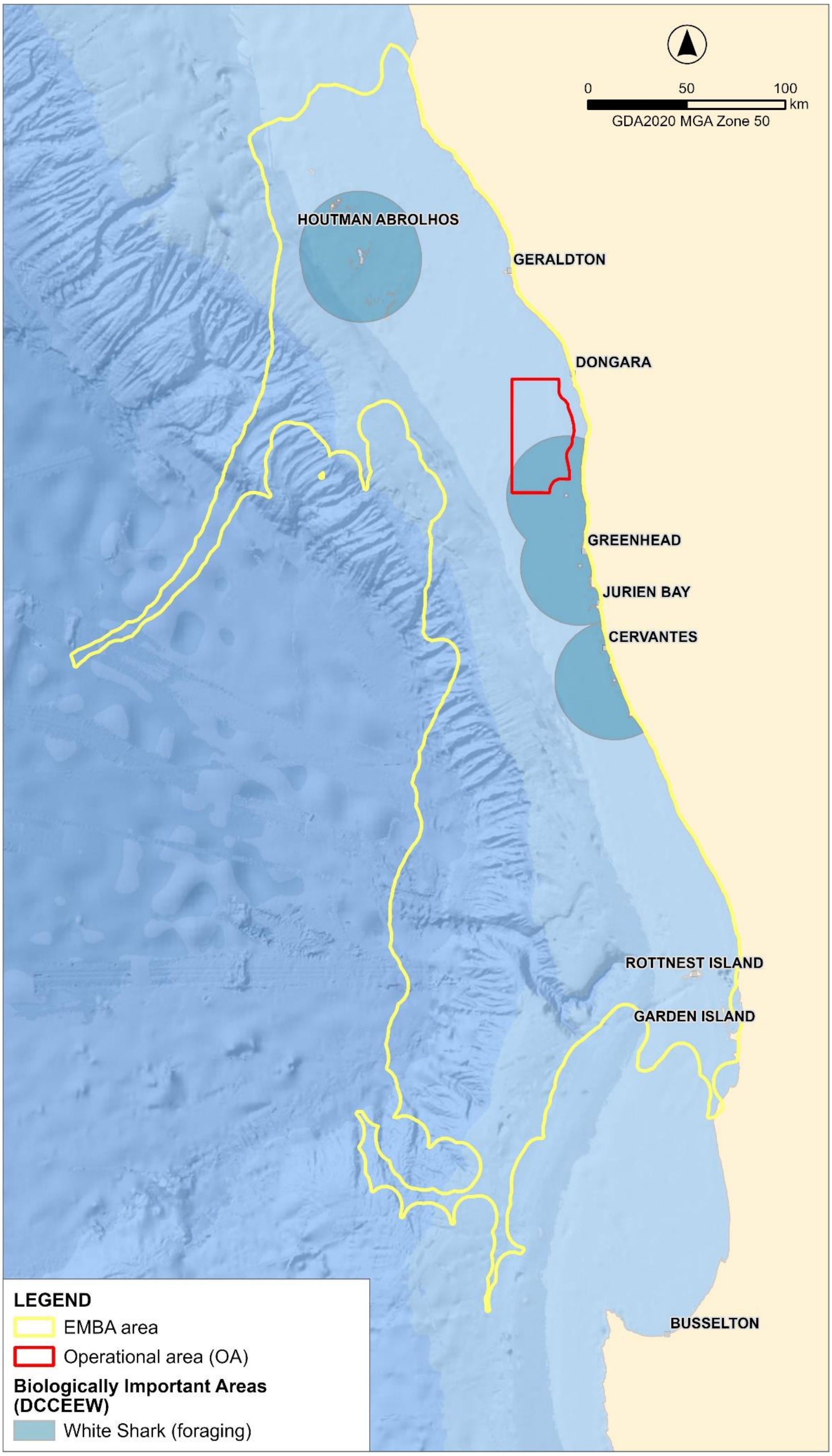

Figure 4-15: White shark foraging BIA overlap with the OA and EMBA

Table 4-8: Threatened and migratory sharks and rays potentially occurring within the OA and EMBA

Common name	Habitat, distribution and seasonality	Presence
Sharks and rays potentially occurring within the OA		
Whale shark	**Habitat and distribution**	May occur
	The whale shark occurs in both tropical and temperate waters with a typically oceanic and cosmopolitan distribution (Colman 1997). They are commonly recorded in WA, the NT and QLD, although they have been sighted occasionally in NSW and Victoria (VIC).	
	Seasonality	
	Whale sharks aggregate at Christmas Island (approximately 2800 km from the OA) between December and January and at Ningaloo Reef (approximately 700 km from the OA) between March and July to feed on krill and baitfish associated with coral spawning events (DoEE 2019). After this period, whale sharks disperse from Ningaloo and are understood to forage in continental shelf waters during spring. Tagged whale shark data includes records of whale sharks departing from Ningaloo in spring and travelling north-west, following the 200 m isobath on the edge of the continental shelf, though some individuals have been observed as far south as Perth (Colman 1997).	
White shark, great white shark	**Habitat and distribution**	Known
	White sharks have been recorded from central QLD around the south coast to north-west WA, with movements occurring between the mainland coast and the 100 m depth contour (DoEE 2019). Great white sharks are frequently recorded in waters around fur seal and sea lion colonies such as the islands off the lower west coast of WA (DoEE 2019). The foraging BIA for white sharks overlaps the OA.	
	Seasonality	
	Great white sharks are known to undertake migrations along the WA coast, with some individuals travelling as far north as Northwest Cape during spring, before returning south for summer (DoEE 2019).	
Shortfin mako shark	**Habitat and distribution**	Likely
	The shortfin mako is found in tropical and warm-temperate seas in water depths up to 500 m (Cailliet et al. 2009). The species is rarely found in waters cooler than 16 °C and is occasionally found close inshore where the continental shelf is narrow (Cailliet et al. 2009). The species is widespread in Australian waters, having been recorded in offshore waters all around the continent’s coastline with exception of the Arafura Sea, the Gulf of Carpentaria and Torres Strait.	
	Seasonality	
	Shortfin mako sharks are a highly mobile and migratory species that can travel large distances (Rogers et al. 2009; Gibson et al. 2021). No seasonal patterns have been identified in Australia, however mako sharks have been shown to use the outer shelf of the continental slope in WA while migrating (Rogers et al. 2009).	
Longfin mako	**Habitat and distribution**	Likely
	Longfin makos inhabit oceanic and pelagic habits, typically in tropical regions. They are a highly mobile species and have a wide-ranging distribution (DoEE 2019) but are rarely encountered. Longfin mako usually occur to depths of 760 m but have been reported to 1752 m (Rigby et al. 2019a; Ebert et al. 2013, Hueter et al. 2016, Weigmann 2016). In Australian waters, the species is found from Geraldton, in WA, and north to Port Stephens in NSW (Last & Stevens 2009). Given the species wide-distribution and preference for deeper waters, the presence of the species within the EMBA is expected to be low.	

Common name	Habitat, distribution and seasonality	Presence
	Seasonality	
	There is insufficient data to determine seasonal distribution, migration times and routes in the region.	
Reef manta ray, coastal manta ray	**Habitat and distribution**	Known
	The reef manta ray is found around the northern coast of Australia between south-western Australia, and central NSW (DoEE 2019). This species is often resident in or along productive near-shore environments, such as island groups, atolls, or continental coastlines. This species tends to inhabit warm tropical or sub-tropical waters. The species is commonly sighted inshore, however is also found around offshore coral reefs, rocky reefs, and seamounts (Marshall et al. 2018).	
	Seasonality	
	Movement patterns are likely site-specific and correlated with cycles in productivity. Individuals have been documented to make seasonal migrations of several hundred kilometres as well as daily migrations of almost 70 km (Marshall et al. 2018; Armstrong et al. 2020). The closest aggregation area for reef manta rays is Ningaloo Reef (approximately 700 km away), during May to September; however, some individuals have occasionally been observed in southwest Australia (Armstrong et al. 2020).	
Giant manta ray, oceanic manta ray	**Habitat and distribution**	May occur
	The giant manta ray lives in tropical, marine waters worldwide, and occasionally in temperate seas between latitudes 30°N and 35°S. In Australia, the species is recorded from south-western WA, around the tropical north to the southern coast of NSW (DoEE, 2019).	
	Seasonality	
	There is insufficient data to prescribe distribution behaviours, migration times and routes and seasonal patterns in the region.	
Freshwater sawfish, largetooth sawfish	**Habitat and distribution**	May occur
	The freshwater sawfish may potentially occur in all large rivers of northern Australia from the Fitzroy River, WA, to the western side of Cape York Peninsula, QLD (DoEE 2019). It is a marine/ estuarine species that spends its first 3–4 years in freshwater (DoEE 2019). The preferred habitat of this species is mud bottoms of river embayments and estuaries, but they are also found well upstream. The species mainly feeds on fishes and benthic invertebrates.	
	Seasonality	
	A study on the movement patterns of other sawfish species, *P. clavata* and *P. zijsron*, showed that the species had a high fidelity to an area, with movements restricted to only a few square kilometres within the coastal fringe, and influenced by tides (Stevens et al. 2008).	
Oceanic whitetip shark	**Habitat and distribution**	Likely
	The oceanic whitetip has a global distribution, occurring in both tropical and subtropical waters, with a temperature range of 18–28 °C but preferring >20 °C (Rigby et al 2019b; Howey-Jordan et al 2013). The species is usually found offshore in the open sea with a preference for surface waters (<200 m) but have been reported in depths of 1082 m (Rigby et al. 2019b).	
	Seasonality	
	Across its range the oceanic whitetip shark is highly migratory, however, there is limited information on the movement patterns and migration paths of this species (Young & Carlson 2020).	
	Habitat and distribution	Known

Common name	Habitat, distribution and seasonality	Presence
Grey nurse shark (west coast population)	Grey nurse sharks (western population) are found in inshore waters, particularly sub-tropical to temperate waters (Daley et al. 2015). The western population is found primarily south-west coastal waters of WA, reaching as far north as the North West Shelf (Last & Stevens 2009). Occasional sightings are reported near the OA.	
	Seasonality	
	The movement pattern of the west coast populations of grey nurse sharks is relatively unknown. Juveniles are known to migrate for new territory; however, seasonal migration patterns have not been observed (Last & Stevens 2009). The eastern populations have complex seasonal patterns, indicating western populations may also. Pupping for the species has been observed in July, outside of the proposed acquisition window for the Eureka 3D MSS (February-March).	
Scalloped hammerhead shark	**Habitat and distribution**	Likely
	In Australia, the scalloped hammerhead is found in NSW, QLD, the NT, and WA (Last & Stevens 2009). The species is predominately found along coastal shelves, though will occasionally travel into intertidal zones (White et al. 2006).	
	Seasonality	
	Scalloped hammerheads migrate yearly for foraging and breeding purposes. The closest aggregation area for the species to the OA is the Shoalwater Islands Marine Park (~250 km away), when peak numbers are observed during January and February (Lopez et al. 2022).	
Sharks and rays potentially occurring within the EMBA		
School shark	**Habitat and distribution**	May occur
	The school shark occurs throughout the temperate coastal waters of southern Australia (Daley et al. 2015). The species moves extensively through the southern waters of Australia, manly in demersal water over continental shelves, but also along upper slopes, at depths from near shore to 550 m. Inshore areas are typically breeding and nursing sites.	
	Seasonality	
	School sharks migrate yearly over long distances, likely associated with breeding, generally heading north in winter and south in summer (Daley et al. 2015). The species pupping occurs between December and January in southern Australia.	
Southern dogfish, endeavour dogfish, little gulper shark	**Habitat and distribution**	Likely
	The southern dogfish occurs in temperate waters of the upper-continental slope from 250 to 800 m depth (Daley et al. 2015). There are two distinct Australian populations, the eastern subpopulation ranging from Townsville (QLD) to Bass Strait (Victoria) and the western population ranging from the Kimberley region to Albany (WA) (Last & Stevens 2009). While the eastern subpopulation is considered Near Threatened, the western population is only considered Least Concern, due to limited fishing pressure.	
	Seasonality	
	The southern dogfish is known to undertake seasonal migrations, although the timing and details of these migratory movements are not understood (Daley et al. 2015).	

4.3.9 Marine reptiles

4.3.9.1 Marine turtles

Marine turtles have similar life cycle characteristics, which include migration from foraging areas to mating and nesting areas. All species, except for flatback turtles, have an oceanic pelagic stage before moving to nearshore waters to breed. The region is significant for supporting large feeding and nesting turtle populations. Four Threatened and Migratory marine turtle species were identified in the EPBC Act Protected Matters Database search as having the potential to occur in the OA and EMBA. Table 4-9 describes their distribution, habitats, life stages and likely presence within and around the OA during the survey. There are no BIAs (including nesting) or Habitat Critical for turtle species in the OA or EMBA.

Table 4-9: Threatened and Migratory marine turtles potentially occurring within the OA

Common name	Habitat, distribution and seasonality	Presence
Marine reptiles potentially occurring within the OA		
Loggerhead turtle	**Habitat and distribution** The loggerhead turtle has a global distribution and occurs in eastern, northern, and western parts of Australia (Limpus 2008a). Loggerhead turtles are known to show fidelity to both their foraging and breeding areas and can make reproductive migrations of over 2600 km between foraging and nesting areas (DoEE 2019). The species is known to forage nearshore, in water depths up to approximately 50–60 m (DoEE 2019). In WA, the species nests on the beaches of Shark Bay (approximately 350 km away) (DoEE 2019, Guinea 1995). As a juvenile, this species feeds on algae, pelagic crustaceans, molluscs, and flotsam whilst as an adult it feeds on gastropod molluscs, clams, jellyfish, starfish, coral, crabs, and fish (DoEE 2019). There is just one anecdotal sighting of a loggerhead turtle (deceased animal washed up on beach) in proximity to the OA in the ALA database. **Seasonality** Nesting occurs between October and February, with a peak in December (DoEE 2019).	Known
Green turtle	**Habitat and distribution** The green turtle has a global distribution and occurs in tropical and subtropical waters, with WA supporting one of the largest green turtle populations in the world (Limpus 2008b). Green turtles nest along WA's North West Shelf, ranging from the Ningaloo Reef (over 700 km away) to the northern Kimberley region. The species primarily forages in shallow benthic habitats (10 m) such as tropical tidal and subtidal coral and rocky reef habitat or inshore seagrass beds, feeding on seagrass beds or algae mats (Hazel et al. 2009). **Seasonality** Nesting occurs between November and March, peaking in December/January (DoEE 2019). Female green turtles go into an inter-nesting cycle after each nesting occurrence. The inter-nesting cycle takes approximately two weeks once nesting commences. The females spend this period in shallow waters beyond the reef edge, where they visit different substrates, occupy different depths, and move up to tens of kilometres from the nesting beach. The species undertakes extensive post-nesting migrations from foraging areas to traditional breeding areas (CoA 2017).	Known
Leatherback turtle	**Habitat and distribution** Leatherback turtles are pelagic feeders, spending extended periods of time in tropical, subtropical, and temperate open ocean waters (Limpus 2009). The species has been recorded feeding in the coastal waters of all Australian states and territories in low densities. Leatherback turtles forage on pelagic soft bodied creatures (such as jellyfish, squid, salps, siphonophores and tunicates) all year round in Australian waters (DoEE 2019). No large rookeries have been identified in Australia (DoEE 2019). Nesting occurs on tropical beaches and subtropical beaches (Marquez 1990), but no major centres of nesting activity have been recorded in Australia. There are two anecdotal sightings of leatherback turtles (deceased animals) in proximity to the OA in the ALA database. **Seasonality** The species is understood to migrate from Australian waters to breed at larger rookeries in neighbouring countries such as Indonesia, Papua New Guinea and Solomon Islands between December and January (DoEE 2019).	Known

Common name	Habitat, distribution and seasonality	Presence
Flatback turtle	**Habitat and distribution**	Known
	The flatback turtle is found in the tropical waters of northern Australia, Papua New Guinea, and West Papua, while nesting is only known to occur in Australia (DoEE 2019). Flatback turtles are known to feed on gastropod molluscs, squid, soft corals, hydroids, and jellyfish (DoEE 2019). Flatback turtle hatchlings do not have an offshore pelagic phase. Hatchlings grow to maturity in shallow coastal waters thought to be close to their natal beaches (CoA 2017). Although turtles remain close to nesting beaches during the inter-nesting period, there is evidence that some flatback turtles undertake long-distance migrations between breeding and feeding grounds (Pendoley et al. 2014).	
	Seasonality	
	Major rookeries are present from Exmouth to the Lacepede Islands (over 800 km away) and along the Kimberley coast and islands. There are significant rookeries on Barrow Island, Thevenard Island, Montebello Islands and Lowendal Islands (CoA 2017). Nesting occurs between November and March, peaking in January (CoA 2017).	

4.3.10 Marine birds

Many migratory shorebird (including those frequenting offshore islands) and seabird species are known to occur in the SWMR. The SWMR is a key breeding, feeding and nesting region of Australia, containing the most significant and diverse seabird breeding islands in Australia's territorial waters (McClatchie et al. 2006). For example, the Houtman Abrolhos is the most important seabird breeding site in the eastern Indian Ocean (BirdLife International 2023). In 1999, the Houtmas Abrolhos was estimated to support >500,000 seabirds, including > 1% of the global population of little shearwater (*Puffinus assimilis*), wedge-tailed shearwater (*Ardenna pacificus*), roseate tern (*Sterna dougallii*), Australian fairy tern (*Sternula nereis nereis*), bridled tern (*Onchoprion anaethetus*), sooty tern (*Onchoprion fuscata*), common noddy (*Anous stolidus*) and the endemic lesser noddy (*Anous tenuirostri*) (BirdLife International 2023).

Many seabirds found in the SWMR, particularly the Procellariiformes (i.e. tube-nosed seabirds), spend most of their lives foraging across large distances of open ocean and only return to land to breed. Some species breed locally (e.g. little shearwater, wedge-tailed shearwater, white-faced storm-petrel, bridled tern and sooty tern), while others breed on distant islands and utilise the waters of the SWMR for foraging during their non-breeding period (e.g. soft-plumaged petrel, northern giant petrel) (Table 4-10). In addition, there are several species of tern (Caspian tern, crested tern, roseate tern, and fairy tern) and gull (Pacific gull and silver gull) that are restricted to coastal waters and/or continental islands year-round.

Seventy-two percent of Australia's seabird fauna are found within the SWMR. 22 species are considered to be ecologically significant to the SWMR i.e. they are either endemic, have a high number of interactions with the region (nesting, foraging, roosting, or migrating) or have life history characteristics that make them susceptible to population decline (McClatchie et al. 2006).

A search of the EPBC Act Protected Matters Database found four Threatened, 13 Threatened and Migratory, and ten Migratory marine birds potentially occurring within the OA. A further five Threatened, ten Threatened and Migratory, and 26 Migratory marine birds potentially occur in the EMBA. Fifteen BIAs for marine bird species were identified overlapping the OA and EMBA (see Table 4-6).

Table 4-10 describes the distribution, preferred habitat, migratory movements, and life stages of the identified marine bird species, including commentary on their likely presence in the OA.

Table 4-10: Threatened and Migratory seabirds potentially occurring within the operational area and EMBA

Common name	Habitat, distribution and seasonality	Presence
Marine birds potentially occurring within the OA		
Common noddy	**Habitat and distribution**	Likely
	In Australia, the common noddy occurs mainly in the ocean off the QLD coast, but the species also occurs off the north-west and central WA coast. A large breeding population of ~160,000 pairs is found at Houtman Abrolhos Islands (BirdLife 2023) and smaller numbers (~3500 pairs) are present on Lancelin Island in WA. During the breeding season, the common noddy breeds on islands, rocky islets and shoals or cays of coral or sand. Birds often nest on bushes, saltbush, or other low vegetation. When not at the nest, adults forage at the edge of the continental shelf or near canyon-like features on the shelf (Shephard et al. 2018). It feeds mainly on fish, although they are known to also take squid, pelagic molluscs, medusa, and aquatic insects. During the non-breeding period (April–September), the species remains at-sea in tropical seas to the north of Australia.	
	Seasonality	
	The seasonality of breeding varies greatly between sites. In WA, breeding occurs between September and April, with a peak between October and December.	
Roseate tern	**Habitat and distribution**	Likely
	The roseate tern occurs in both coastal and marine subtropical/tropical areas. The species inhabits rocky and sandy beaches, coral reefs, sand cays and offshore islands (DAWE 2021a). Roseate terns are a diurnal coastal foraging species that feed on small schooling bait fish, often brought to the surface by predatory fish, such as tuna. This species roosts on land at night. In WA, roseate terns are regularly recorded north from Mandurah to Eighty Mile Beach, in the Pilbara Region (DAWE 2021a). Many breeding pairs are found at the Houtman Abrolhos, with smaller numbers found on islands of the Turquoise Coast. Foraging BIAs for this species overlap the OA and EMBA.	
	Seasonality	
	The movements of the roseate tern are poorly known but birds that breed in the region are probably sedentary or have restricted movements along the coast. Breeding in WA occurs during two distinct periods – summer and autumn (Surman 1998; DAWE 2021a).	
Black-browed albatross	**Habitat and distribution**	May occur
	The black-browed albatross breeds on in the Antarctic waters near Antarctica. Post-breeding, individuals disperse across vast stretches of open ocean and small populations are observed in south-western WA, typically in waters off the edge of the continental shelf (Barrett et al. 2007).	
	Seasonality	
	The black-browed albatross migrates towards the sub-Antarctic breeding islands in early September. Individuals typically remain within 500 km of their breeding island for their entire life cycle (Barret et al. 2007).	
Northern giant petrel	**Habitat and distribution**	May occur
	The northern giant petrel breeds in the sub-Antarctic, and visits areas off the southern Australian mainland post-breeding. During this time, individuals are occasionally observed around Fremantle (WA), particularly during storm fronts, and are sometimes observed as far north as Geraldton (DoEE 2019).	
	Seasonality	

Common name	Habitat, distribution and seasonality	Presence
	Breeding of this species occurs from August to October. The species visits areas off the Australian mainland mainly during the winter months (May–October) (DoEE 2019).	
Fork-tailed swift	**Habitat and distribution**	May occur
	There are sparsely scattered records of the fork-tailed swift along the WA coast. In northern WA, they are common in Broome, with maximum numbers occurring in February. The species is highly mobile with large flocks often recorded preceding or following low pressure systems. The species is found on costal cliffs, islands and inland (DoEE 2019).	
	Seasonality	
	The fork-tailed swift does not breed in Australia, but north in Siberia. The species return form their breeding grounds to Australia in October, reaching the survey area in October-March. The northern migration from southern Australia occurs in April (DoEE 2019).	
Southern giant petrel	**Habitat and distribution**	May occur
	The southern giant petrel breeds in the Antarctic waters and migrates north towards the end of the breeding season, mainly along the Bass Strait; however, small populations are observed in south-western WA (Patterson et al. 2008).	
	Seasonality	
	In summer, the southern giant petrel predominantly occurs in subantarctic to Antarctic waters, usually below a latitude of 60°S. In the winter the species travels north, predominately around southern Australia; however, some individuals travel as far north as Port Headland (WA).	
Indian yellow-nosed albatross	**Habitat and distribution**	May occur
	The Indian yellow-nosed albatross breeds on islands of the southern Indian Ocean. During the non-breeding period it forages in subtropical and warmer subantarctic waters, including the southern Indian Ocean, and is particularly abundant off WA (Rolland et al. 2009). The species concentrates over productive waters of continental shelves, often at coastal upwellings and boundary currents (DCCEEW 2023).	
	Seasonality	
	The species breeds September to April, with a northern migration occurring afterwards (Rolland et al. 2009). The species is most abundant in southern WA between March and May.	
Bridled tern	**Habitat and distribution**	Likely
	In Australia, bridled terns breed on offshore islands from South Australia to northeastern Australia to mid-eastern QLD (DoEE 2019; Dunlop & Greenwell 2022). Large breeding populations are found on islands of the Turquoise Coast and Houtman Abrolhos. The species forages in offshore at convergence zones near the edge of the continental shelf waters. Around April, at the conclusion of the breeding period the terns migrate north to Indonesia, moving through Lombok Strait, Lintah Strait and East Timor (DoEE 2019). The foraging BIA for this species overlaps the OA and EMBA.	
	Seasonality	
	On islands off south-western and eastern Australia, birds breed in the austral spring-summer, disperse annually from breeding islands after breeding, then return to breeding sites in the austral spring (DoEE 2019). In WA, almost all bridled terns return to breeding colonies between late September and mid-October and normally leave from early to mid-April.	
Caspian tern	**Habitat and distribution**	Known
	Within Australia, the Caspian tern has a widespread occurrence and can be found in both coastal and inland habitat (Higgins 2003). In WA, the species is widespread along coastal regions, from the Great Australian Bight to the Dampier Peninsula. Breeding occurs along the entire south-west region (Higgins 2003). The closest breeding populations are found on islands of the Turquoise Coast and Houtman	

Common name	Habitat, distribution and seasonality	Presence
	Abrolhos. These birds are likely to be largely sedentary or make only short-range movements within the region. Caspian terns are a diurnal coastal foraging species that predominantly feed on whiting and mullets, and roost on land at night. The foraging BIA for this species overlaps the OA and EMBA.	
	Seasonality	
	The Caspian tern's main breeding period is September to December. The species will typically stay around their breeding region, though some will migrate (Higgins 2003). The species is likely present in the OA year-round.	
Flesh-footed shearwater	**Habitat and distribution**	May occur
	In Australia, the flesh-footed shearwater is commonly found along the southern continental shelf (south-west WA to south-east QLD). The species breed on islands off the coast of south-west WA and are nocturnally active at breeding grounds (DoEE 2019). The species is a trans-equatorial migrant. The species is unlikely to be encountered in the OA but may occur in the EMBA.	
	Seasonality	
	The flesh-footed shearwater breeds from August to May on islands in south-west WA, with chicks fledging from colonies around May (DoEE 2019). The species migrates north post-breeding, travelling towards the equator for winter, before returning south to breeding grounds in late September.	
Australian lesser noddy	**Habitat and distribution**	May occur
	The Australian lesser noddy is a subspecies endemic to Australia and nest solely on the Houtman Abrolhos Islands (approximately 70 km from the OA). The species remains near the breeding islands throughout the year, though will occasionally move north in winter (Burbidge & Fuller 1989).	
	Seasonality	
	Breeding occurs in spring–summer.	
Australian fairy tern	**Habitat and distribution**	Known
	Within Australia, fairy terns occur along the coasts of VIC, TAS, SA, and WA. In WA, there are two populations of fairy terns. The first is a semi-migratory population that breeds between Israelite Bay on the south-eastern coast and Northwest Cape, and over-winter at the Houtman Abrolhos. The second, probably sedentary population occurs on Pilbara islands, as far north as the Dampier Archipelago near Karratha (Dunlop & Greenwell 2022). Fairy terns are a diurnal coastal foraging species that feed on small schooling bait fish and roost on land at night. Foraging BIAs for this species overlap the OA and EMBA.	
	Seasonality	
	In south-western Australia, fairy terns breed between October and February on the mainland and continental islands. Some birds remain at the Houtman Abrolhos, while others migrate as far north as Northwest Cape, or move south, as far as Israelite Bay (Dunlop & Greenwell 2022).	
Marine birds potentially occurring within the EMBA		
Pacific gull	**Habitat and distribution**	Known
	The Pacific gull is endemic to Australia, found along the southern and western coastlines. Breeding occurs in small colonies or scattered single pairs and usually on islands or high points of headlands. Along the coast in shallow water, the Pacific gull feeds on molluscs, fish, small birds, and other marine life that inhabit tide lines (Lindsay & Meathrel 2008). Breeding pairs are found at Houtman Abrolhos and on islands of the Turquoise Coast. Pacific gulls are restricted to coastal/ island habitats and roosts on ashore at night. Foraging BIAs for this species overlap the OA and EMBA.	
	Seasonality	

Common name	Habitat, distribution and seasonality	Presence
	The Pacific gull breeding season is between October and January. The species does not typically migrate far from their breeding grounds (Surman & Nicholson 2009).	
Sooty tern	**Habitat and distribution**	Known
	In WA, the sooty tern breeds on islands of the Houtman Abrolhos, Lancelin Island and Bedout off the north-west coast. The species nests beneath bushes or in rock crevices. Key breeding populations have been observed on the Houtman Abrolhos Islands (approximately 70 km from the OA) (Surman & Nicholson 2009). Sooty terns are oceanic foragers, typically associated with areas of upwelling. The foraging BIA for this species overlaps the EMBA.	
	Seasonality	
	The sooty tern breeding season occurs during late spring and throughout summer. Post-breeding, sooty terns migrate northwards into tropical waters, north of Australia.	
Wedge-tailed shearwater	**Habitat and distribution**	Known
	The wedge-tailed shearwater breeding distribution in south-western WA covers areas north of and including Rottnest Island, Lancelin Island the Houtman Abrolhos Islands. Overall, the species spends most of its life at sea, but returns to its breeding colonies each year to mate and raise their young. Migration pathways are poorly known, but the WA population is thought to winter in the tropics north of the equator during the non-breeding period (DoEE 2019). The foraging BIA for this species overlaps the OA and EMBA.	
	Seasonality	
	The wedge-tailed shearwater breeding season occurs from September to April (DoEE 2019).	
Little penguin	**Habitat and distribution**	Known
	The little penguin is endemic to Australia and New Zealand and found along the southern coast of Australia from Carnac Island (WA) to Broughton Island (NSW), including Shoalwater Islands Marine Park, Penguin Island, and the Geographe Bay area (DoEE 2019). The species tends to live in areas with rocky shores, sandy beaches, and vegetation cover, and they often nest in burrows or under vegetation. Little penguins are rarely observed north of Perth, and therefore are unlikely to be encountered within the OA but may occur in the EMBA near Perth.	
	Seasonality	
	Little penguins breed from September to February–March (DoEE 2019). Individuals on Penguin Island begin their breeding season earlier compared to those found on the mainland, due to varying environmental conditions.	
Great-winged petrel	**Habitat and distribution**	Known
	The great-winged petrel inhabits offshore islands and waters, and nests in burrows on islands with steep rocky slopes or cliffs (DAWE 2020b). The species can be found in offshore waters along the entire southwest coast of Australia, including the Houtman Abrolhos Islands, the Recherche Archipelago, and the islands of the Dampier Archipelago (Barter 2002). The species is known for its long-distance migration, with some individuals traveling as far as the North Pacific and North Atlantic oceans.	
	Seasonality	
	The great-winged petrel breeding season in the region typically occurs from September to March (DAWE 2020b). The species spends most of its time at sea but returns to its breeding colonies on islands to mate and raise their young.	
White-faced storm petrel	**Habitat and distribution**	Known
	Within Australia, the white-faced storm petrel occurs along the southern coastline, predominantly in the southeast. Major breeding colonies have been observed on the Houtman Abrolhos Islands (approximately 70 km from the OA) (Surman & Nicholson 2009), and smaller colonies occur on Lancelin Island and Turquoise Coast islands. The species is most observed in upwelling areas over the	

Common name	Habitat, distribution and seasonality	Presence
	continental shelf, including the Indian Ocean, 80–160 km offshore (Marchant & Higgins 1990). During the non-breeding season, storm-petrels are likely to be in waters well offshore (Marchant & Higgins 1990). The foraging BIA for this species overlaps the OA and EMBA.	
	Seasonality	
	The white-faced storm-petrel breeding season occurs during late spring/early summer. The species does not typically migrate far from their breeding grounds (Surman & Nicholson 2009).	
Little shearwater	**Habitat and distribution**	Known
	The little shearwater is found along the entire southern coast of Australia, including the Houtman Abrolhos Islands, the Recherche Archipelago, and the islands of the Dampier Archipelago in WA (DAWE 2020b). The species inhabits offshore waters and breed on small islands, in burrows or rocky crevices. Little shearwaters spend most of their lives at sea but return to breeding colonies on islands to mate and raise their young. They are known for their long-distance migrations, with some individuals traveling from their breeding grounds in south-western WA to the north Pacific and Arctic oceans (DAWE 2020b).	
	Seasonality	
	The little shearwater breeding season in the region typically occurs between September and February (DAWE 2020b).	
Far eastern curlew	**Habitat and distribution**	Unlikely
	Within Australia, the eastern curlew has a primarily coastal distribution. They have a continuous distribution from south-east WA, through the Kimberley and along the NT, QLD, and NSW coasts and the islands of Torres Strait. Elsewhere, they are patchily distributed (DoEE 2019). During the non-breeding season in Australia, the eastern curlew is most associated with sheltered coasts, especially estuaries, bays, harbours, inlets, and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (DoEE 2019). Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur on the shoreline of the EMBA.	
	Seasonality	
	This species breeds in the northern hemisphere summer between early May and late June. Post-breeding, adults and juveniles disperse south to foraging grounds, including in Australia (DoEE 2019). Eastern curlews begin to arrive in Australia during spring and remain until early March, before returning to their Northern Hemisphere breeding grounds in late July.	
Red knot	**Habitat and distribution**	Unlikely
	The red knot is primarily found in coastal habitats around the coast of Australia, with large numbers regularly recorded in northern Australia. During the non-breeding period, the red knot mainly inhabits intertidal mudflats, sandflats and sandy, sheltered beaches or shallow pools on exposed wave-cut rock platforms or coral reefs, where it forages on soft substrate near the edge of water, intertidal mudflats or sandflats exposed at low tide. At high tide they may feed at nearby lakes, sewage ponds or floodwaters. They have also been observed foraging on thick algal mats in shallow water and in shallow pools on crests of coral reefs (DoEE 2019). The red knot is feeds diurnally and nocturnally. In non-breeding areas, feeding activity is regulated by tide; they feed less just before and after high tide. The red knot is omnivorous and eats mostly worms, bivalves, gastropods, crustaceans, and echinoderms. Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur on the shoreline of the EMBA.	
	Seasonality	
	The red knot is migratory, breeding in the high Artic and moving south to non-breeding areas between 58°N and 50°S. It lays eggs in June and nests on open vegetated tundra or stone ridge, often close to a clump of vegetation. Peak numbers of this species in the SWMR are usually between September and March (DoEE 2019).	
Common sandpiper	**Habitat and distribution**	Unlikely

Common name	Habitat, distribution and seasonality	Presence
	Common sandpipers are distributed along all the Australian coastline and in many areas inland. They are widespread in small numbers and are often solitary. Roebuck Bay in northern WA is an area of national importance for this species (DoEE 2019). Generally, the species forages in shallow water and on bare soft mud at the edges of wetlands. Birds sometimes venture into grassy areas adjoining wetlands and mangroves. Typically, the common sandpiper eats molluscs such as bivalves, crustaceans such as amphipods and crabs and a variety of insects. Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur within the EMBA.	
	Seasonality	
	The common sandpiper breeds in Eurasia and moves south for the boreal winter, with most of the western breeding populations wintering in Africa, while eastern breeding populations winter in South Africa and Australia. Individuals usually arrive in WA from July onwards, spending the summer months in non-breeding foraging grounds before returning to breeding grounds from February (DoEE 2019). Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur on the shoreline of the EMBA.	
Sharp-tailed sandpiper	**Habitat and distribution**	Unlikely
	The sharp-tailed sandpiper is present in Australia during their non-breeding season. The species inhabits both inland and coastal locations, and in WA they are widely distributed from Cape Arid to Carnarvon, around coastal plains of the Pilbara Region to the south-west and east Kimberly Division (DoEE 2019). The sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emerged grass or low vegetation. Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur within the EMBA.	
	Seasonality	
	Eighty Mile Beach (over 1200 km away from the OA) is the closest internationally important site for the species. The sharp-tailed sandpiper migrates to Australia from late June/early July, before returning to their breeding grounds by April–March.	
Pectoral sandpiper	**Habitat and distribution**	Unlikely
	The pectoral sandpiper is infrequently recorded in WA. It has been observed at the Nullarbor Plain, Reid, Stoke's Inlet, Grassmere Lake, Warden Lake, Dalyup and Yellilup Swamp, Swan River, Benger Swamp, Guraga Lake, Wittecarra, Harding River, coastal Gascoyne, the Pilbara, and the Kimberley. In Australasia, the pectoral sandpiper prefers shallow fresh to saline wetlands. The species is typically found in coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, flood plains, and artificial wetlands (DoEE 2019). Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur on the shoreline of the EMBA.	
	Seasonality	
	The pectoral sandpiper breeds in the northern hemisphere during the boreal summer, before undertaking long distance migrations to feeding grounds in the southern hemisphere. The species occurs throughout mainland Australia between spring and autumn (DoEE 2019).	
Curlew sandpiper	**Habitat and distribution**	Unlikely
	The curlew sandpiper's breeding areas are mainly restricted to the Arctic of northern Siberia (DoEE 2019). During the non-breeding period, curlew sandpipers are found in Australia around the coasts, while also being widespread inland, though in smaller numbers (DoEE 2019). This species forages mainly on invertebrates, including worms, molluscs, crustaceans, and insects, as well as seeds.	

Common name	Habitat, distribution and seasonality	Presence
	Outside Australia, they also forage on shrimp, crabs, and small fish. Curlew sandpipers usually forage in water, near the shore or on bare wet mud at the edge of wetlands (DoEE 2019). Except for migration (up to twice per year), shorebirds are not likely to be seen traversing the OA but may occur on the shoreline of the EMBA.	
	Seasonality	
	The species is known to move into certain areas in Australia during its northward migration in April, before migrating away from Australia during May. They start returning to Australia from August to September (DoEE 2019).	
White-capped albatross	**Habitat and distribution**	Unlikely
	The white-capped albatross is occasionally observed in southern WA but is typically associated with cold, deep waters of the Southern Ocean beyond the shelf edge. Breeding occurs on the southern islands of New Zealand (Baker et al. 2007). The species as been rarely seen in waters north of Perth, and therefore is unlikely to be encountered within the OA.	
	Seasonality	
	The breeding biology and movement patterns are poorly understood for the species (Baker et al. 2007).	
Shy albatross	**Habitat and distribution**	Unlikely
	The shy albatross is an endemic breeder in Australia, breeding on islands off Tasmania, in the southern Indian Ocean. The dispersal migrations of non-breeding shy albatross are poorly understood; however, they are frequently observed off the south coast of WA (Higgins 2003). The species is rarely seen north of Perth and is unlikely to be encountered within the OA.	
	Seasonality	
	The breeding season for shy albatross is December to March, whereafter non-breeding individuals (juveniles and elderly) will migrate east in summer. Breeding individuals will generally stay within 500 km of the breeding islands (Brothers et al. 1998).	
Wandering albatross	**Habitat and distribution**	Unlikely
	The wandering albatross breeds on Macquarie Island, over 1500 km south-east of Tasmania (Higgins 2003). The species feeds in the Southern Ocean and has a circumpolar distribution around Australia. The species can be found south of Shark Bay all the way round to Hervey Bay; however, the greatest population densities are around the Great Australian Bight (Higgins 2003). Wandering albatross are typically associated with deep waters, beyond the shelf edge and is unlikely to be encountered within the OA.	
	Seasonality	
	The wandering albatross breeds biennially, with the breeding cycle lasting 11 months beginning in summer (Brothers et al. 1998). The adults will then migrate east, where it is predicted that the species will travel circumpolar to reach the west coast of Australia, heading towards the breeding grounds in November (Brothers et al. 1998). However, the complete migration pattern of the species is not understood.	
Southern royal albatross	**Habitat and distribution**	Unlikely
	The southern royal albatross is commonly observed in south-east Australia, as well as occasionally in southern WA. Breeding does not occur in Australia, but on the southern islands of New Zealand (Higgins 2003). The southern royal albatross is typically associated with cold and deep waters of the Southern Ocean, well beyond the shelf edge. As such, it is unlikely to be encountered within the OA.	
	Seasonality	
	The southern royal albatross breeds biennially, with the breeding cycle lasting 11 months beginning in summer (Higgins 2003). The species then travels east circumpolar, before reaching the breeding grounds again in November (Brothers et al. 1998).	

Common name	Habitat, distribution and seasonality	Presence
Amsterdam albatross	**Habitat and distribution** The Amsterdam albatross is a rare non-resident visitor to Australia and may occur in south-west and south Australian waters (Brothers et al. 1998). The species breeds solely on Amsterdam Island in the southern Indian Ocean. This species is unlikely to be encountered within the OA. **Seasonality** Amsterdam albatross breed from January to May. The species has a wide migration range, travelling further north during winter and spring, with some populations travelling near south-west WA during summer (Higgins 2003).	Unlikely
Campbell albatross	**Habitat and distribution** The Campbell albatross is a non-breeding visitor to Australian waters. Non-breeding individuals are typically observed in the eastern states of Australia; however, are occasionally observed in south-west WA (Brothers et al. 1998). They are very rare in the Indian Ocean and are typically found in waters deeper than 200 m (Marchant & Higgins 1990). Therefore, they are unlikely to be encountered within the OA. **Seasonality** Non-breeding immatures and adults disperse through the south Pacific and across southern Australian waters year-round, typically travelling north in winter (southern Australia) and south in summer (Antarctic waters) (DoEE 2019).	Unlikely
Bar-tailed godwit	**Habitat and distribution** The bar-tailed godwit breeds in the northern hemisphere but migrates to Australia during the non-breeding period. It is found in the coastal areas of all Australian states, mostly in sheltered bays, inlets, and estuaries. Large populations are found along the WA coast, particularly at Eighty Mile Beach (over 1200 km away from the Operational Area) (Higgins 2003). Bar-tailed godwit are unlikely to be encountered in the OA but may occur in the EMBA. **Seasonality** Bar-tailed godwits leave their breeding grounds in the Northern Hemisphere in July-September, reaching southwest Australia in late August, before returning in late February (Barter 2002).	Likely
Soft-plumaged petrel	**Habitat and distribution** The soft-plumaged petrel is generally found over temperate and subantarctic waters of southern Australia, particularly the south-west (Barter 2002). The species breeds on islands of the southern coast of Tasmania, New Zealand, and sub-Antarctic islands. Birds disperse widely after breeding and forage over cold water north of 55°S, mainly over deep water beyond the continental shelf (NZ Birds Online 2023). The foraging BIA for this species overlaps the EMBA. **Seasonality** The movement patterns of soft-plumaged petrels are poorly documented. Breeding occurs during summer, whereafter the species migrates north-west (Burbidge & Fuller 1989).	May occur

4.3.11 Timing of biological sensitivities

Several biological sensitivities related to the phenology of marine fauna are expected to occur within the OA and EMBA.

Table 4-11 identifies the timing of key biological sensitivities relevant to the OA and EMBA. The fauna included are species listed under the EPBC Act and considered relevant to this EP. The fish species are those identified as key commercial indicator species for the relevant fisheries identified in Section 4.4.2, or brood stock that may have habitat within the OA.

The timing of the Eureka 3D MSS (February–March) has been selected to minimise overlap with these receptors, together with operational and stakeholder considerations.

Table 4-11: Timing of key biological sensitivities relevant to the OA and EMBA

Sensitivity	January	February	March	April	May	June	July	August	September	October	November	December
Proposed Eureka 3D MSS timing												
Humpback whale (north migration)[1]												
Humpback whale (south migration)[1]												
Pygmy blue whale (north migration)[2]												
Pygmy blue whale (south migration)[2]												
*Southern right whale migration[2]												
*Sperm whale migration[2]												
Australian sea lion												
White shark foraging BIA[3]												
*Scalloped hammerhead migration[4]												
WA dhufish spawning[5]												
Snapper (Mid-west/Kalbarri) spawning[5]												
Red-throat emperor spawning[4]												
Baldchin groper spawning[5]												
*Hapuku spawning[5]												
*Blue-eye trevalla spawning[5]												
*Eightbar grouper spawning[5]												
*Bass groper spawning[5]												
**WCDS commercial fishing season												
WRL puerulus settlement[6]												
WRL commercial fishing season												
*Australian lesser noddy foraging[7]												
*Flesh-footed shearwater foraging[7]												
*Little penguin foraging[7]												
Wedge-tailed shearwater foraging[7]												
Caspian tern foraging[7]												
Pacific gull foraging[7]												
Bridled tern foraging[7]												
*Sooty tern foraging[7]												
White-faced storm petrel foraging[7]												
*Soft-plumaged petrel foraging[7]												
*Little shearwater foraging[7]												

Sensitivity	January	February	March	April	May	June	July	August	September	October	November	December
Roseate tern foraging[7]												
Fairy tern foraging[7]												
Coral spawning (primary period)												

1 (Source: DoEE 2019), 2 (Source: DoE 2015, McCauley & Jenner 2010; McCauley & Duncan 2011; Double et al. 2012; Double et al. 2014). 3 (DoE, 2019), 4 (Source: Lopez et al 2022), 5 (Source: DPIRD 2023), 6 (Source: Bellchambers et all 2012), 7(Source: DAWE 2021b, Higgins 2003, DoEE 2019, Burbridge & Fuller 1989, Surman & Nicholson 2009).

* Occur in EMBA only

**Period outside of temporal spawning closures. Based on updated commercial fishing regulations introduced in January 2023. Subject to change depending on demersal scalefish resource recovery

Peak period		Mammals	Fish	Birds	Corals

4.4 Socio-economic and cultural environment

4.4.1 Protected areas

The OA does not overlap with any Australian Marine Park (AMP) or any WA state protected marine areas; however, the EMBA overlaps the following AMPs: Abrolhos AMP, Perth Canyon AMP, Two Rocks AMP, Jurien AMP and the South-west Corner AMP. Values for these AMPs are summarised in Table 4-12 below. Definitions of the different management zones of the AMPs found within the EMBA are provided in Table 4-13.

Management plans for AMPs have been developed and came into force on 1 July 2018. Under these plans AMPs are allocated conservation objectives (IUCN Protected Area Category) based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. These principles determine what activities are acceptable within the different zones of the AMP network. As the Eureka 3D MSS OA does not overlap any AMPs, there are no AMPs that restrict the undertaking of the survey. Therefore, the survey will be undertaken in compliance with the AMP network zone rules. In the event of spill response operations being required within an AMP, emergency spill response activities are allowed in accordance with the Australian National Plan for Maritime Environmental Emergencies (MEE) without the need for a permit, class approval, or activity licence or lease issued by the Director of National Parks (DNP).

The EMBA also overlaps several WA state marine protected areas, including the Jurien, Marmion and Shoalwater Islands Marine Parks; the Abrolhos Islands and Lancelin Island Lagoon Fish Habitat Protection Areas; and the Essex Rocks, Buller, Whittell and Green Islands, Cervantes Islands, Beagle Islands, Lipfert, Milligan, Etc Islands, Sandland Island, Ronsard Rocks, Outer Rocks and Fisherman Islands Nature Reserves. The values and distance from the OA of these WA state protected marine areas are detailed in Table 4-12. The Commonwealth and state Marine Protected Areas (MPAs) are shown in Figure 4-16 and Figure 4-17.

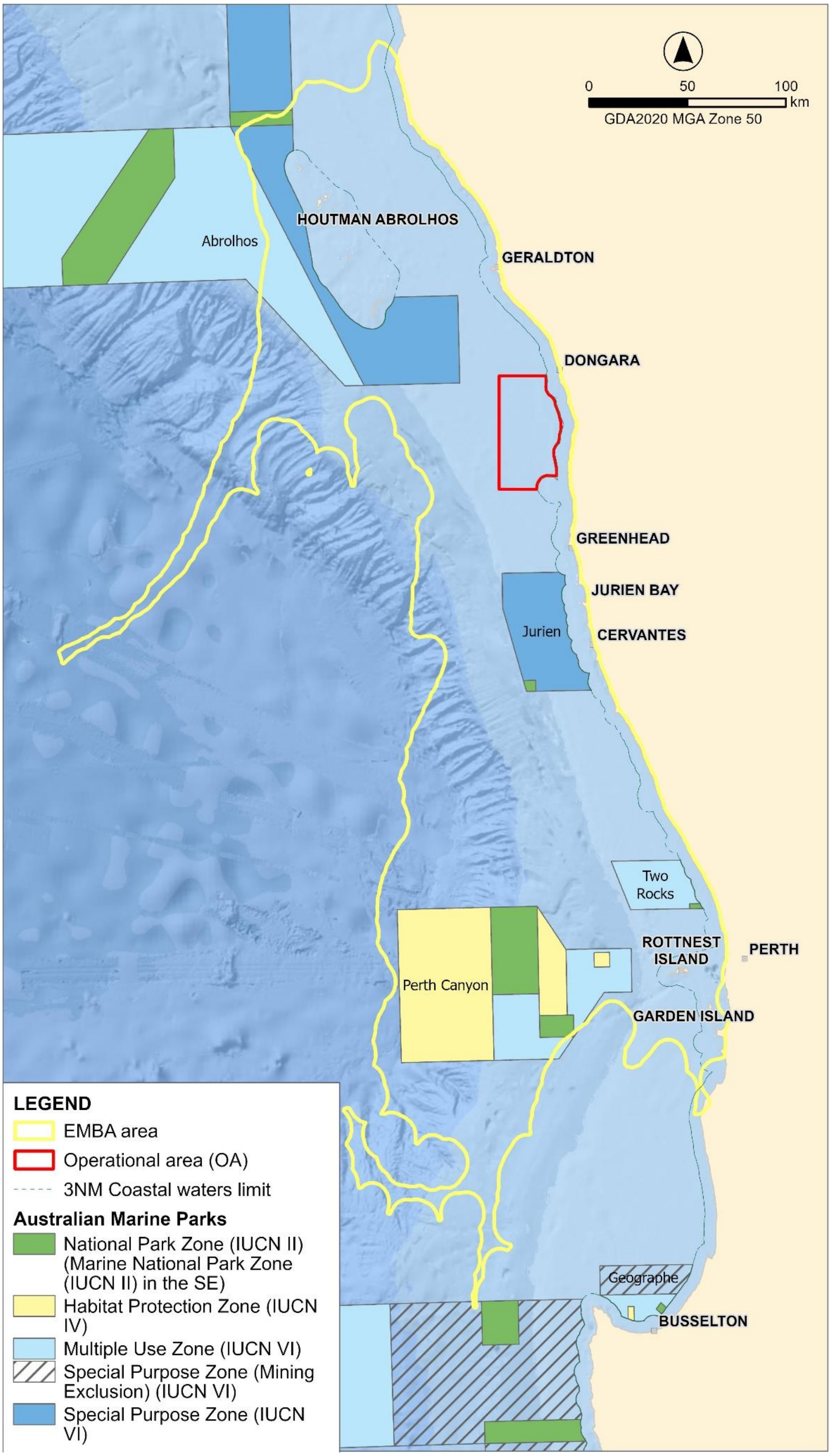

Figure 4-16: Commonwealth protected areas overlapping and adjacent to the OA and EMBA

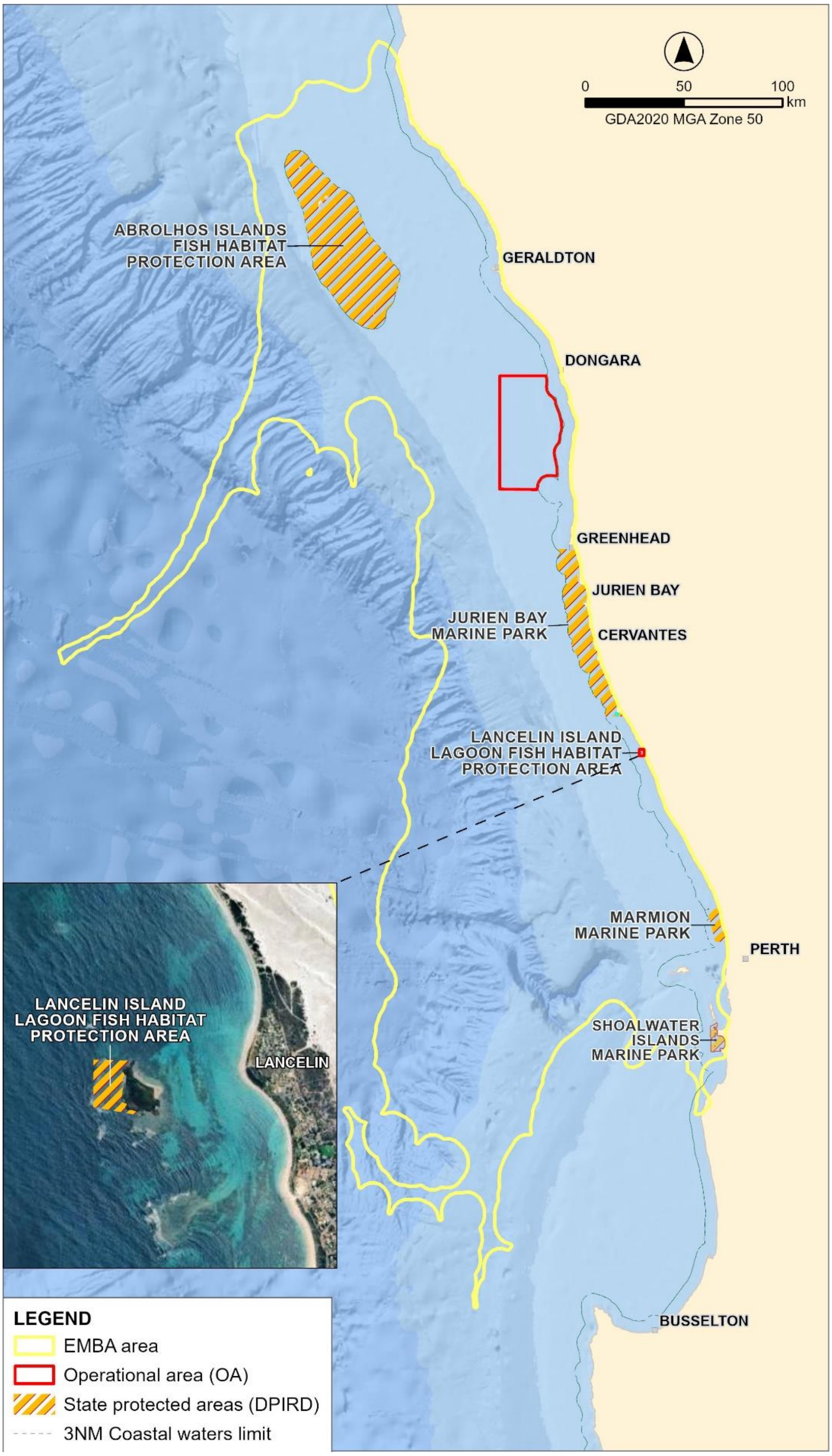

Figure 4-17: State protected areas within the EMBA

Table 4-12: Values of Commonwealth and State marine protected areas overlapping the EMBA

Reserve	Distance from OA	IUCN categories	Key values
Commonwealth Marine Protected Areas			
Abrolhos AMP	20 km W	National Park Zone (IUCN II) Special Purpose Zone (IUCN VI) Multiple Use Zone (IUCN VI)	Conservation values include: • Australia's only known breeding population of lesser noddies • Important feeding and nesting ground for many other seabird species • Diverse benthic and pelagic fish communities (meso-scale eddies, demersal slope, and west coast canyons) • Northernmost breeding colony of Australian sea lion • Important migration pathway for humpback whales (protected species) • Important rock lobster habitat (ecologically and economically important species) • Second largest canyon in Australia (Houtman Canyon) • Nanda and Naaguja people sea country • No international heritage listings apply to the Marine Park at the commencement of this plan; however, the Marine Park is adjacent to the WA Shark Bay World Heritage Property, listed as an area of outstanding universal value under the World Heritage Convention in 1991, meeting world heritage listing criteria vii, viii, ix, and x. (DNP 2018)
Perth Canyon AMP	210 km S	National Park Zone (IUCN II) Habitat Protection Zone (IUCN IV) Multiple Use Zone (IUCN VI)	Conservation values include: • Unique feeding site for pygmy blue whales (largest gathering in Australia) • Important nutrient-rich upwelling • Ancient coastline, diverse and abundant benthic and fish communities due to unique environment (deep sea corals and sponges) • Swan River Traditional Owner sea country • Largest deep-sea canyon in Australia (ancient and unique ecosystem) • Biologically important area for seabirds, blue whales, pygmy blue whales, humpback whales and sperm whales. (DNP 2018; NESP 2018)
Two Rocks AMP	190 km SW	National Park Zone (IUCN II) Multiple Use Zone (IUCN VI)	Conservation values include: • Important rock lobster habitat (ecologically and economically important species) • Swan River Traditional Owner sea country • Valued diving location (recreational value) • Lagoons which support diverse macroalgae, seagrass and marine animals • Breeding ground for key recreational/commercial fish species (western rock lobster, dhufish, and pink snapper) • Ancient coastline between 90 – 120 m depth, valued and unique benthic ecosystem • Important tourism and recreation zone

Reserve	Distance from OA	IUCN categories	Key values
			• Breeding and foraging zones for seabirds, ASLs and migratory pathways for humpback and blue whales. (DNP 2018)
Jurien AMP	40 km S	National Park Zone (IUCN II) Special Purpose Zone (IUCN VI)	Conservation values include: • Humpback and pygmy blue whale migration pathway (protected species) • Shallow seagrass lagoons supporting large biodiversity or marine species • Important nesting grounds for seabirds and Australian sea lions • Unique mix of temperate and tropical species (Leeuwin Current) • Important foraging area for white sharks • Noongar people have responsibilities for sea country in the Marine Park • Valued recreational activities, including fishing and diving. (DNP 2018)
South-west Corner AMP	400 km S	National Park Zone (IUCN II) Special Purpose Zone (Mining Exclusion) (IUCN VI)	Conservation values include: • Localised upwelling leads to high primary production, proving key foraging area for many species: – Western rock lobster (ecologically and economically important species) – Seabirds (contains foraging BIAs) – White sharks – Whale foraging and migration (blue/pygmy blue, humpback, sperm, and southern right) • The Nyungar/Noongar people have responsibilities for sea country in the park • Unique benthic ecosystem due to highly varied sea floor, including canyons, ancient coastline, and deep-sea plateaus (deep sea corals and sponges). (DNP 2018)
State Marine Protected Areas			
Jurien Bay Marine Park	40 km S	WA State Marine Park	Marine Park values include: • Recreational spot for swimming, diving, snorkelling, and kayaking • Recreational fishing (dhufish, snapper, baldchin groper, and whiting) • Unique mix of temperate and tropical marine species • Important breeding areas for seabirds including fairy terns and osprey • Only breeding area for Australian sea lions on the west coast of Australia. (DBCA n.d)
Marmion Marine Park	220 km SW	WA State Marine Park	Marine Park values include: • Recreational spot for swimming, diving, snorkelling, and kayaking • Close proximity to Perth City, providing local area to explore nature • Recreational fishing spots within Marine Park • Humpback whale migration and whale watching tours. (DBCA n.d)
Shoalwater Islands Marine Park	290 km S	WA State Marine Park	Marine Park values include: • Recreational spot for swimming, diving, snorkelling, and kayaking • Close proximity to Perth City, providing local area to explore nature

Reserve	Distance from OA	IUCN categories	Key values
			• Recreational fishing spots within Marine Park. (DBCA n.d)
Abrolhos FHPA	60 km NW	Fish Habitat Protection Area	Purpose and values include: • Maintain sustainable fisheries and aquaculture • Maintain tourism and recreation activities • Nature conservation and protection • Cultural heritage protection • Increased fishing regulation within FHPA to properly manage stocks. (FWA 2001)
Lancelin Island Lagoon FHPA	230 km S		
Essex Rocks	55 km S	Nature Reserves part of Turquoise Coast and greater Jurien Marine Park	Purpose and values include: • Turquoise Coast island nature reserves are a chain of approximately 40 islands, islets, and rocks lying between Lancelin and Dongara • Grouped into 13 nature reserves • Three Australian sea lion breeding islands (Buller, North Fisherman, and East Beagle) • Key dibbler populations on three islands (*Parantechinus apicalis*) • Key seabird breeding islands • Unique CWC marine bioregion: mix of tropical and temperate species • Valued recreational activities, including diving, snorkelling, and fishing • Protected areas for key marine species breeding (including mammals, birds, and fish) • Some commercial fishing, and important nursery habitat for commercial species. (DBCA n.d)
Buller, Whittell and Green Islands	90 km S		
Cervantes Islands	75 km S		
Sandland Island	40 km S		
Outer Rocks	65 km S		
Fisherman Islands	35 km S		
Ronsard Rocks	70 km S		
Beagle Islands	10 km S	Nature Reserves part of Turquoise Coast	
Lipfert, Milligan, Etc Islands	25 km S		

Table 4-13: Management zones and the associated objectives for the AMPs overlapping the EMBA

Management zones	Objective
Multiple Use (IUCN VI)	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.
Special Purpose Zone (IUCN VI)	Managed to allow specific activities though special purpose management arrangements while conserving ecosystems, habitats, and native species. The zone allows or prohibits specific activities.
Habitat Protection Zone (IUCN IV)	Managed to allow activities that do not harm or cause destruction to sea floor habitats, while conserving ecosystems, habitats, and native species in as natural a state as possible.
National Park Zone (IUCN II)	Managed to protect and conserve ecosystems, habitats, and native species in as natural a state as possible. The zone only allows non-extractive activities unless authorised for research and monitoring.

4.4.2 Commercial fisheries

Commercial fishing in WA is comprised of both Commonwealth and WA state managed fisheries that are primarily based on low-volume, high-value products (DPIRD 2020a). The Australian Fisheries Management Authority (AFMA) manages Australian fisheries on behalf of the Commonwealth Government from 3 nm offshore to the edge of the Australian Fishing Zone (AFZ). AFMA carry out the objectives listed in the *Fisheries Administration Act 1991* and the *Fisheries Management Act 1991*. The WA Department of Primary Industries and Regional Development (DPIRD) manages state fisheries that take place predominantly within 3 nm of the coastline, although this default arrangement may be varied through the Offshore Constitutional Settlement (OCS).

Commonwealth and WA state managed fisheries with licence to operate within the OA and/or EMBA are described in the following sections.

4.4.2.1 Review of catch and effort data

Catch and effort data for Commonwealth fisheries with management boundaries that overlap the OA and/or EMBA were sourced from the latest Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Fishery Status Report 2023 (Patterson et al. 2023a).

Catch and effort data for WA state managed fisheries with licence to operate within the OA and/or EMBA were obtained from the DPIRD FishCube database, together with the latest DPIRD State of the Fisheries Report 2021/22 (Newman et al. 2023). FishCube data were obtained for the past ten years (2012–2021) in 10 × 10 nm or 60 × 60 nm Catch and Effort System (CAES) blocks, depending on the fishery, at annual and monthly temporal scales. Data provided by DPIRD included:

- Weight (kg) – a measure of catch per CAES block during the period of interest
- Vessel Count – a measure of the number of vessels that fished in a CAES block during the period of interest
- Licence Count – a measure of the number of licences that were recorded in a CAES block during the period of interest
- Fishing Day Count – a measure of fishing effort, represented by the number of days when one or more vessels fished in a CAES block during the period of interest.

Due to confidentiality reasons, DPIRD is unable to release catch and effort data for CAES blocks where fewer than three vessels fished during the period of interest. Where this applies, the Vessel Count is marked ‘less than three’, while Weight and Fishing Day Count are marked ‘N/A’. Where data are provided in this way, fishing effort was confirmed within the CAES block during that period, but the associated catch and effort data are not available. CAES blocks where no fishing is recorded do not return any data.

It is important to recognise the limitations of referring to CAES blocks with fewer than three vessels. Blocks may experience high catch or effort by fewer than three vessels, i.e. one or two. Alternatively, these blocks may experience less catch or effort than other blocks in which three or more vessels have fished.

Pilot has undertaken a review of up to ten years of catch and effort data which is considered appropriate for this EP to represent the potential for future fishing effort and past fishing effort considering the limited duration of the proposed MSS (40 days, see Section 3) and that the potential impacts to fish and fish stocks from the proposed activity are expected to be temporary (see Sections 7). The review cycle of Commonwealth fisheries' harvest strategies is every 5 years which is aimed at managing performance of the stock or fishery through time as well as the time scale of inter-annual variability of environmental parameters that affect fisheries resources (DAWR 2018), both indicating the suitability of this time scale to fishing decision of individual fishers.

4.4.2.2 Commonwealth managed fisheries

Commonwealth managed commercial fisheries with management boundaries that overlap the OA are:

- Southern bluefin tuna fishery (SBTF)
- Western deepwater trawl fishery (WDTF)
- Western Tuna and Billfish Fishery (WTBF).

The Commonwealth managed commercial fisheries with management boundaries that overlap the OA and/or EMBA are described in Table 4-14.

Table 4-14: Commonwealth managed fisheries with management boundaries overlapping the OA and/or EMBA

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
Southern Bluefin Tuna Fishery (SBTF)	✓	✓	The SBTF covers the entire Australian Fishing Zone (AFZ), out to 200 nm from the coast. The fishery operates year-round, targeting southern bluefin tuna (SBT; *Thunnus maccoyii*). The Australian Fisheries Management Authority (AFMA) uses total allowable catch (TAC) and individually transferable quotas (ITQ) in line with Australia's internationally allocated quota to manage the SBTF (AFMA 2022). Catch and effort is concentrated in the east of the Great Australian Bight, targeting juveniles (2–5 years of age) using purse seine methods, as well as along the eastern coast of Australia using pelagic longline methods (DCCEEW 2022c; Patterson & Dylewski 2023). No catch or effort occurs in WA (Patterson and Dylewski 2023a). Since 1994–1995, five to eight vessels have used purse seine methods each year, while 11 to 24 vessels have used longline methods over the past ten years (Patterson & Dylewski 2023). In 2022, the total reported commercial catch in the SBTF was 5,972 t (Patterson & Dylewski 2023). Whilst no catch or effort occurs in WA, adult SBT may migrate through the OA and/or EMBA between September and April, from their southern feeding areas to their spawning ground between northern WA and Java, Indonesia (Bray & Gomon 2023). Juveniles may also migrate southward through the OA and/or EMBA during their first year (Bray & Gomon 2023; Patterson & Dylewski 2023).	X	X	No catch or effort occurs in WA. Seismic activities may impact adult and juvenile SBT as they migrate through the OA and/or EMBA (see Table 4-2).
Western Deepwater Trawl Fishery (WDTF)	✓	✓	The WDTF covers the western portion of the AFZ from Exmouth to Augusta. The fishery operates year-round, targeting mixed fish species in water >200 m deep, using demersal trawl methods (AFMA 2023a; Keller et al. 2023). Operators catch more than 50 species in habitats ranging from temperate and subtropical in the south, to tropical in the north (Keller et al. 2023). Recent catches have been dominated by ruby snapper (*Etelis sp*.) and a variety of other finfish species (Keller et al. 2023). AFMA manages the WDTF through input controls to limit entry (11 permits) and restrict gear, as well as catch controls with trigger limits for key commercial species. Catch and catch-per-unit-effort (CPUE) triggers for ten species are used based on historical catch between 2000 and 2010 (Keller et al. 2023). Since 2004–2005, one to three vessels have been active in the WDTF. Two vessels were active in 2021–2022, with a total reported commercial catch of 12 t from two active vessels (Keller et al. 2023).	X	✓	Very low catch or effort occurs in WA, with two vessels operating in 2021 – 2022. Given the principal depth range of target species and trawl operations (>200 m deep), the proposed activity will not interact with fishing activities of the WDTF.
Western Tuna and Billfish Fishery (WTBF)	✓	✓	The WTBF operates in the western portion of the AFZ from the SA–VIC border to Cape York Peninsula, as well as the high seas of the Indian Ocean (Patterson et al. 2023b). The fishery targets several highly migratory finfish species including bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus*	✓	✓	Low catch or effort occurs in WA. Seismic activity may affect fishing activities

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
			albacares), albacore tuna (*Thunnus alalunga*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*) (Patterson et al. 2023b). The fishery operates year-round, primarily using pelagic longline methods, as well as occasional minor line methods (DCCEEW 2022d). AFMA uses total allowable commercial catch (TACC) limits (in association with international management bodies such as the Indian Ocean Tuna Commission) to manage the WTBF (Patterson et al. 2023b). In recent years, effort has been concentrated off south-west WA and SA, although five or fewer vessels have operated each year since 2005 (Patterson et al. 2023b). In 2022, the reported total commercial catch of the WTBF was 145 t from five active vessels (Patterson et al. 2023b).			in the WTBF as the area fished may overlap both the OA and/or EMBA.
Small Pelagic Fishery (SPF)	X	✓	The SPF covers the southern portion of the AFZ from the QLD–NSW border to south-west WA. The SPF has three subareas (east, west, and sardine) and operates year-round (AFMA 2023b; Noriega et al. 2023). In the east and west subareas, the SPF targets blue mackerel (*Scomber australasicus*), jack mackerel (*Trachurus declivis*) and redbait (*Emmelichthys nitidus*), primarily using midwater trawling (Noriega et al. 2023). In the sardine subarea, the SPF targets Australian sardine (*Sardinops sagax*) using purse seine methods (Noriega et al. 2023). AFMA manages the SPF through input controls to limit entry and restrict gear, together with TAC and ITQs for each target stock (Noriega et al. 2023). No catch or effort was recorded in WA in the 2021–2022 or 2022–2023 seasons. In 2022–2023, the SPF reported a total commercial catch of 21,080 t from six active vessels (Noriega et al. 2023).	X	X	The OA is outside of the SPF western boundary. The SPF overlaps with the EMBA; however, no catch or effort has occurred in WA in recent years.

4.4.2.3 WA state managed fisheries

There are 14 WA state managed fisheries with management boundaries that overlap the OA and/or EMBA. Review of catch and effort data shows that the following fisheries were active in the OA within the past ten years:

- Marine aquarium fish managed fishery (MAFMF)
- Octopus interim managed fishery (OIMF)
- Open access fishery (OAF)
- Specimen shell managed fishery (SSMF)
- Tour Operator Fishery West Coast (TOFWC; see Section 4.4.3.2.1)
- West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF)
- West Coast demersal scalefish managed fishery (WCDSMF)
- West Coast rock lobster managed fishery (WCRLF).

The WA state managed commercial fisheries with licence to operate within the OA and/or EMBA are described in Table 4-15. The activity of these fisheries is described in the following sections.

Table 4-15: WA state managed fisheries with management boundaries overlapping the OA and/or EMBA

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
Abalone Managed Fishery (AMF)	✓	✓	The OA does not overlap with the area of AMF fishing effort for the ten-year period between 2012 and 2021. The AMF operates year-round in shallow coastal waters along the western and southern coasts of WA, targeting Roe's abalone (*Haliotis roei*), greenlip abalone (*Haliotis laevigata*) and brownlip abalone (*Haliotis conicopora*) using wade and dive collection methods (Newman et al. 2023). In 2021, the total reported commercial catch of Roe's and greenlip/brownlip abalone was 29.7 t and 39 t, respectively (Newman et al. 2023).	X	✓	Fishing activity does not occur in the OA. Target species occur in the OA.
Abrolhos Islands and Mid West Trawl Managed Fishery (AIMWTMF)	X	✓	The OA does not overlap with the area of AIMWTMF fishing effort for the ten-year period between 2012 and 2021. The AIMWTMF typically operates from March to August (subject to management controls) in the Abrolhos Islands region and primarily targets saucer scallops (*Ylistrum balloti*) using demersal trawl methods (Kangas et al. 2021; Newman et al. 2023). In 2021, the reported total commercial catch of saucer scallops in the AIMWTMF was 615 t whole weight or 123 t meat weight (Newman et al. 2023).	X	✓	Fishing activity and/or target species do not occur in the OA.
Mackerel Managed Fishery (MMF)	✓	✓	The OA does not overlap with the area of MMF fishing effort for the ten-year period between 2012 and 2021. The MMF operates year-round in WA waters between the Capes region and the NT border, primarily targeting Spanish mackerel (*Scomberomorus commerson*) and grey mackerel (*Scomberomorus semifasciatus*) in the North Coast and Gascoyne Coast Bioregions, using near surface trolling methods (Newman et al. 2023). In 2021, the total recorded commercial catch of Spanish and grey mackerel was 238 t and 10 t, respectively (Newman et al. 2023).	X	✓	Fishing activity does not occur in the OA. Target species occur in the OA.
Marine Aquarium Fish Managed Fishery (MAFMF)	✓	✓	The OA overlaps with 149 km^2 (or 0.32%) of the area of MAFMF fishing effort for the ten-year period between 2012 and 2021. The MAFMF operates year-round in all WA state waters, targeting up to 1500 species for marine aquarium display purposes, using hand collection methods (Smith et al. 2022 Newman et al. 2023). In 2021, the reported total commercial catch of the MAFMF was approximately 13,000 fish, 16,000 kg corals, 2,286 sponges, and 75,000 invertebrates (Smith et al. 2022 Newman et al. 2023).	✓	✓	Fishing activity and/or target species occur in the OA.
Octopus Interim Managed Fishery (OIMF)	✓	✓	The OA overlaps with 1482 km^2 (or 3.24%) of the area of OIMF fishing effort for the ten-year period between 2012 and 2021. The OIMF operates year-round targeting western rock octopus (*Octopus djinda*, formerly *O. aff. tetricus*) throughout most the WA state waters between Kalbarri and the SA border, primarily using 'trigger trap' methods (Newman et al. 2023). In 2021, the total reported commercial catch of western rock octopus was 487 t (Newman et al. 2023).	✓	✓	Fishing activity and/or target species occur in the OA.
Open Access Fishery (OAF)	✓	✓	The OA overlaps with 1575 km^2 (or 0.76%) of the area of OAF fishing effort for the ten-year period between 2012 and 2021. The OAF operates year-round targeting a range of fish resources. In the West Coast Bioregion, the fishery primarily targets the West Coast Nearshore and Estuarine Finfish Resource (WCNEFR) in coastal and nearshore waters from Kalbarri to the Capes region, using haul, beach seine and gillnetting (DPIRD 2020c; Newman et al. 2023). Catch data for the OAF is not provided by DPIRD.	✓	✓	Fishing activity and/or target species occur in the OA.

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
South West Coast Salmon Managed Fishery (SWCSMF)	✓	✓	The OA does not overlap with the area of SWCSMF fishing effort for the ten-year period between 2012 and 2021. The SWCSMF targets WA salmon (*Arripis truttaceus*), typically in nearshore waters south of the Perth metropolitan area using haul, beach seine and gill netting (Newman et al. 2023). In 2021, total reported commercial catch in the SWCSMF was 89 t (Newman et al. 2023).	X	✓	Fishing activity does not occur in the OA. Target species occur in the OA.
Southern Demersal Gillnet and Demersal Longline Managed Fishery (SDGDLMF)	X	X	The OA does not overlap with the area of SDGDLMF fishing effort for the ten-year period between 2012 and 2021. The SDGDLMF operates year-round, primarily in continental shelf waters between the Capes region (below 33°S) and the SA border, using demersal gillnets and occasional demersal longlines to target sharks, with scalefish as a legitimate by-product (Newman et al. 2023). Catch data for the SDGDLMF is combined with data from the West Coast Demersal Gillnet and Demersal Longline Fishery (WCDGDLF) under the total Temperate Demersal Gillnet and Demersal Longline Fisheries (TDGDLF). In 2020-21, the TDGDLF recorded a total commercial catch of sharks and rays of 835 t and scalefish of 119 t (Newman et al. 2023).	X	✓	Fishing activity does not occur in the OA. Target species occur in the OA.
Specimen Shell Managed Fishery (SSMF)	✓	✓	The OA overlaps with 171 km^2 (or 0.19 %) of the area of SSMF fishing effort for the ten-year period between 2012 and 2021. The SSMF operates year-round along the entire WA coastline and is based upon the collection of shells for the purposes of display, collection, cataloguing, classification, and sale (Newman et al. 2023). Fishers use a variety of collection methods including diving, wading along coastal beaches, and using remotely operated underwater vehicles (Newman et al. 2023). In 2021, the total reported number of specimen shells collected was 5,443 distributed over 200 species (Newman et al. 2023).	✓	✓	Fishing activity and/or target species occur in the OA.
West Coast Deep Sea Crustacean Managed Fishery (WCDSCMF)	✓	✓	The OA does not overlap with the area of WCDSCMF fishing effort for the ten-year period between 2012 and 2021. The WCDSCMF operates year-round between the Capes region and the NT border, in water depths of 500-800 m (DPIRD 2020d). The fishery targets crystal crabs (*Chaceon albus*), as well as champagne crabs (*Hypothalassia acerba*) and giant crabs (*Pseudocarcinus gigas*), using baited pot/trap methods operated in a long-line formation in shelf edge waters (>150 m). In 2021, the total reported commercial catch in the WCDSCMF was 155 t (Newman et al. 2023).	X	✓	Fishing activity and/or target species do not occur in the OA.
West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF)	✓	✓	The OA overlaps with 1575 km^2 (or 4.21%) of the area of WCDGDLMF fishing effort for the ten-year period between 2012 and 2021. The WCDGDLMF operates year-round, primarily in continental shelf waters between Shark Bay and the Capes region (above 33'S), using demersal gillnets and occasional demersal longlines to target sharks, with scalefish as a legitimate by-product (Newman et al. 2023). Catch data for the WCDGDLMF is combined with data from the SDGDLMF under the total TDGDLF. In 2020–2021, the TDGDLF recorded a total commercial catch of sharks and rays of 835 t and scalefish of 119 t (Newman et al. 2023).	✓	✓	Fishing activity and/or target species occur in the OA.
West Coast Demersal Scalefish Interim Managed Fishery (WCDSIMF)	✓	✓	The OA overlaps with 1575 km^2 (or 2.02%) of the area of WCDSIMF fishing effort for the ten-year period between 2012 and 2021. The WCDSIMF operates year-round between north of Kalbarri and southeast of Augusta, targeting a range of demersal species in inshore (20–250 m deep) and offshore (>250 m deep) habitats using boat-based line methods (Newman et al. 2023). In 2021, the total recorded commercial catch in the WCDSIMF was 221 t, with 92 t recorded in the Mid-West management zone (Newman et al. 2023).	✓	✓	Fishing activity and/or target species occur in the OA.

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
West Coast Purse Seine Managed Fishery (WCPSMF)	✓	✓	The OA does not overlap with the area of WCPSMF fishing effort for the ten-year period between 2012 and 2021. The WCPSMF operates between Geraldton and Cape Leeuwin, including development zones in the north and south, targeting small pelagic scalefish using purse seine methods (Newman et al. 2023). In 2020-2021, the total recorded commercial catch of the WCPSMF for all small pelagic scalefish species and zones combined was 504 t (Newman et al. 2023).	X	✓	Fishing activity and/or target species do not occur in the OA.
West Coast Rock Lobster Managed Fishery (WCRLMF)	✓	✓	The OA overlaps with 1,575 km^2 (or 1.94%) of the area of WCRLMF fishing effort for the ten-year period between 2012 and 2021. The fishery operates year-round from 15 January, targeting the western rock lobster (WRL; *Panulirus cygnus*) throughout their geographic range along the lower west coast of WA, using baited traps/pots (Newman et al. 2023). In the 12-month season between 15 January 2021 and 14 January 2022, the total recorded commercial catch in the WCRLMF was 6,334 t (Newman et al. 2023).	✓	✓	Fishing activity and target species occur in the OA.

4.4.2.3.1 Abalone Managed Fishery

The AMF covers WA coastal waters between the NT and SA borders. The commercial fishery operates year-round in shallow coastal waters along the western and southern coasts of WA, targeting Roe's abalone (*Haliotis roei*), greenlip abalone (*Haliotis laevigata*) and brownlip abalone (*Haliotis conicopora*) (Newman et al. 2023). Roe's abalone are primarily caught on the western and southwestern coasts, whilst greenlip/ brownlip abalone are primarily caught on the south-west and southern coasts of WA (Hart et al. 2017; Newman et al. 2023). The AMF is a dive and hand collection fishery. Fishers are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as the market demand and unit prices of abalone (Newman et al. 2023). The AMF is divided into eight management areas, each with annual total allowable commercial catch (TACC) limits (Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in coastal waters off the south-west and south coasts of WA (Figure 4-18). Low (3–20 vessels) and moderate (21–40 and 61–80 vessels) effort was recorded off the Perth coast. Spatial fishing intensity is known to correlate with areas of suitable habitat for target species, typically in shallow (<30 m) waters with easy access to beaches and for divers using hand collection methods (Newman et al. 2023). Fishing activity is also restricted by the 2011 closure of management Area 8 (north of the Moore River) in response to the 2010–2011 marine heatwave (DPIRD 2022a).

The OA does not overlap with the area of AMF fishing effort over the ten-year period (Figure 4-18). Monthly CAES data shows patterns in fishing effort (the sum of fishing vessels above confidential limits) followed a consistent seasonal trend. Average monthly effort was greatest in the summer from November to April, peaking in November, with a corresponding reduction in winter from May to October.

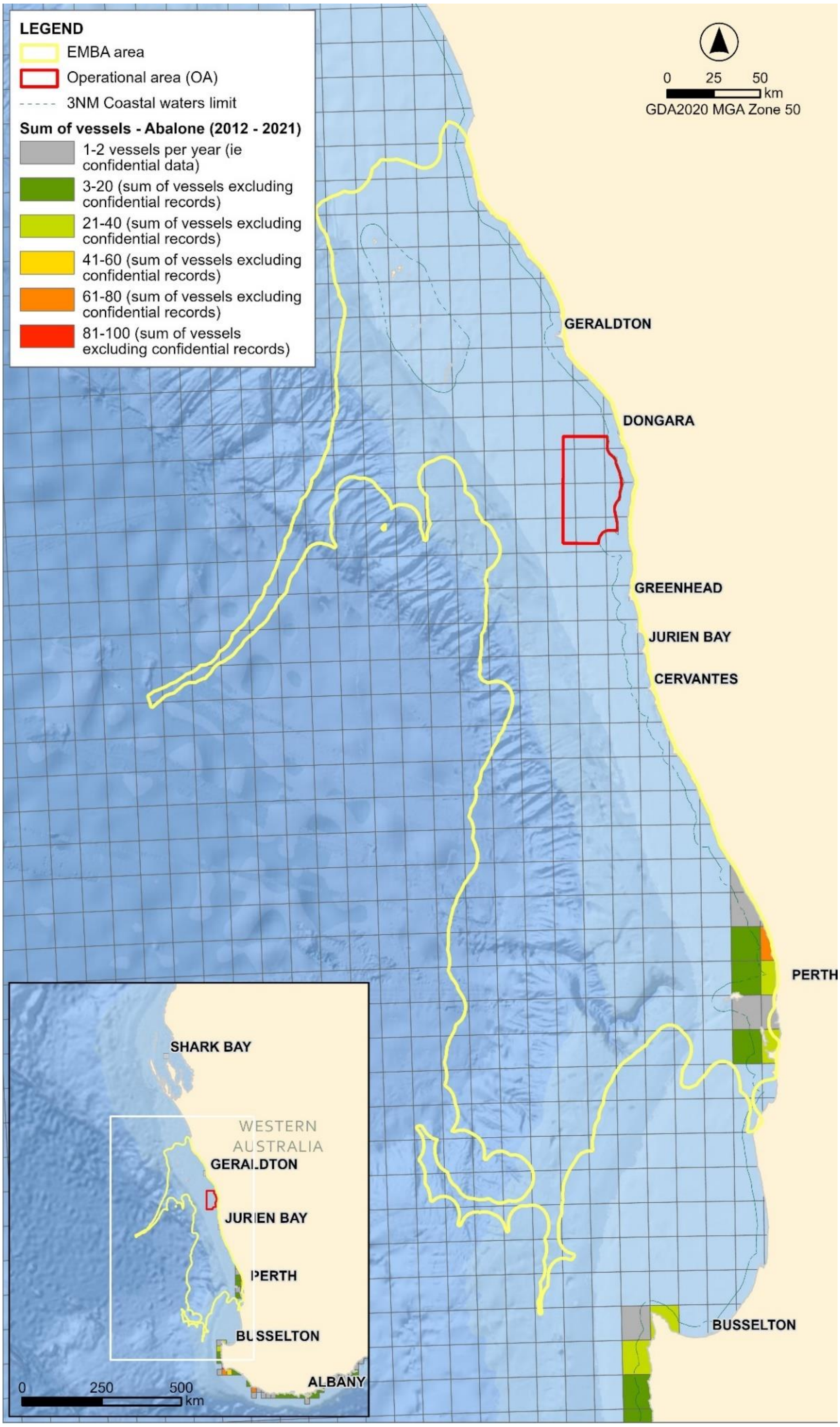

Figure 4-18: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the AMF for 2012–2021 combined

4.4.2.3.2 Abrolhos Islands and Mid West Trawl Managed Fishery

The AIMWTMF operates around the Abrolhos Islands region off the west coast of WA. The fishery typically operates from March to August (subject to management controls) and primarily targets saucer scallops (*Ylistrum balloti*) using demersal trawl methods (DPIRD 2020e; Kangas et al. 2021). The AIMWTMF is managed through a 'constant escapement policy' using gear restrictions and spatial and temporal closures to manage annual catch (Kangas et al. 2021).

CAES data for the AIMWTMF was only available between 2017 and 2021. Fishing effort (i.e. annual vessel counts) over the five-year period between 2017 and 2021 occurred around the Abrolhos Islands and off the coast of Kalbarri (Figure 4-19). Low (3–5 vessels), moderate (6–10 and 11–15 vessels), and high (16–20 vessels) effort was distributed around the Abrolhos Islands. Spatial fishing intensity is known to correlate with areas of suitable habitat for target species. Fishing activity is also restricted by area closures off the WA coast, as well as various localised closures around the Abrolhos Islands.

The OA does not overlap with the area of AIMWTMF fishing effort over the five-year period (Figure 4-19). Monthly CAES data showed fishing effort (the sum of fishing vessels above confidential limits) occurred between April and August, peaking between May and July, with no activity during the temporal closure from September to March.

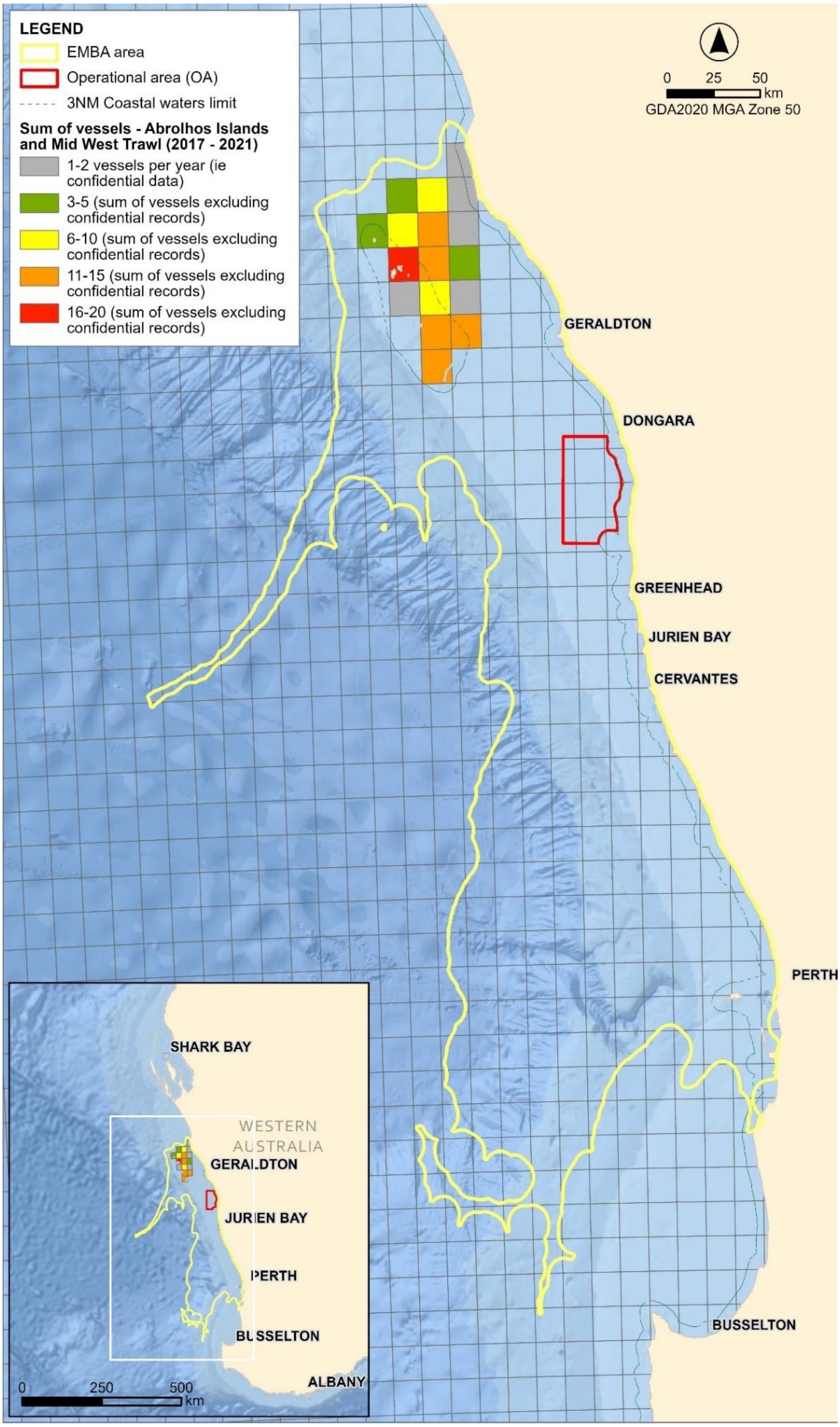

Figure 4-19: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the AIMWTMF for 2017–2021 combined

4.4.2.3.3 Mackerel Managed Fishery

The MMF covers WA waters between the Capes region and the NT border, and out to the extent of the AFZ. The fishery primarily targets Spanish mackerel (*Scomberomorus commerson*) and grey mackerel (*Scomberomorus semifasciatus*), using near surface trolling methods (DPIRD 2022b; Newman et al. 2023). The MMF operates year-round and is divided into three separately managed areas: Kimberley (Area 1), Pilbara (Area 2) and Gascoyne/West Coast (Area 3), with most of the catch effort concentrated in the Kimberley and Pilbara (Newman et al. 2023). Fishing activity is managed using a transferable quota system, which sets an annual TACC in each area, together with restrictions on fishing gear (DPIRD 2022b).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in coastal and inshore waters from Exmouth to the Abrolhos Islands (Figure 4-20). Low and moderate effort was recorded around the Abrolhos Islands and south of Shark Bay (3–6 vessels and 7–12 vessels), with the highest effort concentrated north of Shark Bay and in the north of WA (25–30 vessels). Spatial fishing intensity is known to correlate with areas of suitable habitat for mackerel species, together with proximity to ports along the coastline and at the Abrolhos Islands.

The OA does not overlap with the area of MMF fishing effort over the ten-year period (Figure 4-20). Monthly patterns in fishing effort (the sum of fishing vessels above confidential limits) followed a consistent seasonal trend. Average monthly effort over the ten-year period was greatest between May and October, with reduced effort between November and April.

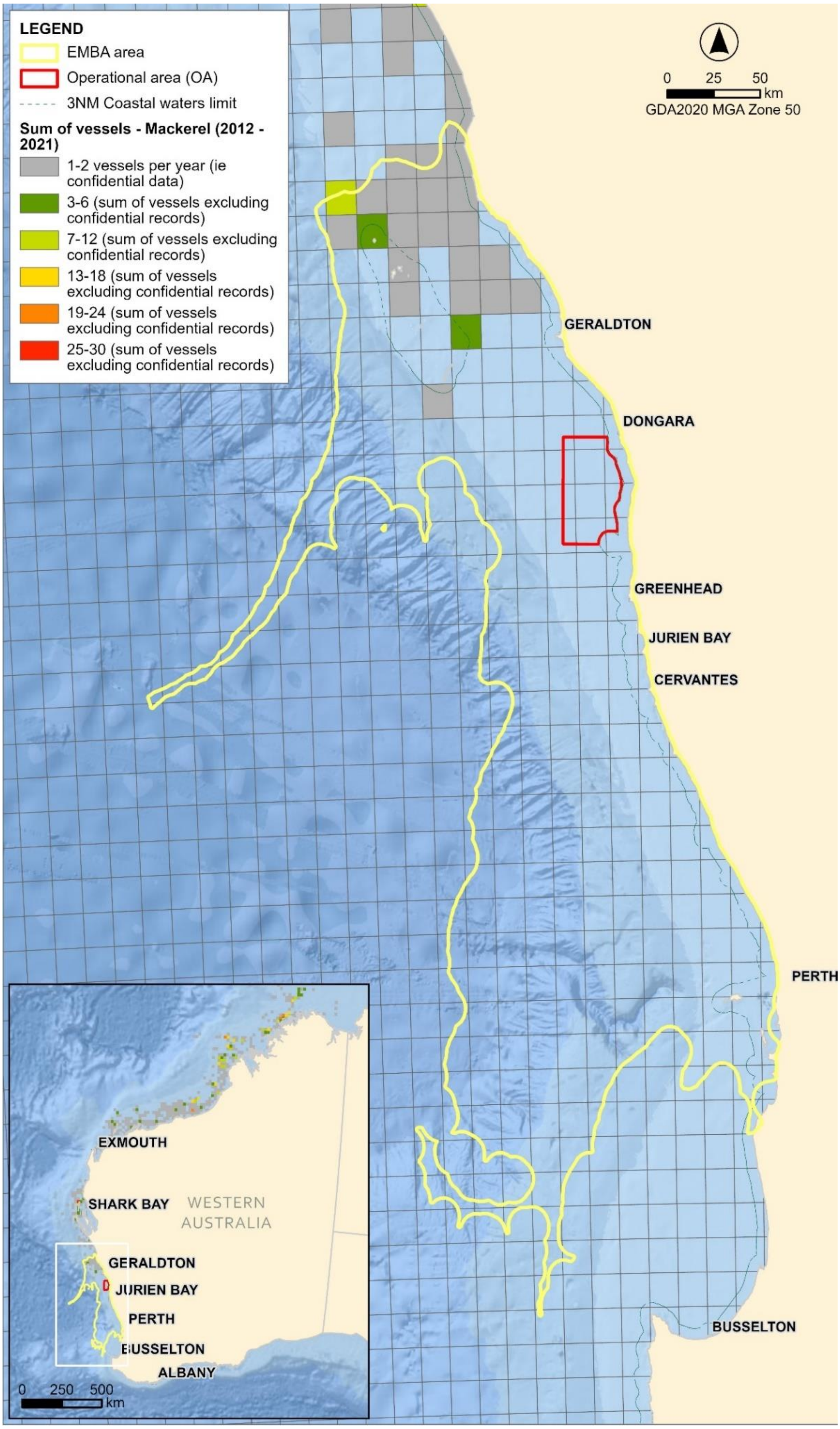

Figure 4-20: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MMF for 2012–2021 combined

4.4.2.3.4 Marine Aquarium Fish Managed Fishery

The MAFMF is a low volume, high value fishery that covers all WA state waters between the NT and SA borders, and out to the extent of the AFZ. The fishery targets up to 1500 species for marine aquarium display purposes, including fish (teleost and elasmobranchs), hard and soft corals, live rock, algae, seagrass, and invertebrates (Smith et al. 2022: Newman et al. 2023). The MAFMF operates year-round, with fishers using hand collection methods that are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as the market demand and unit prices of target species (Newman et al. 2023). The MAFMF is managed through a constant catch harvest strategy, using input and output controls including an Individually Transferable Quota (ITQ) system for certain target species (DPIRD 2018).

Analysis of CAES data shows that fishing effort (i.e. annual licence counts) over the ten-year period between 2012 and 2021 occurred in coastal waters off the north, west and south coasts of WA (Figure 4-21). On the west coast, moderate effort was recorded off the Perth coast and around the Abrolhos Islands (16–30 and 31–45 licences), followed by low level effort off Kalbarri (3–15 licences), and confidential effort running between Kalbarri and the Perth.

Catch effort is known to correlate with areas of suitable habitat for target species, typically in shallow (<30 m) waters with easy access to beaches and for divers using hand collection methods (Newman et al. 2023). Fishing activity is also restricted by practical limitations including depth, time, and tide, together with various spatial closures (Newman et al. 2023).

The OA overlaps with 149 km^2 (or 0.32%) of the total area of MAFMF fishing effort over the ten-year period (Figure 4-21). Data within this overlap are confidential due to the low level of effort. Monthly patterns in fishing effort (sum of fishing licences above confidential limits) varied over the ten-year period, as indicated by the error bars in Figure 4-22, although there was a clear peak during August. However, as 95% of monthly CAES records were confidential, the data may not accurately represent temporal fishing effort.

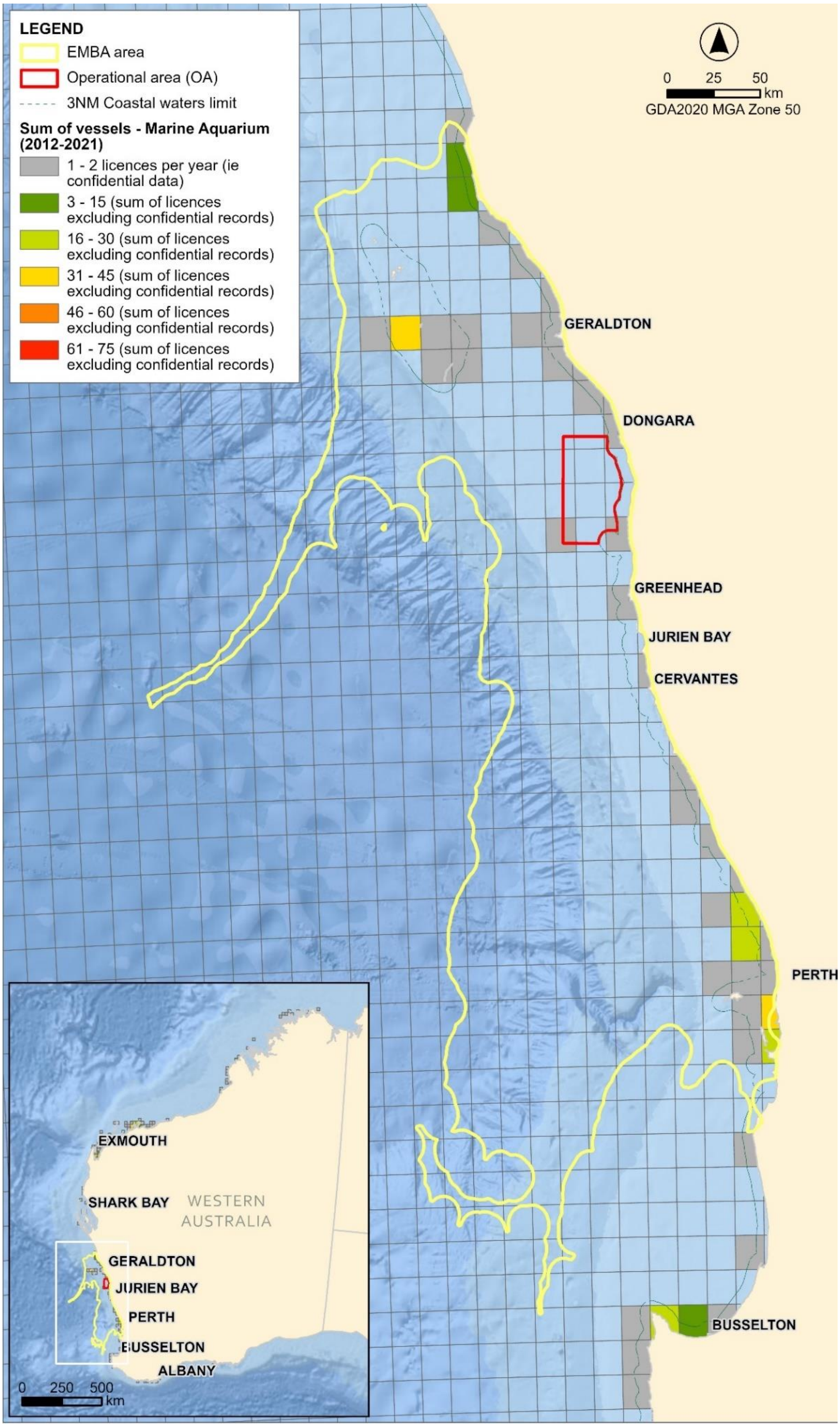

Figure 4-21: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MAFMF for 2012–2021 combined

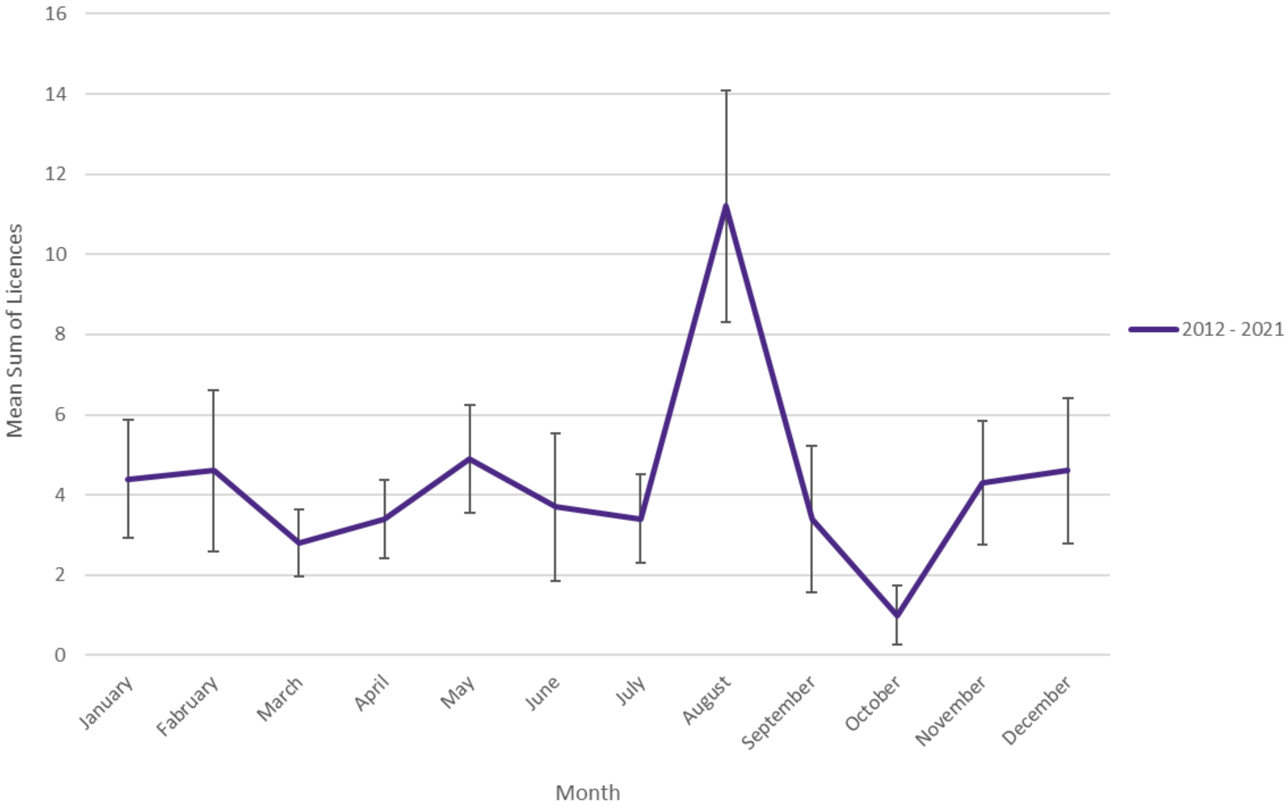

Figure 4-22: Mean monthly sum of licences (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MAFMF for 2012–2021 combined

4.4.2.3.5 Octopus Interim Managed Fishery

The OIMF covers most of the WA state waters between Kalbarri and the SA border, and out to the extent of the AFZ. The fishery operates year-round targeting western rock octopus (WRO; *Octopus djinda*, formerly *O. aff. tetricus*) in nearshore and continental shelf waters, primarily using 'trigger trap' methods (Newman et al. 2023). The OIMF accounts for most of the commercial octopus catch in WA and is divided into three spatial management areas: Zone 1, Zone 2, and Zone 3. Fishing activity is managed using input controls such as gear restrictions and spatial regulations limiting the total number of traps permitted in each zone (Hart et al. 2018; Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in coastal and nearshore waters between Kalbarri and Busselton (Figure 4-23). Low and moderate effort was recorded in coastal and nearshore waters between Geraldton and Mandurah (3–6, 7–12 and 13–18 vessels), with the highest effort concentrated off Green Head (19–24 vessels), Mandurah (19–24 vessels) and Lancelin (25–30 vessels).

WRO complete their life cycle in a range of nearshore habitats in depths up to 70 m, including rocky reefs, seagrass meadows and sandy substrates, typically using limestone reefs around 20 m deep (Hart et al. 2018). Spatial fishing intensity likely follows areas of suitable habitat and depth for traps with a greater catchability of WRO and proximity to ports at Green Head, Jurien Bay, and Lancelin.

Fishing effort also reflects the spatial management of the OIMF. Zone 2 off the west and south-west coast of WA (between 30°30' S and 34°24' S) is allocated the most fishing licences and consequently accounts for approximately 82% of annual catches (Hart et al. 2018), as shown in Figure 4-23.

The OA overlaps with 1,482 km^2 (or 3.24 %) of the area of OIMF fishing effort over the ten-year period (Figure 4-23). CAES blocks within the OA recorded between three and 24 vessels.

Whilst most monthly records were confidential, monthly patterns in fishing effort (the sum of fishing vessels above confidential limits) varied over the ten-year period, as indicated by the error bars in Figure 4-24. Average effort was greater from April to June and October to November, and lower in January, February, July, and August.

WRO is short-lived (up to 1.5 years), with early maturity and year-round spawning (Hart et al. 2018). The consistent fishing effort is likely due to the consistent catchability of WRO, together with the 12-month season in the OIMF, giving fishers the flexibility to operate year-round. Fishers are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as market demand and unit prices of octopus (Newman et al. 2023). External factors may also influence monthly fishing effort. For example, catch in the OIMF increased by 86% from 262 t in 2020 to 487 t in 2021, due to a recovery from COVID-19 related supply and trade limitations (Newman et al. 2023).

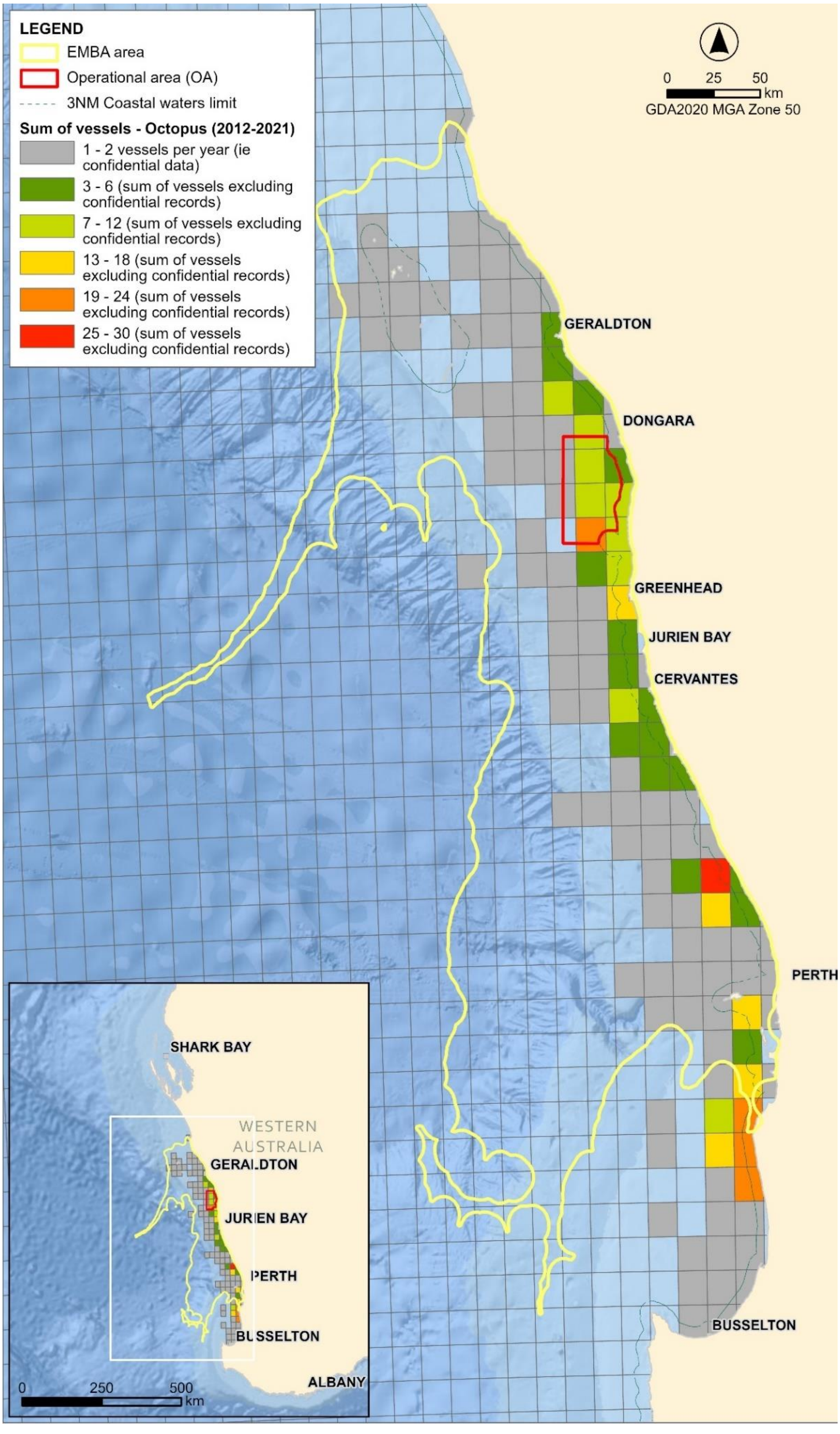

Figure 4-23: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the OIMF for 2012–2021 combined

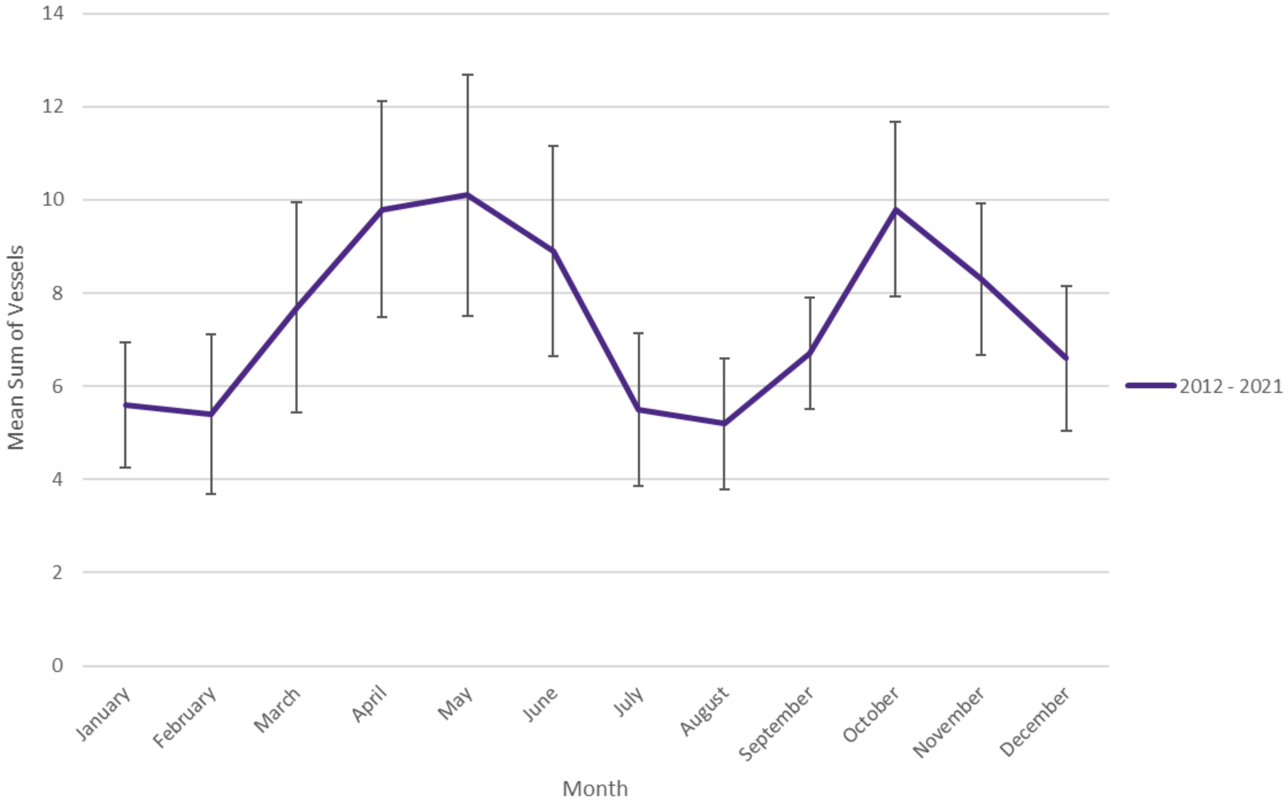

Figure 4-24: Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the OIMF for 2012–2021 combined

4.4.2.3.6 Open Access Fishery

The OAF covers a range of fish resources. In the West Coast Bioregion (WCB), the fishery primarily targets the West Coast Estuarine and Nearshore Finfish Resource (WCENFR), which comprises approximately 15 species in coastal and nearshore waters from Kalbarri to the Capes region (DPIRD 2020c, Newman et al. 2023). Indicator species in the WCENFR include sea mullet (*Mugil cephalus*), Australian herring (*Arripis georgianus*), yellowfin whiting (*Sillago schombergkii*), and Western Australian salmon (*Arripis truttaceus*). The fishery operates year-round in coastal and nearshore waters using haul nets and gillnets (DPIRD 2020c). Fishers are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as the market demand and unit prices of target species (Newman et al. 2023).

Fisheries data for the OAF was only available in course 60 × 60 nm CAES blocks. Consequently, the area of fishing activity may be overestimated, as effort is likely spatially limited to discrete locations within the 60 × 60 nm blocks. Data for the OAF includes the North Coast, Gascoyne Coast and West Coast bioregions combined.

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in coastal waters off the north, west and south coasts of WA (Figure 4-25). The greatest effort was recorded in coastal waters south of Jurien Bay (31–40 vessels) and Perth (41–50 vessels), followed by moderate effort between Geraldton and Jurien Bay (11–20 vessels), and north of Perth (21–30 vessels). Spatial fishing intensity is known to correlate with areas of suitable habitat for target species in coastal and estuarine waters, with proximity to ports at Perth and Jurien Bay.

The OA overlaps with 1,575 km^2 (or 0.76 %) of the total area of OAF fishing effort over the ten-year period (Figure 4-25). CAES blocks within the OA recorded 11–20 vessels.

Monthly patterns in fishing effort (sum of fishing vessels above confidential limits) varied over the ten-year period, as indicated by the error bars in Figure 4-26. Average monthly effort was greatest in the first half of the year from January to a peak in May, and lowest in the second half of the year from June to December.

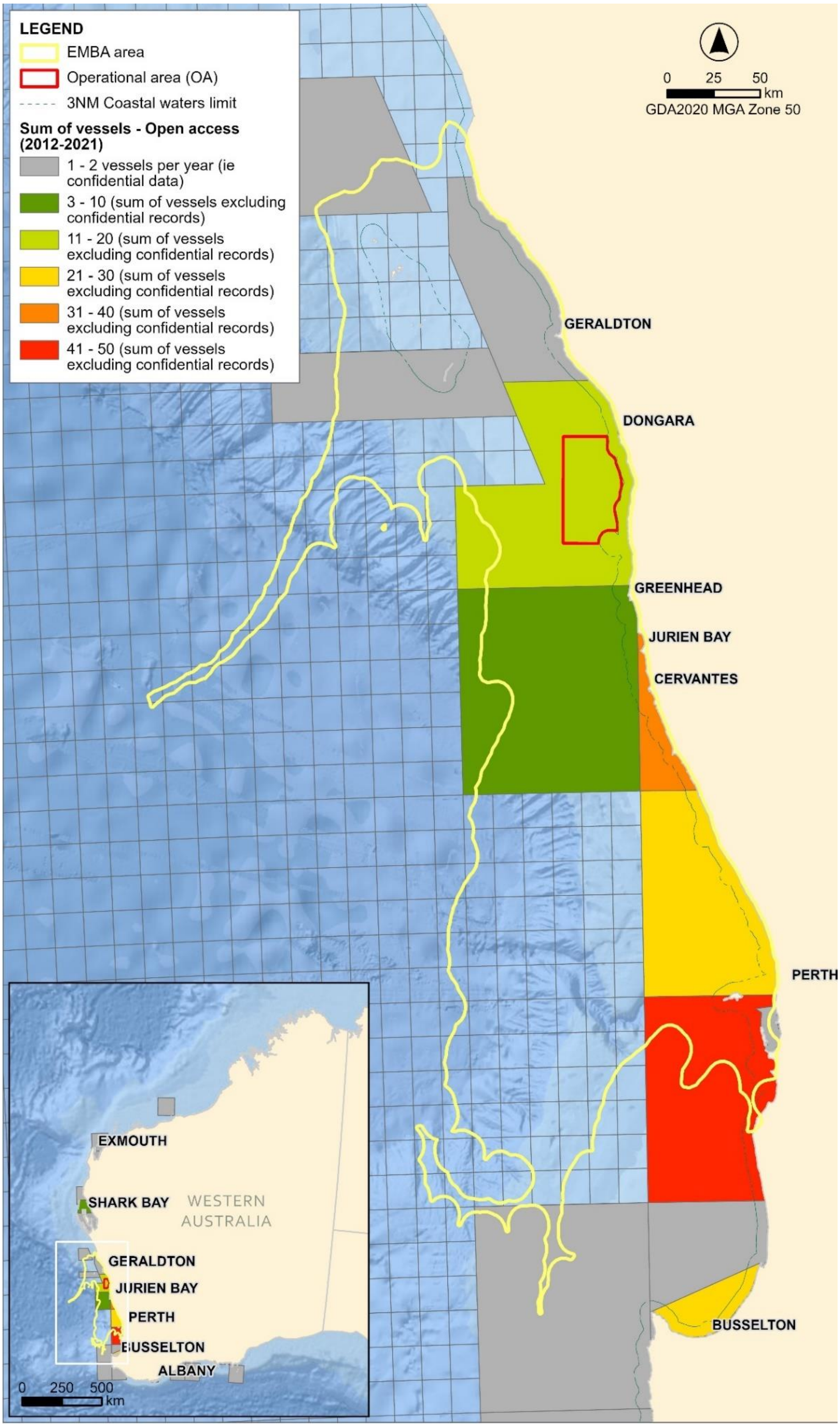

Figure 4-25: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the OAF for 2012–2021 combined

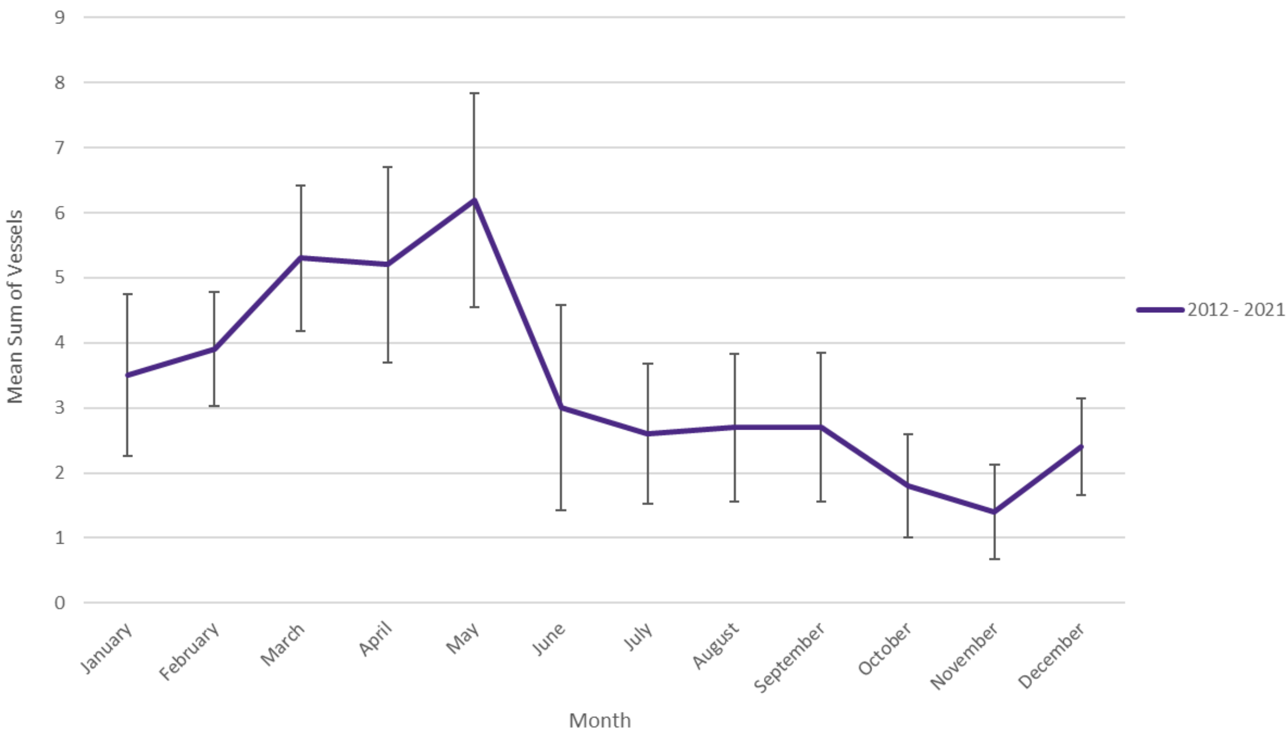

Figure 4-26: Mean monthly sum of vessels (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the OAF for 2012–2021 combined

4.4.2.3.7 South West Coast Salmon Managed Fishery

The SWCSMF covers WA state waters between Geographe Bay and the NT border, and out to the extent of the AFZ. The fishery targets Western Australian salmon (*Arripis truttaceus*) in the south-west coast region of WA, using haul, beach seine and gill net methods (Newman et al. 2023). The range of western Australian salmon extends across multiple jurisdictions, with most of the catch taken off the south coast of Australia. In the west coast region, fishing activity typically occurs in nearshore waters south of the Perth metropolitan area in March–April when large schools form and move around the coast to their spawning area on the lower west coast (DPIRD 2022c). The SWCSMF is managed through a constant exploitation policy, using input controls restricting gear and entry together with area closures (Newman et al. 2023).

The OA does not overlap with the area of SWCSMF fishing effort over the ten-year period (Figure 4-27). Monthly CAES data shows fishing effort (the sum of fishing vessels above confidential limits) occurred in April and May. However, as 95% of monthly CAES records were confidential, the data may not accurately represent temporal fishing effort.

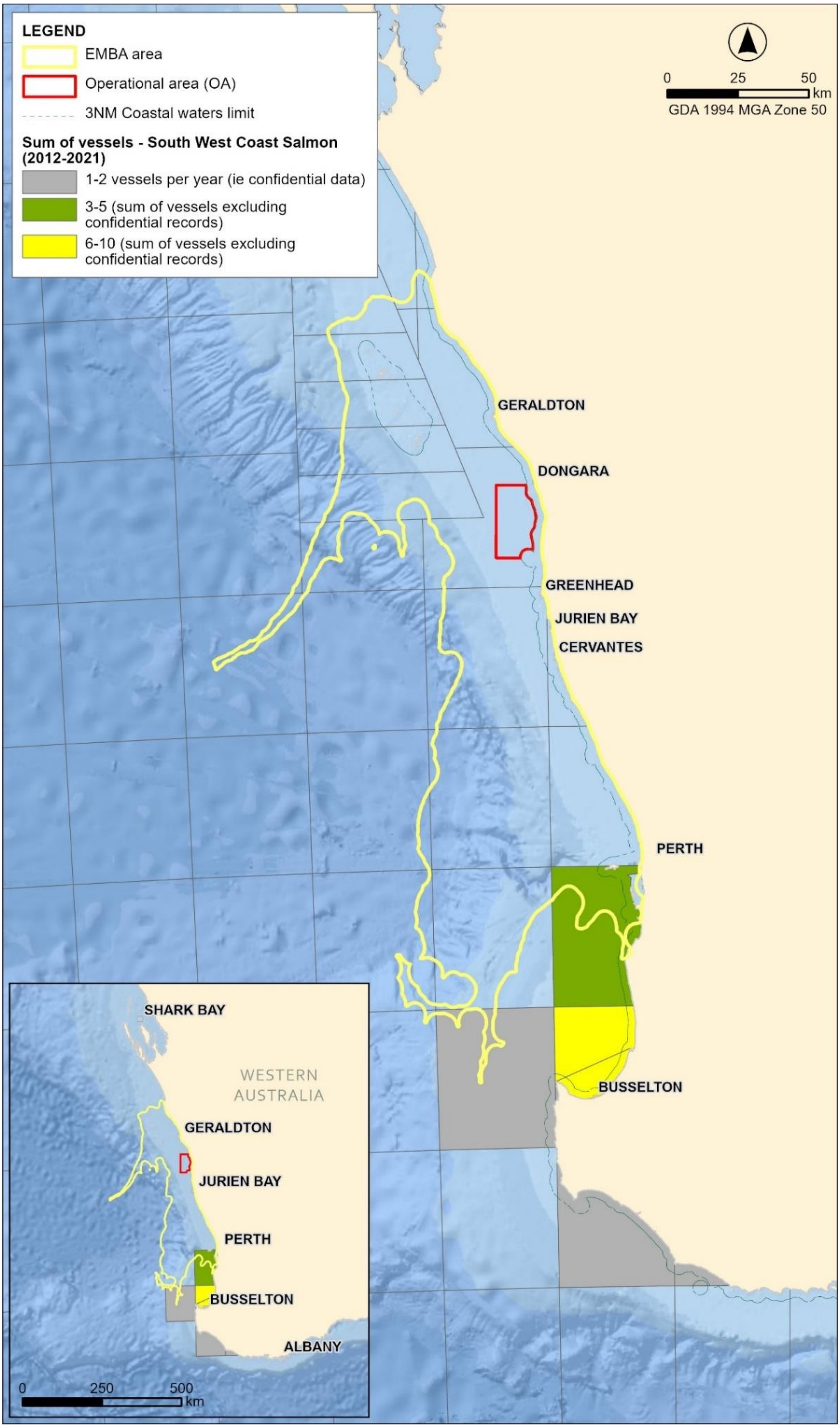

Figure 4-27: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the SWCSMF for 2012–2021 combined

4.4.2.3.8 Southern Demersal Gillnet and Demersal Longline Managed Fishery

The Southern Demersal Gillnet and Demersal Longline Managed Fishery (SDGDLMF) covers WA state waters between the Capes region (below 33° S) and the SA border, and out to the extent of the AFZ. The fishery transitioned from joint Commonwealth/WA state management to state-only management in December 2018 (Newman et al. 2023). The fishery primarily operates in continental shelf waters up to 200 m deep, using demersal gillnets and occasional demersal longlines to target sharks, with scalefish as a legitimate by-product (Newman et al. 2023). Several indicator species are used to represent the overall stock of temperate sharks, which comprise approximately 80% of the shark catch (Newman et al. 2023). The primary indicator species are dusky (*Carcharhinus obscurus*), sandbar (*Carcharhinus plumbeus*), gummy (*Mustelus antarcticus*) and whiskery (*Furgaleus macki*) sharks (Newman et al. 2023). The SDGDLMF is managed through a constant catch harvest strategy, using input controls in the form of transferable time units (i.e. hours of fishing entitlement) and restrictions on gear such as mesh, hook, and net sizes (DoAFF 2021, Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in inshore (20–250 m deep) and offshore (>250 m deep) waters off the south and south-west coasts of WA (Figure 4-28). Most effort was recorded between Busselton and the SA border, with the greatest effort concentrated between Albany and Esperance.

The OA does not overlap with the area of SDGDLMF fishing effort over the ten-year period (Figure 4-28). Monthly CAES data showed fishing effort (the sum of fishing vessels above confidential limits) varied over the period and was greatest between March and May, peaking in April. However, as 97% of CAES records were confidential, the data may not accurately represent temporal fishing effort.

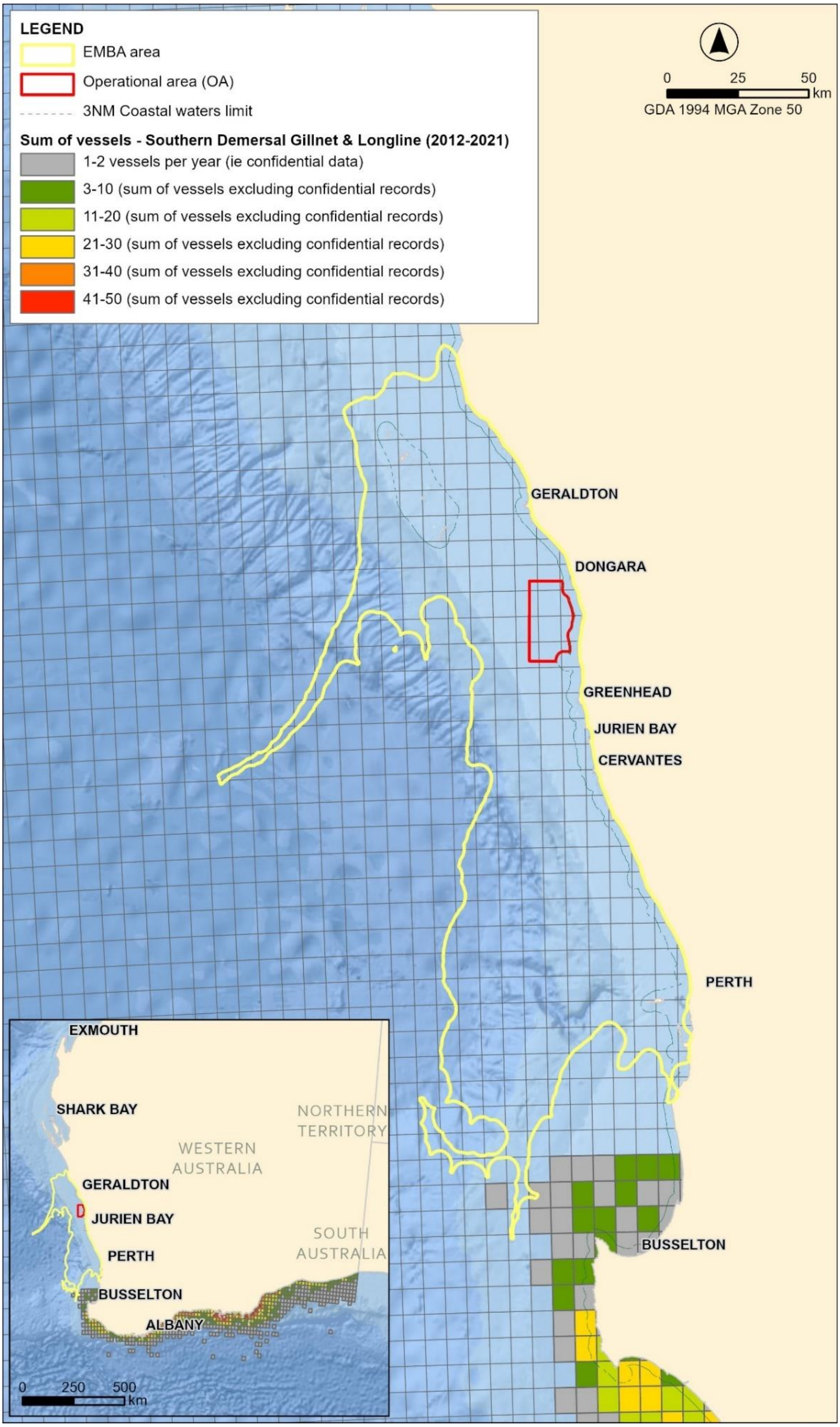

Figure 4-28: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the SDGDLMF for 2012–2021 combined

4.4.2.3.9 Specimen Shell Managed Fishery

The SSMF covers the entire WA coastline between the NT and SA borders and is based upon the collection of shells for the purposes of display, collection, cataloguing, classification, and sale (Newman et al. 2023). Approximately 200 species of specimen shell are collected each year through a variety of methods including shallow water diving, wading along coastal beaches, and using remotely operated vehicles (Newman et al. 2023).

The SSMF operates year-round and is managed using input controls restricting gear and entry, together with permanently closed areas (Newman et al. 2023). Fishers using hand collection methods are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as the market demand and unit prices of target species (Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual licence counts) over the ten-year period between 2012 and 2021 occurred in coastal waters off the north, west and south coasts of WA (Figure 4-29). On the west coast, the greatest effort was recorded south of Cape Naturaliste (21–30 licences) and off Busselton (11–20 licences), followed by moderate effort off Perth (3–10 licences), with low level, confidential effort running between Shark Bay and the Capes region. Catch effort is typically concentrated in shallow (<30 m) waters around population centres, with easy access to beaches and for divers using hand collection methods (Newman et al. 2023). Fishing activity is also restricted by practical limitations including depth, time, and tide, together with various spatial closures (Newman et al. 2023).

The OA overlaps with 171 km^2 (or 0.19%) of the total area of SSMF fishing effort over the ten-year period (Figure 4-29). Data within this overlap are confidential due to the low level of effort. Monthly CAES data showed patterns in fishing effort (sum of fishing licences above confidential limits) varied over the ten-year period. However, as 95% of monthly CAES records were confidential, the data may not accurately represent temporal fishing effort.

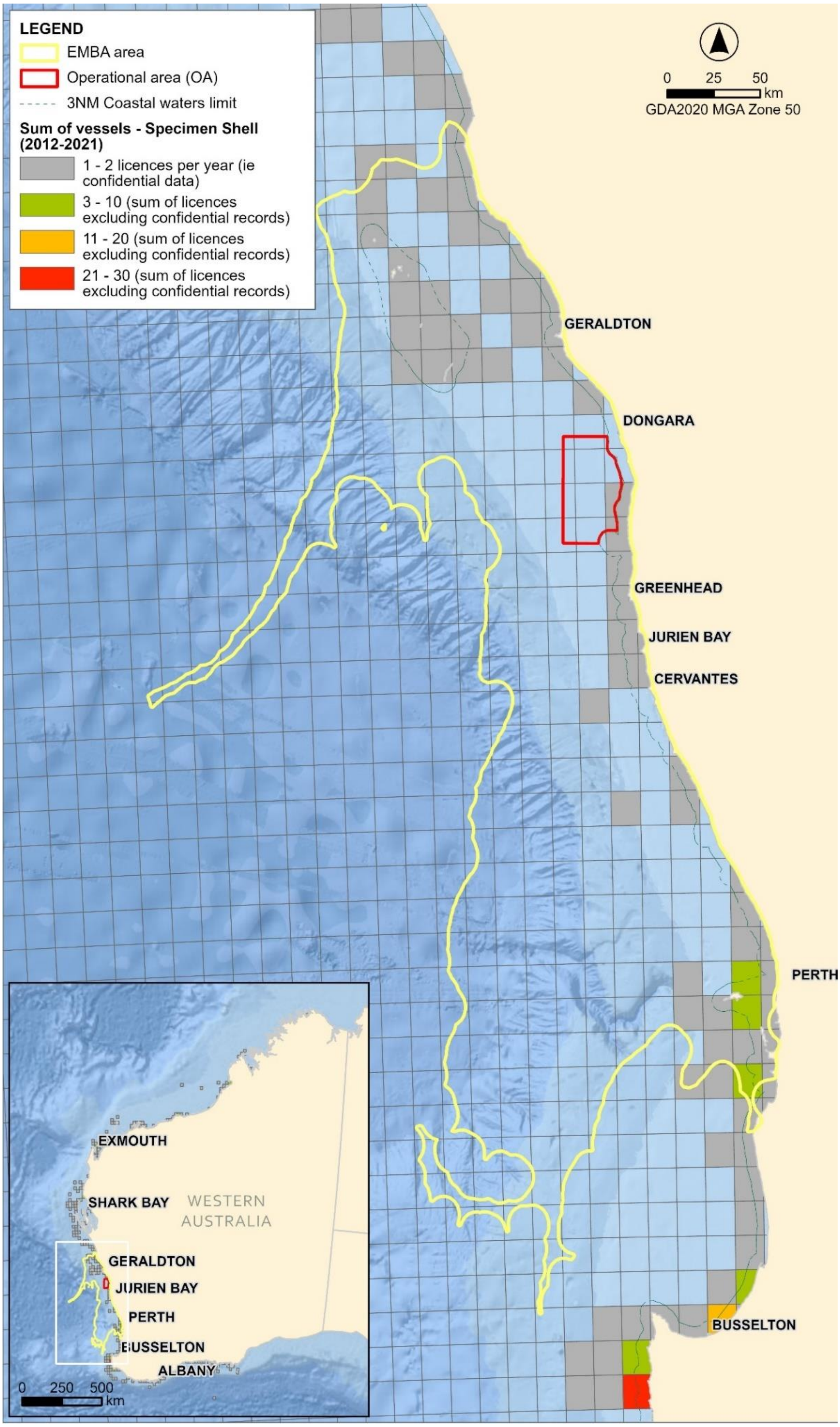

Figure 4-29: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the SSMF for 2012–2021 combined

4.4.2.3.10 West Coast Deep Sea Crustacean Managed Fishery

The WCDSCMF covers all WA state waters north of the Capes region to the NT border, on the seaward side of the 150 m isobath (DPIRD 2020d). The fishery primarily targets crystal crabs (*Chaceon albus*), as well as champagne crabs (*Hypothalassia acerba*) and giant crabs (*Pseudocarcinus gigas*), using baited pots or traps operated in a long-line formation in shelf edge waters 500–800 m deep (DPIRD 2020d; Newman et al. 2023). The WCDSCMF operates year-round and is primarily a quota-managed fishery using a TACC for each target species (Newman et al. 2023). Fishers are typically limited by sea and weather conditions, which are generally more favourable in the summer, as well as export market demand and unit prices of target species, for example around Chinese New Year (How et al. 2015).

Fisheries data for the WCDSCMF in 10 × 10 nm CAES blocks was only available between 2017 and 2021. Fishing effort (i.e. annual vessel counts) over the five-year period between 2017 and 2021 occurred on the seaward side of the 150 m isobath between Exmouth and the Capes region (Figure 4-30). Most fishing activity was confidential due to the low level of effort. Moderate effort was recorded off Perth (3–4 vessels), with both moderate and relatively high effort (3-4 and 5–6 vessels) recorded south of Shark Bay.

The OA does not overlap with the area of WCDSCMF fishing effort over the five-year period (Figure 4-30). Monthly CAES data was 100% confidential and may not accurately represent temporal fishing effort.

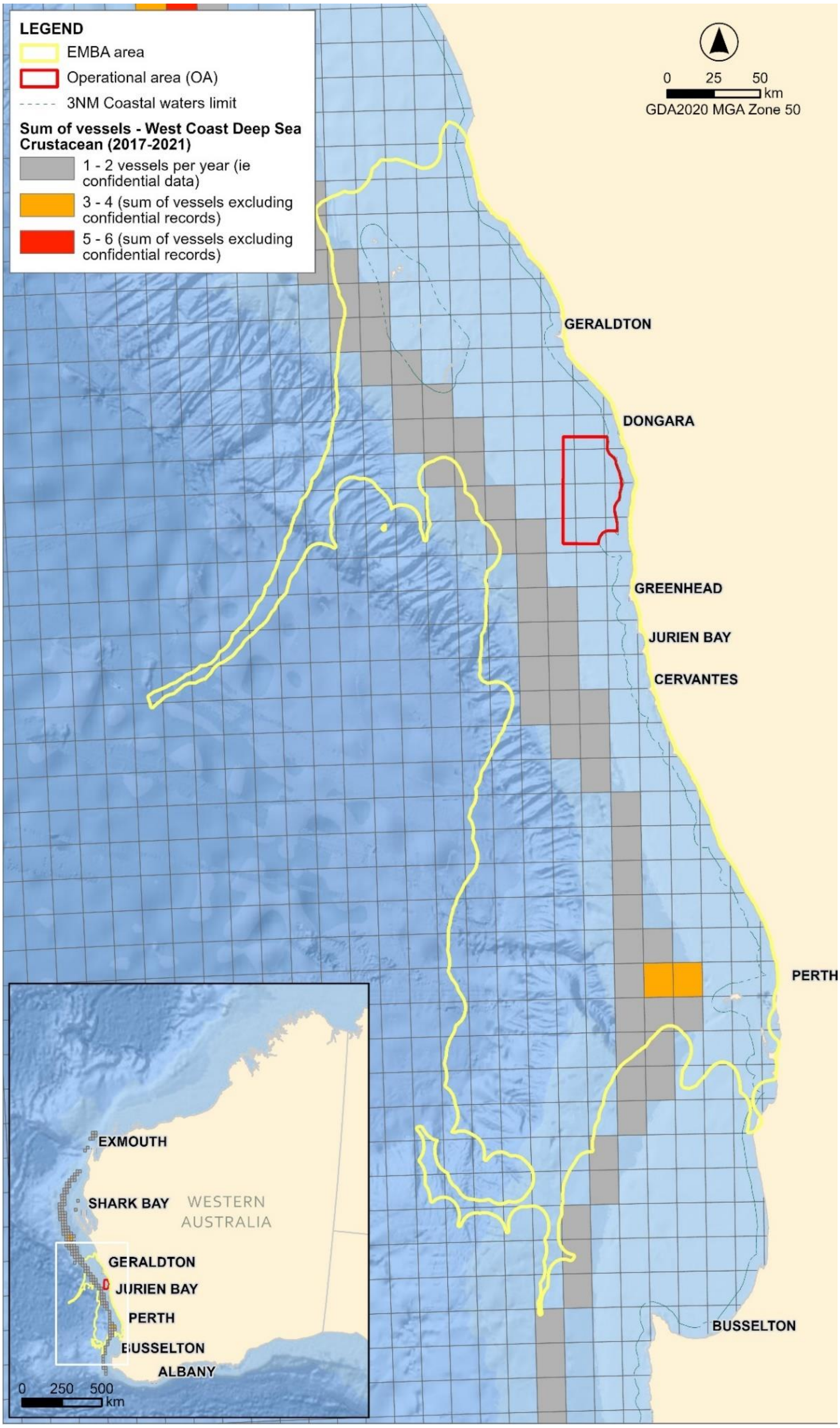

Figure 4-30: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSCMF for 2012–2021 combined

4.4.2.3.11 West Coast Demersal Gillnet and Demersal Longline Managed Fishery

The WCDGDLMF covers WA state waters between Shark Bay and the Capes region (above 33° S), and out to the extent of the AFZ. The fishery primarily operates in continental shelf waters up to 200 m deep, using demersal gillnets and occasional demersal longlines to target sharks, with scalefish as a legitimate by-product (Newman et al. 2023). Several indicator species are used to represent the overall stock of temperate sharks, which comprise approximately 80% of the shark catch (Newman et al. 2023). The primary indicator species are dusky (*Carcharhinus obscurus*) and sandbar (*Carcharhinus plumbeus*) sharks, which are typically targeted along the west coast (WAFIC 2022), as well as gummy (*Mustelus antarcticus*) and whiskery (*Furgaleus macki*) sharks (Newman et al. 2023). The WCDGDLMF is managed through a constant catch harvest strategy, using input controls in the form of transferable fishing time units (i.e. hours of fishing entitlement) and restrictions on gear such as mesh, hook, and net sizes (Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 occurred in inshore (20–250 m deep) and offshore (>250 m deep) waters between Shark Bay and Mandurah (Figure 4-31). The greatest effort was recorded in coastal waters off Green Head at the southern extent of the OA (9–11 vessels), followed by moderate effort in coastal and inshore waters between Geraldton and Lancelin (3–5 and 6–8 vessels).

Spatial fishing intensity is known to correlate with areas of suitable habitat for target shark species, together with proximity to ports along the coastline between Geraldton and Jurien Bay. In WA, adult dusky and sandbar sharks are most abundant in continental shelf waters north of the Abrolhos Islands, while juveniles inhabit in more temperate, south-west waters (Braccini et al. 2018). Adult dusky and sandbar sharks also have high mobility across WA and make regular seasonal migrations from the northwest to temperate waters for pupping (Braccini et al. 2018). The southward movement of target species may contribute to the concentrated fishing effort in more temperate waters, as shown in Figure 4-31.

Fishing activity is also restricted by the current closure of the Abrolhos Islands Fish Habitat Protection Area (FHPA) and the metropolitan management area off the Perth coast (inshore <250 m), as shown by the low vessel counts recorded in these areas in Figure 4-31.

The OA overlaps with 1,575 km^2 (or 4.21%) of the area of WCDGDLMF fishing effort over the ten-year period (Figure 4-31). CAES blocks within the OA recorded between three and 11 vessels, as well as some low-level, confidential effort.

Monthly CAES data was over 99% confidential and may not accurately represent temporal fishing effort. The WCDGDLMF season runs for 12-months, giving fishers with individually transferable time units an incentive to increase efficiency and the flexibility to fish year-round. Fishers are typically limited by sea and weather conditions, which are typically more favourable in the summer months, as well as the catchability and market demand for sharks and scalefish. The seasonal migrations of target species may also influence temporal fishing effort.

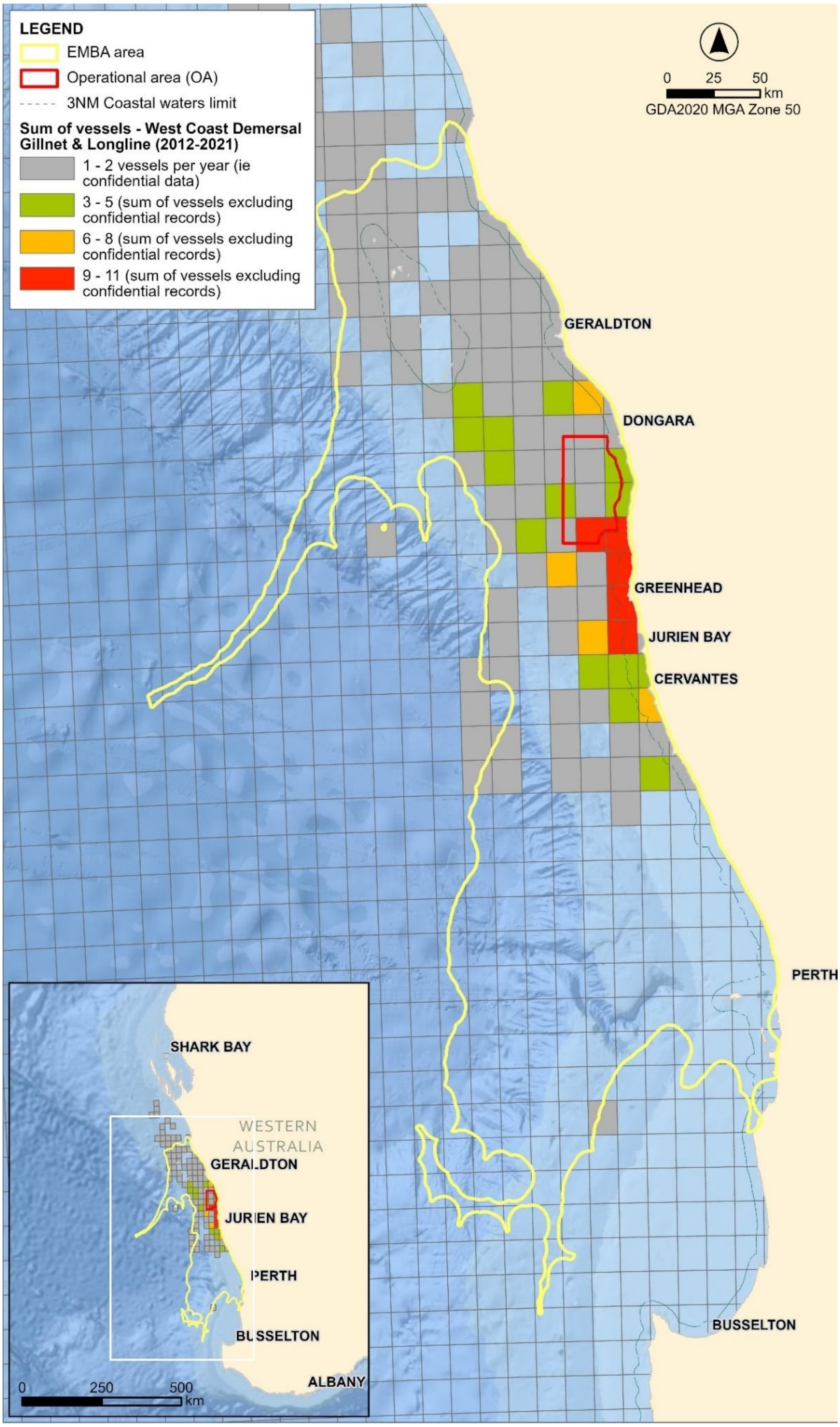

Figure 4-31: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDGDLMF for 2012–2021 combined

4.4.2.3.12 West Coast Demersal Scalefish Interim Managed Fishery

The WCDSIMF covers WA state waters between north of Kalbarri and south-east of Augusta, and out to the extent of the AFZ. The fishery targets approximately 100 demersal species in inshore (20–250 m deep) and offshore (>250 m deep) habitats, using boat-based line methods (Newman et al. 2023).

The WCDSIMF is divided into four management zones: Kalbarri, Mid-West, Metropolitan and South-West, with approximately 64% of the west coast demersal scalefish (WCDS) resource allocated to the commercial sector (Newman et al. 2023). Several indicator species are used to represent the overall stock of WCDS (see Table 4-3), which comprise approximately 75% of the total catch (DPIRD 2021). Inshore indicator species include West Australian dhufish (*Glaucosoma hebraicum*), pink snapper (*Chrysophrys auratus*) and baldchin groper (*Choerodon rubescens*) (Fairclough et al. 2021a; Newman et al. 2023).

The WCDS resource is currently undergoing a long-term recovery phase (Fairclough et al. 2021a; Newman et al. 2023). Management arrangements to recover the resource have been in place since 2010, limiting annual catches in the West Coast Bioregion (Kalbarri to Augusta) to 50% of 2005–2006 levels through permits allocating annual fishing hours. Annual entitlement to fish in the Mid-West area has since ranged from 53–69% of maximum (45% in 2021), with a corresponding decrease in catch below the stock recovery benchmark (Newman et al. 2021, 2023). In January 2023, DPIRD further reduced fishing hours to achieve a 50% cut in TACC to 240 t (DPIRD 2023d). The effort reduction is likely to reduce the number of days fished per commercial line boat to an average of 20 days per year (DPIRD 2023d).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 ranged between Shark Bay and the Capes region, with most vessels recorded within approximately 100 km offshore (Figure 4-32). The greatest effort was concentrated to the west and south-west of the OA and around the Abrolhos Islands (41–60 and 61–80 vessels), followed by moderate effort in inshore waters running adjacent to the coastline between Shark Bay and Jurien Bay (21–40 vessels).

Spatial fishing intensity is known to correlate with areas of suitable habitat for target species such as dhufish and snapper, together with proximity to ports along the coastline and at the Abrolhos Islands. The movement of target species may also influence fishing effort, for example, pink snapper may be targeted by fishers as they migrate to spawning areas in Shark Bay and Cockburn Sound every year. Fishing activity is also restricted by the current closure of the Metropolitan management area (since 2007), as shown by the low vessel counts recorded between Lancelin and south of Mandurah in Figure 4-32.

The OA overlaps with 1,575 km^2 (or 2.02 %) of the area of WCDSMF fishing effort over the ten-year period (Figure 4-32). CAES blocks within the OA recorded between three and 60 vessels, as well as some low-level, confidential effort.

Monthly patterns in fishing effort (the sum of fishing vessels above confidential limits) followed a consistent seasonal trend. Average monthly effort over the ten-year period was greatest in summer from November to May, peaking in December, with a corresponding reduction in winter from June to September (Figure 4-33).

The WCDSMF season runs for 12-months, giving fishers with individual permits (i.e. hours of fishing entitlement) an incentive to increase efficiency and the flexibility to fish year-round. Fishers are typically limited by sea and weather conditions, as well as the market demand for scalefish (Newman et al. 2023). The greater vessel numbers recorded between November and May likely reflects more favourable conditions for line fishing and the greater catchability and unit prices of target species in the summer months (Figure 4-33).

External factors may also influence monthly fishing effort. For example, catch in the Mid-West management area increased from 76 t in 2018 to 100 t in 2020, partly due to an increase in fishing effort in February and March following western rock lobster market changes caused by COVID-19 (Newman et al. 2021, 2023).

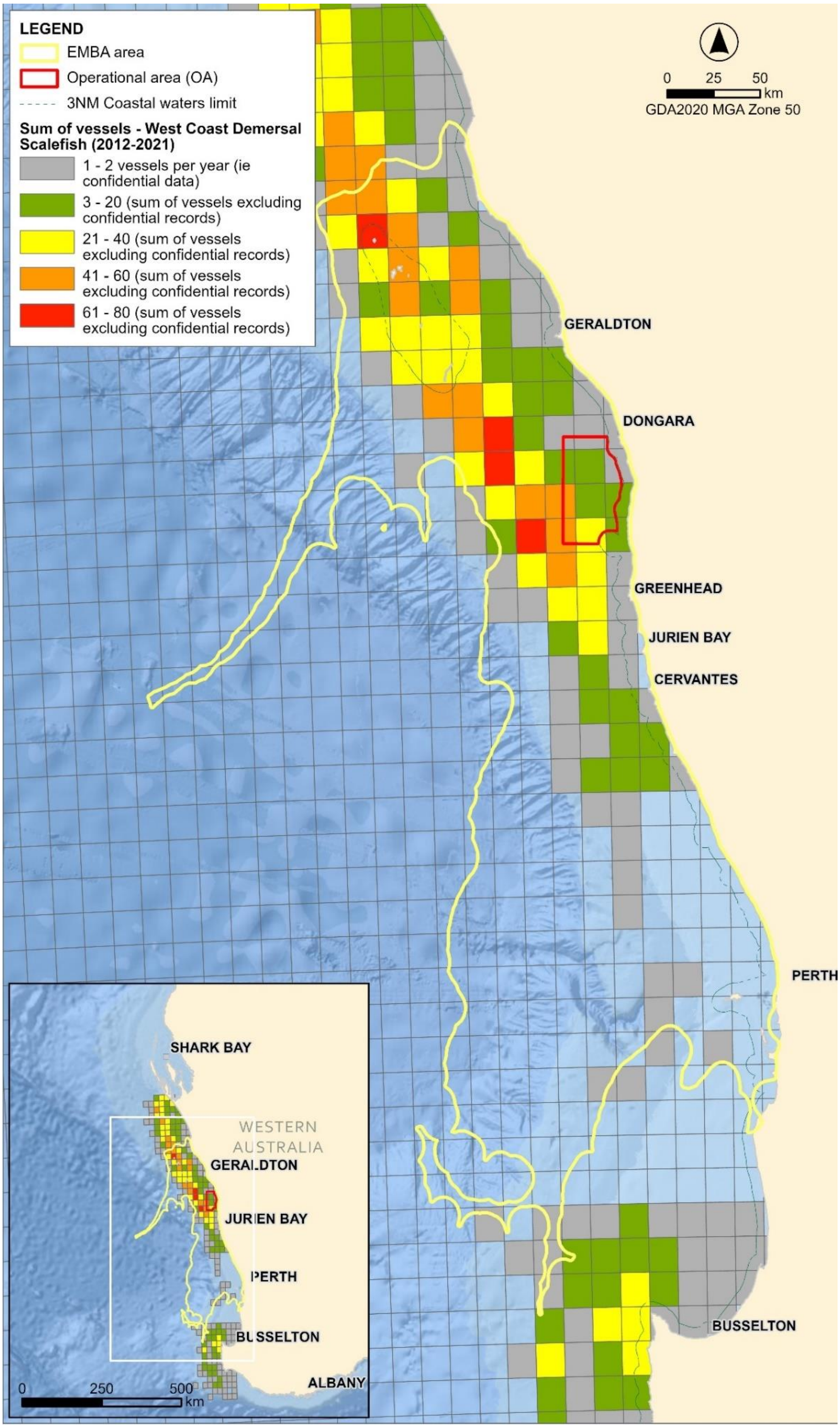

Figure 4-32: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSIMF for 2012–2021 combined

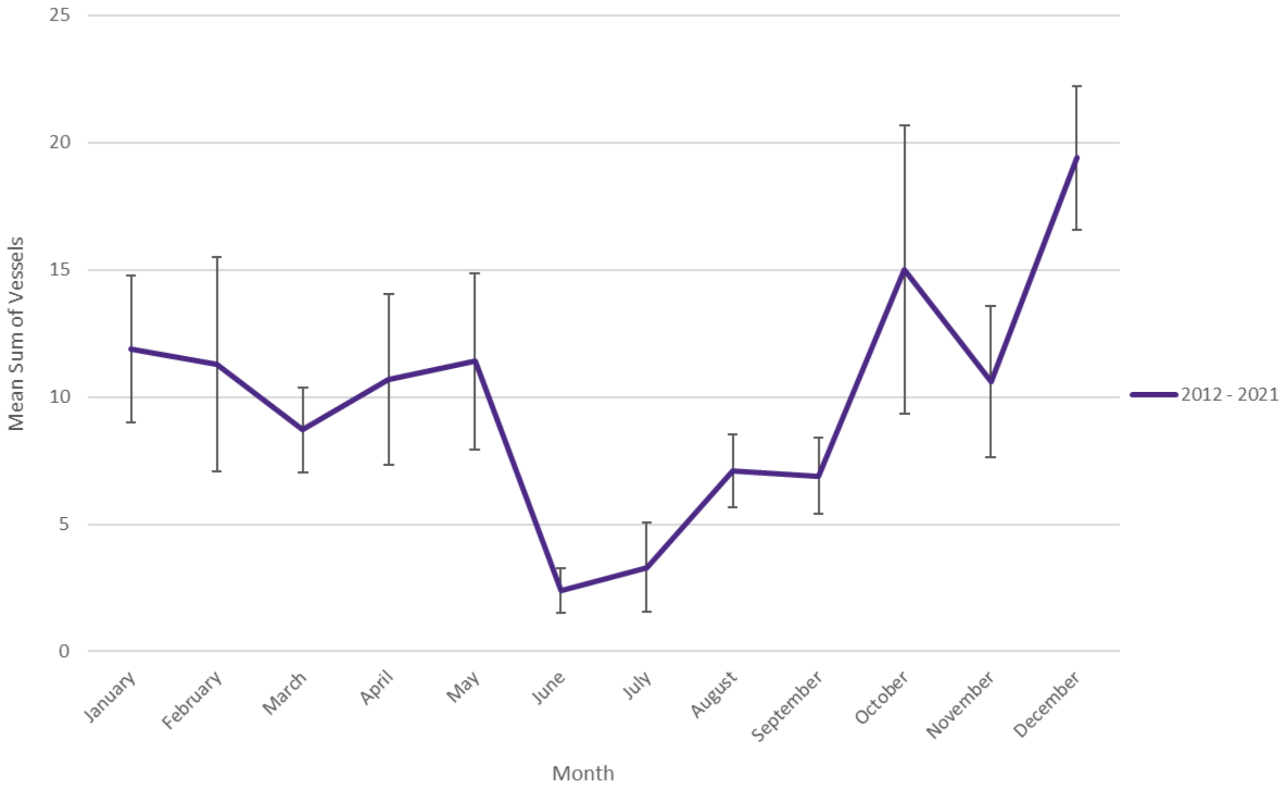

Figure 4-33: Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSIMF for 2012–2021 combined

4.4.2.3.13 West Coast Purse Seine Managed Fishery

The WCPSMF covers WA state waters from Geraldton to Geographe Bay. The fishery targets small pelagic scalefish using purse seine methods. Scaly mackerel (*Sardinella lemuru*) and Australian sardine (*Sardinops sagax*) are the indicator species and dominate the catch (Newman et al. 2023). The WCPSMF operates year-round and is managed through input controls limiting entry and gear type, as well as notional TACC limits for Australian sardines and separately for other small pelagic species (Blazeski et al. 2021; Newman et al. 2023). Fishers are typically limited by sea and weather conditions, which are generally more favourable in the summer months, as well as the market demand and unit prices of target species.

Fisheries data for the WCPSMF was only available in coarse 60 × 60 nm CAES blocks. Consequently, the area of fishing activity may be overestimated, as effort is likely spatially limited to discrete locations within the 60 × 60 nm blocks.

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 ranged from the Abrolhos Islands to Busselton (Figure 4-34). The highest effort was concentrated in Cockburn Sound south of Perth (22–28 vessels), followed by moderate effort off the Busselton coast (8–14 vessels) and low effort north of Perth (3–7 vessels). Spatial fishing intensity is known to correlate with areas of suitable habitat for pelagic target species, typically in coastal waters around the Perth metropolitan area such as Cockburn Sound (Newman et al. 2023).

The OA does not overlap with the area of WCPSMF fishing effort over the ten-year period (Figure 4-34). Monthly CAES data is 96% confidential and may not accurately represent temporal fishing effort.

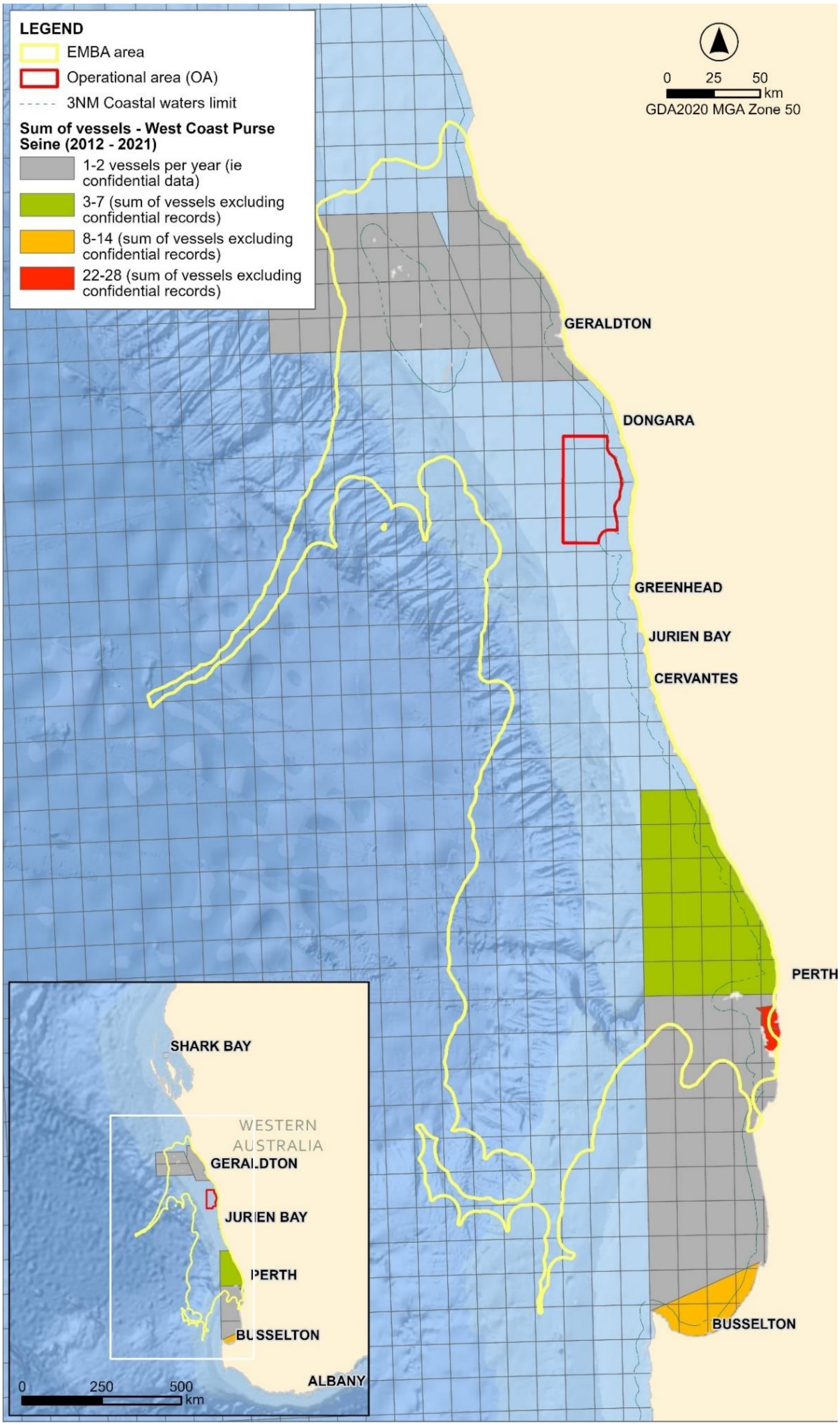

Figure 4-34: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the WCPSMF for 2012–2021 combined

4.4.2.3.14 West Coast Rock Lobster Managed Fishery

The WCRLMF covers WA state waters between Exmouth and Cape Leeuwin, and out to the extent of the AFZ. The fishery targets the western rock lobster (*Panulirus cygnus*) throughout their geographic range along the lower west coast of WA, using baited traps/pots (Newman et al. 2023). Historically, the WCRLMF has been Australia's largest and most valuable single species wild capture fishery (de Lestang et al. 2016).

The WCRLMF is managed in three spatial areas: Zone A (Abrolhos Islands area), Zone B (north of 30°S) and Zone C (south of 30°S). In 2010–2011, the fishery transitioned to an output-based system in response to a downturn in recruitment (Caputi et al. 2014), implementing a transferable quota system to control the annual TACC in each zone while maximising economic yield (DPIRD 2014; Newman et al. 2023).

Analysis of CAES data shows that fishing effort (i.e. annual vessel counts) over the ten-year period between 2012 and 2021 ranged between Shark Bay and the Capes region, with most vessels recorded in nearshore waters between Geraldton and Perth, as well as around the Abrolhos Islands (Figure 4-35). Vessel counts were greatest off the Geraldton coast (226–300 and 301–375 vessels), followed by the Abrolhos Islands (226–300 vessels) and Perth coast (151–225 vessels).

Spatial fishing intensity is known to correlate with areas of suitable limestone reef habitat, with proximity to ports along the coastline and at the Abrolhos Islands. Additionally, since the implementation of a 50% catch share between management Zones A and B to combine with Zone C in 2015, spatial catch variability has reduced by dispersing effort across the fishery (de Lestang et al. 2016).

The movement of WCRL may also influence fishing effort. Juvenile, newly moulted WRL (or 'whites') migrate west from coastal reefs across sandy habitats to deeper offshore breeding grounds (Bellchambers et al. 2017), while a smaller number migrate north following the continental shelf (de Lestang et al. 2016). While there is substantial inter-annual variability in north-ward movement between latitudes 27°S and 30°S (de Lestang et al. 2016), this may contribute to the concentrated fishing effort in the northern areas of the fishery.

The OA overlaps with 1,575 km^2 (or 1.94%) of the area of WCRLMF fishing effort over the ten-year period (Figure 4-35). CAES blocks within the OA recorded between three and 300 vessels.

Monthly patterns in fishing effort (the sum of fishing vessels above confidential limits) followed a consistent seasonal trend. Average monthly effort over the ten-year period was greatest in the summer from December to May, peaking in February, with a corresponding reduction in winter from June to November (Figure 4-36). The 2020 season was excluded from the average due to trade limitations and disruptions caused by COVID-19.

The WCRLMF management structure enables export market demand to drive temporal fishing effort. Since 2013, the commercial season has run for 12 months beginning 15 January, giving fishers with individual catch limits (i.e. transferable quotas) an incentive to increase economic efficiency and the flexibility to fish when the market price for lobsters is high. Asia is the primary export market for WRL, with almost all catch exported to China, together with Hong Kong, Taiwan, and Japan (Newman et al. 2023). Fishing effort reflects export prices and typically peaks shortly after the annual quota is renewed around Chinese New Year in January–February (Figure 4-36).

External economic factors may also influence monthly fishing effort. For example, in 2020 catch effort was substantially reduced during the peak seasonal fishing period in January and February, reflecting a Chinese ban on Australian imports and a crash in export demand due to COVID-19.

Catches of WRL are also limited by sea and weather conditions (Newman et al. 2023), which are generally more favourable in the summer, as shown in Figure 4-36. Historically, seasonal catches of WRL have also been greater in December–January due to the higher catchability of the 'whites' phase, as well as in March–April when undersize WRL moult into legal size (de Lestang et al. 2016). Fishing effort and catch are typically lower in winter, due to more rough weather days, lower catchability, and many females starting to mate and therefore becoming illegal for capture (de Lestang et al. 2016).

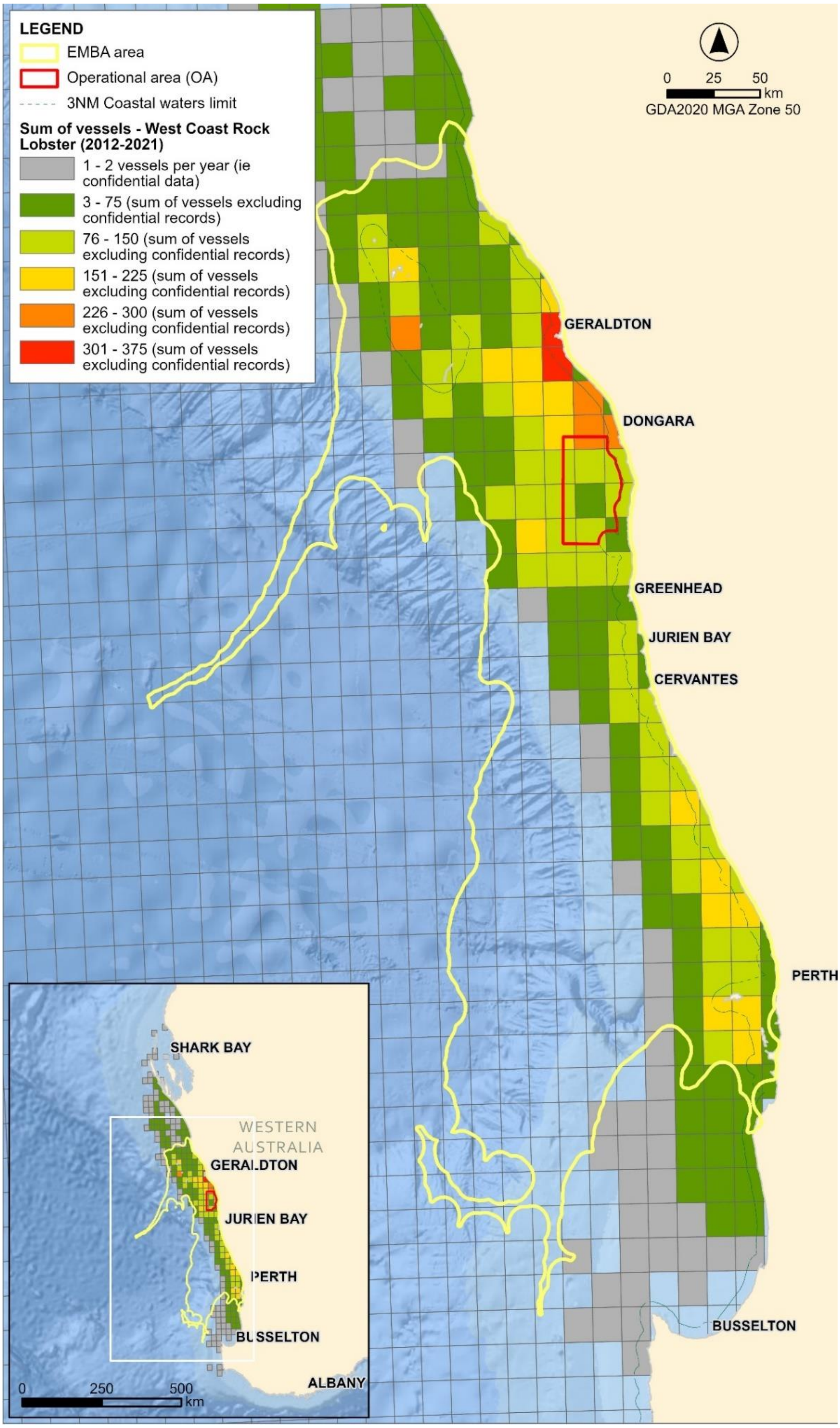

Figure 4-35: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCRLMF for 2012–2021 combined

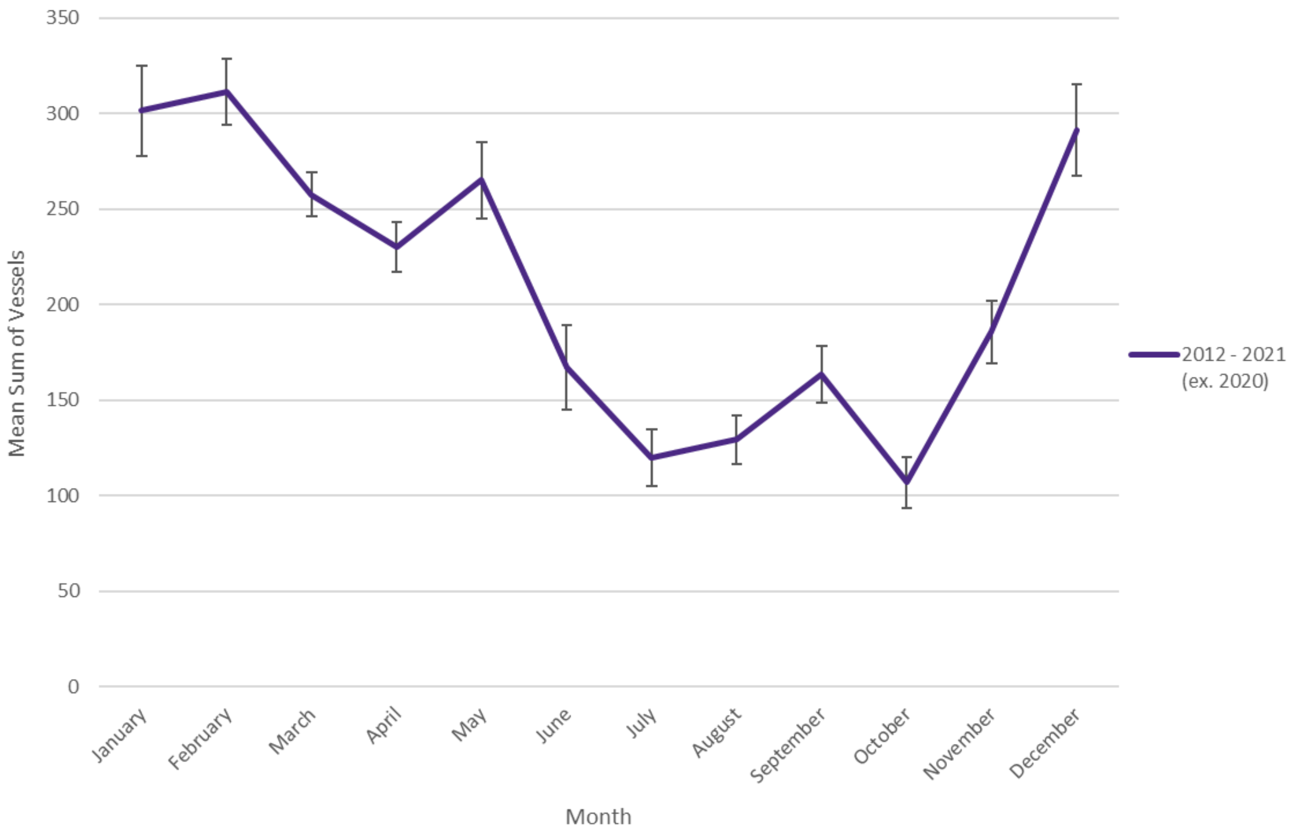

Figure 4-36: Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCRLMF for 2012–2021 combined, excluding 2020

4.4.3 Tourism and recreation

4.4.3.1 Tourism

No tourism activities are known to take place within the OA; however, tourism activities do occur in the EMBA and surrounding region. The primary tourism activities surrounding the OA are recreational fishing, water sports and scenic/wildlife tours. Further details on local tourism are covered in Section 5.

4.4.3.2 Recreational fishing

Recreational fishing is a popular activity in the WCB. Port Denison (6 km east of the OA) is a common recreating fishing hot spot, and recreational vessels may occur within the OA and/or EMBA. Recreational fishing charters also operate in the region (see Section 4.4.3.2.1).

4.4.3.2.1 Tour Operator Fishery West Coast

The TOFWC is based on recreational fishers operating from charter vessels off the WA coast and around the Abrolhos Islands. Charter fishers typically target the large pelagic and west coast demersal scalefish resources using line fishing methods (Newman et al. 2023). The WCDSIMF operates in inshore (20–200 m deep) and offshore (>250 m) habitats, targeting approximately 100 demersal species such as Western Australian dhufish and pink snapper (Newman et al. 2023). Charter fishers are included in the 36% catch allocation for the WCDSIMF recreational sector, with 61 licensed operators reported active in the WCB in 2020–2021 (Newman et al. 2023). The large pelagic resource is distributed throughout WA in offshore pelagic and inshore waters and includes a range of tropical and temperate species, such as mackerels, barracuda, billfishes, cobia, large trevallies, mahi mahi, and tunas (Lewis 2020).

Analysis of CAES data shows that fishing effort (i.e. annual licence counts) over the ten-year period between 2012 and 2021 ranged between Shark Bay and the Capes region (Figure 4-37). The highest fishing effort was concentrated around the Rottnest and Abrolhos islands (106–140 and 141–175 licences), followed by moderate and low effort off the Geraldton, Jurien Bay, and Perth coasts (3–35 and 36–70 licences).

Recreational charter fishing is typically limited by distance and isolation, with most catches taken between Perth and Dampier (Lewis 2020). Spatial fishing intensity is known to correlate with areas of suitable habitat for target species, with easy access for tourists and charter vessels, such as at Rottnest Island and the Abrolhos Islands. The OA overlaps with 942 km^2 (or 1.25%) of the area of TOFWC fishing effort over the ten-year period (Figure 4-37). Data within this overlap are confidential due to the low level of effort.

Monthly patterns in fishing effort (the sum of fishing vessels above confidential limits) followed a consistent seasonal trend. Average monthly effort over the ten-year period was greatest in the summer from December to June, peaking in April, with a corresponding reduction in winter from July to November (Figure 4-38). The 2020 season was excluded from the average due to disruptions caused by COVID-19.

Charter fishing is seasonal, with recreational fishers typically limited by sea and weather conditions, as well as the management controls of targeted fish resources. The greater fishing effort over the summer months likely reflects more favourable conditions for recreational line fishing and the greater catchability of target species.

External factors may also influence temporal recreational fishing effort. For example, in 2020 charter fishing was substantially reduced during the peak seasonal fishing period in April and May, likely because of a crash in charter customer demand due to COVID-19 restrictions.

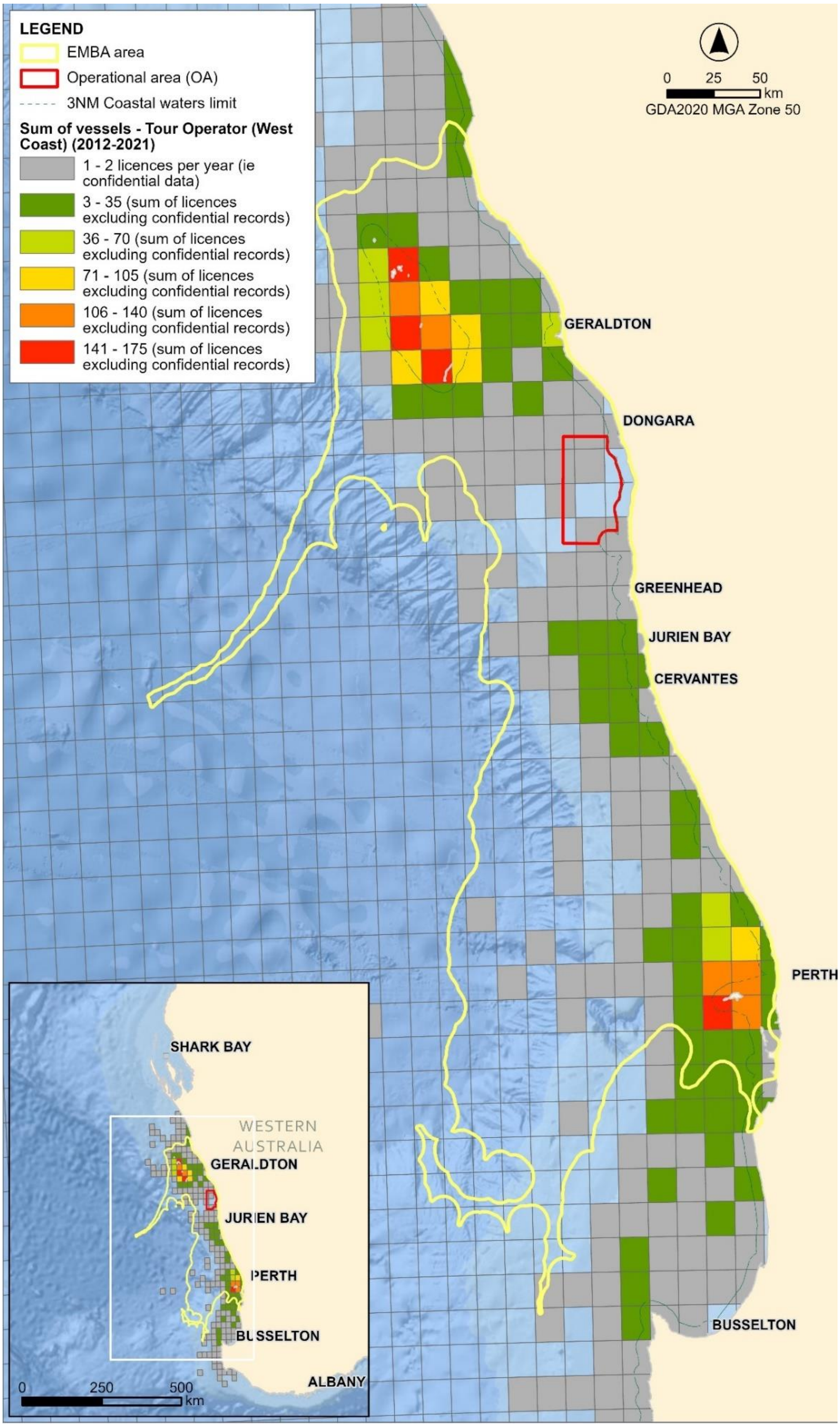

Figure 4-37: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the TOFWC for 2012–2021 combined

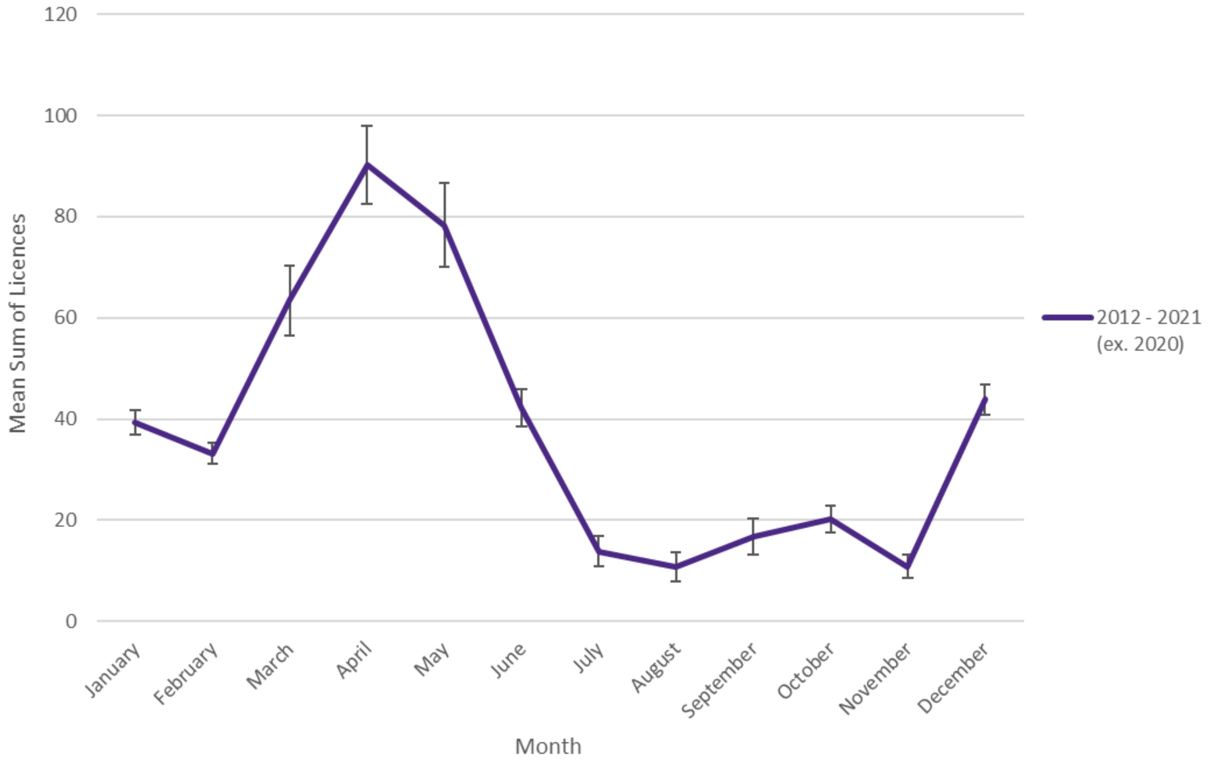

Figure 4-38: Mean monthly sum of licences (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the TOFWC for 2012–2021 combined, excluding 2020

4.4.4 Oil and gas activities

The region currently only supports the Triangle Energy operated petroleum production operation (Cliff Head Development) in Production Licence WA-31-L. The Cliff Head Development wellhead platform is located within the Node Survey Area, and part of the Node Survey Area is crossed by the two pipelines (production and water injection, along with associated power cable and umbilical) that connect the platform to the Arrowsmith stabilisation plant onshore. The pipelines run ~10 km along the sea floor from the wellhead platform to the shore crossing, and are unburied, using the concrete coating weight and rock bolting to provide stability.

Petroleum titleholders with titles that are adjacent to the OA are listed in Table 4-16

It is not considered feasible that other seismic surveys will take place in the region during the time of the Eureka 3D MSS. The last 3D MSS undertaken in the area was in February to May 2013 — the Geelvink 3D MSS and the Turtle Dove Ridge 3D MSS for Murphy Australia Oil (refer NOPIMS). There have been no 2D surveys acquired in the area in the region since 2013.

Table 4-16: Oil and gas permits relevant to the OA

Permit	Permit type	Operator	Distance from the operational area
WA-31-L	Production Licence	Triangle Energy (Operations) Pty Ltd	Overlaps

4.4.5 World and national heritage areas

World heritage sites are natural or manufactured sites, areas, or structures recognised as being of outstanding universal value by the United Nations Educational, Scientific and Cultural Organization (UNESCO). There are no world or national heritage sites within the OA or EMBA. The closest world heritage property (WHP) to the OA is the Shark Bay WHP, located ~300 km north of the OA.

Australia's National Heritage List contains natural, historic, and Indigenous places of significance to the nation and are protected under the EPBC Act (DoEE 2023). One marine Commonwealth heritage listed place occurs within the EMBA: the *Batavia* Shipwreck Site and Survivor Camps Area 1629 – Houtman

Abrolhos. The *Batavia* Shipwreck Site was listed for values meeting Category A, C, D and G of the Commonwealth Heritage List criterion (DoEE 2023).

The *Batavia* is the oldest of the known Verenigde Oost-Indische Compagnie wrecks on the WA coast, wrecked on 4 June 1629. The wreck is relatively undisturbed 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 (DoEE 2023). The wreck of the Batavia occurred after a long and arduous voyage where considerable hardship had already been experienced by the passengers and crew, the survivors reaching Beacon Island. The mutiny and massacre that followed the wreck of the vessel remain unparalleled in Australian maritime history. Archaeological evidence indicates that the two ruined ‘huts’ on West Wallabi Island are the oldest structure built by Europeans on the Australian continent. The mutineers Wouter Loos and Jan Pelgrom de Bye were left on the mainland and are consequently regarded as the first known European residents of the Australian continent.

4.4.6 First Nations cultural heritage

Archaeological evidence indicates that humans have occupied the Australian continent for at least 50–65,000 years, with the Kimberley region potentially the first area to be inhabited (Clarkson et al. 2017, Hayes et al. 2022). This long period of continuous occupation has allowed for the development of considerable cultural value and significance across the land and seascape. During this time First Nations peoples have experienced dramatic change in their landscape due to sea level rise at the end of the Pleistocene ice age, with sea levels stabilising at around their current levels around 9,000 years ago. Archaeological records of habitation by First Nations groups in south-west WA date back to at least 47,000 years ago (DPC 2018). There are extensive registered culturally significant sites along the coastal margins of south-west WA and cultural values in the land and sea country. There are also likely to be considerable intangible cultural heritage values associated with the sea country, in stories and songlines of creation spirits for Noongar nation groups (including Yued, Whadjuk and Gnaala Karla Boodja groups) and the Yamatji people. Undersea cultural heritage values have been the subject of some recent discoveries in the Pilbara region of WA (Benjamin et al 2023), though this is a new field of research with few sites discovered nationally. There are currently no records of inundated tangible cultural heritage values in the shallow coastal areas of southwest WA but limited research has been undertaken.

Pilot has engaged with relevant First Nations groups including Registered Native Title Bodies Corporate (RNTBC), registered Aboriginal corporations, and identified traditional owner groups to help identify relevant cultural heritage values in and adjacent to the OA and EMBA. Pilot has also conducted a search of existing registered Aboriginal Cultural Heritage sites, native title claims and Indigenous Land Use Agreements (ILUAs) in operation for the OA and EMBA. Pilot has investigated the documented cultural heritage values associated with development of management plans for Commonwealth and State Marine Parks and any Indigenous Protected Area programs within the project area. Pilot has also searched publicly available anthropological studies for evidence of intangible cultural heritage values associated with songlines and ceremonial knowledge across the sea country of the relevant language groups and traditional owners of the project area.

4.4.6.1 Native title and Indigenous Land Use Agreements

The Yamatji Nation Agreement Indigenous Land Use Agreement (ILUA: WI2020/002), identifies Southern Yamatji as traditional owners of the area as represented by Yamatji Marlpa Aboriginal Corporation (YMAC). This ILUA extends seaward between 4–12 nm of the coast from just north of Leeman to over 100 km north of Geraldton and overlaps with the OA, bordering with the Yued ILUA area (WI2015/009) (Figure 4-40).

The Yued ILUA is part of the South West Native Title Agreement (SWNTA) and subsequent *Noongar Recognition Act 2016*, which has resolved the single Noongar native title claim for a package of land grants, rights and financial value This agreement extinguishes native title rights for this area. The identified Yued ILUA borders with the Southern Yamatji country near Leeman, and extends 3 nm into sea country, extending southward to an area immediately south of Guilderton (Figure 4-40). The EMBA also overlaps with sea country areas of the Whadjuk Noongar ILUA and Gnaala Karla Boodjah ILUA (Figure 4-40), both part of the SWNTA.

A search of the National Native Title Tribunal (NNTT) Register identified that the OA overlaps of 96 km^2 with the Yamatji Nation Native Title Determination. The EMBA overlaps the Yued Native Title Determination and the Whadjuk people Native Title Determination. The OA is located within the Geraldton Representative

Aboriginal, Torres Strait Islander body (RATSIB) area (Yamatji Marlpa Aboriginal Corporation), while the EMBA overlaps the Geraldton and South West (Native Title Services Goldfields) RATSIB areas.

4.4.6.2 Cultural values of Commonwealth and State Marine Parks and Indigenous protected areas

There are considerable ecological values and cultural values identified within the following National Reserve areas which all overlap with the project EMBA. The listed Australian and State Marine Parks (Section 4.4.1) document traditional owner groups and continued cultural practises of these groups for the identified sea country areas. The WA Government is in the process of developing Joint Management arrangements for all national parks and marine parks in WA, which identify cultural values and traditions as well as developing local Indigenous rangers as part of the management program. The Soutern Yamatji people are currently consulting on the development of an Indigenous Protected Area (IPA) at the Houtman Abrolhos Islands. The IPA consultation area is off Geraldton on the central west coast of Western Australia, and includes the Abrolhos Islands, an important seabird breeding site, and the Hutt Lagoon System, an ecologically significant wetland system. IPAs constitute over 50% of the National Reserve System and are designed to protect ecological and cultural values with a combination of traditional knowledge and western science conservations practises.

4.4.6.3 Cultural heritage sites

In database searches there are no known registered sites of Indigenous cultural heritage significance within the OA; however, 37 sites were determined using the Aboriginal Heritage Inquiry System. Of these 37 sites, only 18 are below the high-water mark (HWM) and therefore within the EMBA. The closest known Aboriginal sites to the OA are the Registered Aboriginal Sites 18907 (Irwin River, SC04) and 5280 (Leander Point), both approximately 6 km east of the OA (Figure 4-40). A search of ‘Other Heritage Places’ on the ACHIS highlighted another 60 heritage places within the EMBA, 37 of which are below the HWM. The closest ‘Other Heritage’ places to the OA are the Other Heritage Places 5918 (Irwin River) and 5574 (Cliff Head), both approximately 6 km east of the OA. These sites include ceremonial areas, burial sites, camp sites and middens and other areas of significance. There are extensive cultural heritage values associated with the area around Rottnest Is (Wadjemup), Garden Island (Meeandip), Fremantle (Walyalup) and Carnac Is for Whadjuk and Bindjareb Noongar peoples. There are no published surveys or listed sites for undersea cultural heritage places within the OA or the project EMBA.Sea country values and intangible cultural heritage.

There are many anthropological studies of the extensive sea country knowledge and cultural values held within songlines, creation (dreamtime) stories and ceremonial practises for coastal and sea country First Nations groups (i.e. Bradley et al. 2010). For the area within the project OA and EMBA, Pilot discovered a number of publicly available texts identifying sea country values, songlines, and totemic animals for the First Nations groups in question. There is also a record of sea country cultural values that were identified during consultations with First Nations groups (Table 4-17).

Sea country values for Whadjuk Noongar people around Fremantle (Walyalup) were identified in the cultural mapping project, Mapping Walyalup Boodja (Collard et al. 2021 Figure 4-39). A depiction of the cultural values identified for this area shows songlines and cultural sites for the area, some of which correspond with the identified cultural sites in Figure 4-40. These include the island sites of Garden Is, Rottnest and Carnac Is, as well as songlines linking the nearshore islands with the mainland as well as routes of land bridges between Rottnest Is and current mainland from oral histories. This project highlights the strong cultural connection of Whadjuk Noongar to these areas and the continued cultural practises and stories for this area.

Discussion with members of the Kwelena Mambakort Wedge Island Aboriginal Corporation have identified their interests for the sea country around Wedge Island (within the Yued ILUA area) and within the EMBA. Discussion with members of the Wattandee Littlewell Aboriginal Corporation have identified important cultural areas and heritage around the Irwin River mouth and adjacent sea country. It is not clear whether this extends to the OA of the project. They have identified strong cultural connections to sea lions in the area of Irwin River mouth and suggested that a songline regarding sea lions is shared along the coast amongst different clans. However, there was no identification of who the knowledge holders of this songline would be for that area.

There are references to totemic animals and songlines associated with various animals in publicly available literature. Whadjuk Noongar people have strong affiliations with whales in particular, *Mamong* transports people who have passed, back to the spiritual world (Wadjemup Whadjuk Booja n.d). Outside of the project

EMBA south coast Noongar people, Wirloman clan of the Minang Noongar people, have strong affiliations with sea country and documented creation stories about ASLs (*Dwoortbaalkaat*), documented in a storybook by Scott (2013). Whilst there is no evidence of the connection of this story through songlines to clans on the west coast (Whadjuk and Yued peoples), early explorers documented the customary use of seals and sea lions by First Nations groups (King 1826).

These resources and consultations have highlighted that sea country cultural values for First Nations groups are known throughout the project EMBA. A summary of the cultural values for First Nations groups, and potential presence within the EMBA, is in Table 4-17. Note that relevant persons have requested that information provided during consultation is not publicly shared, therefore not all information provided in consultation is included in the table below.

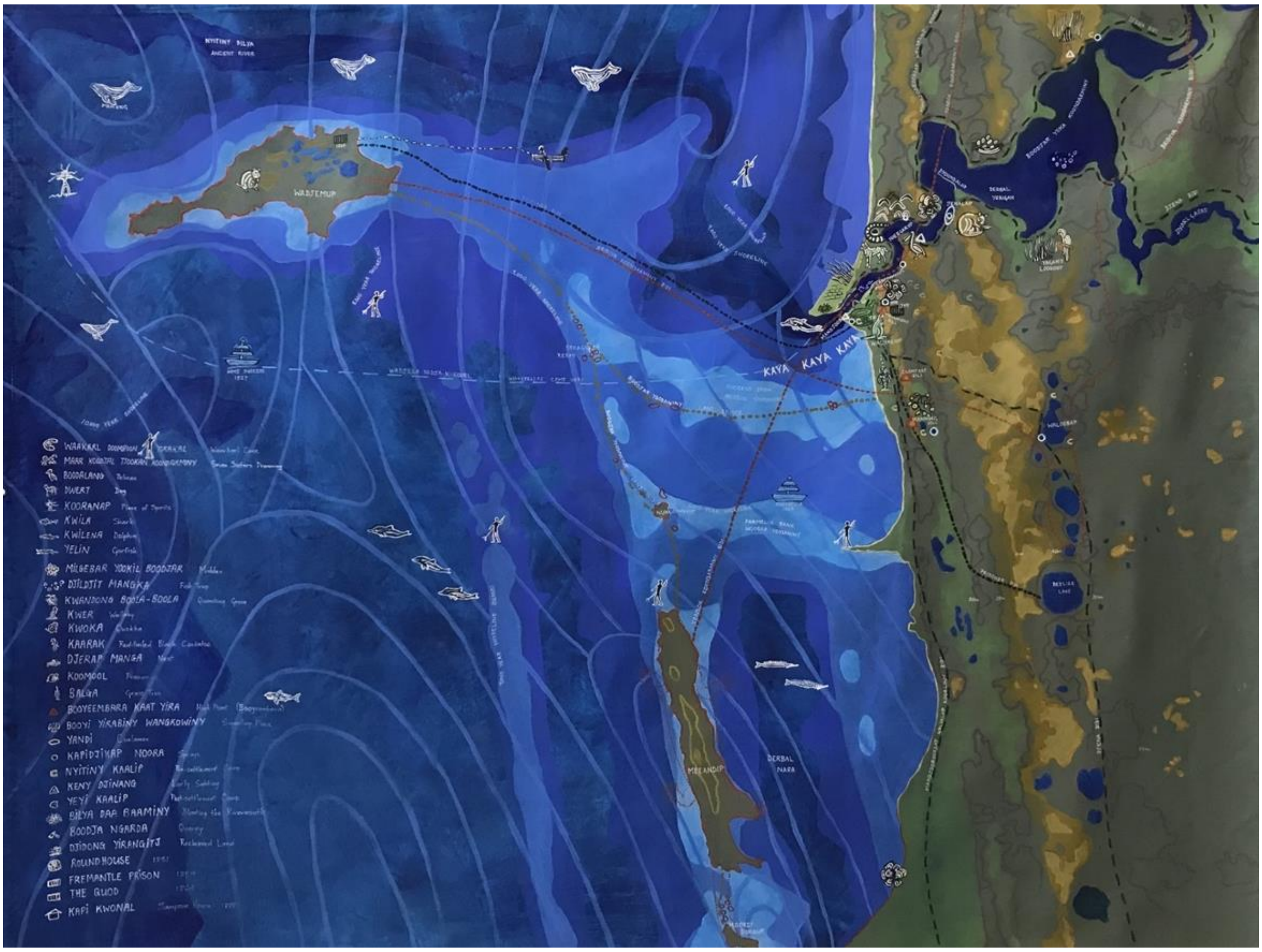

Figure 4-39: Sea country cultural values around sea country of Whadjuk Noongar. Reproduced from Mapping Walyalup Boodja (Collard et al 2021)

Table 4-17: Summary of likely cultural values in the OA and project EMBA based on desktop studies, heritage inquiries

First Nations group/native title claimant group	Cultural values	Source	Present in OA	Present in EMBA
Southern Yamatji	Cultural sites along coastal areas and in freshwater sites, associated cultural heritage values in sea country	ACHIS Inquiry, DPLH	Possible (unspecified)	Yes, listed cultural heritage sites exist
Yued Noongar	Cultural sites along coastal areas and in freshwater sites, associated cultural heritage values in sea country	ACHIS Inquiry, DPLH	Possible (unspecified)	Yes, listed cultural heritage sites exist
Whadjuk Noongar	Cultural sites along coastal areas and in freshwater sites, associated cultural heritage values in sea country Songlines and sea country cultural heritage	ACHIS Inquiry, DPLH Collard et al (2021)	No	Yes, Sea country cultural values exist
Gnaala Karla Boodja	Cultural sites along coastal areas and in freshwater sites, associated cultural heritage values in sea country	ACHIS Inquiry, DPLH	No	Yes, Sea country cultural values exist
Wattandee Littlewell Aboriginal Corporation	Sea lions are a totemic species with strong cultural values connected to sites and stories of them around Irwin Rivermouth	Relevant person consultation	Possible (unspecified)	Yes, Sea country cultural values exist
Kwelena Mambakort Wedge Island Aboriginal Corporation	Sea country values around Wedge Is.	Relevant person consultation	No	Yes, Sea country cultural values exist

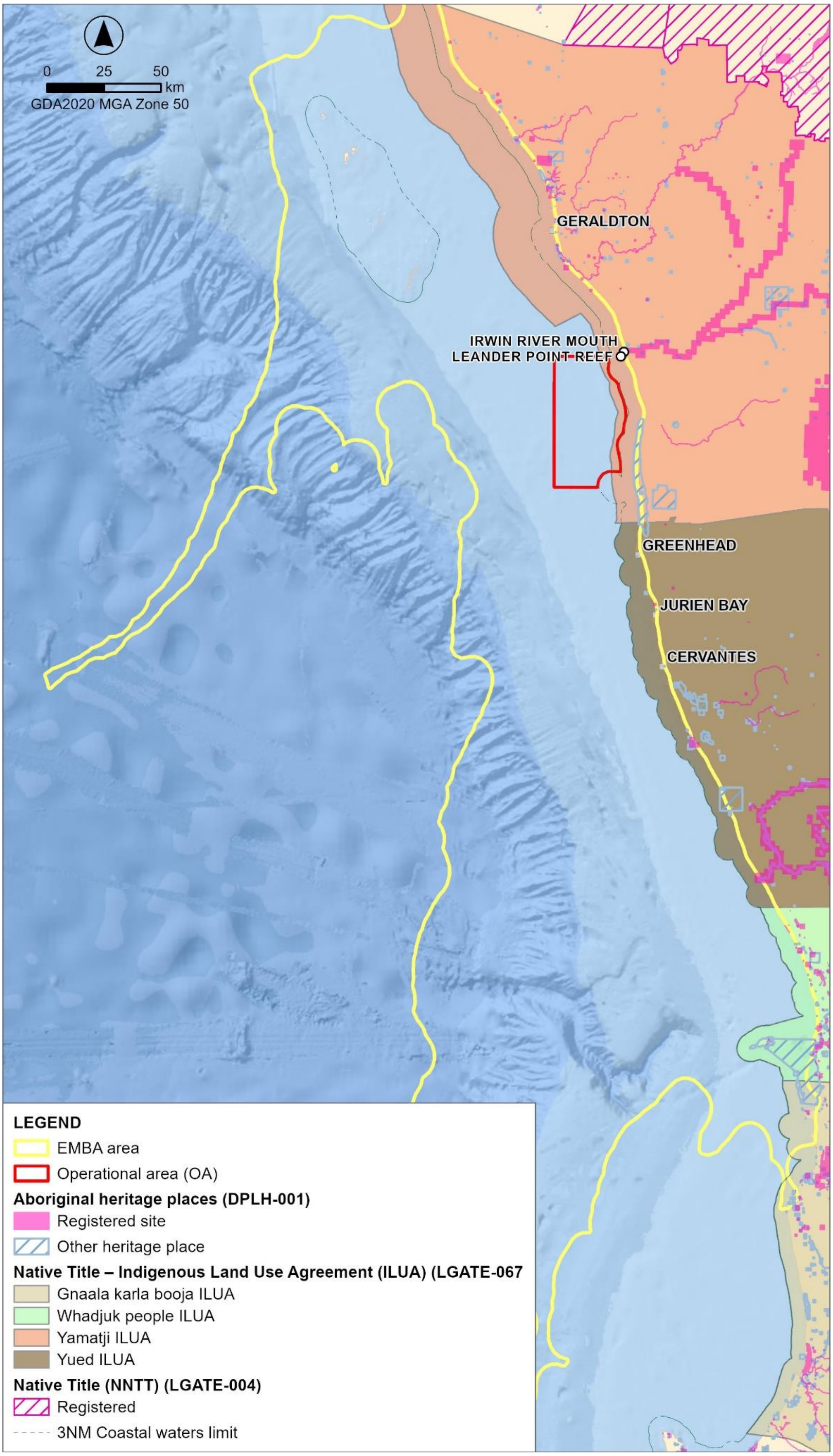

Figure 4-40: Native title and cultural heritage areas in and adjacent to the OA and EMBA

4.4.7 Ramsar wetlands

The Ramsar Convention on Wetlands is an intergovernmental treaty that aims to conserve wetlands of international importance. Ramsar wetlands are recognised as a matter of national environmental significance under the EPBC Act (DoEE 2021a). No Ramsar wetlands occur within the OA or EMBA. The closest Ramsar wetlands is the Peel-Yalgorup System, approximately 400 km south of the OA and beyond the EMBA.

4.4.8 Marine archaeology

All shipwrecks more than 75 years old are protected under the *Underwater Cultural Heritage (Consequential and Transitional Provisions) Act 2018* (DAWE 2022). A search of the Australian Underwater Cultural Heritage Database (AUCHD) indicated that two known historic shipwrecks potentially occur within the OA: the *Leander* and the *Era* near Dongara (Table 4-18). The Western Australian museum (2024) advise that the Leander's exact location has never been found but approximate co-ordinates are provided in the Australian Underwater Cultural Heritage Database (AUCHD). Discussion in a gazette in 1853 (WAM, 2024) implies that the location may be closer to shore than the AUCHD co-ordinates indicate. The Era shipwreck is actually just the mast and bowsprit which blew off the ship in a storm in 1934 but ship itself was not sunk until 1958 in Shark Bay. Neither are listed as a Protected Place under the EPBC Act. A further eight known historic shipwrecks were identified near the OA: the *Swan, Sea prince, Saint Mary, Gussie, Stanford, Carlton, Jessie Edwards, Cambewarra* and two unidentified vessels (Table 4-18). A search using the AUCHD (2021) indicates a further 227 known historic shipwrecks within the EMBA (Figure 4-41).

Table 4-18: Recorded shipwrecks within and near the OA

Vessel name	Year wrecked	Wreck location	Distance from OA
Leander	1853	Dongara	Within OA
Era	1934	Dongara	Within OA
Swan	1869	Dongara	5 km east
"Unidentified whaler"	1867	Dongara	5 km east
Sea prince	1932	Dongara	5 km east
Saint Mary	1905	Leeman	10 km south
Gussie	1909	Dongara	10 km north
Stanford	1936	Geraldton	20 km northwest
"Unidentified ship"	1851	Geraldton	20 km northwest

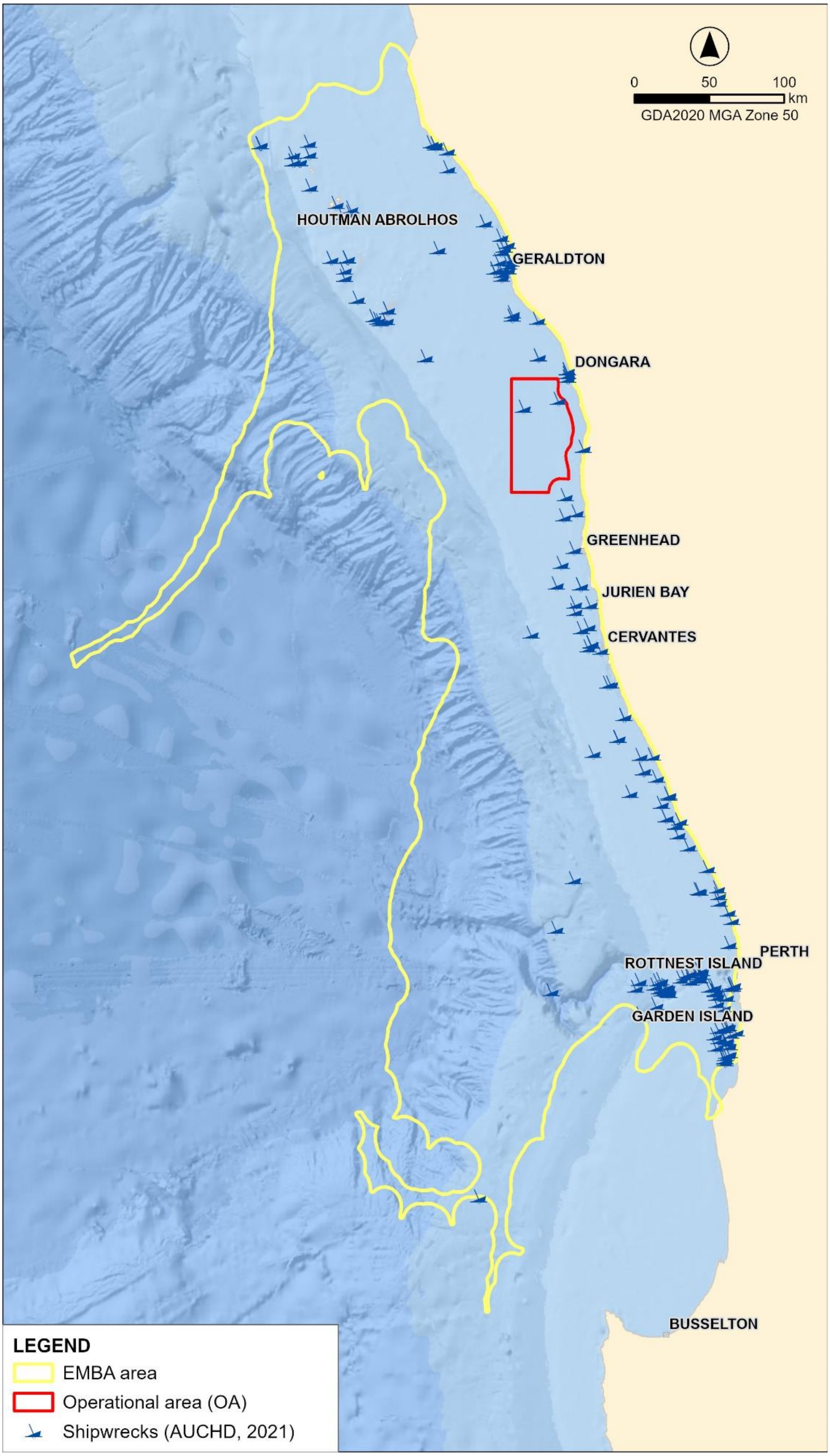

Figure 4-41: Recorded shipwrecks within the OA and EMBA (AUCHD, 2021 database)

4.4.9 Commercial shipping

The Southwest offshore region facilitates several major port facilities, including the state's busiest general cargo port (Fremantle), a potential land backed port (Westport) in Kwinana, as well as the Royal Australian Navy's largest base (HMAS Stirling) on Garden Island (Newman et al. 2023). Geraldton is the closest major port to the OA (approximately 50 km north); however, shipping also occurs from Dongara/Port Denison (approximately 6 km east of the OA). Vessels transiting the region during the proposed survey will primarily include bulk carrier ships (e.g. iron ore, grain, mineral sands, and alumina) and general cargo ships. The western side of the OA intersects with a shipping fairway; however, there is limited traffic through the OA (Figure 4-42). There are many smaller ports and public boat ranges along the coast within the EMBA, with those located at Dongara being close to the OA (approximately 6 km east). The impacts from vessels and ships tend to be concentrated around ports and favoured anchorage areas.

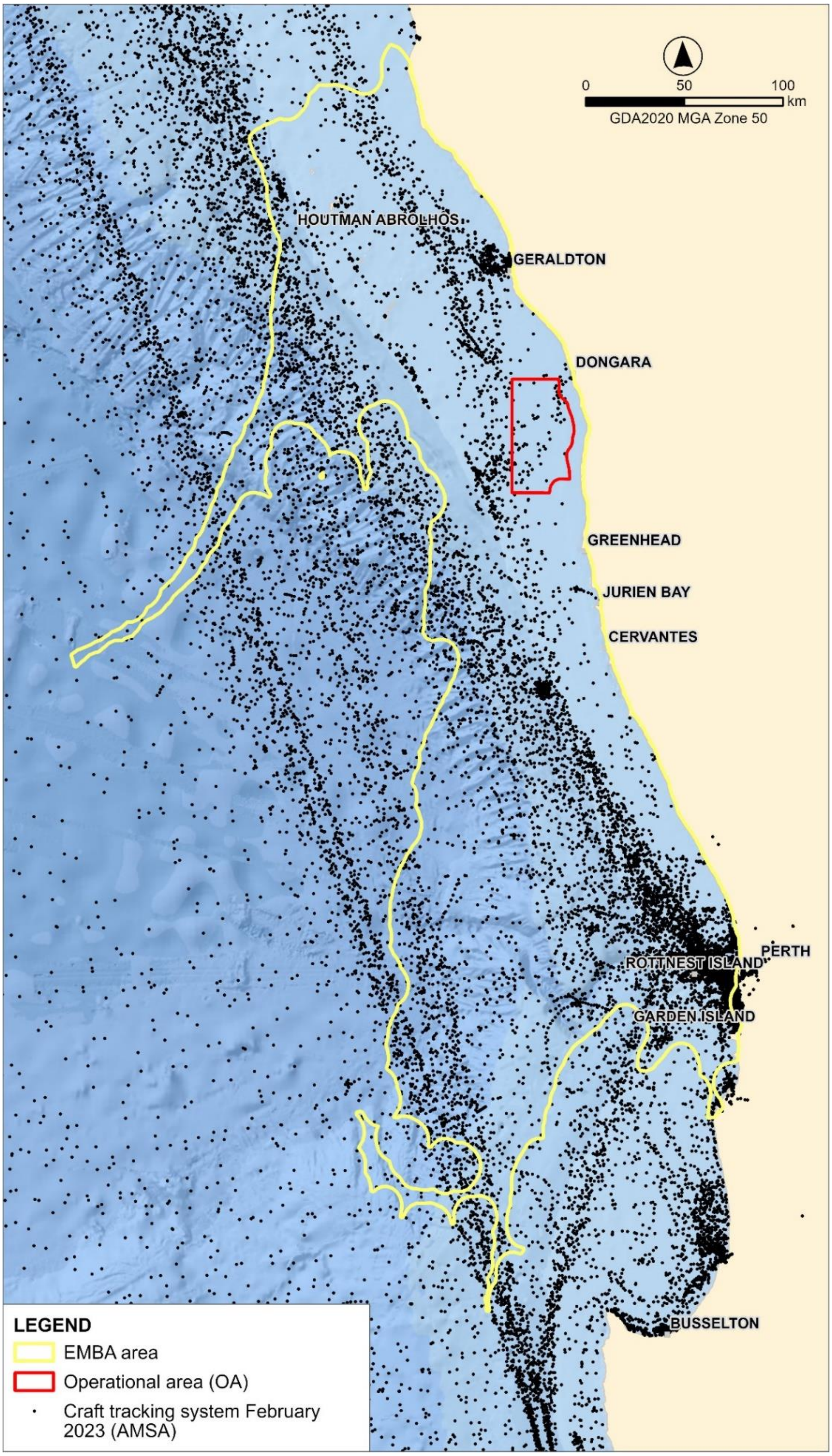

Figure 4-42: Commercial shipping tracks within and adjacent to the OA and EMBA

4.4.10 Communication

There are no telecommunication cables that run through the OA. The EMBA overlaps multiple telecommunication cables that run out of Perth, including telecom cables (2018), telecommunications submarine cables (Fusion) and global submarine cables (Figure 4-43). The closest telecommunications cable to the OA is the ≤900 global submarine cable (approximately 100 km south-west of the OA).

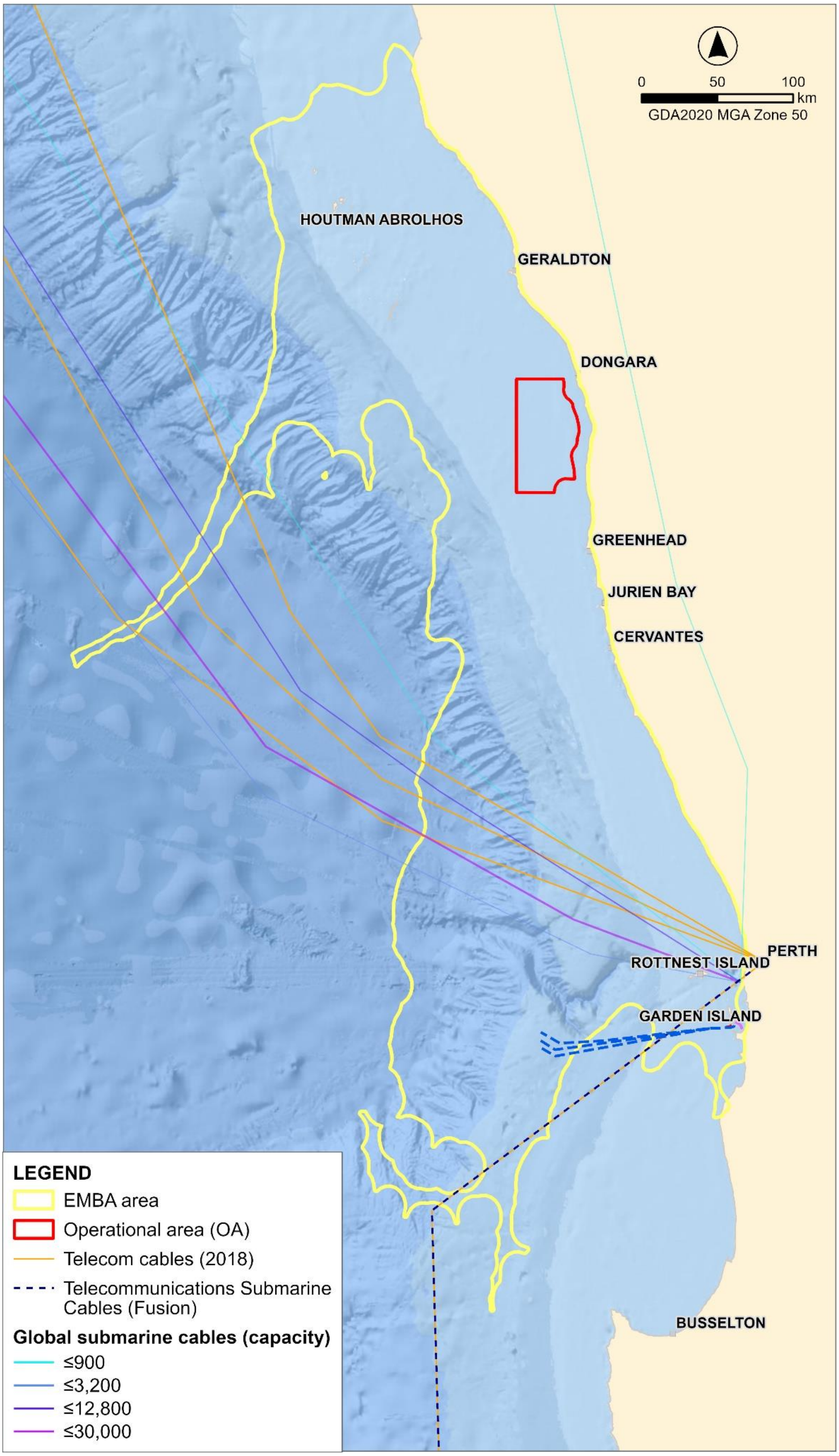

Figure 4-43: Communication lines overlapping the EMBA

4.4.11 Defence activities

The Department of Defence (DoD) operates military firing practice and exercise areas at several locations around Australia. There are no designated defence practice areas within the OA. The closest designated Defence activity area to the OA is the Western Australia Exercise Area (WAXA) approximately 40 km south-west of the OA. The onshore Lancelin Defence Training and Practice areas are located within the EMBA approximately 160 km south of the OA (Figure 4-44).

A search of the Department of Defence's unexploded ordnance (UXO) map indicated no UXO areas within the OA; however, four potential sites within the EMBA. The closest potential UXO area to the OA is located at Geraldton Seaward (50 km north of the OA; "Other"). The other potential sites include Jurien Bay Bombing Range ("Other"), RAN Gunnery Range Lancelin (approximately 160 km south of the OA; "Substantial Potential"), Moore River RAAF Armament Range ("Other") and Rottnest Seaward Firing (approximately 250 km south of the OA; "Slight Potential") (Figure 4-44) (AGDD 2023).

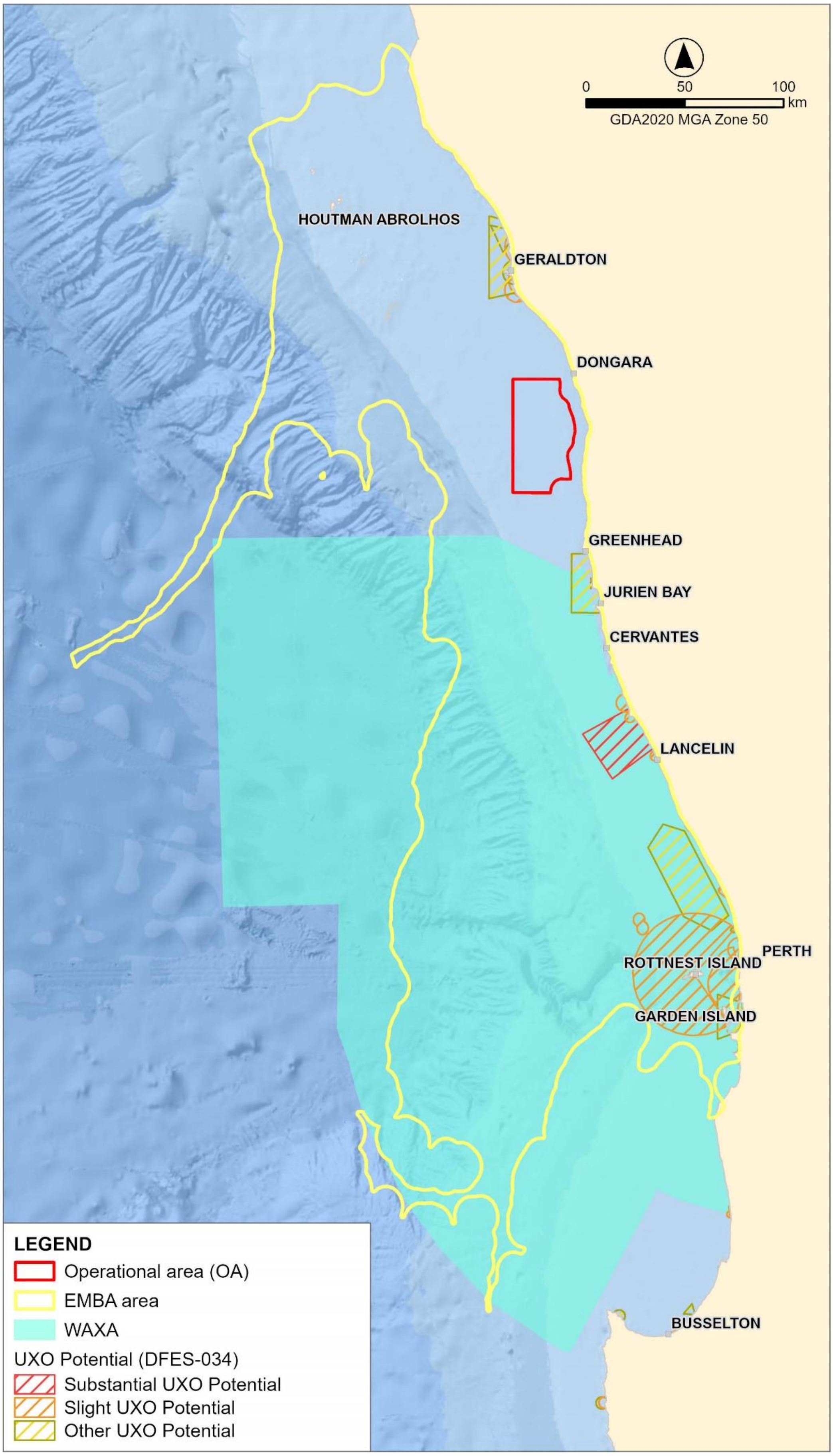

Figure 4-44: Defence areas adjacent to the OA and overlapping the EMBA

5 CONSULTATION

This section describes the relevant person consultation process that must be carried out in preparation for the EP (section 25 OPGGS (E) Regulations). This section documents how Pilot undertook consultation pursuant to Division 3 of the OPGGS (E) Regulations and considered recent case law (see Section 5.1). Pilot gathered information from relevant persons for the environmental assessment process and has responded to, and adopted, appropriate measures based on relevant persons objections, claims and feedback.

Ongoing arrangements for consultation are described in Section 5.6.

By capturing a sufficiently broad area of the public through various targeted media and advertising techniques, Pilot implemented a consultation process capable of identifying all ascertainable relevant persons.[1] Once identified, relevant persons were then provided with sufficient information on the possible consequences of the activity on their functions, interests, and activities, were afforded a reasonable period for consultation and their feedback responded to appropriately. Pilot kept up to date records of such process.

The following appendices should be read in conjunction with this section.

Appendix C: Community Consultation and Engagement Plan

Pilot prepared a Community Consultation and Engagement Plan (CCEP) that describes the consultation method used for this EP and published this document on the project website to inform the public and each relevant person about the consultation process. This method was altered in some areas during consultation, the results of consultation can be found in Section 5.3.

Appendix D: Consultation report

Section 24(b) requires an environment plan contains a report on all consultations under section 25 of any relevant person by the titleholder. This report must include the following:

- A summary of each response made by a relevant person
- An assessment of the merits of any objection or claim about the adverse impact of each activity to which the EP relates
- A statement of Pilot's response, or proposed response, to each objection or claim.

For the readers benefit, the Consultation Report is sorted by relevant person, so each response by the titleholder and the relevant person can be assessed on their merits and easily referred to.

All records of consultation, including provision of information, were recorded as 'Events' in a bespoke consultation management system. An Event is any interaction that Pilot Energy has with one or more relevant persons. Each Event was linked to 'Persons' and/or 'Organisations' as relevant. Event sentiment was recorded with Outgoing meaning the Event related to correspondence sent by Pilot Energy. Event sentiments of Positive, Neutral, or Negative were recorded against all incoming Events.

This appendix also details the efforts used to identify relevant persons and provide the opportunity to self-identify through mediums such as the Eureka website.

Sensitive Information Report (24(b)(iv))

To comply with section 24(b) of the OPGGS (E) Regulations, the full text of all responses by relevant persons consulted under section 25 and any other sensitive information (if applicable) must be included in a Sensitive Information Report. This report will not be published.

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[1] "a consulting process that is practicable but is sufficiently broad so as to collect available input into the possible risks and environmental impacts of the activity and ways of reducing those risks and impacts and managing them to an acceptable level." Despite the strict nature of the obligation to consult with "all" relevant persons, the Court recognises there is a necessary need for these persons to be ascertainable and the duty capable of being discharged in a reasonable time. *Santos NA Barossa Pty Ltd v Tipakalippa* [2022] FCAFC 193 [141] and [136] respectively.

5.1 Legislation and requirements

The following legislation was adhered to during the consultation process:

- *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
- *Environmental Protection and Biodiversity Conservation Act 1999.*

The following NOPSEMA guidelines were complied with:

- NOPSEMA Guideline GL2086 – Consultation in the course of preparing an environment plan – May 2023 (NOPSEMA 2023a)
- NOPSEMA Guidance Note GN1847 – Responding to public comment on environment plans – July 2022 (NOPSEMA 2022a)
- NOPSEMA Guidance Note GN1344 – Environment plan content requirements – December 2022 (NOPSEMA 2022b)
- NOPSEMA Guideline GL1721 – Environment Plan Decision Making Guideline – December 2022 (NOPSEMA 2022c)
- NOPSEMA Guidance Note GN1488 – Oil pollution risk management – July 2021 (NOPSEMA 2021)
- NOPSEMA Guidance Note GN1785 – Petroleum activities and Australian Marine Parks – June 2020 (NOPSEMA 2020)
- NOPSEMA Guideline GL1887 – Consultation with Commonwealth agencies with responsibilities in the marine area – January 2023 (NOPSEMA 2023b)
- NOPSEMA Brochure – Consultation on offshore petroleum environmental plans – May 2023 (NOPSEMA 2023c)
- NOPSEMA Policy PL2098 – Engaging gender-restricted information Draft Policy – May 2023 (NOPSEMA 2023d)
- NOPSEMA Policy PL1347 – Environment Plan Assessment Policy – December 2022 (NOPSEMA 2022d).

Recent case law developments were also considered in Pilot's consultation process:

- *Tipakalippa v National Offshore Petroleum Safety and Environmental Management Authority (No 2)* [2022] FCA 1121
- *Santos NA Barossa Pty Ltd v Tipakalippa* [2022] FCAFC 193 *Cooper v National Offshore Petroleum Safety and Environmental Management Authority (No 2)* [2023] FCA 1158.

The following published consultation guidance was considered in the development of the CCEP and during the consultation process:

- Commonwealth of Australia inquiry report – Making waves: the impact of seismic testing on fisheries and the marine environment (2021)
- Commonwealth of Australia Guidance framework: Supporting cooperative coexistence of seismic surveys and commercial fisheries in Australia's Commonwealth marine area (2022)
- AFMA's Guidelines Form Petroleum Industry Consultation with AFMA (AFMA 2015)
- NOPSEMA Guidance – Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area
- WA DPIRD Fisheries Guidance Statement: Oil and gas industry consultation with the Department (2013)
- WA DoT Guidance Statement for Marine Oil Pollution: Response and Consultation Arrangements (2018)
- WA DMIRS Consultation Guidance Note: For the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009

- WAFIC Commercial Fishing Consultation Framework for The Offshore Oil And Gas Sector guidance July 2023.

5.2 Consultation method

Pilot's consultation method is described in the CCEP (Appendix C) and was applied throughout the environmental planning area (Figure 5-1).

The consultation method employed the principles of the International Association for Public Participation spectrum (IAP2 spectrum) to achieve the goals of the NOPSEMA guidelines and legislation by promoting stakeholder engagement. Pilot's consultation process was designed in the context of section 4 of the OPGGS (E) Regulations to ensure that consultation for the Eureka 3D MSS was carried out in a manner that was sufficiently broad, practicable (*Santos* at [141]) and:

- Consistent with the principles of ecologically sustainable development (ESD) set out in section 3A of the EPBC Act
- By which the environmental impacts and risks of the activity will be reduced as low as reasonably practicable
- By which environmental impacts and risks of the activity will be of an acceptable level.

The iterative approach outlined in Table 1 of the CCEP allowed for consultation to be co-designed through two-way communications with relevant persons. The process provided sufficient information and time, demonstrated that objections and claims had been addressed where appropriate, and maintained clear records for the purposes of assessment. Due to the iterative nature of consultation, the actual methodology employed by Pilot evolved slightly from that detailed in the CCEP and is detailed throughout the rest of this section.

The foundations of the consultation process undertaken for this EP include:

- Maximising the broad capture of relevant persons through appropriate advertisement
- Gathering knowledge about specific environmental, cultural, and societal values
- Providing concise, sufficient information allowing relevant persons to make informed decisions
- Communicating with relevant persons by their preferred medium and in simple, plain English through established information channels
- Allowing appropriate timeframes and encouraging feedback and queries
- Ensuring all relevant persons are aware of the consultation period and process and affording the opportunity to participate in preparation of the EP.

The following table describes the pillars of Pilot's communication and consultation process.

Table 5-1: Consultation principles

Principle	Pilot's approach
Communication	Undertake effective two-way engagement to encourage feedback on relevant, accurate information provided.
Transparency	All points of tension and conflict are addressed and are openly available to the public to comment on the Eureka website.
Collaboration	Relevant persons are heard and collaborated with, to adapt approaches and outcomes based on merit.
Inclusiveness	All relevant persons were and continue to be involved in the consultation process. This will last throughout the life of the Eureka 3D MSS.
Integrity	The process fostered respect through freedom of information on the Eureka website and trust through tailored two-way communication.

5.3 Consultation results

Pilot understands that accurate identification of relevant persons is essential for conducting consultation that is inclusive, effective, and legally compliant, and that it promotes fairness, transparency, and accountability in decision-making processes and can lead to more successful outcomes and reduced risks for all parties involved.

Pilot's process for relevant persons identification as described in "Relevant Persons Identification" of Appendix C provided for the broad capture of relevant persons and information, such that each relevant person who can be identified, was identified. Pilot acknowledges that despite their best efforts and processes, some individuals may remain unidentified or choose not to participate in consultation or may only participate through the public comment period. Pilot has encouraged these individuals to self-identify and engage in ongoing consultation and will continue to do so throughout the activity's lifespan (see Section 5.4).

5.3.1 Consultation with the public

The public is a broader group of people than those who can be identified as relevant persons. Consultation with the public supports the broadest search for relevant persons, who are a subset of the public. It also allows support to non-relevant persons, or persons who opt out of the formal consultation process, to engage with our activities in a way that works for them.

To raise awareness about the Eureka 3D MSS, the following tools were used to capture the widest practicable area of people and information:

Pilot published notices in print media, geotargeted social media, and online to:

- Promote relevant person self-identification through the Eureka website
- Notify the public of commencement of the EP writing process and consultation process
- Advertise information sessions
- Publish information summaries, implementation strategies and risk assessments (detailed in Section 5.3.3).

To combat the challenges faced by a requirement to identify every relevant person, Pilot launched the Eureka website, which created two channels of communication with the public and with relevant persons. This website helped reach and locate as many interested members of the public as possible and provided a simple survey to determine if a person was a relevant person for the purposes of section 25.

The project-specific website https://klarite.mysocialpinpoint.com.au/eureka3d/ was designed to create an open-book space where people can publicly raise concerns and stay informed about the project. On the website, a consultation survey was provided to allow the public to inform Pilot about the best way for them to be engaged and if they deemed themselves a relevant person for the purposes of section 25 of the OPGGS (E) Regulations.

5.3.2 Relevant persons identification

Titleholders are required to identify and consult with each authority, person or organisation who fits the definition of a relevant persons pursuant to section 25 of the OPGGS (E) Regulations. This section demonstrates who is a relevant person for this activity, and the rationale used to determine that status (NOPSEMA 2023a). Key factors considered by Pilot in this process included the nature of the activity, the environment in which it is being undertaken and the possible impacts and risks associated with it.

5.3.2.1 Methods for identification

The following methods were used to find authorities, organisations, and persons who may be affected by the proposed activities.

Table 5-2: Relevant person identification methods

Method	Aim	Result
Contact government agencies and organisations	Relevant government agencies may have information about individuals and organisations that may be affected by the activity.	The NEATS database was used to find titles and titleholders within the environmental planning area. The NOPSEMA EP database was used to find other titleholders with activities within the environmental planning area. Subscribed to the NOPSEMA EP submissions pages for all activities in Western Australia.
Consult with local community groups	Reach out to local community groups, such as those focused on environmental conservation or fishing, as they may have members whose interests or activities could be affected by the activity.	Online searches performed for conservation groups with interests in similar activities. Online searches performed for articles and current campaigns related to similar activities.
Consult with local Indigenous groups	Indigenous groups may have specific cultural or spiritual interests and activities that could be affected by the activity, it is important to consult with them and ensure their rights are respected.	Contact details of land councils were sourced from the National Native Title Council. These groups provided advice as to others that should be consulted.
Conduct online research	We will search for news articles or press releases about similar activities in the area and identifying individuals or organizations that were mentioned.	The values and interests of relevant persons for relevant persons of other similar activities were searched to see if there would be relevant persons for this activity. Local volunteer organisations with a focus on env conservation were searched to see if there was an overlap in interest for this activity. Fishing body websites that have associations with other groups e.g. game fishing associations were reviewed.
Advertise in local newspapers	Advertising in local newspapers to notify the public about the planned activity and ask for any persons with specific interests or activities that may be affected by your activity to come forward.	Advertisements were placed with local newspapers including the Midwest Times and Geraldton Guardian.
Contact industry associations	We will reach out to industry associations as they may have members whose interests or activities could be affected by the activity.	We reached out to industry associations for fishing, including recreational fishing.
Contact local businesses	We will reach out to local businesses, such as tour operators or accommodation providers, as they may have customers whose interests or activities could be affected by the activity.	Searches for local businesses within the environmental planning area or had functions, interests or activities within the environmental planning area.
Contact local educational institutions	We will reach out to local educational institutions, such as universities or research centres, as they may have researchers or students whose interests or activities could be affected by the activity.	We reached out to the Geraldton TAFE and the Batavia Coast Marine Institute and were guided to research organisations to consider as relevant persons for the activity.
Use social media	We will use social media to find relevant persons by searching for hashtags or keywords related to your activity, following local organizations or groups in the area, and reaching out to people who have commented on or shared posts about similar activities.	Social media was used to find relevant persons by searching for hashtags or keywords related to the activity, following local organizations or groups in the area, and reaching out to people who have commented on or shared posts about similar activities. Social media also directed traffic to the website.
Conduct a survey	We will conduct a survey to reach out to a wide range of people and gather information about their interests and activities that may be affected by the activity.	The project website allowed an opportunity for people to self-identify as a relevant person by providing information about the activity such that they could determine if it would impact their functions, interests or activities.
Attend local community events	We will search for local community events that may be appropriate for Pilot to participate in and engage with aggregations of people, some of whom may be affected by the activity.	Shire of Irwin Expo was attended to speak with the general public and determine if there were relevant persons.

In addition to the methods described above, some relevant persons were identified and consulted with through other relevant persons carbon copying them in email chains.

As described in Section 5.3.1, community briefings and information sessions were held at relevant locations proximate to the coast to engage the local communities. They were designed to facilitate relationship building with the public and relevant persons within those locales. Some relevant persons were identified through their attendance at the community sessions.

5.3.2.2 Relevant persons under Section 25(1)(a), (b) and (c)

Section 25(1) defines the below categories for relevant persons:

a. Each Commonwealth, state or Northern Territory agency or authority to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant.

b. If the plan relates to activities in the offshore area of a state – the Department of the responsible State Minister.

c. If the plan relates to activities in the Principal Northern Territory offshore area – the Department of the responsible Northern Territory Minister.

Each department or agency has been identified through online searches, expert advice, review of legislation and review of previous EPs adjacent to the title as described in Section 5.3.2.1. The full list of these relevant persons can be found in Appendix D.

5.3.2.3 Relevant persons under Section 25(1)(d)

Section 25(1) defines the below categories for relevant persons:

d. A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan.

The terms “functions”, “activities” and “interests” are defined below in Table 5-3 as per the OPGGS (E) Regulations, Federal Court judgements and NOPSEMA guidelines.

Table 5-3: Definitions of functions, interests, and activities

Term	Definition
Functions	Refers to “a power or duty to do something”
Activities	To be read broadly and is broader than the definition of ‘activity’ in section 4 of the Environment Regulations and is likely directed to what the relevant person is already doing.
Interests	To be construed as conforming with the accepted concept of “interest” in other areas of public administrative law. Includes “any interest possessed by an individual whether or not the interest amounts to a legal right or is a proprietary or financial interest or relations to reputation”

The Regulations specify that relevant persons include people or organisations whose functions, interests, and activities may be affected by the petroleum activity. The Federal Court of Australia helped to define these terms in the appeal decision of Tipakalippa v National Offshore Petroleum Safety and Environmental Management Authority (No 2) [2022] FCA 1121.

Pilot has grouped people and organisations into subject-centred categories because this allows for tailoring identification, communication, and engagement strategies to each category. An additional benefit is that the search for one member of a group can often lead to the discovery of additional members of that group. The following subject-centred groups have been identified in the preparation of this plan, with a description of how relevant persons were identified within each group. A person could be associated with more than one of these groups while it is more likely that an organisation will associate with just one.

Pilot contacted persons whose functions, interests or activities could not be easily ascertained and validated any assumptions about whether they may be affected by the Eureka 3D MSS.

5.3.2.3.1 Subject-centred groups

Pilot developed subject groups as described in the CCEP to identify relevant persons that fall under Section 25(1)(d). These groups, and the specific methods used to identify relevant persons within them, are described in the table below.

Table 5-4: Subject-centred consultation groups

Subject-centred group	Tailored identification strategies
Commerce	Contacted the local Chamber of Commerce to identify relevant businesses. Online searches conducted for news articles or press releases about marine-based businesses in the environmental planning area.
Commercial Fishers	Assessed overlap of state and Commonwealth fisheries that have the licence to operate within the Operational Area. If they have the licence to operate within the OA, then they were considered relevant. Visited local ports and found local fishers who operate within the environmental planning area. Requested CFA to confirm relevant fisheries to consult for Commonwealth fisheries.
Commercial Shipping	Contacted relevant harbourmasters and shipping agents and enquired about frequent users. Performed online searches for business located at wharves in regional ports.
Conservation Groups	Previously submitted EPs on the NOPSEMA website were reviewed and relevant conservation groups compiled. Online searches performed for conservation groups with interests in similar activities. Online searches performed for articles and current campaigns related to similar activities.
Educational Bodies	Contacted the Department of Education and identified relevant institutions and research programs. Contacted the universities and identified relevant research programs.
Fishing Associations	Online research allowed the target species within the environmental planning area to be identified. The peak fishing association were also able to identify other species-specific associations.
Heritage Groups	Contacted WA heritage organisations to identify other relevant persons. Accessed the Australian Heritage Database to compile potentially relevant persons. Queried the Australasian Underwater Cultural Heritage Database.
Local councils	Searched the WA Electoral Commission database and found relevant councils, shires and cities close to the activity.
Native title land councils (traditional owners and First Nations peoples)	Contact details of land councils were sourced from the National Native Title Council. These groups provided advice as to others that should be consulted.
Other marine users	Performed online searches for groups who use or have a connection to the marine environment, the searches were heavily focused on those users proximate to the environmental planning area.
Petroleum title holders	Utilised the NEATS database to find titles and titleholders within the environmental planning area. Used the NOPSEMA EP database to find other titleholders with activities in the environmental planning area. Subscribed to NOPSEMA EP submissions pages for activities in WA.
Port users	Relevant harbour masters contacted to enquire about frequent users. Online searches conducted for business located at wharves in regional ports.
Ports and harbours	Automatic information system data of vessel activities along the coast was reviewed and frequented ports were established. Reviewed the WA boat ramp database which helped to identify ramps within the environmental planning area. Contacted local councils, cities and shires for local boat ramp listings and users.
Recreational fishers	Engaged with recreational fishing associations and used newsletters/circulars and websites to spread information about the activity and identify relevant persons. Engaged with advisory bodies and reference groups to establish the best approach to identify relevant persons.
Tourism operators	Online searches for marine tours and recreational experiences such as marine mammal observations, diving, and outdoor extreme sports. Requested copies of databases of local business within the environmental planning area from Tourism Western Australia. Enquired with Chambers of Commerce to help identify marine based tourism operators in the environmental planning area. Online and in person searches for marine-based community or sporting events.

5.3.2.3.2 Identification of relevant First Nations persons

First Nations groups like land councils and prescribed body corporates may be relevant persons with a function, interest or activity that may be affected by the activities in an EP. Further, these groups may provide advice in relation to which other First Nations groups or individuals need to be consulted with. This connection of Traditional Owners is represented in the *Native Title Act 1993* (NT Act), that demonstrates consultation with First Nations people is workable through the communal interest they hold with their respective groups. Through this communal interest, the authorities require reasonable notice to group members but not an exhaustive communication with every person (NOPSEMA 2023a).

To discharge the consultation obligation under section 25, the titleholder must demonstrate to NOPSEMA that First Nation groups and group members have been afforded a reasonable opportunity to be consulted with.

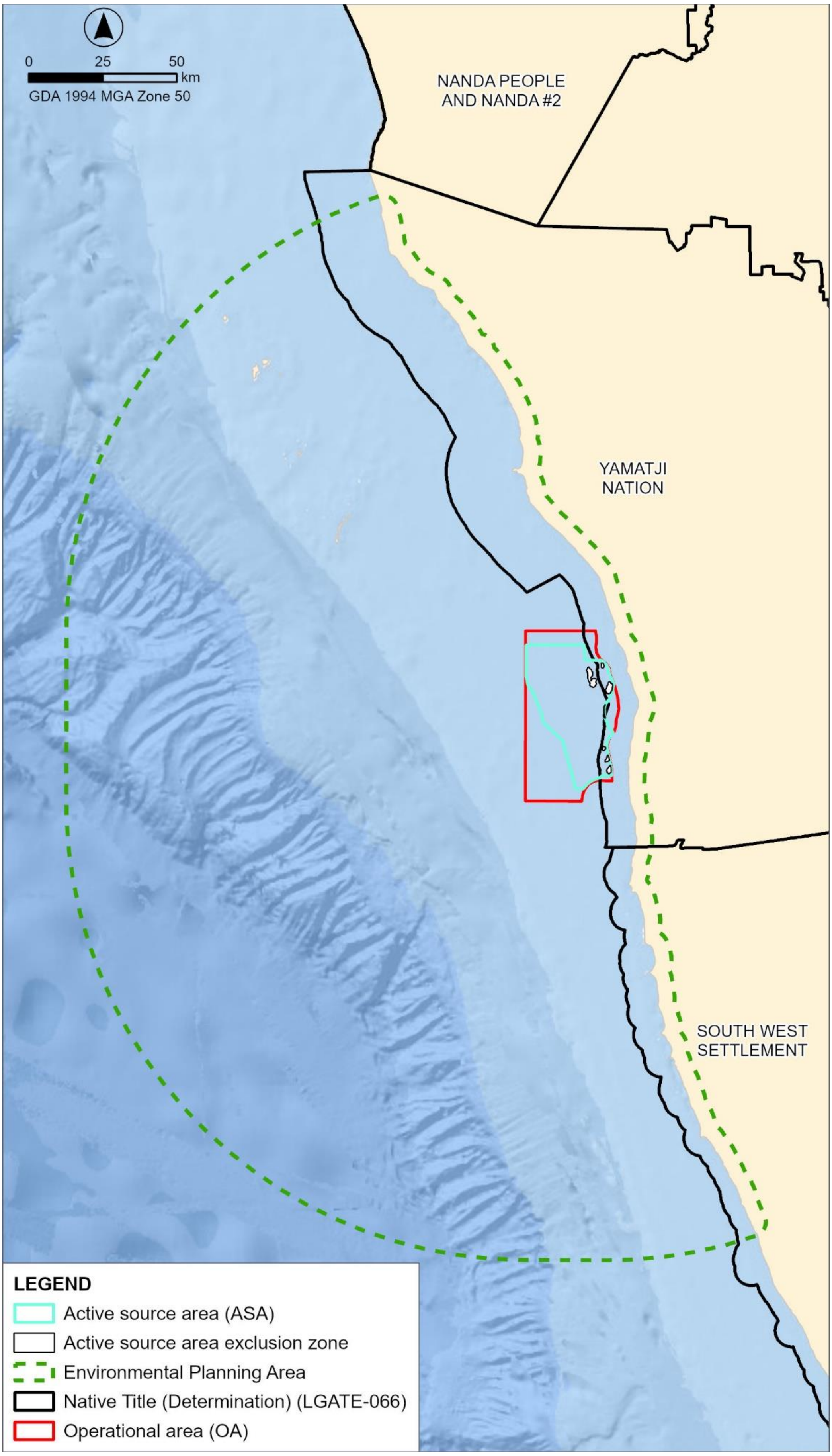


Figure 5-1: Native title determinations within the environmental planning area

Pilot recognises that in the culture of First Nations people, there is often different cultural and consultation requirements that exist in the different communities and representative bodies. These differences create potential challenges in processing and responding to information through methods such as email or phone calls.

The Australian Federal Court has acknowledged that there is good reason to adopt a pragmatic and practical approach to consultation conducted in accordance with regulation 25. It is recognised that titleholders may conduct meetings that are not attended by every single member of a group, provided that a reasonable effort is made to notify group members of the consultation with clear, simple, and directly expressed terms. In these instances, a process of public notification and "self-identification" alone are unlikely to be sufficient to discharge this duty.

The EPA overlaps the Yamatiji and Yued Native Title determination (refer to Figure 5-1 – Yued shown as South West Settlement on figure). The EPA was used as a larger extent range for First Nations consultation investigation. This was done by taking the most northern and southern limits of the polygon and extending the boundaries eastwards until they reached Native Title Determinations. The results of which identified the northernmost area of the South West Settlement, in addition to the northernmost area of the Yamatji nation.

The Yamatji Nation Native Title Determination resulted in the Yamatji Nation Indigenous Land Use Agreement in 2019. Consultation began by developing contact with the Yamatji Marlpa Aboriginal Corporation (YMAC) in March 2023 (event ID #266) with an email detailing the proposed activity and an invitation to consultation. After no response, a follow-up phone call was made to confirm receipt of the project information (event ID #814). Pilot was referred to the heritage team at Yamatji Southern Regional Corporation (YSRC). Pilot therefore has engaged YSRC regarding the Yamatji Nation Native Title Determination.

Through meetings with the YSRC, Pilot was advised that consultation with the different coastal Yamatji nation groups would be best achieved via Cultural Committee Meetings, which were delayed due to the impact of the WA state heritage legislation changes. It was also advised that Pilot could work with YSRC to develop flyers to reach their community at local events.

The YSRC team also advised Pilot to consult with their Sea Country Indigenous Protected Area (SCIPA) program. Pilot offered to host newly certified sea rangers on-board project vessels to provide more opportunities in understanding marine activities in oil and gas in relation to marine species.

The SCIPA program recommended that Pilot consult with two additional individuals from the Wattandee Littlewell Aboriginal Corporation (WLAC) centred on lands on the outskirts of Mingenew. Consultation with WLAC included attendance at their Elders Connect Day with an opportunity to consult with the WLAC community and understand the matters of significance to their tribe.

The Yued Aboriginal Corporation (YAC) was contacted via phone and email (Event ID #2052, #2053 and #2111). The Yued region covers towns of interest to the project including Leeman, Jurien Bay, and Cervantes (Yued 2023). The YAC advised that the recent significant changes to the WA state heritage legislation has resulted in uncertainty in its corporation. No further responses have been received from YAC.

The Kwelena Mambakort Aboriginal Corporation (KMAC) located at Wedge Island responded enthusiastically for consultation and extended the offer to Pilot to attend its KMAC Cultural Awareness Day. Pilot representatives at the event gained valuable insight into culturally significant features of the environment to the KMAC people (see Section 4).

Spiritual and cultural connections to the environment that may be affected by the activity that were learned in consultation with First Nations people has been described in Section 4. Note that some features were requested to not be made public during consultation and therefore are not described in this EP.

5.3.2.4 Relevant persons under Regulation 25(1)(e)

Regulation 25(1) defines the below categories for relevant persons:

e. Any other person or organisation that the titleholder considers relevant.

Pilot was able to identify additional relevant persons by reaching out to people who had been 'carbon copied' in other relevant persons' emails.

5.3.3 Provide sufficient information

Under regulation 25(2) of the OPGGS (E) Regulations, titleholders must give each relevant person sufficient information to allow them to make an informed assessment of the possible consequences of the activity on their functions, activities, and interests.

Every relevant person was engaged through information mediums offering two-way dialogue, was encouraged to disclose their preferred mode of communication, whether it be email or an in-person, face-to-face meeting, and this was catered for. See Appendix D for a summary of these consultations and the Sensitive Information Report for full text responses from relevant persons.

Pilot provided sufficient information to relevant persons by providing:

- Tailored information, responses, and communication mediums to relevant persons. This included further information when requested to ensure relevant persons' understanding and comprehension.
- Published all relevant information regarding the activity on the Eureka 3D MSS website.

All relevant persons were informed of their right to keep their information provided from being published, pursuant to regulation 25(4)(a).

The initial provision of information was broad, simplistic, and easily accessible to the public to engage and capture the maximum possible number of relevant persons.

Where responses were not recorded from relevant persons, the relevant persons were provided further information on a periodic basis in the form of newsletters to ensure a reasonable opportunity and sufficient information has been provided. Where relevant persons did not have email addresses or used a different preferred communication medium, the follow-ups included in-person, phone calls and voicemails.

5.3.3.1 Tailored communication

Rather than using a one size fits all approach, Pilot understands that different people digest and respond to information differently. Once relevant persons were identified, they were consulted regarding which communication channel they prefer and the detail of information they require for effective consultation with Pilot.

Information was tailored to requirements through techniques including:

- Changing the format of information flow depending on the relevant person's needs. For example, some Indigenous groups required in-person, face-to-face meetings, whereas some individuals and groups preferred phone calls and emails.
- Changing the content and complexity of the information based on personal needs.
  - Rather than overwhelming people with information, Pilot provided concise, to-the- point information and evidence surrounding the function, interest or activity that may be affected by the Eureka 3D MSS. For example, commercial fishers received purpose-specific scientific explanations about the immediate effects of seismic exploration on marine wildlife as per WAFIC 2023 consultation guidelines.
- Subject-specific flyers were produced to provide relevant persons with tailored different levels of information. These flyers were unique to the subject-centred groups previously discussed, to facilitate the understanding of risks and response from interested persons.
- Eureka website
  - The Eureka website contains all necessary information related to the Eureka 3D MSS for relevant persons to make an informed assessment of the possible consequences of the Eureka 3D MSS on their functions, interests and activities. Through the design and nature of this publicly available information, relevant persons were able to access the exact information they required to make informed decisions, without needing to ask for it.

Where requested, Pilot provided additional information to relevant persons to enable them to review the proposed activity and determine if there may be a consequence on their functions, interests, or activities.

5.3.3.1.1 Government departments or agencies

The predominant approach used to consult with government departments and agencies was email containing a summary of the activity description, existing environment, and potential impacts of the activity tailored to their function, interest, or activity. Where a response was not received to initial project consultation, at least one follow-up email was sent. In cases where no response was received after a second or third email, the agency was considered to have no objection to the proposed activity. Despite this, Pilot will still consider these departments and agencies relevant for the activity.

5.3.3.1.2 Commercial fisheries, fishers, and fishing associations

Multiple modes of communication were employed by Pilot with commercial fisheries, dependent on the nature of the organisation or individual. For example, relevant individuals were consulted through, including but not limited to, emails, campaign emails, newsletters, in-person meetings and phone calls.

Information provided to commercial fishers, fisheries and industry associations considered the guidance provided in WAFIC's Commercial Fishing Consultation Framework for The Offshore Oil And Gas Sector (July 2023). Early engagement of the commercial fishing industry was sought to determine ideal operational windows for the seismic survey and the location of sensitive fishing areas. Consultation with commercial fishers has been genuine and proportional to the potential impact that the Eureka MSS may have on commercial fishers and fishing stocks, with information provided written in plain language and clarified key issues of concern for commercial fishers.

In particular, documents were produced on seismic impacts to the western rock lobster (considering that a significant proportion of studies conducted have been on the southern rock lobster) for the Western Rock Lobster Council and its members (see the Sensitive Information Report). Western rock lobster presentation slides were made available to the general public and relevant persons via social media and the project website in June 2023.

As the NERA protocol was developed in consultation with fishers on the North West Shelf, and therefore was not directly applicable to Midwest fishers including the WRL fishery, an open comment forum on the NERA protocol was initiated following discussion with individual WRL fishers and industry associations in December 2023.

5.3.3.1.3 First Nations people

Provision of information to First Nations people was primarily verbal in one-on-one or group meetings. Visual aids were used in discussions to aid understanding of what a seismic vessel looks like and how it functions. Verbal discussions were followed up with fact sheets, often tailored with maps to show overlap of Native Title areas with the activity and information on totem species e.g. sea lions.

During consultation one First Nations group requested that a YouTube® explanation video of the fact sheets be created and distributed so that the information could be accessed by those community members who preferred this medium of communication. The YouTube video was made available directly to these groups and to the general public by being uploaded to the project website.

5.3.3.1.4 Recreational fishers

During consultation with RecfishWest, the recognised peak body in WA for recreational fishers, it was requested that a specific recreational fishing fact sheet be developed in response to specific questions most often asked by the recreational fishing community. This fact sheet was developed including links to other online resources for consultation about the activity and supplied directly to RecfishWest, such that they provide it to their interested members.

5.3.3.1.5 Other subject-centred groups

Emails were used as the primary consultation method for all other subject-centred groups. Only one response was received, which did not raise any objections or claims. Other titleholders of offshore petroleum titles have not responded and subsequently it is assumed they have no objection to the activity. This was considered a reasonable approach as other titleholders have the same facilities, resources, and processes to consult with Pilot if they were interested to do so.

In addition to direct communication with relevant persons via emails, the Eureka website was a prominent consultation channel, as well as flyers, social media, and community drop-in sessions at points of interest/ contention as described in the section below.

5.3.3.2 Indirect information pathways

The project-specific Eureka website allowed all members of the public and persons with interest to access information required to make an informed assessment of the possible consequences of the activity on their functions, interests, or activities. Features of the website include:

- An interactive map for the Eureka 3D MSS
  - This map included a boundary of the operational area and environment planning area and invited members of the public to place a ‘marker’ and share public feedback for the activity. There were also instructions indicating that leaving a marker is a contribution as a member of the public and not as a relevant person pursuant to the OPGGS (E) Regulations. These instructions provided an email, phone number, and a link to the consultation survey should someone believe they were a relevant person or wish to provide private feedback to Pilot.
- Consultation survey
  - This key feature provided members of the public a non-confrontational, simplistic way to check if they were a relevant person under the OPGGS (E) Regulations.
- Newsletters
  - Newsletters were used as a tool to give the public short form updates of the project development and what information has been published on the website. These were a tool in the diversification of information that allowed people a general, quick look at the project updates and then directed where to go for further information.
- NOPSEMA information for the community
  - On the Eureka home website is a summary and link to the “NOPSEMA – Consultation on offshore petroleum environment plans” community information flyer. This provided relevant persons and members of the public easy access to information about their ability to communicate and participate in the environmental approval process.
- Webinars
  - These were available to anybody from the public or relevant persons. The purpose was to facilitate two-way communication, construct the consultation process, provide information to the community, seek local knowledge, and promote trust and transparency. A total of five webinars were hosted, recorded and made available via the project website.
- Document library
  - A total of 36 documents are published and publicly available for review on the Eureka website. Information made available on the website includes:
    - CCEP
    - Description of the activity
    - Environmental impact assessments
    - Environmental risk assessments
    - Control Measures
    - Acoustic Modelling Sound Report
    - Information Summaries
    - Newsletters
    - Webinars (recorded and available via YouTube).

- Short summary information flyers
  - Flyers containing details about the petroleum activity, its environmental aspects, and its environmental impacts and risks were produced for distribution alongside other consultation activities and tasks were made available both print and on the Eureka website.
- Community briefing sessions
  - Eleven community briefings and information sessions were held as a platform for sharing information in an open format. The session locations were chosen based on their proximity to the environmental planning area and areas where relevant persons were likely to be located, such as towns with commercial ports. A total of seven general information sessions were held in Jurien Bay, Cervantes, Dongara and Geraldton, with a further three specific to commercial fishers in Fremantle, Geraldton and Cervantes and one more session specific to traditional owners in Mingenew. Sessions were advertised using Facebook®, LinkedIn®, Instagram® and local newspapers. Local councils were also contacted and asked to advertise the sessions; Pilot received no confirmation this was done.
- Print media
  - Recurring advertisements were placed with local newspapers including the Midwest Times, Geraldton Guardian and Jurien Bay local newsletter "Craytales".
- Social media
  - Facebook, Instagram, and LinkedIn were used as social media channels for relevant persons and the general public. They were used to introduce the project and provide links to the website, email address and phone number. Invitation to the general public and relevant persons were made to find out more about activity on the website and providing information on consultation timing. Posts inviting people to sign up to the activity newsletter, webinar and adverting local community sessions were regularly posted. Posts were geotargeted to Cervantes (+40 km), Geraldton (+80 km), Jurien Bay (+61 km), Lancelin (+40 km) and Port Denison (+80 km) and reached up to 45,500 people.

5.3.4 Reasonable period

For consultation to be genuine and meaningful, relevant persons must be given a reasonable period to allow them to make an informed assessment of the possible consequences of the activity on their functions, interests, or activities (GL2086: Section 9). Pilot has determined that a reasonable period for consultation is different for each group and individual and has applied different time periods to different subject-centred groups as shown in the table below.

Table 5-5: Reasonable periods for relevant persons consideration

Subject-centred group	Reasonable period	Rationale
Commerce, commercial fishers, commercial shipping, government agencies, petroleum titleholders, educational bodies, local councils, conservation groups and tourism operators, fishing associations.	Thirty day minimum with sufficient information	Professional nature of these industries, direct relevance of the proposed activity and the depth of knowledge and experience required in these types of roles.
Heritage groups, native title land councils.	Thirty day minimum with sufficient information, with at least one phone call follow-ups	Accessibility to internet and phone lines is sometimes not consistent in these groups and councils, follow-ups required to present a reasonable opportunity.
Interested member of the public, other marine users and port users, recreational fishers, ports, and harbours.	Thirty day minimum with sufficient information, with case-by-case follow-ups	Many of these groups were assessed on a case-by-case basis as Pilot the individual differences these parties may have.

Consultation for the Eureka 3D MSS EP was delivered in five phases (Figure 5-2) commencing in February of 2023 with early engagement of invitations for consultation with an activity overview, location map and diagram showing the consultation framework.

Newsletters were available to relevant persons and the general public from 20 February 2023. Webinars were conducted bimonthly from 1 March 2023 with recordings of the webinars available 1–2 business days following the sessions for general access.

Phase two of consultation commenced in March 2023, where engagement was undertaken to identify relevant persons and provide initial activity information, and feedback was received around the activity location and timing. General public information sessions were held from 28 April 2023 and continued throughout May. The presentation slides were made available to the public via the project website following the sessions. This phase was only intended to be for one month, however due to the depth of conversations regarding the activity location and timing, they continued for three months.

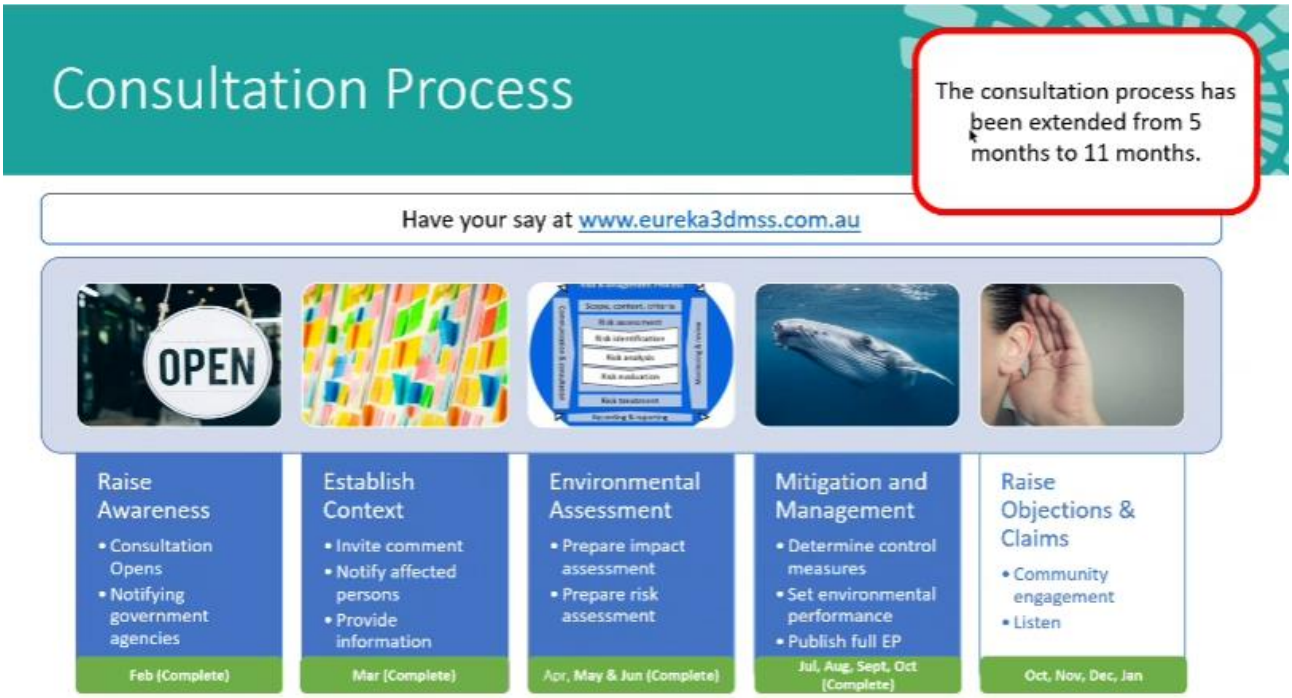


Figure 5-2: Eureka consultation phases

In Phase four, detailed information on the existing environment within the operational area and EMBA were made available to relevant persons and the general public from September 2023. Detailed information of the environmental impact assessments contained within the draft EP document were made available to relevant persons in October 2023. This phase was intended to last for one month, however it lasted for four months as discussions of control measures took place with relevant persons.

Phase five of continued consultation with relevant persons, where Pilot continued to listen to feedback from relevant persons for inclusion in the EP. Community engagement also continued throughout Phase five of consultation.

5.3.5 Assessment of merit of each objection and claim

Feedback was received in writing, verbally during meetings, and through the public comment process. In all cases, feedback was assessed to determine its type so that it could be processed properly. The feedback types were determined to be either:

- An objection.
- A claim.
- A request.
- A statement.
- A complaint.
- A public comment.

All feedback was assigned a type and processed in a standardised way within the CMS. The consideration of each Feedback has been presented in Appendix D. Each Feedback has also been included in the summary report linked to the Event in which it occurred. Where more than one Feedback was received within a single Event, the Event has been duplicated with each Feedback linked to the duplicated Event.

Feedback was determined to have merit if it fit into one of the following categories:

- Adverse Effects Concerns: This category includes any feedback that directly relates to the adverse effects of the activity, such as impacts on marine species, sound effects, visual impacts, and concerns related to oil spills.
- Consultation Process Feedback: Includes feedback relevant to the quality of the consultation process and how stakeholders feel about the engagement efforts.
- Specific Request: This would cover reasonable requests from relevant persons, requests for further information about the activity, and any specific concerns or requirements stakeholders have mentioned.
- Miscellaneous Meritorious Concerns: For feedback that doesn't neatly fit into the other categories, such as errors in distances quoted or general statements needing clarification.

Feedback was determined to have no merit if it fit into one of the following categories:

- Objections Not Related to Adverse Effects: Contains objections that are not about the adverse effects of the activity. This might include objections to the type of title or general objections to oil and gas activities that do not specifically address adverse effects.
- Not Relevant - Other: For any feedback that lacked substance, was abusive, or otherwise lack specific feedback.

Where feedback did not have merit Pilot Energy did not progress through the process beyond the assessment of merit.

A record of all objections and claims received, an assessment of their merit, any changes made in the EP in response to merited objections or claims, and the response provided to the relevant person is provided in Appendix D.

5.3.6 Relevant person input into the EP

Where feedback had merit, Pilot Energy considered what measures could be adopted and separately recorded what measures were adopted because of the consultation. The measures adopted because of the consultations were categorised to indicate the type of measure adopted and was either:

a. Information either as:
    i. Information from a relevant person for input into the EP; or
    ii. Information as it related to giving a relevant person sufficient information for consultation purposes
b. A legislative requirement.
c. An activity limitation.
d. A control measure (or part thereof).
e. A performance standard.
f. An implementation strategy commitment.
g. Other (if not one of the above items).

Measures adopted in categories c – f above, and from category g where it resulted in a change to the EP, are detailed in Table 5-6.

Some measures adopted because of the consultation were often characterised in a way that corresponded with another part of the EP for ease of compliance monitoring. Information requests were usually related to further information required by the relevant person and this information was subsequently provided.

As set out by NOPSEMA (GL2086), the key purpose of consultation under regulation 25 is to ensure that authorities, organisations, and persons (relevant persons) who are potentially affected by activities conducted by the titleholder are consulted, and their input considered in the development of environment plans. Pilot Energy received numerous communications strengthening the understanding of the environmental values and sensitivities that could be affected by the proposed activity, which have been included in Section 4 of this EP.

For full details of the consultation undertaken, merit assessment and summaries of Pilot's response, see Appendix D. Full text responses from these parties that facilitated the EP changes can be found in the Sensitive Information Report.

Table 5-6: Measures adopted in response to consultation

Feedback IDs	Feedback, objection or claim	Measures adopted
282, 284, 348, 362, 454	There are key reef areas in the Operational Area for WRL. Predicted impacts to adult rock lobster are unacceptable and need to be minimised further.	Seismic source will not be operated within a 300 m horizontal distance of the 12 m bathymetric contour around: • Leander Reef • Big Horseshoe Reef • Fourteen other unnamed reef areas within the eastern part of the Active Source Area. See Table 7-20, Performance standard PS13
295	Please reduce the sound source levels you require for the survey.	Pilot will consider (where operational requirements allow) the option of using a smaller seismic source (<2,500 in^3) for acquisition in shallow waters where nodes may be used, rather than towed streamers. See Section 3.3.3
285, 438, 492, 502, 657	Western rock lobster are less robust than southern rock lobster therefore the scientific knowledge of the effects of seismic noise on southern rock lobster does not apply to western rock lobster.	Pilot requested that experts at UTAS undertake a study to evaluate the relevance and transferability of existing scientific knowledge in relation to noise impacts from southern rock lobster to western rock lobster. A draft paper has been prepared but paper not due for finalisation until after submission of EP Rev 2. Additional information on the specific ecology of western rock lobster was added to Section 7.1.5.2 to ensure the impact assessment addresses the unique life history of this species.
287, 332, 343, 358, 364, 499	Commercial fishers will be worse off as a result of not being able to fish, having to fish elsewhere, or damage to our gear. This includes knock-on effects to subsequently displaced fishers and co-ops. The NERA Protocol does not adequately consider these impacts for WRL fishers.	We will adopt the NERA Adjustment Protocol as a starting point, with consultation required to refine content to make it applicable to western rock lobster fishers. The EP makes reference to a commercial fishing industry adjustment protocol to manage claims in Section 7.3. The control is assessed in Table 7-24 and a performance standard (PS 37) is added to Table 7-26.
288, 350, 362	The Beagle Islands are a significant breeding ground for the Australian sea lion, and they may forage out into the Operational Area.	An exclusion zone of 9.2 km horizontal distance around the Beagle Islands has been removed from the Active Source Area. The controls for cetaceans outlined in EPBC Policy 2.1 Part A and Part B4 will also be applied to Australian sea lions to reduce potential impacts to the species. These controls are assessed in Table 7-18 and performance standards (PS 1, 2 and PS 109) are added to Table 7-20
730, 733, 734, 736, 738, 740	Concern that operational methodology is vague	Section 3.3.3 has been reworded to commit to specific methodology in the ASA making it clear that streamers will not be used in the nodal area. Figure 3-2 now clearly shows the nodal area and the active source area exclusion zones around the shallow reef features.
642	Assessment on impacts and descriptions relating to shallow waters has not been adequate	To address claims relating to shallow water impacts the EP has been updated with: • More detail in section 3.1.1 – Active source area • More detail added in section 3.3.1 – seismic source operations • More detail added in section 3.3.3 – ocean bottom nodes • New Figures added to section 3.

Feedback IDs	Feedback, objection or claim	Measures adopted
		In addition to updates in the activity description Pilot have added a control that vessels will be fitted with sonar and depth sounders when working in waters <12 m (Table 7-39; PS 108). This is standard practice in these sorts of vessels and necessary for the management of safe operation of ships (SOLAS). Along with this a performance standard to reference compliance with Marine Order 27 (safety of navigation and radio equipment) has been added to demonstrate that any vessel contracted by Pilot will be adhering to standard maritime laws.
290, 296	The activity will impact commercial fishers in the area.	Control measures have been adopted to manage impacts to commercial fishers during the survey (see Table 7-24), including: • As part of the ongoing notification process, Pilot will notify all relevant persons four weeks prior to the start of the survey to provide details about the anticipated dates for commencement and completion of acquisition. • Commercial fishers actively operating in the OA will be issued a notification 7 to 10-days prior to activities commencing in the OA, including posting of survey notification at local boat ramps. • Where requested, commercial fishers actively operating in the OA will be kept informed of daily survey activities through Pilot's 24-hour look-ahead communication. • Pilot will continue to advise relevant fishers of planned sail-lines and dates and if any issues are raised by fishing relevant persons, Pilot will make reasonable effort to avoid or minimise conflicts. Controls to be considered will include: – Moving to another sail-line – Allowing fishers to fish area prior to seismic acquisition – Minimise survey activity in areas where there is known fishing activity. • Inform the Australian Hydrographic Office of relevant survey details prior to, during (if alterations occur) and on completion of the survey to ensure a Notice to Mariners informs all third parties of survey details and are updated as required. • Pilot will take reasonable steps to avoid or minimise conflict with other marine users, should such a conflict be identified during ongoing notification with relevant persons.
291	Seismic activity will impact whales in the area.	Control measures are in place to manage impacts to whales from underwater noise (see Table 7-18) and from the presence of the survey vessel (see Table 8-2), including that there will be No seismic acquisition during the pygmy blue whale northbound or southbound migration periods (i.e. April to July; and October to January), no seismic acquisition during the southern right whale migration period (i.e. April to October), and no seismic acquisition during the humpback whale migration period (June to November).
312	The impact assessment needs to consider the precautionary principle.	Pilot applies the Oil and Gas UK (OGUK) (2014) Guidance on Risk Related Decision Making to determine the assessment technique applied for each impact or risk. This includes that a precautionary approach is used- this method requires uncertainty in the analysis to be addressed by using conservative assumptions that may result in a control measure being more likely to be adopted.
333, 494	The seismic survey will have ecosystem-level impacts.	The survey timing has been based upon relevant person feedback and assessment of timing of biological, socio-economic and cultural sensitivities, and metocean constraints.

Feedback IDs	Feedback, objection or claim	Measures adopted
		The adopted control measures for the activity described in Sections 7 and 8 are implemented to reduce the impact to the ecosystem.
503, 663	Request that alternative, non-traditional noise source is used in the survey to reduce impacts to marine life.	As described in Section 3.3.1 of the EP, Pilot will consider options for the optimal technology based on what contractors have available at the time of survey to allow for technical advances, within the scope of the parameters provided for in this EP.

5.4 Discharge of consultation requirement under regulation 25

By adhering to the fundamental principles of regulation 25 and conducting meaningful consultation, Pilot adopted appropriate measures resulting from:

- Capturing a sufficiently broad audience to identify relevant persons
- Identifying relevant persons through the techniques previously mentioned
- Providing sufficient information to relevant persons
- Allowing sufficiently reasonable time for relevant persons to digest and respond to information
- Addressing the feedback from relevant persons and responding on a case-by-case basis
- Assessing objections or claims made by relevant persons for merit
- Where input was considered to have merit, using this input in the assessment of the environment and the construction of the EP
- Adopting reasonably practicable measures in the presence of valuable objections
- Providing relevant persons with Pilot’s response to their objection of claim. Whether it be an objective assessment of merit, a continuance in consultation or a reasonably practicable measure
- Publishing a thematic summary of the consultation, including the measures adopted because of the consultation.

Pilot believes that it has provided relevant persons sufficient information and a reasonable period of time to make an informed assessment if their functions, interests or activities may be impacted because of the activity and to provide feedback to Pilot regarding any objections or claims of the activity. Pilot considers that consultation under regulation 25 is complete.

5.5 Public comment period outcomes

The Eureka 3D MSS was submitted to NOPSEMA for completeness check and accepted as complete on 21 February 2024. Following acceptance, the EP was published on the NOPSEMA website for a 30-day public comment period. The EP was available for public comment from 21 February 2024 to 22 March 2024.

A total of 25 public submissions were received during the public comment period. The Public Comment report details comments from the received public comments grouped by themes and matters.

There were several comments made which are out of scope of the public comment process. These included claims related to the following matters:

- Risk of triggering earthquakes from seismic surveys.
- Objections to Cliff Head being used for carbon capture and storage.
- General opposition to seismic activities.
- Concerns about carbon capture and storage activities beyond the scope of this EP.

One submission of the 25 received was in relation to a different petroleum activity and has not been included.

5.6 Ongoing consultation

Consultation will be ongoing during the implementation of this EP as required under section 22(15). Ongoing consultation will be undertaken in accordance with the consultation method described in this section. Further details regarding ongoing consultation can be found in Section 10.9.

6 ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY

6.1 Introduction

Section 21 of the OPGGS(E) Regulations require Pilot to identify, analyse and evaluate the risks and potential environmental impacts associated with the Eureka 3D MSS.

Pilot's impact and risk management process is based on the principles, framework and processes defined by the International Standards Organization (ISO) 31000:2009 Risk Management – Principles and Guidelines. The following sections describe the steps in the risk management process, including the legislative framework, approach taken to identify and evaluate potential impacts and risks associated with the activity, and risk treatment (control) measures that will be adopted to reduce the impacts and risks to as low as reasonably practical (ALARP) and to acceptable levels.

6.2 Communication and consultation

Communication and consultation with internal and external stakeholders takes place during all stages of the risk management process. This is to ensure that those accountable for implementing the risk management process (namely, Pilot and any appointed contractors) and stakeholders understand the basis on which decisions are made, and the reasons why particular actions are required.

Pilot is committed to consulting with relevant persons who may be affected by the activity to identify and understand any concerns and issues, to mitigate impacts and risks highlighted in meritorious submissions and to openly communicate the process with the relevant persons. Input from relevant persons will help to inform the preparations for, and execution of, the Eureka 3D MSS as appropriate. The process of relevant person consultation is described in Section 5.

6.3 Establishing the context

The purpose of establishing the context in the risk management process is to define the external and internal parameters to be considered when managing risk, and to define the risk criteria. This requires assessment of the external and internal environments in which Pilot seeks to achieve its objectives.

The external context comprises the description of the activity (Section 3), the physical, biological, socio-economic and cultural environments (Section 4) and associated potential impacts and risks specific to the nature and scale of the activity (Section 7 and 8), the legislative framework, applicable management plans, standards and guidance (Section 2) and the perceptions and values of external relevant persons (Section 5, Appendix D. The internal context relates to Pilot's culture, processes, structure and strategy, and includes anything within the organisation that can influence the way in which environmental risk is managed. Pilot's commitment to minimising environmental harm and to operating and maintaining a safe and healthy work environment for its employees, contractors and project partners is reflected in its corporate Environment and Sustainability Policy (Appendix A) and HSE management framework (Section 10.2).

6.4 Impact and risk assessment

The environmental impact and risk assessment process uses a systematic, evidence-based approach to evaluate and interpret the impacts and risks associated with its activity and the potential for harm to physical, biological and human receptors. The environmental impacts and risks associated with the Eureka 3D MSS have been assessed using the following steps:

- Definition of the activity (Section 3) and identification of associated aspects and hazards with potential for environmental harm (i.e. physical, chemical or biological entity or incident that induces an adverse response or impact e.g. operation of airguns)
- Identification of the environmental, socio-economic and cultural values within the area that may be affected by the activity, i.e. the existing environment context of the activity (Section 4)
- Identification of aspects of the activity with potential for environmental harm (e.g. underwater noise, light, seabed disturbance) in the context of its nature, scale, and location (Section 7)
- Definition of acceptable levels for each impact and risk (Section 7 and 8)

- Identification of impacts from routine aspects and risks from unplanned/accidental events, and the inherent impact or risk (Section 7 (planned events) and Section 8 (unplanned risks))
- Identification of the 'decision context' and 'assessment technique' relevant to the impact or risk (Section 7 and 8)
- Identification of control measures to be implemented for each aspect in order to reduce the impacts and risks to ALARP (Section 7 and 8)
- Determination of the residual risk of each environmental impact and risk with identified control measures adopted (Section 7 and 8)
- Determination of whether the residual risk is acceptable
- In the event that an impact or risk is not considered acceptable, further practical control measures are considered and adopted until the impacts and risks are considered ALARP and acceptable (Section 7 and 8).

6.4.1 Hazards, impact and risk identification

Information used in identifying the impact and risks associated with the activity has been obtained from the following sources:

- Pilot's description of the location and timing of the survey, and activities to be undertaken in acquiring seismic data (e.g. airgun discharges, sail lines)
- An understanding of general vessel activities/operations during seismic surveys and the potential threats and hazards to stakeholders and the marine environment and where appropriate, terrestrial environments
- Literature reviews on the environmental sensitivity of the receiving environment with respect to species' presence, "biological calendars", habitat distribution and location of biologically important areas (breeding, migration, resting, foraging areas); identification of environmental, socio-economic and cultural values at risk within and adjacent to the OA
- Feedback from relevant persons (onshore and marine) to understand socio-economic and cultural activities and values that may be affected by the proposed activity.

The identified environmental, socio-economic and cultural impacts and risks associated with activities proposed under this EP are listed in Table 7-1 and Table 8-1 along with the residual risk ranking of each, as determined within Sections 7 and 8.

6.4.2 Impact and risk analysis and evaluation

The hazards for each potential environmental aspect were identified using a qualitative assessment process in accordance with the methods and principles described by the ISO 31000:2009 Risk Management – Principles and Guidelines (2009), and Standards Australia Handbook HB 203:2012, Managing Environment-related Risk (2012).

The Eureka 3D MSS impact and risk assessment is based on the evaluation of impacts and risks that are credible, realistic and appropriate to the nature and scale of the activity, and the values and sensitivities of the environment that may be affected (EMBA).

Each impact and risk associated with the planned seismic activity has been evaluated by determining the consequences or effects, including the extent, duration, timing and potential for recovery (Table 6-1), and assessing the likelihood or probability that those consequences may occur (Table 6-2). Potential maximum quantities released, time-scale of release, biological exposure and sensitivities, and regulatory requirements were considered in determining the consequence of the impact/risk. The likelihood of the effect or consequence is based largely on professional judgement of the conditional likelihoods leading to the effect, including the presence of the stressor (impact/risk), the exposure of receptors to the stressor and the sensitivity of the receptors to the stressor.

Table 6-1: Definition of consequence terms

Term	Meaning
Localised	Operational Area extent
Extensive / Medium scale	Within EMBA extent
Regional / Large scale	South-west marine region extent
Short-term	Days to weeks
Medium-term	<12 months
Long-term	>12 months

Table 6-2: Definition of likelihood

Category		Definition/experience (history of occurrence)	Probability
A	Very Unlikely	Conceivable only under extreme circumstances	Event occurs once within ten years
B	Unlikely	A very rare event by standards of industry.	Event occurs once within five years
C	Possible	Has happened in similar businesses but not Pilot	Event occurs once a year
D	Probable	May occur in our business	Event occurs monthly
E	Very Likely	Expected to occur in most circumstances / has occurred at the location	Event occurs weekly

All identified impacts and risks associated with the activity were analysed and evaluated in accordance with the Pilot modified risk matrix (Table 6-3, Figure 6-1). The coloured region signifies the tolerability of the risk criteria. Environmental impact and risks ranked as Low or Moderate are considered generally ALARP and acceptable (i.e. acceptable providing that it can be shown that all practicable impact and risk reduction measures have been taken and they will continue to be taken). Impacts and risks ranked as Significant or High are undesirable or unacceptable and require additional control measures to be implemented to reduce the residual level of risk to ALARP and acceptable.

The outcome of this evaluation provides the 'inherent' impact or risk ranking, i.e. the impact/risk without the application of control measures. The shaded region of the risk matrix signifies the tolerability of the risk ranking.

Table 6-3: Pilot consequence description for environmental and socio-economic/cultural aspects*

Consequence	Environment	Socio-economic/cultural
Low	No impact or negligible impact (<1 month) to localised area and not significant to environmental receptors Full recovery expected in days to weeks	Minor, short- term to no lasting effect, or low-level repairable damage to a community, social infrastructure
Minor	Minor, detectable but insignificant localised change to ecosystems, habitats and local species populations Full recovery expected in days to weeks	Minor disruption, localised scale and temporary effect (days to weeks) on commercial and/or recreational users and community, social infrastructure or areas/items of low cultural or heritage values.
Moderate	Moderate disruption and short-term effect on a proportion of a protected species' population, including impacts on health, critical habitats or critical behavioural processes. No overall threat to populations Medium scale and short-term effect on other habitats/ communities No effects on ecosystem function Recovery in months to one year	Moderate disruption, medium scale and short-term effect (weeks to months) on commercial and/or recreational users and a community, social infrastructure or areas/items of low cultural or heritage values
Major	Major disruption and medium-term effect on a significant proportion of a protected species' population, including impacts on health, critical habitats or critical behavioural processes. No overall threat to populations Medium scale and medium-term effect on other habitats/ communities No effects on ecosystem function Recovery >1 to three years	Moderate disruption, medium scale and effect (months to years) on commercial and/ or recreational users, and to a community, social infrastructure or areas/items of high cultural or heritage significance

Consequence	Environment	Socio-economic/cultural
Severe	Severe disruption and medium to long-term effect (on a protected species' population, including impacts on health, critical habitats or critical behavioural processes Injury or death of individuals of a protected species. Large scale and long-term effect on other habitats/ communities Effects are at an ecosystem function level. Recovery three to >10 years	Major disruption and medium to long-term effect (years to decades) leading to loss of commercial and/or recreational use and total destruction to a community, social infrastructure or areas/items of high cultural or heritage significance

*The word 'significant' used in this table has been defined using the significant impact criteria set out in the MNES significant impact criteria guidelines 1.1. https://www.dcceew.gov.au/sites/default/files/documents/nes-guidelines_1.pdf

Risk Matrix Table		LIKELIHOOD				
		• Unlikely to happen here or elsewhere. • Conceivable under extreme circumstances.	• Unlikely to occur. • A very rare event by standards of industry.	• Possibility of occurring. • Has happened in similar businesses but not Pilot	• May occur in our business.	Expected to occur in most circumstances / has occurred at the location
SEVERITY (CONSEQUENCE)	Severity Level	Very Unlikely	Unlikely	Possible	Probable	Very Likely
		A	B	C	D	E
	5 - Severe	SIGNIFICANT 15	HIGH 19	HIGH 22	HIGH 24	HIGH 25
	4 - Major	MODERATE 10	SIGNIFICANT 14	HIGH 18	HIGH 21	HIGH 23
	3 - Moderate	LOW 6	MODERATE 9	SIGNIFICANT 13	SIGNIFICANT 17	HIGH 20
	2 - Minor	LOW 3	LOW 5	MODERATE 8	SIGNIFICANT 12	SIGNIFICANT 16
	1 - Low	LOW 1	LOW 2	LOW 4	MODERATE 7	MODERATE 11

Figure 6-1: Pilot's risk matrix

6.5 Impact and risk treatment

The treatment of the inherent impacts and risks identified in the assessment process requires application of control measures to reduce them to ALARP and acceptable levels. Pilot has taken the following approach for each of the identified impacts and risks during the assessment:

- Determination of inherent risk (potential risk) without controls
- Identification of appropriate control measures aligned with the decision type (refer to Section 6.5.1)
- Demonstration of ALARP (and determination of the residual risk)
- Demonstration of acceptable level of impact or risk
- Determination of residual risk rating (including controls aligned with decision type).

6.5.1 Decision context and assessment techniques

Pilot applies the Oil and Gas UK (OGUK) (2014) Guidance on Risk Related Decision Making to determine the assessment technique applied for each impact or risk. Pilot has considered previous impact and risk assessments for similar activities, review of relevant published studies (peer reviewed and grey literature) and relevant person consultation concerns/feedback. Wherever possible, site-specific and activity-specific data has been used in the impact/risk assessment; however, in order to address areas of uncertainty, a precautionary approach has been taken and a conservative or “worst case” approach has been applied where there is uncertainty in the level of harm.

The extent to which identified relevant persons have an interest in the decision depends upon the nature of the impact/risk (e.g. magnitude, complexity, uncertainty) and their perception of the impact/risk. The values, views, attitudes, perceptions and concerns of relevant persons consulted for the Eureka 3D MSS have been used in the determination of the decision context. Relevant person concerns have been assessed for merit and adopted control measures (where relevant) are summarised in Section 5.

Once the decision context is established for the impact/risk, this determines the assessment technique to use to identify appropriate control measures. The arrows in Figure 6-2 show the assessment technique(s) likely to be needed to make the decision. Good practice forms the basis of the assessment for all decision contexts. Moving from decision context A to B to C increases the relevance for additional assessment techniques and the role these play in the identification of control measures and decision-making.

- Good Practice: In accordance with recognised guidelines, standards and control measures that are used to manage well-understood impacts and risks arising from activities. This also includes control measures required to meet legislative requirements, codes and standards, including guiding principles such as the principles of ESD as defined in the EPBC Act.
- Engineering (or Environmental) Impact and Risk Assessment: This method may involve application of a range of techniques such as engineering analysis (e.g. underwater sound modelling), impact/risk assessment, cost benefit analysis, professional judgement.
- Precautionary Approach: This method requires uncertainty in the analysis to be addressed by using conservative assumptions that may result in a control measure being more likely to be adopted.

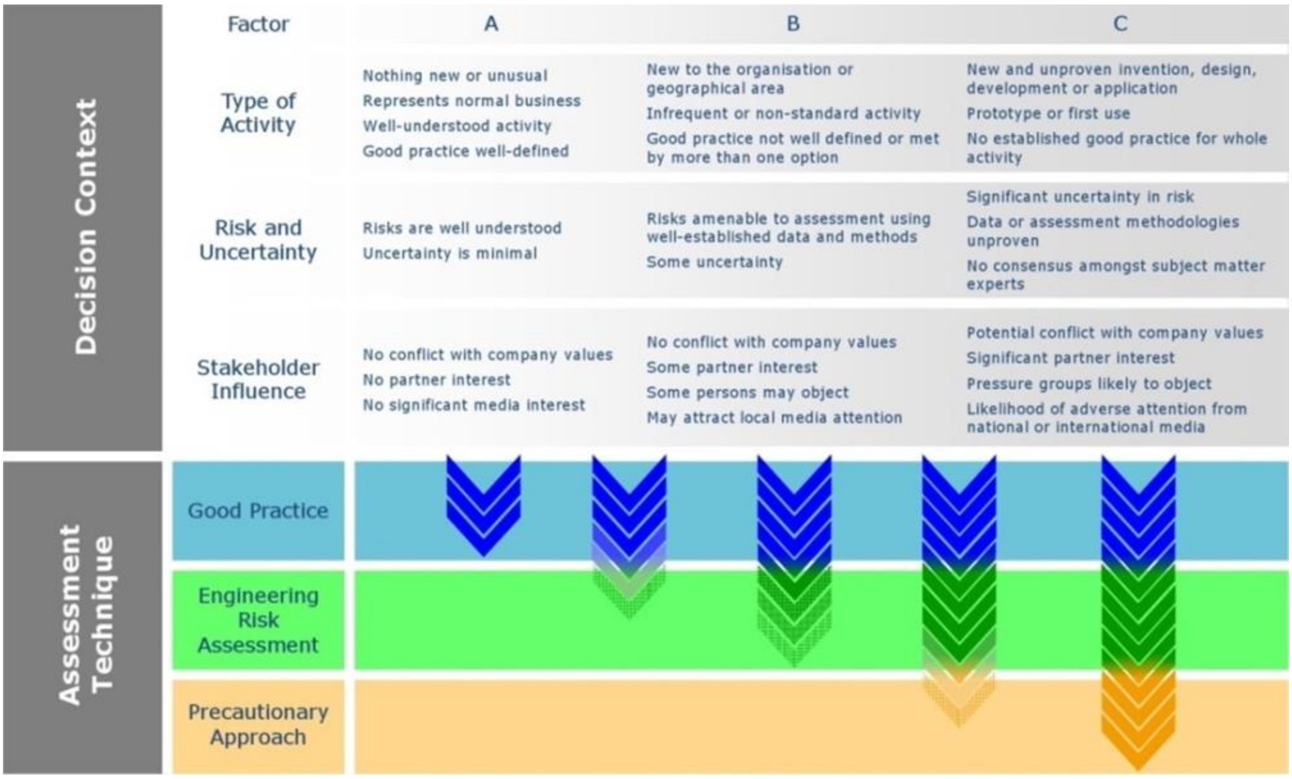


Figure 6-2: Risk related decision support framework (source: OGUK 2014)

6.5.2 Hierarchy of control measures

Pilot has established a hierarchy of controls in accordance with their impact and risk management process as part of their HSE Management System.

Table 6-4: Hierarchy of controls

Control type	Description
Eliminate	Selection of method based on appropriate design, elimination of methods with higher risks, e.g. eliminating seabed damage from anchors by using dynamically positioned vessels.
Substitute	Replace with a lower risk situation, e.g. use gel-filled streamers instead of fluid-filled streamers.
Reduce	Reduce the impact/ risk, e.g. soft-starts during operation of the seismic source to encourage marine fauna to move out of the area, thereby reducing exposure to elevated noise levels.
Engineering/Isolation	Engineer out the impact/risk, e.g. automatic flotation devices to aid in recovering lost streamers.
Administration	Provide instructions, procedures or training to reduce the risk, e.g. waste management and marine fauna interactions, training of crew through environmental inductions.
Protective	Use appropriate protective equipment, (including emergency response and contingency planning), when other control measures are not practical or have not totally removed the hazard.

6.5.3 Demonstration of ALARP

For planned and unplanned events, an ‘as low as reasonably practical’ (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 ‘Moderate’ compared to a risk ranked as `Low’.

6.5.3.1 Practicability

Additional control measures were assessed to demonstrate whether the impact or risk could be further reduced, or if the impact or risk level is ALARP. Treatments considered by Pilot to be reasonably practicable have been implemented, while those considered to be not reasonably practicable have not been implemented, e.g. the cost, time and effort required to implement the measure is grossly disproportionate to the benefit gained.

6.5.3.2 Effectiveness

Pilot's Risk Management Procedure (PE-03-PRO-001) requires that the effectiveness of control measures must be assessed before they are implemented. Determination of effectiveness is subjective and thereby based on professional judgement, taking into account the following considerations:

- Availability – will the control exist and be available when and where you need it?
- Reliability – will the control work as it was designed and intended?
- Impact – what will be the scale of effect if this control works perfectly?
- Duration – what will be the duration or time that the control will have its effect?

6.5.3.3 Cost benefit analysis

The estimated cost criterion consisted of a qualitative assessment by people familiar with the practicalities of implementing the control measures, to evaluate and rate the estimated cost impact of the additional control measure. Monetary values were not quantified; however, the cost was qualitatively ranked as follows:

- High – Very significant or disproportionate cost associated with the implementation of this measure and the cost may be prohibitive or not warranted based on the potential benefit gained. The level of cost is likely to compromise the Eureka 3D MSS objectives and viability.
- Medium – Significant cost associated with implementation of this measure, however it is not considered prohibitive, when compared to the potential risk reduction benefit.
- Low – No significant cost associated with implementation of this measure.

The expected net benefit of the additional control measure in reducing either the likelihood or the consequence of the impact or risk, beyond that achieved by the previously identified control measures was evaluated on a qualitative basis. If a control measure reduced the potential impact or risk significantly, but did not change the residual risk ranking, it may still be considered as a net benefit and a contribution to reaching ALARP.

The potential for each additional control measure to generate negative environmental impacts, health and safety issues or operational risks was considered. Where effects were considered to negate the potential benefit partially or fully, the control measure was not considered for implementation, as it had no net benefit and contribution to reaching ALARP.

Where the benefit (i.e. reduction in impact or risk) of an additional control measure was considered grossly disproportionate to the cost of implementation or the effect on survey efficacy, the control measure was not accepted. As such, the control measures presented in the impact and risk assessment constitute only those that were deemed to result in a reasonable, practicable and effective reduction in the likelihood or consequence of an impact or risk becoming realised, and thereby demonstrating ALARP whilst achieving the objectives of the survey.

6.5.4 Residual impact and risk ranking

The residual impact and risk ranking process is undertaken to assess the effect of control measures in mitigating the inherent risk levels. It follows the identification of the decision context type, ALARP process and establishing appropriate control measures.

Residual risk rankings were based on re-assessment of the likelihood and consequence of the impacts with the mitigating controls in place. Residual risk was assigned using Pilot's risk matrix in Figure 6-1. All identified impacts and risks associated with the activity were analysed and evaluated in accordance with

Pilot's risk matrix. The coloured region signifies the tolerability of the risk criteria Environmental impact and risks ranked as low or medium are generally considered ALARP and acceptable (provided that it can be shown that all practical impact and risk reduction measures have been taken and they will continue to be taken). Impacts and risks ranked high are undesirable or unacceptable and require additional control measures to be implemented to reduce the residual risk to ALARP and Acceptable.

6.5.5 Demonstration of acceptability

Section 21 of the OPGGS(E) Regulations requires a demonstration that residual environmental impacts and risks are of an acceptable level. Acceptance is often represented as an inverted triangle (Figure 6-3) where the level of risk increases from a low risk or "broadly acceptable region" through a "tolerable region" (if impacts/risks are demonstrated to be higher, but ALARP) and then to an "unacceptable region". Acceptability criteria for the different levels of risk are as follows:

- Low: Broadly Acceptable. Good industry practice (including legislation and standards) has been applied and the impact/risk is acceptable without further reduction measures being required. Further effort towards impact/risk reduction is not reasonably practicable without sacrifices (costs, loss of opportunities, or loss of technical quality) grossly disproportionate to the impact/risk reduction benefit.
- Moderate: Acceptable (acceptable / tolerable), providing that it can be shown that all practicable control measures have been implemented, if the sacrifices are not grossly disproportionate to the environmental benefit gained, with continual review of these measures and any potential new ones.
- Significant (Undesirable): Pilot management decision required to accept impacts/risks and proceed. Additional control measures are required to be considered and implemented, if the sacrifices are not grossly disproportionate to the environmental benefit gained, to prevent or reduce the impact/risk to ALARP and be acceptable.
- High (Unacceptable / intolerable): May require redesign of project and/or its parameters, additional control measures are required to be implemented (regardless of sacrifice) to prevent or reduce the impact/risk to ALARP and be acceptable.

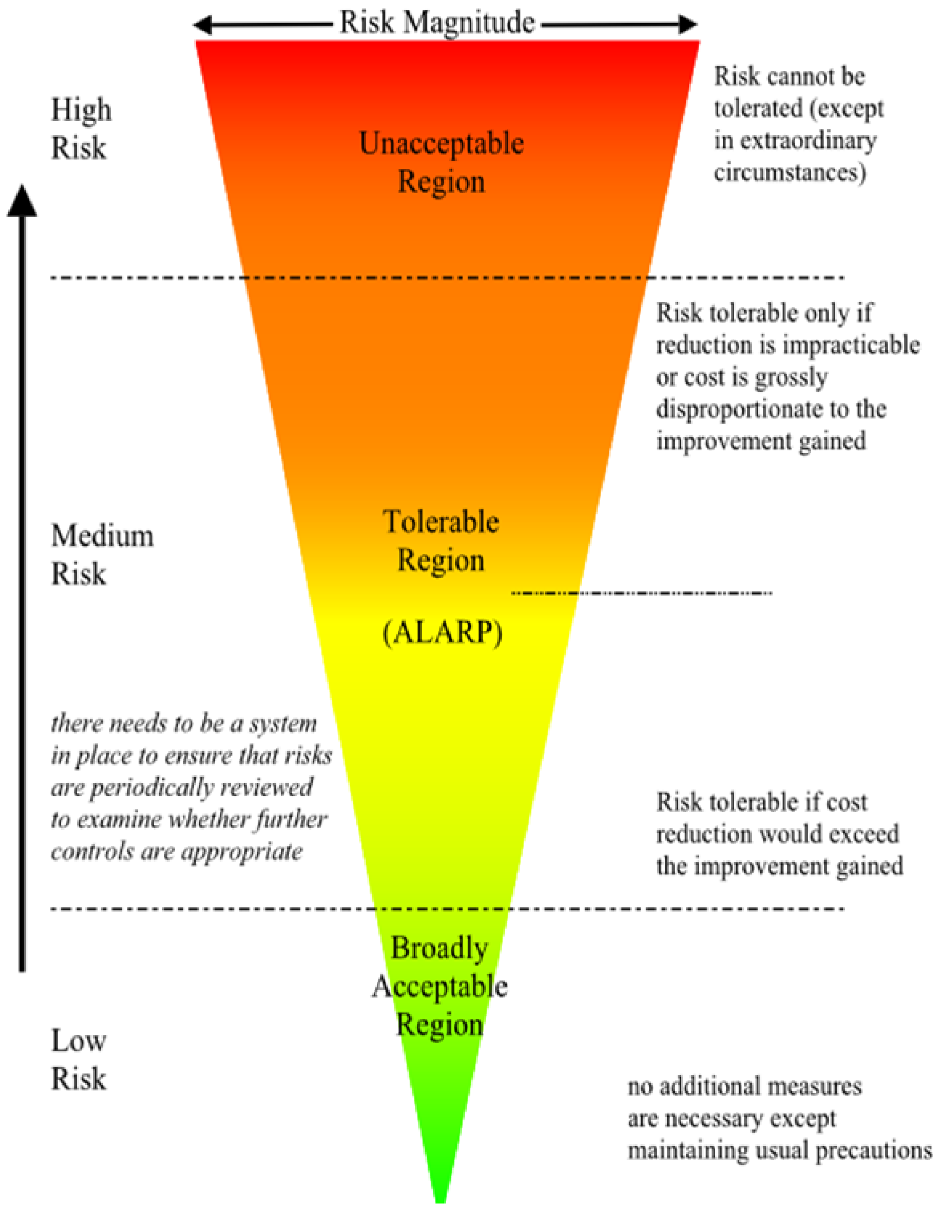


Figure 6-3: Approach to demonstrating ALARP and acceptable levels (source: ISO 31010:2009 Risk management – risk assessment techniques)

Pilot's model for demonstrating acceptable levels of impacts and risks for the Eureka 3D MSS is based upon the criteria described in Table 6-5. Using the appropriate criteria from Table 6-5, acceptable levels of impact were defined prior to conducting the evaluation of individual impacts and risks in Sections 7 and 8. However, not all the criteria for acceptance in Table 6-5 will apply to defining levels of acceptability for all impacts and risks assessed within this EP. Pilot has therefore distinguished between higher and lower order environmental impacts and risks.

Higher order impacts/risks are generally more complex and include those where the environment or receptor affected is protected/threatened, vulnerable to the impact/risk, not widely distributed, or where there is uncertainty in the effectiveness of adopted control measures. Such impacts/risks relevant to the Eureka 3D MSS include underwater noise from seismic operations, accidental oil spill (vessel collision/grounding) and physical interaction with other marine users. It is expected that reasonable effort has been used to identify and evaluate alternative, additional, and improved control measures that may further reduce impacts and risks (NOPSEMA Guideline N-4750-GL1721). Lower order impacts include atmospheric emissions, routine discharges, light emissions, accidental loss of materials, introduced marine species and fuel spills.

Following demonstration that all reasonable and practicable control measures have been adopted to reduce the impacts and risks to ALARP, the pre-defined acceptable levels of impact have been compared with the residual levels of impact and risk. If the residual impact levels lie within the boundaries of the pre-defined acceptable levels, the impact or risk is considered acceptable.

Table 6-5: Criteria for defining acceptable levels of impact

Criteria for acceptance	Definition of criteria
Pilot's Internal Context	• Alignment with Pilot's Environment Policy for the Eureka 3D MSS described in Appendix A. • Pilot's impact/risk matrix defines 'Low risk' as acceptable, 'Moderate risk' as acceptable providing ALARP has been demonstrated, 'Significant risk' as undesirable (i.e. Requiring ALARP demonstration and decision to accept based on Pilot management decision), and 'High risk' as unacceptable (Figure 6-1). • As such, have all reasonable and practical control measures been adopted to reduce the risk or impact without sacrifices being disproportionate to the benefit of the risk reduction?
Legislative Requirements	• The impact/risk is being managed in accordance with existing Australian or international legislation, conventions and/or standards, such as MARPOL 73/78, AMSA Marine Orders, and Marine Notices, EPBC Policy Statements (refer to Section 2) • Aligned with the Principles of Ecologically Sustainable Development (ESD), including application of the precautionary principle and/or how uncertainty has been reduced • The proposed management of the impact/risk is aligned with species-specific or protected area management plans/conservation advice actions or conservation objectives.
Industry Good Practice	• The impact/risk is being managed in accordance with industry good practice (APPEA Code of Environmental Practice and IAGC/IOGP guidelines), and national and international standards (ISO 31010:2009 Risk Management, Standards Australia / Standards New Zealand Risk Management Guidelines)
Social Acceptance	• Concerns raised during relevant person consultation have been assessed for their merits and control measures developed, if appropriate, to manage those concerns. • There are no outstanding merited concerns that have not been assessed.
Existing Environmental Context	• Is the effect on the environment or receptor localised, short-term and recoverable? • Have potential impacts to environmental values or sensitivities been assessed as local, regional (and if applicable global) level in terms of population level and long-term effects? As such, are adopted controls appropriate and adequate in avoiding such effects and thereby reducing risks to ALARP.

6.6 Environmental performance outcomes and standards

Section 5 of the OPGGS(E) Regulations provides definitions for the following

- Environmental performance outcome (EPO): A measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks will be of an acceptable level
- Environmental performance standard: A statement of the performance required of a control measure.

Environmental performance outcomes, standards and measurement criteria for each aspect of the activity that has the potential to cause adverse environmental impacts or risks are detailed in the assessments presented in Sections 7 and 8. Environmental performance will be measured and reported against these standards and measurement criteria, as part of Pilot's commitment to continuous improvement of environmental, health and safety performance.

Pilot will develop and maintain an Environmental Commitments Register (ECR) for the activity, which details the environmental commitments, performance outcomes and criteria outlined in this EP. The ECR is an audit tool to be used during the activity to demonstrate conformance of the activity with the environmental performance commitments made by Pilot. This ECR will be submitted to NOPSEMA as part of the Post-survey Environmental Performance Report (PEPR) within two months following the completion of the survey (Section 10.8.1).

6.7 Monitoring and review

Ongoing monitoring and review are essential to ensure the impact and risk assessments within this EP remain relevant. Introduction of new impacts/risks due to changes in the activity or context, changes in the consequence of impacts/risks, and maintaining effectiveness of adopted controls are addressed in Pilot's Management of Change Procedure (Doc. PE-03-PRO-002) described in Section 10.2.1.

7 ENVIRONMENTAL RISK ASSESSMENT – PLANNED EVENTS

This section of the EP presents the results of the impact assessment of planned events for the Eureka 3D MSS using the methodology described in Section 6. As required by Section 21 of the OPGGS(E) Regulations, this assessment demonstrates that the impacts associated with the activity will be reduced to ALARP and to an acceptable level. Potential impacts associated with transit of the survey vessel and support/chase vessels to and from the OA, are considered outside the activity and therefore outside the scope of this EP and assessment. A summary of the impacts risk ranking for the Eureka 3D MSS is presented in Table 7-1

Table 7-1: Summary of risk rankings for Identified impacts during the Eureka 3D MSS

Potential impacts and risks	Residual risk ranking
Impacts (expected to occur during routine operations)	
Underwater sound – seismic operations	Low – Moderate
Underwater sound – vessel operations	Low
Interactions with other marine users	Low - Moderate
Light emissions – vessels	Low
Routine discharges – vessels	Low
Atmospheric emissions – vessels	Low
Seabed disturbance – placement of ocean bottom nodes	Low

7.1 Impact 1: Underwater sound – seismic operations

7.1.1 Identification of hazard and extent

Hazard	The activity is a typical 3D survey similar to the majority of seismic surveys conducted in Australian marine waters in terms of technical methods and procedures. During the survey, ocean bottom nodes (OBN) may be used within a small area in shallow waters (Node Survey Area) within the ASA; therefore, this activity has been included in this assessment. The dominant source of underwater noise during the Eureka 3D MSS will be from the operation of the seismic source (airgun array). The airgun array will have a maximum volume of 2495 in^3. During the proposed activity, the seismic survey vessel will traverse a series of pre-determined sail lines at 600 to 700 m apart, within the ASA at a speed of approximately 4.5 knots (8 km/hr). Seismic data will be acquired in water depths of 10 to 75 m for up to 40 days. The seismic array is highly directional; focussing sound energy towards the seabed but will also ensonify the surrounding water column to a lesser extent, as demonstrated by the acoustic modelling. The underwater sound generated by the array will be strongest at the source and rapidly decrease with distance from the source. Marine biota in the area of ensonification will be exposed to different received levels of sound energy, depending on their behaviour e.g. whether they flee or are affiliated with habitat or oceanographic features, and where they are in relation to the source. However, actual near-field and far-field received sound levels are influenced by a number of factors including the overall size (capacity) of the acoustic source, the array configuration, water depths in the area, position in the water column, distance from the source and geoacoustic properties of the seabed.
Extent	The areas of ensonification for marine fauna groups are based on the largest area of effect predicted by the underwater sound modelling for the marine fauna thresholds (Appendix G) applied to this assessment. These areas are defined by the following distances from the source: • Plankton – up to 270 m from the source (based on mortality recorded by McCauley et al. 2017) • Sponges and coral – up to 15 m from the source (based on sound levels reported in Heyward et al. 2018 as causing no effects) • Crustaceans (e.g. Lobsters and prawns) – up to 292 m from the source (based on sub-lethal effects recorded by Day et al. 2016a, 2016b) • Squid – up to 2.9 km from the source (based on startle response recorded by Fewtrell & McCauley 2012) • Fishes (demersal species, including site-attached species) – up to 4.06 km from the source (based on TTS effects for accumulated 24-hour exposure scenario) • Fishes (pelagic and demersal species) up to 4.06 km from the source

	• Marine turtles – up to 60 m from the source (based on PTS effects for accumulated 24-hour exposure scenario) • Marine turtles (behavioural response) – up to 4.9 km from the source • Low-frequency cetaceans (pygmy blue, southern right, humpback whales) – potentially up to 43 km from the source (based on TTS effects for accumulated 24-hour exposure) • High-frequency cetaceans (dolphins, beaked whales, sperm whales – *Physeter sp*.) – potentially up to 9.2 km from the source (behavioural response) • Very high-frequency cetaceans (*Kogia sp*.) – potentially up to 9.2 km from the source (behavioural response) • Pinnipeds (sea lions) – potentially up to 9.2 km from the source (behavioural response).
Duration	Duration of survey – up to 40 days in early February to the end of March. This includes 30 days of acquisition with additional time for weather and/or fauna downtime and potential infill.

7.1.2 Levels of acceptable impact

The impact on marine receptors caused by underwater sound from seismic operations will be acceptable when the levels of acceptability are met as described below (Table 7-2).

Table 7-2: Levels of acceptable impact – underwater sound from seismic operations

Levels of acceptable impact	
Marine receptors (general)	• Seismic operations (including soft starts / ramping up) are limited to within the OA • Seismic discharge intensities are limited to the minimal levels at all times while performing operational objectives • Soft-starts of airgun array will be used every time the array is first started • Zoning of ASA to reduce potential impacts on BIAs and to avoid intense ensonification of any one area for the duration of the survey.
Plankton (incl. fish larvae, eggs)	• Minimise overlap of seismic acquisition with spawning activity in important areas for fish/ invertebrates • No long-term impact to zooplankton communities or zooplankton biomass resulting in alteration to ecosystem functioning or population effects.
Fishes (incl. spawning)	• Survey has negligible effects on the spawning output of commercially important species likely to be present within the OA • The activity is not inconsistent with any relevant objectives of the Recovery Plan for the White Shark (DSEWPAC 2013b) as demonstrated by the impact assessment in this EP (refer Section 9) • No population or ecosystem level effects • No impacts to fish populations that would impact the sustainability of fish stocks within the OA
Invertebrates (incl. spawning)	• Survey has negligible effects on the spawning output of commercially important species likely to be present within the OA • No population or ecosystem level effects • No injury to cephalopod populations which would affect the sustainability of commercially fished cephalopod stocks.
Marine turtles	• Predicted effects limited to behavioural disturbance of a small number of individuals • The activity is not inconsistent with any relevant objectives of the Recovery Plan for Marine Turtles (DSEWPAC 2013b) as demonstrated by the impact assessment in this EP (refer Section 9) • No predicted impacts on breeding, migration or foraging of marine turtles • No population level effects.

Cetaceans	• Application of measures defined in Part A and Part B of EPBC Act PS 2.1 and additional measures if necessary to align with conservation management plans and good practice
	• No displacement or exclusion of foraging, aggregating, calving/breeding, migrating cetaceans from BIAs
	• This activity is not inconsistent with the relevant management actions in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia 2015a):
	  – PBWs will continue to use BIAs without injury and are not displaced from foraging areas
	  – Apply Part A and B measures where relevant as specified in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales

	– Behavioural impacts are to be considered when assessing the effect of anthropogenic noise on PBW • This activity is not inconsistent with the relevant recovery actions in the Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a): – The activity will not prevent any SRW from utilising a BIA, or cause injury (TTS and PTS) and/or disturbance – Apply the measures specified in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales – Behavioural impacts are to be considered when assessing the effect of anthropogenic noise on SRW • This activity aligns with the management actions of the humpback whale Conservation Advice by: – Performing site-specific underwater acoustic modelling to assess the impacts from noise on cetaceans – Applying standard measures specified in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (because the seismic survey is not within known calving, resting, foraging or a confined migration pathway, additional measures for HBW are not required) • This activity aligns with the management actions of the sei whale and fin whale Conservation Advice for an assessment of noise impacts • No population level effects.
Australian sea lion	• Predicted effects limited to short term behavioural disturbance of a small number of individuals • This activity is not inconsistent with the relevant management actions in the Recovery Plan for the Australian Sea Lion (DSEWPC 2013a) • Australian sea lions continue to forage within foraging BIAs • Prey species (i.e. western rock lobster, octopus and cuttlefish) remain available within foraging BIA with impacts limited to temporary and localised (within 3 km of moving array) behavioural disturbance • No population level effects.
Commercial and recreational fisheries	• ASA reduced to as small an area as possible to minimise overlap with habitats for adult rock lobster, but some habitat overlap is acceptable • Stakeholder concerns/objections received have been merit assessed and changes to survey activity have been adopted or control measures developed to address merited concerns/objections, where required. No outstanding merited concerns that are not being addressed • Some short-term disruption of fishers with fixed equipment within the ASA (i.e. WRL and octopus fishers) is acceptable • Some short-term displacement of other commercial and recreational fishing activities from the Safe Navigation Area (SNA) during seismic acquisition is acceptable • No ongoing impact on catchability as fishes/invertebrates predicted to recover in the short-term after survey completion.
Protected areas and KEFs	• No impacts on the values of the Abrolhos Marine Park • No impacts on the values of the Jurien Marine Park • No impacts on the values of the Western rock lobster KEF • No impacts on the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons.
Tourism and recreation	• No long-term impacts on local tourism and recreational activities (e.g. Diving, snorkelling, spearfishing, sea lion tours) • Some short-term disruption during seismic acquisition is acceptable.
Relevant persons	• Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/ objections, where required. No outstanding merited objections or claims.

7.1.3 Sound metric terminology

7.1.3.1 Sound levels and the decibel scale

The decibel (dB) scale is used to measure the amplitude or ‘loudness’ of a sound wave. For underwater sounds, the dB scale is denoted relative to the reference pressure of 1 micropascal (μPa) e.g. dB re 1 μPa, whereas the reference pressure level used in air is 20 μPa, which was selected to match human hearing sensitivity. Because of these differences in reference standards, dB sound levels in air are not comparable to underwater sound levels i.e. dB sound levels underwater are much quieter than the same dB sound levels in air (Carroll et al. 2017).

7.1.3.2 Sound metrics

Marine seismic surveys emit pulses of underwater sound. These sounds are termed ‘impulsive’ sounds as they are brief and intermittent with rapid rise times and decay back to ambient levels (within a few seconds).

There are four main metrics used to measure and describe underwater sound pressure and energy that are applied to the assessment of these types of sound, all of which use the decibel scale (adapted from ISO/DIS 18405.2:2017):

- Zero-to-peak sound pressure (PK), the greatest magnitude of the sound pressure during a specified time interval (Figure 7-1); unit: db re 1 µpa; PK levels are relevant to the assessment of potential physical injury and impairment impacts to marine fauna and biota resulting from a single seismic pulse
- Peak-to-peak sound pressure (PK-PK), sum of the peak compressional pressure and the peak rarefactional pressure during a specified time interval (approximately double the zero-to-peak pressure) (Figure 7-1); unit: db re 1 µpa; PK-PK levels, like PK levels, are relevant to the assessment of potential physical injury and impairment impacts to marine fauna and biota resulting from a single seismic pulse
- Root-mean-square sound pressure level (SPL), the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure over the duration of an acoustic event (i.e. the duration of a single seismic pulse) (Figure 7-1); unit: db re 1 µpa; because the SPL represents the effective sound pressure over the full duration of the acoustic event rather than the maximum instantaneous peak pressure, it is regularly used to represent the effective loudness of a sound and to assess the potential for a behavioural response from marine fauna
- Sound exposure level (SEL), a measure related to the sound energy (instead of the sound pressure) in one or more pulses, or the ratio of the time-integrated squared sound pressure to the specified reference value; unit: db re 1 µpa^2·s; SEL is specified in terms of either a per-pulse SEL or an accumulated SEL (sel_{cum}) from multiple pulses over a given period. SEL recognises that the effects of sound can be a function of exposure duration as well as maximum instantaneous peak pressure. SEL can therefore be considered a dose-type measurement with sel_{cum} being used to assess dose-type impacts such as the potential for the gradual onset of temporary threshold shift (TTS) in marine fauna hearing because of prolonged exposure to high sound levels. It is standard practice for sel_{cum} to be assessed over a summation period of 24-hours (SEL_{24h}).

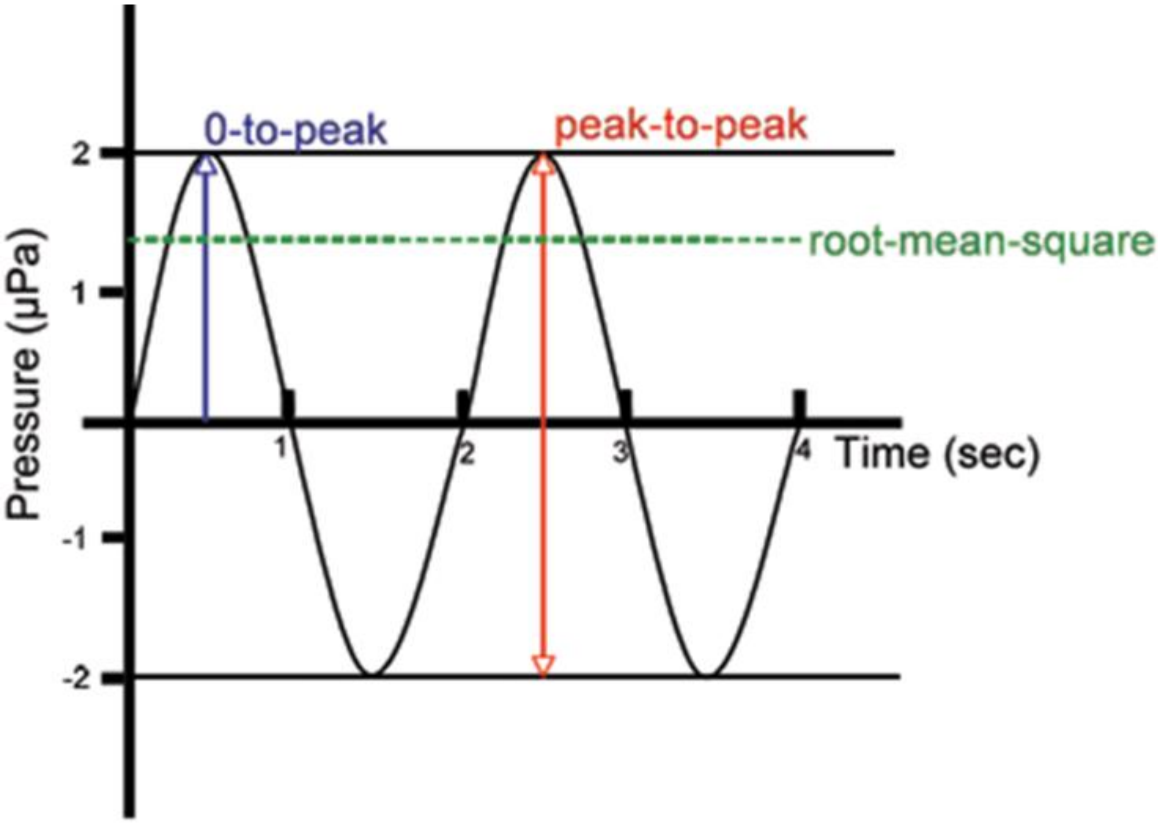


Figure 7-1: Simplified sound wave and sound pressure metrics (DOSITS[1])

7.1.3.3 Particle motion

The particle motion component of sound is also relevant to the assessment of potential impacts to marine fauna. Acoustic particle motion refers to the physical motion caused by a sound wave within the water, seabed or other medium. Unlike pressure, particle motion is directional in nature, although the actual to-and-fro particle displacements that constitute sound are extremely small, in the order of nanometres (Popper & Hawkins 2018). Particle motion can be described in terms of particle displacement (m), velocity (m/s), or acceleration (m/s^2) (Popper et al. 2014; Carroll et al. 2017). Alternatively, it is sometimes expressed in dB with respect to a reference value of displacement (dB re 1 pm), velocity (dB re 1 nm/s) or acceleration (dB re 1 $\mu m/s^2$) (Nedelec et al. 2016).

Particle motion is important because marine invertebrates and most fishes are primarily sensitive to particle motion rather than sound pressure and, therefore, particle motion is the most relevant metric for perceiving underwater sound by invertebrates and most fish species (Popper & Hawkins 2019). However, there is currently limited information available to quantify the particle motion sensitivity of fishes and invertebrates. It is complex and challenging to directly measure particle motion compared to sound pressure, hence most research is presented in the context of sound pressure or exposure levels instead of particle motion (Carroll et al. 2017; Popper & Hawkins 2018). Therefore, while the assessment of underwater noise impacts in this EP considers the role of particle motion and its effect on fishes and invertebrates, the acoustic modelling and impact threshold criteria are based upon sound pressure and sound exposure metrics.

It should be noted that particle motion is most relevant close to the source where it is the dominant component of a sound wave, while pressure will dominate a sound wave propagating over distance (Radford et al. 2012; Morley et al. 2014; Nedelec et al. 2016; Popper & Hawkins 2018). Sound pressure levels received at increasing distance from a source do not, therefore, provide a reliable representation of particle motion. Organisms that are sensitive only to particle motion have typically been found to be sensitive only at close range where these particle motions are greatest (Popper et al. 2014; Edmonds et al. 2016; Popper & Hawkins 2018).

7.1.3.4 Sound frequency and hearing sensitivity

Different animals are sensitive to different sound frequencies, which are measured in hertz (Hz) and kilohertz (kHz). Therefore, if an animal is sensitive to a particular frequency range, a sound in that frequency range will seem louder to that animal than to a different animal which is less sensitive to those frequencies. For example, some large baleen whales are sensitive to very low frequency sounds (7 Hz to 35 kHz), while other toothed whales and dolphin species are considered more sensitive to mid-high frequency sounds (150 Hz to 160 kHz) with their peak hearing frequency somewhere between these frequency ranges (NMFS 2018). Therefore, how loud a sound will be perceived will differ between species.

In some cases, a sound level is specified relative to a given frequency range or is weighted according to the auditory sensitivity of an animal (e.g. low-frequency, medium-frequency and high-frequency groups of cetaceans). This has the advantage of placing the sound into a more biologically relevant context for that animal. If a frequency range or weighting is not specified, the frequency of the sound is generally referred to as “broadband” sound i.e. the sound level accounts for sound across all frequencies, noting again that a particular animal may not be able to detect all of the sound frequencies and associated energy that are emitted.

Therefore, the frequency of a sound and how sensitive different animals are to sound can make a considerable difference to how loud the sound is perceived to be and any resultant impact.

7.1.4 Acoustic modelling

To assess the potential magnitude and extent of impacts from underwater noise produced during the Eureka 3D MSS, Pilot commissioned JASCO Applied Sciences (JASCO) to model sound propagation at several locations that were representative of the different water depths, bathymetry and seabed properties within the ASA (Koessler & McPherson 2023; Appendix G).

The objective of this acoustic modelling study was to evaluate the potential effects of sound on marine fauna including marine mammals, turtles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial and recreational fisheries and divers.

Two nominal acquisition scenarios were considered using both acoustic propagation modelling. Acoustic source and propagation modelling was conducted at six individual single pulse sites. The single pulse sites and the accumulated SEL scenarios were determined based on proposed survey line plans with lines orientated either at 0/180°. The locations of the modelled sites are provided presented in Figure 7-2. This study considered a 2495 in^3 seismic source towed in a double array configuration at an assumed speed of ~4.5 knots with an impulse interval (inter-pulse interval) of 12.5 m and a crossline array separation of 50 m. The acoustic propagation modelling utilised an August sound speed profile as resulted in worst-case propagation conditions (i.e. longer propagation ranges) and can therefore be regarded as ‘worst-case’ for the proposed acquisition time period (February–March) for the survey.

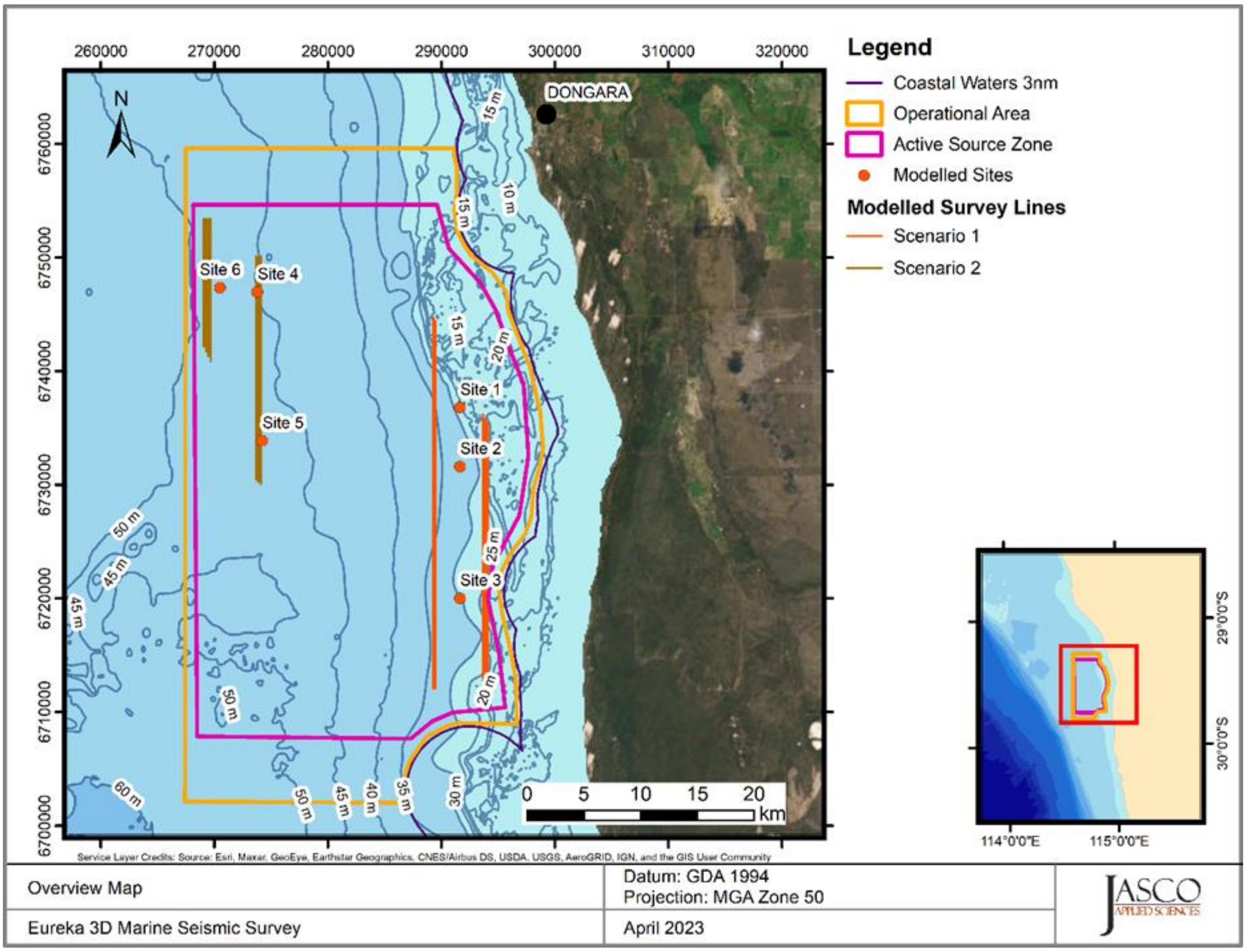


Figure 7-2: Overview of key survey features, modelling locations and the two survey scenarios

The single impulse sites and accumulated SEL scenarios were chosen to be representative of the range of water depths and the potential sound propagation characteristics within the ASA. Sea floor sound levels were assessed at eight different representative water depths within the ASA (10, 12.5, 15, 20, 25, 30, 40, and 50 m).

Contours of the modelled underwater sound fields were computed, sampled either as the maximum value over all modelled depths (maximum-over-depth: MOD) or at the sea floor for the six single pulse locations, and for the two cumulative SEL_{24h} scenarios. The modelled distances to each of the sound exposure thresholds for marine fauna were computed from these contours. Two distances relative to the source are reported for each sound level:

- R_{max} – the maximum range to the given sound level over all azimuths
- $R_{95\%}$ – the range to the given sound level after the 5% farthest points were excluded.

The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment. In some environments a sound level contour might have small anomalous isolated fringes in which case the use of R_{max} can misrepresent the area of the region exposed to such effects. In these instances, $R_{95\%}$ is considered more representative. In environments that have bathymetric features that affect sound propagation then the $R_{95\%}$ may neglect to account for these and therefore R_{max} might better represent the region of effect in specific directions. For this impact assessment the R_{max} values have been considered. In many of the impact assessments, the maximum R_{max} values resulting from the various modelling sites have been referenced (unless specified) which provides a further level of conservatism to the assessment.

The results of the acoustic modelling are presented in relation to the sound exposure thresholds relevant to each receptor group assessed below. The detailed results are provided in the acoustic modelling report (Koessler & McPherson 2023; Appendix G).

7.1.4.1 Animal movement and exposure modelling (animat modelling)

In addition to the propagation modelling outlined above, Pilot commissioned JASCO to perform an acoustic exposure analysis study for pygmy blue whales (*Balaenoptera musculus brevicauda*) within the migration and foraging BIAs to investigate any potential effects on pygmy blue whale northbound migration and foraging from the Eureka 3D MSS, based on use of the 2495 in^3 source with a 12.5 m shotpoint interval.

The ASA is adjacent to the known foraging BIA for pygmy blue whales, as well as to the pygmy blue whale migratory BIA (Figure 4-11 and Figure 4-12). Therefore, animat modelling was undertaken for both foraging and migrating behaviours. Fine-scale data on foraging behaviour are not currently available for pygmy blue whales. Therefore, data from multi-sensor tags deployed on blue whales (*B. musculus*) in the North Pacific were used to inform the feeding behaviours. Using intermediate-duration archival tags (SPLASH MK10) attached to eight blue whales off the coast of California, Irvine et al. (2019) determined two primary feeding behaviours: shallow and deep feeding. These two feeding behaviours differed between male and female blue whales, with females generally diving deeper than males during both shallow and deep feeding. In order to account for these differences, foraging female and male pygmy blue whales were modelled separately, with values derived from Irvine et al. (2019). The remaining parameters for feeding behaviour were primarily sourced from Goldbogen et al. (2011), who deployed 25 multi-sensor suction cup tags (DTAGs) on blue whales off the coast of California. The exceptions were the values for travel speed, which was derived from satellite tags deployed on pygmy blue whales off southern Australia (Möller et al. 2020), and surface interval, which was derived from a satellite tag deployed on a pygmy blue whale off western Australia (Davenport et al. 2022).

The migratory pygmy blue whale behaviour profile was not split by gender as there is no evidence for sex related differences in migratory behaviour. The migratory profile included both migratory and exploratory dives (i.e. shallow dives with no indication of feeding) based on detailed information from Owen et al. (2016), who equipped a sub-adult pygmy blue whale with a multi-sensor tag off Western Australia. Migrating pygmy blue whales were not modelled undertaking feeding behaviour, as per the findings of Owen et al. (2016). In the migratory profile, the two dive types were modelled together such that the animats were migrating 95% of the time and engaged in exploratory dives 5% of the time (Owen et al. 2016). Using data from Owen et al. (2016), the approximate length of a bout of exploratory dives could be determined, as well as the average (±SD) depth of this dive type. The analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. The mean depth of migratory dives was 14 ± 4 m while the mean maximum depth of exploratory dives was 107 ± 81 m. Additional parameters regarding pygmy blue whale behaviour were derived from sources that used multi-sensor tags to record fine-scale dive and movement data (Owen et al. 2016; Möller et al. 2020). Where information was unavailable for pygmy blue whales, parameters were derived from blue whale tagging data (Goldbogen et al. 2011), as per the foraging profile.

The behaviour of migrating pygmy blue whales was modelled to reflect animats transiting through the modelling area on a 334° track during the northbound migration. This represents the animals migrating along the west coast of Australia to Indonesia (Double et al. 2014). The speed of travel for migratory behaviour (1.17 ± 0.60 m/s) and exploratory dives (0.88 ± 0.14 m/s) were calculated from data presented in Möller et al. (2020).

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats to sound arising from the seismic activity. JASMINE integrates the predicted sound field with biologically meaningful movement rules for each marine mammal species (pygmy blue whales for the current analysis) that results in an exposure history for each animat in the model. In JASMINE, the sound received by the animats is determined by the proposed seismic operations. Animats are programmed to behave like the marine animals that may be present in an area. The parameters used for forecasting realistic behaviours (e.g. diving and foraging depth, swim speed, surface times) are determined and interpreted from marine mammal studies (e.g. tagging studies) where available, or reasonably extrapolated from related or comparable species. For cumulative metrics, an individual animats sound exposure levels (SEL) are summed over a 24-hour duration to determine its total received energy, and then compared to the relevant threshold criteria. For single-exposure metrics, the maximum exposure is evaluated against threshold criteria for each 24-hour period.

The exposure criteria for impulsive sounds (described in Koessler & McPherson 2023) were used to determine the number of animats that exceeded thresholds. To generate statistically reliable probability density functions, model simulations were run with animat sampling densities of four animats per square kilometre. The modelling results are not related to real-world density estimates for pygmy blue whales within

BIAs or known core range area, as the density of animals is not known. To evaluate PTS and TTS, exposure results were obtained using detailed behavioural information for pygmy blue whales (refer above).

The seismic source was modelled as a vessel towing an airgun array at a speed of 4.5 knots, with an impulse interval of 12.5 m. The simulated source tracks followed a racetrack configuration with no acquisition occurring during turns. At the time and location of each seismic pulse, the modelled source location with the closest distance was selected for exposure modelling. The track lines, along with the acoustic modelling locations, are shown in Figure 7-2 above (Scenario 2).

The results from the animal movement and exposure modelling provided a way to estimate radial distances to effect thresholds. The distance to the closest point of approach (CPA) for each of the animats was recorded. The $ER_{95\%}$ (95% Exposure Range) is the horizontal distance that includes 95% of the animat CPAs that exceeded a given effect threshold. Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed threshold criteria. This occurs for several reasons, including the spatial and temporal characteristics of the sound field and the way in which animats sample the sound field over time, both vertically and horizontally. The sound field varies as a function of range, depth, and azimuth based on a variety of factors such as bathymetry, sound speed profile, and geoacoustic parameters. The way the animats sample the sound field depends upon species-typical swimming and diving characteristics (e.g. swim speed, dive depth, surface intervals, and reversals). Furthermore, even within a particular species definition, these characteristics vary with behavioural state (e.g. feeding, migrating). As this results in some animats not exceeding threshold criteria even within the $ER_{95\%}$, the probability that an animat within that distance was exposed above threshold within the $ER_{95\%}$ was also computed (Pexp) to provide additional context.

Acoustic ranges are reported for both $R_{95\%}$ and R_{max} (see Appendix D, Koessler & McPherson 2023), however, exposure ranges are reported for $ER_{95\%}$ only since, statistically, ER_{max} is not defined. JASMINE is a Monte Carlo simulation, and the results are probabilistic in nature. This is in contrast with acoustic modelling, where there is a specific maximum isopleth range for a given source/environment set-up.

7.1.4.2 Marine fauna noise effect criteria

The underwater noise effect criteria that have been used to predict the impact ranges (distances from the source) for injury and/or disturbance to marine fauna, include peer-reviewed and accepted thresholds and guideline levels based on the best available science for received sound levels. These criteria cover a range of effects from behavioural disturbance to injury or physiological damage. In the absence of peer-reviewed or recognised criteria, such as for plankton and some invertebrates, the modelling has used reported effects levels from scientific publications. In the absence of directly relevant criteria for some taxa, conservative criteria have been adopted on the basis of international convention and from pile-driving impact studies, which are based on extended exposure to high intensity sound pulses and make no allowance for the receptor to leave the area if the sound level becomes uncomfortable.

7.1.5 Impact analysis and evaluation

This section describes the impacts that may occur on significant marine environmental receptors identified in Section 4 that are known to be sensitive to underwater sound discharges from seismic airgun arrays. This part of the impact assessment method is described in Section 6. Each of the subsequent sections then undertakes the impact analysis as defined in Section 6.

Sensitive receptors/ values	Review of the environmental resources described in Section 4, indicates that discharge of the acoustic source in the Eureka 3D MSS ASA has the potential to affect adversely the following environmental receptors, values and sensitivities, to varying degrees: • Plankton (including fish and benthic invertebrate eggs and larvae) • Benthic invertebrates • Fishes and elasmobranchs • Fish spawning • Transient marine turtles • Marine mammals (whales, dolphins, pinnipeds) • Seabirds • Commercial and recreational fisheries • Tourism and recreation (diving, snorkelling, spearfishing, sea lion tours).
Potential impacts	Potential environmental impacts to these environmental receptors include: • Physical injury to auditory tissues or other air-filled organs • Hearing loss; either temporary threshold shift (TTS) or permanent threshold shift (PTS) • Direct behavioural effects through disturbance or displacement and consequent disruption of natural behaviours or processes, e.g. Migration, feeding, resting, calving • Indirect behavioural effects by impairing/masking the ability to navigate, find food or communicate or by affecting the distribution or abundance of prey species • Indirect effects on the catchability of commercial fish stocks. The area over which seismic sound may adversely impact marine species depends upon multiple factors including the extent of sound propagation relative to the location of receptors, and the sensitivity and range of spectral hearing of different species (Slabbekoorn et al. 2010; Hawkins & Popper 2012). The potential for impact on individual animals depends on a number of factors, including the presence of the animal during the survey period, its proximity to the noise source, its ability to avoid the sound field generated by the airgun array, its specific physiological tolerance and the overlap between its hearing range and the seismic frequency range. Most of the sound energy of the seismic airgun pulses is in the low frequency range of 10 to 200 Hz (McCauley 1994; OGP/IAGC 2011). The marine species most at risk from the low frequency acoustic emissions from seismic operations within the OA are cetaceans, particularly baleen whale species that hear and communicate in a similar low frequency range.

7.1.5.1 Zooplankton

Species sensitivity and sound exposure thresholds

Plankton is a collective term for all marine organisms that are unable to swim against a current. This group is diverse and includes phytoplankton (plants) and zooplankton (animals), as well as fish and invertebrate eggs and larvae, including coral eggs and larval stages. There is no scientific information on the potential for noise-induced effect in phytoplankton and no functional cause-effect relationship has been established. Noise-induced effects on zooplankton, such as copepods, cladocerans, chaetognaths and euphausiids, have been investigated in a number of sound exposure experiments.

Zooplankton includes invertebrate and fish eggs and larvae that are transported by currents and winds and hence cannot take evasive behaviour to avoid seismic sources. With respect to the Eureka 3D MSS, key spawning areas for commercially targeted fish species (assessed under “Fish spawning” below) have been identified as areas where zooplankton populations may be more important.

Larval fish species studied appear to have hearing frequency ranges similar to those of adults and similar acoustic startle thresholds (Popper et al. 2014). Swim bladders may develop during the larval stage and may render larvae susceptible to pressure-related injuries such as barotrauma. Effects of sound upon eggs, and larvae containing gas bubbles, is focused on barotrauma rather than hearing (Popper et al. 2014). Larval stages are often considered more sensitive to stressors than adult stages, but exposure to seismic sound reveals no differences in larval mortality or abundance for fish, crabs or scallops (Carroll et al. 2017).

Parry et al. (2002) studied the abundance of plankton after exposure to airgun sounds but found no evidence of mortality or changes in catch-rate at a population-level. Other studies have also noted limited negative impacts on zooplankton, fish eggs, larvae or fry, and most have reported that impacts occur within a few metres or tens of metres from the source (Kostyuchenko 1973; Dalen & Knutsen 1987; Holliday et al. 1987; Kosheleva 1992; Pearson et al. 1994; Turnpenny & Nedwell 1994; Booman et al. 1996; Payne 2004; Payne et al. 2009). These studies included exposures to sound pressures up to approximately 242 dB re 1 μPa, comparable to those predicted in close range to the Eureka 3D MSS seismic source. Based on these studies, physical impacts to planktonic organisms have typically been found to be limited to within approximately 10 m of the seismic source.

Using this 10 m impact range, a study by McCauley (1994) calculated the impact in a seismic survey area, assuming plankton mortality of 100% within 10 m of a seismic source. This suggested that the total mortality due to seismic testing would impact less than 1% of plankton in the survey area. DNV Energy (2007) and Hawkins & Popper (2012) conducted comprehensive reviews of a number of scientific studies, including those by Kostyuchenko (1973), Dalen & Knutsen (1987), Booman et al. (1996) and Sætre & Ona (1996); the effects of seismic activities on eggs and larvae were predicted to result in average and worst-case mortality rates of 0.0012% and 0.45% per day respectively, which were not deemed significant when compared to a natural mortality rate of 5–15% per day, as applicable to most species during early life stages. Natural mortality rates in larvae can be much higher than this — exceeding 50% per day in some species and commonly exceeding 10% per day (Tang et al. 2014). For example, in a review of mortality estimates (Houde & Zastrow 1993), the mean mortality rate for marine fish larvae was M = 0.24, a rate equivalent to a loss of 21.3% per day.

Impacts to scallop larvae have been identified following intense and lengthy periods of exposure to low-frequency sound. Tank experiments by Aguilar de Soto et al. (2013) showed evidence of morphological abnormalities in early-stage scallop larvae from simulated seismic signals for a 6920 in^3 seismic source. However, the lengthy exposure period of three second pulse intervals for an exposure duration of 90 hours and at 1 m distance from sound source is not realistic of an actual survey. Christian et al. (2003) found major developmental differences between control and treatment groups of snow crab eggs exposed to a peak pressure level of 216 dB SPL every 10 seconds for 33 minutes. Again, the exposure to a constant peak pressure level for a prolonged period is not realistic of an actual survey where the source is moving and so does not remain in one place.

Hawkins (2014) used continuous sonar to record zooplankton layers, comprising copepods, cladocerans, decapod larvae, gastropod larvae, and bivalve larvae, exposed to playback of pile driving sound (pile driving sound typically has a more rapid rise time, more frequent strike rates and therefore a greater sound exposure regime than a seismic survey). Zooplankton layers responded to sound by showing a ‘dent’ in the top of the layer at the onset of the sound sequence, although the change in depth often did not persist for the whole duration of the sound exposure and zooplankton distribution quickly returned to normal.

Day et al. (2016a, 2016b) found no effects on the mortality, abnormality, competency, or energy content of lobster larvae after exposure of early embryonic stages to seismic exposure. In this study, egg-bearing female southern rock lobsters (*Jasus edwardsii*) were exposed to signals from three airgun configurations, all of which exceeded SEL of 185 dB re 1 $\mu Pa^2 \cdot s$ (209-212 dB PK-PK). Lobsters were maintained until their eggs hatched and the larvae were then counted for fecundity, assessed for abnormal morphology using measurements of larval length and width, tested for larval competency using an established activity test and measured for energy content. Overall, there were no differences in the quantity or quality of hatched larvae, indicating that the condition and development of spiny lobster embryos were not adversely affected by airgun exposure. Day et al. (2016a, 2016b) detailed that the results suggest that embryonic spiny lobster are resilient to airgun signals and highlight the caution necessary in extrapolating results from the laboratory to real world scenarios or across life history stages.

McCauley et al. (2017) found that after exposure to airgun sounds generated with a single airgun (150 in^3) zooplankton abundance decreased and mortality in adult and larval zooplankton increased two-to three-fold when compared with controls. In this large-scale field experiment on the impact of seismic activity on zooplankton, a sonar and net tows were used to measure the effects on plankton, and a maximum effect-range of horizontal 1.2 km was determined. The findings contradicted the conventional idea of limited and very localised impact of intense sound in general, and seismic airgun signals in particular, on zooplankton, with the results indicating that there may be noise-induced effects on these taxa and that these effects may even be negatively affecting ocean ecosystem function and productivity.

The study measured zooplankton abundance and the proportion of the population that was dead at three distances from a single 150 in^3 airgun - 0, 200 and 800 m. The experiment estimated the proportion of the zooplankton that was dead, both before and after exposure to airgun noise, using net samples to measure zooplankton abundance, and bioacoustics to identify the distribution of zooplankton. In this study, copepods dominated the mesozooplankton (0.2–20 mm), and impacts were not assessed on microzooplankton (0.02–0.2 mm) or macrozooplankton (>20 mm). However, there was movement of water through the experimental area, which made interpreting their results more difficult (Richardson et al. 2017).

McCauley et al. (2017) provide three findings from the experiment to show that zooplankton were affected by the seismic source:

- The proportion of the mesozooplankton community that was dead increased two- to three-fold
- The abundance of zooplankton estimated by net samples declined by 64%
- The opening of a "hole" in the zooplankton backscatter observed via acoustics.

They found that exposure to airgun noise significantly decreased zooplankton abundance and increased the mortality rate from a natural level of 19% per day to 45% per day (on the day of exposure, and that these impacts were observed out to the maximum range assessed (1.2 km) (Richardson et al. 2017).

Scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Oceans and Atmosphere Business Units were contracted by APPEA to undertake a desktop study that: a) critically reviewed the methodologies and findings of the McCauley et al. (2017) experiment; and b) simulated the large-scale impact of a seismic survey on zooplankton in the North West Shelf region, based on the mortality rate associated with airgun noise exposure reported by McCauley et al. (2017).

The CSIRO review of the McCauley et al. (2017) study found that there were three primary questions raised by the results of the experiment, all of which warrant further investigation (Richardson et al. 2017):

1. Why was there no attenuation of the impact with distance? There is no consistent decline in the proportion of zooplankton that are dead with increasing distance away from the airgun. The energy of the sound waves at a distance of 1.2 km is substantially lower than at the source.
2. Why was there an immediate decline in abundance? It is unclear why there would be a near immediate drop in zooplankton abundance as measured by net samples and acoustic data. If zooplankton were killed, they would not immediately sink from the surface layers, or be rapidly eaten. A drop in abundance would be more likely once the dead zooplankton either sunk to the bottom or were removed by predation. Richardson et al (2017) conclude it is difficult to explain this immediate decline in zooplankton abundance.
3. Was there sufficient replication to be confident in the study findings?

The conclusions were based on a relatively small number of zooplankton samples. A total of 24 samples were collected – two tows each sampling time × three distances from the gun (0 m, 200 m, 800 m) × two levels (Control, Exposed) × two replicate experiments (Day 1, Day 2). This means that there were only 12 samples collected under conditions exposed to the airgun, six on each day of the two experiments. The main potential confounding explanation in the study would be that a different water mass entered the area on each day of the experiment and had lower abundance and higher quantities of dead zooplankton. Richardson et al. (2017) conclude that: "although this is relatively unlikely it cannot be discounted because of the relatively few samples collected and only two replicate experiments conducted".

Independently of the APPEA/CSIRO study, the International Association of Geophysical Contractors (IAGC) conducted its own review of the McCauley et al. (2017) paper. This review came to the following conclusion: "While we found the study interesting, we are also troubled by the small sample sizes, the large day-to-day variability in both the baseline and experimental data, and the large number of speculative conclusions that appear inconsistent with the data collected over a two-day period. Both statistically and methodologically, this project falls short of what would be needed to provide a convincing case for adverse effects from geophysical survey operations." (IAGC 2017).

The second component of the CSIRO study was to estimate the spatial and temporal impact of seismic activity on zooplankton on the North West Shelf from a large-scale seismic survey, considering mortality estimates of McCauley et al. (2017), and accounting for typical growth rates, natural mortality rates, and the ocean circulation in the region The approach modelled a hypothetical 3D survey (2900 km^2 in size, over a 35-day period, in water depths of 300–800 m) on the edge of the North West Shelf during summer. To simulate the movement of zooplankton by currents, the researchers used a hydrodynamic model that seeded 0.5 million particles into CSIRO's Ocean Forecast Australia Model. Zooplankton particles could be hit multiple times by airgun pulses if they were carried by currents into the future survey path. The greatest limitation in this approach was accurate knowledge of the natural growth and mortality rates of zooplankton, and to address this the CSIRO researchers tested the sensitivity of the model to different recovery (growth-mortality) rates, and also the sensitivity of the results to ocean circulation by undertaking simulations with and without water motion (Richardson et al. 2017).

The results of the simulations that included ocean circulation showed that the impact of the seismic survey on zooplankton biomass was greatest in the Survey Region (defined as the survey acquisition area with a 2.5 km impact zone around it) (22% of the zooplankton biomass was removed) and declines as one moves beyond it to the Survey Region + 15 km (14% of biomass removed), and the Survey Region + 150 km (2% of biomass removed). The time to recovery (to 95% of the original level) for the Survey Region and Survey Region + 15 km recovery was 39 days (38-42 days) after the start of the survey and three days (2–6 days) after the end of the survey (Richardson et al. 2017).

The major findings of the CSIRO study were that there was substantial impact of seismic activity on zooplankton populations on a local scale within or close to the survey area, however, on a regional scale the impacts were minimal and were not discernible over the entire North West Shelf bioregion. Additionally, the study found that the time for the zooplankton biomass to recover to pre-seismic levels inside the survey area, and within 15 km of the area, was only three days following the completion of the survey. This relatively quick recovery was due to the fast growth rates of zooplankton, and the dispersal and mixing of zooplankton from both inside and outside of the impacted region (Richardson et al. 2017).

CarbonNet (2018) assessed zooplankton communities in Australia's Gippsland Basin before and after a seismic survey. Ten sites were sampled during the pre-survey period, consisting of six sites occurring within the survey area and four reference sites. During the post-survey period, three sites were sampled near the survey line, as well as three reference sites. Post-survey sampling occurred within three days of acquiring the last survey line. Copepods, cladocerans and salps dominated the pre-survey samples, whereas the dinoflagellate *Noctiluca scintillans* dominated the post-survey samples. There was a high level of variance among samples and no lobster or scallop larvae occurred in any of the samples. Mortality rates were high in both pre- and post-survey samples and the high proportion of dead cladocerans was contributed to their delicate structure being destroyed by the sampling process rather than attributable to any MSS impacts.

A study by Fields et al. (2019) exposed zooplankton (copepods) to seismic pulses at various distances up to 25 m from a seismic source. The source levels produced were estimated to be 221 dB re $\mu Pa^2 \cdot s$. The study observed an increase in immediate mortality rates of up to 30% of copepods in samples compared to controls at distances of 5 m or less from the airguns. Mortality one week after exposure was significantly higher by 9% relative to controls in the copepods placed 10 m from the airguns. Fields et al. (2019) also reported no sub-lethal effects of seismic exposure to the copepods. The findings of the study are consistent with numerous other field studies, as referenced previously, indicating that the potential effects of seismic pulses to zooplankton are limited to within approximately 10 m from the seismic source. Fields et al. (2019) note that the findings of the McCauley et al. (2017) study are difficult to reconcile with the body of other available research. The findings of the McCauley et al. (2017) study may, therefore, provide an overly conservative estimate of the potential effects of seismic pulses to zooplankton.

Day et al. (2021, 2023) undertook a study to determine whether early development and recruitment of southern rock lobsters puerulus and juveniles might be affected by exposure to seismic sound by assessing mortality rates following exposure; impairment of the righting reflex, and development through assessment of progression through the moult cycle. This study also undertook to respond to the finding by McCauley et al. (2017) of increased mortality in zooplankton following exposure to airgun signals that suggests that planktonic, early life stages of marine invertebrates may be more vulnerable than adults or developing embryos. Outcomes of this study are detailed in the section below on crustaceans.

Vereide et al. (2023) conducted a field experiment to assess mortality and naupliar body length of the calanoid copepod *Acartia tonsa* when exposed to the discharge of two 40-inch airguns nauplii were placed in plastic bags and attached to a line at a depth of 6 m, and at a distance of 50 m from the nearest transect line. For each treatment, three bags of nauplii were exposed to one of three treatments for 2.5 hours: Airgun array discharge, a boat control, or a silent control. After exposure, nauplii were kept in filtered seawater in the laboratory without food. Immediate mortality in the nauplii was approximately 14% compared to less than 4% in the silent and boat control. Similarly, there was higher mortality in the airgun exposed nauplii up to six days after exposure compared to the control treatments. Nearly all of the airgun exposed nauplii were dead after four days, while >50% of the nauplii in the control treatments were alive at six days post-exposure. There was an interaction between treatment and time on naupliar body length, indicating lower growth in the nauplii exposed to the airgun discharge (growth rates after four days: 1.7, 5.4, and 6.1 $\mu m\ d^{-1}$ in the airgun exposed, silent control, and boat control, respectively). These experiments indicate that the output of two small airguns affected mortality and growth of the naupliar stages of *Acartia tonsa* in close vicinity to the array (50 m).

Vereide et al. (2023) concluded:

- The results of this study suggest that airgun array discharges affected the growth and mortality of *Acartia tonsa* in early naupliar stages. However, the degree of impact is likely to be stage- and species-specific and may be difficult to separate from background mortality.
- The results observed are consistent with many previous studies that show small effects of airgun discharges on zooplankton mortality. For example, no effects were detected in bivalve larvae sampled 2 km away from the source after exposure to airgun discharges (Parry et al. 2002) or in adult scallops sampled up to 1 km from the source shortly after exposure (Harrington et al. 2010). Similarly, Fields et al. (2019) reported that the mortality of the copepod *Calanus finmarchicus* adults to a two-airgun array discharge increased (<5%) compared to that of the control groups, but only at <10 m from the airguns and no effects at distances from 10 to 50 m.
- There were notable differences in these results from previous studies. For example, in contrast to Fields et al. (2019), this study found significantly higher mortality in the exposed animals compared to the controls at distances of 50–~1,200 m. Although the sound exposure levels were higher in Fields et al. (2019) than those in this study, the animals in this study were exposed to multiple airgun discharges that resulted in a cumulative exposure that lasted much longer. The cumulative exposure of multiple blasts coupled with the younger stage used in this study may help to explain the higher mortality.
- Despite the higher mortality, the immediate mortality observed in this study is much lower than the 50% mortality in zooplankton at >1 km from the source (McCauley et al. 2017). Even though the absolute immediate mortality was lower than that reported by McCauley et al. (2017), the relative increase in mortality compared to the controls was somewhat greater in this study (greater than three-fold increase) than in McCauley et al. (2017) (two-to three-fold increase). However, in McCauley et al. (2017), the mortality in the controls was ~20% compared to less than 4% in this study.
- In this study, the mortality rate in nauplii directly after exposure was lower than the natural mortality rates observed in *Acartia* nauplii (up to 0.35 per day), although this is dependent on temperature, season, and region (Elliott & Tang 2011). This indicates that the population-level effect of airgun exposure might not be detectable from the background mortality.
- The airgun array exposed nauplii grew less and developed slower over four days than the boat and silent control groups. The slower development in the airgun array treatment nauplii was correlated with decreased growth. The progression through developmental stages and increase in body length observed in the control groups in this study is more similar to the development of naturally observed in *Acartia tonsa* nauplii cultured in 10–15°C water than is the development in the airgun array exposed nauplii. Slowed or arrested development at naupliar stages can reduce fitness or cause death. Thus, mortality could be affected long after seismic exposure. The population-level effects that this might have are uncertain.

Guideline thresholds for mortality to eggs and larvae have been proposed based on the sound exposure guidelines by the ANSI-Accredited Standards Committee S3/SC 1, Animal Bioacoustics Working Group (Popper et al. 2014). These guidelines represent the Working Group's efforts to establish broadly applicable guidelines for ichthyoplankton (fish eggs and larvae). The criteria that Popper et al. (2014) suggest for mortality in eggs and larvae are based on levels measured in the study by Bolle et al. (2012) that indicated no damage was caused by simulated repeated pile driving at 207 dB re 1 µPa SPL_{peak} or 210 dB re 1 µPa SEL_{cum}.

Impact assessment

For this impact assessment the sound exposure thresholds for mortality/potential mortal injury (PMI) to fish eggs and larvae from Popper et al. (2014) were applied and consider both PK and SEL_{24h} metrics (Table 7-3). The thresholds were based on limited data and were selected on the basis that Popper et al. (2014) note that they are likely to be conservative. While research generally suggests limited impacts to plankton beyond approximately 10 m distance from seismic sources, the precautionary Popper et al. (2014) thresholds for larval mortality / PMI have been selected to indicate the magnitude and extent of potential impacts from acquisition of the survey.

Table 7-3: Maximum predicted distances (R_{max}) to mortality/PMI thresholds in the water column for fish eggs and larvae, and zooplankton

Sound exposure threshold	R_{max} distance (km)
210 dB re 1 µPa².s (SEL_{24h})	0.06
207 dB re 1 µPa (PK)	0.27

As shown in Table 7-3, the maximum distance (R_{max}) to mortality/PMI thresholds for fish eggs and larvae, and zooplankton, applying the single pulse (PK) threshold from Popper et al. (2014) was 270 m.

Any potential mortality/PMI impacts to zooplankton communities have to be assessed in the context of natural mortality in these populations. Any mortality or mortal injury effects to zooplankton (including fish eggs and larvae) resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates, which are very high — refer discussion above.

The magnitude of such localised impacts is negligible and is not expected to be discernible at the regional scale when considering the large natural spatial and temporal variability and scale of plankton and spawning biomass in the SWMR. In particular, phytoplankton and zooplankton biomass in the oceans can vary significantly at spatial scales ranging from hundreds of metres to hundreds of kilometres and temporal scales of hours, days, seasons and inter-annually, due to tidal and large-scale currents, bathymetry, temperature, salinity, water chemistry parameters and other environmental factors (Gibbons & Hutchings 1996; Holliday et al. 2011; McKinnon et al. 2008; Pearce et al. 2000; Sutton & Beckley 2017). Therefore, changes in zooplankton abundance are likely to be replenished and indistinguishable from natural levels and distributions within hours of a seismic survey vessel passing.

Coral spawning

The OA includes areas of patch reef and emergent reef habitat that are characterised by tropical and subtropical scleractinian (hard coral) species. The dominant mode of coral reproduction is broadcast spawning; however, the spawning period and the degree of synchrony varies between tropical and temperate regions.

As described in Section 4.3.2.1, the primary period of coral spawning in WA, including in the mid-west and around the Abrolhos Islands, is in autumn, often culminating in the mass spawning of many species and colonies during March and/or April (Gilmour et al. 2016). In the temperate southwest, where corals are near their geographical limit, coral spawning occurs around summer and autumn from approximately January to May (Gilmour et al. 2016).

Coral spawn may be present in the water column around reef habitat, and within the ASA from being transported by currents, following mass spawning events in March and/or April. As there have been no studies on impacts to coral spawning from seismic surveys this evaluation applies the information for zooplankton detailed above. As for plankton, coral spawn will be spatially and temporally variable throughout a seismic survey and potential mortality or mortal injury effects to coral spawn must be assessed in the context of natural mortality rates, which as per plankton is high and thus mortality rates caused by exposure to the seismic source would be low compared to natural mortality and unlikely to result in the lack of replenishment of coral populations.

As shown in Table 7-3, the maximum predicted distance to mortality/PMI thresholds in the water column for zooplankton (including coral eggs and larvae) is 270 m. Pilot has proposed seismic source exclusion zones of 300 m around Leander Reef, Big Horseshoe Reef and around a further 13 unnamed reef areas in water depths shallower than 12 m. The seismic source will not be operated within 300 m horizontal distance of the 12 m contour of Leander Reef and Big Horseshoe Reef or within 300 m horizontal distance of the 12 m contour of the other unnamed reef area within the eastern part of the ASA (Figure 7-3). The 300 m exclusion distance provides some additional conservatism against the reported R_{max} for mortality/PMI for coral eggs and larvae.

Zooplankton – impact assessment conclusion

The potential impacts of noise emissions from the seismic source on zooplankton during the seismic acquisition are considered to be ‘localised’ and ‘short-term’, and the activity is not likely to result in any ecologically significant impacts at a population level for any zooplankton, fish eggs or larvae that may be present in the water column within the OA.

7.1.5.2 Benthic invertebrates

Species sensitivity and sound exposure thresholds

Research is ongoing into the relationship between sound and its effects on benthic invertebrates, including the relevant metrics for both effect and impact. Marine invertebrates lack a gas-filled bladder and are unable to detect the pressure component of sound waves (Parry & Gason 2006; Carroll et al. 2017) or "hear" sound in the way that mammals and fish are able to. Instead, invertebrates detect sound by sensing the particle motion component of sound in water and seabed sediments through physiological structures such as sensory hairs, statocysts and muscles, and therefore detect sound at close range (McCauley 1994; Parry & Gason 2006; André et al. 2016; Roberts et al. 2016; Edmonds et al. 2016; Carroll et al. 2017; Popper & Hawkins 2018).

Statocysts, found in a wide range of invertebrates, are utilised by animals to maintain their orientation, direct their movements through the water and may play a key role in controlling the behavioural responses of invertebrates to a wide range of stimuli. Although directly sensitive to particle motion and not to sound pressure, most available research on seismic impacts to invertebrates characterises received sound levels in terms of the sound pressure. Consequently, particle motion, rather than sound pressure, is likely to be a more important factor for benthic invertebrates such as crustacean and molluscs. Water depth and seismic source size are related to the particle motion levels at the sea floor, with larger arrays and shallower water being related to higher particle motion levels, thus more relevant to effects on crustaceans and bivalves (Koessler & McPherson 2023; Appendix G).

A range of physiological responses have been identified in some studies, and these are summarised below.

Crustaceans

Studies by Christian et al. (2003), Department of Fisheries and Oceans Canada [DFO] (2004) and Payne et al. (2007, 2008) exposed snow crabs (*Chionoecetes opilio*) to seismic sound levels of approximately 197–237 dB re 1 µPa PK-PK. No acute or chronic lethal or sub-lethal effects were observed in the weeks to months following exposure, with the exception of Payne et al. (2007, 2008) who noted a decrease in serum enzymes and an increase in food consumption in the weeks to months post exposure, which may indicate stress effects or potential osmo-regulatory disturbance.

As part of a collaborative, multi-disciplinary study conducted offshore on the continental slope (depth range of 107–162 m), Morris et al. (2018) and Cote et al. (2020) compared catch rates and used positioning telemetry in a Before-After-Control-Impact (BACI) study design to assess the behavioural responses of snow crab to exposure from industry seismic vessels. While effects of seismic exposure on snow crab movement could not be ruled out completely, effects were at most quite small relative to natural variation. In contrast, snow crab exhibited much clearer responses to handling, temperature and time of day. Overall, their results suggest that the effects of seismic exposure at this depth (>100 m), specific to the behaviour of adult male snow crab, are at most subtle and are not likely to be a prominent threat to the fishery (Morris et al. 2018; Cote et al. 2020).

Rock lobster

Research undertaken by Day et al. (2016a, 2016b) in Australian waters, exposed captive southern rock lobster (*Jasus edwardsii*) to multiple passes of a seismic source element in 10-12 m water depths. Maximum received sound exposures were 209-212 dB re 1µPa PK-PK, 186 to 190 dB re 1 µPa²·s per-pulse SEL, and SEL_{cum} of 192 to 199 dB re 1 µPa²·s. Exposed and control lobsters were housed in a laboratory for up to a year post-exposure to allow monitoring of longer-term impacts. The findings of the study were published in a report, as well as several scientific articles. These are summarised below.

Mortality:

- Exposure to seismic sound did not result in any mortalities to adult lobsters (Day et al. 2016a, 2016b).

Righting time and statocysts damage:

- Airgun exposure caused damage to the righting reflex and statocysts in southern rock lobsters (Day et al. 2019). Following exposure equivalent to a full-scale commercial array (3100 in^3) passing within 100–500 m, lobsters showed impaired righting and significant damage to the sensory hairs of the statocyst. Reflex impairment and statocyst damage persisted for at least 365 days post exposure and did not improve following moulting. For this study, maximum measured received noise levels were 209–213 dB re 1 µPa (PK-PK).
- In a group of lobsters with pre-existing statocyst damage (assumed to be caused by exposure to high levels of anthropogenic noise), seismic exposure did not cause further statocyst damage, nor was there an increase in righting time (Day et al. 2020).

Stress:

- Increased tail gape (an indication of stress) was present in the summer experiments only, which may be a result of higher temperatures exacerbating a stress response (Day et al. 2016a, 2016b).

Haemolymph physiology and nutritional condition:

- Examination of the impact of seismic acoustic exposure on the haemolymph physiology and nutritional condition of this species and found no effect of seismic exposure on 24 haemolymph biochemical parameters, hepatopancreas index or survival. However, this study did report evidence of a chronic negative impact on immune competency for up to 120 days post-exposure, a potential immune response to infection after 365 days post-exposure; and chronic impairment of nutritional condition 120 days post exposure (Fitzgibbon et al. 2017).These authors concluded that the biochemical haematological homeostasis of rock lobster is reasonably resilient to seismic acoustic signals; however, exposure may negatively influence the rock lobster's nutritional condition and immunological capacity. The impact of these results at an ecological level is not known.

Eggs:

- Increased mortality, delayed development or abnormal development to the egg mass carried by any ‘berried’ females, if present, or larvae produced from those eggs, is highly unlikely. The condition or development of eggs carried by female lobsters at the time of exposure, even at close proximity directly beneath the seismic source, were not affected (Day et al. 2016b). However, these eggs were in an early embryonic developmental stage, just after extrusion and prior to eye development, and were thus entirely soft tissue with no large internal density differences. Later spiny lobster larval developmental stages have developed sensory systems including arrays of pinnate setae along the flagella of the antennae and mechanosensory statocyst organs which they may use for navigation during the critical onshore migration and settlement phase. As such, the experimental results found here may not necessarily be the same for spiny lobsters exposed later in development (including later stage embryos and larvae) and is an area which requires further research to determine the potential impacts of seismic surveys on lobster populations.

The significance of the seismic exposures and whether the sub-lethal effects, such as increased righting times, may have wider ecological implications (e.g. ability to feed, avoid predators and resist disease) warrants further consideration.

Day et al. (2020) reported that some of the control lobsters used in the experiments were collected from a marine reserve and were found to have a high level of pre-existing impairment to statocysts similar to that induced by the seismic exposure experiments. The source of the damage in the lobsters in this study could not be ascertained, but the soundscape comparisons of the collection sites showed that the noisy site had a 5–10 dB greater level of noise, equivalent to a three to ten times greater intensity, in the 10–700 Hz range than was found at the remote collection site. Therefore, this statocyst impairment was considered to be the result of long-term exposure to shipping noise. The lobsters with pre-existing statocyst damage showed no significant differences in righting times between control and exposed lobsters; however, as a group these lobster had the slowest right times of all experiments. It is unclear why exposure to the seismic surveys did not cause additional damage to the statocysts in these animals. Monitoring of the lobster population at the same reserve where the lobsters with pre-existing statocyst impairment were taken from showed that the rock lobster population within the reserve was thriving and at carrying capacity (Green & Gardner, 2009; Kordjazi et al. 2015). Therefore, the levels of statocyst impairment reported in the Day et al. (2016a) study appear to not be impacting on the survival of this lobster population. However, it should be noted that these lobsters were not subject to any fishing pressure and the same aquatic noise that damages the lobster statocysts may also reduce the level of predation they face.

Day et al. (2021, 2022, 2023) examined the potential impacts of seismic surveys on the larval stages of southern rock lobster to determine whether early development and recruitment may be affected. Lobster puerulus (post-larval stage) and juveniles were held in baskets and exposed to multiple passes of a seismic source element in 10–12 m water depths. Maximum received sound exposures were 203-219 dB re 1μPa PK-PK, 181 to 190 dB re 1 μPa²·s per-pulse SEL, and SEL_{cum} of 201 to 205 dB re μPa²·s, comparable to Day et al. (2016a) (Day et al. 2021, 2022, 2023). Lobster puerulus were randomly assigned to control (not exposed to airgun signals) or E0 (exposed to airgun signals at a nominal range of 0 m from the sail line), and juveniles were assigned to control, E0 and E500 (exposed to airgun signals at a nominal range of 500 m from the vessel sail line). The findings of the study are as follows:

- Righting was significantly impaired for all exposure treatments immediately after exposure, indicating that the range of impact extended to at least 500 m from the source (maximum range tested in the study).
- Although exposure did not result in any elevated mortality for puerulus or juveniles, increased righting times likely indicated impaired predator avoidance and defence, which may therefore result in indirect mortality as a result of seismic exposure.
- Puerelus and juvenile E0 treatment lobsters did not show the capacity for recovery, while juvenile E500 lobsters recovered from impairment after the first moult, providing evidence of a range threshold for recovery.
- Intermoult period was significantly increased in E0 juvenile lobsters, and appeared to be increased in puerulus, while juvenile E500 treatment lobsters show a moderate, non-significant increase in moult duration.
- Increased intermoult duration suggested impacted development and potentially slowed growth, and physiological stress.

Impairment resulting from close range (0 m) exposure appeared to be persistent, as previously reported in adults, whereas juveniles exposed at a more distant range (500 m) showed recovery, indicating that exposure at a range of 500 m may not cause lasting impairment to righting (Day et al. 2022, 2023).

Unpublished research conducted by DPIRD Fisheries Research (de Lestang et al. in prep), has investigated the medium- and long-term effects of seismic exposure on wild western rock lobster, *Panulirus cygnus*. Two hundred and ten wild caught lobsters were tagged with spaghetti tags and held in aquaria for ten days prior to being transported to the seismic survey location. One hundred of these lobsters were exposed at a depth of ~5 m, to an 80 in^3 sleeve gun array, with an operating pressure of 2000 psi. The treatment lobsters were held in a line of eight or nine plastic baskets (four lobsters per basket), with the seismic source towed at a depth of 2 m over the middle of the line. Therefore, the minimum exposure range for lobsters in the baskets in the centre of the line was ~3 m. Sound exposure levels received by the treatment lobsters were not measured, as a hydrophone was deployed in the centre of the survey area, ~2 km away from the treatment location. An additional 100 control lobsters were held in the same conditions 5 nm away, well outside the survey area. All lobsters were tagged and released in fished areas. Upon release the animals righting reflex and release behaviour was tested. The treatment group had significantly greater righting time, greater limb loss, and exhibited overall poorer release behaviours, such as drifting, while the control group exhibited more active release behaviours. Recapture rates of the two experimental groups were modelled to obtain estimates of mortality over time. Preliminary results indicated a ~30% (15-45% CI) reduction in recapture rates of exposed animals, compared with the control animals, after one month at liberty, then no difference thereafter (<706 days).

These results may indicate an initial 30% increase in mortality of the exposed animals within the first month post exposure. Any acute mortality may indicate increased predation rates as a result of reduced defence capabilities associated with longer righting times and less active release behaviours. However, this difference in recapture rates could also be indicative of other factors including sub-lethal effects. For example, a behavioural reaction or reduced foraging resulting in reduced pot entry by exposed lobsters. In any case, it is difficult to evaluate the drivers of the different recapture rates and the implications of this study for seismic noise impact assessments prior to publication of a peer-reviewed paper. Existing published studies (e.g. Miller et al., 2023) have documented broad variation in recapture rates of western rock lobster between sites and environmental variables such as swell height, period and sea surface temperature have been shown to be the greatest predictors of catch rates. Publication of a peer reviewed paper will be necessary to establish the robustness of these findings.

In order to put the above analysis of potential effects of seismic survey noise on western rock lobster (WRL) into context it is important to understand the spatio-temporal overlap of the proposed Eureka MSS with rock lobster habitat and life stages. The proposed Eureka MSS is planned to be undertaken between February and March and although the OA overlaps a KEF for WRL the areas of suitable WRL habitat within the OA are likely to be primarily limited to shallow reef habitats. In recognition of this, Pilot have committed to seismic source exclusion zones of 300 m (see below for rationale for this zone size) around Leander Reef, Big Horseshoe Reef and a further 13 unnamed reef areas in water depths shallower than 12 m. There is also potential for adult WRL to be exposed to seismic noise levels that may elicit sub-lethal effects in deeper parts of the ASA during the 'whites' migration when ~4 year old WRL migrate from shallow inshore waters to spawning grounds in offshore waters up to 100 m deep. However, this migration occurs between late November and January each year (Miller et al. 2023), outside the February to March timing for the Eureka MSS. As a result, it is expected that adult WRL exposed to harmful levels of seismic noise will largely be limited to a small number of individuals that may be present outside of reef exclusion areas.

Mating of WRL occurs in August – September and the females generally release fertilised eggs between September and February. These eggs hatch within 4-8 weeks releasing phyllosoma larvae that are carried offshore by nightly wind-driven currents as far as 1500 km from the mainland. Hatching is generally completed by the end of February or March (Gray 1992). The phyllosoma larvae spend 9-11 months in the open ocean before metamorphosing into pueruli which swim across the continental shelf with help from the prevailing currents to settle on inshore reefs. The settlement of puerulus larvae on inshore reefs can occur throughout the year (Miller et al. 2023), but peaks in spring and summer (Gray 1992). There is therefore some potential for the MSS to overlap with the hatching period and the period of puerulus settlement on inshore reefs.

As per the analysis of available science above, there is some potential for increased mortality in puerulus larvae (indirectly through impaired predator avoidance). However, the area and timeframe over which these effects might occur is small relative to the spawning range and protracted period of hatching, larval dispersal and settlement on inshore reefs. In particular, it is expected that the majority of egg hatching will be in water deeper than the ASA, with breeding grounds typically in 40-100 m water depth (de Lestang et al., 2016) and the prevailing dispersal will be offshore away from the ASA. Further, the temporal overlap of the MSS with the peak period of puerulus settlement on inshore reefs is low, i.e. potential for 1 month overlap (30 days of acquisition) within a 6 month peak period (spring -summer). During this period of overlap, there is potential for sub-lethal impairment to puerulus moving within ~ 500 m of the airgun array but due to the protracted settlement period and the mobile nature of the MSS this will only be a small proportion of individuals recruiting to this location.

Molluscs

Kosheleva (1992) identified no detectable effects to marine bivalves and gastropods (mussels and periwinkles) after exposure to a single seismic source element of source level 233 dB re 1µPa at a distance of 0.5 m or greater from the source. Conversely, Matishov (1992) reported a single scallop shell splitting in a sample of three scallops, but this was located 2 m beneath a seismic source element and therefore exposed to maximum sources levels (which is not representative of a typical commercial seismic survey).

A number of Australian studies (Przeslawski et al. 2016a, 2018; Day et al. 2017) have focussed on commercial scallops (*Pecten fumatus*). Przeslawski et al. (2016a, 2018) examined the short-term impacts on scallops and other marine invertebrates from a 2,530 cubic inch seismic array and found no evidence of mortality or change in condition following exposure to a seismic survey. Analysis of images and samples revealed some site-specific differences in scallop abundance, size, condition and assemblages, but these were not related to seismic operations. Day et al. (2017) exposed scallops to maximum received sound exposures of up to 213 dB re 1µPa PK-PK, 181 to 188 dB re 1 µPa².s per-pulse SEL, and SEL_{cum} of 188 to 198 dB re 1µPa².s. The study also predicted ground acceleration of up to 37.57 m/s². Day et al. (2017) concluded that exposures did not result in any immediate mass mortalities, however, repeated exposures resulted in a chronic increase in mortality over timeframes of approximately four months post-exposure, though not beyond naturally occurring rates of mortality. Separate experiments undertaken in 2013 and 2014 yielded mortalities of 3.6–3.8% in control scallops (no seismic exposure), 9.4–11.3% mortality in scallops exposed to a single pass of the seismic source, 11.3–16.1% mortality in scallops exposed to two passes of the seismic source, and 14.8–17.5% mortality in scallops exposed to four passes of the seismic source. The mortality rates were at the low end of the range of naturally occurring mortality rates documented in the wild, which range from 11–51% with a six year mean of 38% (Day et al. 2017). A third experiment in 2015 resulted in 100% mortality to both control scallops and exposed scallops, and accordingly was attributed to other causes and not to seismic exposure (Day et al. 2017).

Sub-lethal effects to exposed scallops were also observed by Day et al. (2017) indicating a compromised capacity for homeostasis and potential immunodeficiency over acute (hours to days) and chronic (months) timescales post exposure. Exposures did not elicit energetically expensive behaviours (i.e. extensive swimming or long periods of valve closure), but scallops showed significant changes in some behavioural patterns during exposure (e.g. “flinch” response) and an increase in recessing into sediment following exposure (Day et al. 2017).

Published sound exposure criteria do not currently exist for acoustic impacts to invertebrates but the available literature above provides an indication of the sound levels and distances within which some impacts may occur. A range of sound levels, from 202 dB re 1 µPa PK-PK to 212 dB re 1 µPa PK-PK, based on the findings of the Payne et al. (2008) and Day et al. (2016a, 2016b, 2017) studies, were applied in the assessment. The Payne et al. (2008) 202 dB re 1 µPa PK-PK is considered to be associated with no impacts to benthic crustaceans (such as prawns, scampi and lobsters), whereas the 209-212 re 1 µPa PK-PK thresholds could be associated with some level of sub-lethal effects in these animals (Koessler & McPherson 2023; Appendix D). A 213 dB re 1 µPa PK-PK level is considered as representative of levels that may result in sub-lethal effects and chronic mortality in molluscs and some other invertebrates based on Day et al. (2017).

The responses of squid to airgun signals were investigated by Fewtrell & McCauley (2012). The authors conducted a number of experiments and examined the received per–pulse SEL for caged squid (*Sepioteuthis australis*). They found that in one trial, where the received level of the first airgun impulse was 162 dB re 1 µPa^2·s, the squid inked. This response was not observed again within this trial; however, the authors stated that it was unknown whether this was due to depleted ink reserves or habituation. In two other trials, the initial received levels were lower (132 and 146 dB re 1 µPa^2·s per–pulse SEL), and although the cumulative received levels did exceed 162 dB re 1 µPa^2 s, no inking behaviour was observed. The authors hypothesised that the results also suggest that a gradual increase in received levels and prior exposure to airgun impulses decreases the severity of the alarm responses in this species. This aligns with findings of general habituation in response to predators in squid (Long et al. 1989). Recent work (Jones et al. 2020) supports these findings as well, indicating potential rapid, short–term habituation by squid to impulsive noise; however, similar response rates were seen 24 hours later, which indicated that squid might re-sensitise to the noise.

The results presented in by Fewtrell & McCauley (2012) were stated by the authors to be preliminary, and while they stated that while it is possible that noise levels greater than 147 dB re 1 µPa^2·s are required to induce avoidance behaviour, the level associated with inking, of 162 dB re 1 µPa^2·s per–pulse SEL, has been considered as a startle response level for squid. In the absence of additional studies and thresholds this level may be considered for other cephalopods; however, it may be limited when applied to other species.

Solé et al. (2017) conducted offshore noise-controlled exposure experiments on common cuttlefish (*Sepia officinalis*), at three different depths and distances from the source and particle motion and sound pressure measurements were performed at each location. Scanning electron microscopy revealed injuries in statocysts, which severity was quantified and found to be proportional to the distance to the transducer. These findings are the first evidence of cephalopods sensitivity to anthropogenic noise sources in their natural habitat. From the measured received power spectrum of the sweep, it was possible to determine that the animals were exposed at levels ranging from 139 to 142dB re 1µPa^2 and from 139 to 141 dB re 1µPa^2, at 1/3 octave bands centred at 315 Hz and 400 Hz, respectively. These results could therefore be considered a coherent threshold estimation of noise levels that can trigger acoustic trauma in cephalopods.

Given the similarities in physiology between squid and octopus, octopus are not thought to be at risk of physical injury even if individuals are exposed to several passes as noted by Fewtrell & McCauley (2012). There is limited information on the hearing sensitivity of octopus to sound stimuli. Kaifu (2008) studied *Octopus ocellatus* and concluded that the statocyst was responsible for the observed responses kinetic sound energy (particle motion). It is unknown how octopuses will respond behaviourally, but since they are benthic and territorial it is thought more likely that they will retreat into their lair as they normally do to perceived threats. They may also freeze and camouflage themselves if out in the open. Octopus are not expected to move very far from their territory and therefore will not be exposed to repeat close passes in short period of time since subsequent survey lines are about 4 km apart. If they remain in the same area they may be exposed to sounds shown to elicit strong responses two to three times throughout the survey period and these events will be several days apart allowing the individual animals to recover.

Day et al. (2023) examined the potential effects of seismic surveys on the octopus (*Octopus pallidus*). Exposure to seismic air gun signals did not result in mortality in either males or female octopus. Both exposed male and female octopus demonstrated impacts to behaviour, with exposed males showing reduced "adventurousness" through a reduced rate of escaping from their tanks and depressed feeding in E0 octopus when compared to their feeding rates later in the study. In female octopus, exposure was correlated to a reduction in maternal care of eggs, particularly as the eggs neared hatching. There was some indication of a reduced number of eggs in the E0 and E500 treatments, which may have been an indication of removal of dead or poorly developing eggs, though it was not conclusive as the number of eggs laid by each individual prior to the start of the study was unknown. There was no indication of harm to the offspring, with hatches generally completing fully with live, competent hatchlings (Day et al. 2023).

In the haemolymph the pH in males was initially low in all treatments compared to expected levels for octopus with the E0 treatment significantly lower than controls, suggesting that handling stress was evident in all treatments but was synergistically exacerbated by exposure. This was followed by alkalosis (rise in pH) in E0 and E500 treatments compared to controls and the E1000 treatment in subsequent weeks, a response that was also observed in the female octopus (Day et al. 2023).

Immune parameters showed a number of impacts, with phagocytosis (cellular process for ingesting and eliminating foreign cells or particles) significantly elevated in female and male octopus in the E0 and E500 treatments. In females, haemocyte vitality was significantly reduced at five days post exposure. The impact of exposure on the phenoloxidase system, an enzyme system responsible for melanisation important for killing pathogens and repairing wounds, was equivocal with some substantial (12–40%) but non-significant increases in activity observed in male octopus at days 1 and 5 post exposure followed by a significant increase of 40–60% over Control activity in the E0 and E500 treatments at day 47 post exposure. In females, a non-significant 15% reduction in activity level at day 5 was followed by a non-significant 100% increase in mean activity at day 17. These results suggest that there was a high degree of variation between individuals, making it difficult to conclude whether there was an impact from seismic exposure to octopus that may be detected with more robust sample sizes or whether the variability in activity is characteristic of this enzyme, making it unsuitable for measuring impact (Day et al. 2023).

Along similar lines, several oxidative stress enzymes showed non-significant differences between treatments that make it impossible to determine whether activities were impacted but sample sizes were not robust enough to draw conclusions. Catalase and superoxide dismutase were generally 20–30% and 5–7% higher, respectively, in exposed E0 and E500 treatments than in Controls early in the study, but these differences lacked statistical significance. Male octopus in all exposed treatments showed a non-significant 10–15% decrease in nitric oxide concentration early in sampling (Days 1 and 12), whereas females showed a significant 100% increase in the E0 treatment compared to Controls at day 5 post exposure. Both malondialdehyde and comet assays were used to investigate DNA damage, with the results of both assays showing no indication of damage in either sex. The glutathione system (acts to prevent/limit damage to important cellular components caused by ROS) showed moderate levels of impact, with no differences observed in any of the three enzymes at day 1 post exposure and a non-significant decrease observed in glutathione reductase and glutathione peroxidase at day 5 post exposure in E0 and E500 octopus. In females, glutathione reductase was significantly elevated in E0 octopus at day 5 and glutathione s-transferase significantly elevated at day 17. The neurotransmitter acetylcholine esterase was significantly reduced in E0 and E500 treatments of day 1 post exposure males and in E500 treatment females at day 17 post exposure (Day et al. 2023).

Overall, Day et al. (2023) concluded that the implications of these findings concerning potential effects in octopus were as follows:

- The results from this study showed no evidence of mortality in either the short- or long-term.
- There was potential that impacted neurotransmitter activity levels underpinned observed behavioural changes in "adventurousness," feeding and maternal care, raising concerns over impact to other behaviours octopus use to interact with their environment that rely on neuromuscular coordination.
- The observed impacts to the immune function and oxidative stress systems were not likely to be severe or persistent enough on their own to suggest long-term damaging effects or impairment.
- Based on the sound and physiology metrics measured here, the overall level of impact was negligible at 500 m and almost non-existent at 1000 m, establishing an exposure threshold range for minimising impact.

Parsons et al. (in press) exposed ≈11,000 silverlip pearl oyster (*Pinctada maxima*) to a four-day experimental seismic survey, plus one vessel-control day. After exposure, survival rates were monitored throughout a full two-year production cycle, and the number and quality of pearls produced at harvest were assessed. This large scale experimental seismic survey exposed adult pearl oysters to received SEL up to 209 dB re 1 µPa^2·s. Oysters from two groups, on one sampling day, exhibited reduced survival and pearl productivity compared to controls, but 14 other groups receiving similar or higher exposure levels did not. The seismic source alone was determined to be very unlikely to cause mortality of *P. maxima*. There was no correlation and little effect of sound levels on *P. maxima* cultured pearl productivity. Reduced survival/pearl retention on one sampling day was determined to be unlikely to be driven by seismic exposure. Therefore, Parsons et al. (in press) found no conclusive evidence of an impact of the seismic source survey on oyster mortality or pearl production.

Sponges and corals

A PK sound level of 226 dB re 1 µPa PK was applied for sponges and corals, based on a study where corals received maximum sound pressure levels of 226-232 dB re 1µPa PK-PK, but no mortality, damage to soft tissue or skeletal integrity, visible signs of stress, change in abundance or community structure was detected immediately after, and up to four months following exposure (Heyward et al. 2018).

Seagrasses

Little is known about the potential effects of underwater noise on other sessile benthos, for instance seagrasses (flowering aquatic plants). In a recent study, Solé et al. (2021) examined morphological and ultrastructural changes in seagrass, after exposure to sounds in a controlled environment. This research focused on rhizome cortical cells and root cap collumella cells in the seagrass *Posidonia oceanica*, both of which contain amyloplasts. Amyloplasts have evolved as analogues of the invertebrate statocysts, sensory organs responsible for gravity perception, which have been shown to be sensitive to noise. The amyloplasts operate like statocysts in *P. oceanica* roots and rhizomes and probably have evolved to have a role in sound and vibration reception. Solé et al. (2021) observed that low-frequency sounds produced alterations in *P. oceanica* root and rhizome amyloplasts, which sense gravity and process sound vibration. Nutritional processes of the plant were affected as well: the study observed a decrease in the number of rhizome starch grains, which have a vital role in energy storage, as well as a degradation in the specific fungal symbionts of *P. oceanica* roots. Given that these effects were most probably associated with the particle motion component of the sound waves generated in the experiment, it is likely that any effects from seismic survey noise on seagrasses in shallow water marine environments would be limited to very close ranges from the source (i.e. <10 m).

Impact assessment

Sound pressure

A range of sound exposure levels from 202 dB re 1 µPa PK-PK (a no effect threshold) to 213 dB re 1 µPa PK-PK were applied in the acoustic modelling study for benthic invertebrates. Sound levels of 209-212 re 1 µPa PK-PK thresholds are potentially associated with some level of sub-lethal effects. As shown in Table 7-4, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, the maximum predicted R_{max} distance was 167 m. The maximum predicted R_{max} distance associated with the 213 dB re 1 µPa PK-PK level for sub-lethal effects (Day et al. 2019) was 103 m at 40 m water depth. Maximum distances to this sound level in shallower waters supporting suitable reef habitat for western rock lobster (< 20 m) is 90 m.

The PK sound level at the sea floor directly underneath the seismic source was estimated at the modelled sites and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); the threshold was reached at a maximum range of 15 m (20 m water depth). Additionally, the 226 dB re 1 µPa PK reported in Heyward et al. (2018) is not a threshold above which impacts are expected to occur, but a level at which no short-term or long-term effects were observed. Impacts to corals and sponges are not expected until significantly higher levels are exceeded, which are not predicted to occur during this survey. Therefore, no measurable impacts to corals and sponges are expected.

Table 7-4: Maximum predicted distances (R_{max}) to effect thresholds for benthic crustaceans at the sea floor

Sound exposure threshold (PK-PK)	R_{max} distance (m)	Water depth (m)
213 dB re 1 µPa	103	40
212 dB re 1 µPa	121	50
210 dB re 1 µPa	136	30

Sound exposure threshold (PK-PK)	R_{max} distance (m)	Water depth (m)
209 dB re 1 µPa	167	50
202 dB re 1 µPa	292	15

At received noise levels of 209 dB re µPa (PK-PK), the maximum predicted R_{max} distance for sub-lethal impacts to crustaceans is approximately 167 m, and therefore there is the potential for some crustaceans to experience sound levels that could result in some low-level, sub-lethal effects (e.g. impairment of reflexes, damage to statocysts and reduction in numbers of haemocytes). These sub-lethal effects could result in a reduction in fitness to some individuals; however, as demonstrated by the research studies on both crustacean and mollusc species, it is unlikely that this would occur to the majority of individuals. The area of western rock lobster habitat exposed to sound levels that may elicit sub-lethal effects is very small relative to the West Coast Rock Lobster Managed Fishery (WCRLMF) that extends from Shark Bay to Cape Leeuwin and is considered a single connected stock. Therefore, impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population. Further to this, the area of this proposed MSS is subject to some of highest levels of recruitment within the fishery (Miller et al. 2023) indicating a recovery potential from settlement of puerulus larvae into these coastal reef habitats.

Chronic mortality may also occur in a small number of organisms (e.g. bivalve molluscs) within the weeks and months following exposure to sound levels equal to or greater than 213 dB re 1 µPa PK-PK (Day et al. 2017), within a maximum R_{max} of up to approximately 103 m from the seismic source.

The distance to the per–pulse SEL startle (inking) response level of 162 dB re 1 μPa^2 s for squid (Fewtrell & McCauley 2012) was reached between 2.90 and 2.03 km.

Particle motion

At the sea floor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds, and as such there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Including recent research, such as Day et al. (2016a, 2016b, 2017), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, authoritative thresholds to inform the impact assessment are not defined. However, levels can be determined for pressure metrics presented in literature to assist the assessment (Koessler & McPherson 2023; Appendix G).

As described above, for crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally, for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016b), 209–212 dB re 1 µPa, are also included.

For bivalves, literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been modelled for comparison with the results of Day et al. (2017). The maximum particle acceleration assessed for bivalves, associated with chronic mortality in some individuals, was 37.57 m/s^2 (Koessler & McPherson 2023; Appendix D). The maximum particle acceleration and velocity, as a function of horizontal range from the centre of the array in broadside directions (which generate the higher amplitude results) was modelled. The distance to no effect was reached between 58 and 7 m, based on a particle acceleration limit of 37.57 m/s^2 at the sea floor, with the maximum distance of 58 m being reached at 10 m water depth.

Reef exclusion zones

Noting the maximum distance to no effect for western rock lobster was 292 m, based on the conservative 202 dB re 1 µPa PK-PK threshold level from Payne et al. (2008), Pilot has proposed seismic source exclusion zones of 300 m around Leander Reef, Big Horseshoe Reef and around a further 13 unnamed reef areas in water depths shallower than 12 m. The seismic source will not be operated within 300 m horizontal distance of the 12 m contour of Leander Reef and Big Horseshoe Reef or within 300 m horizontal distance of the 12 m contour of the other unnamed reef areas within the eastern part of the ASA (Figure 7-3).

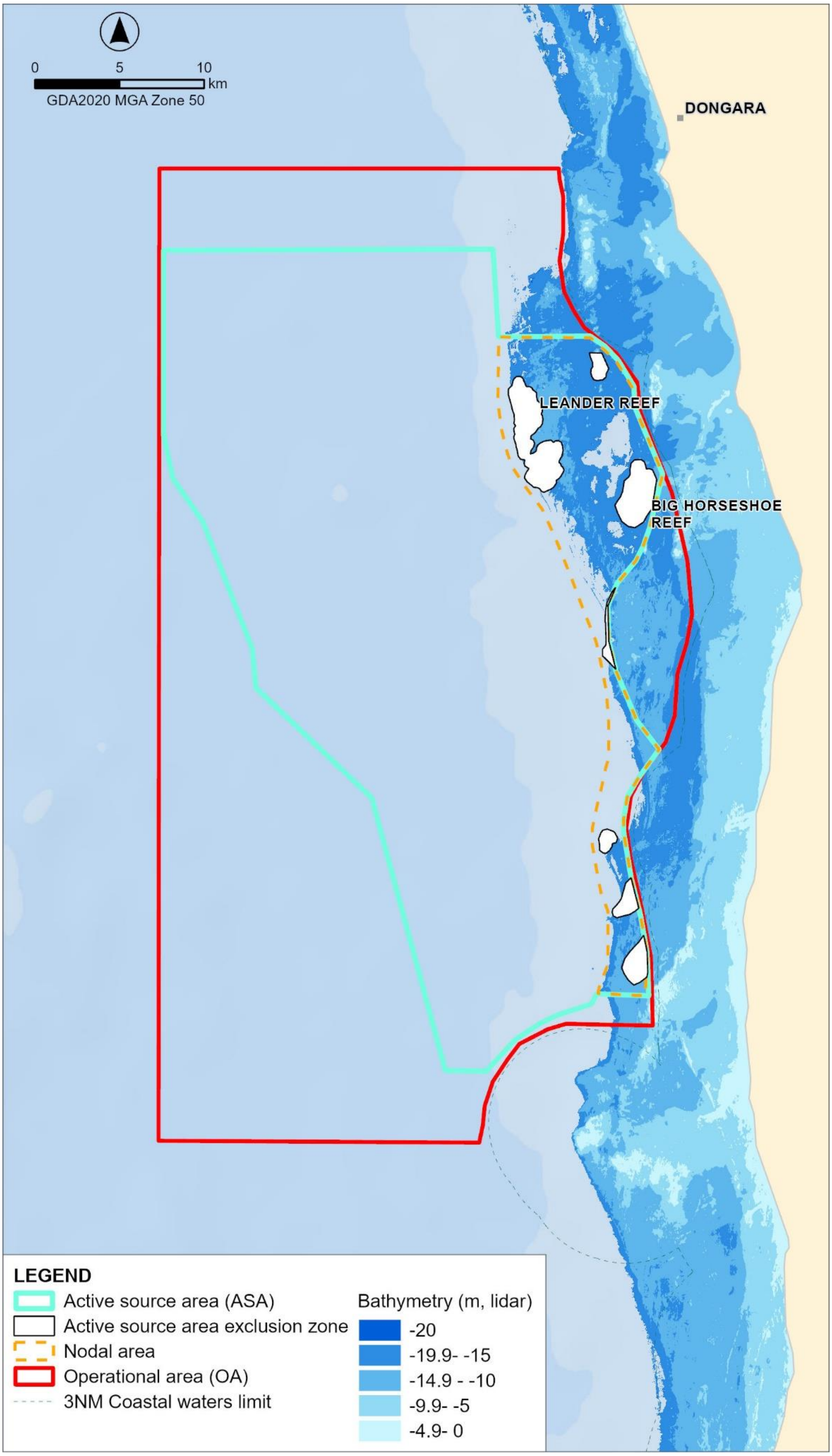


Figure 7-3: Proposed seismic source exclusion zones

Benthic invertebrates – impact assessment conclusion

Based on the above body of research and risk assessment, some benthic invertebrate species may experience sub-lethal effects or a small increase in mortality rates in the weeks or months following seismic exposure within tens or hundreds of metres from the seismic source. Should this occur, the continuous natural cycle of death, recovery and recruitment of invertebrates from adjacent areas will occur in parallel over these same time-scales, and therefore it is questionable whether any impacts from seismic exposure would be detectable from natural fluctuations in relative abundance, benthic community composition and structure. Day et al. (2017) and Payne et al. (2007, 2008) acknowledge that the changes observed in their research are likely within the range of variation that can occur from other common natural and anthropogenic stressors. The ecological implications of such impacts on benthic invertebrate communities are not expected to be significant or long-term.

Therefore, the potential impacts of noise emissions from the seismic source on benthic invertebrates during the acquisition of the survey are considered to be ‘localised’ and ‘short-term’, as the activity is not likely to result in any ecologically significant impacts at a population level for any species of invertebrate that may be present on the sea floor within or adjacent to the ASA.

7.1.5.3 Fishes and elasmobranchs

Species sensitivity and sound exposure thresholds

Every species of fish studied to date is able to hear. Fish produce sounds in a wide range of context such as feeding, mating or fighting, and as a result anything that inhibits the detection of these sounds can have a negative effect on their fitness and survival (Popper & Hawkins 2019). The majority of fish species detect sounds from <50 Hz up to 500–1500 Hz (Popper & Hawkins 2019). A smaller number of species can detect sounds over 3 kHz, while very few species can detect ultrasound over 100 kHz (Ladich & Fay 2013). The critical issue for understanding whether an anthropogenic sound will affect the hearing of a fish is whether it is within the hearing frequency range of the fish and loud enough to be detectable above background ambient noise.

The hearing sensitivity of fish varies depending upon the auditory structures in the inner ear (otoliths surrounded by an epithelium of hair cells) and, if present, the swim bladder (Finneran & Hastings 2000; Nedwell et al. 2004). Otoliths are sensitive only to particle motion, while the swim bladder may provide an indirect route for sound pressure to reach the inner ear. The other main mechano-reception system in fish is the lateral line system, which runs along the side of the body and is more pronounced in some groups of fish than others. The lateral line system responds to particle motion produced in the near-field of a sound source, as well as to tiny water currents set up by the motions of the fish (Nedwell et al. 2004), therefore all fish are sensitive to the particle motion component of sound at close range from a sound source. Particle motion is the most relevant metric for perceiving underwater sound for most species, but with the exception of a few species (Popper & Fay 2011; Popper et al. 2014), there is an almost complete lack of relevant data on particle motion sensitivity in fish (Popper & Hawkins 2018). Some more specialised fish with a swim bladder that they use for hearing are sensitive to sound pressure and are capable of detecting less intense noise and a wider range of frequencies, compared to less-specialised groups of fish (Popper et al. 2014; Carroll et al. 2017; Hawkins & Popper 2017). The susceptibility of fish to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing.

In marine fish, the connection with the swim bladder and ability to detect sound pressure is understood to be present to some varying degree in the families Clupeidae (e.g. herrings, sardines, pilchards and shads), Gadidae (e.g. true cods such as Atlantic cod and whiting), and some nearshore/reef species relevant to tropical Australia, including some species in the families Pomacentridae (e.g. damsel fishes and clown fishes), Holocentridae (soldierfishes and squirrelfishes) and Haemulidae (e.g. grunters and sweetlips) (Nedwell et al. 2004; Braun & Grande 2008; Popper et al. 2014; Popper & Hawkins 2018, 2019). However, the vast majority of marine fish species do not have this hearing specialisation.

A great many fish species possess a swim bladder or other gas-filled cavity but do not have a connection with their hearing, for example various demersal scalefish targeted by the West Coast Demersal Scalefish Managed Fishery (e.g. baldchin groper, snapper, redthroat emperor). Of these demersal scalefish dhufish are an interesting exception, in that they have a mechanical connection (bi-lateral sonic muscles) between the otic region and the swim bladder, which appear to be used for sound production (Parsons et al. 2012, 2013). Fish species that lack a gas-filled cavity altogether, include elasmobranchs (e.g. sharks and rays), some flat fishes, some tunas, and mackerels (Casper et al. 2012; Popper et al. 2014).

The sound exposure thresholds applied for fish and elasmobranchs (sharks and rays) in the acoustic modelling study and in this impact assessment are summarised in Table 7-5 and explained in more detail in the acoustic modelling report (Koessler & McPherson 2023; Appendix G). The modelling study assessed the ranges for quantitative threshold criteria based on the Popper et al. (2014) guidelines for three types of immediate effects to fish:

- Mortality, including injury leading to death
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma
- TTS.

The modelling study considered single pulse (PK) and multiple pulse (SEL_{24h}) metrics for both the entire water column and sea floor in the following categories reflective of the different hearing mechanisms and sensitivity to sound:

- I - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
- II - Fish with a swim bladder that do not use it for hearing
- III - Fish that use their swim bladders for hearing.

For this impact assessment, it is assumed that all fish can detect signals below 500 Hz and so can 'hear' the seismic source.

Table 7-5: Thresholds for seismic sound exposure for fish, adopted from Popper et al. (2014)

Type	Mortality and potential mortality injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
I Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
II Fish: Swim bladder not involved in hearing (particle motion detection)	>210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
III Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate

Notes: Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or 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).

Mortality/injury

It is noted that while thresholds for fish mortality have been included for consideration in this assessment based on the Popper et al. (2014) guidelines, no studies to date have demonstrated direct mortality of free-swimming adult fish in response to airgun emissions, even when fired at close proximity (within 1–7 m) (DFO 2004; Boeger et al. 2006; Popper et al. 2016; Carroll et al. 2017). Although some fish deaths have been reported during cage experiments, these were more likely caused by experimental artefacts of handling fish or confinement stress (Hassel et al. 2004). For free-swimming fish that are able to move away from seismic sources as they approach, the potential for lethal physical damage from airgun emissions is even further nullified. However, reef or bottom-dwelling fish that show greater site attachment may be less inclined to flee from a seismic sound source and experience greater effects as a consequence.

Despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) did not reference an actual occurrence of this effect. At the time of developing the guidelines, no quantified data on injury and mortality from seismic sources on fish had been reviewed by the Working Group. Therefore, the Popper et al. (2014) exposure guidelines for mortality/potential mortal injury and recoverable injury for fish exposed to seismic source emissions are based solely on data from pile driving conducted on predominantly temperate, freshwater fish species. Although seismic surveys and pile driving both produce impulsive sound, their sound characteristics are markedly different; pile driving impulses result in a more rapid rise time in sound pressure than seismic pulses and it is this rapid rise time that has the greatest potential for trauma (Caltrans 2001, 2004; Hastings & Popper 2005; Popper et al. 2006).

Environmental Resources Management Australia (ERM) undertook a detailed literature review of potential fish mortality and physical injury as a result of exposure to seismic sources (ERM 2017). Of the 28 studies reviewed, only three observed direct mortality and in each case, mortalities occurred to caged fish at very close proximity to the seismic source (<2 m), which is not representative of real-life exposures from seismic surveys because fish are free-swimming and are not typically exposed at such close range. The received sound levels that resulted in mortality ranged from 220 to 241 dB re 1 µPa PK; however, other studies reported no mortality or injury at levels as high as 246 dB re 1 µPa PK. Therefore, the sound exposure criteria proposed by Popper et al. (2014) for mortality and injury are considered to be highly conservative and provide a precautionary approach in the assessment of potential injury and mortality effects to fishes from exposure to underwater noise from marine seismic surveys.

Temporary threshold shift

Temporary hearing impairment (TTS) can occur due to fatigue and temporary changes to the epithelium (hair cells) of the inner ear and/or damage to auditory nerves innervating the ear, which has the potential to occur in some fishes exposed to intense sound pressures for prolonged periods of time (Smith et al. 2006; Popper et al. 2014; Liberman 2015). While experiencing TTS, fishes may have a decrease in fitness in terms of communication, detecting predators or prey, and/or assessing their environment. The period over which normal hearing ability returns following the termination of a sound that causes TTS is variable, and dependent on many factors including the intensity and duration of sound exposure (e.g. Popper & Clarke 1976; Scholik & Yan 2001; Amoser & Ladich 2003; Smith et al. 2004a, 2004b, 2006, 2011; Popper et al. 2005, 2007).

The impact threshold of 186 dB re 1 µPa²·s proposed by Popper et al. (2014) in Table 7-5 is based on exposure of a freshwater fish species with a connection between the swim bladder and inner ear (i.e. more specialised hearing than the majority of demersal and pelagic fish species likely to occur in the Eureka 3D MSS OA – the dhufish being an exception) (Popper et al. 2005). Fish that showed TTS recovered to normal hearing levels within 18–24 hours. Given that reliable auditory frequency weightings have not been defined for the three categories of fish in the way they have for cetaceans, the 186 dB re 1 µPa²·s SEL_{24h} criteria in Table 7-5 includes a level of conservatism as:

- The majority of fish that are likely to occur in the OA do not possess a direct connection between the swim bladder and the inner ear; they are therefore sensitive primarily to particle motion rather than sound pressure and may be less sensitive than the types of fish upon which the 186 dB re 1 µPa²·s threshold is derived
- Modelled SELs are based on broadband sounds and may therefore account for more sound energy associated with frequencies that are not within the auditory ranges of the fish species likely to occur in the OA
- The main contribution of sound energy to the onset of TTS will occur over just a few hours when the source is at the closest point of approach; the 24-hour modelled accumulation period accounts for additional sound energy accumulated while the seismic source is at greater distances and potentially not audible to fishes.

It is also noted that many of the available studies on TTS are based on captive fish, whereas free-swimming fishes in the wild are likely to make some effort to avoid the intense sound pressures that contribute the most to the onset of TTS. If TTS does occur, the effects will be temporary and recoverable (Popper et al. 2005).

Popper (2018) in his expert peer review of TTS effects in demersal fishes for the Santos Bethany 3D MSS, located in the Timor Sea, noted:

- It is highly unlikely that there would be physical damage to fish as a result of the survey unless the animals are very close to the source (perhaps within a few metres).

- If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fish do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24-hours (or less) is very likely.
- Nothing is known about the behavioural implications of TTS in fish in the wild. However, since the TTS is likely very transitory, the likelihood of it having a significant impact on fish fitness is very low.

Therefore, while TTS effects in site-attached fishes may occur, the potential for impacts to individuals' fitness and survival is limited and impacts to fish community structures are not expected (Popper 2018).

Behavioural effects

Behavioural effects of noise on fish will vary depending on the circumstances of the fish, hearing sensitivity, the activities in which it is engaged, its motivation, and the context in which it is exposed to sounds (Hawkins & Popper 2017). Responses may include avoidance behaviours, startle reactions, increased swimming speed, change in orientation, change in position in the water column, changes to schooling behaviour (e.g. tightening of school structure), and temporary avoidance of an area (Simmonds & MacLennan 2005; McCauley et al. 2000a; Fewtrell & McCauley 2012; Popper et al. 2014; Carroll et al. 2017). Changes in movement patterns may also temporarily divert efforts away from feeding, egg production and spawning success (Hawkins & Popper 2017). The potential extent and duration of behavioural effects based on studies of seismic exposure are summarised below.

A degree of caution should be given when interpreting behavioural studies, given that many are conducted on captive fish which may not provide an accurate representation of responses in free-swimming fish in the wild (Popper et al. 2014; Salgado Kent et al. 2016; Carroll et al. 2017). Behavioural studies are also highly subjective. Extrapolation of observed effects on fish should also be undertaken with caution (Carroll et al. 2017). This is particularly the case given that many exposure experiments report received SPL or SEL, even though the most relevant metric for most fish species is particle motion (Popper & Hawkins 2018, 2019). Many exposure experiments are undertaken using a single airgun and it is not clear how transferrable the behaviours and received SPL/SEL levels are to a full commercial-sized seismic array, particularly if observed behaviours are in response to particle motion close to the sound source rather than to sound pressure.

Pearson et al. (1992) exposed captive demersal rockfish to multiple 10-minute periods of seismic sound from a seismic source towed at distances of less than 215 m, which is not representative of real-life exposures to a seismic survey. Schools of rockfish were observed to exhibit a 'startle' response (shudders, flexions of the body followed by rapid swimming) at sound levels above 200–205 dB re 1µPa SPL. An 'alarm' response (change in vertical position in the water column to be closer to the seabed, short-term post-exposure behavioural changes) was found to occur above approximately 180 dB re 1µPa SPL, although it was suggested that some individuals may begin to exhibit subtle changes in behaviour and position in the water column at sound levels above 161 dB re 1µPa SPL. Changes in behaviour were found to return to normal before the end of the sound exposure or within just minutes of the sound ceasing, indicating only very short-term, transient effects and potential habituation to the disturbance.

Santulli et al. (1999) exposed caged European sea bass (a demersal species) to a 2500 in^3 seismic source. Limited response was observed at 2.5 km distance, a startle response was observed when the array was at a distance of approximately 800 m, but after passing within 180 m, fish behaviour appeared to return to normal within one hour.

The Scott Reef Study associated with the Woodside Maxima 3D MSS reported in McCauley et al. (2008) and Miller & Cripps (2013) and summarised in Salgado-Kent et al. (2016), included a component that examined how the behaviour of caged fish exposed to seismic signals changed. The study examined the effects to fish species in the Holocentridae family, which have adaptations linking the swim bladder to the otolith system of the inner ear, as well as to bluestripe snapper, a demersal species without such a hearing adaptation, similar to the demersal species that are most likely to occur within the Eureka 3D MSS OA. Fish were exposed to either one or two passes of the active source at three distance categories (45–74 m, 105–131 m, 475–807 m). Alarm responses (including the startle response and behavioural avoidance) occurred within less than 200 m either side of the pass by, but responses were too infrequent to include in analyses. Less significant agitation levels (defined by changing swim direction) in Holocentridae increased with increasing received sound level above 155–165 dB re 1 uPa^2.s SEL, but agitation levels did not seem to increase with increasing received sound levels for the less sensitive bluestripe snapper (McCauley et al. 2008). Fish began to feed and behave normally again within 20-minutes after the passage of the seismic source (McCauley et al. 2008; Miller & Cripps 2013).

McCauley et al. (2000a, 2003) reported that trials involving captive fish (of various species, including snappers, emperors, groupers, trevally, bream, herring, dhufish, mullet, trumpeter and wrasse) exposed to seismic sound showed a common 'startle' response (C-turns), 'alarm' responses (e.g. swimming faster, darting movements and sudden changes in school structure), or less obvious changes such as moving closer to the seabed or huddling closer together. Subtle responses such as moving closer to the seabed or changes in schooling behaviour were suggested to commence when sound levels exceeded approximately 147-151 dB re 1 µPa^2 s SEL. Similar behaviours in pink snapper and trevally were noted by Fewtrell & McCauley (2012) in response to comparable sound levels. These are minimal reactions that are likely to be an indication of awareness and perception of the sound rather than a response that could result in significant ecological impacts. More obvious startle and alarm responses were apparent in trials when received sound levels were in the order of 159-172 dB re 1 µPa^2 s SEL. In situations where a behavioural response was observed, fish were considered to have resumed normal behaviour within 4–31 minutes after cessation of the seismic activity (McCauley et al. 2000a, 2003). Startle and alarm responses reduced with time, indicating some habituation to the sound. No statistically clear trends in physiological stress response were observed following exposure (McCauley et al. 2000a, 2003).

Behavioural observations of two tropical snapper species and another coral reef fish species, spadefish, in field enclosures before, during and after exposure to seismic sound showed that repeated exposure resulted in increasingly less obvious startle responses (Boeger et al. 2006). This is consistent with the potential habituation suggested by McCauley et al. (2000a) and by Fewtrell & McCauley (2012).

McCauley & Salgado Kent (2007) observed the behaviour of goldband snapper in fish traps in the Timor Sea using cameras placed inside the fish traps. A seismic vessel towed two 3090 in^3 seismic sources. Maximum signals reached at the closest trap to each seismic pass-by were 200, 202 and 212 dB re 1 µPa PK-PK (equivalent to approximately 194, 196 and 206 dB re 1 µPa PK). No dramatic behavioural responses of fish to the passing seismic source were observed. Fish generally displayed increased activity immediately after entering a trap presumably as they searched for a way out, with this activity reducing with time. Fish that had been in a trap for some time showed increased activity levels as the operating seismic source approached but were 'quiet' when the array passed at the point of closest approach.

Bruce et al. (2018) tagged tiger flathead and two shark species, which were monitored during a seismic survey undertaken in Australian waters. Sharks moved freely in and out of the study area and exposed sharks did not show any indication of differences in behaviour or distribution compared with control areas. Minor behavioural effects were observed in exposed tiger flathead, which increased their swimming speed during the seismic survey and changed daily movement patterns after the survey but showed no significant displacement. Overall, there was little evidence for consistent behavioural responses (Bruce et al. 2018).

Paxton et al. (2017) observed temperate reef fish, including snapper and grouper species, in 33 m water depths located 7.9 km from a seismic survey line using video recordings. The authors observed fish abundance and habitat use during the evening hours for three days prior to a seismic survey and then during the evening of the day when seismic activity occurred. The authors attempted to measure sound at two other reefs in closer proximity to the survey but the hydrophones malfunctioned. No video recordings were made at the other reefs where hydrophone measurements were attempted. No hydrophone measurements were made at the reef where video recordings took place but maximum sound levels were estimated to be in excess of 170 dB re 1 µPa SPL. Despite no clear visual evidence of behavioural responses in fish during the seismic survey, the authors noted a 78% decline in abundance in the evening following the survey. No further recordings were made to assess when fish abundance returned to pre-exposure levels or how far they may have moved. Therefore, with limited data, it is not clear from this study if reduced abundance is attributed to the seismic sound or other natural factors such as tidal influence or food availability. However, the study may indicate a possible avoidance response and change in local abundance and distribution.

Meekan et al. (2021) undertook a large-scale experiment that quantified the impacts of exposure of an assemblage of tropical demersal emperors (family Lutjanidae), snappers (family Lethrinidae) and groupers (family Epinephelidae) targeted by commercial fisheries to a commercial-scale seismic source on the North West Shelf off Western Australia. Dominant species included bluespotted emperor (*Lethrinus punctulatus*), red emperor (*Lutjanus sebae*), and brownstripe snapper (*L. vitta*). A combination of Baited Remote Underwater Video Systems (BRUVS) and acoustic tagging methods were used to measure the behaviours and movements of fishes at high, medium and low exposure sites, as well as at control sites. The high, medium and low exposure sites were located at horizontal distances from the path of the seismic source of approximately 0–300 m, 2–10 km and 11 km, respectively. The maximum modelled SEL values received at the high, medium and low exposure sites were in the order of 180–200 dB re 1 µPa^2·s, 130–160 dB re 1 µPa^2·s and 115–125 dB re 1 µPa^2·s, respectively. There were no short-term (days) or long-term (months) effects of exposure on the composition, abundance, size structure, behaviour, or movement of fishes at any exposure sites. The authors suggest that it is a reasonable assumption that the behavioural responses of demersal fishes to the bait cue provided by the BRUVS are a realistic proxy of the likely response of the same species to baited hooks or traps used by the commercial fisheries that target them. The acoustic tags and telemetry found little evidence that fish were displaced by the exposure to the seismic source. Movements of tagged fish occurred over a limited area focused on two or three acoustic receivers, and there was no evidence for the departure of tagged fish after exposure. These multiple lines of evidence suggest that seismic surveys have little impact on the behaviours of demersal fishes in this environment.

Some other studies looking at the behavioural response of sound pressure-sensitive Gadidae and Clupeidae species, such as whiting, Atlantic cod and herring, have reported changes in vertical position in the water column, potential avoidance responses and short-term changes in distribution. Chapman & Hawkins (1969) observed that the depth distribution of free-ranging whiting changed in response to an intermittently discharging stationary seismic source, which resulted in fish being exposed to an estimated SPL of 178 dB re 1 μPa. The fish school responded to the sound by shifting downward, forming a more compact layer at greater depth although temporary habituation was observed after one hour of continual sound exposure (Chapman & Hawkins 1969).

Hawkins et al. (2014) exposed free-swimming sprat (a sound pressure-sensitive Clupeidae species with a swim bladder connected to the inner ear) and Atlantic mackerel (a particle motion detecting species without a swim bladder) to playback of impulsive sound. Sprat schools were more likely to disperse laterally in response to received sound levels of approximately 135 dB re 1 μPa^2 s SEL. Mackerel schools were more likely to alter their depth in the water column in response to approximately 142 dB re 1 μPa^2 s SEL. Hawkins et al. (2014) note how the two different species seemed to respond to the sound playback at similar sound levels despite the differences in sound sensitivity of the two species, but suggested that mackerel were simply more “flighty” than sprat and therefore more likely to react. The tests were also undertaken using low sound level playback in very close proximity to the schools of fish and it is not clear how relevant the sound pressure and sound exposure levels are in relation to mackerel given that their response was likely driven by particle motion. The study location, a very small, enclosed, quiet, coastal sea lough, where fish were not accustomed to heavy disturbance from shipping and other intense sound sources is also very different from an open ocean location.

Slotte et al. (2004) monitored the effects of a 3090 in^3 seismic array on migrating herring (Clupeidae) and whiting (Gadidae), mapping their distribution and abundance in relation to the seismic survey lines. There was no significant evidence of immediate, near-field scaring reactions on the horizontal scale in response to acquiring survey lines, but there was some evidence that fish changed position in the water column, moving closer to the seabed. Some short-term changes in distribution were observed but were not statistically significant; fish consistently remained within the immediate vicinity of the survey area, but in a limited number of measurements there was an indication that fish abundance was lower near to the survey area and increased with distance out to a maximum range of 37 km. However, results were inconsistent and clear trends were not observed in all cases. Slotte et al. (2004) concluded that it was not possible to determine how much abundance and distribution were attributed to the seismic survey or to the natural migration patterns and food availability of the fish, or other natural factors. Herring and whiting were found to be abundant in the survey area again after a pause in seismic acquisition and monitoring of fishes for three to four days, indicating that if any displacement did occur as a result of seismic sound exposure, the displacement was temporary (i.e. less than 3–4 days) (Slotte et al. 2004).

In similar studies, Engås et al. (1996) and Engås & Løkkeborg (2002) reported on the effects of seismic surveys on Atlantic cod and haddock (Gadidae) and found that the abundance of fish were lower in the survey area compared with areas outside of the survey area, which the authors hypothesize may be the result of an avoidance response. Some differences in abundance were still detectable within the survey area five days after the survey was completed (Engås et al. 1996; Engås & Løkkeborg 2002).

Conversely, Peña et al. (2013) described the real-time behaviour of herring schools exposed to a full-scale 3D seismic survey, observed using sonar. No changes were observed in swimming speed, swimming direction, or school size that could be attributed to a transmitting seismic vessel as it approached from a distance of 27 km to 2 km, over a six-hour period. The unexpected lack of a response to the seismic survey was interpreted as a combination of a strong motivation for feeding by the fish, a lack of suddenness of the onset of sound, and an increased level of tolerance to seismic pulses.

Davidsen et al. (2019) investigated the effects of seismic sound exposure on the physiology and behaviour of captive Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) using a combination of biologgers and acoustic tags, as well as video monitoring. Experimental sound exposures were 18–60 dB above ambient. Fish were held in a large sea cage and exposed over a three-day period. The cod exhibited reduced heart rate in response to the particle motion component of the sound from the airgun, indicative of an initial flight response. No behavioural startle response to the airgun was observed; both cod and saithe changed both swimming depth and horizontal position more frequently during sound exposure. The saithe became more dispersed in response to the elevated sound levels. The fish seemed to habituate both physiologically and behaviourally with repeated exposure. The authors concluded that sound exposures induced over the timeframes used in this study appear unlikely to be associated with long-term alterations in physiology or behaviour.

Hubert et al. (2020) exposed captive Atlantic cod to one hour of playback of seismic airgun sound pulses with a ten-second shot point interval. Cod were placed in a net pen positioned 7.8 m from the speaker. The mean peak sound pressure and particle acceleration levels at a distance of 9.7 m from the speaker were 164 dB re 1 µPa and 101 dB re 1 nm/s^2, respectively. At a distance of 16.4 m form the speaker, the mean peak sound pressure and particle acceleration levels were 158 dB re 1 µPa and 99 dB re 1 nm/$s^{2,}$ respectively. These levels compare with a mean SPL of the ambient conditions in the pen of 113 dB re 1 µPa and a mean sound particle acceleration of 61 dB re 1 nm/s^2. Results indicated no strong overall pattern of change in swimming patterns or immediate, short-term behaviours during the exposure, compared to baseline periods without playback. However, several individuals changed their time spent in several behavioural states during the 1-hour sound exposure. Several individuals spent more time transiting and less time being locally active or inactive. This may be indicative of changes in energy expenditure, which may be relevant if sound exposure occurs over the long-term. However, due to experimental design limitations, it was not possible to test the significance of these behavioural state trends (Hubert et al. 2020).

van der Knaap et al. (2021) investigated the effect of a 3.5-day, full-scale, seismic survey exposure on the movement behaviour of free-swimming Atlantic cod, using acoustic telemetry. The closest point of approach to the tagging location was 2.25 km. The study found that during the experimental survey, cod did not leave the detection area more than expected from baseline data. However, cod left more quickly than expected, from two days to two weeks after the seismic survey. Furthermore, behavioural analyses indicated that during the exposure cod decreased their activity, with time spent being locally active (moving over small distances, showing high body acceleration) becoming shorter, and time spent being inactive (moving over small distances, having low body acceleration) becoming longer. Additionally, diurnal activity cycles were disrupted with lower locally active peaks at dusk and dawn—periods when cod is known to actively feed.

The following conclusions are made regarding behavioural effects to fish from seismic airguns, based on the literature above:

- Different fish may exhibit different behavioural responses when exposed to seismic survey noise, depending on their activities, motivation and the context in which they receive sound.
- Fish may change position in the water column (i.e. move closer to the seabed) as a response to becoming aware of approaching seismic sound (e.g. Pearson et al. 1992; mccauley et al. 2000a, 2003; Slotte et al. 2004; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Davidsen et al. 2019).
- Exposure to higher sound levels at close range to a seismic source may begin to result in more noticeable startle or alarm responses, such as changes in school structure, increased swimming speed and avoidance of the sound source (e.g. Simmonds & maclennan 2005; McCauley et al. 2000a, 2003; Fewtrell & McCauley 2012; Popper et al. 2014; Carroll et al. 2017).
- Many exposure experiments are undertaken using a single airgun and it is not clear how transferrable the behaviours and received SPL/SEL levels are to a full commercial-sized seismic array, particularly if observed behaviours are in response to particle motion close to the sound source rather than to sound pressure.
- There is some evidence that fish may also tolerate gradual increases in sound levels and habituate to repeated sound exposures (Chapman & Hawkins 1969; McCauley et al. 2000a; Boeger et al. 2006; Fewtrell & McCauley 2012; Peña et al. 2013; Davidsen et al. 2019).
- Many studies indicate that fishes resume normal behaviour shortly after cessation of the acoustic disturbance (within minutes / less than an hour), with no evidence of long-term changes (e.g. Wardle et al. 2001; Pearson et al. 1992; Santulli et al. 1999; mccauley et al. 2000a, 2003; Fewtrell & McCauley 2012; Miller & Cripps 2013; Davidsen et al. 2019).
- Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species on the North West Shelf.

- There is some evidence that changes in distribution may persist for longer than the initial change in behaviour, i.e. position in the water column, schooling behaviours and swim speeds may return to normal relatively quickly (within minutes or hours), but their distribution may not return to normal for hours or days. Potential changes in distribution of fish have been observed in some studies for approximately five days following sound exposure, although such changes are limited to studies that focused primarily on migrating sound pressure-sensitive types of fish with a swim bladder-ear connection (e.g. Clupeidae, Gadidae). These studies also acknowledge that it is difficult to attribute these changes in distribution directly to the seismic survey or to natural migration patterns, food availability or other natural factors (Slotte et al. 2004; Engås et al. 1996; Engås & Løkkeborg 2002). However, it is possible that changes to the behaviour and distribution of some sound-sensitive prey species (e.g. herring, sardines) may have some indirect influence on the distribution of larger predatory fishes during the days following exposure and disturbance.
- Small changes in behaviour or disruption to diurnal activities of pressure-sensitive species of fish (Gadidae) with a swim bladder-ear connection may indicate that activities such as feeding and energy expenditure can be affected if exposed long-term (Davidsen et al. 2019; Hubert et al. 2020; van der Knaap et al. 2021), although these species of fish may also habituate to the sound with repeated exposure (Davidsen et al. 2019).

Given the limited convergence in results from the available studies, the subjective nature of many assessments and the context under which fish received sound, the Popper et al. (2014) ANSI-Accredited Standards Committee Sound Exposure Guidelines for Fishes and Turtles determined that it is not possible to define exact sound level thresholds for changes in fish behaviours. Instead, Popper et al. (2014) applies relative risk criteria (Table 7-5). The criteria reflect the potential for substantial changes in behaviour for a large proportion of the animals exposed to a sound, which may alter distribution, and moving from preferred sites for feeding and reproduction. The criteria do not include effects on single animals or small changes in behaviour such as a startle response or minor movements. As such, Popper et al. (2014) indicate that fish without a swim bladder or with no connection between the swim bladder and the inner ear may experience substantial changes in behaviour within tens or hundreds of metres of a seismic source. These peer-reviewed and accredited sound exposure criteria are reflected in this risk assessment. It is acknowledged that some fishes with swim bladders may show varying levels of awareness of sound pressure at greater distances from the seismic source, but it is important to recognise changes in behaviour that may be of ecological significance from those that are not.

Impact assessment

As described in Section 4.3.3, the OA and surrounding waters represent habitat for a range of bony fishes (teleosts) and elasmobranchs (sharks and rays), including benthic, demersal, and pelagic assemblages. These fish assemblages include various demersal scalefish targeted by the West Coast Demersal Scalefish Managed Fishery (e.g. dhufish, baldchin groper, snapper, redthroat emperor). Behavioural impacts potentially affecting ‘catchability’ of target species, and hence catch rates, for this commercial fishery are assessed in Section 7.1.5.5.

The OA overlaps with large areas of patch and emergent reef habitat. These areas of hard substrate represent significant habitat for both demersal and benthic fish assemblages, including “site-attached” fish assemblages. For the purpose of this risk assessment, site-attached fishes are defined as fish that rely on the benthic habitat and demonstrate a very high degree of site fidelity to the extent that they are unlikely or unable to flee an approaching seismic source and are instead likely to remain/seek refuge within habitat structures.

The EPBC Protected Matters Search identified eight shark species (including the white shark, whale shark and grey nurse shark), one sawfish species and two ray species that may potentially occur within the OA (see Section 4 and Appendix B).

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impacts fish and elasmobranchs by causing mortality/potential mortal injury (PMI), recoverable injury and hearing impairment (TTS and masking) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts at greater distances.

Table 7-6 presents the results of the acoustic modelling study for maximum predicted distances to mortality/ PMI, recoverable injury and TTS onset in fish and fish eggs and larvae. Data is presented for both the entire water column (MOD) and at the sea floor.

Table 7-6: Summary of maximum distances to mortality/PMI, recoverable injury and TTS onset in fish, fish eggs and larvae for single pulse and SEL_{24h} modelled scenarios

Marine fauna group	Potential impact	Sound exposure threshold	R_{max} distance (km)	
			MOD	Sea floor
I Fish: No swim bladder	Mortality/PMI	219 dB re 1 µPa^2·s (SEL_{24h})	<0.06	<0.06
		213 dB re 1 µPa (PK)	0.15	0.07
	Recoverable injury	216 dB re 1 µPa^2·s (SEL_{24h})	<0.06	<0.06
		213 dB re 1 µPa (PK)	0.15	0.07
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	4.66	4.66
II Fish: Swim bladder not involved in hearing	Mortality/PMI	210 dB re 1 µPa^2·s (SEL_{24h})	<0.06	<0.06
		207 dB re 1 µPa (PK)	0.27	0.13
	Recoverable injury	203 dB re 1 µPa^2·s (SEL_{24h})	0.10	0.10
		207 dB re 1 µPa (PK)	0.27	0.13
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	4.66	4.66
III Fish: Swim bladder involved in hearing	Mortality/PMI	207 dB re 1 µPa^2·s (SEL_{24h})	<0.06	<0.06
		207 dB re 1 µPa (PK)	0.27	0.13
	Recoverable injury	203 dB re 1 µPa^2·s (SEL_{24h})	0.10	0.10
		207 dB re 1 µPa (PK)	0.27	0.13
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	4.66	4.66

The following fish types have been identified for this assessment:

- Site-attached fish assemblages
- Demersal fish species, including key commercial indicator species such as dhufish, snapper, baldchin groper and redthroat emperor
- Pelagic fish species, including species targeted by commercial and recreational fishers, such as mackerels, samson fish, tuna species and trevally
- Shark species, including EPBC Act-listed sharks.

Site-attached fish assemblages and demersal fish species

Within the ASA, key bathymetric features that are expected to provide habitats (hard substrate with epibenthos communities) with the potential to support site-attached or habitat dependent fish assemblages are the larger emergent reefs (e.g. Leander Reef, Big Horseshoe Reef) and smaller scattered patch reefal areas. These reefs and the seagrass beds or sand patches that separate them will be occupied by a range of demersal scalefish, including several species targeted by commercial and recreational fishers—dhufish, snapper, baldchin groper and redthroat emperor. The inshore lagoons in the OA are important for the recruitment of commercially and recreationally important species (and it is assumed many other fish species; Fairclough 2021; Parker et al. 2019; Shalders et al. 2018). The Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF is regarded as an important nursery area for many recreational and commercial fish species including western rock lobster, dhufish and snapper. Many juvenile demersal species use inshore, seagrass or sandy habitats for feeding and protection, before migrating offshore as adults to reefs or other habitats.

As shown in Table 7-6, the maximum predicted R_{max} distances to exceedance of mortality/PMI and recoverable injury thresholds of 213 dB re 1 µPa (PK) and 207 dB re 1 µPa (PK) at the sea floor for all hearing groups of fish range from approximately 70 – 130 m from a single impulse. Further detailed modelling of SEL_{24h} levels received at the sea floor was undertaken by Koessler & McPherson (2023; Appendix D), including acquisition in shallow areas where the seismic source may be operated in proximity to reefs. The predicted R_{max} distances to exceedance of mortality/PMI and recoverable injury SEL_{24h} thresholds for all hearing groups of fish at both the sea floor and in the water column was <60 m (refer Table 7-5).

There is the potential for recoverable injury to occur in site-attached fishes in the water column up to a maximum range of approximately 270 m from the seismic source (refer Table 7-6). The seismic source will not be operated within 300 m horizontal distance of the 12 m contour of Leander Reef and Big Horseshoe Reef or within 300 m horizontal distance of the 12 m contour of the other unnamed reef areas within the eastern part of the ASA (Figure 7-3). The 300 m exclusion distance provides some additional conservatism against the reported R_{max} for recoverable injury for fishes in the water column (270 m), noting that the Popper et al. (2014) thresholds for recoverable injury are already considered to be highly conservative, as described above. Further to this, as the survey vessel will need to deviate around these reef exclusion zones multiple times there is potential for increased cumulative sound exposure. In order to minimise this, the survey vessel will not activate the seismic source within 200 m of the reef exclusive zone unless 24 hours has elapsed since the source was last operated within 200m of the exclusion zone for a particular reef feature. This 24-hour interval is expected to reduce the cumulative noise exposure to site-attached fish species based on the reported recovery period of 18 – 24 hours for TTS observed in fish (Popper et al., 2005).

Pelagic fish species

Pelagic fish species likely to be present in OA include mackerels, samson fish, trevally and several species of tuna. Some species (e.g. mackerels) do not possess a swim bladder (Group I fish), while other species do (Group II and III fish). These species may be targeted in the region by recreational fishers.

As shown in Table 7-6, the maximum predicted R_{max} distances to mortality/PMI and recoverable injury for fish with no swim bladder (Group I fish) within the entire water column was within 150 m. For all fish with a swim bladder (Group II and III fish) the maximum predicted R_{max} distance to mortality/PMI within the entire water column was within 270 m. The maximum distance to the TTS threshold in the water column for all fish hearing groups (Group I, II, III) was within 4.7 km. Large, pelagic, fast-swimming fish species such as mackerel, tuna and trevally are highly unlikely to experience TTS effects as they can swim away from a seismic source. Individuals would have to remain within ranges of approximately 4.7 km of the operating seismic source for 24-hours to be exposed to sound levels that could cause TTS.

Pelagic fishes are most likely to exhibit behavioural responses (avoidance) by moving away from an operating seismic source that approaches within a few tens of metres of them. Behaviour may return to normal within minutes. However, it is acknowledged that the behaviours and distributions of the pelagic species could be affected for hours or days following exposure as a result of potential disturbance to more sound-sensitive prey species, such as herrings, sardine’s, sprat and shads.

Shark species

The EPBC Protected Matters Search identified eight shark species (including the white shark, whale shark and grey nurse shark), one sawfish species and two ray species that may potentially occur within the OA.

No sound exposure thresholds currently exist for acoustic impacts from seismic sources to sharks and sawfishes, which are sensitive only to particle motion. As a conservative and precautionary approach, the Popper et al. (2014) exposure guidelines for fish with no swim bladder for injury; 213 dB re 1 μPa (PK) and 219 dB re 1 μPa²·s (SEL_{24h}); and TTS (186 dB re 1 μPa²·s (SEL_{24h}), have been used for this assessment.

As shown in Table 7-6, the maximum predicted R_{max} distances to mortality/PMI/recoverable injury for fish with no swim bladder (incl. sharks) within the entire water column was within 150 m. TTS thresholds across the water column for fish without a swim bladder could be reached within 4.7 km. It is important to appreciate that individual sharks would have to remain within a range of 4.7 km of the operating seismic source (which is also moving) for 24-hours to be exposed to sound levels that could cause TTS.

It is expected that the potential effects to sharks associated with acoustic noise will be the same as for other pelagic fish species, resulting in minor and temporary behavioural change such as avoidance. This aligns with the Popper et al. (2014) guidelines, which detail that there is the potential for high risk of behavioural impacts in fish species near the seismic source (tens of metres), moderate risk within hundreds of metres, and low risk at thousands of metres from the seismic source.

Fishes and elasmobranchs – impact assessment conclusion

The potential impacts of noise emissions from the seismic source on fish and elasmobranchs during the acquisition of the survey are considered to be ‘localised’ and ‘short-term’ and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Based on the timing and duration (up to 40 days) of seismic acquisition, and the proposed control measures, predicted noise levels from seismic acquisition are not considered likely to cause mortality/PMI, recoverable injury or significant TTS effects to fish communities or result in any ecologically significant impacts at a population level.

7.1.5.4 Fish spawning

High intensity impulsive sound emitted from the seismic source has the potential to result in behavioural changes in fish or masking of fish vocalisation, which may temporarily divert efforts away from spawning aggregations, egg production and recruitment success (Hawkins & Popper 2017), or potentially cause displacement resulting in fish abandoning spawning grounds. Anecdotal evidence from previous seismic programs appeared to show immediate effects on fish behaviour and longer-term localised stock depletion.

A recent study examined behavioural responses in spawning Atlantic cod in Norway (McQueen et al. 2022, 2023). Atlantic cod (*Gadus morhua*) may be especially vulnerable to sound disturbance during spawning, as it is a soniferous fish species, with acoustic communication playing an important role in the cod mating system, and a low frequency hearing range (10–650 Hz). During the spawning period, male cod produce low frequency grunts (~50 Hz) that have been associated with aggressive and courtship behaviours. Low frequency noise associated with ship traffic has been found to reduce the effective communication range of spawning cod (Stanley et al. 2017; as cited in McQueen et al. 2023), and low frequency anthropogenic noise can elicit stress responses in cod resulting in reduced egg production and fertilization rates (Sierra-Flores et al. 2015). Additionally, cod tend to demonstrate high site fidelity to spawning areas. There have been reports that free-ranging cod move away from an area in immediate or delayed response to seismic surveys (Engås et al. 1996; van der Knaap et al. 2021).

To investigate whether airgun sound causes cod to leave their spawning grounds, McQueen et al. (2022, 2023) deployed acoustic telemetry arrays were on two cod spawning grounds: test and a reference site. From 2019 to 2021, 136 mature cod from the test site and 45 from the reference site were tagged with acoustic transmitters. Intermittent seismic shooting of two 40 in^3 airguns for 1-week during the spawning periods of 2020–2021 resulted in fluctuating SELs at the test site, comparable to a full-scale industrial survey 5–>40 km away. Residency and survival of tagged cod were analysed with capture–mark–recapture models fitted to the detection and recapture data. Departure rate of the mature cod varied between spawning seasons but was similar between the test and reference sites. Cod demonstrated only weak responses to the disturbance from repeated three-hour treatment periods over five days, swimming on average slightly deeper during seismic exposure compared to silent control periods. This response varied between individuals. Longer-term effects of seismic exposure on swimming depth were not detected. No changes in swimming acceleration, displacement, or area use occurred. Neither survival nor departure significantly differed between seismic exposure and baseline periods. The results indicated that exposure to airguns at received SEL of up to ~145 dB re 1 μPa^2 s, comparable to a seismic survey occurring several kilometres away, did not displace tagged cod from spawning grounds. These results suggest that relatively distant seismic surveys do not substantially alter cod behaviour during the spawning period at received sound exposure levels varying between 115 and 145 dB re 1 μPa^2 s over a five day period (McQueen et al. 2022, 2023).

Impact assessment

This impact assessment is focused on fish spawning and recruitment for relevant key indicator commercial fish stocks.

Sections 4.3.4 and 4.4.3.2 describe the key indicator species that are relevant to the Eureka 3D MSS, which include demersal species targeted by the West Coast Demersal Scalefish Managed Fishery (WCDSMF), and Spanish mackerel targeted by recreational fishers. The reproductive biology of the key demersal indicator fish species results in a very broad distribution of eggs and larvae, and consequently genetic connectivity over a wide geographic range. Multiple batches of millions of pelagic eggs are released during multiple, frequent spawning events and throughout extended spawning periods (Gaughan et al. 2018a).

The following assessment considers the potential magnitude of effects to fish spawning behaviours, and therefore the potential influence of the Eureka 3D MSS on recruitment success and the sustainability of key indicator fish species. The assessment considers:

- Spatial-temporal analysis – to provide context on the proportion of the spawning biomass that may be exposed during the survey
- Consideration of the natural variability in fish distribution, spawning biomass and recruitment

- Consideration of the sustainability status of the fish stocks and fisheries.

While the focus of this assessment is on the key indicator species, the status of these stocks is used by fisheries managers as an indicator of the sustainability status within the broader suite of scalefish species exploited in the region.

Spatial-temporal analysis

A spatial-temporal analysis has been conducted to determine the overlap between the Eureka 3D MSS and the principal spawning ranges and periods of key commercial indicator species. The analysis provides an indication of the proportion of the spawning area and the proportion of the spawning period for each species that may be exposed to sound from the survey.

The following assessment focuses on the following commercial key indicator fish species:

- WA dhufish
- Snapper (Mid-west/Kalbarri)
- Redthroat emperor
- Spanish mackerel (no commercial take in area of Eureka 3D MSS but targeted by recreational fishers).

Other key commercial indicator species for the WCDSMF are baldchin groper, hapuku, blue-eye trevalla, eightbar grouper and bass groper. However, the spatial-temporal analysis was not conducted for these species there is either no overlap between peak spawning period and the proposed acquisition windows for the survey (baldchin groper), or there is no spatial overlap between the principal depth range for the species and water depths across the survey area (i.e. the deeper water indicator species – hapuku, blue-eye trevalla, eightbar grouper and bass groper).

The following spatial-temporal analysis is not intended to provide an exact estimate of how much each species' spawning success rate will be impacted. Instead, this method demonstrates how the proportion of fishes that may be affected is relatively small compared to the larger overall adult spawning biomass, spawning area and spawning periods of each stock, which is important context for the assessment. It is important to note that a number of assumptions have been applied to the analysis in order to address uncertainty about behavioural effects to spawning fishes and provide a conservative and more precautionary estimate of the proportion of spawning fish stocks that may be exposed and potentially affected during the survey. These assumptions are outlined below:

1. **The spatial overlap with each stock is represented by 24-hours of 3D acquisition with a 5 km buffer applied to account for possible uncertainty about the exact range to disturbance to fish.**

   This approach accounts for an area that may be subject to sound exposure from the seismic source. Accounting for the entire ASA or the entire acquisition line plan is overly conservative as it is likely to be significantly larger than the area where fish may be exposed to sound and subjected to disturbance. The 24-hour timeframe is precautionary in order to account for scientific uncertainty in relation to the duration and recovery of behavioural disturbances in fishes. Behavioural changes in the demersal fish species and mackerel in the OA may return to normal within minutes or hours following exposure (e.g. Pearson et al. 1992; Santulli et al. 1999; McCauley et al. 2000a, 2003; McCauley & Salgado Kent 2007; Woodside 2011; Fewtrell & McCauley 2012; Miller & Cripps 2013; Bruce et al. 2018). Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia, including groups of fishes exposed within tens of metres of the passing seismic source.

   McQueen et al. (2022, 2023) found that relatively distant seismic surveys do not substantially alter behaviour in a fish hearing specialist species (Atlantic cod) during the spawning period at received sound exposure levels varying between 115 and 145 dB re 1 μPa^2 s.

   To apply an additional level of conservatism and account for possible uncertainty about the exact range over which fish may be disturbed, a 5 km buffer has been applied to the acquisition lines to account for potential variability in the hearing of different fish species and to broadly represent where some fishes may have some awareness of sound pressure changes, noting that the key indicator demersal and pelagic fish species are primarily sensitive to particle motion effects more so than sound pressure and significant behavioural effects are more likely to be limited to within tens or hundreds of metres of the seismic source (Popper et al. 2014). The 5 km buffer also accounts for the predicted R_{max} distance to TTS onset in all fish hearing groups (4.66 km; refer Table 7-6 above).

Therefore, this 24-hour scenario provides a conservative reflection of the spawning area that may be exposed at any time during the survey. For example, depending upon the actual line sequence acquired, the seismic survey vessel may sail past groups of fishes at a particular location, with disturbance occurring for less than an hour, and then may sail tens of kilometres beyond this point, turning to acquire another line, and may not pass near the same location again until days later; given the 'racetrack' acquisition approach, the same area of seabed and same group of fishes may not be exposed to significant disturbances again during the entire survey.

2. **The spatial extent of the spawning areas for each key indicator fish species has been estimated based on each species' principal depth range and the West Coast Bioregion fisheries management area.**

Genetic connectivity and the biological stocks have been confirmed across significantly larger areas (hundreds of thousands of square kilometres compared with the tens of thousands of square kilometre spawning areas considered in the analysis). The biological stocks of the key indicator species generally extend across the entire west coast region of WA. The biological stock areas may be more relevant to the impact assessment from a biological perspective; however, the boundaries of the biological stocks are not clearly defined and it is noted that genetic connectivity and recruitment within the biological stock ranges occurs over multiple years of spawning and dispersion of eggs and larvae (Martin et al. 2014; Gaughan et al. 2018b). In any given year or a single spawning season, the genetic connectivity between the area of seabed exposed to disturbances from the survey depends on the duration of the egg and larval dispersion phase and the oceanographic currents; connectivity and recruitment in a single season may therefore occur within and well beyond the limits of the West Coast Bioregion fishery management area, but potentially not across the entire biological stock area.

Therefore, to address any potential uncertainty in the biological stock ranges, the West Coast Bioregion fishery management area has been selected to provide a conservative indication of the proportion of the stocks that may be affected in a single spawning season. As a result, the spatial overlaps accounted for in the spatial-temporal analysis are likely to significantly overestimate the percentage of spawning area of each species that may be exposed to sound from the acquisition of the Eureka 3D MSS.

3. **The spatial-temporal analysis is a simplistic approach that assumes that fish spawning in the area and period of exposure will definitely be compromised.**

In reality, it is possible that fishes may continue to spawn regardless of exposure and disturbance, may move away from the seismic source and spawn at another location nearby, or, given that fish behaviours may return to normal within minutes or hours of exposure, spawning may be delayed but may occur a short time later. In either of these cases, the impact on spawning success may be negligible. However, given uncertainty about how the spawning behaviours of individual fishes and populations may be affected in response to seismic sound exposure, it is conservatively assumed that cessation of spawning could occur.

Therefore, the following analysis provides a conservative indication of the proportion of each indicator fish stock that may be exposed during a 24-hour period of 3D acquisition. This provides useful context for the impact assessment, but the extent and duration of actual impacts will likely be significantly smaller.

Table 7-7 presents the spatial overlap with the spawning areas of key indicator species based on each species' principal depth range and the West Coast Bioregion fisheries management area.

Table 7-7: Spatial overlap with spawning ranges of key indicator fish species

Acquisition scenario	Spatial overlap			
	Dhufish (3–200 m)	Snapper (1–200 m)	Redthroat emperor (5–100 m)	Spanish mackerel (1–50 m)
24-hours 3D + 5 km buffer (maximum 415 km^2)	1.6%	1.6%	2.3%	0.8%
Spawning areas have been estimated based on each species' depth range and the West Coast Bioregion fishery management area. It is important to note that genetic connectivity and the biological stocks have been confirmed across significantly larger areas; however, the West Coast Bioregion fishery management area is a useful and conservative indicator for assessment purposes and is consistent with the fisheries management approach.				

A temporal (duration) analysis has also been conducted to determine the maximum overlap between the timing and total potential duration of the Eureka 3D acquisition and the spawning times of key commercial indicator fish species (refer to Table 7-8). It is important to note that the temporal overlap may also over-represent what will likely, in reality, be a disturbance to one out of many spawning events for a very small proportion of fish effected by the passing seismic source at the time of a spawning event. For example, the above demersal fish species are serial/multiple batch broadcast spawners, releasing multiple batches of eggs into the water column over a wide area, and spawn multiple times throughout the spawning period (Newman et al. 2008; Gaughan et al. 2018).

Table 7-8: Temporal overlap with peak spawning periods of key indicator fish species

Acquisition scenario	Temporal overlap			
	Dhufish (Dec–Mar / 122 days)	Snapper (Jun–Aug / 92 days)	Redthroat emperor (Dec–Feb / 91 days)	Spanish mackerel (mid-Sep–mid-Dec / 91 days)
Maximum 21-day duration Feb–Mar or Aug–Sep survey periods	17%	23%	23%	16%

The combined spatial-temporal overlap with the spawning areas and times of the key commercial indicator fish species is presented in Table 7-9.

Table 7-9: Combined spatial-temporal overlap with spawning periods and ranges of key indicator fish species

Acquisition scenario	Spatial / temporal overlap			
	Dhufish (3–200 m) (Dec–Mar / 122 days)	Snapper (1–200 m) (Jun–Aug / 92 days)	Redthroat emperor (5–50 m) (Dec–Feb / 91 days)	Spanish mackerel (1–50 m) (mid-Sep–mid-Dec / 91 days)
24-hours 3D + 5 km buffer Maximum 21-day duration	0.27%	0.37%	0.53%	0.13%

As described above, the proposed timing of the Eureka 3D MSS (February to March) avoids the peak spawning periods for baldchin groper, and so spawning adults of this species will not be affected.

The spatial-temporal overlap with the dhufish, snapper and redthroat emperor stocks is less than 1.0% of their WA stock range and spawning period. The spatial-temporal overlap with the Spanish mackerel stock is less than 0.2% of its WA stock range and spawning period.

Natural variability in spawning biomass and recruitment

To provide further context, the natural levels of variability in spawning and recruitment have been considered. Spawning biomass and recruitment rates fluctuate annually, with years of elevated or reduced recruitment influencing the overall stock population (Marriott et al. 2012). Newman et al. (2003) and Marriott et al. (2012) suggest that both spawning and recruitment success can vary depending upon both environmental (e.g. water temperature, cyclones, El Niño-La Niña cycles) and anthropogenic influences (e.g. fisheries catch levels over and above natural mortality rates).

Extended periods of high exploitation by fisheries can result in decreases in the spawning stock biomass and number of effective spawnings (Newman et al. 2003). As reported in the latest WA State of the Fisheries Report (Fisher et al. 2023), the most recent stock assessment of demersal scalefish targeted by the WCDSMF indicates that while there are some signs of recovery of dhufish in the south of the West Coast Bioregion, indicators for the northern management areas are unlikely to meet recovery milestones by 2030 unless further management action is taken to reduce total fishing mortality (i.e. retained catches and post-release mortality). Accordingly, the biological stock of dhufish is thus classified as inadequate (Fisher et al. 2023). Similarly, the stock assessment for snapper indicates that while the decline of spawning biomass has been halted, recovery milestones are unlikely to be met unless further management action is taken to reduce total fishing mortality (i.e. retained catches and post-release mortality); therefore, the biological stock of snapper is also classified as inadequate (Fisher et al. 2023).

In the context of large natural variability and fisheries catch levels over and above natural mortality rates, the potential for approximately 1.0% of the dhufish or snapper spawning biomass in the West Coast Bioregion fishery management area to be disturbed is expected to have a negligible effect (i.e. no discernible impacts to recruitment and populations). The effects of the survey are unlikely to be discernible from natural variation, given that it is only the groups of fishes exposed at a particular site and point in time that may be affected; spawning will continue undisturbed elsewhere throughout the stocks' ranges and the majority of spawning groups in the region at any point in time will be undisturbed. The affected groups of fishes will also spawn again at multiple other times during the spawning season and so discernible impacts to recruitment and populations are not expected.

The serial, broadcast spawning strategies of the indicator demersal fish species, by their very nature, offsets potential high natural embryo and larval mortality as a result of predation or other environmental factors and thereby spreads the risk or potential opportunity for larval settlement over large areas and long timeframes. Subsequent recruitment of fishes to the adult stock also occurs over extended timeframes and is ongoing. Therefore, in comparison, the occasional, short-term, transient and localised disturbances to groups of fish as a result of a seismic survey would have impacts many orders of magnitude smaller than regional scale environmental/climatic events that would affect entire stocks.

Commercial fish spawning – impact assessment conclusion

Based on the above information and the highly conservative assessment, potential disturbance to a small proportion (up to 1.0%) of the indicator fish stocks in the West Coast Bioregion fisheries management area within one season is not expected to result in any population level impacts, both in the context of natural variability in spawning and recruitment and inadequate stock levels for dhufish and snapper from fishing mortality.

7.1.5.5 Commercial fisheries

Increased sound levels associated with seismic acquisition may modify the behaviour, local abundance and distribution of fish species, and therefore affect commercial fisheries catch rates within the ASA and in adjacent waters. Additionally, seismic acquisition has the potential to affect commercial fisheries via displacement or exclusion of fishers from areas where they normally operate for all or part of the period during which the survey is being acquired. This potential impact is assessed in Section 7.3.

As described in Section 4.4.2, a review of catch and effort data shows that the following WA-managed commercial fisheries were active in the OA within the past ten years:

- Marine aquarium managed fishery (MAMF)
- Octopus interim managed fishery (OIMF)
- Open access fishery (OAF)
- Specimen shell managed fishery (SSMF)
- Tour operator fishery west coast (TOFWC)
- West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF)
- West coast demersal scalefish managed fishery (WCDSMF)
- West coast rock lobster managed fishery (WCRLMF).

Crustaceans

The primary commercially targeted crustacean species in the OA is the western rock lobster. The WCRLMF targets the western rock lobster (*Panulirus cygnus*), off the west coast of Western Australia between Shark Bay and Cape Leeuwin. An analysis of fishing catch and effort data for this fishery shows that the OA only overlaps a very small percentage (1.94 %) of the fished area. In addition, this analysis as well as surveys of commercial rock lobster fishers reflected in Miller et al. (2023) indicate that there is currently low fishing effort in the OA relative to adjacent areas.

Commercial and recreational catch rates in this fishery have been maintained at consistently high levels. These high catch levels and the results of fishery-independent egg production monitoring across the fishery indicate that western rock lobster biomass and egg production in all locations of the WCRLMF are at record-high levels based on nearly three decades of fisheries surveys. The breeding stock is therefore considered sustainable-adequate (Newman et al., 2023).The healthy stock status of the western rock lobster indicates a level of resilience to localised sub-lethal effects to a small number of individuals and these effects are not expected to impact catch rates beyond the immediate survey area. Noise modelling results indicate that sub-lethal effects would be limited to less than 200 m from the airgun array. Further to this, any localised effects are expected to recover due to either recovery of exposed individuals or stock replenishment from recruitment. This is supported by a review of relevant literature on effects of seismic noise on crustacean fisheries.

Parry & Gason (2006) undertook a statistical analysis of catch per unit effort (CPUE) data collected over nearly 30 years in the Victorian southern rock lobster fishery (in southwest Victoria) that showed no influence of historical 2D and 3D MSS activity. Analyses looked at short-term (weekly) and long-term variations (up to seven years) in CPUE to determine whether changes were correlated with the MSS. The surveys occurred in water depths ranging from 10 m to 150 m. The study included surveys occurring during the southern rock lobster spawning period as well as during the lobster fishing season and so would have interacted with adult lobsters and larvae in a similar way to what the proposed Eureka 3D MSS may. This study found no evidence that catch rates were affected in the weeks or years following the surveys; however, Day et al (2016a) suggest that catch rates would have had to decrease by around 50% for this study to detect a result.

Morris et al. (2018) investigated the effects of 2D seismic on the snow crab fishery along the continental slope in Canada in a BACI study over a period of two years. Crabs were exposed to received levels of 187 dB re 1µPa^2 s (single shot) and 200 dB re 1µPa^2 s (cumulative over 24-hours). There were no negative effects on the catch rates in the shorter term (days) or longer term (weeks), and the authors concluded that seismic effects on snow crab harvest (if they do exist) would be smaller than changes related to natural spatial and temporal variation.

Morris et al. (2020) conducted a field experiment to apply a series of comparisons conducted within a BACI study design to investigate the effect of prolonged 3D seismic airgun exposure on the catch rates of snow crab over nine weeks in 2017 and five weeks in 2018. Changes in catch rates at 3D seismic surveying sites were inconsistent across years, with reduced catches in 2017 and increased catches in 2018. Catch rates were similar at experimental and control sites within two weeks after exposure, and the potential effect of seismic surveying was not measured at a distance of 30 km. The large variation in catch rates across small temporal and spatial scales coupled with the absence of notable mechanistic responses of snow crab in past studies to seismic noise in associated snow crab movement behaviour, gene expression and physiology, the authors concluded that the observed differences owing to seismic surveying in their study design are likely a result of stochastic processes external to their manipulation (Morris et al. 2020).

Molluscs

Day et al. (2023) conducted an octopus fishery analysis using a BACI analysis of logbook data to determine whether there was an impact on CPUE from the CGG Gippsland 3D MSS. BACI analysis showed that there was no impact of the seismic survey on the octopus fishery CPUE at the fishing block level. However, independent of this study, short-term declines in CPUE were evident in individual fishers' catch histories reported and analysed through the CGG Gippsland 3D MSS Fisheries Displacement Mitigation plan. This suggests that the fishery logbook CPUE data calculated at the level of fishing block, was not sensitive enough to capture localised changes.

Fishes

Some fishers believe there is a longer-term effect on fish catchability or presence in fished areas; however, it is not possible to isolate possible seismic survey effects from confounding factors such as fishing pressure, climatic changes and variation in natural population dynamics. A series of studies have been undertaken to determine the effects of seismic surveys on fish catches and distribution, primarily in the United States and Europe (e.g. California: Greene et al. 1985; Pearson et al. 1992; Norway: Dalen & Knutsen 1987, Engås et al. 1993; UK: Pickett et al. 1994). While the conclusions from these studies are largely ambiguous, due to the inherently high levels of variability in catch statistics, one study noted that pelagic species appear to disperse, resulting in a decrease in reported catches during the surveys (Dalen & Knutsen 1987).

Engås et al. (1996) and Engås & Løkkeborg (2002) looked at the effects of a seismic exploration on fishing success for haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*). They found that, compared to pre-seismic catches, there was a significant decline in the long line catch rate during and after the seismic study. The catch rate did not return to normal for five days after the end of the seismic study, although evidence of this decline being related solely to the survey is inconclusive. More recently, the same group used sonar to observe the behaviour of blue whiting and Norwegian spring spawning herring during a seismic operation and observed that fish would dive from the seismic source and not return until after the activity had stopped (Slotte et al. 2004).

A study undertaken by the CSIRO and Geoscience Australia (Thomson et al. 2014) examined fisheries catches (10 species of interest) and catch rates for potential effects from 183 seismic surveys undertaken in the Gippsland Basin (Bass Strait). The authors found that there were no clear or consistent relationships between seismic surveys and subsequent fisheries catch rates in their study. However, they cautioned that the results did not imply that such impacts do not exist, but that data was lacking. In terms of duration since a seismic survey occurred, significant positive and negative effects were found but could not be distinguished from inter-annual changes in stock size or availability to fishing gear resulting from other dynamics (Thomson et al. 2014).

In natural situations, the majority of fish are expected to be able to avoid the approaching noise source before it reaches injurious or potentially lethal levels through horizontal or vertical movements. Evidence that fish can actively avoid the source comes from studies of caged fish actively swimming away from the approaching noise source and temporarily reduced catchability in commercial fisheries. Wardle et al. (2001) conducted a field study, using a video camera to document the behaviour of fish in response to noise levels equivalent or greater than those in the proposed survey. This study showed that the resident fish on the site did not evade the active source until it was within a few metres. No direct mortality was observed at sound levels of up to 218 dB (SPL_{pk}).

Not all studies have resulted in behavioural alteration. Feeding Atlantic herring (*Clupea harengus*) schools off northern Norway showed no changes in swimming speed, direction or school size in response to a transmitting seismic vessel as it approached from a distance of 27 km to 2 km, over a 6-hour period (Peña et al. 2013). As fishing areas are large and commercial fish species are free-swimming, if fish are ‘scared’ temporarily from an area, based on evidence presented, it is likely they will be displaced temporarily to another area still within the fishing zone and so able to be caught.

There is little research undertaken on what effect seismic surveys have on fish catchability. Salgado Kent et al. (2016) acknowledge that there has been some effort to relate fisheries catch data to seismic survey effort, but to date none of the Australian efforts to relate finfish catch rates with seismic surveys have yielded results of any meaning. The Gippsland Marine Environmental Monitoring (GMEM) project provided no clear evidence of adverse effects on scallops, fish, or commercial catch rates due to the 2015 seismic survey (Przeslawski et al. 2016b):

‘Catch rates in the six months following the seismic survey were different than predicted in nine out of the 15 species examined across both Danish Seine and Demersal Gillnet sectors. Across both fishing gear types, six species (tiger flathead, goatfish, elephantfish, boarfish, broadnose shark and school shark) indicated increases in catch subsequent to the seismic survey, and three species (gummy shark, red gurnard, sawshark) indicated decreases in catch. These results support previous work in which the effects of seismic surveys on catch seem transitory and vary among studies, species, and gear types.’

Research to date has identified some negative effects, some positive effects, and no effects from seismic surveys on catch rates and abundance. This is likely due to the importance of the context of exposure. In many instances, fish may move away from an area when a seismic survey is being undertaken. This could impact on the catchability and catch rates for the target species of any commercial fisheries occurring in the same area at the same time.

Haddon (2017) further investigated the effect of the 2015 seismic survey in the Gippsland Basin on deepwater flathead catches and concluded that the significant drop in catch per unit effort (CPUE) was very likely negatively influenced by the seismic survey. However, Haddon (2017) went on to add that the seismic survey did not appear to have had a lasting impact on deepwater flathead CPUE, which returned to typical values in the first month following the seismic survey.

A critical review of the potential impacts of marine seismic surveys on fish and invertebrates (Carroll et al. 2017) found that other studies on fish have positive, inconsistent, or no effects from seismic surveys on catch rates or abundance. A desktop study of four species (gummy shark, tiger flathead, silver warehou, school whiting) in the Bass Strait found no consistent relationships between catch rates and seismic survey activity in the area, although the large historical window of the seismic data may have masked immediate or short-term effects which cannot therefore be excluded (Przeslawki et al. 2016b). Przeslawki et al. (2016b) concluded that “These results support previous work in which the effects of seismic surveys on catch seem transitory and vary among studies, species, and gear types”. The body of peer-reviewed literature does not indicate any long-term abandonment of fishing grounds by commercial species, with several studies indicating that catch levels returned to pre-survey levels after seismic activity had ceased (Carroll et al. 2017). As noted by Przeslawski et al. (2016b), it is possible that fish may be displaced from a survey footprint to adjacent areas, however the total number of fish within the fishery stock remains unchanged.

Meekan et al. (2021) found no short-term (days) or longer-term (months) effects of seismic sound exposure on the behaviour and movement of tropical demersal snapper, emperor and grouper species off northern Australia including groups of fishes exposed within tens of metres of the passing seismic source. The authors suggest that the behavioural responses of demersal fishes to the bait cue during the study are a realistic proxy of the likely response of the same species to baited hooks or traps used by the commercial fisheries that target them. Therefore, no long-term impacts on the catchability of demersal fish species are expected.

Effects will be temporary as the seismic vessel traverses each survey line, and fish may move away as the airgun array approaches. As described above, significant behavioural responses in the key indicator demersal fish species (which primarily detect particle motion, with limited, or no sensitivity to sound pressure changes at distance from a seismic source) will likely be limited to distances of a few hundreds of metres from the operating seismic source.

Section 4.4.2 includes an analysis of the area of overlap between the area of historic fishing activity (effort) and the OA for the Eureka 3D MSS. The potential area of disturbance generally represents less than 5% of the areas fished by each fishery (refer Table 4-16) and limited impacts are expected.

It is acknowledged that localised and temporary disturbances to fishing activities from seismic survey activities may occur. However, noting that behavioural impacts to target fish species will likely be limited to distances of a few hundreds of metres from the operating seismic source, with behaviours and distributions returning to normal minutes or hours (or potentially days) after, the potential acoustic disturbance to commercial fisheries and their target species is not expected to exceed the areas and durations of displacement due to the physical presence of the survey. Once the survey is complete, fish behaviours and distributions are expected to return to normal within days, if not hours.

It is likely that alternative and viable fishing grounds are available to fishers during the survey. If viable catch levels can be maintained from other areas, overall annual catch rates and fishery performance are not expected to be significantly impacted. In the event that fishers experience impacts, Pilot has developed a set of compensation principles relevant to commercial fishing activities. In summary, Pilot will consider claims from commercial fishing licence holders where:

- There is genuine displacement from undertaking normal fishing activities that results in economic loss.
- Fishing equipment has been lost or damaged by any activities under Pilot's control.
- Loss of catch that can be demonstrated by licence holders.

The commercial fisheries compensation principles will be consistent with the loss adjustment principles described in *Guidance framework: Supporting cooperative coexistence of seismic surveys and commercial fisheries in Australia's Commonwealth marine area* (Australian Government 2022).

Commercial fisheries – impact assessment conclusion

The potential impacts of noise emissions from the seismic source on commercial fisheries during the acquisition of the survey are considered to be 'localised' and 'short-term', based on behavioural disturbance of target species potentially affecting 'catchability' and hence and catch rates for weeks- months following completion of the survey.

7.1.5.6 Marine turtles

Species sensitivity and sound exposure thresholds

Acute noise, or temporary exposure to loud noise, may result in the avoidance of important habitats and in some situations physical damage to turtles. However, there is a scarcity of data regarding the responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. Marine turtles have the best hearing sensitivity and low frequencies in the range of 100-700 Hz (Bartol & Musick 2003; Finnernan et al. 2017) and are known to have poor auditory sensitivity (Bartol & Ketten 2006; Dow Piniak et al. 2012). Accordingly, PTS and TTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000b) observed the behavioural response of caged sea turtles — green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) — to an approaching seismic airgun. For received levels above 166 dB re 1 μPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 μPa (SPL) they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural response to sea turtles by NMFS and applied in the Arctic Programmatic Environmental Impact Statement (PEIS) (NSF 2011) and the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017). The 175 dB re 1 µPa level from McCauley et al. (2000b) is recommended as the threshold for behavioural disturbance.

Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa²·s (SEL_{24h}). Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of metres) from the airgun.

The sound exposure thresholds applied for marine turtles in the acoustic modelling study, and in this impact assessment, are summarised in Table 7-10. The peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL) presented in Table 7-10 are as reported in Finnernan et al. (2017) for PTS and TTS effects in turtles. The behavioural response threshold presented in Table 7-10 is the 166 dB re 1 µPa (SPL) as applied by the NMFS (NSF 2011), and the 175 dB re 1 µPa (SPL) reported in McCauley et al. (2000b).

Table 7-10: SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine turtles

Effect type	Criterion	Unweighted SPL (dB re 1 µPa)	Weighted SEL_{24h} (dB re 1 µPa²·s)	PK (dB re 1 µPa)
Behavioural response	NSF (2011)	166	N/A	
	McCauley et al. (2000a, 2000b)	175		
PTS onset thresholds* (received level)	Finneran et al. (2017)	N/A	204	232
TTS onset thresholds* (received level)			189	226

* Dual metric acoustic thresholds for impulsive sounds; Use whichever results in the largest isopleth for calculating PTS and TTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered. L_p denotes sound pressure level period and has a reference value of 1 µPa. L_{pk},flat denotes peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa. L_E denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.

Impact assessment

Without appropriate control measures in place, noise emissions from the seismic source have the potential to impact marine reptiles by causing changes to hearing (PTS and TTS) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts.

As described in Section 4.3.9, the OA does not overlap any marine turtle BIA, and the nearest nesting beaches are located in Shark Bay, approximately 350 km to the north. There are anecdotal records of loggerhead and leatherback turtles (deceased animals) in proximity to the OA in the Atlas of Living Australia database, and the seagrass habitats of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF may provide valuable feeding grounds for green and leatherback turtles. Therefore, it is possible that transient individuals could be present in the area during acquisition of the Eureka 3D MSS.

Table 7-11 presents the results of the acoustic modelling study for the maximum R_{max} distances to PTS (injury), TTS, behavioural response and behavioural disturbance thresholds in turtles, for all modelled source scenarios. The results for the thresholds applied for PTS and TTS consider both metrics (single pulse PK and multiple pulse SEL_{24h}).

Table 7-11: Maximum predicted horizontal distances (R_{max}) to PTS, TTS, behavioural response and behavioural disturbance thresholds in turtles, for all modelled scenarios

Hearing group	Sound effect threshold	R_{max} distance (km)
Marine turtles	**Behavioural response**	
	166 dB re 1 µPa (SPL)	4.90
	175 dB re 1 µPa (SPL)	1.58
	PTS	
	232 dB re 1 µPa (PK)	-
	204 dB re 1 µPa².s (SEL_{24h})	0.06
	TTS	
	226 dB re 1 µPa (PK)	-
	189 dB re 1 µPa².s (SEL_{24h})	2.10

A dash indicates that the threshold is not reached within the limits of the modelling resolution (20 m).

Marine turtle PTS thresholds could be reached within 60 m based on the application of the multiple pulse SEL_{24h} threshold as the single pulse PK PTS threshold was not reached within the limits of the modelling resolution. TTS thresholds could be reached within 2.1 km based on the application of the multiple pulse SEL_{24h} threshold as the single pulse PK PTS threshold was again not reached.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24-hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position and represents an unlikely scenario. More realistically, transient marine turtles moving through the OA would not stay in the same location for 24-hours, but rather a shorter period, depending upon their behaviour and the proximity and movements of the source. There are no indications that the OA and adjacent waters include any significant foraging areas for turtles. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine reptiles travelling within this radius of the source will be impaired, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained in that location for 24-hours (Koessler & McPherson 2023; Appendix G.

The likelihood of PTS and TTS occurring to marine turtles is reduced to a degree by the implementation of control measures including an observation zone of 500 m and a shut-down zone of 100 m under Part A of the EPBC Policy Statement 2.1, which reduces the potential for close range sound exposures where the greatest sound contribution is received.

Based on the 166 dB re 1 µPa SPL behavioural threshold criterion a behavioural response could occur within 4.9 km. Based on the 175 dB re 1 µPa SPL behavioural threshold criterion a behavioural disturbance could occur within 1.58 km. Accordingly, turtles approaching the operating seismic source are likely to exhibit a behavioural response (avoidance) such that they would not approach the source close enough to incur a TTS.

Marine turtles – impact assessment conclusion

Based on the assessment above and the implementation of controls, the potential impacts of noise emissions from the seismic source on marine reptiles (turtles) during the acquisition of the survey are considered to be ‘localised’ and ‘short-term’. Impacts are likely to be restricted to temporary behavioural changes (avoidance) to transient turtles that may pass within 4.9 km of the seismic source. Such behavioural changes are expected to only last for the duration of a survey pass with normal behaviour anticipated to resume when the vessel has moved this distance or more away along the seismic sail line.

7.1.5.7 Marine mammals

Species sensitivity and sound exposure thresholds

Marine mammal species differ in their hearing capabilities, absolute hearing sensitivity and their frequency band of hearing (Richardson et al. 1995; Wartzok & Ketten 1999; Southall et al. 2007). Accordingly, Southall et al. (2007, 2019) proposed relatively broad hearing groups based on their known hearing sensitivity and sound production parameters, as well as common auditory anatomical features. For this assessment, four functional hearing groups are included: low-frequency (LF) cetaceans (baleen whales), high-frequency (HF) cetaceans (dolphin, sperm whale, beaked whale species), very high-frequency (VHF) cetaceans (*Kogia sp.*) and otariid pinnipeds in water (ASL).

NMFS (2016) recommend dual marine mammal criteria for the prediction of PTS and TTS from underwater sound modelling – peak SPL ‘unweighted’ criteria and cumulative exposure weighted criteria (Table 7-12). Both sets of criteria are applied in the assessment for marine mammals within this EP.

The marine mammal behavioural threshold is based on the current (NOAA 2019) root mean square (rms) sound pressure level (SPL) criterion for marine mammals. The NOAA (2019) sound level criterion for potential disturbance to marine mammals (cetaceans and pinnipeds) is 160 dB re 1 μPa SPL for impulsive sounds, which is peer reviewed and accepted by the scientific community, and has therefore been used for the assessments in this EP. Whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for the onset of behavioural response for marine mammals.

Table 7-12: Summary of relevant injury and behavioural criteria for marine mammals

Marine mammal hearing group	NOAA (2019)	Southall et al. (2019)			
	Behaviour	PTS		TTS	
	Unweighted SPL (dB re 1 uPa)	PK (dB re 1 uPa)	Weighted SEL_{24h} (dB re 1 $uPa^2 \cdot s$)	PK (dB re 1 uPa)	Weighted SEL_{24h} (dB re 1 $uPa^2 \cdot s$)
Low frequency cetaceans	160	219	183	213	168
High-frequency cetaceans		230	185	224	170
Very high-frequency cetaceans		202	155	196	140
Otariid pinnipeds in water		232	203	226	188

Impact assessment - cetaceans

Biologically important periods for key cetaceans in the region are shown in Table 7-13.

Table 7-13: Biologically important periods for cetaceans

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Notes
Survey timing													
Humpback whale													Sep to Oct – cows/ calves
Pygmy blue whale													Species typically prefers deeper waters
Southern right whale													Occasional sightings north of Geographe Bay

Marine mammals use sound for foraging, orientation, communication, navigation, echolocation of prey and predator avoidance (Richardson et al. 1995) and therefore are sensitive to underwater noise. High levels of anthropogenic underwater sound can potentially have negative impacts; ranging from changes in their acoustic communication, displacing them from an area, and in more severe cases causing physical injury or mortality (Richardson et al. 1995).

Impulse sounds from an airgun array are considered capable of causing instantaneous auditory injury resulting in a permanent threshold shift (PTS) that persists once sound exposure has ceased. PTS may also result from prolonged exposure at lower levels. Hearing loss may be considered permanent if hearing does not return to normal after several weeks. Lower noise levels or shorter exposures to noise have the potential to cause a temporary threshold shift (TTS) where animals would experience temporary auditory injury, and from which they would recover fully, particularly as they move away from the source.

Behavioural responses to low frequency acoustic sound in baleen whales range from tolerance at low–moderate acoustic levels (McCauley et al. 2000a) to graduated behavioural responses including shifts in respiratory and diving patterns (McCauley, 1994) at higher levels. It has been observed that the behaviour of cetaceans to differing sound levels depends on their activity at the time of exposure and is variable between and within species (Richardson et al. 1995). Cetaceans tend to be less responsive to sound when migrating or feeding than when suckling or resting with calves or socialising.

The key marine mammal species within the Eureka 3D MSS OA and adjacent waters that may be affected by underwater noise from seismic operations have been classed into the functional hearing groups as follows:

- LF cetaceans (baleen whales): humpback whales (HBWs), pygmy blue whales (PBWs), southern right whales (SRWs), and potential presence of other species (e.g. fin, sei and Bryde's whales)
- HF cetaceans: limited to transiting individuals for larger dolphins, beaked whales, sperm and killer whales
- VHF cetaceans: limited to occasional transiting individuals of *Kogia sp*.

Underwater noise modelling carried out for the Eureka 3D MSS for an airgun array source of 2495 in^3 predicted distances to received sound levels compared with noise effect criteria threshold levels in Table 7-14.

Table 7-14: Summary of modelled impact ranges for cetaceans

Hearing group / effect	Sound effect threshold	R_{max} distance (km)
LF cetaceans		
PTS	219 dB re 1 uPa (PK)	0.06
	183 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	3.08
TTS	213 dB re 1 uPa (PK)	0.150
	168 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	43.0
HF cetaceans		
PTS	230 dB re 1 uPa (PK)	-
	185 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	-
TTS	224 dB re 1 uPa (PK)	-
	170 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	0.06
VHF cetaceans		
PTS	202 dB re 1 uPa (PK)	0.41
	155 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	0.06
TTS	196 dB re 1 uPa (PK)	0.84
	140 dB re 1 $uPa^2 \cdot s$ (SEL_{24h})	0.44
All cetaceans		
Behavioural response	160 dB 1 uPa (SPL)	9.2

Note; A dash indicates no exceedance of threshold within the limits of the modelling resolution (20 m).

While these modelling results are based on recommendations from relevant guidance, the cumulative PTS and TTS (SEL_{24h}) exposures in particular are not expected to occur in reality; a whale is unlikely to remain stationary while a seismic vessel traverses an area, and mitigation controls such as the low-power and shut down zones would be triggered.

Injury, permanent and temporary threshold shifts

While intense impulse waves from underwater point sources of sound can cause injury to fauna through barotrauma (Richardson et al. 1995; NMFS 2018), airgun arrays are not strictly point sources (DEWHA 2008a) and are less likely than explosives or piling to create sound pressure waves intense enough to cause such injury. Furthermore, as the sound pressure wave propagates away from the source, its duration increases and peak reduces. This transformation into a non-impulsive sound reduces its potential to cause injury in the far-field (NMFS 2018). No instances of instantaneous injury to marine mammals from seismic airguns have been recorded (DEWHA, 2008a) and there is no reason to consider that the Eureka 3D MSS will do so.

Modelled peak pressure noise levels from a single shot of the airgun array on full power indicate that LF cetaceans could suffer PTS within 60 m of the airguns and VHF cetaceans within 410 m. The PTS onset threshold was not reached within the limits of the model (20 m) for HF cetaceans (Table 7-14). PTS is considered highly unlikely throughout the duration of the survey because the standard control measures of the EPBC Act Policy Statement 2.1 (pre-start-up visual observations, soft start, low-power zone and shut down zone) will help ensure that whales are detected if in close proximity to the airgun array before the array is activated, and if they are detected, the airguns will not be started or will be powered down or shut down. The timing of the survey (early February to end of March) is prior to the period of known presence of high densities of whales in the OA, and therefore the presence of whales during this time is expected to be limited to occasional, transient individuals. This acquisition window avoids the migration periods for PBW, HBW and SRW in the region.

Outside of these ranges, individual animals may still sustain PTS but only through prolonged exposure to the airgun signals. The noise modelling for LF cetaceans predicted that prolonged exposure over 24 hours could cause PTS out to a maximum of 3.08 km of the source (Table 7-14). This prediction included close exposure whereby most of the sound energy “dose” would have occurred, and in reality, the range to cumulative PTS onset is likely to be much closer than this. PTS through cumulative exposure is considered unlikely because of the behavioural responses of individual animals (e.g. move away from the source) or the application of the mitigation measures when whales are spotted. Cetaceans that are susceptible to these sound levels comprise all the baleen whales that may be encountered in the OA (Section 4.3.7). Therefore, the standard mitigation measures in the EPBC Act Policy Statement 2.1 Part A apply.

As for a single shot, HF cetaceans are not expected to receive injurious levels if exposed to the seismic source for a 24-hour period (Table 7-14). The noise modelling for VHF cetaceans predicted that prolonged exposure over 24-hours could cause PTS out to a maximum of 60 m of the source (Table 7-14). It is considered highly unlikely that a cetacean would remain so close to the source due to the probable behavioural responses to the noise of the airguns. Furthermore, *Kogia sp*. are not likely to be exposed to prolonged airgun noise in this short range given the implementation of a low-power zone of 2 km and shut-down zone of 500 m as required under EPBC Policy Statement 2.1. It is therefore highly unlikely that any VHF cetaceans will suffer PTS through prolonged exposure to the seismic survey.

Instantaneous TTS can be caused by a single airgun shot if a cetacean is close enough or through repeated exposure to the airgun shots if further away. Instantaneous TTS (PK) for LF cetaceans was predicted to occur within 150 m of the airgun array and within 840 m for VHF cetaceans. The PTS onset threshold was not reached within the limits of the model for HF cetaceans. This is not considered very likely because the airgun array will only be started after the observation zone has been thoroughly searched by MMOs and if cetaceans have escaped detection, will not be exposed to full power because the airgun array will be started on low power (soft-start). This is likely to alert cetaceans to the disturbance and encourage them to move away before full power is achieved. Should cetaceans come within 2 km or 500 m of the airguns on full power, the airgun array will be powered-down or stopped, respectively.

Prolonged exposure to seismic shots has the potential to cause TTS (SEL_{24h}) at greater ranges than single shots. The range to potential cumulative TTS for LF cetaceans was 43 km, 60 m for HF cetaceans and 440 m for VHF cetaceans (Table 7-14). Realistically, a whale will not remain stationary in a fixed position for a 24-hour period (unless it is engaged in foraging within a spatially confined area), and therefore ranges to cumulative TTS are highly conservative. The timing of the survey (early February to end of March) is prior to the period of known presence of high densities of whales in the OA, and therefore the presence of whales is expected to be limited to occasional, transient individuals. Based on the published literature regarding the timing of migration and foraging, significant numbers of whales are not expected to be in the region. Controls measures as per EPBC Policy Statement PS 2.1 Parts A and B are being implemented as precautionary measures in case some individuals are encountered, and also due to the uncertainty about presence for rarer species.

Animat modelling

A summary of radial distances to exposure thresholds for pygmy blue whales, along with probability of exposure for modelled Scenario 2 (refer Section 7.1.4) are included in Table 7-15, which shows results for scenarios for foraging and migrating pygmy blue whale animats. Results include $ER_{95\%}$ exposure ranges calculated for the SEL_{24h} thresholds for both TTS and PTS, and the probability of an animat being exposed above the threshold within the $ER_{95\%}$.

Table 7-15: Summary of animat simulation results for pygmy blue whales for Scenario 2, showing 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (Pexp [%])

Noise effect criteria	Foraging				Migrating	
	Male		Female			
	ER95%	Pexp	ER95%	Pexp	ER95%	Pexp
PTS (SEL24h)1	0.89	63	0.82	66	0.63	54
TTS (SEL24h)2	14.5	57	13.7	59	8.47	70

[1] LF-weighted SEL_{24h} (183 dB re 1 μPa^2·s) (Southall et al. 2019)

[2] LF-weighted SEL_{24h} (168 dB re 1 μPa^2·s) (Southall et al. 2019)

Exposure ranges from animal movement modelling for PTS and TTS criteria are typically shorter than those predicted using acoustic propagation modelling because moving animats generally accumulate sound energy over a shorter time (‘dwell time’). In this study, PTS and TTS exposure ranges were substantially shorter than acoustic ranges to threshold.

All considered scenarios with unrestricted animat seeding resulted in exposures above the PTS and TTS thresholds. The maximum $ER_{95\%}$ for PTS and TTS were 0.89 and 14.5 km, respectively, with corresponding exposure probabilities for animats travelling within that range of 63% and 57%, indicating that 37% and 43% of animats that travelled within the 95th percentile range were not exposed above threshold. This is because the modelled animats move in and out of the ensonified area and change their vertical position in the water column, thereby influencing the length of time they are within the exposure radius. For example, an animat might approach within the predicted exposure range but if they are traveling more quickly on average than other animats, they may not accumulate as much sound exposure, or they may spend more time at depths where sound levels are lower.

The animal movement and exposure modelling presented herein is a more realistic estimate of the dosimetric impact potential for accumulated sound exposure compared to static receiver accumulated sound exposure modelling scenarios presented in Koessler & McPherson (2023).

Based on the results of the animat modelling there will be no overlap between the maximum TTS onset range for migrating pygmy blue whales and the migration BIA, which is located at least 17 km from the ASA at the closest point. There is a marginal TTS onset overlap for both males and females within the known foraging BIA, which is located at ~13 km from the ASA (based on a maximum $ER_{95\%}$ of 14.5 km for males and 13.7 km for females). However, the ASA is located at least 35 km from the most important foraging area in the region (refer Figure 4-11), as calculated by Thums et al. (2022) from the overlap between three metrics of pygmy blue whale spatial use.

It is important to note that the acquisition of the Eureka 3D MSS will not overlap shoulder or peak periods for either the northbound or southbound pygmy blue whale migration, based on the planned acquisition window of February–March 2025 or February–March 2026. Similarly, acquisition of the survey will not overlap the defined migration periods for southern right whales (April to October) or humpback whales (June to November) in the region.

To account for the potential presence of pygmy blue whales within and adjacent to the known foraging BIA outside of migration periods, an additional control and adaptive management procedures will be implemented to manage potential impacts to pygmy blue whales to ensure the activity is not inconsistent with the Conservation Management Plan for the Blue Whale (refer Section 9).

The additional control will be the deployment of two dedicated and trained MFOs on the support vessel during acquisition within the western section of the ASA (blue lines on Figure 3-3) – designated as the Extended Observation Zone for PBW. During acquisition within the Extended Observation Zone for PBW, the support vessel will be positioned 10 km to the west of the survey vessel, and the MFOs will implement the same observation and shut-down zones as described in Table 7-20 below. The MFOs aboard the support vessel will be in direct communication with the lead MFO aboard the survey vessel and will have the authority to request a shut-down if a positively identified (certain or probable confidence level) pygmy blue whale or large unidentified whale is observed within the limits of visibility from the support vessel (refer PS 1 i Table 7-20).

If the support vessel has to leave the Extended Observation Zone for any reason (e.g. for resupply) the survey vessel will stop acquisition and move to lines within the eastern section of the ASA (red lines on

Figure 3-3) Acquisition within the Extended Observation Zone will only recommence when the support vessel is available to re-commence the role of additional spotter vessel.

To account for the limitation that visual monitoring for pygmy blue whales will be limited to daylight hours only, additional adaptive management measures will be implemented will be implemented throughout the survey, in accordance with Part B.6 of EPBC Policy Statement 2.1. As described in Table 7-20. If there are three or more shut-downs for pygmy blue whales within a 24-hour period (including shut-downs triggered by sightings by the support vessel MFOs within the Extended Observation Zone), then the seismic operations must not be undertaken thereafter at night-time or during low visibility conditions.

Seismic operations cannot resume at night-time or during low visibility conditions, until there has been a cumulative 24-hour period of seismic operations (daylight hours with good visibility) during which there has been ≤1 shut-down for pygmy blue whales.

Behavioural disturbance

Behavioural responses to low frequency acoustic sound in baleen whales range from tolerance at low–moderate acoustic levels (McCauley et al. 2000a) to graduated behavioural responses including shifts in respiratory and diving patterns (McCauley 1994) at higher levels. It has been observed that the behaviour of cetaceans to differing sound levels depends on their activity at the time of exposure and is variable between and within species (Richardson et al. 1995). Cetaceans tend to be less responsive to sound when migrating or feeding than when suckling or resting with calves or socialising.

Strong behavioural disturbance from a single shot of the airgun array for all marine fauna groups including cetaceans is predicted to occur out to a maximum distance of 9.2 km from the source (Table 7-14). Southall et al. (2007, 2021) noted that certain marine mammal species and certain marine mammals in specific behavioural modes appear to be significantly more sensitive to noise exposure.

The species most sensitive to behavioural disturbance that may occur in or around the OA are the PBW, SRW and HBW due to the overlap with the BIAs. The timing of the survey (early February to end of March) is outside of the recognised migration periods for all three species, and therefore the presence of individuals is expected to be limited to occasional, transient individuals during this time.

Other whales that may be encountered during the survey in the OA include the southern right, sei, fin and Bryde’s whale. These species may also exhibit a behavioural response out to the modelled range of 9.2 km. Should individuals or groups of these whales be encountered, they may be displaced temporarily as the seismic vessel passes, but their behaviour is likely to return to normal quickly and recommence their natural activities.

HF cetaceans including sperm whales and dolphins, and VHF cetaceans such as *Kogia sp*. may be present in the region; however, there are no known BIAs or important areas for feeding, migration, resting, breeding in or close to the OA. Behavioural disturbance may occur up to 9.2 km. Observers and MFOs on seismic vessels regularly see dolphins and other small-toothed whales in the vicinity of seismic surveys. In general, dolphins avoid operating seismic vessels (Stone & Tasker 2006), and in most cases, the avoidance radii for dolphins are small (1 km or less), with some individuals showing no apparent avoidance (Holst et al. 2006; Moulton & Miller 2005; Stone 2003; Stone & Tasker 2006; Weir 2006). Underwater noise impacts resulting in behavioural effects to HF and VHF cetaceans will be short-term as the vessel traverses sail lines within the acquisition zones and recoverable.

Indirect impacts on baleen whales

Indirect impacts on baleen whales could occur through the loss of zooplankton as a food resource through the airgun sound sources. As concluded in Section 7.1.5.1, the impacts on zooplankton are expected to be localised and will recover rapidly once the vessel moves to other seismic lines and zones. Impacts to zooplankton will be limited to a maximum range of 270 m from the ASA, and consequently these effects will not extend into the PBW foraging BIA.

Impact assessment - pinnipeds

The Australian sea lion (ASL) is the only pinniped with a known breeding site and/or haul-out site in the vicinity of the Eureka 3D MSS OA and EMBA, with the closest breeding colony located ~10 km away from the ASA on Beagle Island, adjacent to the southeast corner of the OA. This is a defined breeding BIA. Additionally, as described in Section 4.3.7, ASL foraging BIAs extend along the western coast of Australia, south of Geraldton down to Perth. The OA overlaps both foraging BIAs (Figure 4-14). As central placed foragers, ASLs forage year-round within the OA.

ASLs are otariids (sea lions and fur seals). Based on the review by NOAA (2013a) the functional hearing range of otariid pinnipeds has been estimated as 100 Hz to 40 kHz. The airgun array proposed for the Eureka 3D MSS will produce pulses across a frequency range of 0–150 Hz, i.e. largely below the functional hearing range of otariids such as the ASL, which are better adapted to detecting higher frequency underwater sounds. Underwater audiograms for some sea lions and fur seals indicate that their greatest sensitivity lies in the range 2–32 kHz and these pinnipeds are therefore likely to be less sensitive to low frequency (<1 kHz) sounds than to higher frequency (>1 kHz) sounds. The low frequency sounds (10–300 Hz) produced by seismic airgun arrays appear to fall below the range of otariid pinniped greatest hearing sensitivity (McCauley 1994). This interpretation must be treated with caution, as little data exists for low frequency thresholds and hearing sensitivities of Australian pinnipeds. However, it is recognised that seismic activity will only be a potential threat to pinnipeds if it takes place close to them (Shaughnessy 1999).

ASLs make underwater sounds including barks, whinnies and buzzing associated with social interactions. It has been measured that the projected energy for these sounds is between 0.25 and 2 kHz frequency (Richardson et al. 1995), and their hearing range is approximately between 0–4 kHz (Pidcock et al. 2003), in comparison to the airgun array proposed for the Eureka 3D MSS, which will produce pulses in the range of 0–150 Hz. Richardson et al. (1995) reported that an airgun caused an initial startle reaction among South African fur seals but was ineffective in scaring them away from fishing gear (Anonymous 1975a; cited in Richardson et al. 1995). Gray seals exposed to noise from airguns reportedly did not react strongly (J. Parsons, in G.D. Greene et al. 1985; cited in Richardson et al. 1995). Seals in both water and air sometimes tolerate strong noise pulses from nonexplosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Richardson et al. 1995). Thus, Richardson et al. (1995) concluded that “we might expect seals to be rather tolerant of, or habituate to, repeated underwater sounds from distant seismic sources, at least when the animals are strongly attracted to an area”.

Monitoring studies conducted in 1996–1997 for an open-water seismic programme in the Alaskan Beaufort Sea indicated that seals (mainly ringed seals) usually tolerate strong sound pulses from nearby seismic vessels (Richardson 1999). Numbers, distance, and behaviour of ringed seals, bearded seals, and spotted seals were investigated during seismic operations offshore northern Alaska (July–September 1996; 11 Bolt 1900LX airguns with a total array volume of 1320 in^3; Harris et al. 2001). About 79% were first seen within 250 m of the seismic vessel, and the sighting rate declined rapidly at lateral distances >50 m. Seals tended to stay farther away during full-array seismic. There was partial avoidance of the zone <150 m from the boat during full-array seismic, but seals apparently did not move much beyond 250 m.

Southall et al. (2007) found that, based on the limited data on pinnipeds in water exposed to multiple pulses, exposures in the ~150 to 180 dB re 1 µPa range (rms values over the pulse duration) generally have limited potential to induce avoidance behaviour in pinnipeds. Received levels exceeding 190 dB re 1 µPa were determined by Southall et al. (2007) to be likely to elicit responses, at least in some ringed seals, which are phociids (Harris et al. 2001; Blackwell et al. 2004b; Miller et al. 2005; cited in Southall et al. 2007). Based on the modelled sound pressure levels (SPL) for the 2495 in^3 proposed for use during the Eureka 3D MSS, SPLs >190 dB re 1 µPa would only occur within ~280 m of the operating array (Koessler & McPherson 2023).

Lalas & McConnell (2016) recorded the responses of New Zealand/long-nosed fur seals (*Arctocephalus forsteri*) during daylight hours during a 3D seismic survey (two identical airgun arrays with a volume of 3090 in^3) offshore southern New Zealand. Results were not conclusive since the sighting rate and the distance also decreased with deteriorating sea state and the survey vessel and the towed instruments created obstacles that elicited a response.

In the case of pinnipeds exposed to sequences of airgun pulses from an approaching seismic vessel, most animals may show little avoidance unless the received levels are high enough for mild temporary threshold shift (TTS) to occur. Southall et al. (2019) proposed injury (i.e. TTS onset) criteria for pinnipeds in water of 226 dB re 1 µPa (SPL), or an SEL of 188 dB re 1 µPa^2 s (refer Table 7-12). SPL / SEL of these magnitudes would only be experienced at extremely close range (e.g. <50 m or so) from an operating array of the size proposed for the Eureka 3D MSS, particularly for otariid species such as Australian sea lions. The noise created during seismic surveys is generally considered to be outside of the hearing range of ASLs and is therefore not considered to be a great source of disturbance, and the species is mobile and can exhibit avoidance behaviour if disturbed.

Underwater sound modelling was carried out for both single shot sites and for 24-hour cumulative exposure scenarios. Single shot (PK) and cumulative thresholds (SEL_{24h}) for PTS were not reached within the limits of the model (Table 7-16). Single shot TTS effects were not predicted to occur within the limits of the model, and cumulative TTS effects were predicted to occur within 60 m of the source (Table 7-16). A sea lion would not remain in a fixed position for a full 24-hour period, and therefore no PTS or TTS impacts to sea lions will occur.

However, it is possible that sea lions could exhibit some behavioural disturbance within 9.2 km of the seismic vessel (based on the NOAA 2019, 160 dB re 1µPa threshold). This is considered a potentially overly conservative threshold (and distance) given the much lower sensitivity of otariids to seismic sound compared with cetaceans.

Table 7-16: Summary of modelled impact ranges for pinnipeds

Effect	Sound effect threshold	R_{max} distance (km)
PTS	232 dB re 1 uPa (PK)	-
	203 dB re 1 uPa^2·s (SEL_{24h})	-
TTS	226 dB re 1 uPa (PK)	-
	188 dB re 1 uPa^2·s (SEL_{24h})	0.06
Behavioural response	160 dB 1 uPa (SPL)	9.2

Note; A dash indicates no exceedance of threshold within the limits of the modelling resolution (20 m)

There is also the potential for impacts to pinnipeds relating to prey displacement. An assessment of the potential acoustic impacts to pinniped prey from an operating array (i.e. mainly fish, western rock lobster, octopus and cuttlefish) has been undertaken in sections 7.1.5.2 and 7.1.5.3. The key findings from these are:

Fishes and elasmobranchs (section 7.1.5.3): Four main fish types were identified in the OA, site attached fish, demersal fish species, pelagic fish species and shark species. The hard substrate and epibenthos communities around the emergent reefs are key bathymetric features that support site attached and demersal fish species, however these areas will mostly be avoided due to a 300m exclusion area at the 12m depth contour. The pelagic fish and sharks are fast swimming species that will exhibit behavioural avoidance response while the seismic source is nearby, but behaviour is expected to return to normal within minutes to hours once the source is removed.

Cephalopods (section 7.1.5.2): Cephalopods are a sound sensitive species and behavioural responses to the seismic source would be expected. Octopus, one of the ASLs key prey items, are benthic and territorial so are not expected to move far as the source passes by them. This means that they will only be exposed to the source 2-3 times with days in between these occurrences to recover.

Invertebrates (section 7.1.5.2): Benthic invertebrates such as WRL cannot move large distances in response to acoustic sound. Sub-lethal impacts to WRL may be observed as a result of exposure to the seismic source however the exclusion areas around reefs will limit this impact and any affected WRL will remain available as prey to ASLs. In summary, it is expected that any impacts on ASL prey species will be 'localised' and 'short-term' and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. The area of temporary prey displacement for more mobile species will be small relative to the large BIA for foraging.

As described in Section 9, there are no action areas, objectives or actions in the Recovery Plan for the Australia Sea Lion (DSEWPC 2013a) that relate to potential impacts from anthropogenic noise on ASLs. The issues paper for ASL's (2013) does identify noise as a secondary threat that requires more research, with potential to impact on behaviour of the ASL and their prey species. Similarly, the South-west Marine Bioregional plan states that the effect of seismic activity on pinnipeds is not well understood and could possibly impact prey availability if not adequately managed (Commonwealth of Australia, 2007).

Marine mammals – impact assessment conclusion

Based on the assessment above, and the implementation of a temporal control to avoid acquisition during northbound and southbound PBW migration, and during the SRW migration period, the potential impacts of noise emissions from the seismic source on cetaceans during the acquisition of the survey are considered to be 'localised' and 'short-term'. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals moving through the OA, with predicted noise levels from the seismic acquisition not considered likely to cause injury effects.

7.1.5.8 Seabirds

Species sensitivity and sound exposure thresholds

There is very little known about the effects of intense underwater sound (i.e. seismic surveys) on marine birds. However, impacts have not been observed during previous seismic surveys (Turnpenny & Nedwell 1994), and it is generally thought that noise produced from activities associated with seismic surveys may impact only those species of birds that spend large quantities of time underwater, either swimming or plunge diving while foraging for food, for example penguins. Pichegru et al. (2017) found that penguins showed a strong avoidance of their preferred foraging areas during seismic activities, foraging significantly further from the survey vessel when in operation and increasing overall foraging effort.

Impact assessment

A total of 27 species of marine birds were identified as potentially occurring in the OA (Section 4.3.10), with foraging BIAs for eight species overlapping with the OA.

Birds foraging within the OA may be exposed to increased sound levels generated by the operating seismic source during foraging dives near the sea surface, and in response they may exhibit a startle response. Birds resting at the surface have limited potential to be affected by the noise emissions underwater due to the limited transmission of sound energy between the water and air interface, though they may also exhibit a startle response if resting in waters near to the operating seismic source. However, given the likely avoidance response of prey species (e.g. fish) in waters immediately surrounding the seismic source, it is unlikely that birds would forage in proximity to the seismic source. In the unlikely event that birds to forage in proximity to the source, this is likely to be limited to individuals only, with these birds expected to temporarily move away from the area as a result.

Seabirds – impact assessment conclusion

The behaviour and distribution of some fish may be affected for short periods during and after exposure to the seismic source, which may result in 'localised' and 'short-term' changes in the distribution of target prey species for some bird species. However, it is expected that the behaviours and distribution of prey at any one time will remain largely unaffected within the OA. Therefore, impacts to seabird populations are extremely unlikely to occur.

7.1.5.9 Impacts on protected area values and management

Pilot has undertaken the impact assessment in accordance with the management strategies and objectives of the South-west Marine Reserves Network Management Plan and consistent with Australia's IUCN Principles (Table 7-17). Protected areas and their conservation values that could be affected by seismic sound from the Eureka 3D MSS are summarised in Table 7-17. There are no known sites of cultural heritage significance in the OA (Section 4.4) nor has there been any objection from cultural heritage stakeholders during consultation (Section 5).

Table 7-17: Protected areas potentially directly or indirectly affected by the Eureka 3D MSS

Protected area	Conservation values that may be affected by the survey	Impacts from survey
Commonwealth protected areas		
Abrolhos AMP	• Important breeding area for lesser noddies	The Abrolhos AMP is located 20 km west of the Eureka 3D MSS OA and will not be affected by

Protected area	Conservation values that may be affected by the survey	Impacts from survey
	• Important feeding and nesting ground for many other seabird species • Important migratory pathway for humpback whales • Breeding and foraging area for the ASL • Diverse benthic and pelagic fish communities • Important rock lobster habitat	the survey. The impact assessment for environmental receptors provided throughout this section demonstrates that the survey will not have significant impact on the values of the area for migration, feeding, resting and breeding/nesting. Pilot has adopted a 'zoned' approach to the Eureka 3D MSS and will implement control measures to avoid impacts to migrating cetaceans (see Section 7.1.5.7).
Jurien AMP	• Important migratory pathway for humpback whales and pygmy blue whales • Important breeding area for ASLs • Important nesting ground for seabirds • Important foraging area for white sharks • Shallow seagrass lagoons supporting large biodiversity of marine species • Valued recreational activities including fishing and diving	The Jurien AMP is located 40 km south of the Eureka 3D MSS OA and will not be affected by the survey. The impact assessment for environmental receptors provided throughout this section demonstrates that the survey will not have significant impact on the values of the area for migration, feeding, resting and breeding/nesting. Pilot has adopted a 'zoned' approach to the Eureka 3D MSS and will implement control measures to avoid impacts to migrating cetaceans (see Section 7.1.5.7).
State protected areas		
Jurien Bay Marine Park	• Important breeding area for ASLs • Important breeding area for seabirds including fairy terns and osprey • Recreational fishing area • Recreational area for swimming, diving, snorkelling and kayaking	The Jurien Bay Marine Park is located 40 km south of the Eureka 3D MSS OA and will not be affected by the survey. The impact assessment for environmental receptors provided throughout this section demonstrates that the survey will not have significant impact on the values of the area for migration, feeding, resting and breeding/nesting.
Key ecological features		
Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF	• Regionally and nationally important for high benthic productivity and aggregations of marine life • Unique diversity of marine species • Seagrass habitats provide valuable feeding grounds for protected species including green and leatherback turtles • Important nursery area for many recreational and commercial fish species including western rock lobster, dhufish and snapper	The marine environment within and adjacent to the west coast inshore lagoons KEF is located within the Eureka 3D MSS OA. No management objectives set. Refer to assessments in: • Section 7.1.5.1 (plankton) • Section 7.1.5.2 (benthic invertebrates) • Section 7.1.5.5 (commercial fisheries) • Section 7.1.5.6 (marine turtles)
Western rock lobster KEF	• Important area for western rock lobster	The western rock lobster KEF is located within the Eureka 3D MSS OA. No management objectives set. Refer to assessments in: • Section 7.1.5.1 (plankton) • Section 7.1.5.2 (benthic invertebrates) • Section 7.1.5.5 (commercial fisheries)

7.1.5.10 Impact analysis on tourism and recreation

Scuba divers and snorkelers

The human auditory system is significantly less sensitive underwater than in air and is further degraded if diving equipment obstructs the ears or face (e.g. diving with a hood or full facemask). Under water, the human ear is about 20 dB less sensitive than it is in air at low frequencies (20 Hz), increasing to 40 dB at mid-frequencies (less than 1 kHz), and increasing to 70–80 dB less sensitive at higher frequencies (Parvin 1998). Divers who wear neoprene hoods have even higher hearing thresholds (lower sensitivity) above 500 Hz because the hood material absorbs high-frequency sounds (Sims et al. 1999). Exposure studies related to divers have typically focused on military sonar exposure, with little information on seismic survey operations, and as such care is required when considering thresholds for non-military divers, particularly for impulsive sounds such as seismic source impulses (Ainslie 2008).

Underwater auditory threshold curves indicate that the human auditory system is most sensitive to waterborne sound at frequencies between 400 Hz to 1 kHz (Parvin et al. 1994), and these frequencies have the greatest potential for damage. Within the literature (all as cited in Ainslie 2008), there is some variation in acceptable SPLs for divers.

The auditory threshold of hearing under-water was lowest at 1 kHz (70 dB re 1 µPa SPL) and increased for lower and higher frequencies to around 120 dB re 1 µPa at 20 Hz and at 20 kHz (Parvin 1998). Fothergill et al. (2000) and Fothergill et al. (2001) conducted controlled acoustic exposure experiments on military divers under fully controlled conditions at a US Ocean Simulation Facility and an US Open water test facility. The following exposure limit for both military and recreational divers was suggested as a conservative measure: For frequencies between 100 and 500 Hz, the maximum SPL should be 145 dB re 1 µPa over a maximum continuous exposure of 100 seconds or with a maximum duty cycle of 20 per cent and a maximum daily cumulative total of three hours. The trading relation between the maximum SPL and duration was 4 dB per doubling of duration (e.g. 141 dB SPL for a 200 second exposure) (Pestorius et al. 2009).

In alignment with these studies, and considering only frequencies between 100 and 500 Hz, Parvin (2005) suggested 145 dB re 1 µPa as a safety criterion for recreational divers and swimmers. Seismic airgun sources are broadband sources, and therefore, for this assessment the most precautionary and conservative diver acoustic impact threshold is the 145 dB re 1 µPa SPL suggested by Parvin (2005). This does not imply that this level is associated with the onset of injury but represents a conservative level for protection against prolonged sound exposure for health and safety purposes.

Pilot has compared the predicted received levels from the sound modelling with the human health assessment threshold of 145 dB re 1 µPa (SPL) proposed by Parvin (2005) for recreational divers and swimmers. Based on this threshold, divers are predicted to hear underwater noise from the seismic survey at up to 24.1–36.4 km from the source depending on the modelled site. However, these maximum ranges are orientated offshore (i.e. in a westerly direction into deeper waters) and should not be considered an offset distance to the coast (Koessler & McPherson 2023; Appendix G). Maximum ranges to the 145 dB re 1 µPa (SPL) threshold in an easterly direction (i.e. inshore into shallower waters) are in the order of 7.1–8.7 km.

Guidance note issued by the UK Diving Medical Advisory Committee (DMAC) “Safe Diving Distance from Seismic Surveying Operations” (DMAC 2020) have suggested that adverse effects may be experienced by divers at distances of up to 27 km from a seismic source, similar to the 145 dB re 1 µPa SPL isopleth in an offshore direction considered above, but do not provide any further details. DMAC (2020) recommends that where diving and seismic activity occur within 30 km of each other, a joint risk assessment should be conducted, and planning/mitigation agreed between parties. Where diving and seismic activities occur within 45 km of each other, all parties should be made aware of the planned activity. These ranges include areas around banks and shoals where divers may be present.

There are no known commercial diving activities planned in the OA, and any recreational diving activities are limited to shallow nearshore water depths (<30 m) (Section 4). In the event of diving operations planned within or within 10 km of the OA, specific dive procedures will be defined in the concurrent operations (CONOPS) / simultaneous operations (SIMOPS) Plan, including an extension of the Cautionary Zone to 10 km, and the requirement for a joint risk assessment in advance of any SIMOPS. Pilot will develop a SIMOPS Plan for the Eureka 3D MSS and affected diving operation in agreement with the affected relevant operator(s). As part of the SIMOPS Plan, Pilot will establish a communications protocol outlining all key contacts, confirming schedules and identifying constraints and buffer distances that need to be observed. No impacts to human divers are predicted.

Tourism Operations

No tourism activities are known to take place specifically within the OA; however, tourism activities do take place in the surrounding region.

Relevant tourism operators will be kept informed of survey activities to ensure that they avoid the area in which the survey vessels are active, with ongoing notification communication happening 7 to 10 days prior to the survey commencement, and ongoing communication happening daily during the survey period, as described in Section 5.

7.1.5.11 Cumulative impacts from seismic airgun discharges

Potential cumulative impacts associated with the Eureka 3D MSS may occur if the survey is undertaken:

- At the same time as another seismic survey within the area, there is an overlap in the areas ensonified by each survey and there are noise sensitive receptors in the overlap zone (concurrent surveys)
- Within an area where previous seismic surveys have occurred, the affected marine biota are still in the same area and have not fully recovered (sequential surveys).

It should be noted that this section does not assess cumulative impacts from future seismic surveys within the area that may occur after the Eureka 3D MSS validity, as this is the responsibility of that titleholder as part of their cumulative impact assessment.

7.1.5.11.1 Concurrent surveys

All currently submitted and approved EPs for seismic surveys have been investigated on the NOPSEMA website and no surveys are planned (EP submitted or accepted) that overlap with the Eureka 3D MSS OA.

In the event of a survey planned at the same time as the Eureka 3D MSS, the industry best practice and conservative 40 km buffer between seismic vessels will keep sound levels below the level at which physiological impacts could occur. CONOPS will be prepared at least one month prior to the planned survey commencement (where necessary) and the seismic vessel will adhere to specific CONOPS procedures when operating within the Cautionary Zone around another the other vessel.

Following acceptance of this EP and as part of the pre-survey planning and notification process, the NOPSEMA website will be monitored for newly accepted EPs for marine seismic surveys which could contribute to cumulative noise in the survey area. If a survey is permitted within 40 km of the Eureka 3D MSS OA, and scheduling for both surveys may overlap, the relevant titleholder will be contacted, and arrangements made to ensure that the potential cumulative impacts will be reduced to ALARP. As a minimum, Pilot will not acquire seismic data within 40 km of another actively acquiring seismic vessel.

Given the very low probability of two seismic surveys occurring simultaneously and the controls that will be implemented to establish and maintain communications prior to and during the survey to ensure such simultaneous activities would maintain an adequate separation distance (40 km), there is very little risk of cumulative impacts to marine receptors. No cumulative impacts are predicted from concurrent surveys.

7.1.5.11.2 Sequential surveys

Cumulative impacts can occur when the timing between activities is less than the recovery rate of any potential impacts to receptors.

The US National Marine Fisheries Service (NMFS) applies a “resetting” of SEL_{cum} after 12 hours of non-exposure (Stadler & Woodbury 2009). Whereby, if there is a 12-hour period between the end of one pile driving operation and the start of the next, the SEL_{cum} for a fish during the pile driving operation is reset to zero for the next set of exposures. In addition, recent work has shown that fish can recover from the startle response of acoustic disturbance within minutes (Bruintjes et al. 2016) and that repeated exposure can lead to habituation and reduced response within weeks (Nedelec et al. 2016). Applying a pile-driving management measure to a seismic survey is highly conservative, given the much lower number of sound pulses associated with seismic surveys and the ability of most fish and other receptors to move away from the source. Populations would be more resilient due to immigration and recruitment of unaffected individuals. Popper (2018) lends weight to the likelihood of recovery and concluded in a recent peer review of a seismic EP that effects in fish are recoverable once the seismic vessel has passed overhead and expected to occur within 24 hours.

Localised changes in zooplankton abundance (including eggs and larvae) are expected to be replaced and indistinguishable from natural levels within hours of exposure to seismic sound, and certainly within a few days of the seismic survey being completed (McCauley et al. 2017; Richardson et al. 2017). Sublethal and chronic lethal effects to some benthic invertebrates could occur for weeks or several months after exposure to seismic sound, however overall changes in benthic community composition and structure are expected to be negligible in the context of natural variability in mortality and recruitment.

Behavioural changes for migrating or foraging marine fauna (e.g. cetaceans, sea lions and white sharks) are expected to return to normal within hours or days of the seismic survey being completed.

There have been no seismic activities undertaken in the region in recent times. The last MSS undertaken in the area was over ten years ago in February to May 2013 — the Geelvink 3D MSS and the Turtle Dove Ridge 3D MSS for Murphy Australia Oil (refer NOPIMS). Therefore, no cumulative impacts from sequential seismic surveys are predicted for the Eureka 3D MSS.

7.1.5.12 Inherent impact evaluation

Using the above discussions, the impact evaluation is summarised in the following and is defined as part of the impact assessment method in Section 6.4.2. Where multiple risks or impacts have been identified on a given group of receptors with differing rankings, the worst case is quoted. Where risk ranking is Low, the potential impacts are deemed to be ALARP and acceptable and are not considered further unless additional treatments can be applied that have conservation benefits. Where risk ranking results are Moderate or higher, ALARP and acceptability will be discussed and demonstrated below.

Inherent impact	Consequence	Likelihood	Risk ranking
	Minor – Plankton	Possible – Plankton	Moderate – Plankton
	Minor – Invertebrates	Unlikely – Invertebrates	Low – Invertebrates
	Minor – Lobster/octopus	Possible – Lobster/octopus	Moderate – Lobster/octopus
	Minor – Fishes	Possible – Fishes	Moderate – Fishes
	Minor – Fisheries	Possible – Fisheries	Moderate – Fisheries
	Minor – Turtles	Possible – Turtles	Moderate – Turtles
	Minor – Cetaceans	Possible – Cetaceans	Moderate – Cetaceans
	Minor – Pinnipeds	Unlikely – Pinnipeds	Low – Pinnipeds
	Minor - Seabirds	Unlikely - Seabirds	Low - Seabirds
	Minor – Protected areas	Unlikely – Protected areas	Low – Protected areas
	Minor – Divers/snorkellers	Possible – Divers/snorkellers	Moderate - Divers/snorkellers

7.1.6 Impact treatment

Taking the above evaluations, treatments for each of the impacts deemed to be Moderate or higher are identified in the following as described in Section 6.5 as part of the impact assessment method.

7.1.6.1 Demonstration of ALARP

The impacts to marine fauna from seismic noise are relatively well understood for some marine fauna groups (e.g. marine mammals) and less well understood for others (e.g. invertebrates, plankton and fish). While none of the risks or impacts demonstrated above have been shown to be significant, there is still some uncertainty in the actual levels of intensity of the sounds or duration of exposure required before injury occurs to some marine taxa. Because of the impacts and the potential consequences identified in Section 7.1.5, and uncertainty of the distribution and abundance of some fauna groups, recognised good practice control measures are not considered appropriate on their own to manage the potential impacts to ALARP and Acceptable levels. Therefore, Pilot is implementing additional control measures.

This assessment also considers the environmental impact to the location specific environmental values and sensitivities of the OA. The potential impacts on cetaceans have been considered in the planning of the survey adjustments to the activity schedule made to avoid impacting biologically important periods as follows:

- Conduct the survey between early February to end of March, to avoid encountering migrating pygmy blue whales, southern right whales and humpback whales when these species are passing through the region on their annual northbound/southbound migrations.

Pilot considers the adopted controls to be appropriate in reducing the environmental impacts associated with underwater sound from seismic operations on marine fauna to ALARP (Table 7-18). There are no other controls or measures that may practicably or feasibly be adopted to further reduce the impacts without disproportionate costs compared to the benefit of the potential impact reduction (Table 7-18).

Table 7-18: Demonstration of ALARP – underwater sound from seismic operations

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – good practice, legislative requirements and recovery plans			
Implementation of all Part A Standard Management Procedures described in EPBC Policy Statement 2.1 relating to the following: • Pre-start-up visual observation • Soft start • Start-up delay • Operational visual monitoring • Power-down and stop work • Night-time and low visibility	Benefits outweigh cost, legal requirement	Yes	Yes

Implementation of EPBC Policy Statement 2.1 Part B.4 increased precaution zones and buffer zones for whales:
• Observation zone:
  – 3 km+ to the limits of visibility for large unidentified whales
  – 2 km to 3 km for all other whales
• Shut-down zone:
  – To limits of visibility for positively identified (certain or probable confidence level) pygmy blue whales, and large unidentified whales
  – 2 km for all whales
Implementation of the following precautionary zones for ASLs:
• Observation zone to 1 km
• Shut-down zone to 500 m
	Benefits outweigh cost, legal requirement	Yes	Yes

Implementation of the following precautionary zones for ASLs: • Observation zone to 1 km • Shut-down zone to 500 m	Benefits outweigh cost	Yes	Yes
Application of EPBC Policy Statement Part B Additional Management Procedures			
Implementation of EPBC Policy Statement 2.1 Part B.1 Additional Management Procedures – MFOs: • Four dedicated trained Marine Fauna Observers (MFOs) will watch for whales and ASLs during seismic operations in daylight hours, throughout the duration of the survey • Two MFOs will be deployed on the survey vessel • Two MFOs will be deployed on the support vessel during acquisition within the western section of the ASA (blue lines on Figure 3-3)–the Extended Observation Zone for PBW. During acquisition within the Extended Observation Zone, the support vessel will be positioned 10 km to the west of the survey vessel, and the MFOs will implement the same	Benefits outweigh cost	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
observation and shut-down zones as described in PS 1 above. The MFOs aboard the support vessel will be in direct communication with the lead MFO aboard the survey vessel, and will have the authority to request a shut-down if a positively identified (certain or probable confidence level) pygmy blue whale or large unidentified whale is observed within the limits of visibility from the support vessel • If the support vessel has to leave the Extended Observation Zone for any reason (e.g. for resupply) the survey vessel will stop acquisition and move to lines within the eastern section of the ASA (red lines on Figure 3-3). Acquisition within the Extended Observation Zone will only recommence when the support vessel is available to re-commence the role of additional spotter vessel. • At least one dedicated MFO undertaking observations during daylight hours per observing vessel (survey vessel and support vessel). If required, the additional MFO will be used during times of increased whale sightings.			
All MFOs engaged for the Eureka 3D MSS will have previous experience observing for marine mammals at sea, and be competent at identifying marine mammals, estimating distance, implementing mitigation actions and recording data. All MFOs will have completed relevant training detailing marine fauna identification and EPBC Act Policy Statement 2.1 requirements.	Benefits outweigh cost	Yes	Yes
All marine fauna detection personnel (MFOs, trained crew) will attend the environmental induction presentation, which will include the environmental sensitivities of the survey area, environmental management strategies, EPO, and EPS as detailed in the EP. At crew changes, this information will be communicated to on-coming personnel during handover.	Benefits outweigh cost	Yes	Yes
Implementation of EPBC Policy Statement 2.1 Part B.6 Adaptive Management Measures to minimise the minimum potential impacts to pygmy blue whales from seismic noise. The following adaptive management measures will be implemented: • If there are three or more shut-downs for pygmy blue whales within a 24-hour period (including shut-downs triggered by sightings by the support vessel MFOs), then the seismic operations must not be undertaken thereafter at night-time or during low visibility conditions • Seismic operations cannot resume at night-time or during low visibility conditions, until there has been a cumulative 24-hour period of seismic operations (daylight hours with good visibility) during which there has been ≤1 shut-down for pygmy blue whales.	Benefits outweigh cost	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Additional control measures for pygmy blue whales			
Use of passive acoustic monitoring (PAM) to detect vocalising whales	PAM was considered as an additional measure to detect PBW during night-time and low visibility conditions. Currently, there is only one PAM system available that has sufficient bandwidth capability to detect PBW vocalisations in the range 10-100 Hz (QuietSea system). There is a low likelihood that Pilot would be able to contract a survey vessel from the only geophysical contractor licensed to use QuietSea in Australian waters (Shearwater).	Yes	No
Reduce size of ASA to minimise potential for injury to PBW within the foraging BIA	Given the implementation of adaptive management measures and minimal overlap of maximum TTS onset range with the PBW foraging BIA, the potential impacts of noise emissions from the seismic source on pygmy blue whales are likely to be restricted to temporary behavioural changes (avoidance) in individuals moving through the OA, with predicted noise levels from the seismic acquisition not considered likely to cause injury effects. Based on the evidence presented in Thums et al. (2022), the likelihood of encountering foraging PBW is considered low. An additional control of a two additional MFOs deployed aboard the support vessel during acquisition within the Extended Observation Zone increases the ability to detect PBW.	No	No
EPBC Act Policy Statement 2.1 Part B.3 – Use of spotter aircraft to detect presence of cetaceans	Increases potential likelihood of environmental impacts, health and safety impacts to personnel due to aircraft in the field. Unacceptable risk to personnel in operating aircraft offshore. Disproportionate cost of aircraft and personnel.	Limited	No
Use of unmanned aerial vehicles (UAVs – drones) to detect presence of cetaceans	Unproven technology in monitoring PBW in offshore marine environments. Dependent on suitable weather conditions (low wind speeds and good visibility).	Limited	No

Control measures	Cost benefit analysis	Impact reduction	Control adopted
	Significant cost of commercial drones and licensed pilots.		
Use of alternative acoustic monitoring techniques (sonobuoys, fixed moorings, AUVs)	Unproven technology in monitoring PBW in offshore marine environments. Significant technical challenges in providing real time data on PBW detections to the survey vessel. Logistical and health and safety risks in deploying and retrieving equipment. Disproportionate cost for additional vessels, personnel and equipment hire.	Limited	No
Other control measures			
In the event that another vessel is acquiring seismic data in the region, the survey vessel shall not acquire data simultaneously within 40 km of the other seismic vessel in order to avoid cumulative impacts to marine fauna.	Benefits outweigh cost	Yes	Yes
An exclusion zone of 9.2 km horizontal distance around the Beagle Islands has been removed from the ASA	Benefits outweigh cost	Yes	Yes
Reduce size of ASA by extending the buffer zone from the Beagle Islands during the potential ASL breeding season from February – September 2025 or revise survey timing to avoid ASL breeding season	Breeding and pupping are land based activities and won't be directly impacted as a result of the seismic survey. Potential indirect impacts associated with disturbance to foraging ASLs or displacement of their prey are considered negligible due to: • Small disturbance ranges for ASLs and their prey relative to the broad foraging areas. • The low sensitivity of otariid pinnipeds to seismic noise, i.e. noise largely below their functional hearing range. • The seismic vessel and ASLs will be mobile so impacts will be limited to the short time frame before the seismic vessel moves away. • Breeding and pupping is a protracted event (approx. 7 months) and the seismic survey is limited to 40 days. • The survey timing has been optimised to avoid overlap with more noise sensitive species, in particular the blue whale (refer Table 4-11).	No	No

Control measures	Cost benefit analysis	Impact reduction	Control adopted
No seismic acquisition during the pygmy blue whale northbound or southbound migration periods (i.e. April to July; and October to January).	Benefits outweigh cost	Yes	Yes
No seismic acquisition during the southern right whale migration period (i.e. April to October).	Benefits outweigh cost	Yes	Yes
No seismic acquisition during the humpback whale migration period (June to November).	Benefits outweigh cost	Yes	Yes
Seismic source validation: In the event that a seismic source is selected for the Eureka 3D MSS that is significantly different to the modelled source, additional acoustic source modelling will be undertaken using the JASCO AASM model to confirm that the far-field horizontal source level specifications of the seismic source selected for the survey are comparable to those assessed in this EP.	Benefits outweigh cost	Yes	Yes
In the event that another vessel is acquiring seismic data in the region, the survey vessel shall not acquire data simultaneously within 40 km of the other seismic vessel in order to avoid cumulative impacts to marine fauna.	Benefits outweigh cost	Yes	Yes
All discharges of the seismic source (including soft starts and bubble tests) will occur only within the ASA.	Benefits outweigh cost	Yes	Yes
No operation of the seismic source within 300 m horizontal distance of the 12 m contour of Leander Reef and Big Horseshoe Reef or within 300 m horizontal distance of the 12 m contour of the other unnamed reef areas within the eastern part of the ASA.	Benefits outweigh cost	Yes	Yes
An interval of 24 hours will be applied to subsequent passes during acquisition and infill of areas 200m from the exclusion zones in the nodal area	Benefits outweigh cost	Yes	Yes
Where potential concurrent operations with diving and/or snorkelling activities are identified, adhere to the following recommended requirements of the DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Pilot will notify divers/snorkellers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the divers/snorkellers involved and Pilot and the seismic contractor in advance of any simultaneous operations.	Benefits outweigh cost	Yes	Yes

7.1.6.1 Residual impact evaluation

Residual impact	Consequence	Likelihood	Risk ranking	Decision type
	Low – Plankton Minor – Invertebrates Low to Minor – Lobster/octopus Minor – Fishes Minor – Fisheries Low – Turtles Minor – Cetaceans Minor – Pinnipeds Minor - Seabirds Minor – Protected areas Minor – Tourism/Divers/snorkellers	Possible – Plankton Unlikely – Invertebrates Unlikely to Possible – Lobster/octopus Unlikely – Fishes Unlikely – Fisheries Possible – Turtles Unlikely – Cetaceans Unlikely – Pinnipeds Unlikely - Seabirds Unlikely – Protected areas Unlikely – Tourism/Divers/snorkellers	Low – Plankton Low – Invertebrates Low to Moderate – Lobster/octopus Low – Fishes Low – Fisheries Low – Turtles Low – Cetaceans Low – Pinnipeds Low - Seabirds Low – Protected areas Low – Tourism/Divers/snorkellers	B

7.1.6.2 Demonstration of acceptability

The definition and process of demonstrating acceptability is defined in Section 5.5.5 of the impact assessment methodology. The impacts have been reduced to an acceptable level as defined by the criteria in Table 7-19.

Table 7-19: Demonstration of acceptability for underwater sound from seismic operations

Receptor / value	Acceptability criteria
Marine receptors (general)	• Activity will be carried out in a manner consistent with EPBC Policy Statement 2.1 • Recovery of fish expected within 12 to 24-hours based on Stadler & Woodbury (2009) and Popper (2018) • Localised changes to zooplankton expected to be replaced and indistinguishable from natural levels within hours, and certainly within a few days based on McCauley et al. (2017) and Richardson et al. (2017) • Overall changes in benthic community composition and structure expected to be negligible in the context of natural variability in mortality and recruitment • Behavioural changes for migrating/foraging marine fauna (e.g. cetaceans, sea lions and white sharks) are expected to return to normal within hours to days • Stakeholder concerns/objections received have been merit assessed and control measures developed where required (Section 5). There are no outstanding merited concerns.
Plankton (incl. fish and invertebrate larvae)	• Only a small proportion of the plankton within the survey area would be exposed at any one time • No population or ecosystem level effects.
Fishes (incl. spawning)	• Impacts limited to low level behavioural responses. Recovery expected within 12 to 24-hours based on Stadler & Woodbury (2009) and Popper 2018, so some if not complete recovery could be expected. • No population or ecosystem level effects.
Invertebrates (incl. spawning)	• Sub-lethal effects or a minor increase in mortality rates in some benthic invertebrate species in the weeks or months following seismic exposure within tens or hundreds of metres from the seismic source. • No population or ecosystem level effects.
Marine turtles	• Minor behavioural disturbance of a small number of individuals potentially transiting through the survey area or foraging in seagrass habitats. • The Marine Turtle Recovery Plan has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.

Receptor / value	Acceptability criteria
Cetaceans	• EPBC Policy Statement 2.1 Part A Standard Management Procedures applied throughout duration of survey • Implementation of EPBC Policy Statement 2.1 Part B.4 increased precaution zones and buffer zones for whales • Implementation of EPBC Policy Statement 2.1 Part B.1 Additional Management Procedures – MFOs • Two MFOs will be deployed on the support vessel during acquisition within the Extended Observation Zone for PBW • Implementation of EPBC Policy Statement 2.1 Part B.6 Adaptive Management Measures to minimise the minimum potential impacts to pygmy blue whales • The survey schedule and the controls adopted align with relevant actions in the Blue Whale Conservation Management Plan, and in the Southern Right Whale Draft Recovery Plan – i.e. No injury is predicted for PBWs and SRWs, and no predicted displacement from their foraging BIAs • Controls adopted align with the relevant actions in the ASL Recovery Plan • By scheduling the seismic survey between early February to end of March, the migration periods for PBWs, SRWs and HBWs are avoided • Control measures (i.e. EPBC Policy Statement 2.1 Part A and Part B Management Procedures) will afford protection to other baleen whales in the event that they may be encountered in the survey area • No population level effects.
Australian sea lions	• No injury (PTS or TTS) to foraging sea lions • No predicted disturbance to breeding sea lions • No population level effects.
Commercial and recreational fisheries	• The survey will not result in changes to the spawning biomass or changes in recruitment of commercially important species that may be discernible from normal natural variation • Impacts of the survey on commercial or recreational fishery catch rates will be limited to short term and localised effects • The potential impacts of noise emissions from the seismic source on spawning of key indicator commercial fish species are considered to be slight and short-term, and the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species that may be spawning within or adjacent to the OA during acquisition activities • The proposed control measures are consistent with key mitigation strategies for seismic surveys published in the WA Department of Fisheries Guidance statement on undertaking seismic surveys in Western Australian waters (DoE 2013) – e.g. use of soft starts; minimise the sound intensity and exposure time of surveys • Pilot has also considered DPIRD's ecological risk assessment of seismic impacts to marine finfish and invertebrates (Webster et al. 2018) during the assessment of impacts and risks to fish spawning and commercial fisheries, noting that the DPIRD risk assessment considers worst-case potential impacts to individual finfish and invertebrates assuming they do not move to avoid an approaching seismic source. This is not representative of real-life sound exposures and does not represent impacts at a population level. Pilot has, therefore, considered additional information to assess impacts to fish spawning and fish stock populations • Ongoing consultation will address any outstanding or arising issues with fishers in accordance with expectations under the OPGGS(E) Regulations.
KEFs	• No predicted disturbance to environmental values associated with KEFs.
Protected areas	• No predicted loss of biological diversity in AMPs or State marine parks (aligned with IUCN principles).
Tourism/Recreation	• The proposed controls and consequence level are consistent with the DMAC 12 guidelines • No tourism operations were identified as being active in the OA, however if this changed any Impacts to tourism and recreation activities would be limited to the time frame to undertake the seismic acquisition.
Relevant persons	• Claims that seismic surveys pose a risk of impact to certain fish and crustacean species has some merit to individual animals. Controls to limit this impact have been applied and are considered ALARP. • Claims were raised that the use and application of scientific papers that referenced the Southern Rock Lobster were not reflective of potential impacts to the Western rock lobster. Pilot's main focus was that both species have a mechanosensory organ called a statocyst that is potentially

Receptor / value	Acceptability criteria
	impacted by the particle motion component of underwater noise and that, as research in all scientific fields is limited it is common practice to draw on similar case studies for impact assessment. As there is uncertainty Pilot has adopted a control measure that precludes operation of the seismic source within the nodal area of the survey with a 300m buffer applied to identified reefs to minimise noise levels in these areas. • Clams were raised that there may be future financial impacts to commercial fishing as a result of the Seismic activity. Pilot found that it was unlikely that catch rates would be impacted outside of the short-term impacts from displacement, however in the unlikely event of impacts to catch rates Pilot has put forward a commitment to implement a Commercial Fishing Industry Adjustment Protocol. This will formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch as a consequence of survey activities. • Claims were raised that the seismic activity may impact on the foraging area of the ASL. No TTS or PTS impact is likely in foraging ASL, however as an added precaution Pilot have extended the EPBC Policy statement 2.1, for whales, to also extend to ASL and initiated a 1km observation zone and 500m shutdown zone for MFO observation of ASL. Additionally an exclusion area of 9.2km was placed on the Beagle Islands. • Relevant person concerns/objections received have been merit assessed and control measures developed where required (Appendix D) and communicated back to relevant persons. • Design changes to address concerns have been incorporated where possible

7.1.6.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for underwater sound from seismic operations are presented below in Table 7-20.

Table 7-20: Environmental performance outcomes, standards and measurement criteria for underwater sound from seismic operations

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 1 Undertake seismic acquisition in a manner that prevents injury to whales and ASLs, and minimises the potential for biologically significant behavioural disturbance. **EPO 2** Limit underwater noise emissions from the seismic source to the area defined and assessed in this EP. **EPO 3** Undertake seismic acquisition in a manner that reduces potential cumulative impacts resulting from the Eureka 3D MSS and other seismic survey operations as far as reasonably practicable.	**PS 1** Implementation of EPBC Policy Statement 2.1 Part A Standard Management Procedures relating to the following: • Pre-start-up visual observation for minimum 30 minutes • Soft start for minimum 30 minutes • Start-up delay • Operations monitoring • Power-down and stop work • Night-time and low visibility. Implementation of EPBC Policy Statement 2.1 Part B.4 increased precaution zones and buffer zones for whales: • Observation zone: – 3 km+ to the limits of visibility for large unidentified whales – 2 km to 3 km for all other whales • Shut-down zone: – To limits of visibility for positively identified (certain or probable confidence level) pygmy blue whales, and large unidentified whales – 2 km for all whales Implementation of the following precautionary zones for ASLs: • Observation zone to 1 km • Shut-down zone to 500 m	**MC 1** MFO data sheets/report confirms EPBC Policy Statement 2.1 is available aboard the seismic vessel and all Part A Standard Management Procedures have been implemented throughout seismic data acquisition. **MC 2** Records demonstrate compliance with Policy Statement 2.1 Part A Standard Management Procedures and Part B.4, including application of precautionary zones for ASLs.
	PS 2 Implementation of EPBC Policy Statement 2.1 Part B.1 Additional Management Procedures – MFOs: • Four dedicated trained Marine Fauna Observers (MFOs) will watch for whales and ASLs during seismic operations in daylight hours, throughout the duration of the survey • Two MFOs will be deployed on the survey vessel Two MFOs will be deployed on the support vessel during acquisition within the western section of the ASA (blue lines on Figure 3-3) – the Extended Observation Zone for PBW. During acquisition within the Extended Observation Zone, the support vessel will be positioned 10 km to the west of the survey vessel, and the MFOs will implement the same observation and shut-down zones as described in PS 1 above. The MFOs aboard the support vessel will be in direct communication with the lead MFO aboard the survey vessel, and will have the authority to request a shut-down if a positively identified (certain or probable confidence level)	**MC 3** Records demonstrate two dedicated MFOs per observing vessel (survey vessel and support vessel) are aboard and undertake observations in accordance with EPBC Act Policy Statement 2.1. **MC 4** MFO data sheets/report demonstrates watch maintained during daylight acquisition **MC 5** CVs for MFOs demonstrates competency and experience

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	pygmy blue whale or large unidentified whale is observed within the limits of visibility from the support vessel • If the support vessel has to leave the Extended Observation Zone for any reason (e.g. for resupply) the survey vessel will stop acquisition and move to lines within the eastern section of the ASA (red lines on Figure 3-3). Acquisition within the Extended Observation Zone will only recommence when the support vessel is available to re-commence the role of additional spotter vessel • At least one dedicated MFO undertaking observations during daylight hours per observing vessel (survey vessel and support vessel). If required, the additional MFO will be used during times of increased whale sightings.	
	PS 3 All MFOs engaged for the Eureka 3D MSS will have previous experience observing for marine mammals at sea, and be competent at identifying marine mammals, estimating distance, implementing mitigation actions and recording data. All MFOs will have completed relevant training detailing marine fauna identification and EPBC Act Policy Statement 2.1 requirements.	
	PS 4 All marine fauna detection personnel (MFOs, trained crew) will attend the environmental induction presentation, which will include the environmental sensitivities of the survey area, environmental management strategies, EPO, and EPS as detailed in the EP. At crew changes, this information will be communicated to on-coming personnel during handover.	**MC 6** MFO commitments presentation; attendance sign-off sheets **MC 7** Pre-survey inspection verifies MFO procedures located on bridge.
	PS 5 Implementation of EPBC Policy Statement 2.1 Part B.6 Adaptive Management Measures to minimise the minimum potential impacts to pygmy blue whales from seismic noise. The following adaptive management measures will be implemented: • If there are three or more shut-downs for pygmy blue whales within a 24-hour period (including shut-downs triggered by sightings by the support vessel MFOs), then the seismic operations must not be undertaken thereafter at night-time or during low visibility conditions. • Seismic operations cannot resume at night-time or during low visibility conditions, until there has been a cumulative 24-hour period of seismic operations (daylight hours with good visibility) during which there has been ≤1 shut-down for pygmy blue whales.	**MC 8** Records demonstrate compliance with pygmy blue whale adaptive management measures as described
	PS 6 In the event that another vessel is acquiring seismic data in the region, the survey vessel shall not acquire data simultaneously within 40 km of the other seismic vessel in order to avoid cumulative impacts to marine fauna	**MC 9** Communication records show that any geophysical contractors operating other seismic survey vessels have been consulted two weeks prior to the survey start and agreed to 40 km separation distance

Environmental performance outcomes	Environmental performance standards	Measurement criteria
		MC 10 Records confirm no incidents when vessels less than 40 km apart and actively acquiring data
	PS 7 No seismic acquisition during the pygmy blue whale northbound or southbound migration periods (i.e. April to July; and October to January) **PS 8** No seismic acquisition during the southern right whale migration period (i.e. April to October) **PS 9** No seismic acquisition during the humpback whale migration period (June to November)	**MC 11** Records demonstrate acquisition of the survey confined to period 1 February to 31 March 2025, or 1 February to 31 March 2026.
	PS 10 Seismic source validation: In the event that a seismic source is selected for the Eureka 3D MSS that is significantly different to the modelled source, additional acoustic source modelling will be undertaken using the JASCO AASM model to confirm that the far-field horizontal source level specifications of the seismic source selected for the survey are comparable to those assessed in this EP	**MC 12** Acoustic modelling (source modelling) for selected seismic source.
	PS 11 In the event that another vessel is acquiring seismic data in the region, the survey vessel shall not acquire data simultaneously within 40 km of the other seismic vessel in order to avoid cumulative impacts to marine fauna	**MC 13** Records demonstrate compliance with the 40 km separation distance. **MC 14** Record demonstrate consultation with other titleholders with acreage within 40 km of the OA, and with other geophysical companies, prior to commencement of the activity.
	PS 12 All discharges of the seismic source (including soft starts and bubble tests) will occur only within the ASA	**MC 15** Seismic vessel gun logs will contain the seismic observers acoustic log of all instances the acoustic source was activated, including the acoustic source sequence activated during soft start procedures. MFO weekly reports to concur with seismic logs regarding number and timing of soft starts. **MC 15** SEA report and vessel logs confirm that the acquisition of seismic data (including soft starts and bubble tests) is limited to within the ASA.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 109 No acquisition within a 9.2 km horizontal distance around the Beagle Islands	**MC 16** Survey records demonstrate that the seismic source has not been operated within the described exclusion zones.
EPO 4 Undertake seismic acquisition in a manner that prevents injury and reduces the potential for TTS in site-attached fishes and invertebrates	**PS 13** No operation of the seismic source within 300 m horizontal distance of the 12 m contour of Leander Reef and Big Horseshoe Reef or within 300 m horizontal distance of the 12 m contour of the other unnamed reef areas (Figure 3-2) within the eastern part of the ASA.	**MC 16** Survey records demonstrate that the seismic source has not been operated within the described exclusion zones.
	PS 106 The seismic survey vessel will not deviate around the reef exclusion zones (within 200 m) with the seismic source activated unless at least 24-hours has passed since the previous line was acquired.	**MC 104** Survey records demonstrate that the seismic source was not operated within 24 hours of an area that had been acquired or infilled in the preceding 24 hours, in the nodal area, 200m from the exclusion zones.
	PS 37 Implementation of a Commercial Fishing Industry Adjustment Protocol to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch as a consequence of survey activities.	**MC 43** Commercial Fishing Industry Adjustment Protocol implemented with relevant commercial fishers prior to commencement of survey activities.
EPO 5 Undertake seismic acquisition in a manner that prevents injury to any scuba divers or snorkellers	**PS 14** Where potential concurrent operations with diving and/or snorkelling activities are identified, adhere to the following recommended requirements of the DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Pilot will notify divers/snorkellers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the divers/snorkellers involved and Pilot and the seismic contractor in advance of any simultaneous operations.	**MC 17** Records demonstrate that relevant DMAC 12 guidelines followed where potential concurrent diving/ snorkelling activities are identified.

7.2 Impact 2: Underwater sound – vessel operations

7.2.1 Identification of the hazard and extent

Hazard	The seismic vessel(s) and the support/chase vessel(s) will generate low levels of machinery noise, especially when using propulsion thrusters. This noise will be at a much lower level than the noise emitted from the active airgun array. Seismic data acquisition will occur on a continuous basis (24-hours a day) throughout the survey (maximum duration of 40 days), with limited periods of time when the seismic source is not operational. While the seismic source is operational, the underwater noise generated by vessels will be a negligible addition to the cumulative noise levels. The assessment of underwater vessel noise below is therefore limited to the periods when underwater noise levels from vessel operations are dominant, and periods when the airgun array is not operational (e.g. line turns, during maintenance / repairs and marine fauna shut-downs). The area is already subject to frequent noise from vessels due to its proximity to relatively busy shipping routes.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March.

7.2.2 Levels of acceptable impact

The impact on marine receptors caused by underwater sound from vessel operations will be acceptable when the levels of acceptability are met as described below:

- Seismic vessel and support/chase operations are limited to within the OA
- Activity is not inconsistent with any relevant objectives of the Recovery Plan and Threat Abatement Plans for relevant species
- Application of EPBC Regulations Part 8 – Interacting with cetaceans and whale watching
- No displacement of marine fauna from BIAs
- No population level effects on EBPC Act listed Threatened and Migratory species
- Vessel operations will be compliant with all relevant legislation and guidelines relating to interactions with marine fauna, notably physical separation distances from cetaceans and pinnipeds
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/ objections, where required. No outstanding merited objections or claims.

7.2.3 Impact analysis and evaluation

This section describes the impacts that may occur on significant marine environmental receptors identified in Section 4 that are potentially sensitive to underwater sound from vessel activities. On conclusion of the impact analysis, the inherent impacts from the hazards are evaluated. This part of the impact assessment method is described in Section 6.4.

Potential impacts	The potential risks and impacts to marine fauna from increased underwater noise associated with normal vessel operations are reasonably well understood limited to behavioural disturbance rather than direct physiological injury. Vessel operations in the region are widely acceptable to the community (due to the existing usage for other marine activities e.g. shipping and fishing), therefore the potential for adverse impacts from vessel noise is considered low. The greatest source of noise during the activity will be from operation of the airgun array, therefore the impact assessment for the effects of increased noise from vessel operations on marine fauna is put into the context in terms of the limited periods during which this could be the dominant noise source—i.e. when the seismic source is not operational. Noise emissions from the seismic and support/chase vessels will be influenced by the activity being conducted by the vessels, for example, the seismic vessel generates less noise when drifting and more when towing the streamer array using the azimuth thrusters. Source levels from typical seismic vessels are approximately 165 to 180 dB re 1 µPa (root mean squared (rms) @ 1 m for vessels <100 m long and 180 to 190 dB re 1 µPa (rms) @ 1 m for vessels >100 m long (Richardson et al. 1995; Kipple & Gabriel 2004; Heitmeyer et al. 2003). Marine fauna at distance from the vessel will be exposed to much lower noise levels due to attenuation of the sound energy as it travels through the water.

Predicted effects	Pygmy blue whales, southern right whales and humpback whales have BIAs that overlap the OA. The timing of the survey (early February to end of March) is outside of the recognised peak migration periods for all three of these species, and therefore the presence of individuals is expected to be limited to occasional, transient individuals during this time. Other whales that may be encountered include the fin, sei and Bryde's whale. The white shark could also be present in the OA, having a wide distribution across the region and a foraging BIA overlapping the OA. There is a haul-out site and breeding colony for the ASL at the Beagle Islands, located ~10 km south of the OA. Additionally, ASLs may forage in the waters of the OA, which are overlapped by foraging BIAs for both males and females. Therefore, it is possible that individual sea lions may be encountered within the OA during the survey. It is also possible that other species of marine fauna that are not regionally significant may transit through the OA, e.g. dolphins and marine turtles. Underwater noise emissions from vessel operations are generally within or below the range of natural noise levels experienced by marine fauna, and therefore not expected to cause any physiological damage to fauna (McCauley 1998, 2003; McCauley & Jenner 2001; Richardson et al. 1995). The primary auditory effect of vessel noise on marine fauna is the potential masking of biologically significant sounds (Southall et al. 2007). Potential behavioural effects on marine fauna due to underwater noise from vessels also include changes in vocalisation characteristics and disturbance to foraging, navigation and reproductive activities. The majority of acoustic energy radiated from large commercial vessels is below 1 kHz, and so the greatest potential for masking exists for marine fauna that produce and receive sounds within this frequency band; primarily baleen whales, pinnipeds, fish, and possibly some toothed whales (Southall et al. 2007). Acoustic masking at higher frequencies (1 to 25 kHz) may affect toothed whales (beaked whales, sperm whales, dolphins and porpoises) in close proximity to the vessels. There has been relatively little behavioural observation of cetaceans exposed to continuous, low-level underwater noise, such as from vessels. An experimental study involving acoustic tagging and controlled exposure experiments with North Atlantic right whales (*Eubalaena glacialis*), showed no effect of vessel noise on the whales. Five of the six individual whales responded strongly (interrupted dive pattern and swam rapidly to the surface) to the presence of an artificial alarm stimulus (series of constant frequency and frequency modulated tones and sweeps) but ignored playbacks of vessel noise (Nowacek et al. 2004). Small cetaceans are commonly observed swimming near vessels; this attraction indicates that the noise is not having a detrimental effect on the animals. The frequency range of vessel noise overlaps the hearing ranges of many fish species (Amoser & Ladich 2003). Hearing impairment (i.e. TTS) has been recorded for fish exposed to continuous noise from small boats and ferries for two hours (Vasconcelos et al. 2007). However, recovery was observed on cessation of vessel noise. In summary, marine fauna that may be present within the OA are mobile and would be expected to actively avoid the seismic and support/chase vessels, especially during data acquisition. When the airguns are not operational, there may be localised behavioural disturbance of fauna in the immediate vicinity of the vessel during operations. However, this would be limited to a temporary change in behaviour due to avoidance of the area but no injury or lasting impact. No injury or mortality of marine fauna as a result of exposure to vessel noise in an already high vessel usage area; and no effects at a population level are predicted.		
Inherent impact	**Consequence**	**Likelihood**	**Risk ranking**
	Minor	Unlikely	Low

7.2.4 Impact treatment

Using the impact evaluations in Section 6.4.2, treatments for each of the impacts are identified in the following as part of the impact assessment methodology described in Section 6.5.

7.2.4.1 Demonstration of ALARP

Complete elimination of the impact is not possible as there is no practical alternative to the use of vessels which allow Pilot to undertake the activity. The impact assessment has determined that, with the implementation of the adopted control measures, underwater noise from vessel operations will not result in a potential impact greater than a localised area of avoidance and short-term effect on marine fauna species. Behavioural disturbance effects are expected to return to cease once the vessels are removed from the area.

The application of recognised good practice is considered appropriate to manage these risks (Table 7-21), specifically those relating to operating seismic vessels and procurement of chase vessels to ensure the noise levels generated by the working vessels are at their lowest levels. The relevant EPBC Regulation managing interactions between vessels and cetaceans is also considered good practice.

However, this risk assessment recognises the survey-specific nature of risks associated with the Eureka 3D MSS and the challenges in predicting the use of the OA by other marine users. To augment decision making, a precautionary approach is applied where uncertainty continues to exist.

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Pilot considers the adopted controls to be appropriate in reducing the environmental impacts associated with underwater sound from vessel operations on marine fauna to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the impacts without disproportionate costs compared to the benefit of the potential impact reduction.

Table 7-21: Demonstration of ALARP – underwater sound from vessel operations

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – legislative requirements, good practice			
All internal combustion engines on-board the vessels will be maintained in accordance with the manufacturer's specifications and hence noise emissions will be typical of vessels in the region.	Benefit outweighs cost	Yes	Yes
Interaction between survey vessel and marine mammals (whales, dolphins and pinnipeds) within the OA will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale Watching and Dolphin Watching 2017 (Commonwealth of Australia 2017): • Vessels will not knowingly travel faster than six knots within 300 m of a whale or 150 m of a dolphin or pinniped • Vessels will not knowingly get closer than 100 m of a whale or 50 m of a dolphin or pinniped • Survey vessel and support/chase vessels will not intentionally approach within 150 m of a dolphin calf or sea lion pup or within 300 m of a whale calf (Reg 8.06(2)) • If a marine mammal approaches the vessel within the above zones, the vessel should avoid rapid changes in engine speed or direction.	Benefit outweighs cost; legal requirement	Yes	Yes
ALARP assessment technique – EIA			
Do nothing – survey not acquired	The survey is critical in providing data to fill in data gaps in the region and to replace existing poor quality seismic data already reprocessed by Pilot. Minimal benefit given the precautionary control measures to be implemented. Costs disproportionately higher than benefits.	Yes	No

Residual impact evaluation				
Residual Impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Low	Unlikely	Low	A

7.2.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot consider that the potential impacts from underwater sound from vessel operations are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-22).

Table 7-22: Acceptability criteria – underwater sound from vessel operations

Acceptability criteria	
Survey and support/chase vessel operations limited to within the OA	• Survey and support/chase vessels only operate within the OA (with exception of transit to/from OA, and in the event of an emergency).
The activity is not inconsistent with relevant objectives in Recovery or Threat abatement plans.	• Recovery Plans and Threat abatement plans had been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.
No population level effects on EBPC Act listed Threatened and Migratory species	• All control measures adopted for managing impacts from underwater sound from seismic operations to ALARP will add protection in reducing exposure of EPBC listed Threatened and Migratory species to vessel noise (refer to Section 7.1.4).
No displacement of marine fauna from BIAs	• No biologically significant behavioural disturbance to marine fauna within foraging, migration, and breeding BIAs (including pygmy blue whales, southern right whales, humpback whales, ASLs, white sharks and seabirds) • The Eureka 3D MSS seismic data acquisition will take place from early February to end of March, i.e. Outside of the migration period for pygmy blue whales, southern right whales and humpback whales. • No predicted disturbance to breeding sea lions
Vessel operations will be compliant with all relevant legislation and guidelines relating to interactions with marine fauna, notably physical separation distances from cetaceans and pinnipeds.	• Vessel operations will be compliant with the EPBC Regulations 2000 Part 8 • Predicted impacts are therefore considered acceptable because these Regulations provide separation distances between vessels and cetaceans.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/ objections, where required. No outstanding merited objections or claims.	• There have been no concerns/objections received from relevant persons regarding vessel noise (Section 5).

7.2.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for underwater sound from vessel operations are presented below in Table 7-23.

Table 7-23: Environmental performance outcomes, standards and measurement criteria for underwater sound from vessel operations

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 6 Minimise impacts of underwater sound from vessel operations during the Eureka 3D MSS on EPBC listed Threatened and Migratory marine mammal species in the OA.	**PS 14** All internal combustion engines on-board the vessel will be maintained in accordance with the manufacturer's specifications.	**MC 17** Records and training matrix demonstrate that a qualified marine engineer is on-board throughout survey
	PS 15 Interaction between survey vessels and marine mammals (whales, dolphins and pinnipeds) within the OA will be consistent with EPBC Regulations 2000 – Part 8 Division 8.1 (Regulation 8.04) – Interacting with cetaceans: • Vessels will not knowingly travel faster than 6 knots within 300 m of a whale or 150 m of a dolphin or pinniped • Vessels will not knowingly get closer than 100 m of a whale or 50 m of a dolphin or pinniped • Survey vessel and support/chase vessels will not intentionally approach within 150 m of a dolphin calf or sea lion pup or within 300 m of a whale calf (reg 8.06(2)). • If a marine mammal approaches the vessel within the above zones, the vessel should avoid rapid changes in engine speed or direction.	**MC 18** MFO report demonstrates no breaches of EPBC Regulations 2000 Part 8. **MC 19** Compliance and marine mammal sighting reports will be completed and provided to NOPSEMA/DCCEEW within three months of completion of the survey.

7.3 Impact 3: Interactions with other marine users

7.3.1 Identification of hazard and extent

Hazard	The survey vessel and support/chase vessels will operate 24-hours a day for the duration of the survey (up to 40 days). During the survey there will be one survey vessel, one support vessel, and at least one chase vessel to manage interactions with other vessels and hazard avoidance duties ahead of the survey vessel (e.g. fishing gear), to assist with streamer deployment and recovery (if required), and other activities as required (e.g. resupply). There may also be additional vessels assisting with the ocean bottom node (OBN) deployment and recovery. Other marine users such as commercial and recreational fishing, charter and dive vessels and commercial shipping may be temporarily displaced by the presence of the survey vessel and the streamers extending up to 7 km behind the vessel. These also present a navigational hazard to other marine users. Data in shallower waters within the Node Survey Area may be acquired using OBN. The nodes will be deployed from the vessel and placed on the sea floor by commercial divers or ROVs. Nodes are expected to be placed in a grid of 250 m × 250 m which would result in the deployment of approximately 1500–2000 nodes. The Node Survey Area where equipment will be deployed covers approximately 119 km² (Figure 3-2) The nodes would be placed at the start of the survey and collected at the end of the survey timeframe. The location of the activity potentially intersects with marine cultural heritage values for the Southern Yamatji and Yued group of Traditional Owners (TOs)s and potentially other TO groups.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March.

7.3.2 Levels of acceptable impact

The impact on other marine users caused by the physical presence of the seismic and support/chase vessels and their equipment will be acceptable when the levels of acceptability are met – as described below:

- Survey activity and equipment are limited to within the OA and only during the survey period
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/objections, where required. There are no outstanding merited objections or claims
- Vessel operations will be compliant with relevant legislation and guidelines relating to navigation and safety at sea
- Third parties are made aware of the presence and movements of the seismic and support/chase vessels at all times through the ongoing relevant person notification program
- Fishers receive sufficient notification of survey operations in each zone through the ongoing relevant person notification program for planning of fishing trips
- Disruption to fishing activities is limited to that required for safe passage of the survey vessel and its towed array whilst it is restricted in its ability to manoeuvre.
- Towed seismic array does not snag/entangle with set fishing gear, such as rock lobster pots and octopus traps, after providing notification.

7.3.3 Impact analysis and evaluation

Potential impacts	• Temporary and intermittent displacement of other marine users such as transiting vessels (including shipping and fishing vessels), boaters, divers/snorkellers and other recreational users • Disruption of fishing activities due to entanglement of fishing gear (trawl nets, fish traps/pots, gillnets and long lines) with the seismic streamers.
Predicted effects	**Commercial and recreational fishing activities** Consultation with relevant persons identified concern over the loss of access to fishing grounds (displacement) and interference with fishing gear (e.g. entanglement). A description of Commonwealth and WA state-managed fisheries with jurisdictional boundaries overlapping the OA is provided in Section 4.4.2. An assessment of the amount of activity by each fishery is provided in Table 4-14 and Table 4-15

Recreational fishers onboard charter and private vessels operating off the WA coast and around the Abrolhos Islands typically target large pelagic and west coast demersal scalefish species. There were 59 licensed tour operators active in 2019/2020 (Newman et al. 2021a), though only 1-2 licences per year in waters within the OA . It is likely that some activity by recreational fishers will occur within the OA, though this is expected to be short-term and intermittent. This may be impacted by the recent extension to banned fishing periods for demersal scalefish, which overlaps with the period of the survey; however, there is no information to advise how long this extension may apply for. It will be necessary for areas in the immediate vicinity of the survey vessel and towed array to be prohibited to recreational and commercial fishing vessels in accordance with maritime regulations relating to safety of navigation. However, only minor disruption to fishing activities is expected for fishers who may set their fishing gear for several hours and/or who are mobile and can move away from the survey vessel whilst still fishing (for example rock lobster and octopus fishers). This is because the survey vessel will be travelling at a slow speed (4.5 knots) and occupies a small space relative to the broader survey area which will remain open to fishing activity.

Activities within the Node Survey Area may also temporarily restrict fishing activities. Given the relatively small area where nodes will be deployed (119 km²) in comparison to the area of historical fishing effort, impacts to commercial and recreational fishing are expected to be negligible.

Pre-survey notifications will commence four weeks prior to the start of the survey for this purpose, with notification 7 to 10 days prior to the survey commencement, and ongoing communication happening daily during the survey period, as described in Section 5.

Tourism activities (e.g. recreational divers/snorkellers, sea lion tours)

No tourism activities are known to take place specifically within the OA; however, tourism activities do take place in the surrounding region.

Relevant tourism operators will be kept informed of survey activities to ensure that they avoid the area in which the survey vessels are active, with ongoing notification communication happening 7 to 10 days prior to the survey commencement, and ongoing communication happening daily during the survey period, as described in Section 5.

Commercial shipping

The western side of the OA potentially intersects with a shipping fairway; however, there is limited traffic through the OA (Figure 4-42). Vessels transiting the region during the proposed survey will primarily include bulk carrier ships (primarily iron ore, grain, mineral sands and alumina), general cargo ships, and smaller vessels transiting in to and out of Port Denison.

The presence of the survey vessels and towed array in the OA has the potential to present a navigational hazard to other vessels; however, third parties will be made aware of the survey and support/chase vessels presence and movements at all times (via Notice to Mariners issued by the Australian Hydrographic Office) and ongoing notification of the survey timing/location, and survey vessel position during the survey will be implemented to manage any potential interactions (refer Section 5).

Oil and gas activities

It is not considered feasible that other seismic surveys will take place in the region concurrently with acquisition of the Eureka 3D MSS. In the event that other oil and gas activities take place, Pilot will develop a Simultaneous Operations (SIMOPS) Plan (or Concurrent Operations (CONOPs) Plan) where required. As part of the SIMOPS Plan, Pilot will establish a communications protocol outlining all key contacts, confirming schedules and identifying constraints and buffer distances that need to be observed for all known concurrent operations.

Cultural heritage values

Consultation has not found any specific potential impacts within the OA relating to cultural heritage however discussions have revealed that some marine animals in the region are significant to some TO groups but those details are not able to be recorded publicly. Consultation also found that there is cultural heritage related to the Irwin River mouth and adjacent sea country but it is not clear whether this extends into the OA and consultation has not identified any explicit impacts of the survey on these values.

Inherent impact evaluation

Inherent impact	Consequence	Likelihood	Risk ranking	Decision type
Rock lobster, octopus and demersal scalefish fishers	Minor	Probable	Significant	B
Other commercial fishers	Low	Probable	Moderate	
Commercial shipping	Low	Possible	Low	
Recreational fishers	Minor	Possible	Moderate	
Tourism activities	Minor	Possible	Moderate	

7.3.4 Impact treatment

7.3.4.1 Demonstration of ALARP

The potential impacts to other marine users during seismic surveys are well understood. Seismic exploration surveys have been conducted along the Australian coast for decades and there are established practices to manage the more common risks. The application of recognised good practice is considered appropriate to manage these risks. These are encapsulated in AMSA Marine Orders specific to safety of navigation and prevention of collisions during seismic operations:

- Marine Order 30 - Prevention of collisions
- Marine Order 27 - Safety of navigation and radio equipment
- Marine Order 21 - Safety and emergency arrangements.

However, this risk assessment recognises the survey-specific nature of risks associated with the Eureka 3D MSS and the challenges in predicting the use of the OA by other marine users. To augment decision making, a precautionary approach is applied where uncertainty continues to exist. As the residual impact to certain commercial fishers is assessed as Moderate, Pilot has adjusted the seismic survey period to avoid acquisition over peak fishing periods for these fisheries as far as possible (Section 4.4.2). In addition, Pilot has undertaken a comprehensive re-assessment of survey design in order to reduce the overall size of the OA and ASA in order to avoid sensitive fishing areas and reduce disruption to fishing activities whilst still maintaining survey objectives. This re-assessment has resulted in a reduction in OA and ASA size of approximately 20 per cent.

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Pilot considers the adopted controls to be appropriate in reducing the environmental risks associated with interactions with other marine users to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of the potential risk reduction (Table 7-24).

Table 7-24: Demonstration of ALARP – interactions with other marine users

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – good practice			
Seismic acquisition will only occur during daylight hours.	There are substantial additional costs and impacts in limiting acquisition to daylight hours. This would double the survey duration. Interactions with fishing and shipping vessels would still potentially occur, therefore costs outweigh benefits.	Yes	No
In the event of SIMOPS, communications will be maintained with other facilities/vessels.	Reduced risk of adverse interaction with other vessels outweighs cost.	Yes	Yes
Vessel-to-vessel transfers will occur away from shipping lanes or other high traffic areas	Reduced risk of adverse interaction with other vessels outweighs cost.	Yes	Yes
AIS broadcast of the vessel type, location, virtual outer tail buoy locations, azimuth, and speed	Reduced risk of adverse interaction with other vessels outweighs cost.	Yes	Yes
Seismic acquisition in other titleholders exploration permits will be undertaken in accordance with Ingress Agreements with the relevant titleholders and an Access Authority granted by NOPTA. A Special Prospecting Authority (SPA) will be in place for acquisition over open acreage.	Standard practice	Yes	Yes
ALARP assessment technique – EIA			
Pilot will consider evidence-based claims from Australian commercial fishing licence holders where: • There is genuine displacement from undertaking normal fishing activities that results in demonstratable economic loss • Deployed fishing equipment has been accidentally lost or damaged by any activities under Pilot's control • There is a loss of catch due to the seismic activity that can be demonstrated.	Benefit to fishers' livelihoods and industry reputation outweighs the cost of compensation.	Yes	Yes
As part of the ongoing notification process, Pilot will notify all relevant persons four weeks prior to the start of the survey to provide details about the anticipated dates for commencement and completion of acquisition.	Early notification of activities will allow relevant persons, in particular fishers, to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.	Yes	Yes
Commercial fishers actively operating in the OA will be issued a notification 7 to 10-days prior to activities commencing in the OA, including posting of survey notification at local boat ramps.	Ongoing notification will allow relevant persons to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.	Yes	Yes
Where requested, commercial fishers actively operating in the OA will be kept informed of daily survey activities through Pilot's 24-hour look-ahead communication.	Short-term notification of activities during the survey will allow relevant persons to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.	Yes	Yes
Provision of bathymetric survey data to commercial fishers who have requested the data.	Pilot will consult with fishers requesting data to determine the format required for supply of data.	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Pilot will continue to advise relevant fishers of planned sail-lines and dates and if any issues are raised by fishing relevant persons, Pilot will make reasonable effort to avoid or minimise conflicts. Controls to be considered will include: • Moving to another sail-line • Allowing fishers to fish area prior to seismic acquisition • Minimise survey activity in areas where there is known fishing activity.	Early notification of activities will allow fishers to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.	Yes	Yes
Inform the Australian Hydrographic Office of relevant survey details prior to, during (if alterations occur) and on completion of the survey to ensure a Notice to Mariners informs all third parties of survey details and are updated as required.	Notices to Mariners are issued to correct and maintain navigational charts and hence inform other vessels of navigation issues related to the MSS. Benefit outweighs cost.	Yes	Yes
Pilot will take reasonable steps to avoid or minimise conflict with other marine users, should such a conflict be identified during ongoing notification with relevant persons.	Design of the survey to minimise interactions, avoid certain areas and allow early notification of activities to enable third parties including fishers to plan activities around the survey and avoid negative interactions. Benefit outweighs cost.	Yes	Yes
Seismic acquisition will only occur outside key fishing seasons.	Fishing occurs all year round in some region of the OA. Avoidance of all fishing seasons is not possible	Yes	No
ALARP assessment technique – precautionary approach			
Do nothing – survey not acquired	Titleholders are required by NOPTA to acquire seismic data within specified time frames.	Yes	No
Avoid shipping routes	Shipping occurs throughout the region and within the OA. Avoiding the western side of the OA would compromise the survey objectives. Vessel interactions are manageable through the support vessel/chase vessels and the cost (loss of survey data) outweighs the benefits.	Yes	No

Residual impact evaluation

Residual impact	Consequence	Likelihood	Risk ranking	Decision type
Rock lobster, octopus and demersal scalefish fishers	Minor	Possible	Moderate	B
Other commercial fishers	Low	Possible	Low	
Commercial shipping	Low	Unlikely	Low	
Recreational fishers	Minor	Possible	Moderate	
Tourism activities	Minor	Unlikely	Low	

7.3.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot consider that the potential impacts from interactions with other marine users are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-25).

Table 7-25: Acceptability criteria –interactions with other marine users

Acceptability criteria	
Seismic vessels remain within the OA during acquisition of seismic data	• Seismic vessels will be limited to the extent of the OA when acquiring seismic data.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/ objections, where required. No outstanding merited objections or claims.	• Relevant persons have presented objections and claims about displacement of commercial fishers for the duration of the survey. Pilot will be communicating with fishers and have generated spatially distinct zones in an order that is communicated well in advance to enable more informed decision making by fishers. Fishing activities will be possible whilst the seismic vessel is located in other areas of the zone in which survey data is being acquired. However if displacement does cause impacts to commercial fisheries Pilot has initiated the Commercial Fishing Industry Adjustment Protocol to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch as a consequence of survey activities. • Relevant person concerns/objections received have been merit assessed and control measures developed where required (Appendix D) and communicated back to relevant persons. • Ongoing notifications will address any outstanding or arising issues with fishers in accordance with expectations under the OPGGS(E) Regulations.
Any related avoiding action by commercial shipping, should it be necessary, should not increase and/or compound the navigational risk to other shipping in the vicinity	• Implementation of a 3 nm Safe Navigation Area (SNA) around the survey vessel and towed array • Resupplying will occur outside shipping lanes and areas of high traffic • Only slight deviations or change of speed is required from a ship to avoid a seismic operation due to the slow speed of acquisition (less than five knots).
Disruption to fishing activities is limited to that required for safe passage of the seismic vessel whilst it is restricted in its ability to manoeuvre	• Fishing activities will be possible whilst the seismic vessel is located in other areas of the zone in which survey data is being acquired.
Fishers receive sufficient notification of survey operations in each zone through the ongoing relevant person notification program	• Completion of spatially distinct zones in an order that is communicated well in advance enables more informed decision making by fishers.
Vessel operations will be compliant with all relevant legislation and guidelines relating to navigation and safety at sea	• The survey vessel will maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the International Convention on the Safety of Life at Sea (SOLAS Convention) • Vessel movements during the survey will comply with all relevant requirements of Marine Orders 30, 27 and 21.
Third parties are made aware of the presence and movements of the survey vessels and associated vessels at all times	Standard navigation practices include: • The bridge on the survey vessel will be manned by Maritime Crew at all times and supported by the Seismic Navigation crew • Multiple mapping/navigation/spatial awareness systems and high precision positional data are available to both maritime and seismic crew at all times • Monitoring and communication of all shipping is available via radar, AIS, radio, satellite phone, email for 24-hours a day • Broadcasting of survey vessel, then shortlisting the potential hazards, and communicating directly with those ships to plan for relative movements of the vessels • The survey vessel and supply/chase vessels will maintain communications with nearby commercial ships and fishing vessels

	• Regularly updated Notices to Mariners are important for warning shipping about the seismic operation • Notify AMSA's Joint Rescue Coordination Centre (JRCC) for promulgation of radio-navigation warnings 24-48 hrs before operations commence • AIS broadcast of the operation, the vessel type, streamers, in water gear, azimuth, speed, intended turning will be received by all vessels in the locality.

7.3.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for physical interactions with other marine users are presented below in Table 7-26. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted above.

Table 7-26: Environmental performance outcomes, standards and measurement criteria for physical interactions with other marine users

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 7 Activities are carried out in a manner that does not interfere with other marine users to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties	**PS 17** Vessel to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012*, COLREGS (International Regulations for Preventing Collisions at Sea 1972), Chapter IV (Radio communications) and Chapter V (Safety of Navigation) of SOLAS (International Convention on the Safety of Life at Sea 1974).	**MC 21** Evidence that vessels comply with COLREGS and relevant chapters of SOLAS. Any records of failure to comply are documented.
	PS 18 Vessel navigational lighting and communication systems managed in accordance with Marine Orders 30, 27 and 21.	**MC 22** Evidence that vessels have navigational lights and communication system that comply with relevant marine orders, including appropriate day shapes, lights and streamers, to indicate the survey vessel is towing and is therefore restricted in its ability to manoeuvre.
	PS 19 Continuous (24-hour) survey operations with multiple trained crew (STCW95/Elements of Shipboard Safety) and monitoring of vessel position (radar) and depth at all times during seismic acquisition.	**MC 23** Records confirm bridge was manned continuously during survey operations, visual and radar watches maintained at all times and that vessel crew have appropriate qualifications.
	PS 20 The Australian Hydrographic Office (AHO) advised of survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation on completion or suspension of activities for issue of Notice to Mariners.	**MC 24** Records of notification of survey details sent to the AHO four weeks prior to survey mobilisation and within two weeks of survey demobilisation (following completion or suspension).
	PS 21 The AHO advised of relevant alterations to survey details as required during the survey for issue of updated Notice to Mariners.	**MC 25** Records of notification of survey details sent to the AHO during the survey in response to altered information
	PS 22 AMSA's JRCC will be advised at the start and/or re-start (after suspension for the season) of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels.	**MC 26** Records demonstrate that AMSA JRCC have been notified of the survey vessel details and movements 24 to 48-hours prior to the start of the survey
	PS 23 AMSA JRCC will be notified at the end of the survey when operations have been completed and/or suspended.	**MC 27** Records demonstrate that AMSA JRCC have been notified of the end (completion and /or suspension) of survey operations.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 24 Survey vessel will be equipped with Automatic Radar Plotting Aid (ARPA) and active AIS for detection of vessels, speed and heading. AIS broadcasts include vessel type, location, virtual outer tail buoy locations, azimuth, and speed.	**MC 28** Records confirm ARPA and AIS active on survey vessels. MC 29 Records confirm AIS broadcast of the vessel type, location, virtual outer tail buoy locations, azimuth, and speed
	PS 25 Support and chase vessels will assist in managing interactions with other vessels and maintain communications with other vessels in the OA.	**MC 30** Records demonstrate that dedicated support and escort vessel are employed for the duration of the activity.
	PS 26 Tail buoys clearly marked to identify streamer ends to other users.	**MC 31** Records confirm all tail buoys marked to identify streamer ends.
	PS 27 In-water equipment lost will be recovered, if retrievable where safe and practicable to do so.	**MC 32** Incident reports made for lost equipment show that recovery where possible.
		MC 33 Detailed records of equipment lost overboard will be maintained and reported to NOPSEMA as recordable environmental incidents (Section 10.8.2), and also reported via the Post-survey Environmental Review Report (PERR) (Section 10.8.1).
	PS 28 AMSA and AHO to be advised of the loss of large items of buoyant waste and lost equipment (potential navigational hazards).	**MC 34** Response from AMSA and AHO confirms receipt of notification in event of lost object incident.
	PS 29 An Access Authority (AA) will be agreed with the Titleholder for WA-31-L.	**MC 35** **Records of AA for data acquisition in permit areas within the Operational Area.**
	PS 30 A Special Prospecting Authority (SPA) will be in place for the areas of open acreage within the ASA.	**MC 36** Records of granted SPA for data acquisition in open acreage areas within in the ASA.
	PS 31 Pre-planning search of NOPSEMA approvals data to identify potential for overlap with other seismic surveys and other Petroleum Operator activities	**MC 37** All other submitted EPs for seismic surveys in the region will be reviewed at least one the month prior to the survey to ascertain potential overlap.
	PS 32 As part of the ongoing notification process, Pilot will notify all relevant persons four weeks prior to the start of the survey with survey details including, timing, location and duration.	**MC 38** Relevant person consultation records show notification of survey details to all relevant persons four weeks prior to the start of the survey.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 33 Commercial fishers actively operating in the OA and will be issued a notification 7 to 10-days prior to activities commencing in the OA, including posting of survey notification at local boat ramps.	**MC 39** Copies of notifications to relevant fishers 7 to 10-days prior to activities commencing in the OA.
	PS 34 Commercial fishers actively operating in the OA will be kept informed of daily survey activities through Pilot's 24-hour look-ahead communication.	**MC 40** Sighting records of 24-hour look-ahead communications with commercial fishers who have requested the data
	PS 35 The seismic vessel shall notify AMSA's Joint Rescue Coordination Centre (JRCC) for promulgation of radio-navigation warnings 24-48 hours before operations commence and on completion.	**MC 41** AMSA's JRCC will require the vessel details (including name, call sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation, requested clearance from other vessels and need to be advised when operations start and end.
	PS 36 Provision of bathymetric survey data to commercial fishers who have requested the data.	**MC 42** Consultation records confirm format and supply of ASA bathymetric data to commercial fishers who have requested the data.
	PS 37 Implementation of a Commercial Fishing Industry Adjustment Protocol to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch as a consequence of survey activities.	**MC 43** Commercial Fishing Industry Adjustment Protocol implemented with relevant commercial fishers prior to commencement of survey activities.
	PS 38 In the event that another vessel is acquiring seismic data in the region, the seismic vessel shall not acquire data simultaneously within 40 km of the other seismic vessel in order to avoid cumulative impacts to marine fauna.	**MC 9** Communication records show that any geophysical contractors operating other seismic survey vessels have been consulted two weeks prior to the survey start and agreed to 40 km separation distance. **MC 10** Records confirm no incidents when vessels less than 40 km apart and actively acquiring data.
	PS 39 Pilot will continue to advise relevant persons (such as commercial fishers) of planned sail-lines and dates and if any issues are raised by relevant persons, Pilot will make reasonable effort to avoid or minimise conflicts. Controls to be considered will include: • Moving to another sail-line • Allowing fishers to fish area prior to seismic acquisition	**MC 44** Survey consultation records show merit assessment and consideration of controls in response to relevant person feedback prior to and during survey.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	• Minimise survey activity in areas where there is known fishing activity.	
	PS 40 Resupplying sites will not be located in shipping channels or high traffic areas	**MC 45** Logs show all resupplying occur away from shipping lanes and high traffic areas
	PS 41 Pilot will take reasonable steps to avoid or minimise conflict with other marine users, should such a conflict be identified during ongoing discussions with relevant persons.	**MC 44** Survey consultation records show merit assessment and consideration of controls in response to relevant person feedback prior to and during survey.
	PS 42 Survey timing will be limited to February – March 2025, or February – March 2026.	**MC 46** Records show no activity in months outside of February - March 2025 or 2026.

7.4 Impact 4: Light emissions – vessels

7.4.1 Identification of hazard and extent

Hazard	Lighting is required for safe navigation (under the *Navigation Act 2012* and Marine Order 30) and for safe work practices at night; however, these light emissions may have adverse impacts on photo-sensitive fauna. Lighting typically consists of bright white (metal halide, halogen, fluorescent) lights used for internal lighting, deck lighting and for navigational purposes. Lighting from the seismic survey vessels will be the largest source of artificial light emissions during the survey, which will be restricted to the OA (except for transiting to/from the mainland and in the event of an emergency). There will be smaller and insignificant light emissions from the support/escort vessels. Light can typically be seen from a horizontal distance = 3.57 x √ height above sea level. The survey vessel operational deck height may be as high as 16 m, thus visible at sea level from approximately 14.3 km (i.e. visible from the coast when in the eastern third of the OA) with deceasing intensity. The commercial fishing, other oil and gas activities and shipping vessel traffic in the area are discussed in Section 4.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

7.4.2 Levels of acceptable impact

The impact on light sensitive marine fauna caused by light emissions from the Eureka 3D MSS seismic and support/chase vessels will be acceptable when:

- The seismic survey is of short duration (maximum 40 days) and vessels do not operate outside of OA (except for transiting to/from the OA and in the case of an emergency e.g. oil spill)
- No predicted effects on EBPC Act listed Threatened or Migratory species at a population level
- Artificial light impacts are managed in accordance with the *National Light Pollution Guidelines for Wildlife* (Commonwealth of Australia 2020) so that “wildlife is:
  - Not disrupted within, nor displaced from, important habitat
  - Able to undertake critical behaviours such as foraging, reproduction and dispersal”.
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited objections or claims.

7.4.3 Impact analysis and evaluation

Potential impacts	Disorientation, attraction or repulsion of sensitive marine fauna (e.g. juvenile seabirds). Disruption to natural behavioural patterns and cycles, e.g. enabling nocturnal foraging and increased predation compared to unlit areas.
Predicted effects	**Seabirds** Artificial lighting has the potential to attract and/or disorientate birds and detrimentally impact dispersal, migration, foraging behaviour or when breeding adults return to colonies at night (Commonwealth of Australia 2020). Procellariiformes (petrels and shearwaters) are commonly subject to attraction and grounding by artificial light, most of which are fledglings, impacted during maiden flights as they disperse from their natal colonies (Rodríguez et al. 2017). There are up to 13 species of seabirds that may forage within or transit through the Eureka 3D MSS OA. Eight species have foraging BIAs that overlap the OA—the Caspian tern, bridled tern, roseate tern, Australian fairy tern, white-faced storm petrel, Pacific gull, wedge-tailed shearwater and little shearwater (described in Section 4.3.10). The nearest breeding colonies for these species occur within the Turquoise Coast Island Nature Reserve, including the Beagle Islands, located between Leeman and Dongara, and further south within the Jurien Bay Marine Park. Some of the most significant breeding colonies are at located at the Houtman Abrolhos Islands, situated 70km to the north-west of the OA. The four species of terns and Pacific gull are all diurnal and roost ashore at night, thus, are not likely to be adversely impacted by artificial light on vessels. It is possible that wedge-tailed shearwaters and little shearwaters may be attracted to artificial light on vessels at night and have the potential to become disorientated then land on the vessel’s deck.

<table>
<tr><td rowspan="4"></td><td colspan="3">Given the short duration of the activity and distance from breeding and resting sites, light disturbance to birds is likely to be restricted to behavioural changes by a potentially small number of shearwaters in the immediate vicinity of the vessels. Any effect of exposure is not expected to impact on migration or other behaviours (nesting/forging) at a population level.
Rescue programs of grounded birds offer an immediate and effective mitigation strategy to reduce vessel lighting impacts (Rodríguez et al. 2017). Lighting impacts to shearwaters can be further reduced or avoided by undertaking surveys outside the fledging season for species likely to be attracted to artificial lights. For example, the peak fledging period is late October-early November for little shearwaters and late April-early June for wedge-tailed shearwaters (Marchant & Higgins 1990).</td></tr>
<tr><td colspan="3">Marine turtles
Artificial light on, or near, nesting beaches poses a threat to marine turtles because it can disrupt critical behaviours such as adult emergence and nesting, hatchling orientation, sea-finding and dispersal behaviour, which may reduce the overall reproductive output of a stock (Commonwealth of Australia 2017). There are no nesting beaches, Habitat Critical or BIAs for turtles anywhere in the mid-west region ,. Foraging, migrating and internesting turtles do no use light as a cue, and consequently any transient individuals moving through the OA during the survey would not be affected by vessel light emissions. Therefore, there are no impacts predicted to occur to marine turtles from vessel lighting emissions during the Eureka 3D MSS.</td></tr>
<tr><td colspan="3">Other marine fauna
Other marine life may also be attracted to the light spill from the vessel. 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). The concentration of organisms attracted to light results in an increase in food source for predatory species, and marine predators are known to aggregate at the edges of artificial light halos. This could potentially lead to increased predation rates compared to unlit areas but population recovery is predicted to be rapid through reproduction and migrations with the tide.
Although this effect is expected to be greater in a stationary vessel, worms, squid, plankton and fish can aggregate directly under downward facing lights on the water. This in turn can attract predatory fauna such as seabirds, cetaceans, fishes and squid. There is minor potential for changes in inter-specific dynamics as some species are more able to exploit the longer foraging periods and to prey on phototropic prey species. The constant movement of the vessels will reduce this potential significantly. It is expected that any potential impact of increased predation would be undetectable at a population level, especially for plankton where recruitment is rapid, particularly given the short duration of the survey and the relatively small area potentially exposed to vessel light emissions.
Cetaceans predominantly utilise acoustic senses to monitor their environment rather than visual sources (Simmonds et al. 2004), so light is not considered to be a significant factor in cetacean behaviour or survival.</td></tr>
<tr></tr>
<tr><td rowspan="2">Inherent impact</td><td>Consequence</td><td>Likelihood</td><td>Risk ranking</td></tr>
<tr><td>Minor</td><td>Unlikely</td><td>Low</td></tr>
</table>

7.4.4 Impact treatment

7.4.4.1 Demonstration of ALARP

There is no safe or practical alternative to the use of artificial lighting during the activity; therefore the associated impacts cannot be totally eliminated. The use of lights for navigational purposes is a legislated requirement, and subsequently a well-practiced and understood activity. The performance standards outlined in this EP align with the requirements of *Navigation Act 2012* (Cth) Part 3 (Prevention of Collisions) and Marine Order 30 - Prevention of collisions.

Additional controls have been considered and adopted where they can further reduce risks to ALARP. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted (Table 7-27).

Table 7-27: Demonstration of ALARP – light emissions – vessels

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – good practice			
Non-essential lighting will be switched off when not in use.	Benefit outweighs cost	Yes	Yes
Use only long wavelength yellow and red light and extensive shrouding	Typically used more for light intensive activities in the vicinity of turtle nesting. Given that there are no nesting sites for light sensitive receptors in close proximity to or in the OA, the cost of re-fit outweighs benefit	Limited benefit due to low likelihood of night-time encounters with sensitive receptors in OA	No
External lighting will be directed onto the deck, reducing light spill to the environment where practicable for safe operations.	Benefit outweighs cost	Yes	Yes
ALARP assessment technique – EIA			
No night-time operations.	Limiting seismic activities to daylight hours would significantly extend the time required to acquire data for individual activities. The majority of activities will take place more than 14 km from land which will reduce likelihood of attraction of shorebirds and seabirds/. There are no nesting sites for light sensitive receptors in close proximity to or in the OA. Negligible environmental benefit in 12-hour operations, but significant increase in vessel charter costs and length of survey (i.e. double the survey duration). Sacrifice (additional vessel costs) disproportionately higher than benefit.	Limited benefit due to low likelihood of night-time encounters with sensitive receptors in OA	No

Residual impact evaluation				
Residual impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Minor	Unlikely	Low	A

7.4.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot consider that the potential impacts from light emissions are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-28).

Table 7-28: Acceptability criteria – light emissions

Acceptability criteria	
The seismic survey is short duration and vessels do not operate outside of OA (except for transiting to/from the OA and in the case of an emergency e.g. oil spill)	• Acquisition is planned to take place between early February to end of March, with vessels constantly on the move. • Impacts are temporary. The survey and supply/chase vessels will be limited to the extent of the OA (except during transits to/from the OA and in the event of an emergency e.g. oil spill).
No predicted effects on EBPC Act listed Threatened or Migratory species at a population level	• Restricted to behavioural changes by a small number of seabirds in the immediate vicinity of the vessels. Any effect of exposure is not expected to impact on migration or other behaviours (nesting/foraging), with no detectable effects at a population level. • There are no other EPBC Act listed Threatened or Migratory species in or near the OA predicted to be negatively affected by light emissions from the survey or support/chase vessels • Low-level and localised effects to fishes, plankton or other marine life with no population or ecosystem level effects • No cumulative impacts predicted as vessels are generally apart unless resupplying for short periods (hours)

	• Survey and support/chase vessels will be in constant motion and will remain within OA, which is for the most part of the survey >14 km from closest shoreline.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns	• No specific relevant person concerns have been raised concerning impacts of light emissions from vessels. • The OA is well used in terms of existing commercial shipping and fishing operations and any additional artificial lighting burden is temporary.

7.4.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for light emissions are presented below in Table 7-29. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.6.4.2.

Table 7-29: Environmental performance outcomes, standards and measurement criteria for light emissions

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 8 External vessel lighting conforms to that required by maritime safety standards	**PS 43** Light glow is minimised by managing external vessel lighting in accordance with: Marine Orders 30 - Prevention of collisions.	**MC 47** Vessel class certifications are current.
EPO 9 Minimise potential for adverse impacts on light sensitive marine fauna	**PS 44** Non-essential vessel lighting will be switched off when not in use.	**MC 48** Inspection during survey confirms non-essential vessel lighting is switched off at night. **MC 49** Induction material demonstrates that vessel crew has been inducted in light spill reduction protocols, especially switching off non-essential lights.
	PS 45 External vessel lighting will be directed onto the deck, reducing light spill to the environment where practicable for safe operations.	**MC 50** Record of inspection during the activity to confirm orientation of all external work lights in use has been checked and adjusted where practicable.

7.5 Impact 5: Routine discharges – vessels

7.5.1 Identification of hazard and extent

Hazard	Seismic survey and support/chase vessels routinely discharge small volumes of liquid and solid waste into the marine environment, such as putrescible wastes (food scraps), deck drainage), bilge water, sewage and grey water (such as water from showers, laundries and dishwashing), cooling water and brine. **Food waste:** Food waste from the vessel galleys will be macerated and discharged. The average volume of putrescible waste from each vessel depends largely on the number of Persons on-board (POB) and is anecdotally around 12 kg/person/day (NERA 2018), totalling 70-140 kg for the larger vessels spread over the day. **Deck drainage: C**omprising seawater from waves/spray, rainwater and deck wash-down water, may contain minor quantities of oil, grease and detergents that have been spilled on the decks. **Bilge waters: I**ncludes deck drainage captured in a closed-loop system (e.g. bunded areas) and machinery/engine space oily water that has been directed to the oil water separator (OWS) for removal of the oil prior to discharge of the treated water once the discharge is ≤15 ppm oil-in-water (OIW) as required by MARPOL. The oil is returned to shore for reuse/disposal. **Sewage and grey water:** The vessels are yet to be determined; however, a typical seismic vessel of the size required carries approximately 70 POB. Support/chase vessels will carry approximately 15 POB. The volume of discharges during the survey are expected to be approximately 170 L/day/person (United States

	Environmental Protection Agency 2011), yielding a total daily grey water volume of approximately 12,000 L for the seismic vessel. **Cooling water:** Seawater is used as a heat exchange medium for cooling machinery engines and other equipment. Seawater is drawn up from the ocean, where it is de-oxygenated and sterilised by electrolysis (release of chlorine from the salt solution) and then circulated as coolant for various equipment through the heat exchangers (in the process absorbing heat from the machinery) and is then discharged to the ocean and may contain low concentrations of residual biocide and scale inhibitors if used to control biofouling and scale formation. **Brine:** (Hyper-saline water) is created through the vessel's desalination process that creates freshwater for drinking, showers, cooking etc. This is achieved through reverse osmosis (RO) or distillation; both processes resulting in the discharge of seawater with elevated salinity. The freshwater produced is then stored in tanks on-board. The potential impacts of routine discharges to marine waters during seismic surveys are well understood with legislative requirements and standard marine industry agreed practices to manage risks. However, due to the proximity of the OA to the shoreline and shallow water depths, no discharges of liquid and solid waste will occur within the OA.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

7.5.2 Levels of acceptable impact

The impact on marine receptors caused by routine vessel discharges will be acceptable when the levels of acceptability are met as described below:

- All vessel operations are compliant with all maritime law relating to routine discharges and industry good practice (MARPOL Annex V & Annex IV, as implemented in Australian waters under Marine Orders 95 & 96).
- Potential impacts to marine fauna (seabirds, pelagic fishes and plankton) in the water column are minor, localised and temporary.
- The seismic survey is short duration and the survey, supply/chase vessels do not operate outside of the OA (except for transiting to/from the OA and in the case of an emergency e.g. oil spill).
- No predicted effects on EBPC Act listed Threatened or Migratory species at a population level.
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. There are no outstanding merited objections or claims.

7.5.3 Impact analysis and evaluation

Potential impacts	Temporary localised decline in water quality in the immediate vicinity of the discharge Localised increase in biological oxygen demand (BOD) Localised increase in turbidity of surrounding waters Temporary toxicity to marine flora and fauna (bilge water discharges) Temporary and localised increase in sea surface water temperature Temporary and localised increase in sea surface salinity
Predicted effects	**Water quality** **Food waste**: Food waste can cause temporary localised increases in the nutrient content of surface waters close to the discharge potentially affecting plankton, pinnipeds and pelagic fish and attracting scavenger seabirds. Rapid dispersion and biodegradation ensure potential impacts are negligible. **Sewage and grey water:** Discharges of treated sewage and grey water will be rapidly diluted in the surface layers of the water column and dispersed by currents. There is potential for phytoplankton uptake of the extra nutrients from sewage and localised, temporary increases in primary productivity. The BOD of the treated effluent is unlikely to lead to oxygen depletion of the receiving waters (Black et al. 1994), as it will be treated prior to release. On release, surface water currents will assist with oxygenation of the discharge. Woodside (2011) conducted monitoring of sewage discharges at their Torosa-4 Appraisal Drilling campaign which demonstrated that a 10 m^3 sewage discharge reduced to approximately 1% of its original concentration within 50 m of the discharge location. In addition to this, monitoring at distances 50, 100 and 200 m downstream of the platform and at five different water depths confirmed that discharges were

rapidly diluted and no elevations in water quality monitoring parameters (e.g. total nitrogen, total phosphorous and selected metals) were recorded above background levels at any station.

Heavier nutrient load, sedimentation and toxicity from sewage discharge can also impact on coral growth and repair. This impact is mostly observed with large quantities of effluent in poorly flushing areas such as bays and less-so in well flushed areas when the quantities are small (Alsabah, 2017)

Grey water from galleys, showers/basins and laundries may include a range of pollutants of varying toxicities such as hydrocarbons, detergents, grease, particulates, chemicals, food waste and coliform bacteria. Grey water is also treated through the sewage treatment plant, so pollutants are largely removed from the discharge.

Given the temporary intermittent nature of the discharges in any one location, the small volumes, treatment before discharge, the rapid dilution and dispersion in the open ocean, high biodegradability and low persistence of sewage and grey water no measurable increases in nutrient concentrations, oxygen demand, turbidity or effects to plankton are expected.

Bilge tanks potentially containing small volumes of hydrocarbons, detergents, solvents and chemicals. The OWS then treats this water to MARPOL requirements before discharging overboard. The volume of treated water discharges is typically small and intermittent.

The greatest risk is to corals, plankton and pelagic fish. These discharges will be rapidly diluted, dispersed and biodegraded to undetectable levels local to the discharge. The small volumes and low concentrations of oily water from bilge discharges may temporarily reduce water quality but are not expected to induce acute or chronic toxicity impacts to marine fauna or plankton through ingestion or absorption through the skin. In the event the OWS malfunctions and discharges of off-specification water, these impacts may occur, though this is only likely in a highly localised area and temporary (meaning that few individuals would be exposed).

Decks that are not bunded and drain directly to the sea may result in the discharge of contaminated water which may cause temporary and localised reduction in surface water quality.

Cooling water: The maximum cooling water discharge rate and temperatures for the vessels that may be used, are unknown but typically are several degrees above ambient, depending on design, efficiency and throughput.

Once in the water column, cooling water will remain in the surface layer, where turbulent mixing and heat transfer with surrounding waters will occur rapidly. This will cause very localised and temporary increases in water temperature, potentially resulting in thermal stress to sensitive biota. Impacts on most marine organisms will be negligible given the buffering and dispersive capacities of the receiving seawater and as the vessels are constantly in motion, the impacts are considered negligible with full recovery in the short term.

Brine: Brine discharge salinity typically ranges from 40 – 60 ppt (parts per thousand). It is denser than seawater (approximately 35 ppt). As such, discharged brine water will sink through the water column potentially exposing receptors that are sensitive to salinity to levels approximately 14-70% above ambient and to potential toxicity impacts from residual biocide and scale inhibitors used to prevent marine growth and corrosion.

However, sinking through the water column will aid rapid mixing with receiving waters and dispersion by ocean surface currents. Modelling of continuous wastewater discharges by Woodside (2008, Torosa South -1) found discharge water temperature decreased rapidly to less than 1°C above background levels within 100 m (horizontally) of the discharge point, and within background levels within 10 m vertically.

Seabirds, pinnipeds, cetaceans, plankton and pelagic fish may be in the immediate vicinity of the discharge. Increased temperatures may result in physiological changes such as avoidance (or attraction), stress or mortality depending in part on mobility and sensitivity.

Walker and MacComb (1990) found that most marine species can tolerate short-term fluctuations of 20-30% in water salinity, so most pelagic species (other than plankton) passing through a denser saline plume would not suffer adverse impacts. Given the rapid, localised dispersion predicted by the modelling, such impacts are considered negligible.

The biocides used in desalinators are typically low concentrations when added, highly reactive, rapidly biodegradable and deactivate during the inhibition process, resulting in little or no residual toxicity on discharge (Black et al. 1994). Given the localised rapid dispersion, the small volumes and the constant movement of the vessels, there is low potential for adverse effects.

Protected areas and other marine habitats and communities

Grey water, sewage, bilge water and putrescible waste discharges will be rapidly diluted and dispersed and the concentrations of any potential contaminant or nutrient will reach background levels quickly. No effects on communities are expected for pelagic or benthic receptors. Any reduction in water quality would be localised and temporary (short term) and unlikely to have any measurable impact on species diversity or abundance. Fisheries and fish resources will not be affected as impacts are localised and temporary. There are therefore no predicted effects to the Abrolhos and Jurien Bay Marine Parks in proximity (~40 km) to the OA.

	The maximum number of vessels in close contact at any time with each other will be two (e.g. re-supply) – as such, they are alongside for a short time and not discharging bilge or sewage, cumulative impacts are unlikely, and consequences rated negligible.		
Inherent impact	**Consequence**	**Likelihood**	**Risk ranking**
	Low	Unlikely	Low

7.5.4 Impact treatment

7.5.4.1 Demonstration of ALARP

The offshore disposal of sewage, grey water and putrescible wastes may cause a small, localised (immediate area), temporary (short-term) increase in the nutrient content in the water column in the immediate vicinity of the discharge. Discharges of brine and cooling water also have the potential to reduce water temperature and increase salinity in the immediate vicinity of the vessel. Due to the small volumes discharged and well-mixed open ocean environment within the OA, any changes to ambient water quality (including salinity and temperature), nutrient levels or dissolved oxygen in the receiving waters are expected to be negligible.

Pilot considers the adopted controls to be appropriate in reducing the environmental impacts associated with routine vessel discharges to the marine environment to ALARP. Additional controls have been considered and adopted where they can further reduce risks to ALARP. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted (Table 7-30).

Table 7-30: Demonstration of ALARP – routine discharges – vessels

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – legislative requirements, good practice			
Installation and use of sewage systems compliant with internationally recognised MARPOL 73/78 Annex IV (sewage) and Annex V (garbage) specifications	Benefit outweighs cost; legal requirement.	Yes	Yes
All waste holding tanks are to be fully operational prior to survey commencement	Benefit outweighs cost.	Yes	Yes
Vessel survey crew will be inducted in waste management and made familiar with the vessel Garbage Management Plan (GMP)	Benefit outweighs cost.	Yes	Yes
Installation and use of oily water separators compliant with MARPOL 73/78 Annex I and Marine Order 91–Marine pollution prevention specifications (i.e. treating OIW <15 ppm)	Benefit outweighs cost; legal requirement.	Yes	Yes
The vessel must not be stationary when undertaking discharge and OIW separator shut off value must be maintained and operational	Benefit outweighs cost.	Yes	Yes
Deck drain scupper plugs available	Benefit outweighs cost.	Yes	Yes
Minor oil/lubricant spills will be mopped up immediately with absorbent materials that will be stored on-board and disposed of onshore as hazardous waste in accordance with the vessel SOPEP	Benefit outweighs cost.	Yes	Yes
ALARP assessment technique – EIA			
No discharge of liquid and solid waste within the nodal area	Benefit outweighs cost; legal requirement. Discharge of untreated food scraps and sewage is not permitted within 12 nm from the nearest land. However discharge of treated and comminuted sewage is allowable within 3NM of land. Given the shallowness of the water and potential sensitive biota, Pilot will not have any vessel discharges whilst in the nodal area. Other	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
	waste outside of the nodal area will be treated as per Marine Orders.		
Retain all or some waste streams on-board to avoid discharging at sea.	Additional storage on-board, increased handling and HSE implications and onshore disposal impacts result in disproportionate costs outweighing benefits.	Limited	No
Installation of a higher specification sewage treatment system	Likely to require refitting most vessels and has availability and schedule impacts	Yes	No
Requiring vessels to use alternative cooling devices such as fin fans	Fin-fan cooler systems typically require additional space and power, introducing additional environmental impacts	No	No

Residual impact evaluation				
Residual impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Low	Unlikely	Low	A

7.5.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot consider that the potential impacts from routine vessel discharges are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-31).

Table 7-31: Acceptability criteria – routine discharges

Acceptability criteria	
Potential impacts to fauna (seabirds, pelagic fishes and plankton) in the water column are minor, localised and temporary	Potential impacts to marine fauna (seabirds, pelagic fishes and plankton) in the water column are minor, localised and temporary.
The seismic survey is short duration and vessels do not operate outside of the OA (except for transiting to/from the OA and in the case of an emergency e.g. oil spill)	Routine discharges from survey, support/chase vessels will be confined to the OA.
Vessels operations will be compliant with all relevant legislative requirements relating to routine discharges from vessels.	The performance standards comply with the requirements of: • MARPOL 73/78, and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, and relevant Marine Orders: – Marine Order 96–Marine pollution prevention–sewage – Marine Order 95–Marine pollution prevention–garbage – Marine Order 91–Marine pollution prevention–oil. Predictions are therefore considered acceptable because MARPOL requires relevant vessels to have a garbage management plan, spill management plans and compliant sewage and OWS systems which if applied correctly will minimise impacts from routine discharges from vessels on a global scale.
No predicted effect on EBPC Act listed Threatened or Migratory species at a population level	• No EPBC Act listed Threatened or Migratory species are predicted to be impacted by the potential impacts from routine vessel discharges. • No more than possible incidental temporary effects to flora and fauna in the local vicinity of the discharge and no impact on critical activities or habitats, wetlands of importance or heritage places. No population or ecosystem level effects. Absence of areas of sensitive habitats susceptible to long-term effects from minor discharges. Full recovery of any areas disturbed with no medium to long-term effects on diversity.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns	No specific relevant person concerns have been raised concerning impacts of routine discharges from vessel operations.

7.5.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for routine vessel discharges are presented below in Table 7-32. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted above.

Table 7-32: Environmental performance outcomes, standards and measurement criteria for routine vessel discharges

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 10 Meet legislated discharge requirements for permissible discharges	**PS 46** Compliance with MARPOL 73/78 Annex IV (sewage) and Annex V (garbage), (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*)); and Marine Order 96–Marine pollution prevention–sewage, and Marine Order 95–Marine pollution prevention–garbage, as required by vessel class. • Vessel will have a Garbage Management Plan (GMP) and Garbage Record Book for vessels >100 GRT or certified to carry 15 persons or more) that sets out the procedures for minimising, collecting, storing, processing and discharging garbage. • Treated sewage discharged >3 nm from land (but not in the nodal area) or untreated sewage discharge >12 nm from land and at a speed of greater than 4 knots. • In the event of a STP malfunction, untreated sewage and grey water is only discharged when the vessel is greater than 12 nm from shore in accordance with Regulation 11 of MARPOL Annex IV (enacted by Marine Order 96). • Operational on-board sewage treatment plant approved by the International Maritime Organization (IMO) International Sewage Pollution Prevention (ISPP) Certificate.	**MC 51** Records of any non-compliance with MARPOL are documented; and corrective actions identified and undertaken. **MC 52** Maintenance records demonstrate regular maintenance undertaken of on-board STP / macerator **MC 53** Survey-specific discharges and emissions register confirms that treated sewage is only discharged when the vessel is >3 nm from shore and outside of the nodal area **MC 54** Survey-specific discharges and emissions register verifies that untreated sewage is only discharged when the vessel is >12 nm from shore. **MC 55** Records demonstrate the vessels hold a valid ISPP certificate and verifies the installation of a MARPOL approved STP, as required by vessel class.
	PS 47 • Operational on-board organic waste macerator compliant with MARPOL Annex V. • All food waste is macerated to ≤25 mm in size prior to overboard discharge, any discharge must be at a speed of greater than 4 knots. • Un-macerated putrescible waste is only discharged overboard when the vessel is greater than 12 nm from the coastline. • Non-putrescible galley waste is returned to shore for disposal.	**MC 56** A MARPOL compliant Garbage Record Book is in place (for vessels >400 GRT or certified to carry 15 persons or more) and verifies waste discharge volumes and locations **MC 57** Records verify that the macerator is functional and regularly maintained. **MC 58** A Garbage Record Book is in place that verifies non-macerated food waste is returned to shore
	PS 48 • All waste holding tanks are to be fully operational prior to survey commencement.	**MC 59** Records demonstrate that the vessels waste holding tanks are fully operational prior to survey.
	PS 49 • Vessel survey crew will be inducted in waste management and made familiar with the vessel GMP.	**MC 60** Records show that the project induction includes information on waste management requirements and Garbage Management Plan, and sign-off register indicates all personnel on-board have received the induction.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 50 Compliance with MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*)); and Marine Order 91–Marine pollution prevention–oil. • Oil content of any discharged water to be <15 ppm. • Bilge water contaminated with hydrocarbons must be contained and disposed of onshore, except if the oil content of the effluent without dilution does not exceed 15 ppm or an IMO approved oil/water separator (as required by vessel class) is used to treat the bilge water. • The survey and support vessels have an International Oil Pollution Prevention (IOPP) certificate as appropriate.	**MC 61** Oil Record Book confirms volume and concentration of discharge. **MC 62** Records demonstrate the survey and support vessels holds a valid IOPP certificate, as required by vessel class. **MC 63** Calibration records verify that the OWS is set to 15 ppm. **MC 64** Vessel engineers / chief engineer to confirm that OIW is in good working order during vessel audit during the survey (inspection within the last 12 months).
	PS 51 The residual oil from the OWS is pumped to tanks and disposed of onshore.	**MC 65** The Oil Record Book verifies that waste oil is transferred to shore.
	PS 52 The vessel must not be stationary when undertaking discharge and OIW separator shut off value must be maintained and operational.	**MC 66** Records show vessel was moving (not stationary) when undertaking discharge and OIW separator shut-off valve was maintained and operational.
	PS 53 Minor oil/lubricant spills will be mopped up immediately with absorbent materials that will be stored on-board and disposed of onshore as hazardous waste in accordance with the vessel SOPEP.	**MC 67** Records show that response measures for minor oil/lubricant spills were carried out in accordance with the SOPEP. **MC 68** Records show that contaminated clean-up wastes stored on-board in covered bins prior to onshore disposal at a licensed waste management facility. **MC 69** Records show spills and leaks are recorded and investigated; and corrective actions identified and undertaken.
EPO 11 Minimise discharges to ocean	**PS 54** Scupper plugs or equivalent drainage control measures are readily available to the deck crew so that deck drains can be blocked in the event of a hydrocarbon or chemical spill on deck to prevent or minimise discharge to the sea.	**MC 70** Site inspection verifies that scupper plugs (or equivalent) are available on the main deck of survey and support vessels.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 12 Equipment that requires cooling by water, and the RO plant, will be maintained in accordance with the vessel PMS so that they are running within specified operating parameters	**PS 55** Engines and associated equipment that require cooling by water will be maintained in accordance with the vessel PMS so that they are operating within accepted parameters.	**MC 71** PMS records verify that the equipment is maintained to schedule.
EPO 13 The marine crew is competent in spill response and have appropriate response resources to respond to a spill.	**PS 56** The vessel crew is competent in spill response and has appropriate response resources in order to prevent or minimise hydrocarbon or chemical spills discharging overboard.	**MC 72** Training records verify that vessel crews receive spill response training.
EPO 14 Level 1 spills (<10 m^3) of oil or oily water overboard are rapidly responded to by the vessel operator.	**PS 57** The vessel-specific Shipboard Oil Pollution Emergency Plan (SOPEP) is implemented in the event of a large spill of hydrocarbons or chemicals overboard.	**MC 73** Incident report verifies that the SOPEP was implemented.

7.6 Impact 6: Atmospheric emissions – vessels

7.6.1 Identification of hazard and extent

Hazard	Atmospheric emissions of greenhouse gases and other pollutants will be produced through: • Combustion of marine gas oil (MGO) or marine diesel oil (MDO) from the survey and support/chase vessel engines and fixed and mobile deck equipment during the survey • Solid non-hazardous waste combustion within an incinerator if logistics do not allow for the timely removal of waste from the vessel. The main emissions that present an environmental impact are: • Nitrous oxides (NO_X) • Sulphurous oxides (SO_X) • Particulate matter <10 µm • Non-methane volatile organic compounds (VOCS) • Benzene, toluene, ethylbenzene and xylenes (BTEX) • Greenhouse gases (predominantly carbon dioxide).
Extent	OA and atmosphere
Duration	Duration of survey – up to 40 days in early February to the end of March

7.6.2 Levels of acceptable impact

The impact on marine receptors caused by atmospheric emissions will be acceptable when the levels of acceptability are met as described below

- No predicted effect on EBPC Act listed Threatened or Migratory species
- Vessel operations will be compliant with all maritime law relating to atmospheric emissions from vessels
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited objections or claims.

7.6.3 Impact analysis and evaluation

Potential impacts	Localised and temporary decrease in air quality due to emission of gaseous and particulate matter from marine gas oil or diesel combustion Contribution to the global greenhouse gas (GHG) effect.
Predicted effects	The potential impacts of atmospheric emissions from vessels are well understood with legislative requirements and industry agreed good practices to manage impacts. The application of recognised good practice is considered appropriate to manage the impact. The combustion of MGO/MDO can create continuous or discontinuous plumes of particulate matter (soot or black smoke) and the emission of non-GHG, such as sulphur oxides (SO_x) and nitrous oxides (NO_x). Inhalation can cause or exacerbate health impacts to humans such as vessel personnel or coastal communities depending on the concentrations of particles inhaled. Similarly, the inhalation of particulate matter may affect the respiratory systems of fauna – in this case, limited to seabirds overflying the vessel/s. Particulate matter released from the source and support vessels will not impact on the health, cause smog or adversely affect the amenity of the nearest human coastal settlements (such as Port Denison and Dongara, and Leeman) as local and offshore winds will rapidly disperse and dilute particulate matter. This rapid dispersion and dilution will also ensure that seabirds are not exposed to concentrated plumes of particulate matter from any exhaust point. All GHG such as carbon dioxide, methane and nitrous oxide will add to the atmospheric GHG load which adds to global warming potential. The predominant source of emissions is the fuel use of the survey vessels. Conservative daily fuel use estimations have been undertaken with the assumption of one Seismic vessel, one supply vessel and three chase vessels. The survey will have one chase vessel however three have been calculated due to the uncertainty of vessel requirements for potential node placement. Using MGO fuel and the daily fuel use estimations the calculation for potential emissions is below in Table 7-33.

	Table 7-33: Potential emissions calculations for Eureka 3D MSS	
	Results	**Volume in t CO2-e**
	Estimated emissions for five vessels used in marine navigation for 30 days of survey	3,684.85
	Estimated emissions for five vessels used in marine navigation for 40 days of survey (30 plus 10 days of contingency)	4,913.13
	The activity is similar to other industrial activities contributing to the accumulation of GHG in the atmosphere including local shipping and commercial fishing in the OA. Additional requirements by the IMO introduced in January 2023 for this class of vessel, require each ship to have a ship specific operational carbon intensity calculated with an expected cumulative improvement in carbon performance leading up to 2030. Given the short duration of the survey (up to 40 days), and constant movement of the vessel, emissions from the combustion of fuel on-board the vessels will not affect sensitive receptors in the vicinity of the OA (including the health or amenity of the nearest human settlements, which are more than 6.5 km from the Operational Area at the closest). Cumulative impacts from multiple vessels being in the same area are not predicted, as combined discharges will still be localised and disperse rapidly with little effects (ecologically or on visual amenity). There will be no refuelling of the survey vessel in the OA.	

Inherent impact	**Consequence**	**Likelihood**	**Risk ranking**
	Low	Unlikely	Low

7.6.4 Impact treatment

7.6.4.1 Demonstration of ALARP

The use of vessels and hence fuel cannot be eliminated. Alternative fuels (solar, wind, biofuels) have not been commercially proven. Pilot considers the adopted controls to be appropriate in reducing the environmental impacts associated with atmospheric emissions from vessels to ALARP. Additional controls have been considered and adopted where they can further reduce risks to ALARP. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted (Table 7-34).

Table 7-34: Demonstration of ALARP – atmospheric emissions - vessels

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique –legislative requirements, good practice			
Compliance with equivalent requirements as those internationally defined in MARPOL 73/78 Annex VI and accepted by the wider international shipping industry	Benefit outweighs cost, legal requirement	Yes	Yes
A specific Ship Energy Efficiency Management Plan (SEEMP) will be in place for the Seismic vessel as per IMO guidelines	Benefit outweighs cost, legal requirement	Yes	Yes
Survey and supply/chase vessels only use MGO or MDO grade fuel as opposed to heavy fuel oil or bunker fuel	Benefit outweighs cost	Yes	Yes
All engines to be well maintained in accordance with manufacturers specifications	Benefit outweighs cost	Yes	Yes
ALARP assessment technique – EIA			
A MARPOL approved incinerator is used to incinerate solid waste (food waste, paper, cardboard, rags, plastics) if logistics do not allow for the timely removal of waste from the vessels.	Benefit outweighs cost	Yes	Yes
Oil and other noxious liquids and solids will not be incinerated.	Benefit outweighs cost	Yes	Yes

Residual impact evaluation				
Residual impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Low	Unlikely	Low	A

7.6.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot considers that the potential impacts from atmospheric emissions from vessels are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-35).

Table 7-35: Acceptability criteria – atmospheric emissions

Acceptability criteria	
Emissions from the survey and supply/chase vessels will result in localised temporary reductions in air quality with no loss of visual amenity	Emissions will be localised to the OA and be rapidly dispersed and diluted in the atmosphere in the short-term by the constantly moving vessels.
No predicted effect on EBPC Act listed Threatened or Migratory species	There are no EPBC Act listed Threatened or Migratory species predicted to be impacted by the potential impacts from atmospheric emissions from vessels. Temporary and localised reduction in air quality. No more than possible incidental effects to passing birds, due to rapid dispersion/dilution and remote location in the open ocean environment at least 5 km offshore
Vessels operations will be compliant with all legislative requirements relating to atmospheric emissions from vessels.	Operations will be compliant with the MARPOL 73/78 the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and Marine Order 97–Marine pollution prevention–air pollution. MARPOL is an internationally agreed standard to minimise pollutant emissions on a global scale.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns that are not being addressed	No specific relevant person concerns have been raised regarding impacts of atmospheric emissions from vessels.

7.6.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for atmospheric emissions from vessels are presented below in Table 7-36. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.6.4.1.

Table 7-36: Environmental performance outcomes, standards and measurement criteria for atmospheric emissions

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 15 Combustion systems comply with MARPOL VI (Prevention of Air Pollution from Ships) requirements.	**PS 58** Compliance with MARPOL 73/78 Annex VI as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and Marine Order 97(Marine pollution prevention–air pollution), where applicable to vessel class including: Survey and support vessel will hold a valid International Air Pollution Prevention (IAPP) Certificate. Only fuel that contains less than 3.5% m/m sulphur will be bunkered. Survey and supply/chase vessels only use MGO or MDO grade fuel. Vessels >400 GRT must ensure that firefighting and refrigeration systems are managed to minimise Ozone Depleting Substances (ODS).	**MC 74** Records demonstrate the vessel(s) hold a valid IAPP certificate, where applicable to vessel class
		MC 75 Inspection of bunkering records to confirm that the survey vessel is using fuel with <3.5% sulphur by mass
		MC 76 MSDS and vessel bunker receipts confirm the use of low-sulphur fuel and MGO or MDO or lighter grade fuel for main engines
		MC 77 ODS book is available and current

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 59 All combustion equipment will be maintained in accordance with the PMS to ensure they are operating to design specifications.	**MC 71** PMS records confirm that combustion equipment is maintained to schedule.
	PS 60 A MARPOL approved incinerator is used to incinerate solid waste (food waste, paper, cardboard, rags, plastics) if logistics do not allow for the timely removal of waste from the vessel.	**MC 78** IAPP certificate verifies the incinerator meets MARPOL requirements.
	PS 61 Incineration is only conducted when the vessel is >12 nm from the shore	**MC 79** Survey-specific discharges and emissions register indicates no incineration within 12 nm of the shore.
	PS 62 Oil and other noxious liquids and solids will not be incinerated.	**MC 80** The Oil Record Book and Garbage Record Book verify that waste oil and other noxious substances are retained on-board for transfer to shore.
EPO 16 Fuel use will be measured, recorded and reported	**PS 63** Fuel use will be measured, recorded and reported for abnormal consumption, and in the event of abnormal fuel use, corrective action is taken to minimise air pollution. Fuel use must be added to the ships Carbon Intensity Indicator (CII) calculation.	**MC 81** Fuel use is recorded in the daily operations reports.

7.7 Impact 7: Seabed disturbance – placement of ocean bottom nodes

7.7.1 Identification of hazard and extent

Hazard	Shallower areas of the ASA have been delineated as the nodal area (Figure 3-2) as they will be better acquired using ocean bottom node (OBN) technology. The nodes have flexible placement and retrieval options including autonomous vehicles, nodes on a rope (NOAR) and commercial divers. The nodes would be placed on the seabed at the start of the survey and collected at the end of the survey timeframe. The placement and retrieval of these small, lightweight nodes on the seabed has the potential to cause minor physical damage to benthic habitats.
Extent	Node Survey Area
Duration	Duration of survey – up to 40 days in early February to the end of March.

7.7.2 Levels of acceptable impact

The impact on marine receptors caused by seabed disturbance from placement of OBNs will be acceptable when the levels of acceptability are met as described below:

- No predicted effect on EBPC Act listed Threatened or Migratory species
- No predicted effect on the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF
- No predicted loss or disturbance to underwater cultural heritage, pipelines or any other subsea infrastructure associated with the Cliff Head Development
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited objections or concerns.

7.7.3 Impact analysis and evaluation

Potential impacts	The known and potential impacts of seabed disturbance are: • Temporary smothering / displacement of a small area of seabed habitat • Localised elevated turbidity • Disturbance/damage to shipwrecks, pipelines and other oil and gas subsea infrastructure.		
Predicted effects	OBNs may be placed on the seabed in water depths shallower than ~12 m. Nodes are expected to be placed in a grid of 250 m × 250 m, which would result in the deployment of approximately 2500 nodes. The Node Survey Area where equipment will be deployed covers approximately 119 km². The shallow waters of the OA partially overlap with the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF, and the OA is entirely within the Western rock lobster KEF. The Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF is a chain of inshore lagoons containing extensive seabeds of macroalgae and seagrass with a unique diversity of marine species. The seagrass habitats provide valuable feeding grounds for protected species such as the ASL and are important nursery areas for many recreational and commercial fish species. There is one known historic shipwreck. the *Leander,* that may be within the Node Survey Area (Figure 7-4, but exact location is unknown) This shipwreck is not listed as a Protected Place under the EPBC Act but is an underwater cultural heritage site protected by the Underwater Cultural Heritage Act 2018. The Cliff Head Development wellhead platform is located within the Node Survey Area, and part of the Node Survey Area is crossed by the two pipelines (production and water injection, along with associated power cable and umbilical) that connect the platform to the Arrowsmith stabilisation plant onshore (Figure 7-4). The pipelines run ~10 km along the sea floor from the wellhead platform to the shore crossing, and are unburied, using the concrete coating weight and rock bolting to provide stability. The temporary placement and retrieval of nodes on the seabed may result in negligible impacts to biota as a result of physical disturbance and elevated turbidity. However, given the localised area where the equipment will be placed and their small footprints, no significant impact to the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons and Western rock lobster KEFs will occur. The temporary placement and retrieval of nodes on the seabed may cause minor physical disturbance and elevated turbidity in and adjacent to the Cliff Head Development pipelines. However, given the small size and weight of the nodes and the widely-spaced grid over which they will be placed, no significant impacts to either the shipwreck site or pipelines are predicted to occur.		
Inherent impact	**Consequence**	**Likelihood**	**Risk ranking**
	Minor	Unlikely	Low

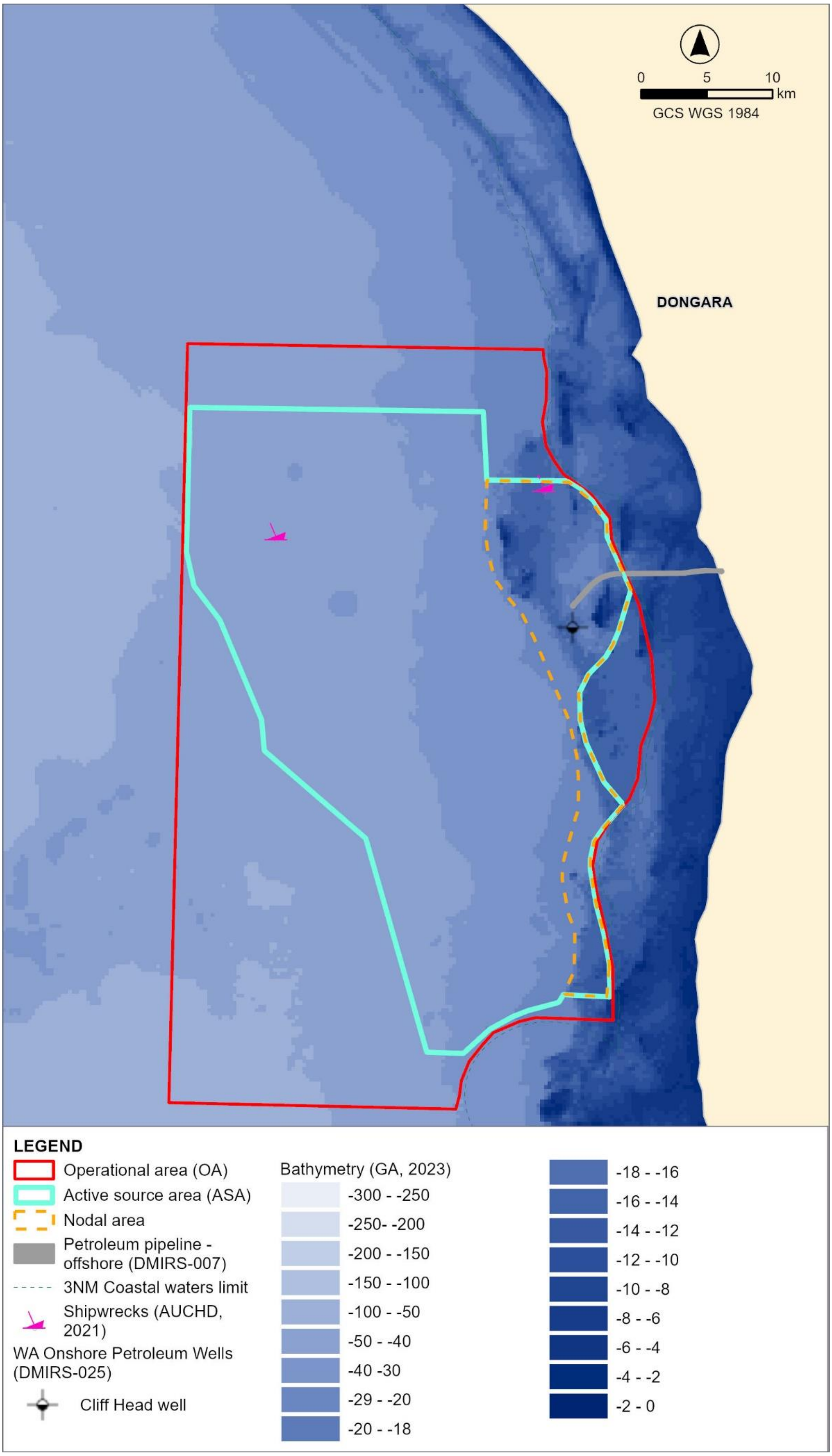


Figure 7-4: Submerged features within the OA

7.7.4 Impact treatment

7.7.4.1 Demonstration of ALARP

Pilot considers the adopted controls to be appropriate in reducing the environmental impacts associated with seabed disturbance from placement of OBNs to ALARP. Additional controls have been considered and adopted where they can further reduce risks to ALARP. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted (Table 7-37).

Table 7-37: Demonstration of ALARP – seabed disturbance – placement of ocean bottom nodes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – good practice, legislative requirements			
No placement of nodes within the 500 m radius petroleum safety zone (PSZ) around the Cliff Head Development wellhead platform	Legislative requirement. Benefit outweighs cost.	Yes	Yes
Environmental monitoring of the seabed prior to and following the Eureka 3D MSS to assess any impacts to the seabed.	Monitoring will not reduce the consequence of any impacts to the seabed, and the costs associated with the level of monitoring required to accurately assess any impacts greatly outweighs the benefits gained.	No	No
Eliminate use of OBNs during the survey	Although the control would reduce the consequence of any impacts to the seabed, it would result in the inability to acquire seismic data in the shallower waters of the ASA, and therefore compromise the geophysical objectives of the survey.	Yes	No
No placement of nodes within close proximity to exposed areas of any identified shipwreck	Legislative requirement. Benefit outweighs cost.	Yes	Yes
Vessels will be fitted with sonar and depth sounders to assess depth of water when in the nodal area or areas <12m deep	Industry standard	Yes	Yes
ALARP assessment technique – EIA			
Nodes will not be placed within 300 m of the 12 m contour of Leander Reef, Big Horseshoe Reef or other unnamed reef areas in the Node Survey Area	Although the control would reduce the consequence of any impacts to the seabed, it would result in the inability to acquire seismic data in the shallower waters of the ASA, and therefore compromise the geophysical objectives of the survey.	Yes	No

Residual impact evaluation				
Residual impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Low	Unlikely	Low	A

7.7.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot considers that the risk of impacts from seabed disturbance from placement of OBNs are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 7-38).

Table 7-38: Acceptability criteria – seabed disturbance –placement of ocean bottom nodes

Acceptability criteria	
The impacts to benthic habitats and communities from placement of OBNs on the seabed will be spatially limited and short-term	• Given the small size and weight (3.3.3) of the nodes and the widely-spaced grid over which they will be placed, no significant impacts to benthic habitats and communities are predicted to occur.
No effect on EBPC Act listed Threatened or Migratory species	• There are no EPBC Act listed Threatened or Migratory species predicted to be impacted by placement/retrieval of OBN on the seabed.
No effect on the values of Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF	• Given the localised area where the equipment will be placed and their small footprints, no impacts are predicted to occur to the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF.
No disturbance or damage to underwater cultural heritage, pipelines or other subsea infrastructure	• Given the small size and weight of the nodes and the widely-spaced grid over which they will be placed, no significant impacts to underwater cultural heritage, pipelines or other subsea infrastructure are predicted to occur. • No placement of nodes within the 500 m PSZ around the Cliff Head Development wellhead platform.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns	• Concerns regarding shallow waters were raised during the public comment period. An additional control has been added to demonstrate that standard industry equipment (i.e sonar, depth sounder) will be utilised to ensure awareness of water depth in areas <12m water depth. Reference to Marine Order 27 was also added to the performance standards.

7.7.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for seabed disturbance from placement of OBN are presented below in

Table 7-39. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.4.4.1.

Table 7-39: Environmental performance outcomes, standards and measurement criteria for seabed disturbance – placement of ocean bottom nodes

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 17 No significant disturbance or damage to benthic habitats and communities, shipwrecks, pipelines or other subsea infrastructure from placement/retrieval of OBNs	**PS 64** Operational procedures will be in place for deployment and retrieval of OBNs	**MC 82** Vessel inspections show evidence of implementing geophysical contractor procedures for node deployment and recovery
	PS 65 Nodes will be retrieved at the end of the survey to prevent long-term loss or disturbance of benthic habitats and communities	**MC 83** Records demonstrate that nodes are retrieved at the end of the survey
	PS 66 Nodes will not be placed within the 500 m PSZ around the Cliff Head Development wellhead platform	**MC 84** Data from survey show that nodes were not placed within the wellhead platform PSZ
	PS 67 The Cliff head Development offshore pipelines and the approximate Leander wreck site will be marked on vessel navigation systems and actively avoided during placement of nodes	**MC 85** Vessel logs show a 500 m exclusion zone around pipelines avoided during placement of nodes. Vessel logs will note if any artefacts of

Environmental performance outcomes	Environmental performance standards	Measurement criteria
		the shipwreck are identified and that these sites were then avoided.
	PS 107 Compliance of Marine Order 27 (Safety of navigation and radio equipment) 2023	**MS 105** Records demonstrate that the survey and support/chase vessels are compliant with Marine Orders 27.
	PS 108 Vessels will be fitted with sonar and depth sounders to assess depth of water when in the nodal area or areas <12m deep	**MS 106** Vessel inspection shows inclusion of sonar and depth sounder equipment in working order.

8 ENVIRONMENTAL RISK ASSESSMENT – UNPLANNED EVENTS

8.1 Summary of risk ranking from unplanned events

This section of the EP presents the results of the risk assessment for unplanned (accidental) events that could occur during the Eureka 3D MSS. As required by Section 21 of the OPGGS (E) Regulations, this assessment demonstrates that with appropriate treatment the risks associated with the activity will be reduced to ALARP and will be of an acceptable level. A summary of the risks and acceptability for the Eureka 3D MSS is presented in Table 8-1.

Table 8-1: Summary of risk ranking for potential risks during the Eureka 3D MSS

Potential risks	Residual risk ranking
Risks (not expected to occur during routine operations)	
Physical interaction – vessel collision with marine fauna or entrapment by equipment	Low – Moderate
Introduction and establishment of invasive marine species	Low
Seabed disturbance – loss of solid objects and unplanned anchoring	Low
Accidental release – hazardous and non-hazardous materials	Low
Accidental oil spill - vessel collision/grounding	Low
Oil spill response	Low

8.2 Risk 1: Physical interaction – vessel collision with marine fauna or entrapment by equipment

A description of the hazards and their extent from the risk of collision or equipment entrapment (environmental aspect) are identified here and is the first stage of the risk and impact assessment process defined in Section 6.4.

8.2.1 Identification of hazard and extent

Hazard	The survey and supply/chase vessels working within the OA may present a potential physical hazard (risk of collision) to large marine fauna such as cetaceans, pinnipeds, marine turtles and sharks that may be transiting through the area at or close to near the sea surface. Vessel movements can result in collisions between the vessel (hull and propellers) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction) and mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours. The survey vessel will be transiting at low speeds (4 to 5 knots) during seismic acquisition. Th support/chase vessels generally travel at higher speeds. The physical presence of header and tail buoys on the streamers may present a potential risk of entrapment for marine fauna, particularly turtles and pinnipeds.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

8.2.2 Levels of acceptable risk

The risk of adverse effects on large marine fauna caused by vessel collision or entrapment by equipment will be acceptable when the criteria below are met:

- Vessel operations are compliant with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans
- No predicted effect on EBPC Act listed Threatened or Migratory fauna at a population level

- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. There are no outstanding merited objections or claims.

8.2.3 Risk analysis and evaluation

This section describes the impacts that may occur on marine environmental receptors identified in Section 4 that may be at risk of collision with vessels or entrapment by equipment in the towed array (header and tail buoys). This part of the risk and impact assessment method is described in Section 6.4. Each of the subsequent sections then undertake the risk and impact analysis as defined in Section 6.4.2.

Potential risks	Vessel collisions are a cause of mortality of marine fauna and large cetaceans. Fauna at highest risk of collision are those that spend a high percentage of time in surface waters, are slow moving and/or large. The risks associated with vessel/equipment interactions with marine fauna are as follows and can range from minimal (e.g. behavioural changes) to severe (i.e. serious injury or mortality): • Vessel collision with marine fauna such as cetaceans, pinnipeds and marine turtles • Entrapment of turtles and pinnipeds by equipment in the towed array (header and tail buoys). The fauna that could occur in the OA during the timing of the Eureka 3D MSS include baleen and toothed whales (particularly during periods of migration), the ASL, white shark and transiting marine turtles. These fauna are mobile and would be expected to actively avoid the survey vessels where possible.
Predicted effects	The survey vessel will maintain a cruising speed of 4.5 knots (8 km/h) during data acquisition and turning. Vessel speed has been identified as a contributing factor in the occurrence and severity of vessel collisions with various marine fauna (Laist & Shaw 2006; Hazel et al. 2007) and for large whale species in particular (Laist et al. 2001; Jensen & Silber 2003; Pace & Silber 2005; Vanderlaan & Taggart 2007). Damage and risk of injury is greatly increased at higher speeds and is a higher risk for vessels travelling at 14 knots (25 km/h) or faster because the fauna have less time to take evasive action (Laist et al. 2001). However, an actively acquiring seismic vessel will acoustically announce its approach from distance and fauna are more likely to be aware and able to evade the slow-moving vessel. Vulnerability of cetaceans to vessel collision will vary according to behaviour (e.g. surfacing habits, direction of travel in relation to shipping routes); morphology; the function of preferred habitat (e.g. breeding, feeding) in areas of vessel activity; and aspects of shipping such as vessel type, speed, density and location. Slow moving species that occur frequently at the surface in areas that overlap with shipping activity are the most vulnerable (Clapham et al. 1999). The likelihood of vessel/cetacean collision being lethal is influenced by vessel speed: the greater the speed at impact, the greater the risk of mortality (Laist et al. 2001; Jensen & Silber 2003). Vanderlaan & Taggart (2007) found that the chance of lethal injury to a large whale because of a vessel strike increases from less than 10% at 4.5 knots, to about 20% at 8.6 knots and 80% at 15 knots. During seismic data acquisition, the survey vessel will be moving at a speed of approximately 4.5 knots, so the risk of lethal injury is lower than for most of the freighters transiting the area. Vessel-whale collisions at this speed are uncommon and, based on reported data contained in the US National Ocean and Atmospheric Administration database (Jensen & Silber 2003) there are only two known instances of collisions when the vessel was travelling at less than six knots, both of these were from whale watching vessels that were deliberately placed amongst whales. There is no published literature on marine turtle entanglement with seismic equipment during seismic surveys; however, Nelms et al. (2016) state that they received anecdotal reports of turtle entrapments in tail buoys and airgun strings during several offshore seismic surveys off the west coast of Africa. Additionally, there is a report of a marine turtle becoming entangled in a discarded seismic cable (Duncan et al. 2018). Humpback, pygmy blue, southern right, Bryde's, fin and sei whales, as well as toothed whales (sperm and killer whales), may be encountered in the OA, but only the humpback whale migration BIA overlaps the OA, while the southern right whale migration and pygmy blue whale foraging BIAs are immediately adjacent to the OA. It is also possible that other species of whale and dolphin could be encountered while traversing the OA. The timing of the survey (early February to end of March) is prior to the period of known presence of migratory whales in the OA (as acquisition will not overlap the migration periods for pygmy blue, southern right and humpback whales), and therefore the presence of whales during this time is expected to be limited to occasional, transient individuals. The closest ASL haul-out site and breeding colony is located ~9 km south of the OA at the Beagle Islands. However, the OA overlaps with foraging BIAs for both male and female sea lions, and so it is possible that vessels may encounter individuals. The OA is also overlapped by a white shark foraging BIA, but white sharks do not tend to spend significant periods of time swimming at or close to the sea surface at slow speeds (behaviours typically exhibited by whale sharks when foraging).

	There are no BIAs or Habitat Critical for marine turtle species in the OA, and just three anecdotal sightings of marine turtles documented in the ALA database in the region of the Eureka 3D MSS; two records of leatherback turtles and one record of a loggerhead turtle (all deceased). Therefore, it is highly unlikely that marine turtles would be encountered by the survey and supply/chase vessels in the OA. In summary, these fauna are mobile and would be expected to actively avoid the survey vessels, especially during data acquisition. Few encounters with large marine fauna are expected and the survey and associated vessels will acquire data at a speed of typically 4.5 knots. However, in the event of a collision it is possible that injury or death of an individual of a protected species could occur.; No effects at an ecosystem function level or population level are predicted. Entrapment with header or tail buoys could result in injury or mortality of turtles or pinnipeds; however, no effects at a population level are predicted to occur.		
Inherent risk	**Consequence**	**Likelihood**	**Risk ranking**
	Major – collision Moderate – entrapment	Possible – collision Possible – entrapment	High – collision Significant – entrapment

8.2.4 Risk treatment

Taking the above evaluations, treatments for each of the impacts deemed to be Moderate or higher are identified in the following as described in Section 6.5 as part of the risk and impact assessment method.

8.2.4.1 Demonstration of ALARP

The risks from vessel collision / equipment entrapment with marine fauna are relatively well understood, with regard to the potential for injury and/or mortality from high-speed collisions. In general, the application of recognised good practice is considered appropriate to manage the risks. In addition, this assessment considers the risk to the location specific environmental values and sensitivities (e.g. likely encounters with large, slow moving marine fauna). To augment decision making further, a precautionary approach is applied where uncertainty continues to exist.

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted. Pilot has applied a precautionary approach in managing potential encounters with cetaceans, pinnipeds and turtles with the application of additional control measures. These are also referred to below.

Pilot considers the adopted controls to be appropriate in reducing the environmental risks associated with collision / equipment entrapment with marine fauna to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs (Table 7-32).

Table 8-2: Cost benefit analysis and residual risk evaluation – vessel collision with marine fauna or entrapment by equipment

Control measures	Cost benefit analysis	Risk reduction	Control adopted
ALARP assessment technique – good practice, legislative requirements			
The interaction of support/chase vessels and the survey vessel (when not towing equipment) with cetaceans, pinnipeds and turtles during the survey will be managed consistently with the Part 8 of the EPBC Regulations (2000): • Project vessels will not travel at greater than 6 knots within 300 m of a cetacean, pinniped or turtle (caution zone) • Project vessels will not approach closer than 50 m for a dolphin, pinniped or turtle, and/or 100 m for a whale (with the exception of animals bow riding) • If the cetacean, pinniped or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots.	Benefits outweigh costs; Legislative requirement.	Yes	Yes
MFO to maintain watch for marine fauna during the day when the seismic source is active, with observed fauna to be avoided if possible.	Benefits outweigh costs.	Yes	Yes
Use of streamer header and tail buoys fitted with appropriate turtle guards, or use of buoys that are of a design that does not represent an entrapment risk to turtles and pinnipeds.	Benefit outweighs cost (increased downtime)	Yes	Yes
Slow speed of survey vessel during seismic acquisition (4.5 knots) will reduce collision risk	Benefits outweigh costs.	Yes	Yes
All vessel crew are inducted in their responsibilities as required regarding marine fauna interactions.	Benefits outweigh costs.	Yes	Yes
All vessel strike incidents are reported, within seven days, to the Secretary of DCCEW via EPBC.Permits@dcceew.gov.au or 1800 920 528	Benefits outweigh costs; aligns with relevant actions for cetacean recovery plans.	Yes	Yes
ALARP assessment technique – EIA			
Two trained marine fauna observers (MFOs) on the survey vessel will watch for cetaceans, pinnipeds and turtles during daylight hours; throughout the duration of the survey.	Benefit outweighs costs.	Yes	Yes
Two trained MFOs on the support vessel during acquisition within the western section of the ASA	Benefit outweighs cost	Yes	Yes

Control measures	Cost benefit analysis			Risk reduction	Control adopted
Use of trained MFOs aboard the support/chase vessels in the eastern section of the ASA.	Given support/chase vessel bridge crews already maintain a constant watch during operations, additional MFOs would not significantly further reduce the risk. Sightings of threatened marine megafauna are unlikely at this time of year in this area of the OA. Costs disproportionately higher than benefits.			Limited	No
Reduce number of vessels in the OA by not using support/chase vessels	Reducing vessels numbers used increases safety risk and reduces ability to manage interactions with other marine users, potential risks are higher than the benefits gained by implementing this control measure.			No	No
No night-time operations	Limiting seismic activities to daylight hours only would significantly extend the time required to acquire data for individual activities. This would at least double the survey time and, therefore, increase the likelihood of interactions with diurnal fauna, the overall duration of seismic impacts, and interaction with commercial fisheries and other marine users and extend the survey into migratory seasons where fauna are more abundant. Costs disproportionately higher than benefits.			Minimal environmental benefit from avoiding night-time operations.	No
Do not acquire the survey	Complete elimination of the risk is not possible as there is no practical alternative to the use of vessels that allows Pilot to undertake the activity. Costs disproportionately higher than benefits.			No	No
Residual risk evaluation					
Residual risk	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**	
	Moderate – collision	Unlikely	Moderate – collision	A	
	Low – entrapment	Unlikely	Low – entrapment	A	

8.2.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot considers that the risk of adverse effects from collision with / entrapment of marine fauna are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 8-3).

Table 8-3: Acceptability criteria – vessel collision with marine fauna or entrapment by equipment

Acceptability criteria	
Vessel operations will be compliant with all relevant legislative requirements.	The interaction of support/chase vessels and the seismic survey vessel (when not towing equipment) with cetaceans, pinnipeds and turtles during the survey will be managed consistently with the Part 8 of the EPBC Regulations (2000). Predictions are therefore considered acceptable because these Regulations provide vessel speeds and approach separation distances between vessels and whales to mitigate risks collisions occurring.
No predicted effect on EBPC Act listed Threatened or Migratory species at a population level.	By aligning EP commitments with Part 8 of the EPBC Regulations and with relevant actions in recovery plans (see below), it is considered that potential collisions with marine fauna or entrapment by equipment will not result in population level effects.
Aligns with any relevant actions in species recovery plans and conservation advice.	Relevant actions identified in recovery plans and conservation advice for EPBC Act listed Threatened or Migratory species (pygmy blue, southern right, humpback, sei, fin whales, ASLs, marine turtles) to minimise vessel collisions are aligned with the control measures adopted. To this effect, this EP: • Ensures all vessel strike incidents are reported in the National Ship Strike Database (see Table 8-2) • Includes requirements for reducing vessel speed or by separating vessels and whales • Enhances education programs to inform vessel operators of best practice behaviours and regulations for interacting with cetaceans, pinnipeds and turtles. This is achieved through ensuring survey and support/chase vessels crews are inducted in their responsibilities as required regarding marine fauna interactions.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/objections, where required. No outstanding merited objections or claims.	No specific relevant person concerns have been raised regarding vessel collisions with marine fauna, or entrapment of fauna by equipment.

8.2.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for collision with marine fauna and entrapment by equipment are presented below in Table 8-4. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.3.4.1.

Table 8-4: Environmental performance outcomes, standards and measurement criteria – vessel collision with marine fauna or entrapment by equipment

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 18 No injury or mortality of cetaceans, pinnipeds or turtles due to a vessel collision or entrapment by equipment	**PS 15** The interaction of support/chase vessels and the survey vessel (when not towing equipment) with cetaceans, pinnipeds and turtles during the survey will be managed consistently with the Part 8 of the EPBC Regulations (2000): • Project vessels will not travel at greater than 6 knots within 300 m of a cetacean, pinniped or turtle (caution zone) • Project vessels will not approach closer than 50 m for a dolphin, pinniped or turtle, and/or 100 m for a whale (with the exception of animals bow riding) If the cetacean, pinniped or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots.	**MC 86** MFOs reports document appropriate responses to cetacean, pinniped and turtle interactions. **MC 18** MFO report demonstrates no breaches of EPBC Regulations 2000 Part 8. **MC 87** Records indicate crew inductions include requirements for implementing the guidelines
	PS 105 Two trained marine fauna observers (MFOs) on the survey vessel will watch for cetaceans, pinnipeds and turtles during daylight hours; throughout the duration of the survey. Two MFO's on the support vessel will watch for cetaceans, pinnipeds and turtles during acquisition within the western section of the ASA.	**MC 4** MFO data sheets/report demonstrates watch maintained during daylight acquisition **MC 5** CVs for MFOs demonstrates competency and experience
	PS 68 Use of streamer header and tail buoys fitted with appropriate turtle guards, or use of buoys that are of a design that does not represent an entrapment risk to turtles and pinnipeds.	**MC 88** Records show that turtle guards are fitted to header and tail buoys, or that buoys used are of a design that does not represent an entrapment risk to turtles and pinnipeds.
	PS 69 Survey vessel will not travel at greater than 5 knots during seismic acquisition.	**MC 89** Vessel log confirms vessels speed did not exceed 5 knots during acquisition.
	PS 70 Survey and support/chase vessels crews are inducted in their responsibilities as required regarding marine fauna interactions.	**MC 90** Records show that the survey and support/chase vessel crew inductions include responsibilities regarding marine fauna interactions
	PS 71 All vessel strike incidents are reported, within 7 days, to the Secretary of DCCEW via EPBC.Permits@dcceew.gov.au or 1800 920 528	**MC 91** MFO report confirms that all vessel strike incidents are reported in the National Ship Strike Database.

8.3 Risk 2: Introduction and establishment of invasive marine species

8.3.1 Identification of hazard and extent

Hazard	The Convention on Biological Diversity (1992) defines a non-native species as "a species introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce". Non-native species are known from all parts of the world and have been transported by several different anthropogenic means (Carlton & Geller 1993). Australia has over 250 invasive marine species (IMS) and although most do not cause a problem, some may become aggressive pests with detrimental effects on biodiversity and ecology (www.marinepests.gov.au). The following activities have the potential to lead to the introduction and transfer of IMS during a marine seismic survey: • Discharge of ballast water from the survey and support vessels • Biofouling on vessel hulls and other external niches (e.g. propulsion units, steering gear and thruster tunnels) • Biofouling of vessel internal niches (e.g. sea chests, strainers, seawater pipe work, anchor cable lockers and bilge spaces) • Marine biofouling of in-water (submersible) equipment (e.g. streamers, tail buoys, OBNs). The potential biofouling risk posed by a vessel relates to its history prior to entering the OA. The main risk factors for marine biofouling are: • Time spent in foreign ports, especially those with known IMS infestations • Transit from similar bioregion • Suitability of OA benthic habitats for IMS establishment • Time since hull cleaning • Condition and age of anti-fouling • Type of ballast water. In-water equipment required for the activity (e.g. airgun array, streamers, header/tail buoys, paravanes, nodes) is transported to and used within the OA. There is the potential that this equipment may be used for other activities prior to being used on this activity. Therefore, there is potential for transfer and establishment of IMS.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

8.3.2 Levels of acceptable risk

The risk of adverse effects on environmental receptors caused by the introduction and establishment of IMS will be acceptable when the levels of acceptability are met as described below:

- Vessel operations will be compliant with all legislative requirements relating to IMS
- No predicted effect on benthic habitats or communities
- No predicted effect on other marine users (e.g. commercial and recreational fisheries)
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited objections and claims.

8.3.3 Risk analysis and evaluation

Potential risks	Introduction and establishment of IMS through biofouling or ballast water discharge has the potential to result in effects to seabed habitat and marine ecosystems due to: • Competition with native species for resources, reducing native species diversity and abundance • Predation on local species.		
Predicted effects	Ballast water exchanges have been implicated in the introduction of marine pest species (DAWR 2017) with impacts including significant eradication and potential cost impacts to commercial fishing. Most introduced marine species in WA occur in temperate waters from Geraldton south, encompassing the OA (Wells et al. 2010). The greatest concentrations of IMS are found in areas with a large number of vessel movements and a diverse marine environment e.g. Cockburn Sound and the lower Swan River, and Fremantle in Perth, and Albany, Bunbury and Esperance south of Perth (Wells et al. 2010). Seven introduced species, none of which are pest species, that may be found in the vicinity of the OA include four species of bryozoans, the acorn barnacle, a colonial ascidian and a solitary ascidian (Wells et al. 2010). In the unlikely event that a species is introduced, and it survives in the new environment, it has the potential to colonise a new region and establish a new population. Over time the population may increase, and the species become established in the area. This can cause a range of ecological effects, including increased competition with native species. However, the probability of successful establishment of IMS is dependent on a number of factors including survival of the propagules during their transfer to the area, the suitability of the environmental conditions at the recipient site (water temperature, salinity, depth, habitat types, competitors, and predators), the survival of the propagules to reproductive state and the continued success of the introduced population. If established, IMS can compete with native species, modify habitats and can threaten endemic diversity and abundance. The shallow water depths of the OA may be conducive to IMS survival; however, establishment of IMS is most likely to occur in areas where large numbers of vessels are present and are stationary for an extended period. During the survey, vessels will be continuously moving, albeit at slow speeds.		
Inherent risk	**Consequence**	**Likelihood**	**Risk ranking**
	Moderate	Possible	Significant

8.3.4 Risk treatment

8.3.4.1 Demonstration of ALARP

The risks and potential effects of the introduction and establishment of IMS during seismic surveys are well understood with legislative requirements and industry agreed good practices to manage risks. The application of recognised good practice is generally considered appropriate to manage the risk.

The Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF) is the lead agency for management of ballast water and sediments on international vessels and administers the mandatory Australian Ballast Water Management Requirements (DAWE 2020) under the *Biosecurity Act 2015*. For the petroleum industry, it regulates the condition of vessels and drill rigs entering Australian waters with regard to ballast water and hull fouling. The regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the biosecurity officers.

Under these arrangements, all vessels that have travelled from international waters are obliged to assess and manage their ballast water in accordance with the DAFF requirements. These arrangements prohibit the discharge of high-risk ballast water within Australian territorial seas (within 12 nm of Australian territories) including Australian ports. It is also recommended by DAFF that ballast exchanges be conducted as far as possible away from shore and in water at least 200 m deep.

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Where the cost of implementing the additional control measures is disproportionate to the benefit gained, they have not been adopted.

Pilot will undertake a biofouling risk assessment of the project vessels and equipment to determine whether the vessels should be either cleaned (hull, niches, workboats and in-water equipment), or can be cleared as a low risk of introducing marine pest species. The risk assessment will follow the recommended approach of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (MPSC 2018). The risk assessment will be conducted prior to vessel entry into Australian waters, or mobilisation to the OA if the vessel is sourced from within Australian waters. If the risk assessment indicates an unacceptable risk of introducing marine species, Pilot will require an inspection and clearance to be conducted.

In-water (submersible) equipment (e.g. airgun array, streamers, header/tail buoys, paravanes, nodes) will be cleaned and maintained regularly and will undergo routine inspection prior to, and during, the activity. Submersible equipment that has been dry for more than three days will be considered low risk as attached organisms will die through desiccation and exposure. Any biofouling observed during the survey that could be considered a potential IMS will be reported to the DAFF and treated in accordance with DAFF instructions (e.g. killed with a biocide).

Pilot considers the adopted controls to be appropriate in reducing the environmental risks associated with introduction and establishment of IMS to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of the potential risk reduction (Table 8-5).

Table 8-5: Cost benefit analysis and residual risk evaluation – introduction and establishment of IMS

Control measures	Cost benefit analysis	Risk reduction	Control adopted
ALARP assessment technique –legislative requirement, good practice			
• No planned ballast water exchanges, but if required, ballast water exchange will occur >12 nm from land • No discharge of ballast water from survey and support vessels within 12 nm of land without prior authorisation from the DAFF. • Ballast water discharges recorded as >12 nm from land in Ballast Water Management Summary Sheet. • Adherence to Australian Ballast Water Management Requirements (DAWE 2020).	Benefits outweigh costs, legal requirement	Yes	Yes
Adherence with National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (MPSC 2018) • Biofouling Record Book kept outlining marine fouling management actions • Biofouling risk assessment shows low risk of IMS presence prior to entry into Australian waters • Recent hull inspections (if required based on biofouling risk assessment) • Survey vessel has a certified anti-fouling coating on the hull and coating is in sound condition. • The risk assessment procedure will comply with Biosecurity Regulation 2016 48(2)(o).	Benefits outweigh costs; legal requirement	Yes	Yes
Routine cleaning and inspection of all submersible equipment (e.g. airgun array, streamers, header/tail buoys, paravanes, nodes), consistent with the requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (MPSC 2018).	Benefits outweigh costs.	Yes	Yes
ALARP assessment technique – EIA			
Use of freshwater ballast on-board the survey vessel to inhibit survival of marine species.	Costs associated with this measure are high, and disproportionate to the benefit.	No	No
Do not discharge ballast water during the survey.	Ballast water discharges are critical for maintain vessel stability. Given the nature of the survey, the use of ballast (including the potential discharge of ballast water) is considered to be a safety-critical requirement.	Control not feasible Not assessed	No
Eliminate use of vessels including the survey vessel and support vessels.	Given that vessels must be used to complete the survey, there is no feasible means to eliminate the source of risk.	Control not feasible Not assessed	No
Source project vessels based in Australia only.	Limiting activities to only use local project vessels could potentially pose a significant risk	Control not feasible	No

Control measures	Cost benefit analysis	Risk reduction	Control adopted
	in terms of the time and duration of sourcing a vessel, as well as the ability of the local vessel to perform the tasks. While the project will attempt to source support vessels locally, it is not always possible. Availability cannot always be guaranteed. There are limited project vessels based in Australian waters and sourcing Australian-based vessels only will cause increases in cost due to pressures of vessel availability.	Not assessed	

Residual risk evaluation

Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Minor	Unlikely	Low	A

8.3.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot considers that the risk of impacts from introduction and establishment of IMS are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 8-6).

Table 8-6: Acceptability criteria – introduction of IMS

Acceptability criteria	
Vessel operations will be compliant with all legislative requirements relating to IMS	• Operations will be compliant with the *Biosecurity Act 2015*, the Australian Ballast Water Management Requirements, and the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry. • Predictions are therefore considered acceptable because the Act and national guidance mandates quarantine requirements and risk assessments for vessels to follow prior to entering Australian waters.
No predicted effect on benthic habitats or communities at an ecosystem level. No predicted effect on other marine users (e.g. commercial and recreational fisheries).	• The shallow water depths of the OA may be conducive to IMS survival; however, introduction and establishment of IMS is most likely to occur in areas where large numbers of vessels are present and are stationary for an extended period. During the survey, vessels will be moving continuously, albeit at slow speeds.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/ objections, where required. No outstanding merited claims or objections.	• No specific relevant person concerns have been raised regarding IMS.

8.3.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for introduction and establishment of IMS are presented below in Table 8-7. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.3.4.1.

Table 8-7: Environmental performance outcomes, standards and measurement criteria – introduction and establishment of IMS

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 19 No introduction and/or establishment of IMS into the OA and adjacent waters	**PS 72** • No planned ballast water exchanges to take place during the activity, but if required, ballast water exchange will occur >12 nm from land (with the exception of an exchange to maintain the stability of the vessel in an emergency) • No discharge of ballast water from survey and support vessels within 12 nm of land without prior authorisation from the DAFF. • Ballast water discharges recorded as >12 nm from land in Ballast Water Management Summary Sheet. • Adherence to Australian Ballast Water Management Requirements (DAWE 2020) to meet the Australian requirements under the *Biosecurity Act 2015*.	**MC 92** Ballast water exchange records show • No recorded occurrence of a ballast water exchange during the survey (with the exception of an exchange to maintain the stability of the vessel in an emergency) without prior authorisation from the DAFF. • Ballast water discharges recorded as >12 nm from land in Ballast Water Management Summary Sheet • Adherence to Australian Ballast Water Management Requirements (DAWE 2020): Maritime Arrivals Reporting Systems (MARS) is available and approved by the Director of Biosecurity • Approved ballast water management options are in place.
	PS 73 Survey and supply vessels comply with National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (MPSC 2018) • Biofouling Record Book kept outlining marine fouling management actions • Biofouling risk assessment shows low risk of IMS presence prior to entry into Australian waters • Recent hull inspections (if required based on biofouling risk assessment) • Risk assessment will comply with Biosecurity Regulation 2016 48(2) • Survey and support vessels have a certified anti-fouling coating on the hull and coating is in sound condition. Anti-fouling system certification is in place in accordance with Marine Order 98 –anti-fouling systems.	**MS 93** • Prior to survey sight operational history since last dry-docking, cleaning, anti-fouling renewal. • Biofouling risk assessment report confirming survey vessel poses low risk of introducing IMS. • Prior to survey a copy of the International Anti-fouling System Certificate is sighted and is in date.
	PS 74 Routine cleaning and inspection of submersible equipment (airgun array, streamers, header/tail buoys, paravanes, nodes), consistent with the requirements of the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (MPSC 2018).	**MS 94** Evidence / records confirm submersible equipment inspected and found free of biofouling prior to commencing the activity. In the event that biofouling is observed on equipment, it is cleaning and a record of the type of cleaning is kept.

8.4 Risk 3: Seabed disturbance – accidental loss of solid objects and unplanned anchoring

8.4.1 Identification of hazard and extent

Hazard	During normal operations, the survey vessel will tow an underwater seismic source and a series of streamers (minimum of six) with a maximum length of ~7 km, at approximately 4.5 knots (8 km/h). The seismic source will be towed at a depth of 6 m beneath the sea surface, and streamers will be towed at a depth of ~7 m below the sea surface. Should a seismic streamer become detached from the survey vessel or drag on the seabed it has the potential to cause minor physical damage to benthic habitats. However, the streamers are fitted with streamer recovery devices (SRDs) (i.e. pressure-activated, self-inflating buoys) that are designed to bring the equipment to the surface if lost accidentally. As the equipment sinks, it passes a certain water depth at which point the buoys inflate and bring the equipment back to the surface. Once at the surface the survey or support vessel will recover the streamer where practicable and safe to do so. Shallower survey areas in the nodal area will be acquired using OBN technology. Planned impacts to benthic habitats from deployment of ocean bottom nodes are described in Section 7.7. Non-hazardous solid materials (i.e. dropped objects) may be released by accidentally dropping objects overboard (e.g. tools, streamer depth controllers) due to human error, equipment failure or adverse weather. Under normal operations, no anchoring will be undertaken by the survey and support/chase vessels within the OA. Unplanned anchoring could occur in the event of an emergency to maintain the safety of the vessel and crew. Anchoring may result in localised disturbance to the benthic environment in contact with the anchor and anchor chain or inadvertently anchoring over shipwrecks, pipelines, other oil and gas subsea infrastructure, or set fishing gear (i.e. rock lobster pots, octopus traps). The extent of disturbance will depend on the nature of the seabed and the area disturbed.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

8.4.2 Levels of acceptable risk

The risk of adverse effects on environmental and socio-economic receptors caused by accidental loss of solid objects or unplanned anchoring will be acceptable when the levels of acceptability are met as described below.

- Any impacts from accidental loss of solid objects or unplanned anchoring will be small scale and short-term.
- Vessel operations will be compliant with industry best practice regarding lifting loads
- No predicted effect on the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF
- No predicted disturbance or damage to shipwrecks, pipelines, other subsea infrastructure or fishing gear from emergency anchoring
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns.

8.4.3 Risk analysis and evaluation

Potential risks	The known and potential environmental impact of seabed disturbance due to accidental loss of solid objects and unplanned anchoring are: • Temporary smothering / displacement of a small area of seabed habitat • Physical damage to benthic habitats and communities • Disturbance/damage to shipwrecks, pipelines, other subsea infrastructure and fishing gear.		
Predicted effects	Dragging of streamers along the seabed may occur in the event that a streamer becomes damaged and sinks to the seabed while the vessel is in motion. However, streamers will be towed at a depth of ~7 m and fitted with SRDs that are designed to bring the equipment to the surface if lost, and therefore it is unlikely that this would occur. The geophysical contractor's operating procedures usually require a minimum clearance requirement of approximately 10 m between the seabed and the deepest point on the streamer. Water depths of the OA range from approximately 10 m (potentially <10m near reefs at low tide) on the eastern perimeter to approximately 75 m in the south-west corner, with most of the OA between 25 and 50 m deep. Seismic data within the Node Survey Area will be acquired using OBNs, removing the need to use the towed streamer array within the shallower waters of the ASA. The shallow waters of the OA partially overlap with the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and the OA is entirely within the Western rock lobster KEF. The Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF is a chain of inshore lagoons containing extensive seabeds of macroalgae and seagrass with a unique diversity of marine species. The seagrass habitats provide valuable feeding grounds for protected species such as ASLs and are important nursery areas for many recreational and commercial fish species. There are two known historic shipwrecks that may be located within the OA; the *Leander* (potentially located within the Node Survey Area but exact location is unknown) and the *Era*, located in ~45 m water depth in the north-western part of the ASA (Figure 4-50). Loss of a streamer may result in localised physical disturbance of substrates, benthic habitats and communities. However, given the size of seismic equipment, only a small area of the seabed would be disturbed and the risk of anything more than short-term effects are unlikely. The survey and supply vessels will use thrusters to maintain position and will not need to anchor unless in an emergency. Should the survey vessel lose propulsion power, the supply vessel will immediately tow it to safety. Should a support/chase vessel lose power, it will be towed to safety by the second support/chase vessel. In the event of emergency anchoring, seabed disturbance will be created at the anchor location and there is likely to be some associated anchor chain drag. In the event of loss of a seismic streamer / unplanned anchoring, potential effects will be limited to physical disturbance of substrates, benthic habitats and communities in a localised area (i.e. immediate footprint of the disturbance), with only short-term effects on communities in the disturbance footprint and no effects on ecosystem function. Additionally, there is the potential for physical disturbance / damage to shipwrecks, pipelines, other subsea infrastructure and fishing gear.		
Inherent risk	**Consequence**	**Likelihood**	**Risk ranking**
	Minor	Possible	Moderate

8.4.4 Risk treatment

8.4.4.1 Demonstration of ALARP

The risks relating to seabed disturbance from accidental loss of solid objects and unplanned anchoring are relatively well understood. In general, the application of recognised good practice is considered appropriate to manage the risks. However, the assessment has also specifically considered the site-specific nature and scale of the risk on sensitive receptors such as the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF.

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Pilot considers the adopted controls to be appropriate in reducing the environmental risks associated with seabed disturbance from accidental loss of solid objects and unplanned anchoring to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of the potential risk reduction (Table 8-8).

Table 8-8: Cost benefit analysis and residual evaluation – seabed disturbance – accidental loss of solid objects and unplanned anchoring

Control measures	Cost benefit analysis	Risk reduction	Control adopted	
ALARP assessment technique – legislative requirements, good practice				
Operational procedures will be in place aboard the survey vessel for deployment and retrieval of towed equipment, to reduce potential for steamer loss.	Benefits outweigh costs	Yes	Yes	
Vessels will be fitted with sonar and depth sounders to assess depth of water when in the nodal area or areas <12m deep	Industry standard	Yes	Yes	
No planned anchoring during the survey unless in the event of an emergency.	Benefits outweigh costs	Yes	Yes	
Streamers equipped with streamer recovery devices (SRDs) designed to bring the equipment to the surface if lost accidentally and facilitate recovery. Streamer tail buoys equipped with RGPS units.	Benefits outweigh costs	Yes	Yes	
Any lost equipment will be recovered where safe and practicable to do so.	Benefits outweigh costs	Yes	Yes	
The approximate locations of the *Leander* and *Era* wreck sites, and the known location of the Cliff Head Development offshore pipeline, will be included on project vessel navigational aids.	Benefits outweigh costs	Yes	Yes	
Project vessels will not enter the 500 m radius PSZ around the Cliff Head Development wellhead platform.	Benefits outweigh costs	Yes	Yes	
ALARP assessment technique – EIA				
In the event of unplanned anchoring all measures will be taken to avoid any shipwreck sites, pipelines, other subsea infrastructure and fishing gear, without compromising vessel or personnel safety	Benefits outweigh costs	Yes	Yes	
Residual risk evaluation				
Residual risk	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
	Minor	Unlikely	Low	A

8.4.4.2 Demonstration of acceptability

Given the nature and scale of the activity, Pilot considers that the risk of impacts from seabed disturbance due to loss of solid objects and unplanned anchoring are of an acceptable level as the predicted impacts are below the defined acceptable levels of impact as described below (Table 8-9).

Table 8-9: Acceptability criteria – seabed disturbance – accidental loss of solid objects and unplanned anchoring

Acceptability criteria	
Any impacts from accidental loss of solid objects or unplanned anchoring will be small scale and short-term	• The survey is planned to occur over a period of a maximum of 40 days. Downtime during this period required to account for weather, interactions with other marine users, and marine fauna management, so it is possible that it could be completed in a shorter space of time.
Vessel operations will be compliant with industry best practice regarding lifting loads	• Operations will be compliant with the vessel's procedures for lifting loads.
No predicted effect on the values of Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and Western rock lobster KEF	• The loss of solid materials or unplanned anchoring will have no significant impact on the values of the KEFs overlapping the OA. • Streamers will be recovered through activation of SRDs, then retrieved back to support or survey vessels.
No predicted disturbance or damage to shipwrecks, pipelines, other subsea infrastructure or fishing gear from emergency anchoring	• The approximate locations of the *Leander* and *Era* wreck sites, and the known location of the Cliff Head Development offshore pipeline, will be included on project vessel navigational aids to ensure unplanned anchoring avoids them. • Project vessels will not enter the 500 m radius PSZ around the Cliff Head Development wellhead platform.

	• The support/chase vessels will immediately assist the survey vessel should it lose propulsion power, and likewise the support/chase vessels will assist each other should either lose power.
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/objections, where required. No outstanding merited claims and objections	• No specific relevant person concerns have been raised regarding seabed disturbance from equipment loss / unplanned anchoring.

8.4.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for seabed disturbance from accidental loss of solid objects and unplanned anchoring are presented below in Table 8-10. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.4.4.1.

Table 8-10: Environmental performance outcomes, standards and measurement criteria – seabed disturbance – accidental loss of solid objects and unplanned anchoring

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 20 No disturbance or damage to benthic habitats/communities, shipwrecks, pipelines, other subsea infrastructure and fishing gear due loss of equipment or unplanned anchoring	**PS 75** Operational procedures will be in place aboard the survey vessel for deployment and retrieval of towed equipment, to reduce potential for steamer loss.	**MC 82** Vessel inspections show evidence of implementing geophysical contractor's procedures for streamer retrieval and recovery.
	PS 107 Compliance of Marine Order 27 (Safety of navigation and radio equipment) 2023	**MS 105** Records demonstrate that the survey and support/chase vessels are compliant with Marine Orders 27.
	PS 76 No planned anchoring during the survey unless in the event of an emergency.	**MC 95** Vessel logs indicates vessel did not anchor in the OA.
	PS 77 Streamers equipped with streamer recovery devices (SRDs) designed to bring the equipment to the surface if lost accidentally and facilitate recovery. Streamer tail buoys equipped with RGPS units.	**MC 96** Records demonstrate that streamers are equipped with SRDs set to auto-inflate at less than actual water depth and in good working order. Records show that streamer tail buoys are equipped with RGPS units.
	PS 78 Lost streamer recovery procedure (including shallow water recovery e.g. by grappling) carried aboard survey vessel.	**MC 97** Records of streamer loss and recovery by support/chase vessels.
	PS 67 The approximate locations of the *Leander* and *Era* wreck sites, and the known location of the Cliff Head Development offshore pipeline, will be included on project vessel navigational aids.	**MC 85** Vessel logs show areas around shipwrecks and pipelines avoided during unplanned anchoring
	PS 27 Any lost equipment will be recovered where safe and practicable to do so.	**MC 98** Records of streamer loss will be documented
		MC 33 Records show equipment lost to the marine environment and attempts to recover lost towed equipment
EPO 21 Avoid objects being dropped overboard	**PS 79** The crane handling and transfer procedure is in place and implemented by crane operators (and others, such as dogmen) to prevent dropped objects.	**MC 99** Completed handling and transfer procedure checklist, PTWs and/or risk assessments verify that the procedure is implemented prior to each transfer.
	PS 80 The crane operators are trained to be competent in the handling and transfer procedure to prevent dropped objects.	**MC 100** Training records verify that crane operators are trained in the loading and unloading procedure.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 81 Visual inspection of lifting gear is undertaken every quarter by a qualified competent person (e.g. maritime officer) and lifting gear is tested regularly in line with the vessel PMS.	**MC 101** Inspection of PMS records and Lifting Register verifies that inspections and testing have been conducted to schedule.

8.5 Risk 4: Accidental release – hazardous and non-hazardous materials

8.5.1 Identification of hazard and extent

Hazard	As part of normal seismic survey vessel operations, a range of chemicals and oily substances (such as lubricating oils, wastes and hydraulic fluid) will be stored on the deck of the survey and support vessels. Hydraulic fluid is also contained in reservoirs, hoses and lines on hydraulic equipment, such as cranes or winches. There is potential for accidental loss of these fluids through operator error or machinery malfunction. In the event of an accidental on-board spill of oily substances or chemicals (such as a containment leak), there is potential for the spill to be washed overboard and released into the marine environment. Chemicals (e.g. solvents and detergents) will typically be stored in small containers of 5 to 25 L capacity with a secondary containment measure (e.g. bunds) in place to contain leaks or spills. Chemicals are stored in internal areas where any leak or spill would be retained on-board and cleaned up in accordance with the SOPEP and associated spill clean-up procedures. For a spill on deck to result in a release to the marine environment, there would need to be an un-confined spill that flowed overboard. Given that the use of oils or other chemicals on deck would be largely confined to bunded areas, this is highly unlikely to occur and would require the failure of a bund or extreme weather conditions. The realistic worst-case spill volume would be typically 25 L (largest capacity container) should a chemical spill in an unconfined area eventuate in release to the marine environment, or a drum is compromised during handling. The project vessels will generate a variety of solid wastes including packaging and domestic wastes such as aluminium cans, bottles, paper and cardboard. Hence, there is the potential for solid wastes to be lost overboard to the marine environment. Wastes on-board are managed in accordance with the on-board waste management plan. Some wastes may be incinerated. Based on industry experience, waste items lost overboard are typically wind-blown rubbish such as container lids, cardboard etc. Such losses typically have occurred during back loading activities, periods of adverse weather and incorrect waste storage.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

8.5.2 Levels of acceptable risk

The risk of adverse effects on marine receptors caused by accidental loss of hazardous and non-hazardous materials (oily wastes and chemicals, solid wastes) from vessels will be acceptable when the levels of acceptability are met as described below.

- Any impacts from accidental loss of hazardous and non-hazardous materials from the project vessels will be small scale and short-term
- Vessel operations will be compliant with legislative requirements relating to hazardous and non-hazardous materials management
- No predicted effect on EBPC Act listed Threatened and Migratory species at a population level
- Activity is not inconsistent with any relevant objectives of the Recovery Plan for relevant species and the Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018)
- Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns.

8.5.3 Risk analysis and evaluation

Potential risks	The known and potential environmental risks from the loss of hazardous and non-hazardous materials (oily wastes and chemicals, solid wastes) include: • Temporary localised decline in water and sediment quality • Temporary toxicity to marine fauna • Providing "rafting" opportunities for marine species (including potential IMS). The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the environment and secondary impacts relating to potential contact of marine fauna with wastes, resulting in entanglement or ingestion and leading to injury and death of

	individual animals. Several Threatened and Migratory species were identified as occurring within the OA, including cetaceans, pinnipeds, turtles and seabirds. However, these species are expected to be transient as there are no known key aggregation areas. However, the temporary or permanent loss of waste materials into the marine environment is highly unlikely to have a significant environmental impact, based on the types, size and frequency of wastes that could occur during the limited time the vessels will be in the OA and the transient nature of the species present. Given this, impacts will have no lasting effect on any species or water and sediment quality.
Predicted effects	**Water quality, and marine habitats and communities** Should accidental disposal of such wastes occur, the effects will be dependent upon the receiving environment and the nature of the hazardous material. There is the potential for fluid storage containers to leak and release their contents on the deck of the vessel. The spilled liquids may be washed overboard or spill overboard in adverse weather. The seabed of the Central West Coast marine region is expected to be broadly characterised by calcareous gravel, sand and silt, and known to support relatively little seabed structure or sessile epibenthos. The area is likely sparsely covered by sessile filter feeding organisms and mobile invertebrates such as echinoderms, prawns and detritus-feeding crabs (DEWHA 2008b). Habitat closer to the shore is categorised as sand and reef, with some small areas of exposed reef and macroalgae meadow, with greater biodiversity and complexity of marine organisms. The shallow waters of the OA partially overlap with the Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF and the OA is entirely within the Western rock lobster KEF. The Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF is a chain of inshore lagoons containing extensive seabeds of macroalgae and seagrass with a unique diversity of marine species. The seagrass habitats provide valuable feeding grounds for protected species such as ASLs and are important nursery areas for many recreational and commercial fish species. Accidental releases of oily wastes and chemical could; however, cause localised decreases in water quality if accidentally released in significant quantities, which could indirectly affect marine flora and fauna. In the event a loss to sea does occur, impacts to the marine environment would be minimal, due to the small potential volumes released, and the fact that spilt oil and chemicals will rapidly evaporate, disperse and weather. Water circulation in the vicinity of the OA is well mixed by winds and tides, and any spilled liquids would be rapidly dispersed and diluted. Release of small volumes of oily waste or chemicals would result in a localised adverse effect on water quality. Any effects to pelagic species would be extremely localised and temporary (short-term) and is unlikely to have any impact on species diversity or abundance within these areas. Given the small volumes involved (maximum container size of typically 25 L) any impacts on the marine environment are likely to be limited to short-term toxicity effects on biota and reduced water quality. The high energy nature of the receiving environment will facilitate rapid dispersion and dilution to non-toxic concentrations. Smaller items lost overboard, or larger items as they break down, may be ingested by marine fauna such as cetaceans, pinnipeds and turtles. However, the probability of this material being accidentally released is rare in the event that the vessel Garbage Management Plan (GMP) is followed correctly.
	Protected species The OA overlaps with pygmy blue whale foraging BIA, and the southern right whale and humpback whale migration BIAs and is immediately adjacent to the pygmy blue whale migration BIA. It is also possible that other species of cetacean could be encountered while traversing the OA. The OA overlaps foraging BIAs for male and female ASLs, and the closest haul-out site and breeding colony is located ~9 km away at the Beagle Islands. The timing of the survey (early February to end of March) is prior to the period of known presence of high densities of whales in the OA, as the acquisition window does not overlap the migration periods for pygmy blue, southern right and humpback whales in the region. Therefore, the presence of whales during this time is expected to be limited to occasional, transient individuals. There are no BIAs or Habitat Critical for marine turtle species in the OA, and therefore marine turtle presence is likely to be limited to occasional transient individuals. White sharks may forage in the OA, with a BIA extending northwards along the 200 m isobath. There are up to 13 species of seabirds that may forage within or transit through the Eureka 3D MSS OA. Eight species have foraging BIAs that overlap the OA—the Caspian tern, bridled tern, roseate tern, Australian fairy tern, white-faced storm petrel, Pacific gull, wedge-tailed shearwater and little shearwater (described in Section 4.3.10). The nearest breeding colonies for these species occur within the Turquoise Coast Island Nature Reserve, including the Beagle Islands, located between Leeman and Dongara, and further south within the Jurien Bay Marine Park.

	Hazardous items may be mistakenly ingested and cause discomfort or adverse health effects for individuals. However, this would be limited to a small number of individual animals and ingesting small volumes of hazardous material; no lethal effects and no population effects would be expected. Vessel operations will be compliant with legislative requirements relating to hazardous and non-hazardous materials management. There are no predicted effects on EBPC Act listed Threatened and Migratory species at a population level. Relevant person concerns/objections received have been merit assessed and control measures developed to address merited concerns/objections, where required. No outstanding merited concerns.		
Inherent risk	**Consequence**	**Likelihood**	**Risk ranking**
	Minor	Unlikely	Low

8.5.4 Risk treatment

8.5.4.1 Demonstration of ALARP

The risks and potential effects to due to accidental release of hazardous materials are well understood, with legislative requirements and industry agreed good practices to manage risks. In general, the application of recognised good practice is considered appropriate to manage the risk. In addition, the assessment has also considered the site-specific nature and scale of the risk (e.g. to sensitive receptors such migrating pygmy blue whales and humpback whales, and foraging ASLs and white sharks).

Pilot Energy is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are not disproportionate to the sacrifice (e.g. cost) of implementation. Pilot Energy considers the adopted controls to be appropriate in reducing the environmental risks associated with seabed disturbance from loss of solid objects to ALARP. There are no other controls measures that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of the potential risk reduction (Table 8-11).

Table 8-11: Cost benefit analysis and residual risk evaluation – loss of hazardous and non-hazardous materials

Control measures	Cost benefit analysis	Risk reduction	Control adopted
ALARP assessment technique – good practice, legislative requirements			
Solid (no fluid-filled) streamers to be used, reducing potential for toxicity from lost streamer.	Benefits outweigh costs. Solid streamers used	Yes	Yes
Survey vessel crew will be inducted in waste management and made familiar with the vessel Garbage Management Plan (GMP).	Benefits outweigh costs	Yes	Yes
• Compliance with MARPOL 73/78 Annex I and Annex V, the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, and relevant Marine Orders: • Marine Order 91–Marine pollution prevention–oil • Marine Order 95–Marine pollution prevention–garbage.	Benefits outweigh costs, legal requirement.	Yes	Yes
Vessel provides direction and specifications for waste storage/handling equipment, and waste storage containers	Benefits outweigh costs	Yes	Yes
Activity is not inconsistent with any relevant objectives of the recovery plan for relevant species and the Threat Abatement Plan for the impact of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018)	Legislative requirement	Yes	Yes
All waste receptacles in locations with potential for overboard waste loss, covered with tightly fitting, secure lids or netting to prevent any solid wastes from blowing overboard	Benefits outweigh costs	Yes	Yes
Hazardous materials will be stored with a form of secondary containment to contain leaks or spills in accordance with their MSDS.	Benefits outweigh costs	Yes	Yes
Deck scupper plugs on-board vessel.	Benefits outweigh costs	Yes	Yes

Control measures	Cost benefit analysis	Risk reduction	Control adopted
Equipment located on deck utilising hydrocarbons (e.g. cranes, winches or other hydraulic equipment) will have as a minimum primary bunding (e.g. deck edge lips or up-stands)	Benefits outweigh costs	Yes	Yes
Spill response bins/kits are maintained and located in close proximity to hydrocarbon storage areas and deck areas for spill recovery / containment	Benefits outweigh costs	Yes	Yes
Spills from fixed internal equipment, such as engines and generators, are enclosed and spills captured via bilges that drain via the OIW separator.	Benefits outweigh costs	Yes	Yes
Minor oil/lubricant spills will be mopped up immediately with absorbent materials that will be stored in covered containers and disposed of onshore as hazardous waste in accordance with the vessel SOPEP	Benefits outweigh costs	Yes	Yes
Survey vessel crew are inducted in their responsibilities for chemical storage and handling and under the SOPEP	Benefits outweigh costs	Yes	Yes
Loose objects on deck will be secured to prevent loss overboard	Benefits outweigh costs	Yes	Yes
ALARP assessment technique – EIA			
Below-deck storage of all hydrocarbons and chemicals	Access to chemicals and oils on deck is required during operations Chemicals would still need to be brought onto deck when required during operations. This measure would inhibit operations; costs outweigh benefits.	Limited)	No
A reduction in the volumes of chemicals and hydrocarbons stored on-board the vessel	Chemical transfer during operations would be required, which has associated risks. Could also result in delays to operations Costs outweigh benefits due to additional risks associated with transfer of chemicals during the survey.	No	No

Residual risk evaluation

Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Low	Unlikely	Low	A

8.5.4.2 Demonstration of acceptability

This risk of adverse effects from an accidental spill resulting from a bunkering incident is therefore considered acceptable because predictions are below the defined levels of acceptability as described below (Table 8-12).

Table 8-12: Acceptability criteria – loss of hazardous and non-hazardous material

Acceptability criteria	
Any impacts from accidental loss of hazardous and non-hazardous materials from project vessels will be short term	• The survey is planned to occur over a maximum 40-day period from early February to end of March, , with downtime during that period to account for weather, interactions with other marine users and marine fauna management; i.e. It is possible that it could be completed in a shorter space of time. The short survey timeframe reduces the risk of an incident.
Vessel operations will be compliant with legislative requirements relating to hazardous and non-hazardous materials management	• Operations will be compliant with MARPOL 73/78 Annex I and Annex V, the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*, and relevant Marine Orders:

	– Marine Order 91–Marine pollution prevention–oil – Marine Order 95–Marine pollution prevention–garbage • Predictions are therefore considered acceptable because MARPOL requires seismic vessel to have a GMP and SOPEP in place, which if applied correctly will prevent accidental loss of hazardous and non-hazardous materials and pollution events
No predicted effect on EBPC Act listed Threatened or Migratory species at a population level	• Given the adopted controls, the likelihood of Threatened and Migratory species ingesting solid materials accidentally released from project vessels is considered unlikely. • The activity is not inconsistent with relevant actions in species recovery plans and threat abatement plans (refer Section 9): – Marine turtle recovery plan – Australian sea lion recovery plan – Grey nurse shark recovery plan – Australian sea lion recovery plan – Southern Right Whale Recovery Plan (draft) – Blue whale conservation management plan – Marine debris threat abatement plan
Relevant person concerns/objections received have been merit assessed and control measures developed to address merited claims/ objections, where required. No outstanding merited claims and objections.	• No specific relevant person concerns have been raised regarding loss of hazardous or non-hazardous substances

8.5.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for accidental release of hazardous and non-hazardous materials are presented below in Table 8-13. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.5.4.1.

Table 8-13: Environmental performance outcomes, standards and measurement criteria for accidental release of hazardous and non-hazardous materials

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 22 Hazardous and non-hazardous wastes are stored, handled, disposed of in a manner that prevents marine pollution.	**PS 82** • Compliance with MARPOL 73/78 Annex V, the *Protection of the Sea (Prev*ention of Pollution from Ships) Act 1983, and Marine Order 95–Marine pollution prevention–garbage. • Survey and support vessels have a Garbage Management Plan (GMP) that must contain as a minimum: • Waste handling equipment, waste storage containers, and closed bins appropriate to the type and volume of waste will be provided at waste storage areas.	**MC 102** Vessel Garbage Management Plan (GMP) is carried on-board and complies with MARPOL requirements. Vessel audit/inspection confirms waste is managed in accordance with the Garbage Management Plan (GMP).
	PS 83 Hazardous wastes materials will be handled and stored in accordance with the corresponding MSDS.	**MC 103** Vessel audit/inspection confirms relevant MSDS' for hazardous waste types are on-board the vessel and are being followed.
	PS 49 Vessel survey crew will be inducted in waste management procedures and made familiar with the vessel GMP.	**MC 60** Records show that the project induction includes information on waste management requirements and Garbage Management Plan, and sign-off register indicates all personnel on-board have received the induction.
	PS 84 Solid streamers to be used	**MC 105** Inspection prior to commencement of survey confirms solid streamers used.
EPO 23 Oily wastes and chemicals are stored, handled, disposed of and cleaned up in a manner that prevents marine pollution.	**PS 50 / PS 85** Compliance with MARPOL 73/78 Annex I, the P*rotection of the Sea (Prevention of Pollution from Ships) Act 1983*); and Marine Order 91–Marine pollution prevention–oil: • Current Shipboard Oil Pollution Emergency Plan (SOPEP) in place • Survey vessel holds a valid IOPP certificate, where required, under vessel class	**MC 106** **Vessel audit/inspection confirms SOPEP on-board survey vessel** **MC 62** Vessel audit/inspection demonstrate the survey vessel holds an IOPP certificate, if required under vessel class **MC 107** Vessel audit/inspection demonstrate that SOPEP drills have taken place
	PS 86 Chemicals and/or hydrocarbons on deck will be stored with a form of secondary containment measure to contain leaks or spills in accordance with their MSDS.	**MC 108** Inspection during survey records demonstrate that hydrocarbon storage is designed and maintained to prevent and contain deck spills entering the marine environment.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 87 Hydrocarbon and chemical storage areas (e.g. engine room) are bunded and/or stored safely to prevent spills overboard and drain to the bilge water tank.	**MC 109** Vessel audit/inspection verifies that the main deck and hydrocarbon and chemical storage areas are bunded and/or stored safely to prevent spills overboard.
	PS 88 Hazardous wastes materials will be handled and stored in accordance with the corresponding MSDS.	**MC 110** Vessel audit/inspection indicates that hazardous wastes materials are stored in accordance with the corresponding MSDS.
	PS 89 All hazardous substances will be included in the Material Safety Data Sheet (MSDS) registers. These registers are available in key locations of the vessels (e.g. bridge, chemical locker) and kept up to date so that chemical spills to deck can be safely managed.	**MC 103** Vessel audit/inspection shows that MSDS' for all hazardous waste types are available on-board.
		MC 111 Vessel audit/inspection shows that MSDS registers are in key locations (i.e. where chemicals are stored) and a relevant crew member is responsible for ensuring they are kept up to date.
	PS 90 Equipment located on deck utilising hydrocarbons (e.g. cranes, winches or other hydraulic equipment) will have as a minimum primary bunding (i.e. deck edge lips or up-stands)	**MC 112** Vessel audit/inspection demonstrates that all equipment located on deck utilising hydraulic fluids have primary bunding
	PS 91 Spills from fixed equipment, such as engines and generators, are enclosed and spills captured via bilges that drain via the oily water separator (OWS).	**MC 113** Vessel audit/inspection confirms oily water from machinery spaces collects in bilges for treating in the OWS to MARPOL requirements.
	PS 53 Minor oil/lubricant spills will be mopped up immediately with absorbent materials that will be disposed of onshore as hazardous waste in accordance with the vessel SOPEP	**MC 67 / MC 68** Vessel audit/inspection shows that response measures for minor oil/lubricant spills were carried out in accordance with the SOPEP, and contaminated clean-up wastes stored on-board in covered bins prior to onshore disposal at a licensed waste management facility.
		MC 73 Vessel audit/inspection of incident reports for minor spills to the marine environment.
	PS 56 Survey vessel crew are inducted in their responsibilities under the SOPEP and is competent in spill response and has appropriate response resources in order to prevent hydrocarbon or chemical spills discharging overboard.	**MC 114** Vessel audit/inspection show that the project induction includes responsibilities of survey crew under the SOPEP and that regular spill drills are being carried out.
		MC 69 Incident reports record lessons learnt, and corrective measures are being implemented on-board.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 54 Scupper plugs or equivalent drainage control measures are readily available to the deck crew so that deck drains can be blocked in the event of a hydrocarbon or chemical spill on deck to prevent or minimise discharge to the sea.	**MC 70** Vessel audit/inspection verifies that scupper plugs (or equivalent) are available on the main deck.
	PS 92 Spill response kits are available in relevant locations around each vessel, are fully stocked and used in the event of a spill to deck to prevent or minimise discharge overboard.	**MC 115** Vessel audit/inspection verifies that spill response kits are available in relevant locations in accordance with vessel plans.

8.6 Risk 5: Accidental oil spill – vessel collision/grounding

8.6.1 Identification of hazard and extent

Hazard	The survey vessels (and supply/chase vessels) will be fuelled with marine gas oil (MGO), carried in separate fuel tanks that are inter-connected and isolatable. In the event of an incident such as a catastrophic vessel collision/grounding that ruptured a fuel tank, a significant volume of fuel may be released to the ocean. The total loss of fuel would be reduced by isolating the compromised fuel tank and transferring fuel to adjacent tanks. Support and chase vessels will typically have similar or smaller fuel tanks. AMSA's Technical Guidelines for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA 2015) recommends that the maximum realistic spill scenario for vessel collisions or grounding is the loss of the entire volume of the single largest fuel tank (AMSA 2015). The vessel to be used for the Eureka 3D MSS has not yet been selected, and so the largest tank in the vessel fleet was used for the purposes of assessing spill risk and identifying appropriate spill response strategies. Consequently, the maximum realistic spill scenario herein is based on the rupture of the largest fuel tank in the fleet with a capacity of 320 m^3 (a Level 2 spill scenario). Modelling allowed for a 6-hour surface release and a modelling duration of 28 days. Such a fuel spill has been used to set the worst-case EMBA (Section 4.1) Although this scenario is considered a realistic worst case, it is also an unlikely occurrence given the control measures in place to manage interactions with other users (Section 7.3.4) and the controls in place to mitigate the loss of fuel in the event of a tank rupture. It is, however, credible that a vessel collision could occur due to the vessel traffic in the shipping routes and fishing in the area. Vessel collision spills make up 11.6% of the marine spills over one tonne, with most of these occurring in ports or other areas where vessels work in close proximity (DNV 2011). Based on a review of the Australian Transport Safety Bureau's marine safety database there are no recorded instances of collisions, grounding or sinking of a seismic vessel or its support vessels in Australian waters in at least the last 30 years (ATSB 2018). The Australian registered research vessel *Rig Seismic* grounded on an uncharted reef while engaged in seismic operations in the Philippines in 1992. The vessel suffered only minor damage and it was re-floated without assistance and no pollution occurred. Spill response risks are addressed in Section 8.8. The vessel(s) might be anywhere within the ASA and buffer zones so an accidental release could occur anywhere within the OA.
Extent	Spill originates in OA, potential to spread to EMBA
Duration	Duration of survey – up to 40 days in early February to the end of March.

8.6.2 Levels of acceptable risk

The risk of adverse effects from a hydrocarbon release resulting from a vessel collision/grounding will be acceptable when:

- There will be no predicted long-term unrecoverable effects on EPBC Act listed MNES, Marine Reserve Management Plan Values and Threatened Species Recovery Plans / Conservation Advice
- There will be no predicted long-term unrecoverable effects on fish stocks or commercial fishing
- No specific relevant person claims or objectives have been raised that have not been addressed. There are no outstanding merited claims or objections.
- Operations are compliant with maritime law, OPGGS Act relating to preventing pollution / collisions at sea reporting and responding effectively to spills.

8.6.3 Risk analysis and evaluation

Potential risks

The risks and potential effects of a fuel spill from vessels associated with the oil and gas industry have been the subject of much investigation, and it is accepted that the risks are much less than those associated with spills from, for example, exploratory and operational oil wells. In general, the risks are well understood, with legislative requirements and industry agreed good practices to manage risks. The application of recognised good practice is considered appropriate to manage the risk; particularly due to the well-mixed open ocean waters of the OA that would hasten the natural weathering and dispersion of the plume. In addition, the assessment has considered the site-specific nature and scale of the risk and the environmental values and sensitivities (e.g. presence of habitats susceptible to medium- to long-term effects and likely encounters with marine fauna).

A precautionary approach has also been taken in the decision-making process, where the oil spill risk assessment is based upon a worst-case spill scenario of complete loss of the contents of one fuel tank in the event of vessel collision/grounding. Given the extremely low likelihood of two very unlikely events occurring (catastrophic collision/vessel grounding and complete loss of the contents of one fuel tank) as the defined realistic worst-case spill scenario, the assessment is considered inherently conservative.

Predicted effects

In the event of a fuel spill, surface slicks and plumes of entrained hydrocarbons can cause a localised reduction in water quality in surface waters, which at specific thresholds and exposure hours may have toxic effects on marine fauna and flora. Potentially affected biota includes plankton, fishes and invertebrates (including commercial stocks such as demersal scalefish, rock lobster and octopus), seabirds, marine mammals (cetaceans and pinnipeds), and turtles that may come into contact with a surface hydrocarbon slick. If surface slicks or entrained fuel were to contact shallow waters or emergent features adjacent to the OA, then a range of benthic habitats and communities could be at risk of impacts depending on the location of the spill and tide/weather conditions. Stranded oil can impact coastal parks and reserves, shorelines and public amenities.

Fuel properties may vary according to the blend of gasoil with heavier feedstocks. A spill of a marine gasoil (MGO) typically used by marine seismic survey vessels and supply/chase vessels has been modelled, albeit at a greater volume than the biggest fuel tank onboard. The low dynamic viscosity (4.0 cP at 25°C) (Table 8-14), means the fuel will spread quickly and will thin out to a film; increasing the initial rate of evaporation.

Table 8-14: Physical characteristics of marine fuel

Parameter	Marine gas oil (MDA blend)			
Density (kg/m^3)	829 (at 25 °C)			
Dynamic viscosity (cP)	4 (at 25 °C)			
Characteristic	**Volatiles (%)**	**Semi-volatiles (%)**	**Low volatiles (%)**	**Residual (%)**
Boiling point (˚C)	<180	180–265	265–380	>380
% of total	6.0	34.6	54.4	5
% of aromatics	1.8	1.0	0.2	-
	Non-persistent			Persistent

The components listed above suggest around 41% of the spilled volume will evaporate within the first day and about 54% of the volume may persist for over a week on the surface under calm conditions. Of the less volatile 54%, about 40% will resist evaporation for 1-3 weeks and thus can contribute to the exposures opportunities considered over the time-scale that is the subject of this assessment. Approximately 5% (by mass) of the oil will not evaporate over the longer term (several weeks). MGOs (and MDOs) are categorised as a Group 2, non-persistent oil according to the International Tanker Owners Pollution Federation (ITOPF 2011). Given that a source vessel has yet to be contracted, the exact blend and characteristics of the fuel to be used are unknown and the characteristics of a typical marine MDA blend have been used in the modelling (Table 8-15).

Table 8-15: Fates of spilled MGO in the marine environment relevant to the Eureka 3D MSS OA

Fate	Description
Spreading	MGO is a relatively low viscosity fuel oil and spreads rapidly, influenced by metocean conditions (waves, wind, tides and currents); faster surface currents result in faster spreading.
Evaporation	Volatile components evaporate to the atmosphere, with increased wind speeds and ambient temperatures resulting in a higher evaporation rate. Lighter hydrocarbon fractions (boiling point <200°C) will typically evaporate almost entirely within 24-hours in temperate conditions. The larger the surface area of a slick increases the rate at

	which it will evaporate. Remaining hydrocarbons will have a higher density and viscosity, which slows the spread and evaporation of the remaining spill.
Dispersion/ entrainment	A large proportion of the spilled MGO will become entrained (or dispersed) in the upper water column; droplets of oil become suspended in the upper layer of the water column assisted by winds and waves. Dispersion occurs more readily with relatively low viscosity MGO in the presence of breaking waves and when wind speeds exceed 5–7 knots (~2.6 to 3.6 m/s). Once dispersed into smaller droplets, the oil is prone to faster biodegradation and photo-oxidation. When metocean conditions are no longer suitable to sustain entrainment, the remaining droplets of oil may return to the sea surface, with the rate of return influenced by the buoyancy of the oil particles. On the sea surface, the droplets may form a slick that is subject to further evaporation. Entrained oil is generally more persistent as it is no longer subjected to evaporation at the surface and it may travel further in subsurface currents than the surface slick.
Dissolution	While most of components within an MGO spill are not water soluble, some components may dissolve in sea water. The lighter fractions of the oil are typically more soluble (e.g. aromatic hydrocarbons), and these are generally also more toxic than the heavier fractions. Given the relatively small portion of soluble hydrocarbons present in MGO, along with their rapid decomposition, the percentage of spilled oil that will become dissolved in the event of a fuel spill is expected to be small.

Weathering rates and the distribution of MGO over time between the water surface, water column and atmosphere will vary with the wind and sea conditions as shown in Figure 8-1 to Figure 8-3.

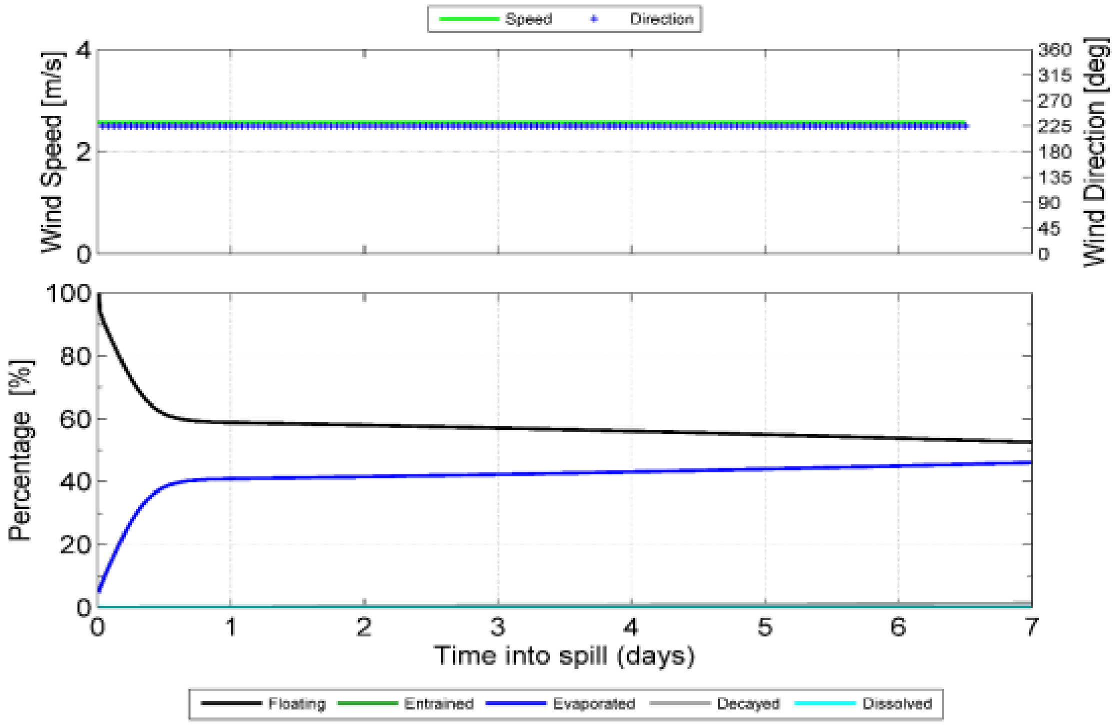


Figure 8-1: Proportional mass balance plot representing weathering of a surface release of 320 m^3 of MGO under theoretical conditions

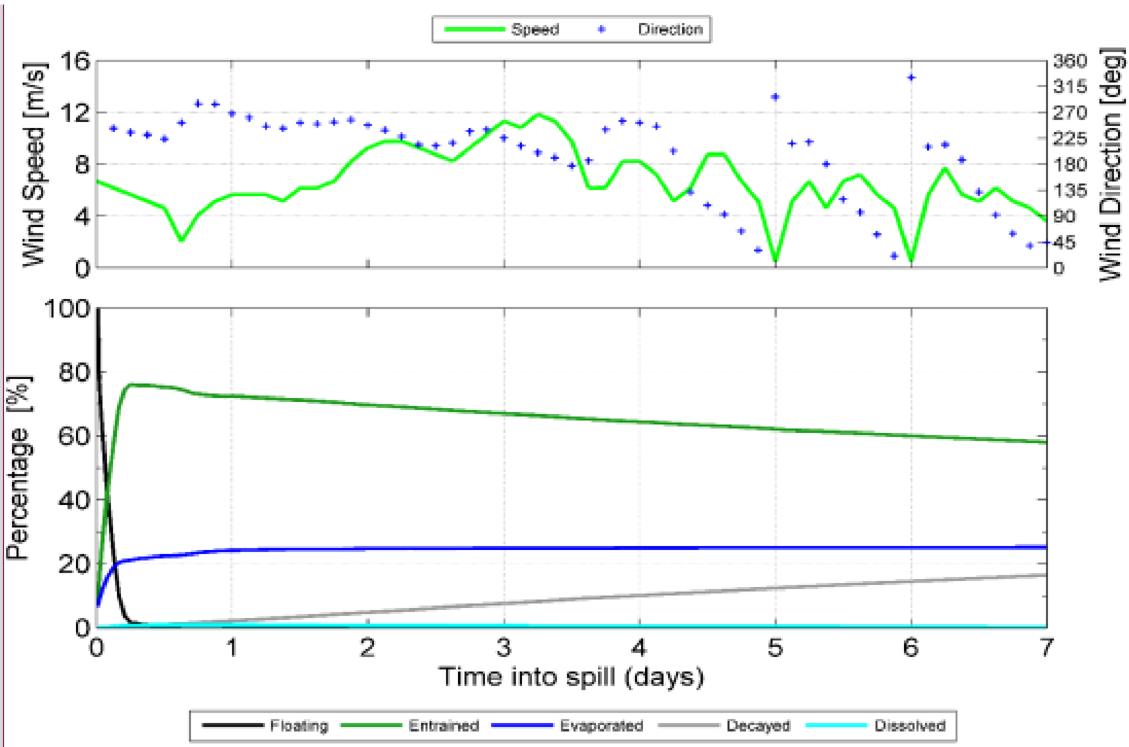
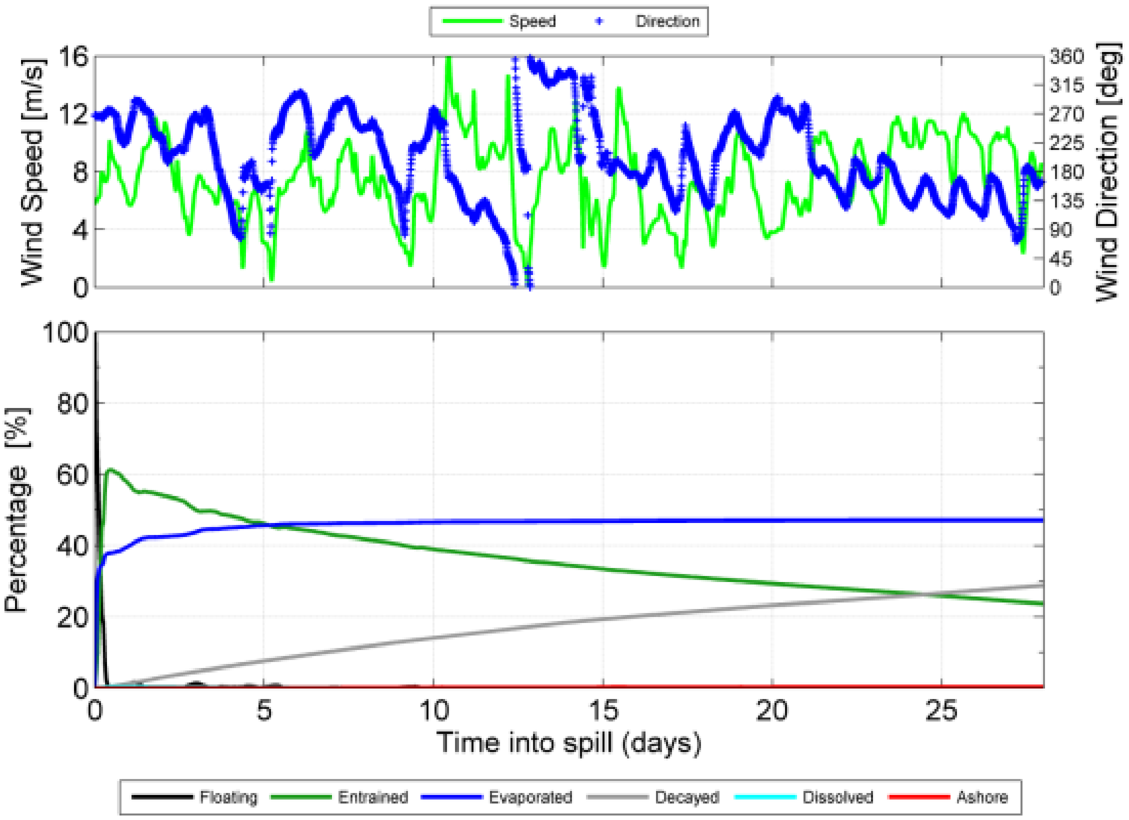


Figure 8-2: Proportional mass balance plot representing weathering of a surface release of 320 m³ of MGO weathering and fates graph, as a function of volume, under 5, 10 and 15 knot static wind conditions



Note: The August to September period was selected as an example due to weather and temperature conditions resulting in less evaporation and more entrainment and therefore showing the worst case proportional mass balance.

Figure 8-3: Proportional mass balance plot representing weathering of a surface release of 320 m^3 of MGO short-term release under an example set of metocean conditions during August to September

Spill modelling study

The modelling study (RPS 2023) used the Spill Impact Mapping and Planning (SIMAP) model to determine the trajectory, spread and weathering of spilled oil as influenced predominantly by the current, wind, wind-generated waves and sea temperature. The modelling and analysis methods undertaken, meet and exceed the ASTM Standard F2067-13 "*Standard Practice for Development and Use of Oil Spill Models*".

To account for trends and variability in these conditions, a 5-year database of wind and current data for the area, spanning the years 1994–2016 was sampled as input to multiple simulations. To improve accuracy, this data was derived from measurements and hind-casting of metocean conditions for the region, carried out by linking meteorological and hydrodynamic models.

Modelled data that integrated real measurements is used in lieu of measurement alone because measurements are made at fixed locations and cannot represent spatial variation over the potential trajectories of oil spills.

Modelling was conducted during two different scenario periods of February to March and August to September over a 28-day duration. The modelling results for both these periods were combined to present annualised results that are a maximum worst-case scenario. After consultation it was decided that the survey would be restricted to the February to March period but the larger EMBA with annualised results over both periods would be retained.

A HYDROMAP model was established over a domain that extended approximately 3300 km east-west by 3100 km north–south over the eastern Indian Ocean. The grid extends into the Southern Ocean to the south and the waters of Indonesia to the north. Approximately 98,600 cells were used to define the region, with four layers of sub-gridding applied to provide variable resolution throughout the domain. The resolution at the primary level was 15 km. The finer levels were defined by subdividing these cells into 4, 16 and 64 cells, resulting in resolutions of 7.5 km, 3.75 km, and 1.88 km.

Bathymetric data used to define the three-dimensional shape of the study domain was extracted from the Geoscience Australia 250 m resolution bathymetry database (Falkner 2009) and the CMAP electronic chart database, supplemented where necessary with manual digitisation of chart data supplied by the Australian Hydrographic Office (AHO). Depths in the domain ranged from shallow intertidal areas through to approximately 7200 m.

Exposure potential was assessed for defined geographic areas, referred to as Sensitive Receptors. Sensitive Receptors defined subsections of the coastline, shorelines of islands, State waters, economic zones, marine parks, sanctuary zones, habitat protection zones, foraging areas and other sensitive areas. Geographic bounds followed specifications from the National and State marine parks and EPBC recovery plans as described in Section 4.

The ‘probabilities’ forecast in the modelling and discussed below are for the arrival of oil at concentrations exceeding defined thresholds at particular areas (defined for Sensitive Receptors). The probability score provides a quantitative ranking of the potential for exposure of specific geographic areas and are calculated as the proportion of simulations (out of a hundred spill simulations) that crossed into that area at a certain concentration (e.g. >50 mg/L). Results are given for a range of threshold concentrations for multiple oil states (I.e. floating, entrained, dissolved). These scores do not indicate the probability that a single individual (for example, an individual bird or whale) would be exposed as a result of a single spill event, because this would require the coincidence of a spill occurring in the first instance and that individual and the oil at the same location within the wider receptor. The reported probabilities are the result of 100 replicate spill simulations.

To undertake analysis for exposure it is necessary to define one or more threshold concentrations that define when exposure will be counted, accounting for the potential for effect of the oil at the threshold concentrations. These thresholds need to serve consideration of a wide definition of effect. Multiple thresholds were used as a guide to the gradation of possible effects. The thresholds defined in Table 8-16 include a short discussion on their basis with details provided in the spill modelling study report (RPS 2023).

Table 8-16: Thresholds used for spill impact assessment

Instantaneous surface oil threshold[1]	Instantaneous in-water threshold	Shoreline threshold[4]
Change to the environment ≤1 g/m^2 Ecological impact: ≤10 g/m^2	Dissolved aromatics[2] Change to the environment ≤10 ppb Ecological impact: ≤50 ppb Entrained oil[3] Change to the environment ≤10 ppb Ecological impact: ≤100 ppb	Low: 10-100 g/m^2 (impacts to shorebirds)

1. Floating surface oil

Estimates for the minimal thickness of floating oil that might result in harm to seabirds through ingestion from preening of contaminated feathers, or the loss of the thermal protection of their feathers, has been estimated by different researchers at approximately 10 g/m^2 (French-McCay 2009) to 25 g/m^2 (Koops et al. 2004). Hence, the 10 g/m^2 threshold is likely to be moderately conservative in terms of environmental harm for effects on seabirds, for example. The lower threshold of 1 g/m^2 is likely to be an indicator of where there is a visual presence of an oil slick that may trigger social and economic impacts but where there is little potential for environmental impact.

2. Dissolved (largest contributor to toxicity)

Low: 10 ppb–50 ppb

Actual toxicity depends on both concentration and the duration of exposure, being a balance between acute and chronic effects. To put these thresholds into context, global data from French et al. (1999) and French-McCay (2003, 2002), which showed that species sensitivity (fish and invertebrates) to dissolved aromatics exposure in the water column >4 days (96-hour LC_{50}) under different environmental conditions varied from 6 ppb-400 ppb, with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae).

Based on scientific literature, the lower threshold of 10 ppb is not considered to be of significant biological impact and represents the low exposure area contacted by the spill. The higher thresholds of 50 ppb and is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002). The Australian and New Zealand Environment and Conservation Council (ANZECC) and Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000 water quality guidelines (ANZECC/ARMCANZ 2000) listed 7 ppb as the trigger value for investigation and protection of 99% of species. As an instantaneous occurrence, it is considered precautionary and indicative of water quality change that may exert behavioural or sub lethal effects due to short duration.

Based on scientific literature, the lower threshold of 10 ppb is not considered to be of significant biological impact and represents the outer boundary of the area contacted by the spill. The higher thresholds of 50 ppb and 400 ppb is more likely to be indicative of potentially harmful exposure to fixed habitats over short exposure durations (French-McCay 2002).

3. Entrained (soluble aromatics)

The 10 ppb threshold represents the lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC/ARMCANZ (2000) water quality guidelines. Due to the requirement for relatively long exposure times (>24-hours) for these concentrations to be significant, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained plumes, or when entrained hydrocarbons adhere to organisms or is trapped against a shoreline for periods of several days or more. The 10 ppb threshold exposure zone is not considered to be of significant biological impact. This exposure zone represents the area contacted by the spill and conservatively defines the outer boundary of the area of influence from a hydrocarbon spill.

The 100 ppb threshold is considered conservative in terms of potential for toxic effects leading to mortality for sensitive mature individuals and early life stages of species. This threshold has been defined to indicate a potential zone of acute exposure, which is more meaningful over shorter exposure durations. The 100 ppb threshold has been selected to define the moderate exposure zone. Contact within this exposure zone may result in impacts to the marine environment.

4. Shoreline contact

Shoreline oil concentrations are relevant to describing the risks of oil stranding on shorelines and beaches. French et al. (1996) and French-McCay (2009) have defined an oil exposure threshold of 100 g/m^2 for shorebirds and wildlife (furbearing aquatic mammals and marine reptiles) on or along the shore, which is based on studies for sub-lethal and lethal impacts. The 100 g/m^2 threshold has been used in previous environmental risk assessment studies (French McCay et al. 2004; French-McCay 2003; NOAA 2013b). This threshold is also recommended in AMSA's foreshore assessment guide as the acceptable minimum thickness that does not inhibit the potential for recovery and is best remediated by natural coastal processes alone (AMSA 2015). Contact within these exposure zones may result in impacts to the marine environment. A threshold of 10 g/m^2 has been defined as the zone of potential 'low' exposure. This exposure zone represents the area visibly contacted by the spill and defines the outer boundary of the area of influence from a hydrocarbon spill.

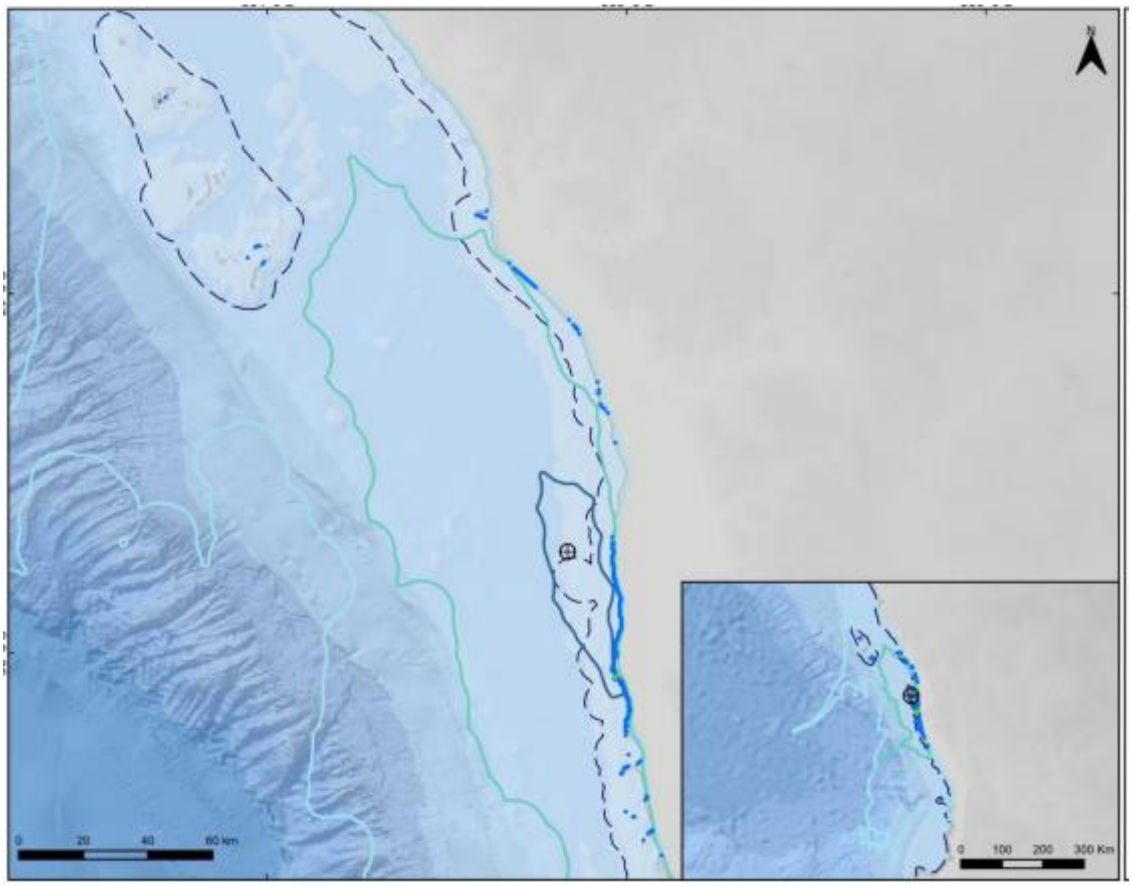


Figure 8-4: Predicted annualised zones of potential contact with surface floating oil, shoreline, entrained, and dissolved from a 320 m^3 accidental spill of MGO

Receptors most at risk within the EMBA, whether resident or migratory include plankton, fishes and invertebrates, cetaceans, pinnipeds, sea and shorebirds and shoreline habitats. In addition, the following receptors were considered-cultural and heritage values (e.g. shipwrecks) community amenities, commercial and recreational fishing, shipping and other users. Special attention was given to sensitive biota and protected species, MNES, KEFs and threatened communities as well as the values of State and Commonwealth marine protected area, including open water pelagic habitats.

The primary impact pathways have been identified as:

- Potential for toxicity and physical oiling for biological receptors and the coating of historical wrecks, public facilities (such as beaches, boat ramps, heritage sites etc.)
- Potential disturbance to shoreline habitats, risk of vessel strikes etc. from post-spill response and monitoring operations (discussed in Section 8.7).

Considering the likely receptors in the EMBA (refer Section 4) and their sensitivities (Table 8-14), the main thresholds for the risk assessment are summarised below, with additional grades discussed in the full report (RPS 2023) to ensure completeness of the risk assessment.

Given the short-lived nature of a spill scenario in general and the nature of MGO and its predicted weathering, the focus is on instantaneous impacts. Simulations confirm little or no opportunity for long-term impacts through ongoing contamination.

Potential impacts and probability of exposure to sensitive receptors

Seabirds and shorebirds

There are numerous listed threatened and/or migratory seabird and shorebird species that could occur in the OA or EMBA and could potentially forage or nest as detailed in Section 4.3.9. The details of the potential impacts to these receptors from each oil fraction is described below.

Surface and shoreline oil

Seabirds rafting, resting, diving, preening and feeding at sea have the potential to contact surface oil at various exposure levels. If seabirds have a long duration of exposure to areas of heavy surface oiling, it is likely that some individuals may die as a result of exposure through pathways such as reduced insulation and waterproofing (leading to hypothermia dehydration, drowning or starvation), ingestion, impaired flight and navigation, food chain biomagnification and tissue damage (ITOPF 2011; AMSA 2017). Direct oiling of nests is considered extremely unlikely given their location above the water line, but plumage contamination of adults can affect hatchling success (French-McCay 2009). Penguins spend much of their time in water and if oiled rapidly lose insulation and buoyancy (Hook et al. 2016). The *Iron Baron* vessel spill (325 tonnes bunker fuel, Tasmania,1995) is estimated to have resulted in the deaths of up to 20,000 penguins (Hook et al. 2016).

Shorebirds foraging for food in intertidal areas or along the high tide mark/splash zone may encounter weathered hydrocarbons that may be brought back to nests and/or ingested. Being weathered, oils transported to the sandy nests (e.g. of hooded plovers or fairy terns) is likely to permeate through the sand, limiting accumulation on the feathers of young or adults. Toxicity effects from ingestion of contaminated prey caught in the intertidal zone are unlikely as given the characteristics of MGO, the more toxic volatile components are likely to have evaporated prior to stranding.

However, the potential of exposure from surface and shoreline oil is very limited to the volatile nature of MGO, which rapidly evaporates, dissolves and entrains. The sea surface area and area of shoreline that could be affected by oil at biologically relevant concentrations is extremely small relative to the distribution of the bird species that could be affected. Surface oil is only expected to travel up to 33 km from the spill location and shoreline contact is only expected at Bowes River - Broken Anchor Bay, Glenfield Beach - Bowes River, Green Head – Leeman, Leeman – Coolimba and Thirsty Point - Booker Valley receiving greater than 10 g/m^2. Therefore, foraging and the health of birds in these relatively small areas could be impacted by surface and shoreline oiling. However, MGO quickly permeates porous sediments (NOAA 2012), limiting duration of exposure to fauna on the shoreline. In addition, MGO has a relatively small proportion of longer-chain residual components (<5% that persist over weeks) compared to other hydrocarbons and is there not expected to have long-term effects on shorelines. Similarly, impacts from surface oil are expected to be relatively short-term as the surface oil will rapidly disperse.

The bird species detailed in Table 4-10 could be present in the event of a spill; however, the presence of each species will vary seasonally, and some species may not be present. The wide geographical range of most shorebirds and seabird species within the EMBA are likely to result in impacts only to individuals or populations at one location but not necessarily extend to populations on a regional or global scale.

Dissolved/entrained oil

The areas with elevated entrained and dissolved hydrocarbons are single trajectories and short term. Fish and invertebrate prey species residing in or swimming through these small discontinuous zones that are prey for seabird and shorebirds will have a low probability of suffering acute or chronic toxicity effects, so birds consuming them are similarly not expected to suffer toxicity effects at a population level.

Marine turtles

Four species of marine turtles listed as MNES under the EPBC Act were identified as potentially occurring in the EMBA (Section 4.3.8). All four marine turtle species are listed as both Threatened and Migratory with ‘foraging, feeding or related behaviour known to occur within area’. No marine turtle Habitat Critical or BIAs (e.g. foraging, internesting, mating and nesting areas) are recognised within the EMBA, despite having been defined for each of the listed turtle species. All species of marine turtles in Australian waters are managed under the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017).

Spilled oil may impact reptiles through oiling sensitive tissues (eyes, respiratory) and through ingestion via contaminated food or absorption through the skin causing dermal pathologies. Contamination of eggs

	can result in toxic impacts to embryos with decreased survival of hatchlings and increased deformities and hatchlings being impaired by shoreline oil and more prone to predation (Shigenaka & Milton 2003). Turtles are therefore vulnerable to surface oiling from an oil spill however it should be noted that adult turtles only spend 1–10% of their time at the sea surface with each dive lasting between 30–70 minutes (French-McCay 2009). In addition, there are no Habitat Critical or BIAs for marine turtles within the EMBA and the low chance of encountering significant numbers of turtles in general during the survey, limits potential impacts to individuals and the risk is negligible. Overall, given the rapid evaporation (limiting inhalation exposure to the early phase of a spill) and weathering of surface oil, the infrequent occurrence of marine turtles in the EMBA, and the short time turtles typically spend at the surface, the absence of nesting beaches or other Habitat Critical/BIAs in the EMBA means any impacts to marine turtles are expected only on individual basis and the risk is assessed as negligible.
	Marine mammals – pinnipeds A description of pinnipeds (sea lions and seals) in the EMBA is provided in Section 4.3.7. The PMST report identified one threatened pinniped species, the ASL, that is known to occur within the EMBA. This species is listed as Endangered under the EPBC Act. Although not protected under the EPBC Act as a Threatened or Migratory species, the long-nosed fur seal also occurs in the EMBA. As pinnipeds spend time on or near the surface, they are at risk from sea surface oils through direct oiling. Direct oiling of fur seal pups can induce hypothermia by destroying their lanugo insulation. Adult fur seals have blubber but oil can still affect waterproofing qualities (other pinnipeds are less impacted) oil can “stick” flippers to fur seal bodies preventing escape from predators or hindering swimming skin, eye, respiratory irritation/damage leading to infections and starvation inhalation of vapours may damage the respiratory system (AMSA 2011). **Entrained and dissolved oil** Ingestion of oil (e.g. contaminated prey, cleaning pups etc.) may damage digestive tracts, suppress immune systems or damage mucous membranes. There is 100% probability that ASL foraging areas could be contacted entrained oil at 10ppb and up to 98% probability of contact from dissolved oil. **Shoreline oil** Seals may override their avoidance of noxious spills in order to stay near haul out areas and pups, (Geraci & St Aubin1988) increasing risk of exposure. Oil residues may possibly disguise scent that seal pups and mothers rely upon to identify each other leading to pup abandonment and starvation (Fogden 1971). Engelhardt (1982) states seals have the enzyme systems necessary to convert some adsorbed hydrocarbons into polar metabolites which can be excreted in urine. Volkman et al. (1994) report benzene and naphthalene ingested by seals is rapidly absorbed into the blood through the gut causing acute stress with damage to the liver considered likely, and death where large volumes are ingested. Due to the extreme philopatry of females and limited dispersal of males between breeding colonies, the removal of only a few individuals annually may increase the likelihood of decline and possible extinction of small colonies. This could further weaken genetic resilience, impacting its ability to cope with other natural or anthropogenic impacts and could reduce genetic diversity between colonies, placing small breeding colonies under pressure of survival from even low levels of anthropogenic mortality. Known haul-outs, resting sites and foraging waters around breeding colonies (Beagle Islands, North Fisherman Is, Buller Is, Carnac Island, Garden Island) all have ≤1% probability of >1 g/m^2 floating oil. The ASLs and long-nosed fur seals may be exposed to surface MGO while surfacing, exiting and entering the water, and depending on duration and concentration, may result in irritation to mucous membranes around the eyes and nose. There is 100% probability that Australian sealion foraging areas could be contacted by floating oil at concentrations greater than 1g/m^2 in the event of an oil spill. Should the seal inhale volatile vapours from a fresh slick acute and/or chronic toxicity impacts could result. This would be unlikely to occur to more than several individuals at most and given the brief time spent on the surface, unlikely to result in permanent damage or mortality. Likewise, ASLs and long-nosed fur seals may be exposed to shoreline oil and experience some degree of dermal contact. Surface oil is highly unlikely to contact shorelines and if shoreline contact occurs the length of shoreline contact is very small (refer Shoreline section above). Therefore, the potential for contact with pinnipeds while they occupy shorelines is very small. The area of potential contact with surface floating oil is limited to the area shown in Figure 8-5. Since the presence of the surface oil is temporary and the area is an extremely small portion of their foraging area the risk to pinnipeds from an oil spill is considered low.

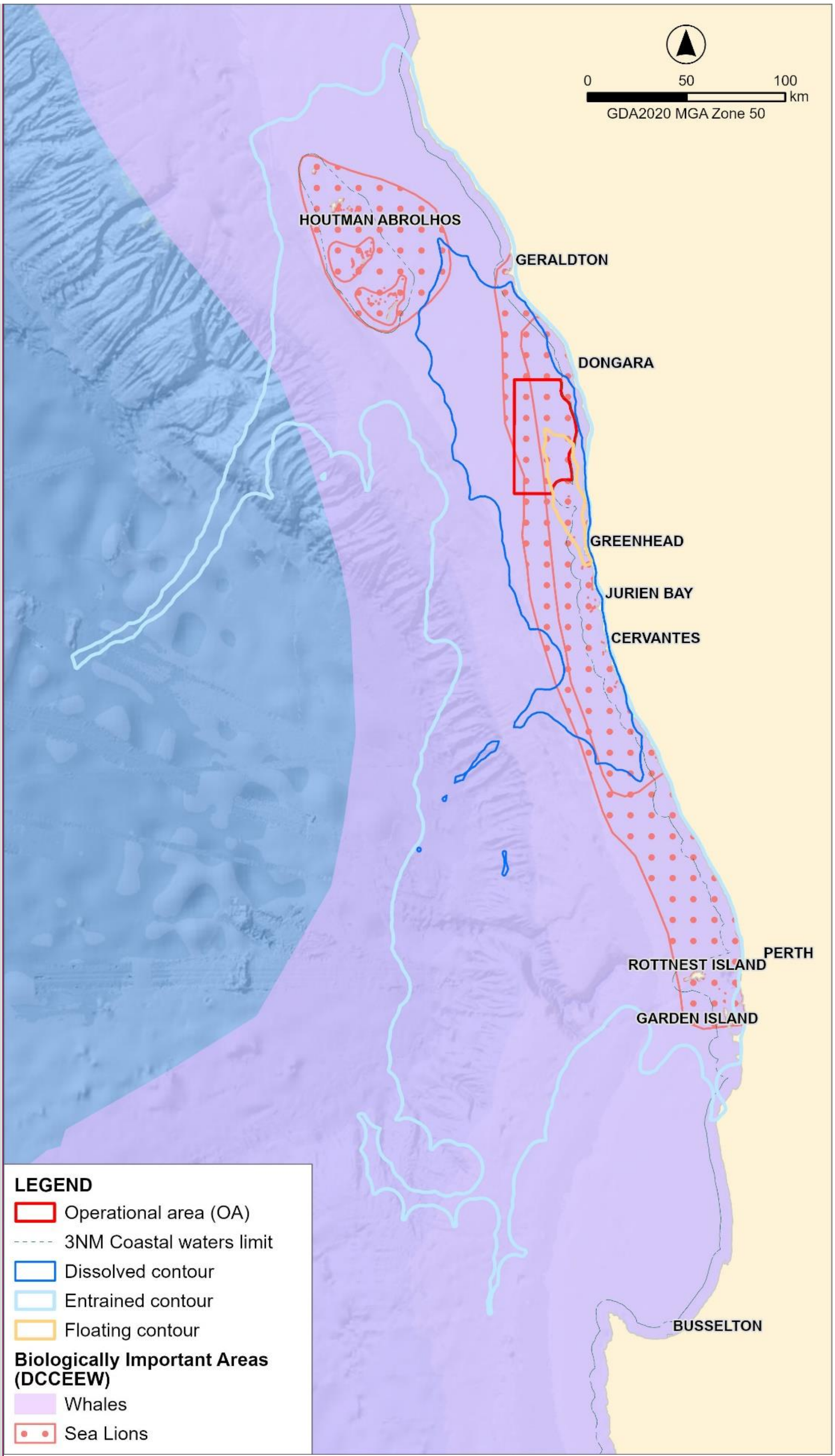


Figure 8-5: Marine mammal BIAs with areas overlapped by dissolved (≤10 ppb), entrained (≤10 ppb), and floating oil (≤1 ppb)

	Marine mammals – cetaceans A description of the cetaceans within the EMBA is provided in Section 4.3.7. The EMBA supports internationally significant populations of several cetaceans. The PMST report identified 38 marine cetacean species with 12 listed as Threatened / Vulnerable and/or Migratory MNES under the EPBC Act that may potentially occur within the EMBA. The National Conservation Value Atlas (NCVA) showed that five of these species have BIAs defined within the EMBA (Section 4.5.8). The EMBA overlaps with foraging BIAs for pygmy blue whales and sperm whales, migration BIAs for pygmy blue whales, humpback whales and southern right whales. As mammals, (air breathing) cetacean species are vulnerable to sea surface oiling. The inhalation of oil droplets, vapours or fumes may damage mucous membranes, damage airways or may cause death depending on the extent of exposure. Some cetacean feeding methods lead to greater likelihood of ingestion. For example, baleen whales are particularly vulnerable when feeding as they filter feed by skimming the sea surface for krill. This can lead to ingesting surface oil and fouling of their baleen plates. If large quantities of zooplankton (key prey) exposed to the spill were ingested, chronic toxicity impacts to baleen whales may occur (see plankton) Toothed cetaceans (e.g. dolphins) feed directly on fish and squid and are less likely to ingest surface oil. Cetaceans have mostly smooth skin with limited area of pelage (i.e. hair-covered skin) or rough surfaces (e.g. barnacles) which will cause oil adherence. Adsorption through the skin is therefore limited (low) and dissolved hydrocarbons are expected to have less impact (Geraci & St Aubin 1988). Maternal transfer of contaminant to embryos is reported in NRDA (2012) and Hook et al (2016). Effects include hypothermia, organ dysfunction, damaged lungs and airways, gastrointestinal ulceration, eye and skin lesions, decreased body mass and stress with behaviour changes. After the Macondo spill (2010), dolphin populations from Louisiana, USA that had been exposed to prolonged and continuous oil showed higher incidences of lung and kidney disease than those in other urbanised environments (Hook et al. 2016). The spill may have contributed to unusually high perinatal mortality in bottlenose dolphins (Hook et al. 2016). As a highly mobile species, in general it is unlikely cetaceans traversing and foraging within the EMBA will be constantly exposed to hydrocarbons in the water column (surface or dissolved) for long continuous durations (e.g. >96 hrs) that could lead to chronic toxicity effects. However, pelagic species may continue to be attracted to specific areas for breeding or feeding, in spite of a tendency to avoid noxious spill. As such weathered oils may continue to present a problem to baleens by fouling their sieves. French-McCay (2009) stated that a 10-25 g/m^2 oil threshold has the potential to impart a lethal dose on some marine species, however, also estimates a probability of 0.1% mortality to cetaceans if they encounter these thresholds based on the proportion of the time spent at surface. Biological consequences of physical contact with very localised areas of low to high concentrations surface oil are unlikely to lead to any long- term impacts, with temporary skin irritation and very light fouling/matting of baleen plates likely to occur (it is unknown whether the latter would affect feeding ability). Therefore, effects at the population level on the cetaceans present in the EMBA are considered unlikely. Given the low numbers of cetaceans foraging and transient through the area during the seismic survey period (February to March – i.e. outside the migratory periods for pygmy blue, southern right and humpback whales in the region), the rapid dispersion of MGO and subsequent weathering of volatiles (limiting inhalation exposure to the early stage of a spill) and the relatively small, discontinuous pockets of elevated entrained and dispersed oil, impacts are not forecast at a population level, consequences are ranked minor and the risk is Low.
	Plankton Zooplankton is vulnerable to oil due to its small size, high surface area to volume ratio and (in many cases) high lipid content (which facilitates oil uptake) (Hook et al. 2016), causing mortality, decline in egg production and swimming speed. Hydrocarbons have been shown to result in detrimental impacts to phytoplankton (González et al. 2009) but according to Varela et al. (2006) studies of planktonic communities following spills of a similar nature to that of a vessel fuel tank spill did not detect statistically significant impacts resulting from hydrocarbon exposure. Hook et al. (2016) reports phytoplankton as not typically sensitive to oil impacts but does accumulate oil rapidly due to small size and high surface area, with effects on photosynthesis dependent on concentration range. Variations in the temporal scale of oceanographic processes typical of the ecosystem can have a greater influence on plankton communities than a direct spill (Volkman et al. 1994) as reproduction by survivors or migration from unaffected areas rapidly replenishes losses with field observations showing minimal or transient effects on marine plankton. Once background water quality has been re-established, communities will take weeks or months to recover allowing for seasonal influences on the assemblage characteristics (ITOPF 2011). Plankton populations in the EMBA are expected to be highly variable both spatially and temporally and are likely to comprise characteristics of tropical and temperate Australia populations. Plankton within the EMBA are expected to reflect the conditions of the SWMR on-shelf areas. The Leeuwin Current also plays a key role in the distribution of species in the region. The warm water transported southward has

	extended the distribution of tropical and subtropical species to areas further south than would otherwise occur. Plankton found in the open waters of the EMBA are expected to be widely represented within waters of the greater SWMR with recruitment through migration likely within weeks to months maximum. Given the expected rate at which the spill would disperse and weather, the dynamic nature of planktonic communities (Davenport et al. 1982), and the variability in plankton populations in both space and time, impacts to marine plankton are predicted to be minimal, transient and insignificant in the long-term. However, consideration must be given to the importance of coastal krill in the cetacean (e.g. pygmy blue whale) and fish food chains.
	Fishes (including sharks) A description of fishes and sharks in the EMBA is provided in Section 4.3.3 and 4.3.7 respectively. Pathways to exposure include direct dermal contact (e.g. oiling gills (Hook et al. 2016)), ingestion (directly and through contaminated prey; refer Plankton section above) and inhalation (diffusion of elevated dissolved components across the gills). Impacts range including mortality, decreased size, inhibited swimming, changes in oxygen consumption, changes to reproduction, DNA damage, organ lesions and increased parasitism. Sub-lethal impacts include a range of organ malfunctions, gill hyperplasia and increased infection as well as alterations in behaviours such as feeding, migration, swimming and burrowing behaviours (Kennish 1996). Embryos, larvae and juveniles are at the most sensitive life stage, with exposure potentially resulting in decreased spawning success and abnormal larval development. Fishes and sharks are non-air breathing so less affected by surface oils. Some syngnathid species (i.e. seahorses, pipefishes) associated with nearshore reefs and rafts of floating seaweed may come into contact with surface oil. Some demersal species may be susceptible to oiled sediments particularly those that are site-restricted (e.g. to reefs and seabed features). Pelagic species in the water column are susceptible to entrained and dissolved components but tend to be highly mobile and less likely to suffer extended exposure due to patterns of movement. Adult fish kills reported after spills occur mostly in shallow water, near shore benthic species (Volman et al. 2004). The overlap of the oil fractions with the white shark BIA is shown in Figure 8-6. Given the widespread distributions of the white shark (listed as Vulnerable and Migratory), shortfin mako shark (Migratory) and porbeagle shark (Migratory) it is likely that these species may traverse the EMBA. Surface, entrained and dissolved fractions of MGO have the potential overlap with the white shark foraging BIA. However, in the south-west white shark population individuals are very sparsely distributed with an estimated 760 to 2250 adults present between the west coast of Tasmania and Exmouth on the WA coast (Hillary et al. 2018). This very low density coupled with the low concentration and ephemeral nature of an MGO spill is likely to result in a reduced risk of impact to the white shark population. Most fish are mobile and unlikely to incur sufficient exposure over a period long enough to be impacted above harm thresholds. The majority of fish tend to remain in the mid pelagic zone, limiting contact with surface hydrocarbon. MDO/MGO spills in open water are diluted so rapidly that adult fish kills are rarely observed (NOAA 2012) and (ITOPF 2011). Hence, impacts from surface oil are predicted to be low and not at population levels. Numerous commercially targeted fish and larvae could be exposed within the EMBA in the unlikely event of a spill. Fish associated with benthic habitats and KEFs in the EMBA could also be exposed to entrained and dissolved fractions of MGO. Fish within the moderate zone of exposure and that are unable to avoid the area of exposure may experience some sublethal and lethal effects. These effects will pass after the MGO spill has dispersed resulting in concentrations unlikely to cause ongoing effects.

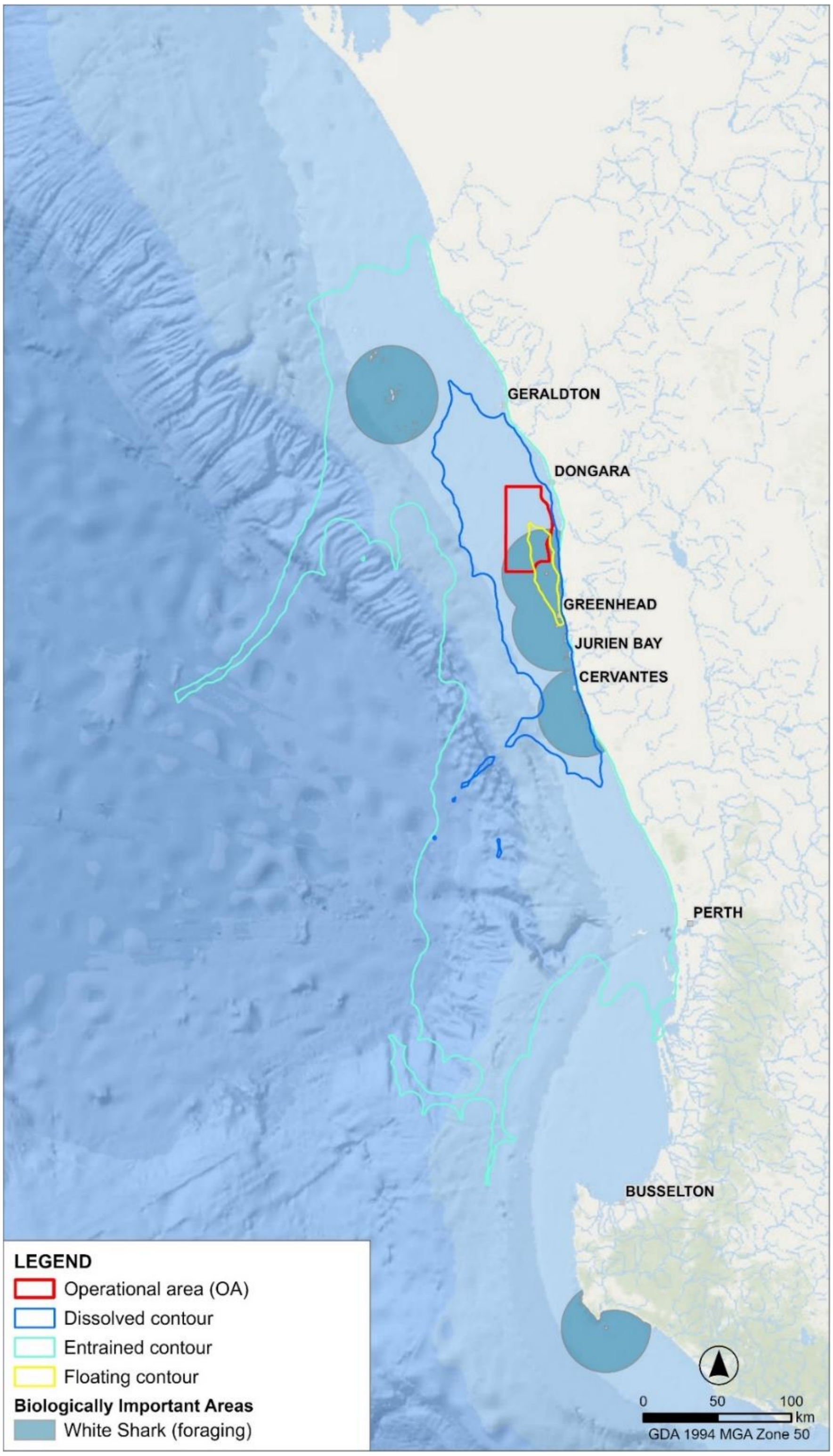


Figure 8-6: White shark foraging BIA with areas overlapped by dissolved (≤10 ppb), entrained (≤10 ppb), and floating oil (≤1 ppb)

Shorelines

A description of shoreline types within the EMBA is presented in Section 4.4.3. They tend to be regularly cleaned by wave action and have a low sediment total organic carbon, thus a low abundance of marine life (Hook et al. 2016). The low organic carbon and large particle size means shoreline oil permeates readily, the depth of penetration depending on particle size (greater penetration in coarse beach sand than in fine muds in tidal flats and estuaries). The low viscosity of MGO means it quickly penetrates, aided by burrows (e.g. worm holes) and root pores.

	Oil can accumulate in cracks, crevices, rock pools, overhangs and shade areas that provide habitats for soft bodies fauna such as sea anemones, sponges and seasquirts (Hook et al. 2016). The vulnerability of these communities depends on topography, composition and position. A vertical rock face on a wave exposed coast is likely to be remain unoiled if a slick is held back by the action of the reflected wave. A gradual sloping boulder shore in a calm backwater of a sheltered inlet can trap large amounts of oil which may penetrate the substratum. The complex patterns of water movement close to rocky coastlines can concentrate oil while oil often collects on the high tide mark while lower parts may be untouched (IPIECA 1995). The waves and tide that washed the oil onto the rocks soon starts to remove it, with the rate of weathering depending on wave exposure, weather conditions, shore characteristics etc. Gradual leaching can result in constant low-level pollution and microbial breakdown begins which is slower in cold or temperate environments. Silts and clay can assist removal by flocculation. Marine snails and other grazing fauna can remove significant amounts of oil. As oil weathers it becomes more viscous and less toxic, often leaving little residue on shore rock. This can remain an unsightly stain for years but is unlikely to cause further ecological damage. Oil tends not to remain on wet rock or algae but likely to stick firmly if the rock is dry (IPIECA 1995). The impact of oil on any marine organism depends on the toxicity and viscosity, amount of oil, sensitivity of the organism and length of contact. Even where the immediate damage to rocky shores from oil spills has been considerable, it is unusual to result in a long-term damage and the communities have often recovered within two or three years (IPIECA, 1995). This is because oil is not normally retained in the rocky shores in a form or quantity that causes long-term impacts, and also because most rocky shore species have a considerable potential for re-establishing populations. Many rocky shore animals have also been found to withstand heavy oiling – it typically requires smothering for a few tides to fatally impact barnacles and intertidal sea anemones. Limpets, littorinid snails and other grazing molluscs are usually more susceptible. A particularly toxic oil may result in high mortality through a direct effect or through a narcotic effect where the oil causes the animals to lose their grip on the rock, become available to predators or die of desiccation (IPIECA 1995). As long as the shoreline is not further oiled, the spores of macroalgae also settle and grow resulting in an abnormally dense cover of seaweed. Simultaneously the juvenile limpets and snails which settle and develop in damp and protected sub-habitats, move out to gradually repopulate the open rock. They grow quickly on the large quantities of food and gradually reduce the seaweed cover to normal levels. The whole process may take less than 2–3 years for the shore to look ‘normal’ although in some cases the balance between the algae and grazers may take longer to stabilise (IPIECA 1995). Oiling greater than 1g/m^2 threshold could result in acute toxicity and mortality of many invertebrate communities, especially where oil penetrated through animal burrows (IPIECA 1999). However, rapid recovery is expected as components are weathered and removed from the environment and recruitment from unaffected individuals and nearby areas occurs. The results of exposure to oil may be acute (e.g. die-off of amphipods and replacement by more tolerant species such as some worm species (IPIECA 1999) or chronic (e.g. gradual accumulation of oil and genetic damage) (Hook et al. 2016). After the *Sea Empress* spill off the coast of Wales in 1996, many amphipods (sandhoppers), cockles and razor shells died with mass strandings of both intertidal species (such as cockles) and shallow sub tidal species. Populations of mud snails recovered within a few months, but some amphipod populations had not returned to normal after one year. Long-term depletion of sediment fauna could have adverse effects on birds or fish that use the tidal flats as feeding grounds (IPIECA 1999). Due to the volatile nature of MGO very little shoreline contact is predicted. The shorelines that could be contacted by oil greater than 10 g/m^2 are shown in Figure 8-7. The only shorelines that could be contacted by MGO include Glenfield Beach (3 km), Green Head (8 km) and Leeman (2 km). The only island shorelines that could be contacted by MGO include the Houtman Abrolhos Islands (3 km) and the Pelsaert group (3 km). Therefore, the flora and fauna that inhabit these areas of shoreline could be impacted by the physical (smothering) and toxic effects of MGO. However, these effects are likely to be temporary due to the volatile nature of MGO.

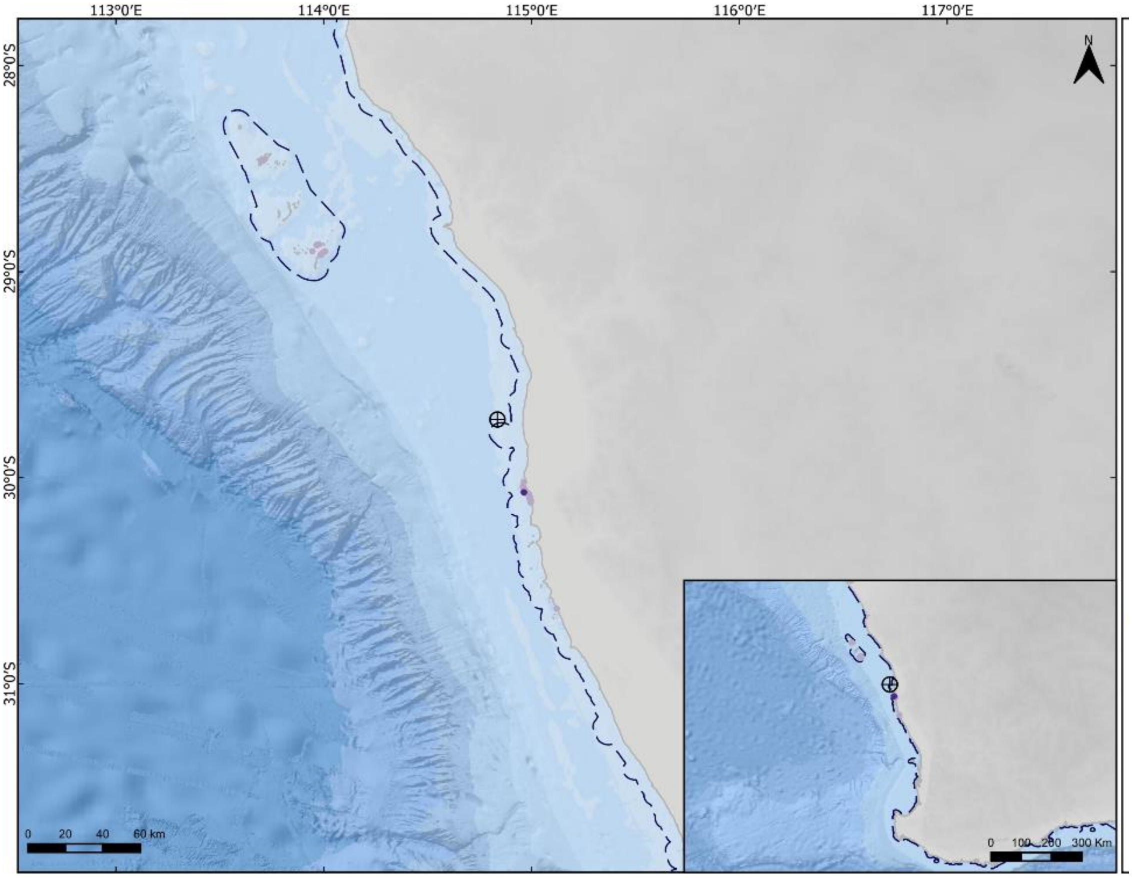


Figure 8-7: Areas of shoreline that could potentially be contacted by hydrocarbons

Benthic habitats

Acute or chronic exposure through surface contact and/or ingestion can result in toxicological risks. The presence of an exoskeleton (e.g. crustaceans such as rock lobster) will reduce hydrocarbon absorption through the surface membrane but invertebrates with no exoskeleton and larval forms may be more vulnerable to impacts from pelagic hydrocarbons.

Marine invertebrates and larva are likewise more at risk from entrained and dissolved hydrocarbons than adults with an exoskeleton. Should localised impacts to larval stages occur, population recruitment that year can be impacted. Tissue taint of invertebrates exposed to hydrocarbons can remain for several months, although taint may eventually be lost. NOAA (2002) describes lobsters when exposed to a light hydrocarbon losing their taint after 2-5 months.

Minute oil droplets may impact aquatic biota mechanically (e.g. filter feeders) or act as a conduit for exposure to semi- soluble hydrocarbons taken up by the gills or digestive tract (McCay-French 2009). Toxicity is primarily attributed to water soluble polycyclic aromatic hydrocarbons (PAHs), especially dissolved naphthalene. ANZECC/ARMCANZ (2000) identifies the 96-hr LC_{50} concentrations for naphthalene as 57,000 ppb for the bivalve mollusc (*Katelysia opima*) and 850 to 5700 ppb for six species of marine crustaceans.

Dispersed and non-dispersed oil can also deplete oxygen in bottom waters through the bacterial metabolism of oil (and/or dispersants), and surface oil blocking light (NRDA 2012).

After the Macondo well blowout (Gulf of Mexico, 2010) BP (2015) reported that less than 2% of the sediment samples tested exceeded EPA benchmarks for aquatic biota, and these were largely sampled from the area close to the wellhead (BP 2015). Felder et al. (2014) studied offshore benthic seaweeds in water depths of 55–75 m before and after the blowout, finding a post spill die-off of seaweeds and a decrease from 60 species to 10. Crabs, lobsters and prawns associated with the seaweeds and benthic substrates also declined as much as 29–42%, although other influences may have been involved so definitive links to the oil spill are not possible. Nevertheless, residual hydrocarbons may have contributed to localised deaths, decline in fertility of surviving female decapods and reduced recruitment (Felder et al. 2014).

Following the Montara well blowout in the Timor Sea in 2009, surveys of the Barracouta and Vulcan shoals (which lie about 20–30 m below the surface in surrounding deep waters greater than 150 m) did not detect obvious visual signs of major disturbance (Heyward et al. 2010). Due to the lack of pre-impact data, the presence of low-level severely degraded oil at some shoals detected later could not be directly linked to the Montara spill.

	Both the entrained and dissolved fractions of MGO have the potential to contact benthic habitats at 10 ppb causing chronic exposure and 100 ppb causing toxic effects. Figure 4-9 and Figure 8-8 show the reefs, shoals, banks and KEFs that could be contacted by thresholds of oil that could affect benthic organisms. Other benthic organisms within these zones that are not associated with a recognised benthic habitat feature could also exposed to entrained and dissolved MGO. Thes impacts are likely to be temporary due to the transient and pulsed nature of the spill and are predicted to fully recover fully, resulting in a low impact. Surface oil is unlikely to impact benthic habitats except on shorelines which is detailed above.
	KEFs In the event of an oil spill there is the potential for several KEFs to be contacted either dissolved, entrained oil or both fractions (Figure 8-8). Contact by surface oil has not been considered credible because all the KEFs are seabed features and surface oil by definition cannot make contact with them. An overlap between the dissolved or entrained oil with a KEF indicates there is potential for contact in the event of a spill. However, the probability of contact with a KEF varies through space and time with changes in weather and metocean conditions and the probability of contact is very low at greater distances from the source of the spill. The Western rock lobster KEF could be contacted by dissolved and entrained oil at biologically relevant thresholds. It is possible for this KEF to be contacted by dissolved oil from just north of Geraldton to approximately 100 km south of Cervantes. Entrained oil could affect a greater portion of the Western rock lobster KEF with possible contact extending approximately 200 km north of Geraldton to approximately 150 km south of Perth at concentrations greater than 10 ppb. However, for both dissolved and entrained oil fractions only a small portion of the KEF between these northern and southern points could be contacted by dissolved oil at concentrations greater than 10 ppb. The area of the KEF that could be contacted by oil is small relative to the size of the KEF. The Western demersal slope and associated communities KEF and Perth Canyon and adjacent shelf break and other west coast canyons KEF could only be contacted by entrained oil greater than 10 ppb (with the exception of a very small overlap with dissolved oils). The potential overlap with entrained oil extends from the most southern extent of the KEFs to the about 150 km north of Geraldton. The area of the KEFs that could be contacted by oil is very small relative to the size of the KEF. All the Commonwealth marine environment surrounding the Houtman Abrolhos Islands could be contacted by entrained oil greater than 10 ppb. Only a very small portion of the south-eastern edge of the KEF could be contacted by dissolved oil at concentrations greater than 10 ppb. The Commonwealth marine environment within and adjacent to the west coast inshore lagoons KEF from approximately 100 km north of Geraldton to approximately 100 km south of Perth could be contacted by entrained oil at concentrations greater than 10 ppb. The area of this KEF potentially contacted by dissolved oil is significantly smaller than that contacted by entrained, spanning from near Geraldton to a small portion of the KEF about 300 km south of Geraldton. The Ancient coastline at 90-120 m depth KEF could be contacted by both dissolved and entrained oil fractions with the entrained fraction covering a significantly larger area than the dissolved. However, this KEF extends the length of the WA coastline and therefore the area covered by the potential spill is an extremely small portion of the KEF. The physical structures of the KEF, such as the rocky reefs, limestone pavements and benthic contours are unlikely to be affected by the dissolved and entrained oil fractions. However, the flora and fauna communities that inhabit the KEFs could be impacted by an oil spill and the nature and extent of these potential impacts are detailed int the relevant sections of this impact assessment. Given that the Ancient coastline at 90-120 m depth KEF is important in the region, such impacts are notable. However, being a large dynamic, open, and well-mixed ocean environment, and given the nature and behaviour of the MGO, impacts are expected to be recoverable within a year and not have any individual or cumulative consequence higher than Low.

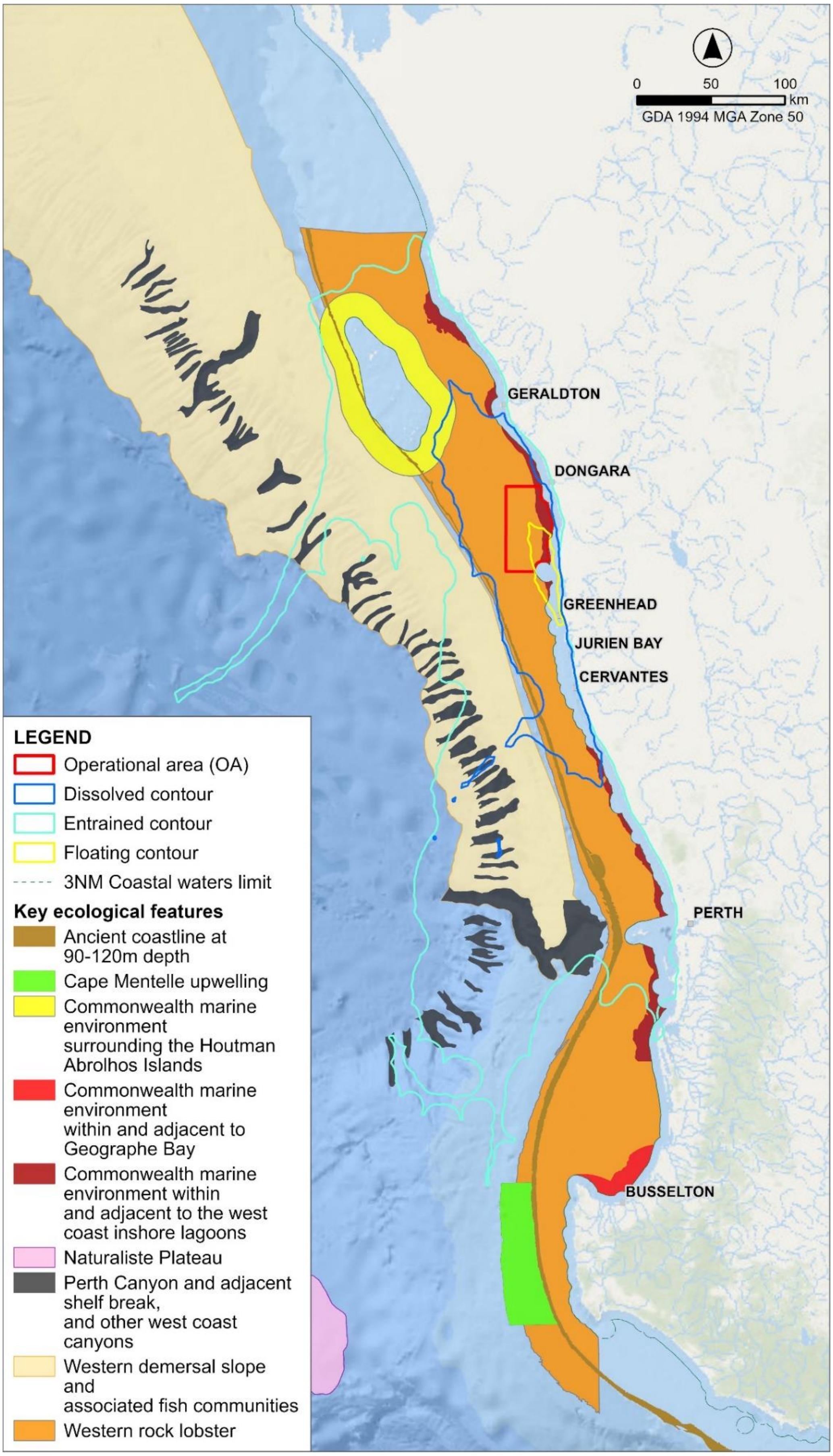


Figure 8-8: Overlap of KEFs with dissolved, entrained and floating oil

Macroalgal and coral communities

A description of macroalgal communities is provided in Section 4.3.2.

Macroalgae

Macroalgae are generally limited to growing on intertidal and sub tidal rocky substrata in shallow waters to 10 m water depth, so may be exposed to subsurface, entrained and dissolved hydrocarbons. However, some are susceptible to surface hydrocarbons exposure more so in intertidal habitats as opposed to subtidal habitats.

Blumer (1971) and Cintron et al. (1981) document smothering, fouling and asphyxiation effects on marine plants. In macroalgae, oil can act as a physical barrier for the diffusion of carbon dioxide across cell walls (O'Brien & Dixon 1976), the impact depending largely on the degree of exposure and how much the hydrocarbon adheres to the algae which varies with oil state and stickiness. The presence of mucilage layer or fine 'hairs' will influence how much oil sticks. Connell & Miller (1981) reviewed post spill field studies noting a wide range of variability in the level of impact, but in all instances the algae appeared to be able to recover rapidly from even heavy oiling. This was due to the fact that for most algae, new growth is produced near the base of the plant while the distal parts exposed to the oil are continually lost. French-McCay et al. (2004) indicated that oiled kelp beds had a 90% recovery within 3–4 years of impact however full recovery to pre-spill diversity may not occur for longer periods.

Intertidal macroalgal beds are more prone to oil spills than subtidal beds because although the mucous coating prevents oil adherence, oil that is trapped in the upper canopy can increase the persistence of the oil, which impacts upon site attached species. Additionally, when oil sticks to dry fronds on the shore they can become overweight and break as a result of wave action (IPIECA 2002). Hook et al. (2016) on the other hand, states that kelp is typically resistant to oil though the fauna associated with it may be more sensitive. IPIECA (1995) also states that brown seaweeds are relatively insensitive to oil due to the slimy mucilage that coats all their surfaces so that even after a heavy oiling, most of the seaweeds are washed clean by the next high tide and largely remain undamaged.

Edgar & Barrett (1995) studied the impacts on, and the recovery of, subtidal reefs affected the *Iron Baron* spill (Northern Tasmania, 1995), that the release of large quantities of fuel oil did not substantially affect populations of sub tidal reef associated organisms with no significant change in numbers of species on reefs nor in the densities of the most abundant animal and plant species.

Macroalgae response to hydrocarbons depends on its life stage, with gamete, larval and zygote stages more at risk than adult growth stages (Lewis & Pryor 2013). Toxic effects concentrations for algae exposed to hydrocarbons varied greatly amongst species with studies ranging from 0.002-10,000 ppm (Lewis & Pryor 2013).

Macrophytes including seagrasses and macroalgae require light to photosynthesise. So, in addition to the potential impacts from direct smothering exposure to entrained and dissolved hydrocarbons, the presence of entrained oil in the water column can affect the light quantities and the ability of macrophytes to photosynthesis.

Macroalgae will generally be limited to seabed areas within the photic zone (approximately less than 100 m deep) where rocky and hard substratum exists. These areas include the islands (e.g. Beagle Islands, Abrolhos Islands and Rottnest Island) and rocky reefs within approximately 100 km of the shoreline. Impacts from entrained and dissolved fractions of oil are most likely in water depths >5 m, while surface oil has the potential to impact macroalgae in intertidal areas and to depths of approximately 5 m.

Corals

Exposure of entrained and dissolved hydrocarbons to shallow subtidal corals has the potential to result in lethal or sublethal toxic effects, resulting in acute impacts or death at moderate-to-high exposure thresholds (Loya & Rinkevich 1980; Shigenaka 2001; DoT 2018), including increased mucus production, decreased growth rates, changes in feeding behaviours and expulsion of zooxanthellae (Peters et al. 1981; Knap et al. 1985). Adult coral colonies, injured by oil, may also be more susceptible to colonisation and overgrowth by algae or to epidemic diseases (Jackson et al. 1989). Lethal and sublethal effects of entrained and dissolved oils have been reported for coral gametes at much lesser concentrations than predicted for adult colonies (Heyward et al. 1994; Harrison 1999; Epstein et al. 2000). Goodbody-Gringley et al. (2013) found that exposure of coral larvae to oil and dispersants negatively impacted coral settlement and survival, thereby affecting reef resilience. Sub-lethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri & Heyward 2000). In the unlikely event of a marine diesel spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is potential for a reduction in successful fertilization and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri & Heyward 2000).

Coral communities in the EMBA are predominantly associated with the island fringing reefs and other reefs, banks and shoals (Figure 4-7). The probability of exposure to corals at these locations varies depending on their location and the oil fraction type, with corals in shallow intertidal areas being the only corals potentially impacted by floating oil. The probability of impacts to corals by floating oil above $1 g/m^2$ at all reefs, shoals and islands is <1%. Impacts from entrained oil above 10 ppb is highest at the Abrolhos Islands at 41% and at Geelvink Channel Shoals at 41%. The probability of impacts from dissolved oil above 10 ppb<1% at all the islands and of all the reefs, banks and shoals is highest at North Tail Reef (4%).

Commercial fisheries

A description of commercial fisheries in the EMBA is provided in Section 4.4.2.

Table 8-17 below lists overlap between the oil fraction types and the historically fished areas of the WA-managed commercial fisheries. The thresholds used to delineate the overlap do not infer a biological or ecological impact but warrant further investigation under the ANZECC guidelines.

Table 8-17: Overlap between each WA-managed commercial fishery and floating at ≤1g/m^2, dissolved at ≤10 ppb, and entrained oil at ≤10 ppb

Fishery	Historical catch/effort		
	Floating	Dissolved	Entrained
Abalone Managed Fishery (AMF)	X	✓	X
Abrolhos Islands and Mid-West Trawl Managed Fishery (AIMWTMF)	X	✓	X
Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLMF)	✓	✓	✓
Mackerel Managed Fishery (MMF)	X	✓	X
Marine Aquarium Fish Managed Fishery (MAFMF)	✓	✓	✓
Octopus Interim Managed Fishery (OIMF)	✓	✓	✓
Open Access Fishery (OAF)	✓	✓	✓
South West Coast Salmon Managed Fishery (SWCSMF)	✓	✓	✓
Specimen Shell Managed Fishery (SSMF)	✓	✓	✓
West Coast Deep Sea Crustacean Managed Fishery (WCDSCMF)	✓	✓	✓
West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF)	✓	✓	✓
West Coast Demersal Scalefish Managed Fishery (WCDSMF)	✓	✓	✓
West Coast Purse Seine Managed Fishery (WCPSMF)	X	✓	✓
West Coast Rock Lobster Managed Fishery (WCRLMF)	✓	✓	✓

Lost or reduced fishing time can result if fisheries are unable to access specific fishing areas due to spill response activities, possible exclusion zones and avoidance of areas where vessels and equipment may be oiled. Temporary fisheries closures may be established by WA Department of Fisheries or voluntarily by the fishermen themselves because of the risk of the catch being tainted. Davis et al. (2002) reported detectable tainting after a 24-hour exposure to crude concentrations of 0.1 ppm, marine fuel concentrations of 0.33 ppm and diesel concentrations of 0.25 ppm. Concentrations of petroleum in fish, crustacea and mollusc tissues can pose significant potential for adverse human health effects and until products are cleared by health authorities they could be restricted for sale and human consumption. The main potential impact of real or perceived tainting of target species is financial loss to licence holders and fishing crew; however, there may also be wider economic consequences such as reduced employment in fishing services in the region.

Nevertheless, a fisheries closure due to tainting concerns is expected to be short-term. After the Montara oil spill (Timor Sea, 2009) as a precautionary measure, the WA Department of Fisheries advised commercial fishers to avoid fishing in waters affected by oil from this spill, suggesting fish were not safe for human consumption. However, testing of fish caught in the visible slick found no detectable petroleum hydrocarbon in fish muscle samples, suggesting they were safe for human consumption. Limited ill effects were detected in a small number of fish (PTTEP 2013). No consistent effects of exposure on fish health could be detected within two weeks following the end of the well release. In addition, the majority of studies (both laboratory trials or fish collected after spills) find evidence of elimination of PAHs in fish tissue, returning to reference levels within two months of exposure (Challenger & Mauseth 2011; Davis et al. 2002; Gagnon & Rawson 2011).

The impacts to commercial fishing from a public perspective may be more significant and longer term than the ecological impacts. Decreased catches may also occur due to ecological impacts on target species within the area of the spill. Larvae of commercial species and their planktonic food sources are the most vulnerable to hydrocarbon impacts (refer Plankton section above). Various species are likely to spawn in the area, whether in shallower shelf waters (e.g. whiting and snapper) or deeper slope waters

	(e.g. pink ling and blue grenadier) (Section 4.7). Most of these species are broadcast spawners making their larvae vulnerable to the effects of an oil spill. However, in the case of those species in which the spawning period overlaps the period of the proposed seismic survey, the area of a potential oil spill is very small relative to the area over which spawning occurs, and broad-scale mixing as a result of oceanic currents is expected to minimise potential impacts of a short-term oil spill. In terms of impacts to adults, Gagnon & Rawson (2011) studied a number of fish species after the Montara blowout in the Timor Sea (light condensate) in four phases. Immediately after the blowout ceased, fish were exposed to and metabolised hydrocarbons, however, no consistent adverse effects on fish health or reproductive activity were detected. Five months after the blowout, continued exposure was indicated through the detection of elevated liver detoxification enzymes and PAH biliary metabolites in three out of four species collected, and elevated oxidative DNA damage. A year later, trends showed a return to reference levels with often (but not always) comparable biomarker levels in fish collected form reference and impacted sites. No reported studies of oil spills on cartilaginous fish (including sharks rays and sawfish) were found in the literature. It is not known how the data on bony fish would relate to cartilaginous fish. Fish assemblage recovery depends on the intensity and duration of the spill, composition of the hydrocarbon and any dispersant used and life cycle attributes e.g. abundant short lived fecund species may recover quicker than long lived less abundant species with small movement ranges. Given the forecast rapid weathering and dissipation of a spill and the relatively small area where for a short period entrained and dissolved hydrocarbons could exceed thresholds, impacts from a hydrocarbon spill are unlikely to result in measurable effects on fishery catch returns. and impacts on commercial stocks and fishermen is expected to be minor.
	Other Users – Public Amenity, Scuba Diving and Snorkelling Hydrocarbon presence on the sea surface may create a safety hazard to other marine users. Volatilisation of hydrocarbon lighter ends may initially create conditions at the sea surface at the time of the initial release with a resultant fire hazard potential. Safety hazards associated with the release quickly reduce with distance, and time, from the spill. As such, safety impacts to third party marine users could only be experienced within very small distance of the spill source and within a short time of release given the weathering characteristics of MGO. The shorelines that could be contacted by floating oil are detailed above in the shoreline section. The presence of oil on these shorelines could create a safety and public amenity in the event of a spill. Recreational boating, fishing, swimming and diving is popular along much of the mid-west coast of WA. There are various coastal communities such as Geraldton, Dongara, Cervantes and Leeman and small squatters camps, such as Grey, support the boating, fishing, diving and swimming throughout most of the year. Surface oil can coat fishing equipment/vessels especially where equipment is retrieved to the vessel and dissolved and entrained fractions could taint recreational catches and contaminate recreational equipment such as dive gear. Other users would primarily be impacted by being displaced by the surface slick. As such, recreational fishing effort and swimming/diving would be expected to be moved outside the area of the impact of the slick. Public sensitivity is rated as High but given the intermittent nature of the coastline oiling from a single event, the spread-out nature of the coastal towns, the rapid evaporation and dissipation of MGO and temporary nature of any closures, impacts are assessed as Moderate.
	Places of heritage and cultural Indigenous importance, and Commonwealth and State marine protected areas **Heritage (marine and indigenous archaeology)** A description of shipwrecks and other heritage sites is provided in Sections 4.4.8 and 4.4.5 respectively. Impacts of a spill include oiling, which is relevant to those values that are not fully submerged and are below the high-water mark. No shipwrecks that are located in <5 m water depth have been identified inside the floating oil contour. Impacts on submerged wrecks are discussed sparsely in the literature. Some research (BOEM 2018) has shown that the abundance and diversity of bacterial communities living on wrecks, making them more habitable for marine life (such as coral, crabs and fish) has increased following the Macondo spill. Figure 4-5 shows the quantity and location of shipwrecks that could potentially be contacted by entrained oil. No Commonwealth heritage listed sites (see Section 4.7) are impacted by surface oil. The *Batavia* shipwreck in the Abrolhos Islands could be contacted temporarily by entrained oil; however, as described above the impacts are expected to be negligible. Cultural Indigenous importance: A description of known cultural heritage values is provided in section 4.4.6 and an assessment of the potential impact to marine species of cultural significance is included earlier in this section. The closest known registered sites that are below the HWM include the Irwin River (18907) and Leander Point (5280); however, these sites are on the shoreline and there is no predicted impact to shoreline in this area. Sea Country interests have been identified within the EMBA but with the limited spill size and expected rapid evaporation and dissipation of MGO, impacts to cultural heritage are assessed as low. Marine protected areas: A description of marine protected areas is given in Sections 4.4.1.

The potentially contacted types of shorelines range from rocky beaches, sandy beaches, mud flats and estuaries. Each of these will influence the volume of oil that could be retained ashore and its thickness before saturation occurs. Sandy beaches may allow oil to infiltrate through the sediments, thus increasing its ability to hold more oil ashore over tidal cycles and various wave actions than an equivalent area of water; hence, oil can increase in thickness onshore over time.

Algae and immobile benthic animals that colonise intertidal rocky shores are vulnerable to oil spills. Filter feeders such as molluscs are especially liable to ingest oil with lethal and various sub-lethal effects. The latter include alteration in respiration rates, decreases in filter feeding activity, reduced growth rates, biochemical effects, increased predation, reproductive failure and mechanical destruction by waves due to inability to maintain hold on substrate (Ballou et al. 1989; Connell & Miller 1981).

A review by Connell & Miller (1981) of field studies conducted after spill events indicated a high degree of variability in level of impact, but in all instances, the algae appeared to be able to recover rapidly from even very heavy oiling. They attributed the rapid recovery of algae to the fact that for most algae new growth is produced from near the base of the plant while the distal parts (which would be exposed to the oil contamination) are continually lost.

Laboratory tests have illustrated the sensitivity of seagrasses to both surface oil and dissolved or physically dispersed hydrocarbons (e.g. Hatcher & Larkum 1982). Stress response has also been demonstrated for seagrass at low hydrocarbon concentrations similar to that expected to occur in oil spill situations (Thorhaug et al. 1991).

The susceptibility of seagrass to hydrocarbon spills will depend largely on their distribution. Deeper communities will be protected from oiling under all but the most extreme weather conditions. Shallow seagrasses are more likely to be affected by dispersed oil droplets or, in the case of emergent seagrasses, by direct oiling. Intertidal seagrass communities would theoretically be the most susceptible because the leaves and rhizomes may both be affected. Refer Macroalgae section above.

Subtidal areas exposure to dissolved aromatic and entrained hydrocarbon concentrations were both predicted to be below the low exposure level, and that there is only a slight chance of a spill impacting any areas where seagrasses might occur (e.g. Corner Inlet).

Commonwealth and State Marine parks: A number of Commonwealth Marine parks are described briefly for in the table below (Table 8-18). Table 8-18 below is a summary of the probability of exposures for a selection of marine parks (see full report in Appendix E) for additional smaller or less exposed Parks.

Table 8-18: Summary of probabilities (%) of exposure to marine protected areas

	>10 g/m^2 floating oil	>100 ppb entrained oil	Probability of shoreline contacted >10 g/m^2	Comment
Commonwealth Marine Parks				
Abrolhos AMP	<1	24	N/A	No shoreline. Approximately only half of MP could be contacted by entrained oil. Low impacts to features of high biodiversity, protected birds and mammals (e.g. humpbacks), plankton and management plan values.
Jurien AMP	<1	10	N/A	Low probability of impacts to seabird and shorebird habitats, and seagrasses.
Perth Canyon AMP	<1	<1	N/A	Negligible probability of exposure to sensitive receptors.
South-West Corner AMP	<1	<1	N/A	Negligible probability of exposure to sensitive receptors.
Two Rocks AMP	<1	<1	N/A	Negligible probability of exposure to sensitive receptors.
State Marine Parks				
Jurien Bay MP	<1	29	10	
Marmion MP	<1	<1	<1	
Shoalwater Islands MP	<1	<1	<1	

NC: No contact. NA: Not Applicable

This is a selection of parks and reserves with higher exposures and/or have higher values. While some other marine parks and reserves may have coastlines that could be exposed to a spill the probability of weathered oil coming ashore above thresholds that may affect coastal habitats (>100 g/m^2) is low and full

	recovery expected within a year). Given the low level of impact predicted, the values expressed in the Marine Park Management Plans are met and risks to cultural values are assessed as Low.		
Inherent risk	**Extent:** Small extent of pollution on the surface water to within a few 100 kms. Very minimal to negligible contact with shorelines. Injury or death to marine fauna and seabirds through ingestion or contact. Duration: days, weeks or months depending on level of contact, location and receptors. **Level of uncertainty of risk:** High. Spill source volumes are limited, noting modelling used a volume (320 m^3). The environmental impact of MGO is well understood, and very conservative thresholds have been selected to define the EMBA.		
	Consequence	**Likelihood**	**Risk ranking**
	Minor	Unlikely	Low

8.6.4 Risk treatment

8.6.4.1 Demonstration of ALARP

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are practicable – and hence not disproportionate to the sacrifice (e.g. cost) of implementation Control measures have not been adopted where the cost of implementation is disproportionate to the benefit gained.

The potential for a vessel collision leading to a spill cannot be eliminated completely. Power that could be used as a substitute (such as solar, wind or biofuels) are not commercially proven in such applications. Pilot considers the adopted controls to be appropriate in reducing the environmental risks to ALARP. No other controls measures have been identified that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of risk reduction (Table 8-19).

Table 8-19: Cost benefit analysis and residual risk evaluation of accidental oil spill – vessel collision/ grounding

Control measures	Cost benefit analysis	Risk reduction	Control adopted
ALARP assessment technique – legislative requirements, good practice			
Compliance with specifications set by internationally recognised maritime legislation – MARPOL 73/78 Annex I	Benefits outweigh costs; Legal requirement	Yes	Yes
Vessel design such that the fuel tanks are located internally and protected by other tanks e.g. water ballast or void space. Note – the location of the fuel tanks on the analogue vessel are designed such that the water ballast tanks protect the fuel tanks	The costs of retro-fitting unprotected tanks and/or the non-availability of such vessels (hence impacts to schedule) outweighs the benefit	Yes	No.
Survey and supply/chase vessels will be compliant with: • Marine Order 91 – Marine pollution prevention—oil • Marine Order 30 - Prevention of collisions • Marine Order 27 - Safety of navigation and radio equipment • Marine Order 21 - Safety and emergency arrangements	Benefits outweigh costs; standard procedures	Yes	Yes
The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners	Benefits outweigh costs	Yes	Yes
AMSA's JRCC will be advised of the survey vessel's details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels. This information will be notified to AMSA JRCC 24 to 48 hours before operations commence via email address (rccaus@amsa.gov.au) or phone (1800 641 792 or +61 2 6230 6811)	Benefits outweigh costs	Yes	Yes
AMSA JRCC will be notified at the end of the survey when operations have been completed (via email address (rccaus@amsa.gov.au) or phone: 1800 641 792 or +61 2 6230 6811)	Benefits outweigh costs	Yes	Yes

Control measures	Cost benefit analysis	Risk reduction	Control adopted
Support/chase vessels will undertake surveillance (during a spill) and manage interactions with other marine users' vessels transiting near the seismic vessel or streamers	Benefits outweigh costs	Yes	Yes
Vessel to maintain appropriate lighting, navigation and communication systems at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention	Benefits outweigh costs; legal requirement	Yes	Yes
Continuous (24-hour) survey operations, with survey team and bridge crew monitoring for other vessels at all times during seismic acquisition	Benefits outweigh costs	Yes	Yes

Residual risk evaluation				
Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Minor	Unlikely	Low	B

8.6.4.2 Demonstration of acceptability

The risk of adverse effects from an accidental spill resulting from a vessel collision/grounding is therefore considered acceptable because predictions are below the defined levels of acceptability as described below (Table 8-20).

Table 8-20: Acceptability criteria – accidental oil spill – vessel collision/grounding

Acceptability criteria	
There will be no predicted long-term unrecoverable effects on EPBC Act listed MNES, marine reserve management plan values and Threatened species recovery plans/conservation advice	Should a spill occur, the SOPEP and OPEP will be implemented to mitigate risk. The risk of exposure at levels that may cause unrecoverable impacts to MNES is predicted to be low due to the rate of weathering, spreading out of the surface slick, and limited vertical distribution of dissolved and entrained components into surface waters. This risk is therefore considered to be acceptable because: • Vessel operations are a well understood and practiced activity, with multiple barrier levels in place to mitigate risk of a vessel collision/grounding and subsequent spill. • Should there be a spill, the risk of interaction with the surface slick is low (relatively small spatial area, restricted predominantly to surface waters and the low spatial density of MNES). • MGO is a substitute for HFO for all vessels which has greater environmental impacts if spilled. Levels of MGO with potential to cause ecological harm are likely to be spatially restricted, spatially transient and not persistent. • There are no residual impacts above Low for any MNES, KEF, or marine protected area. • The performance standards listed above and the development and implementation of a project-specific OPEP aim to prevent a spill, and where this is not possible, minimise fuel loss and impacts to sensitive receptors. • The National Recovery Plan for albatrosses and petrels 2022 (DCCEEW 2022b) lists marine pollution as a threat for albatross and giant petrels requiring population monitoring to deal with marine pollution. The risks posed by response operations do not impact this action. The conservation advice and management plans for cetaceans for blue, humpback, sei and fin whales identify hydrocarbon spill as threats, though there are no specific aims to address this. Performance standards listed here aim to prevent and minimise such spills.
There will be no predicted long-term unrecoverable effects on fish stocks or commercial fishing	Recovery of fish populations and habitats depend on the spill volume, duration and characteristics (including any dispersants). Recovery also depends on the life cycle characteristics of the fish – those that are plentiful, short-lived and highly productive may recover quicker than the less abundant and long-lived species. The range of movement of fishes and the type of habitat will also influence the level of impact on fishes and their recovery. Hook et al (2016) suggests there are no reports of oil spills in the open ocean causing adult fish kills, possibly as some species can rapidly metabolise and excrete hydrocarbons.
No specific relevant person concerns have been raised and are unresolved	There were no specific relevant person claims in relation to Oil Spill risk.

Operations are compliant with maritime law and OPGGS Act relating to preventing pollution/collisions at sea, reporting and responding to spills	Operations will be compliant with nationally and internationally recognised standards and regulations: • MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*)) Survey and supply/chase vessels will be compliant with: • Marine Order 91 – Marine pollution prevention—oil • Marine Order 30 - Prevention of collisions • Marine Order 27 - Safety of navigation and radio equipment • Marine Order 21 - Safety and emergency arrangements Predictions are therefore considered acceptable because these Acts and Orders provide marine pollution prevention measures to mitigate risks of spills occurring. The performance standards outlined in this EP align with the requirements of: • OPGGS Act 2006 (Cth): Section 572A-F (Polluter pays for escape of petroleum).

8.6.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for accidental oil spill (vessel collision) are presented below in Table 8-21.

Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 8.5.4.1.

Table 8-21: Environmental performance outcomes, standards and measurement criteria –accidental oil spill – vessel collision/grounding

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 24 Vessel crews are prepared to respond to a spill, including Vessel master initiating action to reduce fuel loss	**PS 85** Compliance with MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*); and Marine Order 91 - Marine pollution prevention—oil): • Current SOPEP in place • All vessels hold a valid IOPP Certificate, where required, under vessel class	**MC 106** Records demonstrate the SOPEP is in place on the survey vessel **MC 62** Records demonstrate all vessels hold an IOPP certificate, if required under vessel class
	PS 93 The SOPEP and OPEP are approved and tested prior to the survey vessel commencing acquisition (emergency response drills) and to test interfaces between the SOPEP, OPEP, NatPlan, and Western Australia OSCP.	**MC 116** Records demonstrate the SOPEP and OPEP are approved, tested (desktop exercise) and available to relevant persons on the survey vessel
	PS 94 Responsibilities of vessel crew under the OPEP and SOPEP are communicated to relevant personnel and included as part of the project induction	**MC 114** Records show that the project induction (including induction material) includes responsibilities of vessel crew for response and notification protocols under the OPEP and SOPEP
	PS 95 All relevant crew trained in implementation of the OPEP and SOPEP	**MC 116** Training, induction and competency matrix to confirm that crew have been trained on implementation of the OPEP and SOPEP prior to commencing seismic data acquisition
	PS 96 The Vessel Master/s will authorise actions in accordance with the vessel- specific SOPEP (or equivalent according to class) and the survey- specific OPEP to limit the escape of MDO.	**MC 73** Daily operations reports verify that the SOPEP and OPEP were implemented.
EPO 25 Communications to advise others of presence to prevent collision	**PS 97** Survey and supply/chase vessels will be compliant with: • Marine Order 30 - Prevention of collisions • Marine Order 27 - Safety of navigation and radio equipment • Marine Order 21 - Safety and emergency arrangements	**MC 118** Records demonstrate that the survey and support/chase vessels are compliant with Marine Orders 30, 27 and 21
	PS 20 The Australian Hydrographic Office (AHO) advised of the survey details (survey location, timing) four weeks prior to mobilisation and following demobilisation for issue of Notice to Mariners	**MC 24** Records of notification of survey details sent to the AHO four weeks prior to survey mobilisation and within two weeks of survey demobilisation

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 22 AMSA's JRCC will be advised of the survey vessels details (including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels. This information will be notified to AMSA JRCC 24 to 48 hours before operations commence via email address (rccaus@amsa.gov.au) or phone (1800 641 792 or +61 2 6230 6811)	**MC 26** Pre-survey notification demonstrates that AMSA JRCC have been notified of the survey vessel details and movements 24 to 48 hours prior to the start of the survey
	PS 23 AMSA JRCC will be notified at the end of the survey when operations have been completed (via email address (rccaus@amsa.gov.au) or phone: 1800 641 792 or +61 2 6230 6811).	**MC 27** End of survey notification demonstrates that AMSA JRCC have been notified of the completion of survey operations
	PS 98 Escort/support vessel(s) will undertake surveillance (during a spill) and manage interactions with other marine users and vessels transiting near the seismic vessel or streamers	**MC 119** Support vessel log confirms vessel is employed for the duration of the activity and manages interactions with other marine users and vessels
	PS 17 All vessels to maintain appropriate lighting, navigation and communication at all times to inform other users of the position and intentions of the survey vessel, in compliance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention	**MC 21** Records show no failure to comply with requirements for appropriate navigation, lighting and communication during survey, in accordance with the *Navigation Act 2012* and Chapter 5 of the SOLAS Convention. Any records of failure to comply are documented
	PS 19 Continuous (24 hour) survey operations, with survey team and bridge crew monitoring vessel position and depth at all times during seismic acquisition	**MC 23** Records confirm bridge was manned continuously during survey operations, and that survey vessel crew have appropriate qualifications
EPO 26 No HFO spill in marine environment	**PS 58** Survey vessels and support/chase vessels will not use heavy fuel oil	**MC 76** Bunkering records demonstrate MGO or MDO used on all vessels
EPO 28 Collect operational monitoring data to support the spill response and collect scientific monitoring data to characterise environmental impacts.	**PS 99** Pilot will undertake operational and scientific monitoring in accordance with the Operational and Scientific Monitoring Program (OSMP).	**MC 120** Daily operations reports and overall study reports verify that the OSMP was implemented.

8.7 Risk 6 – Oil spill response

8.7.1 Identification of hazard and extent

Hazard	In the event of an oil spill, a number of potential responses may be initiated; dependent on direction from the Control Agency (AMSA, refer to Section 8.7), the location and size of the spill, the potential for sensitive environmental receptors to be impacted and the resources available. Typical responses generally involve additional vessels and may involve equipment and field survey teams. These extra activities introduce additional risks to environmental, socio-economic and cultural receptors, as well as increasing the likelihood of many of the impacts and risks assessed within this EP. The following response strategies have been considered for the two credible spill scenarios (representing one Level 1 and one Level 2 spill) under this EP, and are assessed with relevance to the Eureka 3D MSS in Table 8-3: • Monitor and evaluate • Mechanical dispersion • Containment and recovery • Shoreline protection • Shoreline clean-up • Chemical dispersion
Extent	EMBA
Duration	Duration of survey – up to 40 days in early February to the end of March.

8.7.2 Levels of acceptable risk

The risk of adverse effects from oil spill response activities on environmental, socio-economic and cultural sensitive receptors will be acceptable when:

- Spill response strategies have been selected following an assessment of their potential benefits and/or dis-benefits using an industry-standard approach (i.e. Net Environmental Benefit Analysis (NEBA) or Spill Impact Mitigation Assessment [SIMA])
- There will be no predicted unrecoverable effects on EPBC Act listed MNES
- Operations will be undertaken by suitably-qualified personnel and are compliant with maritime law relating to spill response.

8.7.3 Risk analysis and evaluation

Potential risks	The activities associated with a hydrocarbon spill response introduce additional risks to marine fauna and habitats, as well as increasing the likelihood of many of the impacts and risks already described within this EP. Examples of additional risks include: • Increased risk of disturbance of seabirds/shorebirds/marine megafauna • Increased risk of vessel strikes • Physical damage to shallow subtidal habitats and communities (e.g. reefs, seagrass) from anchoring of shoreline protection booms • Increased risk to shallow subtidal habitats and communities from remobilisation of intertidal hydrocarbons/dispersed hydrocarbons and/or chemical control agents applied intertidally • Damage to sensitive intertidal habitats and food resources due to trampling, vehicles, cropping, removal of oiled sediment, hot water/jet washing, chemical control agents/dispersants.
Predicted effects	Application of spill response strategies from vessel spills, where not adequately assessed, have the potential to significantly increase impacts to environmental sensitivities in comparison to an unmitigated spill (e.g. *Exxon Valdez*). Several of the proposed methods have the potential for increasing impacts if applied without appropriate consideration (e.g. shoreline clean-up, application of chemical control agents/dispersants). In cases where no assessment of potential risks from spill response strategies has been undertaken, the potential inherent risk is considered to be:

Inherent risk	Consequence	Likelihood	Risk ranking
	Minor	Possible	Moderate

8.7.4 Risk treatment

8.7.4.1 Demonstration of ALARP

Pilot is committed to ensuring continual risk reduction and identifying if additional control measures may be applied that are practicable – and hence not disproportionate to the sacrifice (e.g. cost) of implementation, in line with the ALARP assessment process. Control measures have not been adopted where the cost of implementation is disproportionate to the likely benefit gained.

Pilot considers the adopted controls to be appropriate in reducing the environmental risks to ALARP (Table 8-22). No other controls measures have been identified that may practicably or feasibly be adopted to further reduce the risks of impacts without disproportionate costs compared to the benefit of risk reduction.

Response actions will be based on a Spill Impact Mitigation Assessment (SIMA) approach, which will be used to consider the advantages and disadvantages of the different spill response options to determine if there would be a net environmental benefit or dis-benefit resulting from the implementation of a particular response in comparison to an unmitigated spill response strategy. SIMA considers the hydrocarbon type, the sensitivities of the regional area of the spill, and the potential effects (positive and negative) of the proposed response strategy. The decision context focuses on the potential level of impact, spatial scale of impact and duration of impact. The method to be used will be in line with global industry best-practice (IPIECA 2019; IPIECA_API-IOGP 2017).

SIMA is used for preliminary assessment to determine the initial spill responses required. In the actual event of a spill, the SIMA is revisited every operational cycle as more information becomes available e.g. on actual conditions, spill trajectory path and locations of sensitive receptors; and/or where a significant change in risk has been identified. This review process allows response strategies to be dimensioned to the nature and scale of the actual incident to provide optimal results (refer to the OPEP in Section 8.7.9).

Table 8-22: Cost benefit analysis and residual risk evaluation – oil spill response

Control measures	Cost benefit analysis	Risk reduction	Control adopted
ALARP assessment technique – good practice			
In the event of an oil spill, the survey Vessel Master will implement available controls and resources of the SOPEP	Benefits outweigh costs; legal requirement	Yes	Yes
Commercial and recreational fishers and other users in the area would be advised of any large spill and associated response activities via Pilot's 24-hour 'look-ahead' correspondence	Benefits outweigh costs requirement	Yes	Yes
A hydrocarbon spill will be immediately (verbally within 2-hours) reported to ensure all notifications are provided as per Section 10.8.2	Benefits outweigh costs; regulatory requirement	Yes	Yes
Operational monitoring will be undertaken e.g. to inform AMSA about the behaviour, likely trajectory and key sensitivities at risk from a spill (Section 8.7.10)	Benefits outweigh costs	Yes	Yes
Oil spill response training and competencies are to be maintained to avoid unplanned environmental impacts due to human error	Benefits outweigh costs	Yes	Yes
ALARP assessment technique – EIA			
Response actions will be based on a Spill Impact Mitigation Assessment (SIMA) approach, which considers the advantages and disadvantages of the different spill response options to determine if there would be a net environmental benefit resulting from the implementation of a particular response relative to an unmitigated spill impact.	Benefits outweigh costs	Yes	Yes

Residual risk evaluation				
Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Minor	Unlikely	Low	A

8.7.4.2 Demonstration of acceptability

This risk of adverse effects from a spill response is therefore considered acceptable because predictions are below the defined levels of acceptability as described below (Table 8-23).

Table 8-23: Acceptability criteria – oil spill response

Acceptability criteria	
Spill response strategies will have been selected following an assessment of their potential benefits and/or dis-benefits using an industry-standard approach (i.e. SIMA)	Spill response strategies will be assessed using SIMA before being implemented. This allows assessment of response strategies against each other, and in comparison, to an unmitigated spill impact. The process will be continuously implemented throughout the response. SIMA are accepted industry-standard approaches (IPIECA 2019; IPIECA_API-IOGP 2017). This risk is therefore considered to be acceptable because: • Spill response strategies would have been assessed for the potential to increase risk to environmental, socio-economic and cultural sensitivities, in line with global industry standards • There is a process in place that allows continuous assessment and re-assessment, including following identification of a significant change in risk.
There will be no unrecoverable effects on EPBC Act listed MNES	Should a spill occur, the OPEP will be implemented to mitigate risk. The 'Monitor and Evaluate' strategy will be implemented as soon as reasonably practicable after the release (preferably within 2-hours of the first report). Oil Spill Trajectory Modelling (OSTM) will reduce uncertainty in response and be used to focus response efforts. OSTM will be ground-truthed using on-site vessel and/or aerial observations, and deployment of satellite tracked drifter buoys. Vessel observations may be ongoing, even after implementation of an aerial observation response. On-site spill response equipment will be used to respond in the first instance (under the direction of AMSA as Control Agency), whilst other response resources are mobilised to the field. This risk is therefore considered to be acceptable because: • Vessel operations are a well understood and practiced activity • Each vessel has a vessel-specific SOPEP in place prior to commencement of operations • SOPEP responsibilities will have been covered in vessel inductions • The response will be managed and implemented by an experienced government response organisation specialised in vessel-based spills that has trained responders, provides spill response advice, contributes to spill response exercises, and has responded to numerous spills worldwide • 'Monitor and Evaluate' and Operational Monitoring will provide situational awareness, monitor the effectiveness and potential impacts of spill response activities, and support identification of risks and protection priorities • Spill response waste will be removed from the environment and disposed of appropriately.
Operations are compliant with maritime law	Operations will be compliant with: • MARPOL 73/78 Annex I (as applied in Australia under the *Protection of the Sea* (*Prevention of Pollution from Ships*) Act 1983) • Marine Order 91 – Marine pollution prevention—oil • Marine Order 30 – Prevention of collisions • Marine Order 21 – Safety and emergency arrangements • Marine Order 27 – Safety of navigation and radio equipment Predictions are therefore considered acceptable because these Acts and Orders provide marine pollution prevention measures to mitigate risks of spills occurring.

8.7.4.3 Environmental performance outcomes, standards and measurement criteria

The environmental performance outcomes, standards and measurement criteria appropriate to measure performance of the adopted control measures for oil spill response are presented below in Table 8-24. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 8.7.4.1.

Table 8-24: Environmental performance outcomes, standards and measurement criteria – oil spill response

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 29 Spill response arrangements to minimise impacts to the environment implemented in accordance with the vessel SOPEP and OPEP in this EP	**PS 99** For a level 1 spill, the survey vessel master will implement available controls and resources of the SOPEP	**MC 73** Incident report verifies the SOPEP was implemented
	PS 100 Depending on the nature and scale of the spill, an Incident Action plan will be prepared by the planning officer to guide response activities	**MC 121** Incident Action Plan and Incident Log confirm OMPs and SMPs are activated in accordance with the initiation criteria provided in Table 9-1 and 9-2 of the Joint Industry OSM Framework (APPEA, 2021)
	PS 101 Response actions will be based on a SIMA approach defined by AMSA/DoT	**MC 122** SIMA outcomes and/or reports
	PS 102 The survey vessel master is responsible for notification (written and verbal) of a spill to the sea to the AMSA JRCC and subsequent reporting (as per Section 8.7.4)	**MC 123** Records of verbal communications and copies of marine pollution report (POLREP) report and situation reports (SITREPs) as per Section 8.7.4
	PS 103 Commercial and recreational fishers and other users in the area would be advised of any large spill and associated response activities via Pilot's 24-hour 'look-ahead' correspondence	**MC 124** Copies of relevant person notifications and incident report(s) in the event of a spill
	PS 98 Support vessels undertaking the Eureka 3D MSS are used as vessels of opportunity to monitor the spill (operational monitoring) if safe to do (as agreed with AMSA)	**MC 125** Incident Report/operational monitoring reports, consultation records
	PS 104 On-call Scientific Monitoring response service agreement in place	**MC 126** Copy of service contract with Scientific Monitoring subcontractor prior to commencement of the survey

9 RECOVERY PLAN AND THREAT ABATEMENT PLAN ASSESSMENT

As described in Section 2.1.1, NOPSEMA will not accept an EP that is inconsistent with a recovery plan or threat abatement plan for a listed threatened species or ecological community. This section describes the assessment that Pilot has undertaken to demonstrate that the Eureka 3D MSS is not inconsistent with any relevant recovery plans or threat abatement plans.

For the purposes of this assessment, the relevant Part 13 statutory instruments (recovery plans and threat abatement plans) are:

- Recovery Plan for Marine Turtles in Australia 2017–2027 (Commonwealth of Australia 2017)
- Conservation Management Plan for the Blue Whale 2015–2025 (Commonwealth of Australia 2015a)
- Conservation Management Plan for the Southern Right Whale (DSEWPC 2012c)
- Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a)
- Recovery Plan for the Australian Sea Lion (DSEWPC 2013a)
- Recovery Plan for the White Shark (*Carcharodon carcharias*) 2013 (DSEWPC 2013b)
- Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) 2014 (DoE 2014b)
- Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans 2018 (Commonwealth of Australia 2018).

Table 9-1 lists the objectives and (where relevant) the action areas of these plans, and also describes whether these objectives/action areas are applicable to government, the Titleholder and/or the Eureka 3D MSS. For those objectives/action areas applicable to the Eureka 3D MSS, the relevant actions of each plan have been identified, and an evaluation has been conducted as to whether impacts and risks resulting from the activity are clearly inconsistent with that action or not. The results of this assessment against relevant actions are presented in Table 9-2 and Table 9-8.

Table 9-1: Identification of applicability of recovery plan and threat abatement plan objectives and action areas

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
Marine Turtle Recovery Plan			
Long-term Recovery Objective: Minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so they can be removed from the EPBC Act threatened species list	Y	Y	Y
Interim Recovery Objectives			
Current levels of legal and management protection for marine turtle species are maintained or improved, both domestically and throughout the migratory range of Australia's marine turtles	Y		
The management of marine turtles is supported	Y		
Anthropogenic threats are demonstrably minimised	Y	Y	Y
Trends in nesting numbers at index beaches and population demographics at important foraging grounds are described	Y	Y	
Action Areas			
A. Assessing and addressing threats			
A1. Maintain and improve efficacy of legal and management protection	Y		
A2. Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability	Y		
A3. Reduce the impacts of marine debris	Y	Y	Y
A4. Minimise chemical and terrestrial discharge	Y	Y	Y
A5. Address international take within and outside Australia's jurisdiction	Y		
A6. Reduce impacts from terrestrial predation	Y		
A7. Reduce international and domestic fisheries bycatch	Y		
A8. Minimise light pollution	Y	Y	Y
A9. Address the impacts of coastal development/infrastructure and dredging and trawling	Y	Y	
A10. Maintain and improve sustainable Indigenous management of marine turtles	Y		
B. Enabling and measuring recovery			
B1. Determine trends in index beaches	Y		
B2. Understand population demographics at key foraging grounds	Y		
B3. Address information gaps to better facilitate the recovery of marine turtle stocks	Y	Y	Y
Conservation Management Plan for the Blue Whale			
Long-term Recovery Objective: Minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list	Y	Y	Y
Interim Recovery Objectives			
The conservation status of blue whale populations is assessed using efficient and robust methodology in Australian waters is described	Y		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales	Y	Y	Y
Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place	Y		
Anthropogenic threats are demonstrably minimised	Y	Y	Y
Action areas			
A. Assessing and addressing threats			
A.1: Maintain and improve existing legal and management protection	Y		
A.2: Assessing and addressing anthropogenic noise	Y	Y	Y
A.3: Understanding impacts of climate variability and change	Y		
A.4: Minimising vessel collisions	Y	Y	Y
B. Enabling and Measuring Recovery			
B.1: Measuring and monitoring population recovery	Y		
B.2: Investigating population structure	Y		
B.3: Describing spatial and temporal distribution and defining biologically important habitat	Y	Y	
Draft National Recovery Plan for the Southern Right Whale			
Long-term Vision: The population has increased in size to a level that the conservation status has improved, and the species no longer qualifies for listing as threatened under any of the EPBC Act listing criteria	Y	Y	Y
Interim Recovery Objectives			
Current levels of Commonwealth and State legislative and management protection for southern right whales are implemented, maintained, or improved so threats continue to be managed and reduced over the life of the plan	Y		
Anthropogenic threats are managed consistent with ecologically sustainable development principles and do not impede recovery of southern right whales	Y	Y	Y
The population demographics of the eastern and western southern right whale populations are monitored using robust methodology to demonstrate that the abundance, areas of occupancy, and habitat use of southern right whales is increasing	Y		
The population structure of southern right whales in Australian waters is clearly characterised, including the level of interchange of individuals, to evaluate the degree to which the western and eastern populations are separate populations	Y		
Capability of Indigenous Australian, research, citizen science and general community groups is improved to assist in addressing recovery actions of southern right whales in Australia	Y		
Action areas			
A: Assess and Address Threats			
A.1: Maintain and improve efficacy of current legal and management protection	Y		
A.2: Address habitat degradation impacts from marine infrastructure developments: coastal and offshore development	Y		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
A.3: Understand impacts of anthropogenic climate change and variability on population recovery	Y		
A.4: Reduce entanglements from active or discarded commercial fishing gear	Y		
A.5: Assess and address impacts from anthropogenic noise.	Y	Y	Y
A.6: Manage and mitigate the threat of vessel strike	Y	Y	Y
B: Measure Recovery			
B.1: Measure and monitor population demographics and recovery	Y		
B.2: Characterise population structure	Y		
B.3: Determine offshore distribution and migratory paths	Y		
B.4: Improve capability of Indigenous Australian, research, citizen science and general community groups to assist management of southern right whales	Y		
Recovery Plan for the Australian Sea Lion			
Overarching Objective:			
To halt the decline and assist the recovery of the Australian sea lion throughout its range in Australian waters by increasing the total population size while maintaining the number and distribution of breeding colonies with a view to: • improving the population status, leading to future removal of the Australian sea lion from the threatened species list of the EPBC Act. • ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific Objectives:			
Objective 1: Mitigate interactions between fishing sectors (commercial, recreational and Indigenous) and the Australian sea lion to enable the recovery of all breeding colonies	Y		
Objective 2: Mitigate the impacts of marine debris on Australian sea lion populations	Y	Y	Y
Objective 3: Mitigate the impacts of aquaculture operations on Australian sea lion populations	Y		
Objective 4: Investigate and mitigate other potential threats to Australian sea lion populations, including disease, vessel strike, pollution and tourism	Y	Y	Y
Objective 5: Continue to develop and implement research and monitoring programs that provide outputs of direct relevance to the conservation of the Australian sea lion	Y	Y	
Objective 6: Increase community involvement in, and awareness of, the recovery program	Y		
Recovery Plan for the White Shark			
Overarching Objective:			
To assist the recovery of the white shark in the wild throughout its range in Australian waters with a view to: • Improving the population status, leading to future removal of the white shark from the threatened species list of the EPBC Act	Y	Y	Y

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
• Ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future			
Specific Objectives:			
Objective 1: Develop and apply quantitative measures to assess population trends and any recovery of the white shark in Australian waters and monitor population trends	Y		
Objective 2: Quantify and minimise the impact of commercial fishing, including aquaculture on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters	Y		
Objective 3: Quantify and minimise the impact of recreational fishing on the white shark through incidental (illegal and/or accidental) take, throughout its range in Australian waters	Y		
Objective 4: Where practicable minimise the impact of shark control activities on the white shark	Y		
Objective 5: Investigate and manage (and where necessary reduce) the impact of tourism on the white shark	Y		
Objective 6: Quantify and minimise the impact of international trade in white shark products through implementation of CITES provisions	Y		
Objective 7: Continue to identify and protect habitat critical to the survival of the white shark and minimise the impact of threatening processes within these areas	Y		
Objective 8: Continue to develop and implement relevant research programs to support the conservation of the white shark	Y		
Objective 9: Promote community education and awareness in relation to white shark conservation and management	Y		
Objective 10: Encourage the development of regional partnerships to enhance the conservation and management of the white shark across national and international jurisdictions	Y		
Recovery Plan for the Grey Nurse Shark			
Overarching Objective:			
To assist the recovery of the grey nurse shark in the wild, throughout its range in Australian waters, with a view to: • Improving the population status, leading to future removal of the grey nurse shark from the threatened species list of the EPBC Act • Ensuring that anthropogenic activities do not hinder the recovery of the grey nurse shark in the near future, or impact on the conservation status of the species in the future	Y	Y	Y
Specific Objectives:			
Objective 1: Develop and apply quantitative monitoring of the population status (distribution and abundance) and potential recovery of the grey nurse shark in Australian waters	Y		
Objective 2: Quantify and reduce the impact of commercial fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
Objective 3: Quantify and reduce the impact of recreational fishing on the grey nurse shark through incidental (accidental and/or illegal) take, throughout its range	Y		
Objective 4: Where practicable, minimise the impact of shark control activities on the grey nurse shark	Y		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
Objective 5: Investigate and manage the impact of ecotourism on the grey nurse shark	Y		
Objective 6: Manage the impact of aquarium collection on the grey nurse shark	Y		
Objective 7: Improve understanding of the threat of pollution and disease to the grey nurse shark	Y	Y	Y
Objective 8: Continue to identify and protect habitat critical to the survival of the grey nurse shark and reduce the impact of threatening processes within these areas	Y	Y	
Objective 9: Continue to develop and implement research programs to support the conservation of the grey nurse shark	Y		
Objective 10: Promote community education and awareness in relation to grey nurse shark conservation and management	Y		
Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans			
Objectives:			
Contribute to long-term prevention of the incidence of marine debris	Y	Y	
Understand the scale of impacts from marine plastic and microplastic on key species, ecological communities and locations	Y	Y	Y
Remove existing marine debris	Y		
Monitor the quantities, origins, types and hazardous chemical contaminants of marine debris, and assess the effectiveness of management arrangements for reducing marine debris	Y		
Increase public understanding of the causes and impacts of harmful marine debris, including microplastic and hazardous chemical contaminants, to bring about behaviour change	Y		

Table 9-2: Assessment against relevant actions of the Marine Turtle Recovery Plan

Part 13 statutory instrument	Relevant action areas/objectives	Relevant actions	Evaluation	EPO, PS and MC
Marine Turtle Recovery Plan	**Action Area A3:** Reduce the impacts from marine debris	**Action:** Support the implementation of the Marine Debris Threat Abatement Plan (TAP)	Refer Section 8.5 **Not inconsistent assessment:** The assessment of accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to marine turtles.	Table 8-10
	Action Area A4: Minimise chemical and terrestrial discharge	**Action:** Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to	Refer Sections 8.5, 8.6 and 0 **Not inconsistent assessment:** The assessment of accidental release of chemicals/hydrocarbons has considered the potential risks to marine turtles. Spill risk strategies and response program include management measures for turtles.	Refer to Table 8-10 and Sections 10.6 and 10.7. Detailed oil spill preparedness and response performance outcomes, standards

Part 13 statutory instrument	Relevant action areas/objectives	Relevant actions	Evaluation	EPO, PS and MC
		recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs		and measurement criteria for the activity are present Appendix E.
	Action Area A8: Minimise light pollution	**Action:** 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	Refer Section 7.4. **Not inconsistent assessment:** The assessment of light emissions has considered the potential impacts to marine turtles. Foraging or migrating turtles are not impacted by light from offshore vessels. Vessel light emissions could cause localised and temporary behavioural disturbance to isolated transient individuals. The nearest habitat critical to the survival of marine turtles is located in Shark Bay, a least 350 km north of the Operational Area.	Table 7-29
	Action Area B3: Address information gaps to better facilitate the recovery of marine turtle stocks	**Action:** Understand the impacts of anthropogenic noise on marine turtle behaviour and biology	Refer Sections 7.1 and 7.2 **Not inconsistent assessment:** The assessment of acoustic emissions has considered the potential impacts marine turtles. Vessel and seismic acoustic emissions could cause localised and short-term behavioural disturbance to isolated transient individuals. The nearest habitat critical to the survival of marine turtles is located in Shark Bay, a least 350 km north of the Operational Area	Table 7-5 and Table 7-23
Assessment summary The Marine Turtle Recovery Plan has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

Table 9-3: Assessment against relevant actions of the Blue Whale Conservation Management Plan

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
Blue Whale Conservation Management Plan	**Action Area A.2:** Assessing and addressing anthropogenic noise	**Action 2:** Assessing the effect of anthropogenic noise on blue whale behaviour **Action 3:** Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to use the area without injury, and is not displaced from a foraging area	Refer Section 7.1 **Not inconsistent assessment:** The assessment of acoustic emissions has considered the potential impacts to pygmy blue whales. PTS or TTS effects to pygmy blue whales are not predicted to occur from exposure to a single impulse. However, as the activity is taking place in relatively close proximity to a known foraging BIA and a migration BIA for pygmy blue whales there is a possibility of encountering individual whales. Acquisition of the survey will not overlap either the northbound or southbound migration period for pygmy blue whales.	Table 7-20

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
			If individual blue whales are encountered, the application of EPBC Policy Statement 2.1 Part A Standard Management Procedures and extended observation and shut-down zones (Part B.4) will minimise the likelihood of PTS or TTS effects. Seismic source discharge will not occur within 13 km of the foraging BIA. To conservatively account for the animat modelling predicted maximum range at which foraging pygmy blue whales may experience TTS (14.5 km) two additional MFOs will be deployed on the support vessel during acquisition within the western section of the ASA (Extended Observation Zone). The support vessel will be positioned 10 km to the west of the survey vessel, close to the boundary of the foraging BIA. The ASA is located at least 37 km from the most important foraging area for pygmy blue whales adjacent to the mid-west coast, as identified in Thums et al. (2022). EPBC Policy Statement 2.1 Part B.6 Adaptive Management Procedures will be implemented if there are three or more shut-downs for PBW within a 24-hour period. Acoustic modelling predicted that behavioural responses in pygmy blue whales could potentially occur out to 9.2 km from the seismic source. The impact assessment has determined that seismic acquisition may be undertaken in a manner that is not inconsistent with the requirements of the Conservation Management Plan for the Blue Whale.	
	Action Area A.4: Minimising vessel collisions	**Action 2:** Ensure all vessel strike incidents are reported in the National Ship Strike Database. **Action 3:** Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented	Refer Section 8.2. **Not inconsistent assessment:** The assessment of vessel collision with marine fauna has considered the potential risks to pygmy blue whales. If the activity overlaps with the northbound migration, individuals may deviate slightly from the migratory route, but will continue on their migration unhindered. Vessel collisions with pygmy blue whales are highly unlikely to occur, given the very slow vessel speeds and presence of MFOs.	Refer to Table 8-4
Assessment summary The Blue Whale Conservation Management Plan has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

Table 9-4: Assessment against relevant actions of the Draft National Recovery Plan for the Southern Right Whale

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
Southern Right Whale Draft National Recovery Plan	**Action Area A5:** Assess and address impacts from anthropogenic noise	**Action 2:** Actions within and adjacent to southern right whale BIAs and HCTS should demonstrate that it does not prevent any southern right whale from utilising the area or cause injury (TTS and PTS) and/or disturbance **Action 3:** Ensure environmental assessments associated with underwater noise generating activities include consideration of national policy (e.g. EPBC Act Policy Statement 2.1) and guidelines related to managing anthropogenic underwater noise and implement appropriate mitigation measures to reduce risks to southern right whales to the lowest possible level **Action 4:** Quantify risks of anthropogenic underwater noise to southern right whales, including behavioural disturbance, changes to vocalisations, and physiological effects to whales	Refer Sections 7.1 & 7.2 **Not inconsistent assessment:** The assessment of acoustic emissions has considered the potential impacts to southern right whales. PTS or TTS effects to southern right whales are not predicted to occur from exposure to a single impulse. However, as the activity is taking place immediately adjacent to a migration BIA for southern right whales there is a possibility of encountering individual whales, and acoustic modelling predicts a TTS onset range of 43 km for LF cetaceans, such as southern right whales. Acquisition of the survey will not overlap the April to October migration period for southern right whales, as defined in the National Conservation Values Atlas. The impact assessment has determined that seismic acquisition may be undertaken in a manner that is not inconsistent with the requirements of the Draft Recovery Plan for the Southern Right Whale.	Table 7.5 and Table 7.8
	Action Area A6: Manage and mitigate the threat of vessel strike	**Action 3:** Ensure environmental impact assessments and associated plans consider and quantify the risk of vessel strike and associated potential cumulative risks in BIAs **Action 5:** Ensure all vessel strike incidents are reported in the National Ship Strike Database managed through the Australian Marine Mammal Centre, Australian Antarctic Division	Refer Section 8.2. **Not inconsistent assessment:** The assessment of vessel collision with marine fauna has considered the potential risks to southern right whales. Vessel collisions with southern right whales are highly unlikely to occur, given the very slow vessel speeds and presence of MFOs. Additionally, the activity will not overlap the defined migration period for southern right whales in the region (April to October).	Refer to Table 8-4

Assessment summary

The Draft National Recovery Plan for the Southern Right Whale has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.

Table 9-5: Assessment against relevant actions of the Recovery Plan for the Australian Sea Lion

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
Australian Sea Lion Recovery Plan	**Objective 2:** Mitigate the impacts of marine debris on Australian sea lion populations	**Action 2.2:** Assess the impacts of marine debris on Australian sea lion populations **Action 2.3:** Develop and implement measures to mitigate the impacts of marine debris on Australian sea lion populations	Refer Section 8.5 **Not inconsistent assessment:** The assessment of accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to Australian sea lions.	Table 8-10
	Objective 4: Investigate and mitigate other potential threats to Australian sea lion populations, including disease, vessel strike, pollution and tourism	**Action 4.1:** Improve the understanding of—and where necessary mitigate—the threat posed to Australian sea lion populations by illegal killings, vessel strike, pollution and oil spills	Refer Sections Section 8.2, 8.5, 8.6 and 0 **Not inconsistent assessment:** The assessment of vessel strike and the accidental release of chemicals/hydrocarbons has considered the potential risks to Australian sea lions. Spill risk strategies and response program include management measures for Australian sea lions.	Refer to Table 8-4, Table 8-10 Table 8-13 **Error! Not a valid result for table.** and Table 8-24 and to Sections 10.6 and 10.7. Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the activity are presented in Appendix D.
Assessment summary The Recovery Plan for the Australian Sea Lion has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

Table 9-6: Assessment against relevant actions of the Recovery Plan for the White Shark

Part 13 statutory instrument	Relevant action areas/objectives	Relevant actions	Evaluation	EPO, PS and MC
White Shark Recovery Plan	**Overarching Objective:** To assist the recovery of the white shark in the wild throughout its range in Australian waters with a view to: • Ensuring that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future	No relevant actions	Refer Section 8 **Not inconsistent assessment:** The impact assessment has considered the potential impacts and risks to white sharks. The activity will not hinder the recovery of the white shark as it does not overlap habitat critical to the survival of the species.	N/A
Assessment summary The Recovery Plan for the White Shark has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

Table 9-7: Assessment against relevant actions of the Recovery Plan for the Grey Nurse Shark

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
Grey Nurse Shark Recovery Plan	**Objective 7:** Improve understanding of the threat of pollution and disease to the grey nurse shark	**Action 7.1:** Review and assess the potential threat of introduced species, pathogens and pollutants	Refer Sections 8.3 and 8.5. **Not inconsistent assessment:** This EP includes an assessment of the impacts from accidental introduction of invasive marine species and accidental release of solid wastes on marine species.	Table 8.10
			Refer Sections 8.6 and 8.7. **Not inconsistent assessment:** The assessment of accidental release of chemicals / hydrocarbons has considered the potential risks to grey nurse sharks.	Table 8.10 Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the activity are presented in Appendix D.
Assessment summary The Recovery Plan for the Grey Nurse Shark has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

Table 9-8: Assessment against relevant actions of the Marine Debris Threat Abatement Plan

Part 13 statutory instrument	Relevant action areas/objectives	Relevant actions	Evaluation	EPO, PS and MC
Marine Debris Threat Abatement Plan	**Objective 1:** Contribute to long-term prevention of marine debris.	**Action 1.02:** Limit the amount of single use plastic material lost to the environment in Australia.	Refer Section 8.5 **Not inconsistent assessment:** The assessment of accidental release of solid hazardous and non-hazardous wastes has considered the potential risks to vertebrate wildlife.	Table 8-10
Assessment summary The Marine Debris TAP has been considered during the assessment of impacts and risks, and the activity is not considered to be inconsistent with the relevant actions of this plan.				

10 IMPLEMENTATION STRATEGY

10.1 Introduction

The implementation strategy for this EP has been developed to comply with the requirements of section 22(1) of the OPGGS(E) and describes the specific measures and arrangements that will be implemented for the duration of the activity to ensure that:

- All environmental impacts and risks of the activity will be continually identified and reduced to a level that is ALARP.
- Control measures detailed in the EP are effective in reducing the environmental impacts and risks of the activity to ALARP and acceptable levels.
- EPOs and EPSs set out in the EP are met.
- Arrangements are in place to respond to, and monitor impacts of, oil pollution emergencies.
- Relevant person consultation is maintained throughout the activity as appropriate.

10.2 HSE management system

The Eureka 3D MSS will be conducted under the framework of the Pilot Environment and HSE Policies (Appendix A), Pilot Environmental Management Procedure, the survey vessel's HSE MS, and other relevant procedures and plans.

The seismic activity will also operate under a project-specific HSE plan that Pilot and the vessel operator will develop for the Eureka 3D MSS. The Project HSE Plan is a tailored document that ensures Pilot's environmental management standards and intended performance outcomes are achieved at operational level throughout the activity, while identifying and enabling the selected seismic contractors' own procedures to be utilised where appropriate. The Project HSE Plan will incorporate regulatory and client environmental requirements including procedures for the following:

- Emergency response
- Waste management
- Hazardous materials and handling
- Fuel/oil spills.

The seismic contractor's vessel HSE documentation will be reviewed for compliance with the relevant requirements described in this EP prior to the commencement of the activity. In the event of a gap between the existing plans and procedures and the requirements of this EP, the project HSE plan will ensure all control measures are adequately covered in the implementation of the EP.

10.2.1 EP Management of change and revision (Section 22(2))

Management of changes (MoC) relevant to this EP will be managed in accordance with Sections 18, 19 and 39 of the OPGGS (E) Regulations. Changes will be assessed and managed in relation to the requirements of the OPGGS(E) Regulations, including whether any of the following requirements are potentially compromised or triggered:

- Section 18 "Operations must comply with the accepted environment plan"
- Section 19 "Operations must not continue if new or increased environmental risk identified"
- Section 39 "Revision because of a change, or proposed change, of circumstances or operations".

Pilot understands the importance of proper application of change management processes and robust documentation of MOC procedures, particularly so that ALARP and acceptability can continue to be demonstrated throughout the survey and the life of the EP. Pilot's MoC Procedure is consistent with these priorities, and Pilot will continue to implement this procedure to ensure changes are managed in a controlled manner.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a formal revision under section 39 of the OPGGS (E) Regulations, will be considered a 'minor revision'. Minor administrative changes to this EP, where an assessment of the environmental risks and impacts is not required (e.g. document references, phone numbers, etc.), will also be considered a 'minor revision'.

10.2.1.1 Triggers for MoC

For the Eureka 3D MSS, the following activities will trigger a MoC process which will need to be approved by the Pilot Project Manager:

- A new scope (e.g. timing, location or changes to operational details such as vessel type, equipment, processes or procedures), which has the potential to impact on the environment not assessed for environmental impact previously or authorised in existing management plans and procedures
- Change to the existing activity, scope, equipment, process or procedures which have the potential to impact on the environment or interface with an environmental receptor
- Changes in the external environment managed and monitored by the Project Manager
- Provision of new information that differs to that included in this EP, such as:
  - Potential changes in scientific knowledge regarding impacts and risks from seismic activities
  - New environmental sensitivities within or adjacent to the survey area
- Changes to EPBC Act listed Threatened and Migratory species status or Part 13 statutory instruments (recovery plans, threat abatement plans, conservation advice, wildlife conservation plans)
- Issue of new regulatory requirements (e.g. AMP Management Plans)
- Identification of new relevant person objections or claims that are assessed to have merit
- Non-conformances (audits, inspections, etc.) which identify control measures may no longer manage environmental impact/risk to ALARP or acceptable criteria. Non-conformances are monitored by the Pilot Client Site Representative and the Environment Advisor
- Incidents which identify new or increased impacts and risks arising from activities not previously identified in the accepted EP. Incidents are monitored by the Client Site Representative and Environment Advisor
- Reduced ability to effectively implement the EP to meet its stated performance standards (e.g. MFO taken ill and demobilised)
- Potential new advice from external relevant persons (Section 5).

A review of the Eureka 3D MSS EP will be undertaken in the pre-mobilisation phase to ensure that any changes to legislation, science, relevant person requirements or other management requirements are fully accounted for and assessed.

10.2.1.2 MoC process

Once potential changes have been identified that trigger a MoC, the following steps will be initiated and documented in accordance with Pilot's Management of Change Procedure (Doc. PE-03-PRO-002):

- Stop work, or delay commencement of new activity
- A risk and impact assessment performed, using the same procedures as outlined in Section 6. This will determine if the increase in risk is significant and would therefore trigger a requirement to revise and resubmit the EP under Section 39
- If resubmission is required, work or new activity is to be suspended until the revised EP is accepted by NOPSEMA
- If resubmission not required, conduct and document detailed risk and impact assessment in a MoC register
- Consult relevant persons if changes may affect their activities or interests (based on previous feedback)

- Develop any additional control measures required to reduce risks and impacts to ALARP and ensure they are acceptable
- Update EP implementation plan/strategy as necessary.

Work on new or modified activities that do not trigger a Section 39 resubmission will only recommence on the authority of the Project Manager.

10.3 Roles and responsibilities (Section 22(3))

Key roles and responsibilities for Pilot and contractor personnel in relation to implementation, management and review of this EP are described below (Table 10-1). Roles and responsibilities for environmental management during the activity are a combination of generic/standard professional duties, such as complying with shipboard garbage management procedures, complemented by project-specific requirements arising from this EP, such as regulator-specific reporting arrangements Pilot will ensure that all personnel are suitably trained and competent in their respective roles (Section 10.5). Roles and responsibilities for oil-spill incidents are outlined in 10.7 The roles and responsibilities of key shore-based and vessel-based project members are summarised in Table 10-1.

Table 10-1: Eureka 3D MSS roles and key environmental responsibilities

Role	Key environmental responsibilities
Onshore	
Project manager	• Ensure the activity is undertaken as per the performance outcomes of the EP. • Provide sufficient resources to implement management measures to achieve the performance outcomes of the EP. • Manage change requests for the activity and notifying the environment advisor (EA) of any scope changes in a timely manner. • Liaise with regulatory authorities as required. • With the support of the EA, ensure that ongoing monitoring for potential changes that may have a bearing on the EP are undertaken • Ensure environmental incident reporting meets regulatory requirements. • Ensure corrective actions raised from environmental inspections/audits or incidents are closed out • Review results of conformance audits conducted during the program and make recommendations where required. • Ensure that all reportable incidents are reported to NOPSEMA as per requirements • Ensure that all recordable incidents are reported to NOPSEMA as per requirements • Liaise with contractors to ensure communication and understanding of environmental sensitivities and requirements outlined in this EP. • Ensure submission of the PERR to NOPSEMA.
Environment advisor	• Prepare environmental induction pack • Track compliance of the EPOs, EPS' and MC as per the requirements of this EP • Assist with the review, investigation and reporting of environmental incidents as required • Assist with environmental monitoring and inspections or audits are performed as per the requirements of this EP • Liaise with relevant regulatory authorities as required • Assist in preparing required external regulatory reports • Support the Project Manager to ensure communication of environmental responsibilities to personnel and contractors

Role	Key environmental responsibilities
Vessel managers - survey and supply vessels	• Establishing and reviewing the annual QHSE plan for the vessel. • Ensuring the vessel's conformance with all company standards, policies and procedures. • Provide copies of documents, records, reports and certifications requested by Pilot are provided in a timely manner. • Ensuring major incidents (Lost Time Injury and/or Hi-potential or above) are thoroughly investigated, root cause analyses performed, corrective actions completed, logged and closed out. • Participation in key audits. • Ownership of the vessel's HSE statistics, leading and lagging indicators and overall HSE performance. • Communication of any environmental incidents or non-conformances to Pilot as soon as practicable. • Ensuring that all relevant QHSE documentation is in place for the vessel, according to the company's QHSE Management System requirements.
Stakeholder liaison	• Relevant person consultation for the activity is undertaken in a timely and thorough manner. • Objections or claims raised by relevant persons are recorded and reported to the project manager and survey environmental adviser. • A relevant person consultation log is maintained. • Continuous liaison and notification carried as outlined in the EP.
Offshore	
Client site representative	• Ensuring all personnel have received an environmental induction and the induction includes environmental sensitivities, control measures, specific roles and responsibilities of all vessel crew members. • Immediately alerting the project manager of any changes in operations which could impact negatively on environmental performance or for changes in operation which alter the environmental risk profile of the activity. • Ensuring survey operations are carried out in accordance with the control measures and EPOs adopted within this EP. • Monitoring and reporting on the conformance of all EP commitments through observations and assessments of performance against the measurement criteria. • Communicate any environmental incidents or non-conformances to Pilot immediately. • Ensuring incidents are fully investigated and corrective actions monitored to close-out. • Ensuring data and records are collected for the PERR.
Survey environmental adviser	• Prepare environmental induction and vessel inspection information. • Provide a briefing to project personnel and survey vessel crew members of the environmental sensitivities of the OA, environmental management strategies, EPOs and EPSs detailed in the EP as part of the environmental induction process. • Ensure all relevant personnel have received and understood the spatial and temporal exclusions provided in the EP in relation to charts. • Assist with review, investigation and reporting of environmental incidents. • Ensure environmental inspections/audits are undertaken as per the requirements of the EP. • Maintain and advise operations manager of the status of the Corrective Action Register • Monitor and provide evidence of conformance to the environmental commitments as outlined in this EP and ensure the Compliance Register is updated. • Assist in preparation of external regulatory reports required for the survey, in line with environmental approval requirements and the Pilot HSE incident reporting procedures. • Prepare a report of the overall environmental performance upon completion of the survey, including the results of audits and any incidents, and forward to the project manager. • Collate data for and assist in the preparation of the PERR. • Performing the role of the senior MFO.

Role	Key environmental responsibilities
Vessel masters	The survey and supply/chase vessel masters have overall responsibility for HSE management aboard their respective vessel, implement the contractor's HSE policies and procedures, and motivates employees in support of the company's HSE policies and procedures. The survey and supply/chase vessel masters comply with all requirements of maritime law and the rules and regulations as defined by national and international authorities. The survey and supply/chase vessel masters have ultimate responsibility for ensuring the safe execution of all vessel operations including: • Ensure the safe execution of all operations of the survey/supply/chase vessel • Overall responsibility for HSE management aboard the survey/supply/chase vessel • Ensure vessel operations are being conducted in accordance with the legislative requirements and this EP, including waste management and emergency/oil spill response • Ensure vessel audits, inspections, emergency drills, training, hse and inductions are undertaken as per the EP and other regulatory requirements • Ensure maintenance of equipment and records meet statutory requirements • Implement the vessel's SOPEP and OPEP procedures in the event of an oil spill (Section 8.7), including first response to an incident using the resources immediately available to the vessel • Immediately notify the client site representative of any incidents/activities arising from vessel operations that are likely to have a negative impact on the performance outcomes detailed in this EP • Support the client site representative in ensuring that all relevant HSE documents are understood and adhered to • Report hydrocarbon or other chemical spillage to the party chief • Establish and maintain radio contact with other vessels in the Eureka 3D MSS OA and adjacent waters • Notify AMSA, the project manager and the vessel manager in the event of a notifiable oil spill.
Marine fauna observers	• Ensure conformance with the relevant environmental performance requirements under this EP, including inspections and adequate fauna watch and implementation of EPBC Policy Statement 2.1 Part A and Part B management procedures adopted for the survey. • Record any non-conformances with EPBC Act Policy Statement 2.1 management procedures adopted for the survey. • Maintain and distribute records of marine fauna sightings and submitting daily and final survey sighting reports to the client site representative and project manager. • Submit notification of any incidents involving vessel collision and/or equipment entanglement with marine fauna, in accordance with the EPBC Regulations. • Provide environmental inductions for survey personnel (where relevant), including details of the environmental sensitivities of the OA, control measures and performance outcomes and standards detailed within this EP. • Preparation of the MFO Report.
Vessel personnel	• Conduct activities in a professional and safe manner with attention to good housekeeping procedures and work practices. • Undertake work as advised in environmental induction. • Immediately report any incidents to the vessel master. • Encourage improvement in environmental performance wherever possible. • Bring any marine mammal sightings to the attention of the MFOs.

10.4 Environmental performance monitoring and evaluation (Section 22(2))

10.4.1 Review of environmental performance (Section 22(5))

Pilot will monitor the performance of the control measures during the activity. Environmental performance during the survey will be reviewed by the environment advisor to ensure that:

- EPOs and EPSs are being met, reviewed and where necessary amended (to continue to reduce the environmental impacts and risks of the activity to ALARP)
- Potential non-conformances and opportunities for continuous improvement are identified and corrective actions implemented

- All environmental monitoring requirements have been met before completing the activity.

The following arrangements will be established to review the environmental performance of the activity:

- Inspections of the vessels will be carried out before and during the survey to ensure that procedures and equipment for managing routine discharges and emissions are in place to enable conformance with the EP
- The performance of key equipment as described in this EP (i.e. OIW separator) will be checked as per the vessel maintenance schedule to ensure ongoing reduction of risks and impacts to ALARP, and any potential issues (i.e. observations of poor operating condition/performance or non-conformances) are continually monitored and raised as soon as practicable
- A summary of the EP commitments for the activity will be supplied to relevant personnel aboard the survey and support/chase vessels, and implementation of the environmental performance standards will be monitored by the survey environment advisor.

Any non-conformance with the EPSs outlined in this EP will be subject to investigation and follow-up action as detailed in Section 10.8.

Pilot will also undertake an internal review of the environmental performance of the Eureka 3D MSS at the conclusion of the survey. The review will consider:

- An evaluation of conformance with the Compliance Register
- Improvements to the implementation strategy included within the EP
- Conformance with the Project HSE Plan, Pilot’s HSE MS and the seismic vessel’s HSE MS as well as Pilot’s Policies, Manuals and Procedures
- The management of any non-conformances identified during the survey, including reportable and recordable incidents
- Any concerns identified by relevant persons during and after the completion of the survey, followed by appropriate liaison as required
- Outcomes of any NOPSEMA inspection reports and feedback.

10.4.2 Monitoring, auditing and management of non-conformance (Section 22(5))

10.4.2.1 Monitoring and record keeping (Section 22(6))

Pilot will undertake monitoring as per the EPOs and EPSs in Sections 7 and 8, and keep compliance records for items outlined as measurement criteria in the same sections There will be a record of emissions and discharges as required under section 22(6) of the OPGGS(E). This record will include all emissions and discharges to the air and water and can be monitored and audited against the environmental performance standards. In accordance with section 52 and 53 of the OPGGS(E), Pilot will store and maintain all versions of the EP and documents or records relevant to the EP implementation for a period of five years. Audits and inspections

Pilot will maintain a Compliance Register that will serve as an audit tool during the Eureka 3D MSS. The register will be sufficiently detailed to demonstrate that the EPOs and EPSs included in this EP have been met. The register will detail:

- The EPOs and EPSs for the Eureka 3D MSS
- Measurement criteria to enable an auditor to determine if the Eureka 3D MSS has complied with the relevant EPSs
- The person/party responsible for implementing management measures to meet the EPO.

Prior to the survey, Pilot will undertake:

- A vessel audit/inspection to confirm that the vessel management systems are consistent with the environmental management controls detailed in this EP. This will ensure that procedures and equipment for managing routine discharges and emissions are in place to enable conformance with the EP. The audit will be documented, and any corrective actions closed out

- A review of the risk of potential introduction of IMS, potentially including an inspection to confirm that the vessel does not pose an unacceptable risk of introducing IMS
- An audit of the on-board spill response capability of the seismic vessel against its SOPEP and relevant controls in this EP, to verify spill preparedness.

Conformance will be monitored on a regular basis by the client site representative.

Any non-conformance with the EPS outlined in this EP will be subject to investigation and follow-up action as detailed in Section 10.8.

The findings and recommendations of audits/inspections will be documented and distributed to relevant personnel for comments. It is likely that inspections and audits will result in recommendations for improvement opportunities. The audit or inspection may also identify breaches in environmental performance. Any non-conformance is noted and communicated immediately to the client site representative and the vessel master, as well as being documented in the audit or inspection report.

HSE performance of the survey will be discussed within Pilot during management phone calls between the vessel and head office, and weekly during on-board HSE meetings.

The environmental inspection results will be included with the Post-survey Environmental review Report (PERR) submitted to NOPSEMA after completion of the survey.

10.4.2.2 Management of non-conformance

All breaches of the EPOs and EPS' in this EP are considered non-conformances (non-compliance). Non-conformances may be identified during an audit, inspection, crew observation or as a consequence of an incident.

In accordance with Pilot's Non-Conformance and Corrective Action Procedure (PE-07-PRO-003) all environmental incidents and non-conformances must be reported, assessed and classified. All EP non-conformance issues will be communicated immediately to appropriate offshore and onshore management personnel. This expectation will be reinforced at inductions, daily toolbox meetings and weekly HSE meetings. Any EP non-conformances will be investigated as per the survey contractor's and Pilot investigation procedures (Pilot's Incident Management Procedure PE-07-PRO-001). Following an investigation, remedial actions will be developed to prevent recurrence and these actions will be tracked to completion as described below, and as per Pilot's Incident Management Procedure.

Non-conformances and associated lessons learnt are communicated to the offshore crew during daily toolbox meetings before each shift and at weekly HSE meetings on-board the vessel and implemented if appropriate.

At all times during the survey the client site representative will be on-board the survey vessel. The client site representative has the authority to stop work at any time. Survey operations will be suspended if there is a non-conformance that increases the risk of significant negative impacts to the environment and the client site representative (or other authorised person) is not satisfied that measures are in place to avoid a repeat of the incident. Survey operations may also be stopped where the client site representative or other authorised person considers there is a legitimate risk of an HSE incident, a breach of legislative requirements or a breach of this EP.

10.5 Training and competencies (Section 22(4))

10.5.1 Training and inductions

All personnel involved with the Eureka 3D MSS will be given a project-specific environmental induction prior to commencing work. This induction will cover environmental responsibilities relevant to the duties and responsibilities of the roles described in section 10.3 including:

- Environmental, socio-economic and cultural sensitivities and values in the ASA and OA
- Environmental and risks and potential impacts associated with the activity

- Waste management and chemical management procedures
- Emergency response and spill management procedures outlined in the OPEP and vessel SOPEP
- Procedures for marine fauna interactions (including MFO duties and obligations)
- Roles and environmental responsibilities of key personnel on-board the survey vessel
- The importance of following procedures and using company processes to identify environmental risks and mitigation measures
- The EP importance and the monitoring and reporting on performance outcomes and standards using measurement criteria
- Procedures for reporting environmental hazards, incidents, near misses and opportunities for improvement
- Opportunities for employee communication and participation
- Prohibition on recreational fishing on all project vessels.

A record of the induction will be retained by the project manager with the endorsement of personnel who attended. All personnel are required to sign an attendance sheet to confirm their participation in and understanding of the induction. The contractor will also conduct their own company and vessel-specific inductions independently.

10.5.2 Competency and ongoing awareness

The survey vessel contractor will provide marine crew who are trained and competent to undertake their respective activities on-board the vessel. All MFO personnel will be familiarised with relevant EP commitments and their responsibilities for implementing them. MFOs will have a minimum of 20 weeks previous experience (recommended by the Marine Mammal Observer Association [MMOA]) of observing for marine mammals at sea, to have gained the skills to be competent at identifying marine mammals, estimating distance, confidence in implementing mitigation actions and experience recording data, in accordance with EPBC Policy Statement 2.1 requirements.

The MFOs will provide an information session to control room operators and other essential personnel at the start of the survey regarding their fauna observation duties and the communication protocols required with the control room operators to ensure shut-downs and power downs occur efficiently.

The following activities will serve to reinforce and maintain ongoing environmental awareness of vessel personnel for the Eureka 3D MSS. Records will be produced for each of these meetings:

- Project kick-off meeting: Held at the start of the activity and reviews the contractual and HSE specifications for the activity, the scope of work, vessel-specific HSE plans, environmental outcomes, performance standards and measurement criteria within this EP
- Daily progress meetings (on-board): Review all survey operations and incidents of the previous day, actions are recorded within the daily progress report. Attended by vessel master and heads of departments plus the client site representative
- Toolbox meetings: Attended by all personnel involved in a specific operation (i.e. operations involving major hazards and/or involving more than one person). This meeting reviews the activity and reinforces the adoption of control measures within this EP to prevent adverse environmental and safety impacts. Recorded within the daily progress report.

All personnel will be encouraged to communicate any concerns, suggest improvements to the control measures implemented for any particular task or operation during the activity and comment on any proposed changes to equipment, systems, or methods of operation of equipment, where these may have HSE implications.

10.6 Emergency response (Section 22(3))

Pilot's emergency preparedness and response arrangements are documented within the Pilot Emergency Response Procedure (PE-05-PRO-003) and will be included within the Project HSE Plan. In addition, the seismic vessel will have a vessel-specific Emergency Response Plan (ERP) and SOPEP. These documents will be reviewed by Pilot to ensure they meet the requirements for emergency and oil spill response specified within this EP.

Pilot will ensure that any subcontracted vessel operator has established systems to ensure emergency plans are developed, implemented and maintained and that these plans address those incidents that are reasonably foreseeable. Information that is considered when identifying potential emergency situations include the following:

- Results of hazard identification and impact/risk assessments
- Legal requirements
- Previous incident (including accident) and emergency experience
- Emergency situations known to have occurred in similar organisations
- Information related to accident and/or incident investigations posted on the websites of regulators or emergency response agencies.

The Project HSE Plan contains instructions for vessel emergency, medical emergency, search and rescue, reportable incidents, incident notification and contact information to ensure that:

- All potential emergencies are identified
- Emergency response plans are documented, accessible and clearly communicated
- Roles and responsibilities are clearly defined
- Adequate equipment, facilities and trained personnel are available to respond to emergency situations to mitigate adverse consequences
- Inspection and testing of critical emergency equipment is performed
- Emergency drills and exercises are conducted to assess emergency response capacity and capabilities
- Lessons learned are communicated to the appropriate people
- Adequate treatment and medical management are available for injured employees.

10.6.1 Emergency response initiation

In the event of an Oil Spill emergency, in the first instance the survey Vessel Master will assume overall on-site command and act as the on-scene commander (OSC). In the event of a Level 2 release or above, AMSA or the WA Department of Transport (DoT) will take over control of the response in their role as Control Agency and provide direction to the OSC. All persons on-board the vessel will be required to act under the OSC's directions. The survey vessel master will maintain communications with the vessel manager and project manager and/or other emergency services in the event of an emergency.

When an oil spill emergency occurs, the initial alert will usually be made from the emergency location itself, such as from the vessel master or client site representative to the Incident Management Team (IMT), as well as to relevant Commonwealth and state agencies (such as AMSA). The IMT will be mobilised upon initial contact and emergency response will be initiated. This will be carried out by working directly with the established emergency services operating in the area. The survey and support vessel(s) will have equipment on-board for responding to emergencies including, but not limited to, medical equipment, firefighting equipment and oil spill response equipment.

Upon receiving notification of an emergency, the vessel marine crew will respond in accordance with its SOPEP. The OSC will maintain the direct link between the vessel and the IMT.

In the event of an emergency, the survey vessel master will notify the onshore vessel manager and the project manager, who will activate the IMT. Pilot will, if necessary, be ready to provide technical and tactical resources to the emergency response. The project manager will liaise with the IMT, provide support to the response as required and provide regular reports until the response is terminated.

The vessel master is responsible for implementing source control arrangements detailed in the vessel specific SOPEP.

10.6.2 Adverse weather procedures

The activity will occur between early February and the end of March and it is unlikely that major weather events will occur, however, dissipating tropical cyclones may track down from the west coast infrequently during late summer and can have significant impacts on the coastline, causing extreme winds, storms surge, and storm waves (Eliot & Pattiaratchi 2010).

The survey vessel will receive daily weather forecasts and should poor/bad weather be imminent, the vessel master shall implement weather monitoring to assess conditions on site. The amount of monitoring and subsequent action would be dependent on the severity of the weather front and resulting actions will comply with the vessel's ERP.

10.7 Oil pollution emergency plan (Section 22(8))

The Eureka 3D MSS OPEP (Appendix E), which supports the individual vessel-based SOPEPs, details the interaction between contractor-related spill response plans and Pilot response arrangements. These response arrangements are consistent with, and supported by, the:

- National Plan for Maritime Environmental Emergencies (NATPLAN): Australian Maritime Safety Authority (AMSA) – has jurisdiction and is the Control Agency for vessel spills which affect Commonwealth waters.
- State Hazard Plan for Maritime Environmental Emergencies (State Hazard Plan): The WA Department of Transport (DoT) is the Control Agency for marine oil spills in WA state waters (DoT 2020).

The seismic and support vessels IMO-compliant SOPEPs, prepared in accordance with IMO guidelines for the development of shipboard oil pollution emergency plans (resolution MEPC.54 (32) as amended by resolution MEPC.86 (44)), include oil spill response arrangements and provisions for testing the SOPEP (oil pollution emergency drills), as required under section 22(8) of the OPGGS(E). Typical oil spill response actions for shipboard oil spills are contained in the Eureka 3D MSS OPEP.

Initial actions undertaken by a vessel in the event of a spill to limit environmental impacts, are detailed in the Eureka 3D MSS OPEP.

10.7.1 Oil pollution roles and responsibilities

The responsibility for responding to an oil spill is dependent on location and spill origin. The National Plan sets out the divisions of responsibility for an oil spill response. Table 10-2 provides guidance on the designated Control Agency and Jurisdictional Authority for Commonwealth and state waters and for vessel and petroleum activity spills. It is important to note that in Commonwealth waters vessels involved in seismic surveys are considered to be 'vessels' and not 'petroleum activities'. However, in WA waters marine seismic surveys are a petroleum activity where they are associated with exploration for hydrocarbon reservoirs or evaluation of these resources.

Table 10-2: Jurisdictional and Control Agencies for hydrocarbon spills

Jurisdictional boundary	Spill source	Jurisdictional authority	Control agency		Relevant documentation
			Level 1	Level 2/3	
Commonwealth waters (3 to 200 nm from territorial/state sea baseline)	Vessel [2]	AMSA	AMSA		Vessel SOPEP National Plan Eureka 3D MSS OPEP (this document)
	Petroleum activities[3]	National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)	Titleholder		Activity OPEP
WA state waters (state waters to 3 nm and some areas around offshore atolls and islands)	Vessel	WA Department of Transport (DoT)	DoT	DoT	Vessel SOPEP SHP-MEE Oil Spill Contingency Plan (OSCP) (DoT, 2015)
	Petroleum activities	DoT	Titleholder	DoT	Eureka 3D MSS OPEP (this document) SHP-MEE

Within Pilot there will be an Incident Management Team (IMT) for response to hydrocarbon spills. The IMT will be made up of Pilot staff, consultants and an OSM Service Provider. Figure 10-1 illustrates the structure of the OSM Management team during the response phase. The IMT leader is ultimately accountable for managing the response operation. Depending on the event individual people may perform multiple roles.

The following roles will also provide key support:

- The survey vessel master will be responsible for notifications and reporting all spills to the sea to the AMSA JRCC, via a POLREP form included in the vessel SOPEP. Further reports will be sent at regular intervals to inform relevant stakeholders and agencies (AMSA, NOPSEMA, DCCEEW, Pilot, survey contractors, etc.)
- The client site representative on-board the vessel is responsible for reporting directly to Pilot. The project manager is then responsible for notifying NOPSEMA of any spills in Commonwealth waters.

[2] Vessels are defined by Australian Government Coordination Arrangements for Maritime Environmental Emergencies (AMSA, 2017a) as a seismic vessel, supply or support vessel, or offtake tanker. Note: this definition does not apply to WA State waters.

[3] Includes a 'Facility', such as a fixed platform, FPSO/FSO, MODU, subsea infrastructure, or a construction, decommissioning and pipelay vessel. As defined by Schedule 3, Part 1, Clause 4 of the OPGGS Act.

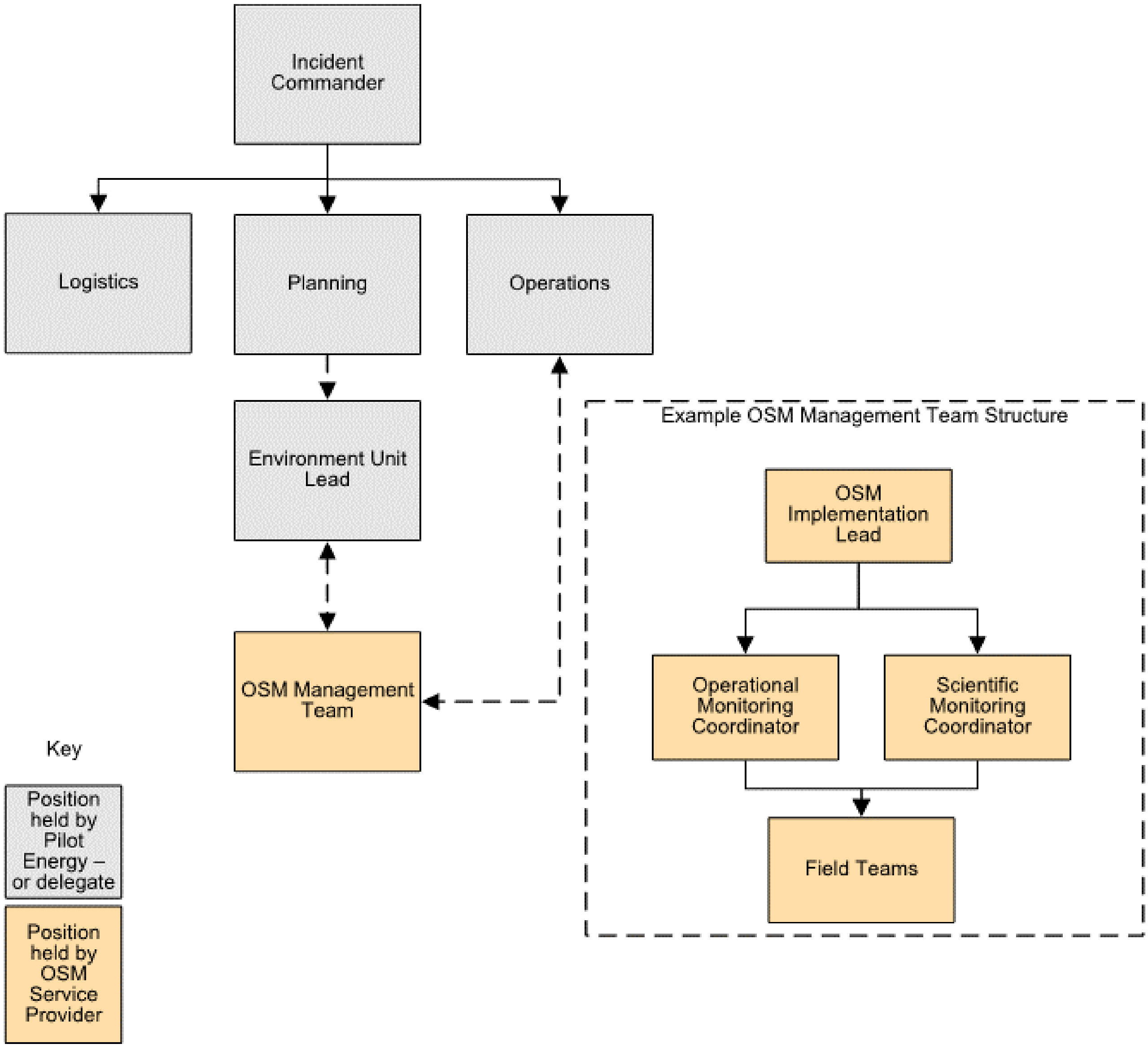


Figure 10-1: Pilot IMT structure with OSM team

10.7.2 Drill and training (OPEP/SOPEP)

The OPEP will be desktop tested prior to commencing the Eureka 3D MSS.

The arrangements for testing the OPEP are commensurate with the nature and scale of the worst-case oil spill scenario and the short duration of the survey.

Vessel-based SOPEP tests are undertaken by vessels routinely as per MARPOL Annex I (Regulation 15) requirements, and drill outcomes reviewed as part of the ongoing monitoring and improvement of emergency response control measures. A desktop drill of the Eureka 3D MSS OPEP, including the vessel SOPEP, will be conducted to assess the effectiveness of the arrangements, taking into account the nature and scale of the risk of a hydrocarbon event, prior to survey commencement. Specifically, the drill will test the following:

- Roles and responsibilities of those involved in oil spill response are clear and understood
- Communication sequence from the vessel master to vessel-contractor onshore management and the Control Agency, including notification of the AMSA JRCC is adequate, current and includes all relevant details
- Communication between the client site representative and the project manager and subsequent notification authorities is adequate and timely

- That vessel-based spill surveillance is in place and relevant people understand the tracker buoy deployment
- Equipment and procedures intended for source control on-board the vessels are available for use as outlined in the vessel SOPEP.

The outcomes of the Eureka 3D MSS OPEP drill will be documented, reviewed and improvements identified (as needed). Should any inadequacies, altered contractual arrangements or improvements to arrangements be identified via testing, these corrective actions will be registered (refer to Section 10.2.1) and if required the EP/OPEP will be amended for these items via an MoC process (refer Section 10.2). This is the responsibility of the project manager who is responsible for assessing any changes to the OPEP against the criteria in OPGGS (E) Regulations - section 39 and where necessary, the EP/OPEP submitted to NOPSEMA as a formal revision.

10.7.3 Maintaining currency

Pilot will monitor AMSA and DoT's published plans and should the plans change, Pilot will assess the implications of any changes to the OPEP arrangements as described in this EP. Any change to the activity itself, or the potential impacts and risks associated with it, will result in a review of the EP (including the OPEP) to ensure the measures in place remain suitable and there is no significant increase in impact or risk.

10.7.4 OSMP

The Eureka 3D MSS OSMP (Appendix F), considers the nature and scale of the activity and the potential monitoring requirements of the spill risks involved (refer Section 8.6). The OSMP has the objectives to:

- Identify high priority protection areas within the EMBA in real time.
- Specify monitoring methodologies.
- Detail the process Pilot will follow to determine the monitoring studies that will be implemented in order to:
  - Provide situational awareness and assist in planning and execution of spill response to minimise environmental harm.
  - Provide for short-term and long-term environmental damage and recovery assessments.

10.8 Reporting (Section 22(7) and 51)

10.8.1 Environmental performance reporting

The outcomes of the environmental performance during the survey (Section 8.3) will be summarised in the PERR. The outcomes of the review will be incorporated into environmental management measures applied to future activities to further improve Pilot's environmental performance. The requirements for reporting and recording environmental performance are outlined in Table 10-3.

Table 10-3: Environmental performance reporting

Requirements	Timing
Submit an end-of-survey PERR to NOPSEMA, in accordance with section 22(7) and 51 of the OPGGS(E). This reports conformance against each of the performance outcomes and standards as outlined in Sections 7 and 8 of this EP and: • A summary of all reportable and reportable incidents (if any), investigation details, corrective actions determined and actioned • Monitoring records • Details of all cetacean sightings (if any) • A copy of the completed compliance register for the activity, including all supporting records • Inspection/audit outcomes • Summary of the survey operations conducted.	Submit to NOPSEMA within three months of seismic survey completion. Provide marine fauna observation data to DCCEEW within three months of survey completion.

10.8.2 Environment incident reporting (section 24 and 47)

Under section 24 and 47 of the OPGGS(E), Pilot is required to notify NOPSEMA of any reportable and recordable incident within a specified timeframe. Environmental incidents will be reported to the relevant government agency by the client site representative. The requirements for reporting and recording incidents are outlined in Table 10-4.

Following any recordable or reportable incident, Pilot will undertake an incident investigation and this information will be communicated to all relevant personnel. All recordable and reportable incidents will be documented in the PERR by the project manager, and including details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence. The project manager and client site representative will follow up actions taken to ensure that the corrective actions have been taken to close it out. When planning future activities, Pilot will review the reportable and recordable incidents that have occurred previously to incorporate any lessons learned as part of Pilot's continual improvement process.

Table 10-4: Routine and incident reporting requirements

Requirements	Timing
Recordable incident reporting	
Legislative Definition: A "recordable incident" 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."	Submit to NOPSEMA 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. Email: submissions@nopsema.gov.au.
As a minimum, the written incident report must include a description of: • a record of all recordable incidents that occurred during the calendar month • all material facts and circumstances concerning the recordable incidents • any actions taken to avoid or mitigate any adverse environmental impacts of the recordable incidents • the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the recordable incident • the action that has been taken, or is proposed be taken, to prevent similar incidents occurring in the future.	
Reportable incident – verbal notification	
Legislative definition: A "reportable incident" means "an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage."	NOPSEMA: as soon as practical and no later than two hours. Ph 08 6461 7090 submissions@nopsema.gov.au Verbal notifications must also be given as soon as is practicable to AMSA and State Agencies First contact in the event of a Level 1 or Level 2 hydrocarbon spill: AMSA: 1800 627 484 (Refer to Appendix E for details of oil spill notification and reporting requirements).
Based on the impact/risk assessments undertaken in Sections 7 and 8, Pilot considers environmental incidents that have a consequence of moderate or higher These are the identified impacts and risks that may result in a reportable incidents: • Collision with large marine fauna (cetaceans, pinnipeds, marine turtles) causing injury or death.	
Verbal notification of reportable incident must be given to NOPSEMA as soon as practicable (not later than two hours) after the occurrence of the reportable incident/after the time Pilot Energy becomes aware of the reportable incident. The verbal notification must include the following information: • All material facts and circumstances concerning the incident that the titleholder knows, or is able, by reasonable search or enquiry, to find out • Any actions taken to avoid or mitigate any adverse environmental impacts of the reportable incident • The corrective action that have been taken, or is proposed to be taken, to stop, control or remedy the reportable incident.	
Notify the Western Australian Museum if any previously unrecorded shipwrecks are found	Obligated under the *Maritime Archaeology Act 1973* to report here. No timing identified.
Notify Department of Biodiversity, Conservation and Attractions (DBCA) in the event of oiled wildlife	Managed through IMT process

<table>
<tr><th>Requirements</th><th>Timing</th></tr>
<tr><td colspan="2">Reportable incident – written notification</td></tr>
<tr><td>As per Section 47 of the OPGGS(E), as soon as practicable after the verbal notification (and no later than 3-days after the first occurrence of the reportable incident), a written record of the notification must be provided to:
• NOPSEMA
• NOPTA
• Department of the responsible State Minister (WA).</td><td>As soon as practicable following verbal notification to NOPSEMA
Email NOPSEMA: submissions@nopsema.gov.au
Email NOPTA: info@nopta.gov.au</td></tr>
<tr><td>As per Section 48 of the OPGGS(E), this initial notification to NOPSEMA must be followed up by a written report. As a minimum, the written incident report will include:
• All material facts and circumstances concerning the incident that the titleholder knows, or is able, by reasonable search or enquiry, to find out
• Any actions taken to avoid or mitigate any adverse environmental impacts of the reportable incident
• The corrective action that have 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 similar recordable incidents occurring in the future.</td><td>As soon as practicable, and not later than three days following the first occurrence of the incident
Email NOPSEMA: submissions@nopsema.gov.au</td></tr>
<tr><td>As per Section 48 of the OPGGS(E), within 7-days after giving a written report of a reportable incident to NOPSEMA, the titleholder must give a copy of the report to:
• NOPTA
• Department of the responsible State Minister (WA).</td><td>Within seven days of providing a written report to NOPSEMA
Email NOPTA: info@nopta.gov.au</td></tr>
<tr><td>Notify the DCCEEW of any impacts to MNES specifically injury to or death of EPBC Act listed Threatened or Migratory species</td><td>Within seven days of the incident
protected.species@environment.gov.au or compliance@environment.gov.au</td></tr>
<tr><td>Notify the DCCEEW and AMSA of a vessel strike with a cetacean</td><td>Within 72 hours of the incident. Upload information to: EPBC.Permit@dcceew.gov.au or through 1800 920 528 and via the AMSA Incident report</td></tr>
</table>

10.8.3 Other reporting

10.8.3.1 Oil pollution emergency plan reporting

In the event of implementation of the OPEP, Pilot will also provide any required reports to oil spill response agencies as described in Appendix E.

10.8.3.2 Marine fauna reporting

In accordance with the EPBC Act Policy Statement 2.1 a record of marine fauna interaction procedures employed during operations will be maintained. The MFO Report on the conduct of the survey, and any marine fauna sightings/interactions (including any whale-instigated shut-downs of the acoustic source) will be provided to DCCEEW within three months of the completion of the survey. The report will contain:

- The location, date and start-up time of the survey
- Name, qualifications and experience of any MFO involved in the survey
- The location/times/reasons when observations were hampered by poor visibility, low light conditions or high winds
- The location and time any start-up delays, power downs or stop work procedures instigated as a result of whale sightings
- The location, time and distance of any cetacean, pinniped and turtle sightings
- The date and time of completion of the survey.

The following procedures will be implemented during the survey to ensure all marine fauna sightings are properly recorded and reported:

- Detailed reports of all cetacean sightings will be recorded
- At the completion of the survey the MFO report will be provided to DCCEEW.

In the event of a collision with marine fauna a report will be made to the Secretary of DCCEEW on EPBC.Permits@dcceew.gov.au or 1800 920 528. This report will occur as soon as practicable, however no more than seven days upon becoming aware of the incident. A report to AMSA is also required through a form 18, notified within 72 hours (AMSA incident report).

10.8.3.3 AMSA reporting

In accordance with the *Navigation Act 2012*, AMSA's JRCC will be immediately notified (i.e. within one hour), by the survey vessel master (via the national 24-hour emergency hotline) by the survey vessel master in the event of:

- Any oil pollution incident in Commonwealth waters (Level 1 or 2 spill)
- Any spill greater than 10 m^3 (ten tonnes) in Commonwealth waters (Level 2 spill)
- The vessel sustaining or causing an accident, occasioning loss of life or serious injury
- The vessel receiving damage or defect which affects its seaworthiness
- Serious danger to navigation (e.g. a sizable piece of equipment overboard likely to float, creating a shipping hazard)
- Vessel collision with marine fauna.

10.9 Ongoing consultation (Section 42)

10.9.1 Notifications

Pilot will keep relevant persons up to date with activity status by sending periodic notifications to relevant persons. Key milestones or events that trigger a notification include:

- EP acceptance by NOPSEMA
- Prior to survey commencement
- Upon survey completion
- In the event of a significant incident (e.g. large fuel spill)
- If the seismic vessel is required to depart the Operational Area to avoid adverse weather (notification will be communicated by the AMSA Joint Rescue Coordination Centre as a navigational safety warning)
- If there is a change to the MSS activity scope that may affect the relevant person interests, activities or functions
- If a new or significant increase in potential impact or risk is identified that (after identification of additional control measures to manage those impacts or risks) may affect the relevant person interests, activities or functions.

All notifications will include the relevant details of the activity including the activity title, location and contact details.

The routine reporting obligations that Pilot will undertake with external organisations are outlined in Table 10-5.

Table 10-5: Other EP notifications

Requirement	Timing
Routine reporting	
If survey commences >4 months after EP acceptance: • Ensure any new relevant persons are identified • Once the schedule has been determined, notify all relevant persons of the dates, seeking feedback regarding fishing areas/activity with respect to timing • Identify alternative operating arrangements in response to feedback (and update relevant persons if required).	Pilot will undertake a review four months prior to commencement of the activity.
Send update and reminder to all relevant persons of survey including commencement date and duration, survey line plan layout, vessel communication details and protocols and contact details for further relevant person feedback. Identify alternative operating arrangements in response to feedback (and update relevant persons if required).	One month prior to activity starting.
Reminder to fisheries and fishing relevant persons of survey details and contact information for fishers to provide information on planned fishing activity.	Seven to ten day lookahead prior to survey commencement and on re-start (if survey is suspended)
Notify fisheries and fishing relevant persons on halting (i.e. suspension) and on completion of survey	Immediately upon completion
Notify all relevant persons in the area of operation of the survey vessel location and planned movements over the next 24 hours	Broadcast twice daily bulletins during the survey by radio, AIS and email.
Notify the Australian Hydrographic Office (AHO) of the survey commencement date and duration to enable a Notice to Mariners to be issued.	Email the AHO four weeks prior to the confirmed survey start date at: datacentre@hydro.gov.au
Notify the AHO of altered information during the survey to enable a Notice to Mariners (NTM) to be issued.	Email the AHO fortnightly (if required) to report altered information at: datacentre@hydro.gov.au
Notify the AHO on halting (i.e. suspension) and on completion of the survey.	Email the AHO on completion of demobilisation from the operational area at: datacentre@hydro.gov.au
Notify NOPSEMA of the start date of the survey in accordance with Section 54 of the OPGGS(E).	Email NOPSEMA (submissions@nopsema.gov.au) at least ten days prior to the survey starting.
Notify NOPSEMA of the end date of the survey in accordance with Section 54 of the OPGGS(E).	Email NOPSEMA (submissions@nopsema.gov.au) within ten days of completion of the survey.
Notify regulators at the end of the operation of the EP.	Within one month of survey completion. Email: submissions@nopsema.gov.au mail to: operational.report@ecodev.vic.gov.au
Notify AMSA prior to survey commencement with vessel details (including name, call sign and Maritime MMSI), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels.	Email AMSA's JRCC 24-48 hours prior to survey commencement at: rccaus@amsa.gov.au or phone 1800 627 484
Notify AMSA in order to start and cease daily AUSCOAST warnings.	Email AMSA's JRCC within 24-hours of the start and completion of the survey at: rccaus@amsa.gov.au.
Notify AMSA on halting (i.e. suspension) and on completion of the survey with vessel details (including name, callsign and Maritime MMSI), satellite communications details (including INMARSAT-C and satellite telephone), area of operation and halting and/or requested clearance from other vessels suspension of activities.	Email AMSA's JRCC at: rccaus@amsa.gov.au or phone 1800 627 484
Ballast water non-conformances and queries	DFAT

10.9.2 Management of objections and claims

If any objections or claims are raised during ongoing consultation these will be substantiated via evidence such as publicly available credible information and/or scientific or fishing data. Where the objection or claim is substantiated, where applicable, it will be assessed as per the risk assessment process and controls applied where appropriate to manage impacts and risks to ALARP and an acceptable level. Relevant persons will be provided with feedback as to whether their objection or claim was substantiated, and if not why, and if it was substantiated, how it was assessed and if any controls were put in place to manage the impact or risk to ALARP and an acceptable level.

If a change to the activity or controls adopted during the activity occurs as a result of relevant person consultation, including the provision of evidence regarding an impact or risk to commercial fishing due to the survey, the change will be managed in accordance with the Management of Change process (Section 10.2.1).

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Appendix A:
Pilot Energy Pty Ltd Environment Policy

Pilot Energy Limited

ABN: 86 115229 984

ENVIRONMENTAL & SOCIAL SUSTAINABILITY STATEMENT

The Company is an oil and gas exploration and production company that is pursuing the diversification and transition to the development of integrated renewable energy, hydrogen and carbon management projects by leveraging its existing oil and gas tenements and infrastructure to cornerstone these developments.

Pilot strongly believes that the integration of environmental sustainability considerations in our daily business decisions and strategies will make us a more resilient and agile business in the long term, improving our performance and motivating our people. The Company recognises our responsibility to minimise the impact of our operations on the environment and to participate in the transition towards net zero emissions by 2050.

In order to participate in the transition, we are undertaking a range of feasibility assessments related to renewable energy, hydrogen and carbon capture and storage. Subject to these studies, Pilot sees its future business growth in the areas of renewable energy, hydrogen production and carbon capture and storage. In the meantime, the Company is committed to reducing its Scope 1 and 2 GHG emissions through energy efficiency efforts, finding alternative sustainable energy sources, production processes and technology improvements.

The Company has identified, and manages, the Company's environmental, social and governance risks to which it has material exposure, and the Board is responsible for managing those risks in a manner consistent with the Company's Risk Management Policy which is available in the Corporate Governance section of the Company's website here.

In addition, the Company has an Audit and Risk Committee, which is responsible for the review, implementing and managing the Company's risk management program. This Committee ensures that areas of risk (contemporary and emerging) are, and have been, identified and that the appropriate internal controls are being implemented and are operating efficiently in all material respects.

The Board will continue to review Pilot's environmental and social sustainability and associated risk management framework to satisfy itself that it continues to be sound; that Pilot's practices and procedures align; to determine whether there have been any material changes in the business risks the Company faces; and to ensure that the Company is operating within the risk appetite of the Board. Additionally, the Board will continue to evaluate, and seek to improve (as appropriate), Pilot’s environmental and internal risk management and control processes by relying on the ongoing reporting obligations of the Company and discussions of the management regarding material environmental and social risks.

October 2021

Appendix B:
Protected Matters Search Tool Report

Australian Government

Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 23-Feb-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	2
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	94
Listed Migratory Species:	79

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	68
Commonwealth Heritage Places:	2
Listed Marine Species:	114
Whales and Other Cetaceans:	37
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	17
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

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

State and Territory Reserves:	40
Regional Forest Agreements:	None
Nationally Important Wetlands:	4
EPBC Act Referrals:	103
Key Ecological Features (Marine):	7
Biologically Important Areas:	34
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

National Heritage Places [Resource Information]

Name	State	Legal Status
Historic		
Batavia Shipwreck Site and Survivor Camps Area 1629 - Houtman Abrolhos	WA	Listed place
Natural		
Lesueur National Park	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
EEZ and Territorial Sea

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.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
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
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
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]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		

Scientific Name	Threatened Category	Presence Text
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may 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 likely to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat 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	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	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 likely 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
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to 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	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Turnix varius scintillans Painted Button-quail (Houtman Abrolhos) [82451]	Vulnerable	Species or species habitat known to occur within area
Zanda latirostris listed as Calyptorhynchus latirostris Carnaby's Black Cockatoo, Short-billed Black-cockatoo [87737]	Endangered	Breeding known to occur within area
FISH		
Hoplostethus atlanticus Orange Roughy, Deep-sea Perch, Red Roughy [68455]	Conservation Dependent	Species or species habitat likely to occur within area
Nannatherina balstoni Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
INSECT		
Hesperocolletes douglasi Douglas' Broad-headed Bee, Rottnest Bee [66734]	Critically Endangered	Species or species habitat may occur within area
MAMMAL		
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 penicillata ogilbyi Woylie [66844]	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
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Parantechinus apicalis Dibbler [313]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat known to occur within area
PLANT		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to 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
Banksia mimica Summer Honeypot [82765]	Endangered	Species or species habitat may 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 within area
Caladenia elegans Elegant Spider-orchid [56775]	Endangered	Species or species habitat known to occur within area
Caladenia hoffmanii Hoffman's Spider-orchid [56719]	Endangered	Species or species habitat known to occur within area
Caleana dixonii listed as Paracaleana dixonii Sandplain Duck Orchid [87944]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Chorizema humile Prostrate Flame Pea [32573]	Endangered	Species or species habitat may occur within area
Chorizema varium Limestone Pea [16981]	Endangered	Species or species habitat known to occur within area
Conostylis micrantha Small-flowered Conostylis [17635]	Endangered	Species or species habitat may occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may 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 likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat may occur within area
Drummondita ericoides Morseby Range Drummondita [9193]	Endangered	Species or species habitat known to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Eucalyptus cuprea Mallee Box [56773]	Endangered	Species or species habitat likely to 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
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 may occur within area
Marianthus paralius [83925]	Endangered	Species or species habitat known to occur within area
Pterostylis sinuata Northampton Midget Greenhood, Western Swan Greenhood [84991]	Endangered	Species or species habitat known to occur within area
Stachystemon nematophorus Three-flowered Stachystemon [81447]	Vulnerable	Species or species habitat likely to occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Wurmbea tubulosa		
Long-flowered Nancy [12739]	Endangered	Species or species habitat known to occur within area
REPTILE		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Ctenotus lancelini		
Lancelin Island Skink [1482]	Vulnerable	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-tailed Skink [64483]	Endangered	Species or species habitat may 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	Foraging, feeding or related behaviour known to occur within area
SHARK		
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

Scientific Name	Threatened Category	Presence Text
Centrophorus zeehaani		
Southern Dogfish, Endeavour Dogfish, Little Gulper Shark [82679]	Conservation Dependent	Species or species habitat likely to occur within area
Galeorhinus galeus		
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat may occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sphyrna lewini		
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat known to occur within area
SPIDER		
Idiosoma nigrum		
Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely 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]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea		
Sooty Shearwater [82651]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat 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	Species or species habitat may 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	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely 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	Foraging, feeding or related behaviour likely to occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to 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	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
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 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	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Eubalaena australis as Balaena glacialis australis		
Southern Right Whale [40]	Endangered	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 may occur within area
Megaptera novaeangliae		
Humpback Whale [38]		Congregation or aggregation known to occur within area
Mobula alfredi as Manta alfredi		
Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area
Mobula birostris as Manta birostris		
Giant Manta Ray [90034]		Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour 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

Scientific Name	Threatened Category	Presence Text
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
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 tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	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
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 likely to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely 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
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
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 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 Lands [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.

Commonwealth Land Name	State
Defence	
Defence - GERALDTON TRAINING DEPOT "A" Company 16th Battalion [50195]	WA
Defence - GERALDTON TRAINING DEPOT "A" Company 16th Battalion [50197]	WA
Defence - GERALDTON TRAINING DEPOT "A" Company 16th Battalion [50196]	WA
Defence - GREENOUGH RIFLE RANGE [50234]	WA
Defence - LANCELIN TRAINING AREA [50120]	WA
Defence - LANCELIN TRAINING AREA [50121]	WA
Unknown	

Commonwealth Land Name	State
Commonwealth Land - [50625]	WA
Commonwealth Land - [50626]	WA
Commonwealth Land - [50561]	WA
Commonwealth Land - [50586]	WA
Commonwealth Land - [50553]	WA
Commonwealth Land - [51978]	WA
Commonwealth Land - [50576]	WA
Commonwealth Land - [51491]	WA
Commonwealth Land - [50374]	WA
Commonwealth Land - [50355]	WA
Commonwealth Land - [52214]	WA
Commonwealth Land - [51888]	WA
Commonwealth Land - [50369]	WA
Commonwealth Land - [50368]	WA
Commonwealth Land - [51886]	WA
Commonwealth Land - [51486]	WA
Commonwealth Land - [50630]	WA
Commonwealth Land - [51118]	WA
Commonwealth Land - [50396]	WA
Commonwealth Land - [50494]	WA
Commonwealth Land - [50594]	WA
Commonwealth Land - [51100]	WA
Commonwealth Land - [51434]	WA
Commonwealth Land - [50559]	WA
Commonwealth Land - [50413]	WA
Commonwealth Land - [50410]	WA
Commonwealth Land - [51432]	WA

Commonwealth Land Name	State
Commonwealth Land - [50315]	WA
Commonwealth Land - [51481]	WA
Commonwealth Land - [50371]	WA
Commonwealth Land - [50502]	WA
Commonwealth Land - [50370]	WA
Commonwealth Land - [50575]	WA
Commonwealth Land - [50508]	WA
Commonwealth Land - [50606]	WA
Commonwealth Land - [50574]	WA
Commonwealth Land - [50593]	WA
Commonwealth Land - [50598]	WA
Commonwealth Land - [50592]	WA
Commonwealth Land - [50588]	WA
Commonwealth Land - [51111]	WA
Commonwealth Land - [50585]	WA
Commonwealth Land - [50584]	WA
Commonwealth Land - [50583]	WA
Commonwealth Land - [50582]	WA
Commonwealth Land - [52111]	WA
Commonwealth Land - [51099]	WA
Commonwealth Land - [50587]	WA
Commonwealth Land - [50381]	WA
Commonwealth Land - [50562]	WA
Commonwealth Land - [50563]	WA
Commonwealth Land - [50560]	WA
Commonwealth Land - [50378]	WA
Commonwealth Land - [50379]	WA

Commonwealth Land Name	State
Commonwealth Land - [50376]	WA
Commonwealth Land - [50377]	WA
Commonwealth Land - [51098]	WA
Commonwealth Land - [52201]	WA
Commonwealth Land - [50402]	WA
Commonwealth Land - [50375]	WA
Commonwealth Land - [50373]	WA
Commonwealth Land - [50372]	WA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Historic		
Geraldton Drill Hall Complex	WA	Listed place
Natural		
Lancelin Defence Training Area	WA	Listed place

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Species or species habitat may occur within area
Ardenna pacifica as Puffinus pacificus Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine 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 overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area overfly marine area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Chalcites osculans as Chrysococcyx osculans		
Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area
Charadrius bicinctus		
Double-banded Plover [895]		Roosting known to occur within area overfly marine area
Charadrius leschenaultii		
Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat 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 overfly marine area
Chroicocephalus novaehollandiae as Larus novaehollandiae		
Silver Gull [82326]		Breeding known to occur within area
Diomedea amsterdamensis		
Amsterdam Albatross [64405]	Endangered	Species or species habitat 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	Species or species habitat may 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	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area overfly marine area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area overfly marine 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
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area overfly marine area
Hydroprogne caspia as Sterna caspia Caspian Tern [808]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding 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 overfly marine area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area overfly marine area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Onychoprion anaethetus as Sterna anaethetus Bridled Tern [82845]		Breeding known to occur within area
Onychoprion fuscatus as Sterna fuscata Sooty Tern [90682]		Breeding 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
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may 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 overfly marine area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour 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 huttoni Hutton's Shearwater [1025]		Foraging, feeding or related behaviour known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Rostratula australis as Rostratula benghalensis (sensu lato)		
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area
Stercorarius skua as Catharacta skua		
Great Skua [823]		Species or species habitat may occur within area
Sterna dougallii		
Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons as Sterna albifrons		
Little Tern [82849]		Species or species habitat may occur within area
Sternula nereis as Sterna nereis		
Fairy Tern [82949]		Breeding known to occur within area
Thalassarche carteri		
Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to 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	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable	Species or species habitat may occur within area
Thalasseus bergii as Sterna bergii		
Greater Crested Tern [83000]		Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Thinornis cucullatus as Thinornis rubricollis Hooded Plover, Hooded Dotterel [87735]		Species or species habitat known to occur within area overfly marine area
Tringa brevipes as Heteroscelus brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area overfly marine area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area overfly marine area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area overfly marine area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area overfly marine area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		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

Scientific Name	Threatened Category	Presence Text
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 subelongatus West Australian Seahorse [66722]		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
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
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
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
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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 lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		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
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
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Neophoca cinerea		
Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Reptile		
Aipysurus pooleorum		
Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known 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
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour 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]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata		
Minke Whale [33]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
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
Delphinus delphis Common Dolphin, 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

Current Scientific Name	Status	Type of Presence
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Hyperoodon planifrons Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima as Kogia simus Dwarf Sperm Whale [85043]		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]		Congregation or aggregation 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

Current Scientific Name	Status	Type of Presence
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		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
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 related behaviour known to 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
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

Current Scientific Name	Status	Type of Presence
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		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]

Park Name	Zone & IUCN Categories
Perth Canyon	Habitat Protection Zone (IUCN IV)
Perth Canyon	Habitat Protection Zone (IUCN IV)
Perth Canyon	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Perth Canyon	Multiple Use Zone (IUCN VI)
Perth Canyon	Multiple Use Zone (IUCN VI)
Two Rocks	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Jurien	National Park Zone (IUCN II)
Perth Canyon	National Park Zone (IUCN II)
Perth Canyon	National Park Zone (IUCN II)
South-west Corner	National Park Zone (IUCN II)
Two Rocks	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Abrolhos	Special Purpose Zone (IUCN VI)

Park Name	Zone & IUCN Categories
Jurien	Special Purpose Zone (IUCN VI)
South-west Corner	Special Purpose Zone (Mining Exclusion) (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Protected Area Name	Reserve Type	State
Abrolhos Islands	Fish Habitat Protection Area	WA
Beagle Islands	Nature Reserve	WA
Beekeepers	Nature Reserve	WA
Boullanger, Whitlock, Favourite, Tern And Osprey Islands	Nature Reserve	WA
Buller, Whittell And Green Islands	Nature Reserve	WA
Cervantes Islands	Nature Reserve	WA
Dongara	Nature Reserve	WA
Drovers Cave	National Park	WA
Escape Island	Nature Reserve	WA
Essex Rocks	Nature Reserve	WA
Fisherman Islands	Nature Reserve	WA
Houtman Abrolhos Islands	National Park	WA
Jurien Bay	Marine Park	WA
Lancelin And Edwards Islands	Nature Reserve	WA
Lancelin Island Lagoon	Fish Habitat Protection Area	WA
Lesueur	National Park	WA
Lipfert, Milligan, Etc Islands	Nature Reserve	WA
Marmion	Marine Park	WA

Protected Area Name	Reserve Type	State
Nambung	National Park	WA
Neerabup	National Park	WA
Nilgen	Nature Reserve	WA
Outer Rocks	Nature Reserve	WA
Port Gregory	NRS Addition - Gazettal in Progress	WA
Ronsard Rocks	Nature Reserve	WA
Rottnest Island	State Reserve	WA
Sandland Island	Nature Reserve	WA
Southern Beekeepers	Nature Reserve	WA
Unnamed WA11883	5(1)(h) Reserve	WA
Unnamed WA33799	Nature Reserve	WA
Unnamed WA34039	5(1)(h) Reserve	WA
Unnamed WA44682	5(1)(h) Reserve	WA
Unnamed WA46983	5(1)(h) Reserve	WA
Unnamed WA46984	5(1)(h) Reserve	WA
Unnamed WA48205	5(1)(h) Reserve	WA
Unnamed WA48858	Nature Reserve	WA
Unnamed WA49994	Conservation Park	WA
Utcha Well	Nature Reserve	WA
Wanagarren	Nature Reserve	WA
Wedge Island	Nature Reserve	WA
Yanchep	National Park	WA

Nationally Important Wetlands [Resource Information]

Wetland Name	State
Hutt Lagoon System	WA
Lake Thetis	WA

Wetland Name	State
Loch McNess System	WA
Rottnest Island Lakes	WA

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Jurien East Road Upgrade, 3 km NNE Jurien Bay, WA	2020/8740		Post-Approval
Midwest Offshore Wind Farm	2022/09264		Assessment
Samphire Offshore Wind Farm	2022/09306		Assessment
Yogi Magnetite Project, 225km east, northeast of Geraldton, WA	2017/8124		Assessment
Controlled action			
Airborne sonar trials	2001/540	Controlled Action	Completed
Alkimos city centre and central development, WA	2015/7561	Controlled Action	Post-Approval
Alkimos Coastal Node	2020/8861	Controlled Action	Further Information Request
Alkimos Seawater Desalination	2019/8453	Controlled Action	Assessment Approach
Butler North District Open Space playing fields development, Wanneroo, WA	2017/8053	Controlled Action	Post-Approval
Catalina Residential Development	2010/5785	Controlled Action	Post-Approval
Coburn Mineral Sand Project	2003/1221	Controlled Action	Post-Approval
construction and operation of a unmanned platform at the Cliff Head oil field, a	2003/1300	Controlled Action	Post-Approval
Construction of the Oakajee Port and Rail Project	2011/5797	Controlled Action	Post-Approval
development of land based tourist facilities on Long Island	2006/2792	Controlled Action	Post-Approval
Eglinton/South Yanchep Residential Development	2011/6021	Controlled Action	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Eglinton Estates - Clearing of native vegetation from Lot 1007 & part Lot 1008	2010/5777	Controlled Action	Post-Approval
Hematite (iron ore) Mine and Beneficiation Plant	2001/542	Controlled Action	Completed
Jindee Residential Development	2012/6631	Controlled Action	Post-Approval
Karara Magnetite Project	2006/3017	Controlled Action	Post-Approval
Leeuwin Offshore Wind Farm	2022/9160	Controlled Action	Assessment Approach
Mitchell Freeway Extension and Wanneroo Road Upgrade, WA	2018/8367	Controlled Action	Post-Approval
Mitchell Freeway Extension between Burns Beach Rd and Hester Av, Neerabup, WA	2013/7091	Controlled Action	Post-Approval
Mount Gibson Iron Ore Pellet Project	2000/95	Controlled Action	Completed
Nava-1 Cable System	2001/510	Controlled Action	Completed
Oakajee Rail Development	2010/5500	Controlled Action	Post-Approval
Ocean Reef Marina Development	2009/4937	Controlled Action	Completed
open cut mine & assoc infrastructure	2005/2381	Controlled Action	Post-Approval
Port Enhancement Project	2001/266	Controlled Action	Post-Approval
Proposed Urban Development of Lots 1005 & 1006	2008/4638	Controlled Action	Post-Approval
Residential development,Lot 609, Yanchep Beach Road, Yanchep, WA	2014/7146	Controlled Action	Post-Approval
Residential development Lot 1004 Alkimos WA	2011/5902	Controlled Action	Post-Approval
Shark Hazard Mitigation Drum Line Program, WA	2014/7174	Controlled Action	Completed
Shenton Park Subdivision	2004/1479	Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Tourism Facility and Associated Infrastructure	2005/2038	Controlled Action	Post-Approval
Urban and Residential Development at Lot 9 Brighton	2011/6137	Controlled Action	Post-Approval
Urban development in accordance with the Local Structure Plan	2008/4601	Controlled Action	Post-Approval
Urban Residential Development at Lot 9049 Marmoin Avenue	2009/5155	Controlled Action	Post-Approval
Yanchep Rail Extension, WA	2018/8262	Controlled Action	Post-Approval
Not controlled action			
Alkimos seawater desalination plant, offshore investigations, WA	2018/8224	Not Controlled Action	Completed
Amberton West urban development - Part lot 9005 Eglington WA	2013/7068	Not Controlled Action	Completed
APX-West Fibre-optic telecommunications cable system, WA to Singapore	2013/7102	Not Controlled Action	Completed
Butler Railway Extension Project - Nowergup Depot Eastern Alignment	2011/5989	Not Controlled Action	Completed
Cliff Head 6 appraisal well	2004/1702	Not Controlled Action	Completed
Cliff Head Appraisal Wells	2003/938	Not Controlled Action	Completed
Construction of several passing lanes between Lancelin and Jurien Bay, WA	2015/7509	Not Controlled Action	Completed
Development of new Alkimos Wastwater Treatment Plant	2007/3259	Not Controlled Action	Completed
Drilling between Kalbarri and Cliff Head	2005/2185	Not Controlled Action	Completed
Eradication of the European House Borer, Perth metropolitan area, WA	2009/5027	Not Controlled Action	Completed
Establishment of a 12.7 ha Gypsum Mine	2007/3398	Not Controlled Action	Completed
Expedition 369-Australian Cretaceous Climate and Tectonics, Australian EEZ waters	2017/7891	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Exploration drilling program located in exploration permits WA-286-P and TP/15	2002/676	Not Controlled Action	Completed
Extension of 7.5km of the Joondalup Line electrified passenger railway from Cla	2010/5632	Not Controlled Action	Completed
Fremantle Ports Inner Harbour Capital Dredging Proposal	2005/2477	Not Controlled Action	Completed
Geo-science Investigations	2005/2069	Not Controlled Action	Completed
Glenfield Beach Project	2012/6359	Not Controlled Action	Completed
Hadda 1,Flying Foam 1,Magnat 1 exploration drill	2004/1697	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
Indian Ocean Drive Passing Lane and Widening 52-258 SLK	2017/7884	Not Controlled Action	Completed
Indian Ocean Drive Widening, Gingin Shire, WA	2018/8346	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
INDIGO West Submarine Telecommunications Cable, WA	2017/8126	Not Controlled Action	Completed
Lancelin Caravan Park Project, Hopkins Dve & Casserley Way, Lancelin	2015/7546	Not Controlled Action	Completed
Maintenance Dredging in the Geraldton Port Outer Channel	2010/5488	Not Controlled Action	Completed
Ocean Reef Marina Development, City of Joondalup, WA	2014/7237	Not Controlled Action	Completed
Oman Australia Cable Installation, WA	2021/8922	Not Controlled Action	Completed
Oman Australia Cable - Marine Route Survey	2020/8731	Not Controlled Action	Completed
Residential development, Lots 9010 and 9031, Yanchep Beach Rd, Yanchep	2016/7642	Not Controlled Action	Completed
Residential Development Eglinton West, Lot 5000 & part Lot 5001,	2014/7137	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Pipidinny Road, Eglinton			
residential subdivision	2005/1965	Not Controlled Action	Completed
Rottnest Lodge Redevelopment	2019/8565	Not Controlled Action	Completed
Scientific Sonar Trial	2002/680	Not Controlled Action	Completed
Seismic Survey, Bremer Basin, Mentelle Basin and Zeewyck Sub-basin	2004/1700	Not Controlled Action	Completed
WA-286-P Exploration Drilling Programme	2007/3863	Not Controlled Action	Completed
Yellowfin Tuna Aquaculture Trial	2003/1115	Not Controlled Action	Completed
Yngling-1 exploration well for WA-368-P	2007/3523	Not Controlled Action	Completed
Not controlled action (particular manner)			
2D Marine Seismic Survey in Permit Area WA-337-P	2003/1158	Not Controlled Action (Particular Manner)	Post-Approval
2D seismic survey	2008/4493	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey	2007/3800	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey Within WA-382-P	2007/3799	Not Controlled Action (Particular Manner)	Post-Approval
Australian Square Kilometre Array Pathfinder telescope & infrastructure	2009/4891	Not Controlled Action (Particular Manner)	Post-Approval
Australia to Singapore Fibre Optic Submarine Cable System	2011/6127	Not Controlled Action (Particular Manner)	Post-Approval
develop and operate a new deepwater port	2010/5760	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Grand Southern Margin 2D Marine Seismic Survey	2008/4599	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
Laying a submarine optical fibre telecommunications cable, Perth to Singapore and Jakarta	2014/7332	Not Controlled Action (Particular Manner)	Post-Approval
Marine Environmental Survey	2012/6275	Not Controlled Action (Particular Manner)	Post-Approval
Marine reconnaissance survey	2008/4466	Not Controlled Action (Particular Manner)	Post-Approval
Marine Seismic Survey for oil and gas in Commonwealth waters off the WA coast.	2004/1802	Not Controlled Action (Particular Manner)	Post-Approval
Marine Seismic Survey in Permit WA-481P	2012/6626	Not Controlled Action (Particular Manner)	Post-Approval
Nexus Energy Seismic survey WA	2006/2569	Not Controlled Action (Particular Manner)	Post-Approval
North Perth Marine Survey	2011/6067	Not Controlled Action (Particular Manner)	Post-Approval
Study of behavioural responses of Austn Humpback Whales to seismic surveys, offshore Dongara, WA	2013/6927	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			

Title of referral	Reference	Referral Outcome	Assessment Status
Referral decision			
3D Marine Seismic survey	2007/3725	Referral Decision	Completed
3D Marine Seismic survey	2007/3729	Referral Decision	Completed
3D Seismic Survey	2012/6245	Referral Decision	Completed
CO2 3D Seismic Survey Vlaming Sub-Basin	2012/6343	Referral Decision	Completed
Exploration Drilling 2014/2015 WA-481-P	2013/7043	Referral Decision	Completed
Grand Southern Margin 2D Marine Seismic Survey	2008/4573	Referral Decision	Completed
Narelle 3D Marine Seismic Survey	2008/4575	Referral Decision	Completed
Proposed exploration drilling activities, Abrolhos Commonwealth Marine Reserve	2013/6949	Referral Decision	Completed
Residential Subdivision of 60ha, Swan Location 2424	2004/1928	Referral Decision	Completed
Sonar Trials and Acoustic Trials	2001/538	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 90-120m depth	South-west
Cape Mentelle upwelling	South-west
Commonwealth marine environment surrounding the Houtman Abrolhos Islands	South-west
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	South-west
Perth Canyon and adjacent shelf break, and other west coast canyons	South-west
Western demersal slope and associated fish communities	South-west
Western rock lobster	South-west

Biologically Important Areas		
Scientific Name	Behaviour	Presence
Seabirds		
Anous stolidus Common Noddy [825]	Foraging	Known to occur
Anous stolidus Common Noddy [825]	Foraging (provisioning young)	Known to occur
Anous tenuirorstris melanops Australian Lesser Noddy [26000]	Foraging (provisioning young)	Known to occur
Ardenna carneipes Flesh-footed Shearwater [82404]	Aggregation	Known to occur
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging (in high numbers)	Known to occur
Eudyptula minor Little Penguin [1085]	Foraging (provisioning young)	Known to occur
Hydroprogne caspia Caspian Tern [808]	Foraging (provisioning young)	Known to occur
Larus pacificus Pacific Gull [811]	Foraging (in high numbers)	Former Range
Larus pacificus Pacific Gull [811]	Foraging (in high numbers)	Known to occur
Onychoprion anaethetus Bridled Tern [82845]	Foraging (in high numbers)	Known to occur
Onychoprion fuscata Sooty Tern [82847]	Foraging	Known to occur
Pelagodroma marina White-faced Storm petrel [1016]	Foraging (in high	Known to occur

Scientific Name	Behaviour	Presence
	numbers)	
Pterodroma macroptera macroptera Great-winged Petrel (macroptera race) [1035]	Foraging (provisioning young)	Known to occur
Pterodroma mollis Soft-plumaged Petrel [1036]	Foraging (in high numbers)	Known to occur
Puffinus assimilis tunneyi Little Shearwater [59363]	Foraging (in high numbers)	Known to occur
Sterna dougallii Roseate Tern [817]	Foraging	Known to occur
Sterna dougallii Roseate Tern [817]	Foraging (provisioning young)	Known to occur
Sternula nereis Fairy Tern [82949]	Foraging (in high numbers)	Known to occur
Seals		
Neophoca cinerea Australian Sea Lion [22]	Foraging (male)	Likely to occur
Neophoca cinerea Australian Sea Lion [22]	Foraging (male and female)	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Whales		
Balaenoptera musculus Blue and Pygmy Blue Whale [36]	Foraging (abundant food source)	Known to occur
Balaenoptera musculus Blue and Pygmy Blue Whale [36]	Foraging (high density)	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus Blue and Pygmy Blue Whale [36]	Foraging (on migration)	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging Area (annual high use area)	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Migration	Known to occur
Eubalaena australis Southern Right Whale [40]	Calving buffer	Known to occur
Eubalaena australis Southern Right Whale [40]	Seasonal calving habitat	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north)	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north and south)	Known to occur
Physeter macrocephalus Sperm Whale [59]	Foraging (abundant food source)	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

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

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

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

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 03-Mar-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	32
Listed Migratory Species:	43

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	57
Whales and Other Cetaceans:	14
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	12
Key Ecological Features (Marine):	2
Biologically Important Areas:	16
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
EEZ and Territorial Sea

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour likely to 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 likely to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	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
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may 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	Species or species habitat may occur within area
FISH		

Scientific Name	Threatened Category	Presence Text
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
MAMMAL		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour 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
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat likely to occur within area
REPTILE		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
SHARK		
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
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sphyrna lewini		
Scalloped Hammerhead [85267]	Conservation Dependent	Species or species habitat likely to occur within area

Listed Migratory Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
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
Diomedea amsterdamensis		
Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Hydroprogne caspia Caspian Tern [808]		Foraging, feeding or related behaviour 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]		Foraging, feeding or related behaviour likely to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may 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	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Migratory Marine Species		
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 may 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	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
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
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Mobula alfredi as Manta alfredi Reef Manta Ray, Coastal Manta Ray [90033]		Species or species habitat known to occur within area
Mobula birostris as Manta birostris Giant Manta Ray [90034]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
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 likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to 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 overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Hydroprogne caspia as Sterna caspia Caspian Tern [808]		Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Larus pacificus Pacific Gull [811]		Foraging, feeding or related behaviour known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		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
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Onychoprion anaethetus as Sterna anaethetus Bridled Tern [82845]		Foraging, feeding or related behaviour likely to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Stercorarius skua as Catharacta skua Great Skua [823]		Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may 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	Species or species habitat may occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		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

Scientific Name	Threatened Category	Presence Text
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		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
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 lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		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

Scientific Name	Threatened Category	Presence Text
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		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
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat likely to occur within area
Reptile		
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known 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

Scientific Name	Threatened Category	Presence Text
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour 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]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may 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 may 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
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species 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 likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
construction and operation of a unmanned platform at the Cliff Head oil field, a	2003/1300	Controlled Action	Post-Approval
Not controlled action			
Cliff Head 6 appraisal well	2004/1702	Not Controlled Action	Completed
Cliff Head Appraisal Wells	2003/938	Not Controlled Action	Completed
Drilling between Kalbarri and Cliff Head	2005/2185	Not Controlled Action	Completed
Exploration drilling program located in exploration permits WA-286-P and TP/15	2002/676	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
INDIGO West Submarine Telecommunications Cable, WA	2017/8126	Not Controlled Action	Completed
Not controlled action (particular manner)			
2D seismic survey	2008/4493	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey	2007/3800	Not Controlled Action (Particular Manner)	Post-Approval
Marine Seismic Survey for oil and gas in Commonwealth waters off the WA coast.	2004/1802	Not Controlled Action (Particular Manner)	Post-Approval
Marine Seismic Survey in Permit WA-481P	2012/6626	Not Controlled Action (Particular Manner)	Post-Approval
Westralia SPAN Marine Seismic Survey, WA & NT	2012/6463	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
3D Marine Seismic survey	2007/3729	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	South-west
Western rock lobster	South-west

Biologically Important Areas

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna pacifica		
Wedge-tailed Shearwater [84292]	Foraging (in high numbers)	Known to occur

Scientific Name	Behaviour	Presence
Hydroprogne caspia Caspian Tern [808]	Foraging (provisioning young)	Known to occur
Larus pacificus Pacific Gull [811]	Foraging (in high numbers)	Known to occur
Onychoprion anaethetus Bridled Tern [82845]	Foraging (in high numbers)	Known to occur
Pelagodroma marina White-faced Storm petrel [1016]	Foraging (in high numbers)	Known to occur
Puffinus assimilis tunneyi Little Shearwater [59363]	Foraging (in high numbers)	Known to occur
Sterna dougallii Roseate Tern [817]	Foraging	Known to occur
Sternula nereis Fairy Tern [82949]	Foraging (in high numbers)	Known to occur
Seals		
Neophoca cinerea Australian Sea Lion [22]	Foraging (male)	Likely to occur
Neophoca cinerea Australian Sea Lion [22]	Foraging (male and female)	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Migration	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north)	Known to occur
Megaptera novaeangliae Humpback Whale [38]	Migration (north and south)	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

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

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

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

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

Search Criteria

37 Registered Aboriginal Sites in Shapefile - MAW1243J_SC1_F2M_ProjectEMBA_F1gm2_E10ppb_D10ppb

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at AboriginalHeritage@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land **within or adjacent to** the following Indigenous Land Use Agreement(s): Yued Indigenous Land Use Agreement, Whadjuk People Indigenous Land Use Agreement.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.wa.gov.au/organisation/department-of-the-premier-and-cabinet/south-west-native-title-settlement.

Further advice can also be sought from the Department of Planning, Lands and Heritage at AboriginalHeritage@dplh.wa.gov.au.

Copyright

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.

Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:

- **File Restricted = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact AboriginalHeritage@dplh.wa.gov.au.
- **Boundary Restricted = No:** Place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least $4km^2$) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Restrictions:**
  - **No Restrictions:** *Anyone* can view the information.
  - **Male Access Only:** Only *males* can view restricted information.
  - **Female Access Only:** *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
1063	GREENOUGH RIVER MIDDEN.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Ceremonial, Midden / Scatter, Camp	*Registered Knowledge Holder names available from DPL	269079mE 6806349mN Zone 50 [Unreliable]	S02850
3418	ROTTNEST: PEACOCK HILL	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	361696mE 6459232mN Zone 50 [Reliable]	S02700
3440	ROTTNEST: CYCLEWAY	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	361485mE 6459571mN Zone 50 [Reliable]	S02750
3467	ROTTNEST: TRANSIT CELL	No	No	No Gender Restrictions	Registered Site	Man-Made Structure	*Registered Knowledge Holder names available from DPL	362138mE 6459231mN Zone 50 [Reliable]	S02698
3468	ROTTNEST: OLD HOSPITAL	No	No	No Gender Restrictions	Registered Site	Historical	*Registered Knowledge Holder names available from DPL	361974mE 6459164mN Zone 50 [Reliable]	S02699
3509	KARLI SPRING.	No	No	No Gender Restrictions	Registered Site	Mythological, Water Source	*Registered Knowledge Holder names available from DPL	373739mE 6499949mN Zone 50 [Reliable]	S02589
3540	ROTTNEST: LODGE/QUAD.	No	No	No Gender Restrictions	Registered Site	Ceremonial, Historical, Repository / Cache	*Registered Knowledge Holder names available from DPL	362020mE 6459118mN Zone 50 [Reliable]	S02555
3567	MINDARIE WAUGAL	Yes	Yes	No Gender Restrictions	Registered Site	Artefacts / Scatter, Mythological	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	S02471
3653	MOORE RIVER	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	358639mE 6530649mN Zone 50 [Unreliable]	S02269
3780	ROTTNEST: LONGREACH BAY	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	361505mE 6459844mN Zone 50 [Reliable]	S02116
3781	Wadjemup Aboriginal Prisoners Cemetery (ROTTNEST)	No	No	No Gender Restrictions	Registered Site	Skeletal Material / Burial	*Registered Knowledge Holder names available from DPL	361889mE 6459235mN Zone 50 [Reliable]	S02118
3782	ROTTNEST: GOLF COURSE	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	361588mE 6459401mN Zone 50 [Reliable]	S02119

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
4667	GREENOUGH RIVER	No	No	No Gender Restrictions	Registered Site	Midden / Scatter, Skeletal Material / Burial	*Registered Knowledge Holder names available from DPL	271638mE 6801651mN Zone 50 [Unreliable]	S02275
5287	SOUTH GATES BURIAL SITE	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Skeletal Material / Burial	*Registered Knowledge Holder names available from DPL	268738mE 6808451mN Zone 50 [Unreliable]	S01009
5338	MIDDLE HEAD MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	311639mE 6650650mN Zone 50 [Unreliable]	S00941
17596	Limestone Reef	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DPL	369301mE 6508657mN Zone 50 [Reliable]	
17599	Yanchep Beach	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DPL	369739mE 6508075mN Zone 50 [Reliable]	
17958	SGA-2	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	270388mE 6802800mN Zone 50 [Reliable]	
17959	SGA-3	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Shell	*Registered Knowledge Holder names available from DPL	271138mE 6802150mN Zone 50 [Reliable]	
18794	Westbank Beach Burial	Yes	Yes	No Gender Restrictions	Registered Site	Skeletal Material / Burial, Other: Isolated Artefacts	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
20008	Gingin Brook Waggyl Site	Yes	Yes	No Gender Restrictions	Registered Site	Historical, Mythological, Camp, Hunting Place, Plant Resource, Water Source	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
20051	Kwelena Mambakort - Wedge Island	Yes	Yes	No Gender Restrictions	Registered Site	Artefacts / Scatter, Ceremonial, Grinding Patches / Grooves, Historical, Midden / Scatter, Rockshelter, Arch Deposit, Camp, Hunting Place, Meeting Place, Shell, Water Source	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
20052	Wedge Island Coast Sandune Quinilup Springs/ Yonga Kep Wari	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Grinding Patches / Grooves, Historical, Midden / Scatter, Camp, Hunting Place, Meeting Place, Named Place, Water Source	*Registered Knowledge Holder names available from DPL	326413mE 6593758mN Zone 50 [Unreliable]	

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
20749	MOORE RIVER WAUGAL	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DPL	389623mE 6549812mN Zone 50 [Reliable]	
20772	Jindalee	Yes	Yes	No Gender Restrictions	Registered Site	Mythological, Natural Feature, Water Source	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
20853	Geraldton Southern Transport Corridor Field Site 04	No	No	No Gender Restrictions	Registered Site	Natural Feature	*Registered Knowledge Holder names available from DPL	264906mE 6813588mN Zone 50 [Reliable]	
21588	Kinsale	No	No	No Gender Restrictions	Registered Site	Mythological, Plant Resource	*Registered Knowledge Holder names available from DPL	376880mE 6494205mN Zone 50 [Reliable]	
21589	Rosslare Soak	No	No	No Gender Restrictions	Registered Site	Ceremonial, Mythological, Camp, Water Source	*Registered Knowledge Holder names available from DPL	376768mE 6493683mN Zone 50 [Reliable]	
21620	Chandala Brook #Duplicate of ID 3525	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DPL	389626mE 6549540mN Zone 50 [Reliable]	
24761	Greenough River	No	No	No Gender Restrictions	Registered Site	Mythological, Natural Feature	*Registered Knowledge Holder names available from DPL	389523mE 6893919mN Zone 50 [Reliable]	
31746	Golf Course South Glass Artefact Scatter	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Arch Deposit	*Registered Knowledge Holder names available from DPL	361571mE 6459258mN Zone 50 [Reliable]	
31747	Golf Course Northeast Site Glass Artefact Scatter	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Arch Deposit	*Registered Knowledge Holder names available from DPL	361774mE 6459604mN Zone 50 [Reliable]	
39235	WAD-2021-001	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Historical	*Registered Knowledge Holder names available from DPL	361745mE 6459415mN Zone 50 [Reliable]	
39236	WAD-2021-003	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Historical	*Registered Knowledge Holder names available from DPL	361665mE 6459662mN Zone 50 [Reliable]	
39237	WAD-2021-002	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Historical	*Registered Knowledge Holder names available from DPL	361800mE 6459454mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

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39238	WAD-2021-004	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Historical, Arch Deposit	*Registered Knowledge Holder names available from DPL	361602mE 6459630mN Zone 50 [Reliable]	
39239	SSPAA-2017-01	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Historical, Arch Deposit	*Registered Knowledge Holder names available from DPL	361746mE 6459336mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

List of Other Heritage Places

Search Criteria

60 Other Heritage Places in Shapefile - MAW1243J_SC1_F2M_ProjectEMBA_F1gm2_E10ppb_D10ppb

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- Restrictions:
  - No Restrictions: Anyone can view the information.
  - Male Access Only: Only males can view restricted information.
  - Female Access Only: Only females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Aboriginal Heritage Inquiry System

List of Other Heritage Places

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
1064	SOUTHGATE DUNE	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	268638mE 6806651mN Zone 50 [Unreliable]	S02851
1067	GREENOUGH RIVER WELL.	No	No	No Gender Restrictions	Lodged	Camp, Water Source, Other: SOURCE	*Registered Knowledge Holder names available from DPL	269479mE 6805314mN Zone 50 [Unreliable]	S02854
3193	LEDGE POINT WELL.	No	No	No Gender Restrictions	Lodged	Water Source	*Registered Knowledge Holder names available from DPL	344297mE 6559168mN Zone 50 [Reliable]	S00600
3237	LEDGE POINT.	No	No	No Gender Restrictions	Stored Data / Not a Site	Camp, Water Source	*Registered Knowledge Holder names available from DPL	345136mE 6565151mN Zone 50 [Unreliable]	S00542
3357	GUILDERTON SOUTH.	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Camp	*Registered Knowledge Holder names available from DPL	358639mE 6529649mN Zone 50 [Unreliable]	S00149
3358	MOORE RIVER SOUTH 1 - 5.	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Camp	*Registered Knowledge Holder names available from DPL	357639mE 6529649mN Zone 50 [Unreliable]	S00150
3399	ROTTNEST: LITTLE ARMSTRONG.	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Arch Deposit	*Registered Knowledge Holder names available from DPL	358819mE 6459542mN Zone 50 [Reliable]	S02775
3400	ROTTNEST: CITY OF YORK BAY.	No	No	No Gender Restrictions	Stored Data / Not a Site	Artefacts / Scatter, Arch Deposit	*Registered Knowledge Holder names available from DPL	357886mE 6459042mN Zone 50 [Reliable]	S02776
3443	ROTTNEST: CEMETERY NORTH	Yes	Yes	No Gender Restrictions	Stored Data / Not a Site	Modified Tree, Skeletal Material / Burial	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	S02668
3541	ROTTNEST: LODGE EXTENSIONS	No	No	No Gender Restrictions	Stored Data / Not a Site		*Registered Knowledge Holder names available from DPL	361964mE 6459006mN Zone 50 [Reliable]	S02556
3542	ROTTNEST: SHIELD.	No	No	No Gender Restrictions	Stored Data / Not a Site	Other: SHIELD (NO STRATIGR.CONTEXT	*Registered Knowledge Holder names available from DPL	361854mE 6459196mN Zone 50 [Reliable]	S02557
3776	INDIAN OCEAN	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological	*Registered Knowledge Holder names available from DPL	372624mE 6445362mN Zone 50 [Reliable]	S02169

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
3783	ROTTNEST: VLAMINGHS LOOKOUT	No	No	No Gender Restrictions	Stored Data / Not a Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	361763mE 6458807mN Zone 50 [Reliable]	S02120
3784	ROTTNEST: STABLES	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	360989mE 6458699mN Zone 50 [Reliable]	S02121
3829	ROTTNEST: FISH HOOK BAY	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Engraving	*Registered Knowledge Holder names available from DPL	353782mE 6455943mN Zone 50 [Reliable]	S02099
4403	NABAROO.	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Camp	*Registered Knowledge Holder names available from DPL	344639mE 6558650mN Zone 50 [Unreliable]	S00049
4515	GREENHEAD MIDDEN	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	303672mE 6671892mN Zone 50 [Reliable]	S02657
4669	GREENOUGH MOUTH	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	268638mE 6807651mN Zone 50 [Unreliable]	S02280
4761	GREENOUGH MIDDEN	No	No	No Gender Restrictions	Lodged	Midden / Scatter	*Registered Knowledge Holder names available from DPL	270428mE 6803106mN Zone 50 [Unreliable]	S01964
5281	GREENHEAD	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	303690mE 6671575mN Zone 50 [Reliable]	S01003
5282	SANDLAND ISLAND	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DPL	307638mE 6655650mN Zone 50 [Unreliable]	S01004
15297	ENEABBA WEST.	No	No	No Gender Restrictions	Stored Data / Not a Site	Ceremonial, Fish Trap, Camp, Water Source, Other: TRACK	*Registered Knowledge Holder names available from DPL	305214mE 6704425mN Zone 50 [Reliable]	S03045
17957	SGA-1	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Shell	*Registered Knowledge Holder names available from DPL	268388mE 6806900mN Zone 50 [Reliable]	
17960	SGA-4	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter, Shell	*Registered Knowledge Holder names available from DPL	269320mE 6804150mN Zone 50 [Reliable]	

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
17962	SGS-1	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	268538mE 6806550mN Zone 50 [Reliable]	
17963	SGS-2	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	268638mE 6806150mN Zone 50 [Reliable]	
17964	SGS-3	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	270138mE 6804850mN Zone 50 [Reliable]	
17965	SGS-4	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	269350mE 6803700mN Zone 50 [Reliable]	
17966	SGS-5	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	269900mE 6803000mN Zone 50 [Reliable]	
17967	SGS-6	No	No	No Gender Restrictions	Lodged	Shell	*Registered Knowledge Holder names available from DPL	271338mE 6801600mN Zone 50 [Reliable]	
19138	Wetlands & Watercourses Moore River to Bullsbrook	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
19183	Red Gully Creek	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological, Plant Resource	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
20053	Wedge Island Camping Ground Shell Middens	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Historical, Midden / Scatter, Camp	*Registered Knowledge Holder names available from DPL	326883mE 6592327mN Zone 50 [Unreliable]	
20592	Bathurst Point Lighthouse Site	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Other: "Site is very old".	*Registered Knowledge Holder names available from DPL	362135mE 6459843mN Zone 50 [Reliable]	
20650	Lennard Brook	No	No	No Gender Restrictions	Lodged	Mythological, Natural Feature, Water Source, Other: Creek	*Registered Knowledge Holder names available from DPL	389582mE 6549648mN Zone 50 [Reliable]	

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
20862	Rottnest Island (Wadjemup)	No	No	No Gender Restrictions	Stored Data / Not a Site	Artefacts / Scatter, Historical, Man-Made Structure, Midden / Scatter, Mythological, Quarry, Rockshelter, Skeletal Material / Burial, Arch Deposit, Camp, Hunting Place, Massacre, Meeting Place, Natural Feature, Shell, Water Source	*Registered Knowledge Holder names available from DPL	359511mE 6457858mN Zone 50 [Reliable]	
21616	Boonanarring Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
21617	Wallering Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
21618	Nullilla Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
21619	Breera Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DPL	396128mE 6561778mN Zone 50 [Reliable]	
23053	Alkimos Waugal	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological, Natural Feature, Plant Resource, Water Source, Other: Dreaming Trail	*Registered Knowledge Holder names available from DPL	374083mE 6501474mN Zone 50 [Unreliable]	
23867	Bathurst Point Artefact	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter	*Registered Knowledge Holder names available from DPL	362175mE 6459816mN Zone 50 [Reliable]	
24404	Swamp	No	No	No Gender Restrictions	Lodged	Mythological, Water Source	*Registered Knowledge Holder names available from DPL	374344mE 6499148mN Zone 50 [Unreliable]	
24406	Dunes	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological, Natural Feature	*Registered Knowledge Holder names available from DPL	375001mE 6499683mN Zone 50 [Reliable]	
24408	Dunes	No	No	No Gender Restrictions	Lodged	Mythological, Natural Feature	*Registered Knowledge Holder names available from DPL	375050mE 6497881mN Zone 50 [Unreliable]	
24731	Kornt Gil-Git	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Fish Trap, Midden / Scatter, Camp, Shell	*Registered Knowledge Holder names available from DPL	325870mE 6595318mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

List of Other Heritage Places

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
26191	Chillion Kornt, Wetj Boya	Yes	Yes	No Gender Restrictions	Lodged	Artefacts / Scatter, Fish Trap, Midden / Scatter, Rockshelter	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
31748	Golf Course Isolated Finds	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Other: 7 - 10 isolated artefacts	*Registered Knowledge Holder names available from DPL	361471mE 6459063mN Zone 50 [Reliable]	
36974	Lake Thetis	No	No		Lodged		*Registered Knowledge Holder names available from DPL	315872mE 6623496mN Zone 50 [Reliable]	
38004	Rottnest Island Wadjemup	Yes	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Fish Trap	*Registered Knowledge Holder names available from DPL	361589mE 6459090mN Zone 50 [Reliable]	
38567	Moodja Keepla	No	No		Lodged	Mythological	*Registered Knowledge Holder names available from DPL	327452mE 6589735mN Zone 50 [Reliable]	
38568	Kart Balai	No	No		Lodged	Artefacts / Scatter, Ceremonial, Midden / Scatter, Mythological, Camp, Meeting Place, Shell	*Registered Knowledge Holder names available from DPL	328100mE 6589537mN Zone 50 [Reliable]	
38765	Kapa	Yes	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Ceremonial, Man-Made Structure, Midden / Scatter, Mythological, Meeting Place, Named Place, Shell	*Registered Knowledge Holder names available from DPL	327885mE 6589237mN Zone 50 [Reliable]	
38767	Moort Koornt	Yes	Yes	No Gender Restrictions	Lodged	Artefacts / Scatter, Grinding Patches / Grooves, Historical, Midden / Scatter, Arch Deposit, Camp, Meeting Place, Named Place, Shell, Water Source	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
38768	Cala Koorliny Kada	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Ceremonial, Midden / Scatter, Camp, Shell	*Registered Knowledge Holder names available from DPL	327975mE 6590128mN Zone 50 [Reliable]	
38769	Nyininy Boya	Yes	Yes	No Gender Restrictions	Lodged	Artefacts / Scatter, Ceremonial, Midden / Scatter, Camp, Shell, Water Source	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	
38814	Wedj Noongar Koorl	Yes	Yes	Male Access Only	Lodged	Artefacts / Scatter, Grinding Patches / Grooves, Camp, Shell	*Registered Knowledge Holder names available from DPL	Not available when location is restricted	

Aboriginal Heritage Inquiry System

List of Other Heritage Places

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
38905	JB21-E01	No	No	No Gender Restrictions	Lodged	Water Source	*Registered Knowledge Holder names available from DPL	312139mE 6648375mN Zone 50 [Reliable]	
39352	WH22-002	No	No	No Gender Restrictions	Lodged	Ceremonial, Historical, Mythological, Natural Feature, Other: Soak	*Registered Knowledge Holder names available from DPL	362314mE 6458594mN Zone 50 [Reliable]	
39353	WH22-001	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Other: glass artefacts	*Registered Knowledge Holder names available from DPL	362356mE 6458546mN Zone 50 [Reliable]	

Appendix C:
Community Consultation and Engagement Plan

Eureka 3D
MARINE SEISMIC SURVEY

Community Consultation and Engagement Plan

February 2023

Pilot Energy

Revision History

Revision	Date	Description
0	31/1/23	Reviewed by Pilot Energy
1	6/2/23	Updated for publication

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Table of Contents

Definitions and Abbreviations

Term	Definition
Activities	In reference to consultation with a relevant person, activities are a thing a person or group does/is already doing.
ALARP	As Low As Reasonable Practicable
CCEP	Community Consultation and Engagement Plan
EIA	Environmental Impact Assessment
EMBA	Environment that May Be Affected
EP	Environment Plan
ERA	Environmental Risk Assessment
Function	In reference to consultation with a relevant person, functions are a role that is performed or something to be exercised.
Interests	In reference to consultation with a relevant person, interests are any interest above that of the public.
MSS	Marine Seismic Survey
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OSMP	Operational and Scientific Monitoring Plan
Petroleum activity	means operations or works in an offshore area undertaken for the purpose of exercising a right conferred on a petroleum titleholder under the OPGGS Act by a petroleum title
Relevant person	A person specified under Division 2.2A of the Regulations
The Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
Work Program	The petroleum activities proposed to be carried out to meet our corporate objectives

Introduction

Pilot Energy Limited ("Pilot"), a publicly listed Australian company, holds a 100% interest in WA-481-P, an oil and gas exploration permit located in the offshore Northern Perth Basin, Western Australia (**Figure 1**). As part of its permit work commitments, Pilot intends to carry out the Eureka 3D Marine Seismic Survey in WA-481-P.

As part of operating in Australia, Pilot recognises the need to introduce ourselves to local communities, build relationships, and gain our social licence to operate. We also are required to undertake consultation in preparation of environmental approvals called an Environment Plan (EP). This Community Consultation and Engagement Plan (CCEP) is a key pillar for Pilot in describing how we will undertake our consultation activities in Australia.

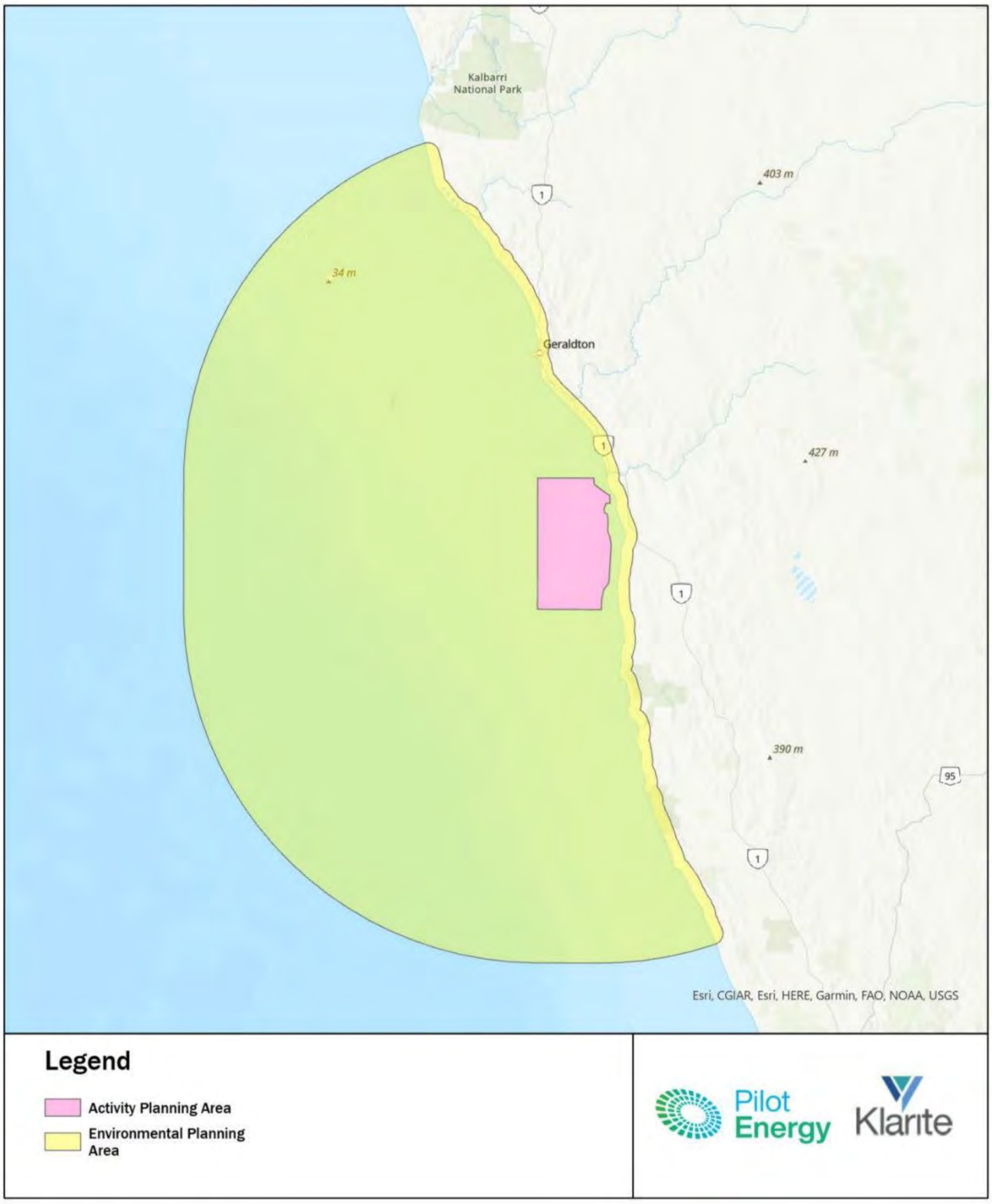


***Figure 1** – Exploration permit WA-481-P, offshore Western Australia*

Scope

This document covers community consultation and engagement in the broadest meaning of those terms. It does not cover elected officials nor the public. The scope of this CCEP is to describe the process Pilot will use to progress and document consultation and engagement activities in relation to the Eureka 3D MSS Environment Plan (EP).

This document is prepared as part of the EP and will be submitted to NOPSEMA for assessment. It is published at the commencement of the preparation of the EP to share our community consultation and engagement activities and support effective consultation.

Aim and Objectives

The aim of Pilot's consultation efforts is to ensure that the petroleum activity is planned and executed in a way that respects the rights, interests and concerns of all relevant persons and that it is socially and environmentally responsible.

The objectives of Pilot's consultation efforts are to:

- Identify relevant persons who may be affected by the activity.
- Assist in providing sufficient information and time to allow relevant people to make an informed assessment of the potential consequences on their functions, interests and activities.
- Gather knowledge about the environmental values, sensitivities and social and cultural features of the areas in which we intend to operate.
- Reveal feedback from the community and address any objections and claims of relevant persons that may arise.
- Help ensure that environmental risks from the activity are reduced to ALARP and acceptable levels
- Establish information flows between Pilot and relevant persons.
- Help identify, and consider, important environmental characteristics or mitigation opportunities presented by relevant persons.
- Ensure that the magnitude and significance of impacts have been properly assessed.

Outcomes

There are two target outcomes of Pilot's community consultation and engagement activities.

1. Improve the predictive quality of the environmental impact and risk assessments.
2. Gain and maintain social licence to operate in Australia.
3. Perform the consultations as required by local Australian environmental law in a timely manner.

Background and Context

Work Program Overview for WA-481-P

Pilot plans several offshore petroleum activities within a coordinated Work Program to achieve its exploration objectives. The activities include 2D seismic data reprocessing, geological and geophysical studies, 3D and 2D seismic acquisition, and drilling of an exploration well. Further activities may be added to the Work Program dependent on the outcomes of previous activities.

Legislation and Other Requirements

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (the Regulations) are the prevailing legislation that govern how Pilot is required to engage in offshore petroleum activities in WA-481-P. In December 2022, the Federal Court of Australia considered parts of the Regulations in a landmark judgement[1]. The findings of the Federal Court have been incorporated into this CCEP. Other guidelines considered in the preparation of this CCEP are included in the References.

Acceptable Levels of Environmental Impact and Risk

Section 280 of the OPGGS Act requires that a titleholder must carry on its activities in a manner that does not interfere with navigation, fishing, conservation of the resources of the sea and seabed, exploration for, recovery of or conveyance of a mineral, construction or operation of a pipeline, offshore infrastructure activities, or the enjoyment of native title rights and interests, or other lawful activities to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the titleholder. One of the objectives of the Regulations is that petroleum activities must be carried out in a manner by which the environmental impacts and risks will be of an acceptable level. Importantly, these clauses implement Australian government policy about mutual marine use and a policy that recognises the offshore petroleum industry is not a no impact industry.

This plan uses these clauses to govern our engagement and consultation processes, activities, and decision making. Acceptable levels of environmental impact and risk are context specific, so they are established in the preparation of each individual Environment Plan. However, generally, the following levels of environmental impact and risk are considered of an acceptable level:

- No person, organisation, or authority is worse-off because of offshore petroleum activities.
- Environmental impacts that are short-term, temporary, and recoverable.
- Environmental risks have consequences that are preventable and effectively managed.

These general criteria will be complemented by additional defined acceptable levels of environmental impact and risk that will be activity-specific and developed during consultation in the preparation of the Environment Plan.

Engagement and Consultation Principles

This document is prepared in accordance with ISO 31001, which stipulates consultation as integral to all stages of risk management. When we engage with external authorities, organisations, or persons the following principles guide our work. We recognise that effective consultation requires the fostering of relationships, a clear and co-designed process, and the identification of substantive issues. The following principles apply to these three preconditions for effective consultation and in all our activities.

1. Open: Being honest, open and direct in our engage with relevant person.
2. Inclusive: Hearing people and listening to understand. We want to be easy to talk to.

[1] Santos NA Barossa Pty Ltd v Tipakalippa [2022] FCAFC 193

3. Collaborative: Encourage people to be part of the engagement and work towards minimising impacts on each other.
4. Respectful: Valuing the knowledge and experience of people. Grateful for people's time and input.
5. Meaningful: Ensuring that our communication can be reciprocal, timely and empowering.

Relevant Persons Identification

Identification of potentially affected communities is the critical first step in being able to successfully manage and address the concerns and issues of groups, organizations, or individuals who may be affected by or may impact the Work Program. The community can be disaggregated in many ways and a person can reveal themselves within the community differently. Pilot is proactive in its identification activities which are undertaken at the start of the activity. Identification activities are ongoing throughout the tenure of the title with increased efforts in preparation of an EP.

Categorising the people within the community is a useful way to group activities and plan engagement activities that are fit-for-purpose for those groups. The legislation uses four main categories: the public, authorities, organisations, and persons. The Regulations create a distinction between the public and *relevant persons* (authorities, organizations, and persons) who are mandatory consultees in the preparation of each EP.

Pilot will adopt these categories for its activities.

Consultation with the Public

Pilot will facilitate two streams of activities. One stream of activities relate to public engagement and the other relates to consultation with relevant persons. Both streams commence with the publication of a dedicated activity-specific website. Comments raised through the website will be taken to be submitted by members of the public. The website will go live on 1 February 2023 and end when the EP is no longer in force. After 5 months, on 30 June 2023, both streams will pause while the EP is prepared for submission to NOPSEMA.

Running these two streams of consultation supports the broadest search for relevant persons, who are a subset of the public. It also allows support to non-relevant persons, or persons who opt out of the formal consultation process, to engage with our activities in a way that works for them. The two streams of relevant persons consultation and public engagement are shown in Figure 2 below.

An activity specific website will be a central repository of information about the activity which will allow the public to raise concerns, share location-based information, and provide feedback to Pilot regardless of whether they meet the definition of being a relevant person. This includes the provision of initial information to the public sufficient to allow a person to self-identify as a relevant person. Persons who contribute to the preparation of the EP through the website will be providing information directly into the EIA and ERA processes that are being carried out in parallel to the engagement activities. Commenting through the website does not qualify as a relevant person and they will be encouraged to undertake a consultation survey to determine if they are a relevant person.

The public is a broader group of people than those who can be identified as relevant persons. Without proactive action from Pilot, the first time the public are made aware of the activity in the EP is too late for relevant persons to self-identify as someone who may be affected by our activities. Therefore, Pilot will publish notices in print media, social media, in local radio adverts, and online to:

- Notify the public of the commencement of the preparation of an EP.
- Encourage relevant persons to self-identify to be consulted with.
- Notify the public of the commencement of the consultation process.
- Encourage people concerned to visit the website.

In addition to Pilot's public engagement activities the Regulations provide a mechanism for the public to make comment on each EP for seismic or exploration drilling activity. This mechanism allows the public to comment directly to the regulator on their views about the proposed activity. The public comment period occurs upon submission of the EP.

Relevant Persons: Authorities, Organisations, and Persons

The steps above cannot be relied upon to identify all relevant persons. Pilot will be proactive in pursuing relevant persons and providing the opportunity for each of them to be consulted as per the regulated process. Pilot must tell the authority, person or organisation that they have been identified as a relevant person and that the subsequent consultation effort is being undertaken as per the prescribed process and we are obligated to expressly advise them of titleholder obligations for consultation.

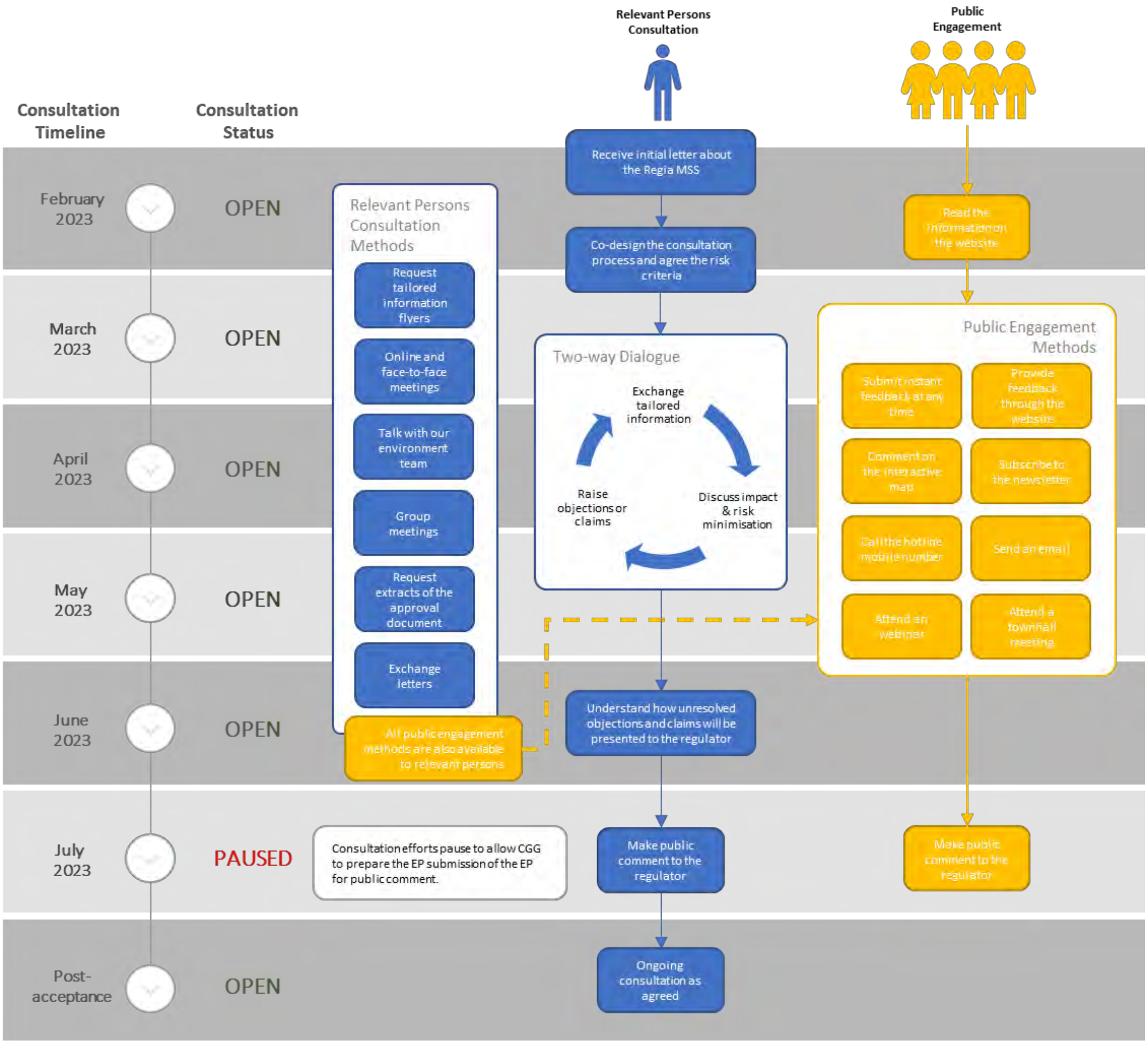


Figure 2 - Eureka 3D MSS Consultation Activities

Identification of relevant persons

Pilot uses the following methods to find authorities, organisations, and persons who may be affected by our activities.

1. **Contact government agencies and organizations:** Relevant government agencies may have information about individuals and organizations that may be affected by the activity.

2. **Consult with local community groups:** Reach out to local community groups, such as those focused on environmental conservation or fishing, as they may have members whose interests or activities could be affected by the activity.
3. **Consult with local Indigenous groups:** Indigenous groups may have specific cultural or spiritual interests and activities that could be affected by the activity, it's important to consult with them and ensure their rights are respected.
4. **Conduct online research:** We will search for news articles or press releases about similar activities in the area and identifying individuals or organizations that were mentioned.
5. **Advertise in Local Newspapers and on Local Radio stations:** Advertising in local newspapers or on local radio stations to notify the public about the planned activity and ask for any persons with specific interests or activities that may be affected by your activity to come forward.
6. **Contact industry associations:** We will reach out to industry associations related to fishing, shipping, and oil and gas exploration in the area, as they may have members whose interests or activities could be affected by the activity.
7. **Contact local businesses:** We will reach out to local businesses, such as tour operators or accommodation providers, as they may have customers whose interests or activities could be affected by the activity.
8. **Contact local educational institutions:** We will reach out to local educational institutions, such as universities or research centres, as they may have researchers or students whose interests or activities could be affected by the activity.
9. **Use social media:** We will use social media to find relevant persons by searching for hashtags or keywords related to your activity, following local organizations or groups in the area, and reaching out to people who have commented on or shared posts about similar activities.
10. **Conduct a survey:** We will conduct a survey to reach out to a wide range of people and gather information about their interests and activities that may be affected by the activity.
11. **Attend local community events:** We will search for local community events that may be appropriate for Pilot to participate in and engage with aggregations of people, some of whom may be affected by the activity.

Authorities

Authorities are relevant to each of Pilot's activities for the WA-481-P Work Program. Each Department or Agency has been identified through online searches, expert advice, review of legislation and review of previous EPs adjacent to the title. Some authorities have published specific guidelines on how they wish to be consulted as relevant persons under the Regulations. These have been hyperlinked in the list below.

Australian Commonwealth Agencies

NOPSEMA Guideline GL1887 identifies the following government agencies as relevant persons as they have responsibilities within the Commonwealth marine area.

- Australian Fisheries Management Authority (AFMA)
- Australian Maritime Safety Authority (AMSA)
- Department of Agriculture, Fisheries and Forestry (DAFF)
    - Fisheries
    - Biosecurity (vessels)
    - Biosecurity (marine pests)
- Department of Climate Change, Energy, the Environment and Water (DEECCW)
    - Australian Antarctic Division (AAD)
    - Underwater Cultural Heritage
    - Sea Dumping
- Department of Defence (DoD)

- Australian Hydrographic Office (AHO)
- Department of Foreign Affairs and Trade (DFAT)[2]
- Director of National Parks (DNP)

The full list[3] of Commonwealth agencies was reviewed to find additional Commonwealth agencies. The following agencies were identified as relevant persons:

- Australian Communications and Media Authority (ACMA)
- Commonwealth Fisheries Association (CFA)
- National Native Title Tribunal (NNTT)
- Maritime Border Command (MBC)

Western Australian Authorities

The full list[4] of Western Australian agencies will be reviewed to find relevant persons. The following agencies will be contacted to determine whether they are relevant persons.

- Environmental Protection Authority (EPA)
- Heritage Council of Western Australia
- Department of Primary Industries and Regional Development (DPIRD)
- Department of Biodiversity, Conservation and Attractions (DBCA)
- Department of Transport (DoT)
- Department of Planning Lands and Heritage (DPLH)
- Department of Mines, Industry Regulation and Safety (DMIRS).

People and Organisations

The Regulations specify that relevant persons include people or organizations whose functions, interests, and activities may be affected by the petroleum activity. The Federal Court of Australia helped to define these terms in the appeal decision of Tipakalippa v National Offshore Petroleum Safety and Environmental Management Authority (No 2) [2022] FCA 1121.

Pilot has grouped people and organisations into subject-centred categories because this allows for tailoring identification, communication, and engagement strategies to each category. An additional benefit is that the search for one member of a group can often lead to the discovery of additional members of that group. The following subject-centred groups have been identified in the preparation of this plan. A person could be associated with more than one of these groups while it is more likely that an organisation will associate with just one.

Subject-centred Groupings			
Commerce	Tourism operators	Traditional Owners	Port users
Petroleum titleholders	Commercial fishers	Recreational fishers	Native title land councils
Conservation groups	Fishing associations	Commercial shipping	Local councils
Educational bodies	Other marine users	Ports and harbours	Heritage groups

The search for persons or organizations who are relevant persons starts as a global public search because the definitions of functions, interests, and activities are not geographically constrained. However, certain groups, such as other marine users, are likely to be proximate to the activity.

[2] Not a relevant person as the proposed activity does not cross into or impact on waters outside of Australia's maritime jurisdiction.

[3] Full list of Commonwealth agencies can be found here https://www.directory.gov.au/departments-and-agencies

[4] The full list of Western Australian agencies can be found here https://www.directory.gov.au/departments-and-agencies

We assume that there will be more relevant persons proximate to the activity and therefore consultation efforts will be greater in these locales. However, the subject-centred approach allows identification of relevant persons to be tailored within that group allowing global searches to be carried out where this is more likely to reveal relevant persons.

Identification of relevant persons by subject-centred groups

The identification of persons or organizations within the subject-centred groups will be tailored and will evolve as engagement within these groups is carried out. In all cases each person contacted will be asked to support in the identification of relevant persons and encouraged to share information about the petroleum activity and how to contact us.

Information about each of these subject-centred groups that supports the identification of relevant persons can be found in materials published by the DCCEEW under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) including:

- **Plans of Management:** including for World and National Heritage places, Ramsar wetlands, Australian marine parks, Commonwealth reserves and Commonwealth Heritage places.
- **Recovery Plans:** for listed threatened species and ecological communities
- **Policy Statements:** including significance impact guidelines and industry specific guidelines
- **Other material:** including management principles, online databases, factsheets and other publications.

Tourism operators

To identify tourism operators the following searches will be performed:

- Online searches for marine tours, and recreational experiences such as marine mammal observations, diving, and thrill-seeking experiences.
- Request to Tourism Australia and Tourism WA to query any databases of local businesses along the coastline within the socio-economic risk EMBA.
- Enquiry with local Chambers of Commerce to identify marine based tourism operators in the region.
- Search for upcoming marine-based community or sporting events.

Traditional Owners

To identify Traditional Owners the following searches will be performed:

- Visit the local government authority websites (the shire or municipal council) who often include an acknowledgement of the local traditional owners.
- State and territory government websites also include information about traditional owners in their jurisdictions, especially in the context of information about local offices.
- Search online for states and territories Aboriginal and Torres Strait Islander consultative bodies, which themselves might offer advice.
- Contact land councils representing the local Aboriginal or Torres Strait Islander communities can help.
- Online searches for Native Title groups and corporations on the Prescribed Bodies Corporate website.
- Register searches on the National Native Title Tribunal website.
- Geospatial searches by completing the forms here on the National Native Title Tribunal website.

Note that any person with Native Title claims of any standing will be categorised as a relevant person.

Port users

To identify port users the following searches will be performed:

- Contact made with relevant harbourmasters to enquire about frequent users.
- Online searches for businesses located at wharfs in regional ports.

Petroleum titleholders

To identify petroleum titleholders the following searches will be performed:

- Use the NEATS database to find titles and titleholders within the hydrocarbon spill risk EMBA.
- Use the NOPSEMA EP database to find other titleholders with activities.
- Subscribe to the NOPSEMA EP submissions pages for all activities in Western Australia.

Commercial fishers

To identify commercial fishers the following searches will be performed:

- Request data from FishCube to understand historical fishing activity within the underwater noise EMBA (for seismic acquisition).
- Visit local ports to find local fishers who operate in the area.

Recreational fishers

To identify recreational fishers the following searches will be performed.

- Engagement with recreational fishing associations to use newsletters/circulars or websites.
- Request contact details for license holders.
- Request to engage with advisory bodies or reference groups to establish the best approach to identify relevant persons.

Native title land councils

To identify native title land councils the following searches will be performed:

- Seek contact details of land councils from the National Native Title Council.

Conservation groups

To identify conservation groups the following searches will be performed:

- Review of previously submitted EPs on the NOPSEMA website.
- Online searches for conservation groups with interests in oil spills.
- Online searches for new articles and current campaigns related to our activity.

Fishing associations

To identify fishing associations the following tasks and searches will be performed:

- Identify the target species within the hydrocarbon spill risk EMBA through online research.
- Ask the peak fishing association to identify other species-specific associations.
- Request contact details for license holders.

Other marine users

To identify other marine users the following searches will be performed:

- Online searches for groups who use or have a connection to the marine environment. This search will focus on marine users within and proximate to the hydrocarbon spill risk EMBA.

Commercial shipping

To identify commercial shipping entities the following searches will be performed:

- Contact made with relevant harbourmasters and shipping agents to enquire about frequent users.
- Online searches for businesses located at wharfs in regional ports.

Local councils

To identify local councils, shires, and cities, the following searches will be performed:

- Search the WALGA directory for councils, shires, and cities proximate to the hydrocarbon spill risk EMBA.

Educational bodies

To identify educational and research bodies the following searches will be performed:

- Contact the Department of Education to identify relevant institutions and research programs.
- Contact the universities located in Western Australia to identify any relevant research programs.
- Contact the Western Australian Marine Science Institution (WAMSI).

Note: for this category the exposure thresholds for monitoring of hydrocarbon spill impacts will be used rather than the socio-economic thresholds because this is more relevant to the likely activities of research institutions.

Commerce

To identify commercial entities the following searches will be performed:

- Contact the local Chamber of Commerce to identify local marine-based businesses.
- Online searches for news articles or press releases about marine-based businesses in the area.

Ports and harbours

To identify ports and harbours (including boat ramps) the following searches will be performed:

- Review of automatic identification system (AIS) data of vessel activities along the coast to establish frequented ports.
- Review the WA DOT boat ramp database.
- Contact local councils, cities, and shire for listing of local boat ramps and users.

Heritage groups

To identify heritage groups the following searches will be performed:

- Contact the Heritage Council of Western Australia to identify other relevant heritage organisations
- Query the inHerit database which is the WA State register of heritage places.
- Query the Australian Heritage Database
- Query the Australasian Underwater Cultural Heritage Database
- Query Geoheritage (WA)

The Consultation Framework

A framework of consultation stages will be implemented, within which there is flexibility to tailor the consultation to subject-centred groups and individual needs. This includes the provision of initial information to the public sufficient to allow a person to self-identify as a relevant person. The early engagement of relevant persons will provide the clarity of the consultation process required to underpin effective consultation. Further, early engagements with relevant persons enable discussions about the expectations a relevant person may have about the type and level of detail of information required through the process. The framework has been designed to align with ISO 31001 in that it should be iterative throughout its numerous stages as per Table 1.

This consultation framework covers both public engagement and consultation with relevant persons. The timeframes show when certain information is intended to be made available to the public. Consultation with relevant persons will occur within the overall timeframe, subject to any variations required after co-design of the consultation process.

Table 1 - Consultation framework and schedule

Stage	Purpose	Information to Publish	~Timing
0	To prepare the engagement and consultation activities		7-months pre-submission
1	To introduce the activity and this consultation plan and seek input into the co-design of the consultation processes.	- Community Consultation and Engagement Plan - Description of Activity - EIA and environmental risk assessment (ERA) processes and assessment criteria	6-months pre-submission
2	To provide the environmental context to the activities and information relevant persons and the public.	- Description of Environment - Legislative Requirements - Implementation Strategy - Preliminary EIA	5-months pre-submission
3	To provide the environmental analysis undertaken to predict the levels of impact and risk that the environment is exposed to.	- Predicted levels of impact - Predicted levels of risk - Independent reports (e.g., noise modelling, oil spill modelling)	4-months pre-submission
4	To provide the evaluation of and control measures adopted for the environmental impacts and risks including how relevant persons feedback has been incorporated.	- EIA summaries - ERA summaries - Treatment Plans (e.g., OPEP, OSMP, Adjustment Protocol)	3-months pre-submission
5	To provide an opportunity for relevant persons to raise objections or claims about any adverse impact on their functions, interests, and activities.	- Notice of the consultation process complete and ongoing	2-months pre-submission
6	To complete the consultation records for first submission of the EP.		1-month pre-submission
7	To provide updates during the assessment process including the feedback provided by NOPSEMA and the way in which the titleholder is addressing the matters raised	- NOPSEMA letters to the titleholder - Latest versions of the submitted/resubmitted EP	During the assessment process
8	To provide updates on the activity and the monitoring of environmental impacts and risks	- Activity commencement and cessation notifications - Ongoing notifications to commercial fishers and other marine users - Environmental incident reports (recordable and reportable incidents)	Prior to and during the activity

Undertaking a petroleum activity is a complex task that requires extensive planning, integration of many component parts, and detailed risk management. To deliver the activity successfully an integrated schedule governs the timing of all activities including the preparation of EPs and the conduct of the consultation required. This framework caters for some flexibility in the community engagement and consultation activities. This is recognised in the first stage of the framework which encourages relevant persons to influence the design of the subsequent processes and activities. This framework acknowledges that consultation activities cannot be 'one-size-fits-all' and there is an obligation to adapt our consultation activities to what we hear from the community and relevant persons.

However, like all businesses, we must operate within a schedule. Therefore, each stage of the framework has an indicative timeframe of one month for each of the stages to occur. This equates to a 5-month consultation process run in parallel with the preparation of the EP. This timeframe is considered reasonable given that at each stage within the framework the public, and relevant persons, will be able to have full access to the documents that underpin the environmental assessments as they are prepared. As will be shown later in this plan, the community will be able to make comment on those documents and engage in the process to the extent that they want to either as a relevant person or as a member of the public.

Reasonable Period for the Consultation

Pilot is required to provide a 'reasonable period' to relevant persons once they have received 'sufficient information' to make an informed assessment of the potential consequences of the activity on their functions, interests, and activities. Whilst the framework is adaptable to what we hear from relevant persons the minimum definition of a 'reasonable period' will be:

- At least 5-months from the notice of commencement of the consultation process
- At least 30-days following the provision of sufficient information to the relevant person

Sufficient Information

Information provided must be sufficient to allow an informed assessment of the possible consequences of the activity on the functions, interests, or activities of the relevant person. What constitutes sufficient information as part of a consultation process will differ depending on the relevant person(s). The information provided to relevant persons will consider:

- the functions, interests, or activities of the relevant person.
- the environmental impacts and risks that may affect them.
- the degree to which a relevant person is affected.

The overarching consultation framework and its schedule will remain as the base case for the consultation effort. However, the specific processes applied to relevant persons will need be defined in collaboration with those persons for each EP. The type, format, and level of detail of information necessary is likely to vary for different relevant persons depending on the above factors. However, Pilot recognises that for some relevant persons there may never be enough information for them to assess how they may be affected (i.e., in the case of a general objection to petroleum activities). Therefore, the framework has been designed in such a way that the EIA and ERA summaries will be made publicly available (and therefore to all relevant persons) for a minimum of 30-days prior to first submission of the EP. This design implies that sufficient information is, at least, the full EP contents that will be put before the regulator upon which they will decide whether to accept or refuse to accept the EP.

Notwithstanding the above measures to publish the full draft EP prior to submission, Pilot will undertake the consultation processes and activities without relying on this measure as the way sufficient information will be provided to relevant persons. We recognise that generic information flyers, targeted electronic mailouts, and links to a webpage will not be considered sufficient. We will endeavour to tailor the information we provide in a convenient and digestible format that respects the needs and activities of each relevant person. The exact method of communicating sufficient information cannot be determined without talking to relevant persons (unless the person or organisation has published guidance. However, Pilot has a variety of communication methods available to use such as in-person meetings, phone calls, email, letters, social media, public meetings, and newsletters.

Engagement and Consultation Activities

The regulatory expectation for co-design of consultation processes means that detailed planning in advance of talking to relevant persons is somewhat limited as the needs of the relevant person need to be taken into consideration. This doesn't remove the need for a preferred consultation and engagement plan to be developed. Rather, it means that the engagement and consultation activities need to be adapted in response to circumstances.

Consultation Methodology

Once a relevant person is identified, consultation will be undertaken in line with the International Association for Public Participation IAP2 spectrum (IAP2 Spectrum), which is considered best practice for stakeholder engagement. Table 2 outlines the methods of engagement Pilot has used in carrying out the consultation within the IAP2 spectrum.

Table 2 shows how the IAP2 Spectrum aligns with our consultation efforts on specific goals. It links the communication channels available to Pilot to the IAP2 spectrum and assesses the effectiveness of consultation methods. The assessment of effectiveness of a communication channel included consideration of the following:

- Accessibility to the channel
- Accessibility of information
- Depth and quality of information able to be communicated
- Least burden on the person
- Opportunity to respond to the information
- Ability to show genuine consideration of the views prior to a decision.

Table 2 – Consultation goals, channels, and assessment of effectiveness

Relevant IAP2 Spectrum element	Consultation goal	Consultation channels	Assessment of effectiveness
Inform	To provide balanced and objective information to assist persons in understanding the problems, alternatives and/or solutions. To seek and further understand the environmental values and sensitivities in the EMBA.	Activity specific website. Activity information flyers. Print media notices. Mandated public comment process.	The methods adopted cover a wide range of persons and provide specific information about the Pilot activity, and its environmental impacts and risks. As an exploration EP, the full EP is available for public exhibition prior to submission to NOPSEMA for assessment, which provides the opportunity for the public to provide feedback directly to NOPSEMA.
Consult	To obtain specific feedback on analysis, alternatives and/or decisions from potentially relevant persons.	Exchange of letters/emails. Informal discussions. Activity update flyers.	Adapting consultation process so that they are fit-for-purpose and tailored to the relevant person and/or provided updates to specific information as the activity definition is developed.

Relevant IAP2 Spectrum element	Consultation goal	Consultation channels	Assessment of effectiveness
Involve	To work directly with relevant persons throughout the process to ensure that their functions, interests, and activities are consistently understood, considered, and addressed.	Phone calls. Online meetings. Face-to-face meetings.	The methods adopted in this category are targeted and support the provision of detailed and tailored information to allow informed assessment of the possible consequences of the Pilot activity on the relevant persons' specific functions, interests or activities and building of one-on-one relationships.
Collaborate	To partner with the public in each aspect of our decision making including the development of alternatives and the identification of the preferred solutions.	Dual consultation process for the public and relevant persons. Participatory decision making.	The dual consultation processes allow anyone to engage as they prefer to. Both processes will directly influence the design of the activity, its environmental management measures, and the decision about whether the activity is environmentally acceptable.
Empower	To provide the opportunity to co-design the consultation process and directly influence the final design of the activity.	Final decisions are placed in the hands of an independent regulator.	Pilot Energy will accept the decision of NOPSEMA about whether it has done enough to demonstrate the requirements of the Regulations have been met.

Consultation with Relevant Persons Process Flowchart

Relevant persons may reveal themselves at any time in the preparation of an EP, during the activity, or after the activity is finished. As a result, the following flowchart governs how each relevant persons will be treated irrespective of the stage within the framework.

Consultation Activities and Tasks

The following tables identify all the activities and the tasks that will be carried out in preparation of an EP and provides guidance for how these activities should be completed. The Regulations require that all consultation activities are specific to each EP.

The consultation and engagement activities that Pilot are prepared to undertake are listed below and are expanded on in the following tables. This CCEP must be adaptable to the needs of relevant persons therefore not all activities listed below will take place, rather this is a list of activities that Pilot is prepared to undertake should the need be identified. The 'triggers' in each of the corresponding table provide guidance to when the activity and tasks will be implemented. If the activity will occur the trigger is captured as '*Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters*.'

- Establish an activity-specific online presence (Table 3)
- Public notices in print and social media and on radio (Table 4)
- Publication of information flyers (Table 5)
- Written correspondence (Table 6)
- Phone calls (Table 7)
- Online meetings (Table 8)
- Face-to-face meetings (Table 9)
- Group meetings (Table 10)
- Webinars (Table 11)
- Establish a consultation reference group (Table 12)
- Community meetings (Table 13)

- Public notices at prominent locations (Table 14)
- Pilot activity news subscription service (Table 15)
- Maintain a telephone hotline service (Table 16).

Table 3 - Establish an activity-specific online presence

Consultation Activity	**Establish an activity specific online presence**					
Purpose	The purpose of this activity is to establish a central place for all activity specific information that needs to be easily accessible to as many people as possible at any time during the consultation process and during the activity. The website will function as the single source of truth for information provided to the community and be a place for the community to provide feedback. Social media activity sites will act to direct traffic to the website.					
Triggers	- Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
0	Build an activity-specific webpage and social media activity pages.	N/A	Nil	Minimum of 7-months prior to EP submission	Surrender of title	Once
1	Publish the details of the proposed activity and the consultation process going forward	Authorities, Organizations, and People	All	Minimum of 6-months prior to EP submission	Surrender of title	Year-round
2	Interactive map: Create a place for people to provide location-based feedback on the proposed activity	Authorities, Organizations, and People	All	Minimum of 5-months prior to EP submission	Acceptance of the EP	Year-round
2	Issues comment board: create a page for anyone to raise specific concerns and comment on them	Authorities, Organizations, and People	All	Minimum of 5-months prior to EP submission	End of the activity	Year-round
2	Community survey: seeking information on the environment that may be affected	Authorities, Organizations, and People	All	Minimum of 5-months prior to EP submission	End of stage 4	Once
4	Community survey: provide a form for people to raise objections and claims	Authorities, Organizations, and People	All	Minimum of 3-months prior to EP submission	End of stage 4	Once

Table 4 - Public notices in print and social media and on radio

Consultation Activity	**Public notices in print and social media and on radio**					
Purpose	The purpose of these activities is to increase awareness of the petroleum activity and direct interested persons to the website. Notices are to be placed in local, regional, and other relevant print media. Notices and updates are also printed on social media platforms LinkedIn and Facebook. Subject-centered groups may have their own newsletters or print communication methods that should be used, if possible, to communicate within those groups.					
Triggers	- Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters. - Upon significant changes to the petroleum activity.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
1	Notices in local papers, on social media platforms, and on local radio notifying of the activity, the consultation process, and the way to "self-identify".	Persons	All	Start of phase 1	End of phase 5	Monthly
1	Notices in regional papers (West Australian) notifying of the activity, the consultation process, and the way to "self-identify".	Persons, Organizations	Marine Users	Start of phase 1	End of phase 5	Monthly
1	Notice in national papers (The Australian) notifying of the activity, the consultation process, and the way to "self-identify".	Persons, Organizations	All	Start of phase 1	-	Once
5	Notices in local, regional, and national newspapers and on social media inviting objections or claims on the proposed activity and its environmental management.	All	All	Start of phase 4	-	
8	Notices in local, regional, and national newspapers and social media informing the outcome of the NOPSEMA assessment and, if accepted, inviting self-identification as a relevant person at any time.	All	All	Upon final decision by NOPSEMA	-	

Table 5 – Information flyers

Consultation Activity	**Information flyers**					
Purpose	Short summary flyers containing activity specific context about the petroleum activity, its environmental aspects, and its environmental impacts and risks will be produced for distribution alongside other consultation activities and tasks. They will be accessible through the website and appended to correspondence as necessary. If a relevant person requests more information, or the information in a different form, subject-specific flyers will be created to further tailor the information to the subject-centered group. For example, if fishers request information about impacts on their target species a tailored flyer will be produced.					
Triggers	- Upon completion of EP content - Upon request through consultation					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
0	Flyer: Description of activity	All	All	Start of phase 1	-	Once
1	Flyers: Environmental aspects	All	All	Start of phase 1	-	Once
Any	Prepare flyers as per requests for information from relevant persons	Organizations, Persons	Marine Users	Start of phase 1	End of the activity	On request

Table 6 – Written correspondence

Consultation Activity	**Written correspondence**					
Purpose	To provide formal consultation between the titleholder and a relevant person. Written correspondence is useful to initiate consultation with authorities and organizations					
Triggers	- Upon identification of a relevant person					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
1	Communicate with all identified authorities and organizations to commence the consultation process. Focus of the letter/email is to notify the commencement of the preparation of the EP and invite co-design of the consultation process.	Authorities, Organizations	Petroleum titleholders, educational bodies, fishing associations, local councils, ports and harbors, heritage groups, native title land councils, and Traditional Owners.	Start of Stage 1	-	Once
1	Communicate with all identified fishers to commence the consultation process. Focus of the letter/email is to notify the commencement of the preparation of the EP and invite co-design of the consultation process.	Persons	Fishers	Start of Stage 1	-	Once
All	Continue the consultation processes as agreed.	All	All	-	-	Once
2	Request input on the environmental values and sensitivities within the risk EMBA through the interact map on the website.	All	All	Start of Stage 2	-	Once
5	Written notice that the draft EP is available online and request any residual objections or claims that haven't been addressed by the consultation process to date.	All	All	Start of stage 5	Start of Stage 6	Once

Table 7 – Phone calls

Consultation Activity	**Phone calls**					
Purpose	To supplement written correspondence to assist in delivering the message effectively and build relationships with the receiver. Cold calls are not part of this activity and are not supported as an effective method of commencing consultation.					
Triggers	- After written correspondence has been sent. - To arrange other consultation activities.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
1-5, 7 & 8	Call relevant persons to confirm receipt of correspondence and offer the opportunity to ask any questions.	All	All	One week after correspondence sent	-	Once

Table 8 – One-on-one online meetings

Consultation Activity	**One-on-one online meetings**					
Purpose	As many of the decision makers for Pilot are in Brisbane online meetings with relevant persons are the preferred method of meeting with relevant persons. With attendees' permission they can be transcribed for ease of record keeping. It is likely that meetings will follow some form of written correspondence. Like all meetings, the agenda and frequency of meetings will be specific to the needs of the relevant person.					
Triggers	- Upon request from a relevant person. - To assist in delving deeper into the substantive issues of a relevant persons. - To resolve objections or claims that cannot be easily managed.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
2-5, 7 & 8	Online meetings to be held if triggered with a clear agenda communicated and agreed beforehand.	All	All	As needed	-	On requests or as agreed

Table 9 – Face-to-face in person meetings

Consultation Activity	**Face-to-face in person meetings**					
Purpose	Face-to-face meetings are the preferred means of building relationships with relevant persons.					
Triggers	- Relevant person requests a face-to-face meeting - During Pilot staff visits to Western Australia. - If other consultation activities have failed to resolve substantive issues					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
2-5, 7 & 8	Online meetings to be held if triggered with a clear agenda communicated and agreed beforehand.	All	All	As needed	-	On requests or as agreed

Table 10 – In person group meetings

Consultation Activity	In person group meetings					
Purpose	In person group meetings can be useful to communicate the same messages and content to multiple relevant persons at the same time and allow for deeper debate on the substantive issues that affect the who group. A group meeting might be effective if there are multiple representatives of a relevant organization where it is more efficient to meeting collectively rather than with each representative individually.					
Triggers	- On request from an organization. - On request from more than 10 relevant persons in the same subject-centered group.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
2—5, 7 & 8	Organize a meeting at a convenient location for relevant persons.	All	All	As needed	-	On requests or as agreed

Table 11 – Webinars

Consultation Activity	Webinars					
Purpose	Hosted periodically online these open briefings are available to anyone who registers to attend i.e., the public and relevant persons. The purpose is to communicate the consultation process, provide instruction on how to determine if you are a relevant person, seek input and local knowledge, and build trust in the community.					
Triggers	- Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
2-5, 7 & 8	Host an online webinar specific to each petroleum activity that anyone can register to attend.	All (and the public)	All	-	-	Monthly

Table 12 – Establish a consultation reference group

Consultation Activity	Establish a consultation reference group					
Purpose	A consultation reference group is designed to provide Pilot with input into decision making within the consultation framework, the consultation methodology, and the consultation processes. It is designed as a consultative group across the multiple petroleum activities within the Work Program. It would meet regularly throughout the Work Program to provide feedback to Pilot on its consultation efforts and how they can be improved.					
Triggers	- If the co-design consultation processes reveal themselves to be ineffective. - If there are trade-offs between relevant persons that may need community input to resolve.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
2	Offer relevant persons who are directly affected the opportunity be on a consultation reference group.	Authorities, Organizations	Commercial Fishers, Native Title Land Councils, Local Councils, Conservation Groups, fishing associations, and Traditional Owners	As needed	-	As defined by the group

Table 13 – Community briefings

Consultation Activity	Community briefings					
Purpose	These are open forums held at relevant locations proximate to the coast to engage the local communities in the Work Program. They are designed to facilitate relationship building with the public and relevant persons within those locales.					
Triggers	- If the environmental assessment identifies signification impacts or risks that cannot be avoided.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
3, 4, or 5	Undertake a roadshow of community briefings at strategic locations with appointments for anyone to come and meet the Pilot team and discuss their concerns.	Persons	Recreational fishers, Traditional Owners, Port users, other marine users.	As needed	-	Once in the Work Program

Table 14 – Public notices at prominent locations

Consultation Activity	Public notices at prominent locations					
Purpose	These notices can be targeted to relevant subject-centered groups in place they may receive other notices or messages.					
Triggers	- If other activities have identified relevant persons by their identity cannot be shared, for example, if fishing records show activity but because of confidentiality either the exact location fished, or the fisher, cannot be identified through other means. - If other activities have identified that relevant persons may have been inadvertently missed. - If this activity is requested by associations or other relevant persons.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
1 & 4	Public notices to be placed on the notice boards at local post offices, boat ramps, public houses, and local councils about the stage of consultation we are at.	Persons	Traditional owners (fishers), commercial fishers, recreational fishers, tourism operators, and other marine users.	Start of the stage	-	Once per stage
8	Public notices to be placed at locations defined as useful by relevant persons.	Persons	Traditional owners (fishers), commercial fishers, recreational fishers, tourism operators, and other marine users.	Start of the stage	-	Once

Table 15 – Pilot activity news subscription service

Consultation Activity	Pilot activity news subscription service					
Purpose	Any person will be able to subscribe to a newsletter that will outline the latest information on Pilot full Work Program including the status of the activities and the status of the EP.					
Triggers	- Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
All	Short 2-page max newsletters will update all subscribers about the status of the Work Program, the activities, and the approvals.	All	All	Start of stage 1	End of activity	Monthly

Table 16 – Maintain a telephone hotline service

Consultation Activity	**Maintain a telephone hotline service**					
Purpose	Any person will be able to contact this service to find out about the activity from a person directly involved in the project who is familiar with the activity and environmental management requirements.					
Triggers	- Upon the decision to seek environmental approvals for a petroleum activity in Australian Commonwealth waters.					
Implementation						
Framework Stage	**Task**	**Relevant Person Category**	**Target Group(s)**	**Start Date**	**Completion Date**	**Frequency**
All	Maintain a telephone hotline service.	All	All	Start of phase 1	End of the activity	

Coordination of Activities

All consultation and engagement activities will be coordinated by the Pilot Consultation Team who are also responsible for updating this plan and communicating the change to internal stakeholders and, where relevant, external audiences.

Assessment of Merit of Objections or Claims

Feedback of any type will be welcomed throughout the consultation process. If received through our public engagement activities, it will be documented in the website management system and is considered in the preparation of the EP. If feedback is received through our relevant persons consultation activities, it will be recorded in our consultation management system and forms part of the EP.

Listening to feedback and attempting to understand the substantive issues is the first step in mitigating them. The process in Appendix A will be applied to assess the merit of objections and claims received from relevant persons. It is preferred that this process take place in meetings rather than through written correspondence, though this may not always be possible.

An assessment of merit of each objection or claim will be carried out by CGG with external experts as needed. A relevant person's objection or claim has higher merit when one or more of the following criteria is met:

- The objection or claim is relevant to environmental management of the activity.
- The objection or claim is relevant to the persons functions, interests, and activities.
- The objection or claim can be resolved through the adoption of additional control measures, an activity design variation/limitation, or through changes to the implementation strategy for the EP.

An objection or claim may be resolved by providing more information and/or adopting one of the three main types of 'measures' which can be adopted because of the consultations:

1. Control measures (with associated environmental performance outcomes and standards)
2. Activity design variations/limitations applied within the activity description.
3. Inclusions within the Implementation Strategy of the EP.

Despite our best efforts to resolve all objections and claims we understand that relevant persons may not agree with our treatment of their objection or claim. In such circumstances the consultation processes can continue provided that the relevant person has received a response about our assessment of their objections and claims and is aware how our respective views will be presented to NOPSEMA.

Ongoing Consultation

Regulation 14(9) of the Regulations requires ongoing consultation to be incorporated into the Implementation Strategy of the EP (see Chapter 9). This CCEP is a part of the Implementation Strategy of each EP.

Pilot will continue to search for relevant persons before, during, and after all our activities up until the EP has ended or expired. Pilot will continue the discourse with relevant persons and organisations after this time to maintain relationships for future activities. In addition, Pilot will keep relevant persons up to date with the status of the title by sending periodic public notifications and correspondence to all relevant persons who have not explicitly requested that communications cease.

Pilot acknowledges that relevant persons may have decided not to engage in the consultation processes but may reconsider that decision at any time. As such, Pilot will continue to provide notifications to relevant persons if they haven't specifically requested to be excluded from the consultation processes. Pilot will apply the same consultation processes that applied in preparation of each EP for the duration of the activity.

Post-EP acceptance, key milestones that will trigger further consultation with relevant persons include:

- EP acceptance and the availability of the accepted EP on the NOPSEMA website.
- Notification prior to petroleum activity commencement (the notification period varies from one day to five weeks pre-activity depending on the relevant person).
- Completion of activity (between one and 10-days, depending on the relevant person).
- Any reportable incidents (e.g., large fuel spill).
- If there is a change to the Pilot activity scope that would affect the relevant person in a new or different manner to that which has been discussed.

Communication of changes

Pilot acknowledges that changes to activities based on knowledge underpinning the environmental impact and risk assessments occur from time to time. In the event of such a change that affects a relevant person's functions, interests, or activities, Pilot will complete an assessment that includes provision of information to affected relevant persons in respect of the change and consideration of their feedback.

As required by the Regulations, Pilot shall assess the merits of any new claims or objections made by a relevant person because of the change that may have an adverse impact on their functions, interests, or activities. If the claim has merit, where appropriate, Pilot will modify the management of the Pilot activity.

Pilot will seek to finalise its determination of the merits of any claim or objection received before the activity starts, and if after commencement, within 1 week of receipt and undertake any resulting management of change actions as soon as practicable, but preferably within that timeframe. The assessment of merit and any resulting management of change actions will be shared with the concerned relevant persons. For objections and claims that do not require a change in management of the activity, Pilot will respond to relevant persons providing reasoning and supporting information (as relevant) to support Pilot's conclusions. This may include and outline of the options/controls explored to mitigate the degree to which the person may be affected and/or demonstration that the impact or risk in question has been reduced to ALARP and acceptable levels.

Any claims or objections raised by relevant persons after submission of the EP will be assessed for merit and a response provided. If a change to the Pilot activity or controls adopted during the Pilot activities occurs because of relevant persons consultation, the change will be managed in accordance with the processes outlined in the relevant EP.

Monitoring

Effectiveness of Consultation

It is Pilot's intention to consult effectively in preparation of the EP, during the activity, and throughout the tenure of the title. The effectiveness of our consultation will be determined in the following ways:

- **Responsiveness**: We will have effectively consulted when we have reached out to relevant persons, listened to their concerns, and taken appropriate actions to address those concerns.
- **Two-way communication**: Consultation is an ongoing process of two-way communication, not just providing information. Effective consultation is when we have actively listened to the views and concerns of relevant persons and taken them into account in our decision making.
- **Inclusion**: We will have effectively consulted when we can show we have reached out to a diverse range of people, including those who may be particularly affected by your activity.
- **Timing**: We have effectively consulted when we have reached out to relevant persons early in the planning process, throughout the preparation of the EP, and throughout the duration of your activity.
- **Transparency**: We have effectively consulted when we can show we have provided relevant persons with accurate and transparent information about your activity and have been open and honest in your communication.
- **Feedback**: We have effectively consulted when we have received feedback from relevant persons and have taken appropriate actions to address their concerns.
- **Compliance**: You have effectively consulted when you have followed all relevant laws and regulations related to consultation, such as ensuring that the rights of all persons are respected.

Records Management

Engagement and consultation activities with relevant persons will be logged by the person who carried out the activity in the consultation management system.

Key Performance Indicators

The following key performance indicators will be monitored to judge the effectiveness of this CCEP, the consultation processes, and the consultation activities.

1. Numbers of relevant persons start high and begin to lower indicating that our identification processes are working.
2. Relevant persons are responded within 24-hours acknowledging receipt of a correspondence.
3. Relevant persons have a considered response from Pilot within 14-days of receiving correspondence.
4. Website visits on issues decline as control measures are adopted and the activity design changed in response to relevant person concerns.
5. The EP is submitted to NOPSEMA with no outstanding issues from relevant persons.

References

The following requirements and guidance have been followed during the consultation process:

The OPGGS(E) Regulations

NOPSEMA policies, guidance, and information papers, including:

PL1347 - Environment plan assessment policy (19 May 2020).

GL1721 - Environment plan decision making (10 June 2021).

GL1887 - Consultation with Commonwealth agencies with responsibilities in the marine area (3 July 2020).

GN1344 - Environment plan content requirements (11 September 2020).

GN1488 - Oil pollution risk management (7 July 2021).

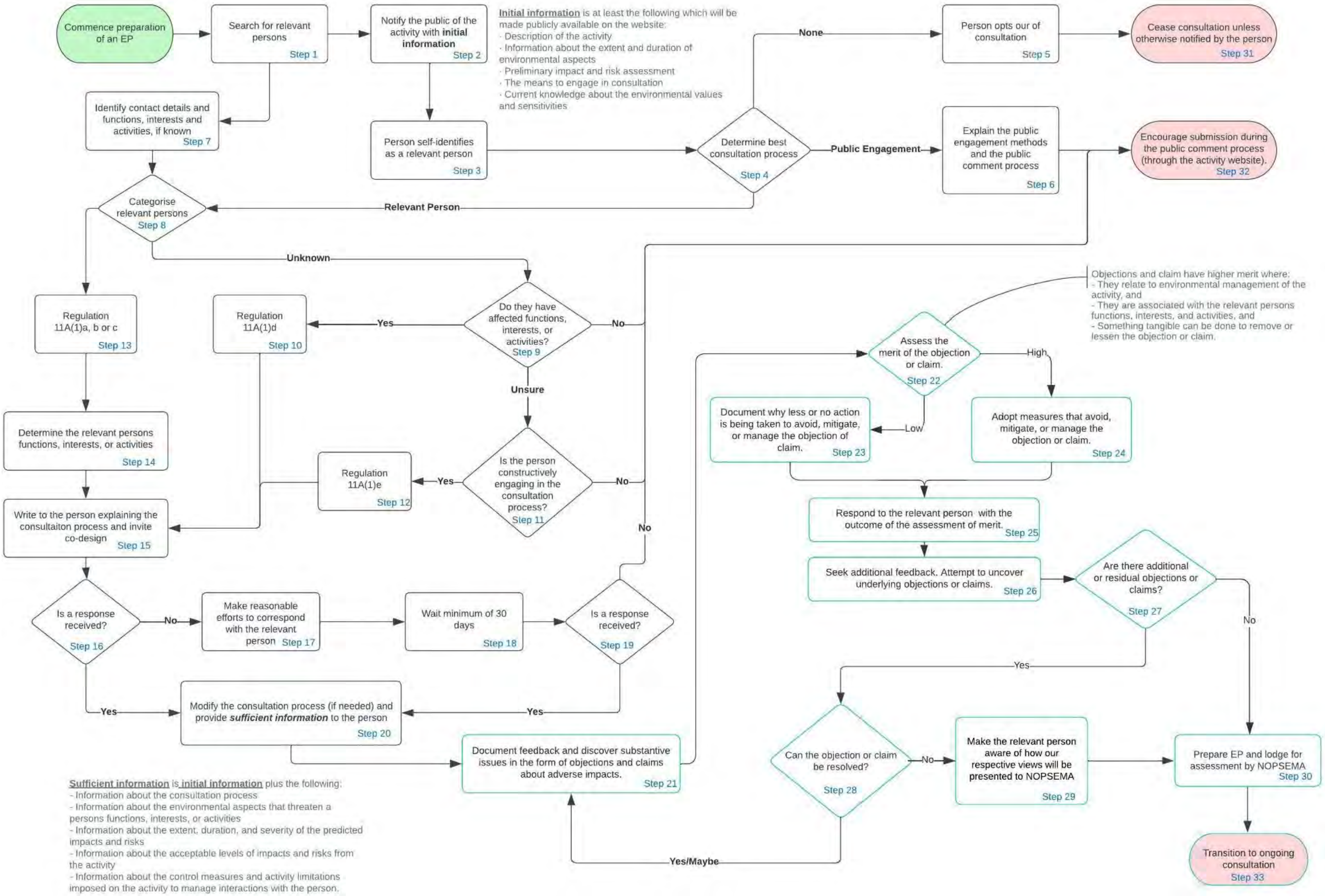
GN1785 - Petroleum activities and Australian marine parks (3 June 2020).

GN1847 - Responding to public comment on environment plans (11 September 2020).

Other relevant guidance, including:

- AIATSIS Engaging with Traditional Owners Guidance: fpicsnapshot2020.pdf (aiatsis.gov.au)

Appendix A – Consultation Process



Appendix D:
Consultation report

Public Report on Consultations

This report on consultations has been prepared to comply with Section 24 of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023. The extensive nature of the consultations makes efficient presentation of the records challenging. To comply with the regulatory guidelines a PDF of the tables has been provided. To improve transparency and accessibility a filterable Excel worksheet has been provided where possible. The PDF and Excel files are copies of one another.

Consultations occurred with many individuals on behalf of their employer. These records have been prepared and organised by the relevant employer except when the individual indicated that they wish to be consulted as a relevant person. When this occurred, all records of correspondence with the individual have been presented collectively in the individuals report.

The purpose of each document within this report is as follows:

Item	Document Title and Purpose	Double Click Paperclip to Open PDF	 Excel
1	**Organisation Master List** This document is a list of all relevant persons who are authorities or organisations. It is ordered by regulatory category (Section 25) and then by subject-centred category. This document records the identification method, the regulatory category (Section 25), the functions, interests, and activities of the relevant person, and assigns a unique 'Organisation ID' to each entity. Any authority or organisation who voluntarily participated in consultation was considered a relevant person.		
2	**Person Master List** This document is a list of all relevant persons who are not authorities or organisations. It is ordered by subject-centred category and all individuals are considered relevant persons under Section 25(1)(d). This document records the identification method and functions, interests, and activities of the individual, if ascertainable. Any individual who voluntarily participated in the consultation was considered a relevant person.		
3	**Report On All Consultations – Organisations** This document is the primary record of all events for authorities and organisations. It is ordered by regulatory category (Section 25), then by subject- centred category, then by date order (oldest to newest). The report contains all interactions (called Events), the event type, an event summary, and assigns an Event ID. If feedback (objections or claims etc.) was received this is shown against the corresponding event along with how the feedback has been processed in accordance with Section 24(b). If 'Feedback Summary' is blank, no feedback was received during that event. Where multiple feedback was received in one Event, the Event has been duplicated.		
4	**Report On All Consultations – Persons** This document is the primary record of all events for individuals. All entries are assigned to regulatory category 25(1)(d). The data is ordered by subject-centred category and then by date order (oldest to newest). The report contains all interactions (called Events), the event type, an event summary, and assigns an Event ID. If feedback (objections or claims etc.) was received this is shown against the corresponding event. The feedback was then processed in accordance with Section 24(b) and updated following review prior to submission. If 'Feedback Summary' is blank, no feedback was received during that event. If multiple feedback was received in one Event, the Event has been duplicated.		
5	**Feedback Master List & Full Assessment of Merits of Objections & Claims** Each feedback was categorised into either an objection or claim (as required by the Regulations), or a complaint, a request (usually for information), or statement. This report shows the systematic treatment of feedback from relevant persons and provides more detail on the consideration of the feedback than is shown in report Items 3 & 4. A record of the feedback is often a culmination of a dialogue over time rather than specifically linked to a single event. The 'measure adopted' was recorded at the time of data entry and reviewed prior to submission for its appropriateness in light of the passage of time.		

In addition, there are several documents that are more efficiently shown collectively to reduce duplication in other parts of this report, or as they relate to the consultation process that was undertaken in preparation of the Environment Plan. The following items are available in this consultation report:

Item	Document Title and Purpose	Double Click Paperclip to Open PDF	Excel
6	**Consultation Hub Website Report** This document shares the content that was available for relevant persons through the Eureka Consultation Hub. Statistics for the use of the website are shown. It also contains an electronic copy of the consultation survey provided to support visitors determine if they may be affected by the activity.		N/A
7	**Social Media Report** Report provides copies of the posts made through various social media platforms and the statistics associated with their uptake from viewers.		N/A
8	**Print Media Report** Report provides copies of adverts place in regional and national papers raising awareness about the consultation opportunities for relevant persons. Evidence of advertising the EP's public comment period is also provided.		N/A
9	**Interactive Map Comment Report** Members of the public were able to make comments on an interactive map on the Eureka Consultation Hub. This report provides a record of the comments received and a response. Commenters acknowledge that comments were not being made as a 'relevant person'. All commenters were contacted to ascertain if they were relevant persons.		N/A
10	**Information Sessions and Webinar Report** This report is a copy of the slide presented at the community information sessions and during webinars. Videos of the webinars were made available on the Eureka Consultation Hub.		N/A
11	**Campaign Email Report** This document provides copies of emails to subscribers and known relevant persons. After each email event a report provides a summary report for the success of the campaign.		N/A

The sensitive information report is provided as a repeat of this public report, plus additional fields to aid NOPSEMA's assessment. The following materials are provided to NOPSEMA and are not included in this public report.

Item	Document Title and Purpose	PDF	Excel
12	**Information Given During Consultation Report** This document provides copies of all documents and information given by Pilot Energy to relevant persons. It is a large compilation of documents and is provided separately to this report. It is organised by relevant person and date (oldest to newest).	**Confidential and provided separately**	
13	**Consultation Survey & Instant Feedback Report** The consultation survey was available on the Consultation Hub and contains personal information meaning it must be kept confidential. Instant feedback was available for anyone to quickly raise concerns.	**Confidential and provided separately**	
14	**Full Text Copies of Correspondence** This report is confidential and contains: - Information requested to kept confidential by relevant persons. - Full text copies of all correspondence and documents sent & received.	**Confidential and provided separately**	

Appendix E:
Oil pollution emergency plan

Eureka 3D Marine Seismic Survey

Revision	Date	Reason for issue	Reviewers	Approvers
A	13/03/2023	Internal Review		
B	26/07/2023	Internal Review		
0	06/12/2023	Issued for Use	RPS	RPS

Table of Contents

List of Tables

List of Figures

Terms

Term/Acronym	Definition
3D	Three dimensional
ADIOS2	Automated Data Inquiry for Oil Spills 2.0
AFMA	Australian Fisheries Management Authority
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Marine Safety Authority
BAOAC	Bonn Agreement Oil Appearance Codes
CEO	Chief Executive Officer
CMT	Crisis Management Team
DBCA	WA Department of Biodiversity Conservation and Attractions
DCCEEW	Cwth Department of Climate Change, Energy, the Environment and Water
DWER	WA Department of Water and Environmental Regulation
DFAT	Cwth Department of Foreign Affairs and Trade
DISR	Cwth Department of Industry, Science And Resources
DMIRS	WA Department of Mines, Industry Regulation and Safety
DoT	WA Department of Transport
DPIRD	WA Department of Primary Industries and Resource Development
EMBA	Environment that May Be Affected
EMSA	European Maritime Safety Authority
EP	Environment Plan
ERT	Emergency Response Team
ESC	Environmental Scientific Coordinator
FOB	Forward Operating Base
GIS	Geographic Information System
GPS	Global Positioning System
HMA	Hazard Management Authority
IAP	Incident Action Planning
ICC	Incident Command Centre
IMT	Incident Management Team
IPIECA-IOGP	International Petroleum Industry Environmental Conservation Association - International Association of Oil & Gas Producers
ITOPF	International Tanker Owners Pollution Federation
JSA	Job Safety Analysis
MARPOL	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MEE	Maritime Environmental Emergencies
MEECC	Maritime Environmental Emergency Coordination Centre (DoT)
MEER	Maritime Environmental Emergency Response (unit) (DoT)
MGO	Marine Gas Oil

Term/Acronym	Definition
MNES	Matters of National Environmental Significance
MSS	Marine Seismic Survey
NEBA	Net Environmental Benefit Analysis
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OPGGS (Env)	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (Env) Regulations)
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPICC	Offshore Petroleum Incident Coordination Committee
OSC	On Scene Commander
OSCP	Oil Spill Contingency Plan
OSM-BIP	Operational and Scientific Monitoring – Bridging Implementation Plan
OSTM	Oil Spill Trajectory Modelling
OWR	Oiled Wildlife Response
POLREP	Pollution Report
PPE	Personal Protective Equipment
RCC	Rescue Coordination Centre (AMSA)
SEMC	State Emergency Management Committee
SHP-MEE	Western Australian State Hazard Plan for Maritime Environmental Emergencies
SIMA	Spill Impact Mitigation Assessment
SIMAP	Spill Impact Mapping and Analysis Program
SMP	Scientific Monitoring Plan
SMPC	State Marine Pollution Coordinator (DoT)
SMPEP	Shipboard Marine Pollution Emergency Plan
SOPEP	Shipboard Oil Pollution Emergency Plan
WA	Western Australia
WAOWRP	Western Australian Oiled Wildlife Response Plan

First strike activations

The initial response to an oil spill incident will be undertaken by the Vessel Master. For vessel oil spill incidents, the Vessel Master will act in accordance with the relevant Shipboard Oil Pollution Emergency Plan (SOPEP) where applicable, which will include notification to the relevant Control Agency (refer to Section 2.2 and 2.3).

Table A-1 outlines the first strike response actions that need to be followed in the event of a spill.

Table A-1: First strike actions

Responsibility	Actions
Observer	❑ Provide details of the incident to the Vessel Master.
Vessel Master/On-Scene Commander (OSC)[1]	❑ Monitor the safety of all personnel. ❑ Take immediate actions to control the source of the spill, in accordance with the vessel-specific SOPEP. ❑ If source control is not possible, ensure vessel safety by clearing the immediate vicinity of the spill, if possible. ❑ Conduct risk assessment and assess safe approach routes. ❑ Contact relevant Jurisdictional Authority and Control Agency, as soon as practicable, to inform them of the incident, providing as much information as possible via POLREP (Refer to Table 2-2 for a description of Jurisdictional Authorities and Control Agencies). ❑ Notify Pilot Energy Survey Representative of the spill.
Pilot Energy Survey Representative on vessel	❑ Notify the Pilot Energy Duty Manager of the incident and ensure source control measures being implemented. ❑ Aid the Vessel Master/OSC in preparing the POLREP[2] and provide as much information[3] to the Incident Management Team (IMT) as soon as practicable, including: – Name and details of vessel – Location and coordinates – Date and time the release occurred or was first reported – How it was detected – Names of any witnesses – Hydrocarbon type (e.g. Marine Diesel Oil (MDO)), any Material Safety Data Sheets – Vessel's Oil Record Book (contains information on volumes and contents in each tank) – Cause of the spill (e.g. collision) – Source of spill (e.g. fuel tank) – Approximate volume of spill (better to overestimate) – If the spill is controlled or continuous – Weather, tide and current details – Trajectory of the spill (what direction is the slick spreading) – If any fauna has been observed nearby (e.g. whales, dolphins, seabirds)

1 The Vessel Master may act as the OSC or nominate a delegate for this role.

2 This information will also be required when completing incident reports and reports to external agencies.

3 Some details may be limited in the initial POLREP. Aim to get the initial report submitted as soon as possible and follow up with more detail as it becomes available.

Responsibility	Actions
	– Notifications undertaken. ❑ Provide updated POLREPs to the IMT as required. ❑ Use personal Incident Log to record events. ❑ Take photos and send to the IMT, if possible.
Duty Manager/ IMT Operations Section Chief Note: Duty Manager may take on the role of IMT Operations Section Chief or handover command to the IMT Operations Section Chief	❑ Notify Incident Commander as soon as practicable that an incident has occurred and determine if IMT activation is required. ❑ Ensure IMT has been activated (if required). ❑ Confirm incident report and capture key details relating to the incident (obtain POLREP). ❑ Undertake external notifications and reporting (Refer to Section 4). ❑ Remain as the sole liaison and communication interface between the IMT Incident Commander and the Pilot Energy Survey Representative on the vessel.
IMT Incident Commander	❑ Evaluate initial incident report. ❑ Maintain contact with Control Agency to confirm actions (Australian Marine Safety Authority (AMSA) or Western Australian Department of Transport (WA DoT) IMT) (see Section 2.2). ❑ Confirm level of the incident in consultation with Control Agency. ❑ Activate IMT in consultation with Duty Manager/Operations Section Chief. ❑ Notify Crisis Duty Manager Leader of incident (if level 2 or 3). ❑ Remain as the decision-making interface between the IMT and the Crisis Management Team (CMT) Leader.

Once first strike actions are completed and initial notifications to the Control Agency are made, Pilot Energy shall maintain direct contact with the Control Agency and act as a Supporting Agency throughout the response. This includes providing essential services, personnel, material or advice in support of the Control Agency. In addition, Pilot Energy will implement monitoring activities as outlined in the Eureka 3D Marine Seismic Survey Operational and Scientific Monitoring Bridging Implementation Plan (OSM-BIP) (Appendix H).

1. Introduction

1.1 Purpose

This Oil Pollution Emergency Plan (OPEP) outlines oil spill response arrangements for spill scenarios that may occur from a three dimensional (3D) seismic survey undertaken within the Operational Area for the Eureka 3D Marine Seismic Survey (MSS) Environment Plan (EP) (**Error! Reference source not found.**). It describes the spill response management arrangements, protection priorities and the process for selecting suitable oil spill response strategies.

This OPEP addresses the requirements of the Offshore Petroleum and Greenhouse Gas Storage (OPGGS) (Environment) Regulations 2009 and forms a supporting document to the Eureka 3D MSS EP. It is also consistent with the National Plan for Maritime Environmental Emergencies (National Plan) (AMSA, 2020) managed by AMSA and the Western Australian (WA) State Hazard Plan for Maritime Environmental Emergencies (SHP-MEE) (DoT, 2021).

1.2 Scope

This OPEP only applies to acquisition of the proposed Eureka 3D MSS. It excludes all other petroleum related activities. It also excludes marine hydrocarbon spills originating from vessels outside of the Eureka 3D MSS EP Operational Area, which will be addressed by the vessel's SOPEP or Shipboard Marine Pollution Emergency Plan (SMPEP), as applicable to vessel class.

Refer to Section 3 of the Eureka 3D MSS EP for further details on the activity.

1.3 Location

This OPEP applies to a hydrocarbon spill originating within the Eureka 3D MSS Operational Area, which is located within Commonwealth waters off the mid-west coast of Western Australia (WA) (**Error! Reference source not found.**), within the northern Perth Basin, in exploration permit area WA-481-P and associated AA and SPA areas.

1.4 Objectives

The objectives of this OPEP are to:

- Meet the requirements of the OPGGS (E) Regulations.
- Provide alignment with arrangements in the WA State Emergency Management Plan (SEMC, 2022), specifically the WA SHP-MEE and the National Plan.
- Define the oil spill response arrangements that are in place for the credible spill scenarios.
- Provide guidance to the IMT in relation to spill response selection and response implementation.
- Provide procedures for identifying appropriate resources to support a marine hydrocarbon spill response associated with a seismic survey.

1.5 Interface with internal documents

In addition to this OPEP, a number of other Pilot Energy documents provide guidance and instruction relevant to the spill response, including:

- Pilot Energy Emergency Response Procedure (PE-05-PRO-003)
- Pilot Energy Incident Management Procedure (PE-07-PRO-001)
- Eureka 3D MSS OSM-BIP (Appendix H).

Other documents, including an emergency contact form, will be generated to meet the specific requirements of the survey. These will be finalised in the pre-mobilisation phase for up to date information.

1.6 Document review

This OPEP is required to be reviewed, and if applicable updated, to ensure that all relevant information is accurate, and that new information or improved technology is evaluated and used to adapt and improve the management of spills.

Reviews and revisions to this OPEP will be undertaken as per the Eureka 3D MSS EP review and revision process detailed in Section 10 of the Eureka 3D MSS EP.

This could include changes required in response to one or more of the following:

- When major changes have occurred, which affect oil spill response coordination or capabilities.
- Changes to the Eureka 3D MSS EP that affect oil spill response coordination or capabilities (e.g. a significant increase in spill risk, inclusion of new activity).
- Following routine testing of the OPEP if improvements are identified.
- After a Level 2/3 spill incident.

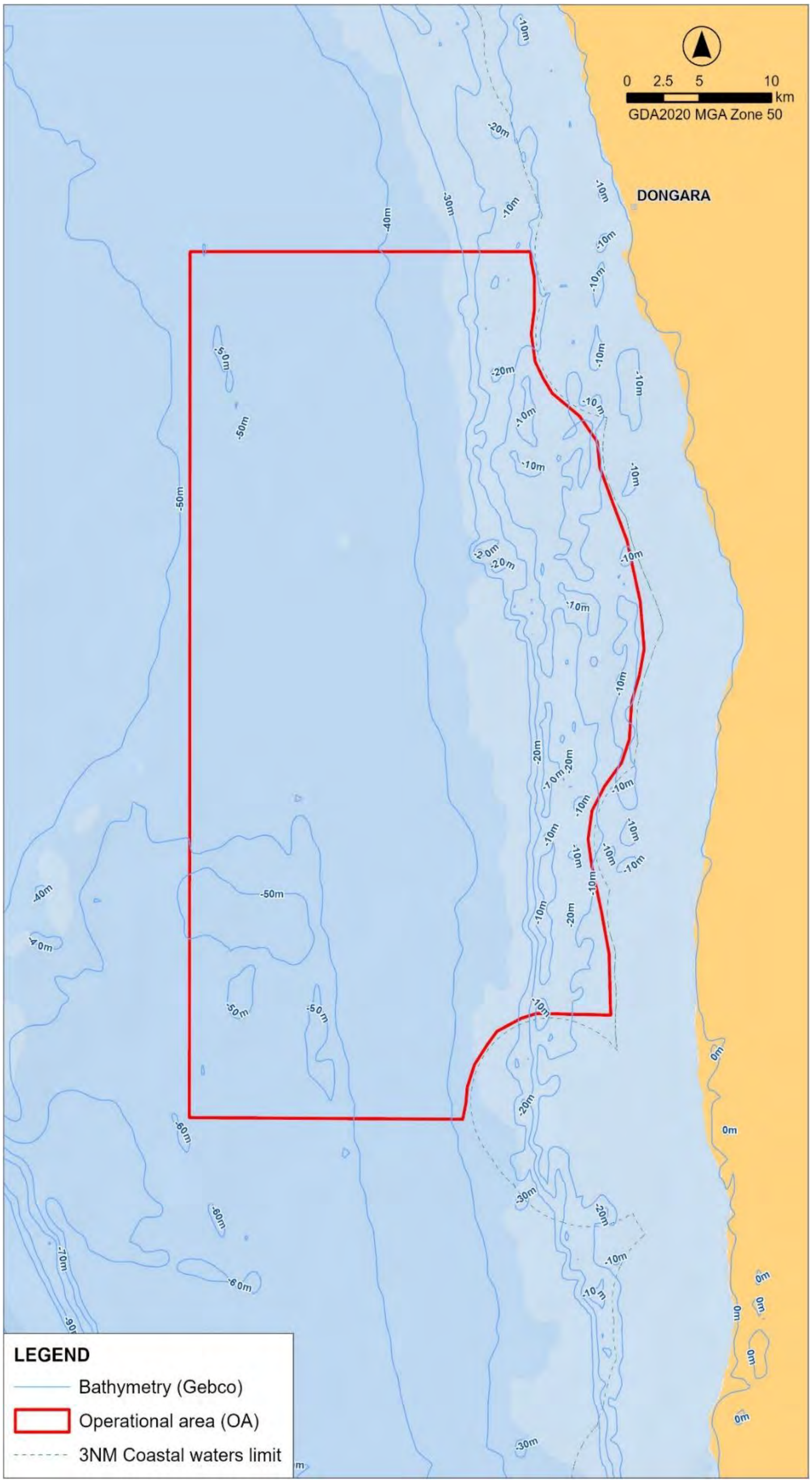


Figure 1-1: Eureka 3D MSS Operational Area

2. Spill Management Arrangements

2.1 Response levels and escalation criteria

The National Plan and the WA SHP-MEE identify three levels of incidents, which are consistently applied by Pilot Energy.

An incident level (also referred to as 'tier') will determine where the resources will be drawn from to respond to the spill and the level of incident management that is required to manage the response effort.

In the event of a spill occurring where effective response is considered beyond the capabilities within a level, the response will be escalated immediately to the next level. The decision to escalate a response to a higher level (as defined in Table 2-1) will be made by the responsible Control Agency.

If the response level is undetermined, then a worst-case scenario should be assumed when activating resources, as it is always possible to scale down the response effort.

Table 2-1: Pilot Energy Incident Level Guidance

	Incident management response level		
Characteristic	**Level 1**	**Level 2**	**Level 3**
General description and escalation criteria	An incident that has not caused severe injury to personnel or damage to assets or the environment Incident does not threaten the safety of a vessel/facility and can be managed by the local response team and its resources	An incident that exceeds Level 1 capability and requires the assistance of the IMT and external support services/agencies If no external support is required, an incident may be classified in a higher tier if there is potential for escalation or damaging public image or government relations	An incident that exceeds Level 2 capabilities and resources and requires the assistance of the CMT Incident may attract media coverage or create public outrage and has the potential to cause, or does cause, a major impact
AMSA National Plan Levels and escalation criteria	Level 1 Generally able to be resolved by Responsible Party through the application of local or initial response resources (first strike response)	Level 2 Typically, more complex in size, duration, resource management and risk than Level 1 incidents. May require deployment of resources beyond the first strike response	Level 3 Characterised by a high degree of complexity, require strategic leadership and response coordination. May require national and international response resources
IMT activation	Vessel or Facility's local response team activated	IMT activated	IMT activated
Resources at risk			
Human	Potential for serious injuries	Potential for loss of life	Potential for multiple loss of life
Environment	Isolated impacts or with natural recovery expected within weeks.	Significant impacts and recovery may take months. Monitoring and remediation may be required.	Significant area and recovery may take months or years. Monitoring and remediation will be required.

	Incident management response level		
Characteristic	**Level 1**	**Level 2**	**Level 3**
Wildlife	Individuals of a small number of fauna species affected	Groups of fauna species or multiple numbers of individuals affected	Large numbers of fauna (individuals and species) affected
Economy	Business level disruption	Business failure	Disruption to a sector
Social	Reduced services	Ongoing reduced services	Reduced quality of life
Infrastructure	Short term failure Non-safety/operational critical failure	Medium term failure Potentially safety/operational critical failure	Severe impairment Safety/operational critical system failure
Public affairs	Local and regional media coverage	National media coverage	International media coverage

2.2 Control agencies and jurisdictional authorities

The responsibility for responding to an oil spill is dependent on location and spill origin. The National Plan sets out the divisions of responsibility for an oil spill response. Definitions of Jurisdictional Authority and Control Agency are as follows:

- Control Agencies: the organisation assigned by legislation, administrative arrangements or within the relevant contingency plan, to control response activities to a maritime environmental emergency. Control Agencies have the operational responsibility of response activities but may have arrangements in place with other parties to provide response assistance under their direction.
- Jurisdictional Authority: the agency which has responsibility to verify that an adequate spill response plan is prepared and, in the event of an incident, that a satisfactory response is implemented. The Jurisdictional Authority is also responsible for initiating prosecutions and the recovery of clean-up costs on behalf of all participating agencies.

Table 2-2 provides guidance on the designated Control Agency and Jurisdictional Authority for Commonwealth and State waters and for vessel and petroleum activity spills.

It should be noted that in Commonwealth waters, vessels involved in seismic surveys are considered to be ‘vessels’ and not ‘petroleum activities’. However, in WA waters marine seismic surveys are a petroleum activity where they are associated with exploration for hydrocarbon reservoirs or evaluation of these resources.

2.3 Seismic survey spills in Commonwealth waters

AMSA manages the National Plan and is the Control Agency for all vessel-based spills in the Commonwealth jurisdiction. This includes vessels undertaking seismic surveys and associated supply or support vessels.

The Vessel Master is responsible for implementing source control arrangements detailed in the vessel specific SOPEP. Once initial notifications to the Control Agency are made, Pilot Energy shall maintain direct contact with the Control Agency and act as a Supporting Agency throughout the response. This includes providing essential services, personnel, material or advice in support of the Control Agency. In addition, Pilot Energy will implement monitoring activities as outlined in the Eureka 3D MSS OSM-BIP.

2.4 Seismic survey spills in WA waters

Although the National Plan defines seismic survey spills to be ‘vessel-based’ spills, this definition does not apply to WA waters, or to cross jurisdictional arrangements involving WA. As seismic survey spills are petroleum activity spills in WA waters, if a Marine Oil Pollution incident occurs enters, or has the potential to enter, State waters, the DoT is the Hazard Management Agency (HMA) (DoT CEO or proxy). The Assistant Executive Director (or proxy) has been nominated by the HMA to perform the role of State Marine Pollution Coordinator (SMPC) (as prescribed in Section 1.3 of the SHP–MEE) and DoT will take on the role as a Control Agency. The role of the SMPC is to provide strategic management of the incident response on behalf of the HMA.

Where DoT has assumed the role of Control Agency, Pilot Energy will provide all necessary resources to assist DoT.

2.5 Cross jurisdiction vessel spills

If a Level 2/3 vessel spill crosses jurisdictions between Commonwealth and State waters, two Jurisdictional Authorities will exist (AMSA for Commonwealth waters and DoT for WA State waters). The Control Agency will remain with the original nominated agency or organisation unless otherwise appointed through agreement between the HMA / Jurisdictional Authority of both waters. Pilot Energy will continue to provide all necessary resources (including personnel and equipment) as a Supporting Agency.

AMSA may request that DoT manage a vessel incident in Australian Commonwealth waters (DoT, 2021).

2.6 Pilot Energy Incident Management

For the period of a seismic survey Pilot Energy will maintain an IMT that is commensurate to the response level (Section 2.1) for the survey oil spill risk and impacts. The IMT structure, roles and responsibilities are outlined in Section 10 of the Eureka 3D MSS EP. IMT competencies and training schedule is outlined in Section 10 of the Eureka 3D MSS EP.

Table 2-2: Jurisdictional and Control Agencies for Hydrocarbon Spills

Jurisdictional boundary	Spill source	Jurisdictional authority	Control agency		Relevant documentation
			Level 1	Level 2/3	
Commonwealth waters (three to 200 nautical miles from Territorial/State sea baseline)	Vessel [4]	AMSA	AMSA		Vessel SOPEP National Plan Eureka 3D MSS OPEP (this document)
	Petroleum activities[5]	National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)	Titleholder		Activity OPEP
Western Australian (WA) State waters (State waters to three nautical miles and some areas around offshore atolls and islands)	Vessel	WA Department of Transport (DoT)	DoT	DoT	Vessel SOPEP SHP-MEE Oil Spill Contingency Plan (OSCP) (DoT, 2015)
	Petroleum activities	DoT	Titleholder	DoT	Eureka 3D MSS OPEP (this document) SHP-MEE

[4] Vessels are defined by Australian Government Coordination Arrangements for Maritime Environmental Emergencies (AMSA, 2017a) as a seismic vessel, supply or support vessel, or offtake tanker. Note: this definition does not apply to WA State waters.

[5] Includes a ‘Facility’, such as a fixed platform, FPSO/FSO, MODU, subsea infrastructure, or a construction, decommissioning and pipelay vessel. As defined by Schedule 3, Part 1, Clause 4 of the OPGGS Act.

2.7 Integration with other organisations

2.7.1 Western Australia – Department of Transport

Pilot Energy will notify the DoT Maritime Environmental Emergency Response (MEER) unit as soon as reasonably practicable (within 2 hours of spill occurring) if an actual or impending spill may impact WA State waters. On notification, the SMPC will activate their Maritime Environmental Emergency Coordination Centre (MEECC) and the DoT IMT. Titleholders will work in partnership with DoT during such instances, as outlined within the DoT's Offshore Petroleum Industry Guidance Note – Marine Oil Pollution: Response and Consultation Arrangements (DoT, 2020).

Pilot Energy will conduct initial response actions in State waters as necessary in accordance with this OPEP and the Eureka 3D MSS OSMP-BIP and continue to manage those operations until formal handover of incident control is completed. Appendix 1 in the Offshore Petroleum Industry Guidance Note provides a checklist for formal handover. Beyond formal handover, Pilot Energy will continue to provide all necessary resources, including personnel and equipment, to assist the DoT in performing duties as the Control Agency.

For a cross-jurisdictional response, there will be a Lead IMT (DoT or AMSA) for each spill response activity, with DoT's control resting primarily for State waters activities. Appendix 2 in the Offshore Petroleum Industry Guidance Note provides guidance on the allocation of a Lead IMT to response activities for a cross-jurisdictional spill.

To facilitate coordination between DoT and AMSA during a cross-jurisdictional response, a Joint Strategic Coordination Committee will be established. The Joint Strategic Coordination Committee will be jointly chaired between the SMPC and a nominated representative of AMSA and will ensure alignment of objectives and provide a mechanism for de-conflicting priorities and resourcing requests.

For a cross-jurisdictional response, Pilot Energy will be responsible for ensuring adequate resources are provided to DoT as Control Agency, initially 11 personnel to fill roles in the DoT IMT or Forward Operating Base (FOB) (DoT, 2020) and operational personnel to assist with those response strategies where DoT is the Lead IMT. Concurrently, DoT will also provide two of their personnel to the Pilot Energy IMT as described in the Offshore Petroleum Industry Guidance Note. Pilot Energy's Representative is to attend the DoT Fremantle Incident Command Centre (ICC) as soon as possible after the formal request has been made by the SMPC. It is an expectation that the remaining initial cohort will attend the DoT Fremantle ICC no later than 8 am on the day following the request being formally made to Pilot Energy by the SMPC. Pilot Energy delegated personnel designated to serve in DoT's FOB will arrive no later than 24 hours after receipt of formal request from the SMPC.

Figure 2-1 shows the overall cross-jurisdictional organisational structure referenced from the SHP-MEE.

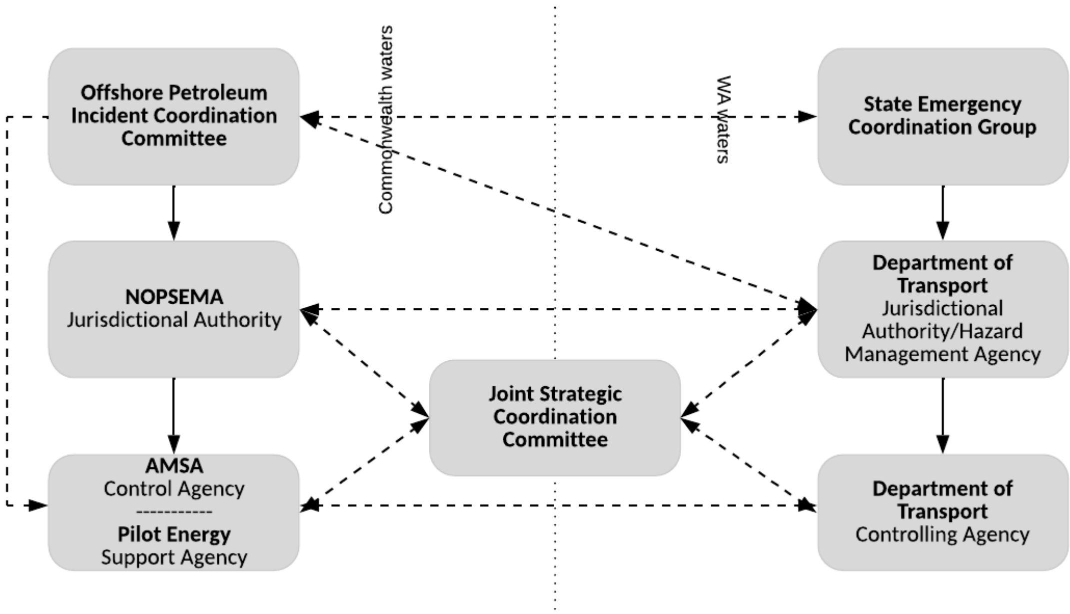


Figure 2-1: Cross-Jurisdictional Organisational Structure

2.7.2 AMSA

AMSA is the designated Control Agency for vessel spills in Commonwealth waters. Therefore, should a vessel spill enter Commonwealth waters, AMSA may also become a (or the) Control Agency. Arrangements for coordination and potential transfer of Control Agency status are outlined in AMSA Guidance Note NP-GUI-023: Coordination of Cross-Border Incidents (AMSA, 2017b).

AMSA is to be notified immediately of all ship-source incidents through the AMSA Rescue Coordination Centre (RCC) Australia (refer to project emergency contacts register).

AMSA manages the National Plan, Australia's key maritime emergency contingency and response plan (AMSA, 2020). AMSA also has a range of National Plan supporting documents containing related policies, guidance and advisory information.

2.7.3 Western Australian Department of Biodiversity, Conservation and Attractions

The Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) has responsibilities associated with wildlife and activities in national parks, reserves and State marine parks. The *Biodiversity Conservation Act 2016* (WA) is the legislation that provides DBCA with the responsibility and Statutory Authority to treat, protect, and destroy wildlife. In State waters, DBCA is the Jurisdictional Authority for Oiled Wildlife Response (OWR), providing advice to the Control Agency (DoT). The role of DBCA in an OWR is outlined in the Western Australian Oiled Wildlife Response Plan (WAOWRP) (DBCA, 2022a).

For a Level 2/3 petroleum spill that originates within or moves into State waters, DoT will be the Control Agency responsible for overall command of an oiled wildlife response. Pilot Energy will provide all necessary resources (equipment and personnel) to DoT to facilitate this response.

For matters relating to environmental sensitivities and scientific advice in State waters DBCA may provide an Environmental Scientific Coordinator (ESC) to support the SMPC and/or DoT Incident Controller.

This may include advice on priorities for environmental protection, appropriateness of proposed response strategies and the planning and coordination of scientific monitoring for impact and recovery assessment.

2.7.4 Department of Industry, Science and Resources

The Commonwealth Department of Industry, Science and Resources (DISR) will be the lead Commonwealth Agency for the provision of strategic oversight and Commonwealth government support to a significant offshore petroleum incident (including oil spill incidents). DISR will be notified by NOPSEMA of a significant oil pollution incident and under the Offshore Petroleum Incident Coordination Framework will stand up the Offshore Petroleum Incident Coordination Committee (OPICC) as the mechanism to provide Commonwealth strategic advice and support to the incident. To facilitate information between the petroleum titleholder IMT and Offshore Petroleum Incident Coordination Committee, Liaison Officer/s will be deployed from DISR to the Pilot Energy IMT.

For incidents that are classified at a greater level than level 3 (See section 2.1), a whole of government crisis committee will be formed under the Australian Government Crisis Management Framework to provide strategic advice and support and the Offshore Petroleum Incident Coordination Committee will not be convened, although DISR will remain as the lead agency.

2.8 Incident Action Planning

The incident action planning (IAP) process is built on the following phases:

1. Understand the situation.
2. Establish incident objectives.
3. Develop the plan.
4. Prepare and disseminate the plan.
5. Execute, evaluate and revise the plan.

The Control Agency will use the IAP process to determine and document the appropriate strategies as more information becomes available during an incident response. The Control Agency IMT will use an IAP for each operational period following the initial first-strike assessments, notifications, and activations undertaken by the Pilot Energy.

As Support Agency, Pilot Energy may be requested by the Control Agency to develop, or support the development of an IAP to help guide the incident response.

The DoT have a suite of Incident Management System templates to assist with the preparation of an IAP. These can be found under the Incident Management System drop down list here

3. Response Strategy Selection

3.1 Strategic spill impact mitigation assessment

Titleholders typically use a Spill Impact Mitigation Assessment (SIMA) or Net Environmental Benefit Analysis (NEBA) as their decision support tool to consider available information that helps them select the most suitable response strategies or combination of strategies that would minimise impacts to ecological, cultural, economic and social values (hereafter referred to as receptors). Different response strategies provide varying levels of effectiveness and protection under different environmental conditions, depending on the individual spill (Coelho et al., 2014).

Conducting a SIMA is an important step in the oil spill planning and preparedness process and is often called a Strategic SIMA. An overview of this assessment process is provided in Figure 3-1. To complete a Strategic SIMA, all available information on a potential spill is considered (e.g. oil type, volume, duration of release), together with any vector mapping or spill trajectory modelling to consider potential impacts to sensitive receptors.

A list of possible response strategies are considered from a 'response toolbox', as detailed in Section 3.3.1.

A detailed assessment of the benefits and drawbacks of each response strategy is completed to help determine the combination of strategies that would be most suited to each maximum credible spill scenario. This includes 'primary response strategies' and 'secondary response strategies', with the former typically being more reliable and effective in reducing impacts from an individual spill.

Table 3-6 details the Strategic SIMA for the Eureka 3D MSS spill scenario of an MGO spill from a vessel collision. It details the response strategies applicable or not applicable for an MGO spill.

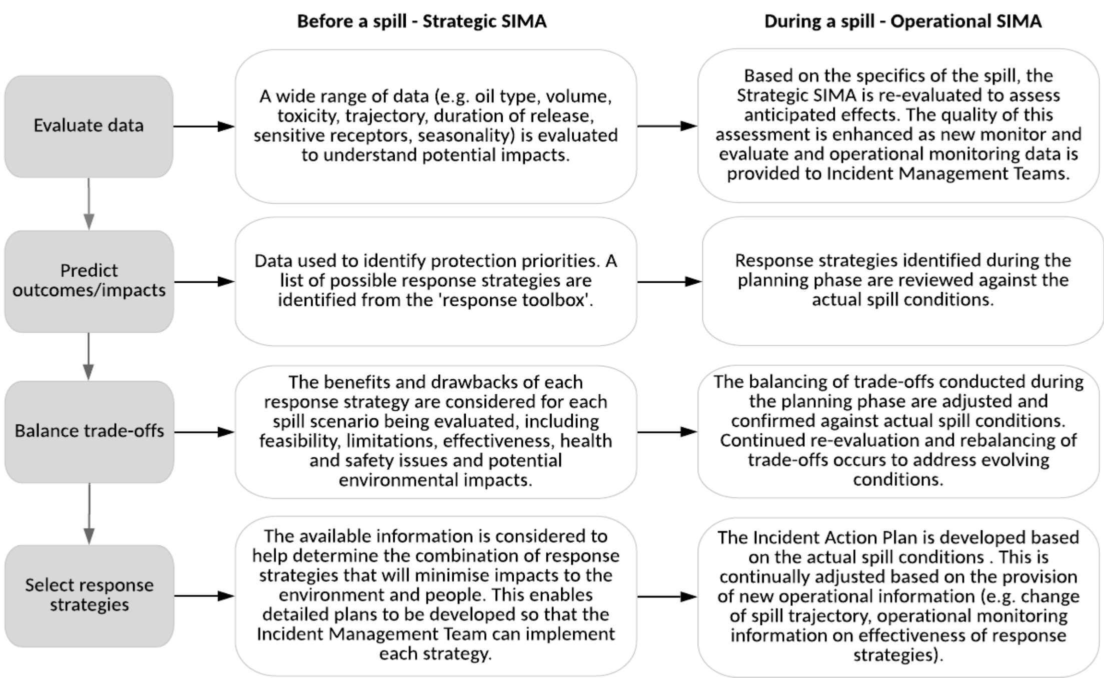


Figure 3-1: Spill Impact Mitigation Assessment Overview

3.2 Evaluate data

3.2.1 Spill scenario

The worst-case spill scenario in the Eureka 3D MSS EP (as presented in Table 3-1) is an MGO spill from a vessel collision in the south-east corner of the Operational Area, at a location that is approximately 12 km from the mainland coastline and approximately 5 km from the Beagle Islands.

Table 3-1: Worst-Case Credible Spill Scenario – Eureka 3D MSS

Spill scenario	Hydrocarbon type	Maximum credible volume released (m^3)	Release duration
Vessel collision	MGO	320	6 hours

3.2.2 Hydrocarbon properties

MGO is a product that contain a mixture of volatile and persistent hydrocarbons. Table 3-2 shows the approximate physical properties and boiling point range of MGO.

When released to the marine environment, MGO will spread quickly and thin out to low thickness levels, thereby increasing the rate of evaporation. Due to its chemical composition, up to 65% will generally evaporate over the first two days depending upon the prevailing conditions and spill volume.

MGO has a strong tendency to entrain into the upper water column (0 m–10 m) (and consequently reduce evaporative loss) in the presence of moderate winds (> 10 knots) and breaking waves. However, MGO can re-surface when the conditions calm.

Table 3-2: MGO Representative Characteristics

Hydrocarbon type	Density (kg/m^3)	Viscosity (cP)	Component	Volatile (%)	Semi-volatile (%)	Low volatility (%)	Residual (%)
			BP (ºC)	<180	180–265	265–380	>380
MGO	820–860 (at 15 °C)	2–4.5 (at 40 °C)	% of total	16.4	49	31.9	2.7

3.2.3 Spill Modelling Results

The worst-case credible spill scenario shown in Table 3-1 was used as the basis for modelling, which was performed using a three-dimensional spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program). The SIMAP model calculates the transport, spreading, entrainment, evaporation and decay of surface hydrocarbon slicks as well as the entrained and dissolved oil components in the water column.

A total of 100 spill trajectories were simulated for the time of year that the survey might be conducted (February and March) using a number of unique environmental conditions sampled from historical metocean data. The scenario was tracked for 28 days.

The modelling outputs do not represent the potential behaviour of a single spill (which would have a much smaller area of influence) but provides an indication of the probability of any given area of the sea surface being contacted by hydrocarbons above impact thresholds. For the purpose of spill response preparedness, outputs relating to floating oil and oil accumulated on the shoreline are most relevant (i.e. oil that can be diverted, contained, collected or dispersed through the use of spill response strategies) for the allocation and mobilisation of spill response resources.

Table 3-3 presents the stochastic modelling results for floating concentrations and shoreline accumulation volumes for the vessel collision spill for February to March. Oil spill modelling did not predict any shoreline accumulation above the moderate exposure thresholds above 10% probability for either season.

Modelling results for dissolved and entrained oil for the worst-case scenario have not been included given there are limited response strategies that will reduce subsurface impacts. However, Pilot Energy uses the modelling results for entrained oil from the worst-case scenario for the purposes of identifying scientific monitoring priority areas as outlined in the Eureka 3D MSS OSM-BIP.

Table 3-3: Stochastic Modelling Results – Scenario 1 (February to March) - MGO spill (RPS, 2023)

Location	Probability (%) of floating oil exposure ≥10 g/m^2	Minimum time before floating oil exposure (hours) ≥10 g/m^2	Maximum probability (%) of shoreline loading ≥10 g/m^2	Minimum time before shoreline accumulation ≥10 g/m^2 (hours)	Maximum probability (%) of shoreline loading ≥100 g/m^2	Minimum time before shoreline accumulation ≥100 g/m^2 (hours)	Peak volume ashore (m^3) ≥100 g/m^2	Maximum length of shoreline contacted (km) ≥100 g/m^2
Bowes River – Broken Anchor Bay (B)	<1	NC	1	472	<1	NC	NC	NC
Glenfield Beach – Bowes River (C)	<1	NC	1	234	<1	NC	NC	NC
Green Head - Leeman	<1	NC	1	54	1	60	<1	<1
Illawong – Cliff Head	6	3	<1	NC	<1	NC	NC	NC
Leeman Coolimba	<1	NC	1	56	<1	NC	NC	NC
Thirsty Point – Booker Valley	<1	NC	1	491	<1	NC	NC	NC
Abrolhos Islands	<1	NC	1	234	<1	NC	NC	NC
Pelsaert Group	<1	NC	1	234	<1	NC	NC	NC
Wallabi Group	<1	NC	1	472	<1	NC	NC	NC
NC= No contact								

3.2.4 Sensitive Receptors and Protection Priorities

For any oil spill entering or within WA State waters/shorelines, the WA DoT is the Control Agency and ultimate decision-maker regarding identification and selection of protection priorities.

Spill modelling results were used to predict the Environment that may be Affected (EMBA) for Eureka 3D MSS (refer to section 8). The EMBA is the area in which activities associated with Eureka 3D MSS may result in environmental impacts – defined as the area potentially impacted by hydrocarbons from a spill event above impact concentration thresholds. Within the EMBA, priority protection areas have been identified. Priority protection areas are emergent features (i.e. coastal areas and islands) that are predicted to be contacted above moderate exposure values and would be targeted by nearshore spill response operations such as protection and deflection and shoreline clean-up.

Table 3-4 lists the priority protection areas for this activity.

Table 3-4: Priority Protection Area – Eureka 3D MSS

Protection Priority Areas	Key sensitivities	DoT Ranking (Floating oil)[6]	DoT Ranking (Dissolved oil)
Green Head – Leeman (DoT shoreline cell #193)	• Extensive meadows of seagrass that grow in shallow lagoons which provide an important nursery habitat for juvenile fish and western rock lobster (CALM, 2000) • Macroalgal communities • Abalone occur on intertidal reefs • Humpback whale and bottlenose dolphins (*Tursiops truncatus*) regularly seen in the area (CALM, 2000) • White shark foraging • Inshore islands between Cliff Head and Grey are important breeding areas for seabirds (Dunlop and Wooller, 1990; CALM, 2004) • Seabird foraging • Only breeding area for Australian sea lions on the west coast of Australia: – Reside and breed on Buller Island, North Fisherman Island, East Island, Beagle Island (CALM, 2004) – Approximately 800 sea lions – Isolated genetically distinct sub-population • Sea lion foraging • Boullanger Island dunnart is only found on Boullanger Island (CALM, 2004) • Dibblers are found on Boullanger and Whitlock islands (CALM, 2004) • Cultural heritage- mainland areas have been identified as a significant area for Noongar people • The coast area between Green Head and Jurien has the largest number of midden deposits in the south-west of WA (CALM, 2004) • Coast dunes in the Jurien Bay region were used as burial sites (CALM, 2004) • Several shipwrecks have been recorded between Cliff Head and Grey (CALM, 2004)	4	3

[6] Provision of Western Australian Marine Oil Pollution Risk Assessment – Protection Priorities: Assessment for Zone 3: Midwest (Advisian, 2018).

3.3 Predict Outcomes

3.3.1 Response 'Toolbox'

Possible response strategies for a surface oil spill include:

- Monitor and evaluate
- Source control
- Containment and recovery
- (Mechanical) physical dispersion
- Chemical dispersion – surface application
- Shoreline protection
- Shoreline clean-up
- In-situ burning
- Oiled wildlife response

Support functions:

- Waste management
- Scientific monitoring

3.3.2 Response Planning Thresholds

In addition to the impact assessment thresholds described in the Eureka 3D MSS EP Section 8.6.3, response thresholds have been developed for response planning to determine the conditions that response strategies would be effective. These thresholds are provided as a guide for response planning based on case studies that have demonstrated some response strategies (e.g. chemical dispersant application) require certain oil spill thicknesses and conditions to be effective.

The thresholds assist with understanding worst-case spill scenario response strategy capability requirements when used in conjunction with oil spill trajectory modelling results. Modelling informs the predicted spatial extent of the spill at certain response thresholds, which in turn can inform response strategy capability.

Response planning thresholds are provided in Table 3-5.

Table 3-5: Surface and Shoreline Hydrocarbon Thresholds for Response Planning

Hydrocarbon (g/m^2)	Description	Justification
≥ 1	Estimated minimum threshold for commencing some monitoring components (e.g. water quality monitoring) and monitoring and evaluation tactics (e.g. aerial surveillance)	This thickness approximates the range of socio-economic effects and helps to establish the spatial extent for scientific monitoring (NOPSEMA, 2019).
≥ 10	Estimated minimum threshold for commencing all triggered monitoring components	This approximates the lower limit for harmful exposures to birds and marine mammals (NOPSEMA, 2019) so assists with planning for related scientific monitoring components.
≥ 50	Estimated minimum floating hydrocarbon threshold for on water response strategies	Surface chemical dispersants are most effective on hydrocarbons that are at a thickness of 50–100 g/m^2 on the sea surface. EMSA (2010) recommends thin layers of spilled hydrocarbons should not be treated with dispersant. This includes Bonn Agreement Oil Appearance Codes (BAOAC) 1–3 (EMSA, 2010). However, this may not always be practical in the field, as the actual thickness of a slick can vary greatly over even short distances (IPIECA-IOPG, 2015). Hence, this threshold is applied for planning purposes but should be judged according to real-time conditions in the event of a spill. McKinney and Caplis (2017) tested the effectiveness of various oil skimmers at different oil thicknesses. Their results showed that the oil recovery rate of skimmers dropped significantly when oil thickness was less than 50 g/m2.
≥ 100	Estimated floating hydrocarbon threshold for on water response strategies Estimated minimum shoreline accumulation threshold for shoreline clean-up (if required) and subsequent waste management	This threshold is often used as the minimum thickness for effective shoreline clean-up (Owens and Sergy, 2000; French-McCay, 2009).

3.4 Balance trade-offs and select response strategies

Selecting which response strategies to use often involves making trade-offs (e.g. risk, feasibility, flexibility, effectiveness), based on which environmental receptors should receive priority for protection. A Strategic SIMA is presented in Table 3-6 and indicates the applicability of each possible response strategy (Section 3.3.1) for the worst case spill scenario of a MGO spill from a vessel collision (Section 3.2.1).

Table 3-6: Strategic SIMA for Eureka 3D MSS vessel collision MGO spill

Response strategy	Evaluation	Recommendation
Source control	In the event of a vessel spill, the Vessel Master would revert to the Ship Oil Pollution Emergency Plan (SOPEP), which is a MARPOL requirement for applicable vessels and not addressed by this SIMA.	n/a
Monitor and evaluate	The requirement for situational awareness is critical to implement a coordinated, focussed and effective spill response. This strategy has several tactics (e.g. tracking buoys, aerial surveillance) and is scalable according to the nature and scale of the spill. SIMA will always support the implementation of 'Monitor and Evaluate' given the clear benefits in maintaining situational awareness throughout the duration of a spill event and little or no environmental impact associated with its implementation. Therefore, the benefits of undertaking this response are considered to significantly outweigh the potential environmental risks/impacts.	Primary response strategy
Natural recovery	Natural recovery is often the most effective response for light hydrocarbons (Group 1-3), including MGO. MGO products lose a large percentage of their volume via natural weathering and fate processes in the first 24 hours following a spill. It is unlikely that significant response resources would be able to be deployed within this time, so much of the spill volume will weather and evaporate prior to the arrival of additional response resources. Allowing the product to weather naturally can often create less overall impact than intrusive methods of clean-up and response (e.g. the net impact of allowing small volumes of product to naturally degrade on sensitive offshore islands may be less than sending in shoreline clean-up teams and equipment, which may damage nesting locations, disturb fauna and create significant waste volumes).	Primary response strategy
Containment and recovery	Unlikely to be effective as MGO products will rapidly degrade in the open ocean environment. For containment and recovery to be effective, a sufficient oil thickness is required be achieved by the containment booms (minimum of 50 g/m^2). This strategy is often limited to heavier and more persistent Group 3 and 4 (ITOPF) hydrocarbons.	Not recommended
In-situ burning	To conduct in-situ burning, meteorological conditions and sea-state must allow the deployment of especially designed fire-retardant booms, which are required to corral hydrocarbons to a sufficient thickness to permit ignition and ongoing combustion. MGO is a rapidly evaporating and spreading hydrocarbon and is not expected to be available at sufficient thicknesses for ignition.	Not recommended
(Mechanical) physical dispersion	The benefits of undertaking this response are not considered to significantly outweigh the potential risk to human health due to the volatility of the hydrocarbon products. Mechanical dispersion is not considered a suitable response strategy for MGO scenarios.	Not recommended
Chemical dispersion – surface application	MGO has high natural spreading, dispersion and evaporation rates in the marine environment and would be too thin to enable effective use of chemical dispersants. Chemical dispersants have a window of opportunity, after which effectiveness decreases. This includes a workable area for dispersant application, adequate surface thickness and presence of dispersible components of oil. These characteristics typically exist in the initial hours following a release. Dispersant use is not considered to be effective	Not recommended

Response strategy	Evaluation	Recommendation
	on the spill scenarios given they are not continuous releases and slick characteristics amenable to dispersant operations will unlikely be present by the time dispersant operations are mobilised. Adding chemical dispersants would introduce more chemicals into the marine environment, for little to no benefit.	
Shoreline protection and deflection	Shoreline protection and deflection activities involve mobilising personnel and equipment to remote coastal environments, which can result in physical disturbance to intertidal and shoreline habitats. It would also require small inshore vessels and calm weather to be effective and temporary staging areas for waste that would be generated from the recovery of floating oil. The effectiveness of this response will be dependent on local bathymetry, sea state, currents, tidal variations and wind conditions at the time of implementation. It is typically more effective in areas with low to moderate tidal ranges on low energy coastline types such as sandy beaches. Moderate to high tidal ranges generally include stronger currents and larger/longer intertidal areas that make it less effective and more difficult to keep booms in place. Activities would focus on areas of high protection value in low energy environments based upon real-time operational surveillance, provided the environmental and metocean conditions are favourable for an effective implementation. An Operational SIMA should demonstrate that protection would result in an overall benefit to receptors. Consequently, this option may not be applicable across all areas or receptors identified as having priority for protection.	Secondary response strategy – to be deployed if operational SIMA indicates it would result in a net benefit.
Shoreline clean-up	Shoreline clean-up activities involve mobilising personnel and equipment to remote coastal environments, which can result in physical disturbance to intertidal and shoreline habitats. This may cause more impacts than leaving the hydrocarbon to degrade naturally, especially if the oiling is light. Intrusive activities such as physical removal of waste using manual labour or mechanical aids requires careful site-specific planning to reduce secondary impacts of habitat disturbance, erosion and spreading oil beyond shorelines. Secondary impacts can be minimised using trained personnel to lead operations. Logistically, clean-up operations will require site access, decontamination, waste storage, PPE, catering and transport services to support personnel working on shorelines. Given the relatively small volumes predicted to come ashore for most locations, and the high rates of natural biodegradation of diesel, it would be better to focus on high priority areas for clean-up. This strategy is considered to be a secondary response strategy where it is safe and practical to implement and where an Operational SIMA demonstrates that clean-up would result in an overall benefit to receptors.	Secondary response strategy - to be deployed if operational SIMA indicates it would result in a net benefit.
Oiled wildlife response	Oiled wildlife response (OWR) includes wildlife surveillance/reconnaissance, wildlife hazing, pre-emptive capture and the capture, cleaning, treatment, and rehabilitation of animals that have been oiled. In addition, it includes the collection, post-mortem examination, and disposal of deceased animals that have succumbed to the effects of oiling.	Primary response strategy

Response strategy	Evaluation	Recommendation
	Wildlife surveillance/reconnaissance will likely form the main component of an OWR associated with the MGO scenarios.	

3.5 Operational SIMA

An Operational SIMA is an iterative process that is used to help guide an IMT during a response. An outline of an Operational SIMA process is provided in Figure 3-1 and considerations to help refine the Operational SIMA are provided in Table 3-7. Real-time data from monitor and evaluate and operational monitoring activities should be incorporated into the Operational SIMA, so that the IMT can adjust the response according to the effectiveness of tactics during each operational period.

Following implementation of the initial (first strike) response, the Strategic SIMA (Table 3-6) will form the basis for the initial Operational SIMA.

The initial Operational SIMA should be a priority action for the Planning Section once they are activated but may be based on limited information. However, the overall response effort should not be delayed due to a lack of some information. The Operational SIMA can always be revised when more information is available.

The Planning Section is responsible for completing the Operational SIMA and to determine if outputs from the Strategic SIMA are still appropriate. The Operational SIMA should be revised during each new Operational Period and should incorporate post-spill trajectory modelling data, surveillance data, operational monitoring data and should be incorporated into the IAP.

Table 3-7: Operational SIMA Considerations

Response strategy	Considerations
Monitor and evaluate	• Which monitor and evaluate tactics will provide reliable and accurate data for the individual spill? • What sensitive receptors are in the current or anticipated trajectory? • What is the assessed volume and size of the spill? • Is the product weathering as anticipated? • What data is being returned from operational monitoring and how can this be used to aid decision making? • How do the response options and tactics seem to be influencing the spill? Shoreline assessment (only): • Will access to remote shorelines be safe and feasible? • Will assessment teams disturb sensitive seasonal nesting species?
Protection and deflection	• Have the protection priorities been ground-truthed and are there seasonal receptors that should be prioritised for protection? • Are conditions (e.g. tides, current, sea state) favourable for this strategy to be effective in open ocean environments immediately surrounding the emergent sensitivities (reefs)? • Can tactics be deployed in time? • Will access to the shallow intertidal areas on top of emergent sensitivities be safe and feasible? • Can the IMT access suitable shallow draft vessels to safely establish booming arrangements (e.g. does vessel have ability to transfer anchors and booms; does it have adequate tie-points?). • Is there potential that reefs could be damaged from anchor drag?
Shoreline clean-up	• What volumes and/or concentrations of hydrocarbons are present or expected on the shoreline and what would be the impact to leave the product to weather naturally (taking into consideration the effects of MGO as a lighter hydrocarbon type – high evaporation rates but more toxic and greater ability to penetrate sediments)? • Have the protection priorities been ground-truthed and are there seasonal receptors that should be prioritised for protection?

Response strategy	Considerations
	• Will access to remote shorelines be safe and feasible? • Will responders disturb sensitive seasonal nesting species? • Would it reduce overall impacts to send small teams of clean-up personnel?
Oiled wildlife response	• Is there adequate monitoring for wildlife, taking into consideration temporal and spatial species-specific considerations? • Are known species breeding or nesting? • What level of wildlife impact has occurred or is expected to occur? • What wildlife response strategies are feasible and safe?

4. External Notifications and Reporting Requirements

Pilot Energy is responsible for making external notifications and reporting. Table 4-1 outlines external notification and reporting requirements required for Level 2-3 incidents, noting that regulatory reporting may apply to smaller Level 1 spills.

Contact details for the regulatory agencies outlined in Table 4-1 are provided with the project emergency contacts register.

Table 4-1: External Notifications and Reporting

Agency or Authority	Type of Notification / Timing	Legislation/ Guidance	Reporting Requirements	Responsible Person/Group	Forms
AMSA **(Rescue Coordination Centre)**	Verbal notification without delay to include: • name of ship/s involved • time, type and location of incident • quantity and type of harmful substance • assistance and salvage measures • any other relevant information Written POLREP form, within 24 hours of request from AMSA	National Plan for Maritime Environmental Emergencies MARPOL	All slicks trailing from a vessel All spills to the marine environment (notwithstanding the size or amount of oil or sheen) All spills where National Plan equipment is used in a response	Vessel Master	Incident reporting requirements: https://www.amsa.gov.au/marine-environment/marine-pollution/mandatory-marpol-pollution-reporting Online POLREP – https://amsa-forms.nogginoca.com/public/
NOPSEMA **(Incident Notification Office)**	Verbal notification within 2 hours after Pilot Energy becomes aware of the incident Written report as soon as practicable, but no later than 3 days	*Offshore Petroleum and Greenhouse Gas Storage Act 2006* Offshore Petroleum Greenhouse Gas Storage (Environment) Regulations 2009 (as amended 2014)	A spill associated with the activity that has caused, or has the potential to cause, moderate to significant environmental damage: Vessel loss of containment (MDO/MGO)	Notification by Pilot Energy IMT	Incident reporting requirements: https://www.nopsema.gov.au/environmental-management/notification-and-reporting/
National Offshore Petroleum Titles	Written report to NOPTA within 7 days of the initial	Guidance Note (N-03000-GN0926) Notification and Reporting of Environmental	Spill in Commonwealth waters that is	Notification by Pilot Energy IMT	Provide same written report as provided to NOPSEMA

Agency or Authority	Type of Notification / Timing	Legislation/ Guidance	Reporting Requirements	Responsible Person/Group	Forms
Administrator (NOPTA) **(Titles Administrator)**	report being submitted to NOPSEMA	Incidents - https://www.nopsema.gov.au/assets/Guidance-notes/A198752.pdf	reportable to NOPSEMA		
Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) **(Director of monitoring and audit section)**	Email notification as soon as practicable	*Environment Protection and Biodiversity Conservation Act 1999*	If Matters of National Environmental Significance (MNES) are considered at risk from a spill or response strategy, or where there is death or injury to a protected species	Notification by Pilot Energy IMT	Not applicable
Parks Australia **(24-hour Marine Compliance Duty Officer)**	Verbal notification as soon as practicable	*Environment Protection and Biodiversity Conservation Act 1999*	All actual or impending spills which occur within a marine park or are likely to impact on an Australian marine park	Notification by Pilot Energy IMT	No forms, but the following information should be provided: • Pilot Energy's details • Time and location of the incident (including name of marine park likely to be affected) • Proposed response arrangements as per the OPEP • Details of the relevant contact person in the IMT
Australian Fisheries Management Authority (AFMA)	Verbal phone call notification as soon as practicable (within 24 hours)		Fisheries within the environment that may be affected (EMBA) Consider a courtesy call if not in exposure zone	Notification by Pilot Energy IMT	Not applicable

Agency or Authority	Type of Notification / Timing	Legislation/ Guidance	Reporting Requirements	Responsible Person/Group	Forms
If spill is heading towards WA waters					
WA DoT **(WA Maritime Environmental Emergency Response (MEER) unit)**	Immediate notification to the MEER Duty Officer Follow up with written POLREP, as soon as practicable Written Situation Report (SITREP) submitted within 24 hours of being directed by DoT	State Hazard Plan – Maritime Environmental Emergencies	All actual or impending spills in WA waters, regardless of source or quantity	Immediate notification by Pilot Energy IMT POLREP to be submitted by Pilot Energy IMT SITREP to be submitted by Pilot Energy IMT	DoT POLREP: http://www.transport.wa.gov.au/mediaFiles/marine/MAC-F-PollutionReport.pdf SITREP: http://www.transport.wa.gov.au/mediaFiles/marine/MAC-F-SituationReport.pdf
Department of Mines, Industry Regulation and Safety (DMIRS) **(Petroleum Environment Duty Officer)**	Verbal notification within 2 hours Notification report within 3 days	Guidance Note on Environmental Non-compliances and Incidents	All actual or impending spills in WA waters	Notification by Pilot Energy IMT	Environmental and Reportable Incident/ Non-compliance Reporting Form http://www.dmp.wa.gov.au/Documents/Environment/ENV-PEB-189.docx
Department of Biodiversity Conservation and Attractions (DBCA) **(State Duty Officer)**	Verbal notification as soon as practicable	WA Oiled Wildlife Response Plan	Notify if spill has the potential to impact or has impacted wildlife in State waters (to activate the Oiled Wildlife Advisor)	Notification by Pilot Energy IMT	Not applicable
Department of Water and Environmental Regulation (DWER)	Initial verbal or electronic notification of the discharge as soon as practicable Written notification of the incident to the CEO of the DWER, copied to the local DWER Industry Regulation Office, as soon as practicable	*Environmental Protection Act 1986* (Section 72) Environmental Protection (Unauthorised Discharge) Regulations 2004	Call DWER 24 hour Pollution Watch hotline *Environmental Protection Act 1986* (WA): Spill or discharge of hydrocarbons to the environment	Notification by Pilot Energy IMT	Reporting requirements: https://www.dwer.wa.gov.au/your-environment/51-reporting-pollution/110-reporting-a-life-threatening-incident-or-pollution-emergency

Agency or Authority	Type of Notification / Timing	Legislation/ Guidance	Reporting Requirements	Responsible Person/Group	Forms
			that has caused, or is likely to cause pollution, or material or serious environmental harm (Level 2 / 3 spills) Environmental Protection (Unauthorised Discharge) Regs.: Unauthorised discharge (where there is potential for significant impact or public interest) to environment of Schedule 1 material		
Department of Primary Industries and Resource Development (DPIRD) **Fisheries**	Verbal notification as soon as practicable (within 24 hours)	Agreed consultation	Notify if spill has the potential to impact or has impacted fisheries in State waters	Notification by Pilot Energy IMT	Not applicable
If spill is heading towards international waters					
Department of Foreign Affairs and Trade (DFAT) **(24-hour consular emergency centre)**	Verbal phone call notification within 8 hours, if the spill is likely to extend into international waters	Not applicable	Notify DFAT that a spill has occurred and is likely to extend into international waters Inform DFAT of the measures	Notification by Pilot Energy IMT	Not applicable

Agency or Authority	Type of Notification / Timing	Legislation/ Guidance	Reporting Requirements	Responsible Person/Group	Forms
			being undertaken to manage the spill		

5. Source Control

Source control involves stopping the discharge of hydrocarbons from the source of the spill. If the source of the spill is a vessel, then the vessel owner is responsible for undertaking source control, although the titleholder may be requested to provide support.

Vessel based source control includes measures that can be undertaken aboard the vessel (e.g. shutoff valves, diversion to unaffected tanks) and support from other vessels (e.g. magnetic patches, salvage, transfer of hydrocarbons to alternate vessel) to control the source, reduce the loss of hydrocarbons and prevent escalation of the incident. This information is detailed in the relevant Ship Oil Pollution Emergency Plan (SOPEP).

6. Monitor and Evaluate

Monitor and evaluate involves the collection and evaluation of information to provide and maintain situational awareness in the event of a spill. Monitor and evaluate activities should be conducted throughout the spill response, as it provides the IMT with ongoing information on sensitive receptors at risk of impact from the spill and the effectiveness of spill response operations. This information should be used by the IMT when updating response (operational) SIMAs and in the development of IAPs.

The monitor and evaluate response strategy includes a range of tactics which may be suitable for the spill scenarios covered by this OPEP. The relevance and suitability of individual tactics will need to be considered when preparing the Operational SIMA for individual spills. Initiation of suitable tactics (with the exception of tracking buoys and fate/weathering modelling) will need to be confirmed by the Control Agency, prior to deployment.

- Deployment of tracking buoy(s) – requires a buoy to be deployed to the water at the leading edge of the spill to track the movement of the spill.
- Fate and weathering modelling – uses computer modelling (e.g.ADIOS2) to estimate the weathering of an oil spill.
- Oil spill trajectory modelling – uses computer modelling (e.g. SIMAP) to estimate the movement, fate and weathering of spills.
- Visual observation (via aerial and/or vessel surveillance) – requires trained observers to identify and characterise spills. Survey platforms typically include aircraft and/or vessels. Is also used to ground truth oil spill trajectory modelling and monitor the effectiveness of response options.
- Satellite surveillance and data capture – uses satellite technology to identify and track oil spills.

6.1 Initiation and termination criteria

Tactic	Initiation criteria	Termination criteria
Tracking buoy	Notification of a Level 2/3 spill	Tracking buoy deployment will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or As directed by the relevant Control Agency
Fate and weathering modelling (e.g. ADIOS2)	Notification of a Level 2/3 spill - may be deployed in a Level-1 incident (to be determined by On-Scene Commander)	Spill fate and weathering modelling will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or As directed by the relevant Control Agency
Oil Spill Trajectory Modelling (OSTM)	Notification of a Level 2/3 spill; and Requested by the relevant Control Agency	OSTM will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or As directed by the relevant Control Agency
Vessel surveillance	Notification of a Level 2/3 spill - may be deployed in a Level-1 incident (to be determined by On-Scene Commander); and Requested by the relevant Control Agency	Vessel surveillance will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or As directed by the relevant Control Agency
Aerial surveillance	Notification of a Level 2/3 spill; and	Aerial surveillance will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or

Tactic	Initiation criteria	Termination criteria
	Requested by the relevant Control Agency	As directed by the relevant Control Agency
Satellite surveillance and data capture	Notification of a Level 2/3 spill; and Requested by the relevant Control Agency	Satellite surveillance will continue for 24 hours after the source is under control and a surface sheen is no longer observable; or Satellite surveillance is no longer required to provide situational awareness; or Agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the tactic

6.2 Implementation guide

Table 6-1 provides guidance on tasks and responsibilities that the IMT should consider to support the Control Agency if they implement this response strategy. The Control Agency is responsible for the implementation of the response and therefore, depending on the circumstances of the spill, may determine that some tasks be varied, should not be undertaken or should be reassigned.

Table 6-1: Monitor and evaluate implementation guide

Responsibility		Task	Consideration	Complete
Tracking buoy (if selected)				
Initial Actions	Pilot Energy Representative/Operations Section	Request onsite vessel to deploy tracking buoy		❑
	Vessel Master	Direct personnel to deploy buoy from the vessel: • Remove buoy from packaging; • Remove On/Off magnet and place in safe location (back in the box); and • Deploy buoy into the water from height not greater than 10 m unless the buoy design is robust to do so from a greater height’	Buoy should be deployed as close as possible to the leading edge of the spill (personnel and vessel safety is priority and must be considered by Vessel Master prior to selecting this tactic)	❑
	Pilot Energy Representative	Inform IMT that buoy has been deployed and provide IMT with current weather conditions	Note deployment details in incident log	❑
	Planning Section	Verify deployment of tracking buoy using tracking buoy login details	Tracking buoy login details located in the Project Emergency Contacts Directory	❑
Ongoing Actions	Planning Section	Use tracking buoy data to regularly update Common Operating Picture/Situation Boards in IMT		❑
	Planning Section	Provide tracking buoy data to Control Agency as soon as possible	Control Agency could provide data to spill trajectory provider improve the accuracy of spill model	❑
	Planning Section	Liaise with Control Agency to seek direction regarding any additional deployments of tracking buoys		❑
Trajectory and fate/weathering modelling (if selected)				
Initial Actions	Planning Section	Conduct hydrocarbon distribution, fate and weathering assessment using Automated Data Inquiry for Oil Spills (ADIOS2) using information available on oil type and provide information to Control Agency		❑

Responsibility		Task	Consideration	Complete
	Planning Section	Use information to regularly update Common Operating Picture/Situation Boards in IMT		❑
	Planning Section	Provide tracking buoy data to Control Agency as soon as possible		❑
ACTIONS BELOW ARE INDICATIVE ONLY AND ARE AT THE FINAL DETERMINATION OF THE CONTROL AGENCY				
Initial Actions	Planning Section	Contact Control Agency to request modelling through AMSA National Plan arrangements Complete Spill Trajectory Modelling Request form and provide to Control Agency	Complete Spill Trajectory Modelling Request form can be found here - https://www.amsa.gov.au/forms/national-plan-spill-trajectory-modelling-request Modelling should be undertaken within 4 hours of the request being sent to OSTM Service Provider, then every operational day during the spill response. Note all actions in incident log	❑
Ongoing Actions	Planning Section	Request trajectory modelling be provided daily throughout the duration of the response and integrate data into Common Operating Picture/Situation Boards		❑
	Planning Section	Use results from monitor and evaluate activities, and/or operational monitoring data (where available) to improve spill trajectory model accuracy	Provide available data to OSTM Service Provider at the end of each operational period	❑
Vessel surveillance (if selected)				
Initial Actions	Pilot Energy Representative/Operations Section	Determine if there are any nearby vessels available to follow spills and aid surveillance activities	Support vessels may be able to provide surveillance	❑
	Operations Section	Obtain approval from Control Agency to commence vessel surveillance in the vicinity		❑
	Vessel Master	Provide IMT initial report on estimated spill volumes and movement based on visual observation (if possible)	Preliminary observations are intended to provide initial projections of spill trajectory and scale prior to more detailed modelling and surveillance. These observations should be immediately verified by more detailed surveillance A Vessel Surveillance Observation Log is provided in Visual Surveillance Logs.	❑

Responsibility		Task	Consideration	Complete
Ongoing Actions	Planning Section	If vessel surveillance is feasible, ensure surveillance data is regularly incorporated into the Common Operating Picture/Situation Boards		❑
Aerial surveillance (if selected)				
Initial Actions	Operations Section	Contact AMSA to initiate aerial surveillance (via National Plan arrangements)	Trained observers should be familiar with the Bonn Agreement Aerial Operations Handbook (Part III) (Bonn Agreement, 2016). An Aerial Surveillance Observation Log is provided in Visual Surveillance Logs. Trained aerial observers are available from AMSA National Response Team (via the National Plan)	❑
	Operations Section	Once approval obtained, confirm availability of aerial surveillance platform to conduct initial surveillance flight	If aviation asset available near spill location, utilise where possible to gather as much information about the spill. If aviation asset not available at spill location, IMT is to seek available resources. It is possible that the initial surveillance flight will not include a trained aerial surveillance observer. Initial flights can be conducted using a standard crew and initial surveillance should not be delayed waiting for trained personnel. Ensure all safety requirements are met prior to deployment. There should be an attempt to obtain the following data during initial surveillance: • name of observer, date, time, aircraft type, speed and altitude of aircraft • location of slick or plume (GPS positions, if possible) • spill source • size of the spill, including approximate length and width of the slick or plume • visual appearance of the slick (e.g. colour) • edge description (clear or blurred) • general description (windrows, patches etc.) • wildlife, habitat or other sensitive receptors observed	❑

Responsibility		Task	Consideration	Complete
			• basic metocean conditions (e.g. sea state, wind, current) • photographic/video images	
	Operations Section	Obtain approval from Control Agency to commence surveillance flights in the vicinity of the spill	Operations Section is to assume primary coordination for all flights if approved by Control Agency	❑
	Operations Section	Once initial flight is complete, IMT in consultation with the Control Agency to determine if additional flights are required		❑
	Operations Section	In addition to arranging initial flight, mobilise aircraft and trained observers to the spill location to undertake surveillance activities if approved by the Control Agency (these can be cancelled if initial flight determines no additional surveillance is required)	Aerial platform should be capable of providing the following: • immediate accessibility from a designated airport • capability to fly at 150 feet • provision of aircraft crew for 1 x aircraft and space for at least one trained aerial observer	❑
	Operations Section	All records to be relayed to IMT and Control Agency when aircraft returns from observation flight	Visual observations from aircraft have inherent subjectivity due to the effect of the angle of insolation on the surface of the ocean. Optical techniques are also dependent on cloud cover and daylight. Where possible, a verbal report via radio/telephone en-route providing relevant information should be considered if the aircraft has long transits from the spill location to base	❑
Ongoing Actions	Operations Section	In consultation with the Control Agency, develop a flight schedule for ongoing aerial surveillance	Frequency of flights should consider information needs of IMT to help maintain the Common Operating Picture and determine ongoing response operations	❑
Satellite imagery (if selected)				
Initial Actions	Intelligence/Planning Section	Contact AMSA to initiate satellite services		❑
	Intelligence/Planning Section	Combine satellite data with other optical imagery (aerial surveillance, vessel-based observations) to mitigate issues of angle of insolation, thick cloud cover and night	Satellite derived data can be used to broaden aerial survey data in terms of both spatial and temporal scale and provide images	❑

Responsibility		Task	Consideration	Complete
Ongoing Actions	Intelligence/Planning Section	Request satellite imagery be provided every 48 hours throughout the duration of the response and integrate data into Common Operating Picture/Situation Boards		❑
General Actions (to be coordinated between Pilot Energy IMT and Control Agency)				
Surveillance Team		Record relevant data e.g. equipment used, time deployed, weather conditions, Job Safety Analysis (JSA) for all tasks		❑
Surveillance Team		Hold pre-mobilisation survey team meeting, including communication of field survey schedules (provision for field personnel rotation)		❑
IMT		Obtain weather and tidal information from the Bureau of Metrology and on-scene observers		❑
IMT		Assemble competent field team(s) (if required), including required personal protective equipment (PPE). Arrange any required inductions and/or permits		❑
IMT		Arrange transportation (e.g. flights, vehicles), accommodation and food/equipment for field teams		❑
IMT		Activate Geographic Information Systems (GIS) personnel to develop maps that can overlay surveillance data to enhance situational awareness of the spill		❑
IMT		Review fate and weathering, tracking buoy, oil spill modelling data and satellite data with field surveillance data (aerial and vessel surveillance) to validate spill fate and trajectory	Use available data to conduct Operational SIMA and confirm that pre-identified response options are still appropriate	❑
IMT		Use monitor and evaluate data to periodically reassess the spill and modify the response (through the IAP), as required		❑

6.4 Monitor and evaluate - environmental performance

Table 6-2 indicates the environmental performance standards and measurement criteria for the following Environmental Performance Outcome:

- Support implementation of monitor and evaluate tactics in order to provide situational awareness to inform Control Agency decision making.

Table 6-2: Environmental Performance – Monitor and Evaluate

Performance Standard	Measurement Criteria
Response Preparedness	
Tracking buoy available on seismic vessel and maintained according to manufacturer specifications for duration of the titleholder survey	Records demonstrate that tracking buoys are available on vessels and maintained according to manufacturer specifications for the duration of the seismic survey
Response Implementation	
Offer support to the Control Agency in the selection and initiation of suitable monitor and evaluate tactics within 2 hours of notifying Control Agency of spill	Records demonstrate that IMT offered support to Control Agency in the selection and initiation of monitor and evaluate tactics within 2 hours of notifying Control Agency of spill
Deploy tracking buoys close to leading edge of spill (providing it is safe to do so) within 2 hours of Vessel Master being made aware of the spill	Records indicate that tracking buoys deployed close to leading edge of spill within 2 hours of Vessel Master being made aware of the spill
Initiate hydrocarbon distribution, fate and weathering assessment using ADIOS2 within 2 hours of IMT being made aware of the spill	Records indicate IMT initiated hydrocarbon distribution, fate and weathering assessment within 2 hours of spill notification
Provide available data from monitor and evaluate activities to modelling provider at the end of each operational period to help improve spill model accuracy	Records indicate that at the end of each operational period available data from monitor and evaluate activities was submitted to service provider to help improve spill model accuracy
Provide available monitoring data to Control Agency at the end of each operational period for inclusion into the Common Operating Picture and Operational SIMA to aid in response decision making	Incident Log shows available monitoring data provided to Control Agency at the end of each operational period

7. Natural Recovery

Natural recovery is a no impact response. There are no initiation or termination criteria, nor capability required to implement it apart from supporting strategies such as monitor and evaluate and oil spill monitoring.

Natural recovery is the process of letting hydrocarbons degrade naturally in the environment, either offshore or onshore. This section addresses offshore natural recovery, including degradation on or in the water column.

Oil on the ocean disperses and breaks up via several processes. Natural processes acting on the oil such as evaporation, dissolution, dispersion into the water column, biodegradation and photo oxidisation reduce the volume of oil over time. Evaporation can be the most important mechanism to reduce the volume of oil, especially in the short term. Approximately 65-80% of an MGO spill will generally evaporate over the first two days, depending upon the prevailing conditions and spill volume.

Whilst offshore natural recovery involves no direct response activities to mitigate the spill, it may be an appropriate response strategy to complement other intervention-based response strategies; or as a primary response strategy if other strategies are likely to cause a greater impact than leaving the oil to degrade naturally. It may also be the only viable response strategy during inclement weather (e.g. tropical cyclones), as responding could place personnel at risk.

Table 7-1 provides guidance on when natural recovery may be a suitable response option.

There is no implementation guide provided for this response option, as no direct tasks are required. However, if natural recovery is selected as a suitable response strategy, the Operational SIMA would need to confirm that natural recovery remains a suitable response strategy throughout the spill response.

Table 7-1: Natural Recovery Application Guidance

Recommended	Not Recommended
• For light, non-persistent hydrocarbons, such as ITOPF Group 1-2 hydrocarbons (e.g. MGO, condensate, hydraulic oil) • Product is weathering rapidly due to environmental conditions (e.g. high energy coastline, wave action) • Product is too thin for effective use of dispersants or containment and recovery • If responding during inclement weather conditions would place response personnel at risk	• For persistent hydrocarbons, such as ITOPF Group 3-4 hydrocarbons (Crude oil, Intermediate Fuel Oil, Heavy Fuel Oil) • Environmental conditions are not favourable for rapid degradation (e.g. calm seas) • Slick is continuous enough and thick enough to treat with dispersants or via containment and recovery methods

8. Shoreline Protection and Deflection

Spill modelling predicts if a worst-case vessel collision spill (refer to Section 3.2.1) were to occur during Eureka 3D MSS activities, there is a low probability of minimal shoreline contact (<1 m^3). Shoreline protection and deflection has been included as a secondary response strategy for the worst-case scenario, and would only be implemented if an operational SIMA demonstrated it would result in an overall benefit to receptors.

Protection and deflection tactics are utilised to divert hydrocarbons away from sensitive shoreline receptors and are more effective if they are deployed ahead of spill contact. They are typically used to protect smaller, high priority sections of shoreline. The relevant Control Agency has operational responsibility for the implementation of shoreline protection activities. Protection priorities are identified in

Table 3-4 but will need to be confirmed by the relevant Control Agency when the Operational SIMA is prepared.

The relevance and suitability of individual tactics (or combination of tactics) will need to be considered when preparing the Operational SIMA for individual spills. Initiation of suitable tactics will need to be confirmed by the Control Agency, prior to deployment.

- Shoreline booming – involves the use of a variety of booming techniques to exclude oil (exclusion booming), divert oil to a collection point where it can be removed from the environment (diversion booming) and redirecting flow of oil away from a priority area (deflection booming).
- Berms, dams and dikes – uses sandbags or embankments to exclude oil from sensitive areas
- Shoreside recovery – uses nearshore skimmers to collect oil corralled by nearshore booms (also used during shoreline clean-up).
- Passive recovery - uses sorbent booms or pads to collect oil and remove it from the environment. This can be used as a pre-impact tactic where sorbents are laid ahead of the spill making contact with the shoreline.
- Non-oiled debris removal – involves the removal of debris (e.g. seaweed) from the shoreline to prevent it being oiled, which in turn reduces impacts to wildlife and the volumes of waste produced during shoreline clean-up activities.

The effectiveness of shoreline protection and deflection tactics will be dependent upon metocean and wind conditions. Protection booms should only be installed in areas where tidal currents are below 0.75 knots.

8.1 Initiation and termination criteria

Initiation criteria	Termination criteria
Level 2 or 3 spills where shorelines with protection priorities will potentially be impacted; or SIMA demonstrates that the response strategy and selected tactics are likely to result in a net environmental benefit; and Requested by the relevant Control Agency	SIMA has determined that this strategy is unlikely to result in an overall benefit to the affected shoreline/s; and Control Agency decides to terminate the response strategy

8.2 Implementation guide

The locations for nearshore protection and deflection operations will be evaluated by the relevant Control Agency throughout the incident response and will consider monitor and evaluate data and the protection priorities. In addition, the information obtained from monitor and evaluate activities will be used by the IMT in the development of the Operational SIMA to inform the most effective protection tactics (if any) to apply to individual sites. This will also consider the feasibility and effectiveness of selected tactics.

Deployment of equipment and personnel is to be at the direction of the WA DoT as the Control Agency in State waters.

Table 8-1 provides guidance to the IMT on the actions and responsibilities that should be considered to support the Control Agency if they implement this response strategy. The Control Agency is responsible for the implementation of the response and therefore, depending on the circumstances of the spill, may determine that some tasks be varied, should not be undertaken or should be reassigned.

Table 8-1: Shoreline Protection and Deflection Implementation Guide

Responsibility		Task	Consideration	Complete
Initial Actions	Planning Section	Notify relevant authorities if there are likely to be any impacts on shorelines. See Table 4-1 for details on notifications. See Table 2-2 for details on Control Agency responsibilities.		❑
	Planning Section	Collect and provide spill trajectory modelling, other operational monitoring data and existing sensitivity information/mapping to Control Agency for confirmation of priority protection areas and Operational SIMA.		❑
ACTIONS BELOW ARE INDICATIVE ONLY AND ARE AT THE FINAL DETERMINATION OF THE CONTROL AGENCY				
Initial Actions	Planning Section	In conjunction with Control Agency conduct Operational SIMA to determine if protection and deflection is likely to result in a net environmental benefit using information from shoreline assessments and any tactical response plans for the area. See Section 3.5 for guidance on Operational SIMA.	Shoreline Clean-up Assessment Teams are responsible for preparing field maps and forms detailing the area surveyed and making specific clean-up recommendations (Refer to the Pilot Energy OSM-BIP for information on OMP: Shoreline Clean-up Assessment). The condition of affected shorelines will be constantly changing. Results of shoreline surveys should be reported as quickly as possible to the IMT and Control Agency to help inform real-time decision making. In consultation with Control Agency, engage a Heritage Advisor if spill response activities overlap with potential areas of cultural significance.	❑
Initial Actions	Planning Section	If Operational SIMA indicates that there is an overall environmental benefit, support Control Agency in the development of a Shoreline Protection Plan (IAP sub-plan) for each deployment area.	Shoreline Protection Plan may include (but not be limited to): • Priority nearshore and shoreline areas for protection • Locations to deploy protection and deflection equipment • Permits required (if applicable)	❑

Responsibility		Task	Consideration	Complete
			• Protection and deflection tactics to be employed for each location • List of resources (personnel and equipment) required • Logistical arrangements (e.g. staging areas, accommodation, transport of personnel) • Timeframes to undertake deployment • Access locations from land or sea • Frequency of equipment inspections and maintenance (noting tidal cycles) • Waste management information, including logistical information on temporary storage areas, segregation, decontamination zones and disposal routes • No access and demarcation zones for vehicle and personnel movement considering sensitive vegetation, bird nesting/roosting areas and turtle nesting habitat (utilise existing roads and tracks first).	
Ongoing Actions	Planning Section	In conjunction with Control Agency conduct regular Operational SIMA to confirm effectiveness of tactics and demonstrate benefit of continuing to implement shoreline protection and deflection activities.		❑
General (to be coordinated by Control Agency and Pilot Energy IMT to provide support)				
Emergency Response Team (ERT)		Record relevant data e.g. equipment used, time deployed, weather conditions, JSA for all tasks.		❑
ERT		Hold pre-mobilisation survey team meeting, including communication of field survey schedules (provision for field personnel rotation).		❑
IMT		Obtain weather and tidal information from the Bureau of Metrology and on-scene observers.		❑

Responsibility	Task	Consideration	Complete
IMT	Assemble competent field team(s) (if required), including required PPE. Arrange any required inductions and/or permits.		❑
IMT	Arrange transportation (e.g. flights, vehicles), accommodation and food/equipment for field teams.		❑
IMT	Establish staging areas.		❑
IMT	Establish decontamination facilities (as required) for all equipment, vessels and personnel.		❑
IMT	Prepare a communications plan for field personnel.		❑

8.3 Shoreline protection and deflection – environmental performance

Table 8-2 indicates the environmental performance standards and measurement criteria for the following Environmental Performance Outcome:

- Support implementation of shoreline protection and deflection tactics to protect prioritised receptors from contact with hydrocarbons.

Table 8-2: Environmental Performance – Shoreline Protection and Deflection

Performance Standard	Measurement Criteria
Response Implementation	
Support Control Agency in the preparation of the Operational SIMA to determine if shoreline protection is likely to result in a net environmental benefit.	Records demonstrate that support offered to Control Agency in the preparation of an Operational SIMA.
Locations for nearshore protect and deflect operations will be evaluated by the relevant Control Agency throughout the incident response and will consider monitor and evaluate data and protection priorities.	Incident log.
If Operational SIMA indicates that there is an overall environmental benefit, support Control Agency in the development of a Shoreline Protection Plan (IAP sub-plan).	Shoreline Protection Plan (IAP sub-plan) is dated and indicates preparation done in conjunction with Control Agency and prior to shoreline protection operations commencing.

Performance Standard	Measurement Criteria
Shoreline protection activities will be implemented under the direction of the Control Agency.	Records demonstrate that shoreline protection activities implemented under the direction of the Control Agency.

9. Shoreline Clean-up

Spill modelling predicts if a worst-case vessel collision spill were to occur during Eureka 3D MSS activities (refer to Section 3.2.1), there is a low probability of minimal shoreline contact. Out of 100 simulations only one simulation predicted shoreline accumulation above 100 g/m^2 which was at Green Head – Leeman, with a volume of less than 1 m^3 predicted over less than 1 km of shoreline (refer to Table 3-3). Shoreline clean-up has been included as a secondary response strategy for the worst-case scenario, and would only be implemented if an operational SIMA demonstrated it would result in an overall benefit to receptors.

The relevant Control Agency has operational responsibility for the implementation of shoreline clean-up activities. Protection priorities are identified in

Table 3-4 but will need to be confirmed by the relevant Control Agency when the Operational SIMA is prepared.

Shoreline clean-up aims to remove hydrocarbons from shorelines and intertidal habitat to achieve a net environmental benefit. Removal of these hydrocarbons helps reduce remobilisation and contamination of wildlife, habitat and other sensitive receptors. Shoreline clean-up is often a lengthy and cyclical process, requiring regular surveys (via OMP: Shoreline Clean-up Assessment) to monitor the effectiveness of clean-up activities and assess if they are resulting in any adverse impacts.

The locations for shoreline clean-up operations will continue to be evaluated by the relevant Control Agency throughout the incident response and will take into account monitor and evaluate data, operational monitoring data and the protection priorities identified.

The relevance and suitability of individual tactics (or tactics used in combination) will need to be considered when preparing the Operational SIMA for individual spills. Initiation of suitable tactics will need to be confirmed by the Control Agency, prior to deployment.

- Natural recovery – involves leaving the oil on the shoreline and allowing it to degrade naturally over time
- Manual and mechanical removal – requires the use of machinery, hand tools (or a combination) to remove hydrocarbons and oiled materials
- Washing, flooding and flushing – involves using water, steam, or sand to flush hydrocarbons from impacted shoreline areas
- Sediment reworking and surf washing – uses various methods to move oiled material into the intertidal zone where the hydrocarbons are washed out by wave action.

The information obtained from Shoreline Clean-up Assessment Teams should be used by the IMT and Control Agency in the development of the Operational SIMA to inform the most effective clean-up tactics (if any) to apply to individual sites. A minimum threshold of 100 g/m^2 (concentration of accumulated hydrocarbons on shorelines) is used to determine the lower limit for commencing clean-up operations (Table 3-5).

9.1 Initiation and termination criteria

Initiation criteria	Termination criteria
Level 2 or 3 spills where shorelines with protection priorities will potentially be impacted; or SIMA demonstrates that the response strategy and individual tactics are likely to result in a net environmental benefit; and Requested by the relevant Control Agency	SIMA has determined that this strategy is unlikely to result in an overall benefit to the affected shoreline/s; and Control Agency decides to terminate the response strategy

9.2 Operational considerations

Large scale operations involving large numbers of personnel may cause adverse environmental impacts at sensitive shoreline locations. The constant removal of hydrocarbons mixed with sand and debris, even via manual removal can result in a removal of large volumes of substrate (e.g. sand, pebbles). If intrusive clean-up is conducted frequently, over a long period of time and along contiguous lengths of coastline, this may result in geomorphological changes to the shoreline profile and adverse impacts to shoreline invertebrate communities which provide an array of ecosystem services (Michel et al., 2017).

An Operational SIMA should consider the safety constraints and ecological sensitivities of these shorelines (Refer to considerations presented in Table 3-7). If an Operational SIMA deems clean-up is likely to result in a net environmental benefit, it may be beneficial for operations to be conducted by smaller teams (max 10 people/team) over a longer period. Intermittent manual treatment (<20 visits/month) and use of passive recovery booms is likely to be more effective than intrusive methods (e.g. intrusive manual removal >20 visits/month). Although this may take longer to undertake the clean-up, the benefits often outweigh the impacts as smaller teams are more targeted, recover more hydrocarbons and less sand and debris, reducing trampling of hydrocarbons into the shore profile and will minimise ecological impacts on the shorelines and their sensitive species.

Clean-up endpoints should be established in consultation with key stakeholders (e.g. Parks Australia, WA DBCA) early in the clean-up process.

9.3 Implementation guide

The locations for shoreline clean-up operations will be evaluated by the relevant Control Agency throughout the incident response and will consider monitor and evaluate data and the protection priorities. In addition, the information obtained from monitor and evaluate activities will be used by the IMT in the development of the Operational SIMA to inform the most effective protection tactics (if any) to apply to individual sites. This will also consider the feasibility and effectiveness of selected tactics.

Table 9-1 provides guidance on tasks and responsibilities that Pilot Energy will undertake to support the Control Agency should they implement this response strategy. The Control Agency is responsible for the implementation of the response and therefore, depending on the circumstances of the spill, may determine that some tasks be varied, should not be undertaken or should be reassigned.

Table 9-1: Shoreline clean-up implementation guide

Responsibility		Task	Consideration	Complete
Initial Actions	Planning Section	Notify relevant authorities if there are likely to be any impacts on shorelines. Refer to Table 4-1 for details on notifications. Refer to Table 2-2 for details on Control Agency responsibilities.		❑
	Planning Section	Collect and provide spill trajectory modelling, other operational monitoring data and existing sensitivity information/mapping to Control Agency for confirmation of priority protection areas and Operational SIMA.		❑
	Planning Section	In conjunction with Control Agency, consult with Director of National Parks whilst preparing Operational SIMA for Designated Marine Parks.		❑
ACTIONS BELOW ARE INDICATIVE ONLY AND ARE AT THE FINAL DETERMINATION OF THE CONTROL AGENCY				
Natural recovery (if selected)				
Initial Actions	Planning Section	If Operational SIMA supports natural recovery, use monitor and evaluate data to periodically reassess the condition of the shoreline/s and modify tactics, if required by the Control Agency.		❑
Manual and mechanical removal; washing, flooding and flushing; and/or sediment reworking and surf washing (if selected)				
Initial Actions	Planning Section	If Operational SIMA supports shoreline clean-up, support Control Agency in the development of a Shoreline Clean-up Plan (IAP sub-plan) for inclusion in the IAP.	Shoreline Clean-up plan may include (but not be limited to): • Clean-up objectives • Clean-up end points • Clean-up priorities • Assessment and location of staging areas and worksites (including health and safety constraints, zoning) • Permits required (if applicable) • Chain of command for onsite personnel	❑

Responsibility		Task	Consideration	Complete
			• List of resources (personnel, equipment, PPE) • Details of accommodation and transport • Waste management information, including logistical information on temporary storage areas, segregation, decontamination zones and disposal routes • No access zones (to minimise disturbance to sensitive receptors) Refer to IPEICA-IOGP (2016) for additional guidance on shoreline clean-up planning and implementation.	
Ongoing Actions	Operations Section	Support Control Agency in monitoring the effectiveness of shoreline clean-up operations by continual implementation of Shoreline Clean-up Assessment.	Where possible, maintain same composition of Shoreline Clean-up Assessment Teams. If the same personnel are able to recommend clean-up techniques and then monitor their implementation, they will be better placed to adapt their recommendations as the clean-up progresses and judge when the agreed end-points have been met.	❑
General (to be coordinated by Control Agency and Pilot Energy IMT to provide support)				
IMT		Record relevant data e.g. equipment used, time deployed, weather conditions, JSA for all tasks.		❑
IMT		Hold pre-mobilisation survey team meeting, including communication of field survey schedules (provision for field personnel rotation).		❑
IMT		Obtain weather and tidal information from the Bureau of Metrology and on-scene observers.		❑
IMT		Assemble competent field team(s) (if required), including required PPE. Arrange any required inductions and/or permits.		❑
IMT		Arrange transportation (e.g. flights, vehicles), accommodation and food/equipment for field teams.		❑

Responsibility	Task	Consideration	Complete
IMT	Establish decontamination facilities (as required) for all equipment, vessels and personnel.		❑
IMT	Prepare a communications plan for field personnel.		❑
IMT	Consult with key stakeholders to develop clean-up end points for shorelines.		❑

9.4 Shoreline clean-up – environmental performance

Table 9-2 indicates the environmental performance standards and measurement criteria for the following Environmental Performance Outcome:

- Support implementation of shoreline clean-up tactics to remove stranded hydrocarbons from shorelines in order to reduce impact on coastal protection priorities and facilitate habitat recovery.

Table 9-2: Environmental Performance – Shoreline Clean-up

Performance Standard	Measurement Criteria
Response Implementation	
Support Control Agency in the preparation of the Operational SIMA to determine if shoreline clean-up is likely to result in a net environmental benefit.	Records demonstrate that support offered to Control Agency in the preparation of an Operational SIMA.
Control Agency and IMT consult with Director of National Parks whilst preparing Operational SIMA for Designated Marine Parks.	Records demonstrate that Director of National Parks consulted when preparing Operational SIMA for Designated Marine Parks.
Shoreline clean-up activities will be implemented under the direction of the Control Agency.	Records demonstrate that shoreline clean-up activities implemented under the direction of the Control Agency.
Locations for clean-up operations will be evaluated by the relevant Control Agency throughout the incident response and will consider monitor and evaluate data, operational monitoring data and protection priorities.	Incident log.
If Operational SIMA indicates that there is an overall environmental benefit, support Control Agency in the development of a Shoreline Protection Plan (IAP sub-plan).	Shoreline Protection Plan (IAP sub-plan) is dated and indicates preparation done in conjunction with Control Agency and prior to shoreline protection operations commencing.

10. Oiled Wildlife Response

The short-term effects of hydrocarbons on wildlife may be direct such as the external impacts from coating or internal effects from ingestion and inhalation. Oiled wildlife response (OWR) includes wildlife surveillance/reconnaissance, wildlife hazing, pre-emptive capture and the capture, cleaning, treatment, and rehabilitation of animals that have been oiled. In addition, it includes the collection, post-mortem examination, and disposal of deceased animals that have succumbed to the effects of oiling.

Long-term effects of a spill on wildlife may be associated with loss/degradation of habitat, impacts to food sources, and impacts to reproduction. An assessment of such impacts is covered under scientific monitoring.

The relevant Control Agency has operational responsibility for the implementation of an OWR as outlined in Sections 10.1 and 10.2. It is however also an expectation that Pilot Energy will conduct the initial first-strike response actions for wildlife and continue to manage those operations until the Control Agency takes over. Once the Control Agency takes over, the Pilot Energy will function as a Support Agency, and continue to provide planning and resourcing support.

10.1 Commonwealth waters

The Commonwealth of Climate Change, Energy, the Environment and Water (DCCEEW) is the Jurisdictional Authority for oiled wildlife in Commonwealth waters, although for vessel-based spills, the Control Agency function remains with AMSA. If an oiled wildlife response is required then this would be initiated through AMSA, who can access Australian Marine Oil Spill Centre (AMOSC) oiled wildlife resources.

10.2 Western Australian waters

If an OWR is required in WA State waters, the Department of Biodiversity, Conservation and Attractions (DBCA) will lead the OWR under the control of the WA DoT (as Control Agency). The key plan for OWR in WA is the WA Oiled Wildlife Response Plan (WAOWRP) (DBCA, 2022a) and the WA Oiled Wildlife Response Manual (WA OWR Manual) (DBCA, 2022b).

10.3 Magnitude of wildlife impact

Given the distribution and behaviour of wildlife in the marine environment, a spill which only impacts offshore waters is likely to result in limited opportunities to rescue wildlife. In such instances, continued wildlife reconnaissance, carcass recovery, sampling of carcasses that cannot be retrieved and scientific monitoring are more likely to be the focus of response efforts. In contrast, a spill which results in shoreline accumulation is likely to result in far greater wildlife impacts and opportunities to rescue wildlife.

Spill modelling predicts if a worst-case vessel collision spill (refer to Section 3.2.1) were to occur during Eureka 3D MSS activities, there is a low probability of minimal shoreline contact. Using the WAOWRP (DBCA, 2022a) *Guide for Rating the Wildlife Impact of an Oil Spill* (

Table 10-1) it is predicted that low wildlife impacts are likely associated with this scenario.

Table 10-1: WAOWRP Guide for rating the wildlife impact of an oil spill (DBCA, 2022a)

Wildlife Impact Rating	Low	Medium	High
What is the likely duration of the wildlife response?	< 3 days	3 – 10 days	> 10 days
What is the likely total intake of animals?	< 10	11 - 25	> 25
What is the likely daily intake of animals?	0 -2	2 – 5	> 5
Are threatened species, or species protected by treaty, likely to be impacted, either directly or by pollution of habitat or breeding areas?	No	Yes – possible	Yes - likely
Is there likely to be a requirement for building primary care facility for treatment, cleaning and rehabilitation?	No	Yes - possible	Yes - likely

10.4 Wildlife priority protection areas

For planning purposes, determination of wildlife priority protection areas is based on stochastic modelling of the worst-case spill scenario, the known presence of wildlife, and in consideration of the following:

- presence of high densities of wildlife, threatened species, and/or endemic species with high site fidelity
- greatest probability and level of contact from floating oil and/or shoreline accumulation
- shortest timeframe to contact.

The wildlife priority protection areas for a spill associated with Eureka 3D MSS activities are outlined in Table 10-2.

Depending on the timing of a potential hydrocarbon spill, certain species could be more impacted because of key seasonal biological activities such as breeding, mating, nesting, hatching or migrating.

Table 10-2: Wildlife priority protection areas

Wildlife priority protection area	Wildlife
Illawong – Cliff Head (DoT shoreline cell # 191)	• Inshore islands are important breeding areas for seabirds • Australian sea lion • Humpback whales and other inshore cetaceans
Green Head – Leeman (DoT shoreline cell # 193)	• Inshore islands are important breeding areas for seabirds • Australian sea lion • Humpback whales and other inshore cetaceans • Dunnart and dibbler found on Boullanger Island

10.5 Initiation criteria

Initiation criteria	Termination criteria
Notification of a Level 2/3 spill	When the SIMA for oiled wildlife response activities indicates no further action required; and Control Agency decides to terminate the response strategy

10.6 Implementation guide

Table 10-3 provides guidance to the IMT on the actions and responsibilities that should be considered when implementing an oiled wildlife first-strike plan. In State waters, Pilot Energy will conduct the initial first-strike response actions for wildlife and continue to manage these operations until DBCA is activated as the lead agency for wildlife response and formal handover occurs. Following formal hand over, Pilot Energy will function as a support organisation for the OWR and will be expected to continue to provide planning and resources as required.

Wildlife surveillance/reconnaissance is a critical component of an oiled wildlife first-strike. Wildlife reconnaissance should be undertaken in close consultation with personnel undertaking relevant operational monitoring activities. The information gathered from wildlife reconnaissance and all relevant pre-existing wildlife data/information should be used to inform decisions and aid the on-going development of the OWR portion of the IAP.

Table 10-3: OWR implementation guide

Responsibility		Task	Consideration	Complete
Initial Actions	Surveillance personnel	Personnel conducting monitor and evaluate activities shall report wildlife sightings in or near the spill trajectory (including those contacted with hydrocarbons or at risk of contact) and report them to the IMT within two hours of detection.	Record all reports of wildlife potentially impacted and impacted by spill. Record reports on: • Time / date • Location / GPS coordinates • Access to location • Numbers of individuals (estimate) • Species (if known) • Condition of implanted animals (if available) • Take phots of the affected wildlife and / or affected surrounds, if possible	❑
	Environment Unit Lead	If wildlife is sighted and are at risk of contact or have been contacted: In Commonwealth waters notify AMSA who can access AMOSC oiled wildlife resources In State waters notify DoT and DCBA State Duty Officer	Refer to Table 4-1 for reporting requirements.	❑
	Environment Unit Lead	Notify Department of Agriculture, Water and the Environment if there is a risk of death or injury to a protected species (including Matters of National Environmental Significance [MNES]).	Refer to Table 4-1 for reporting requirements.	❑
	Environment Unit Lead	Review all wildlife reports from surveillance or opportunistic activities and contact personnel who made the reports (if possible) to confirm information collected.		❑
ACTIONS BELOW ARE INDICATIVE ONLY AND ARE AT THE FINAL DETERMINATION OF THE CONTROL AGENCY				
Initial Actions	Planning Section	Support Control Agency in the development of an OWR Plan (IAP sub-plan) for inclusion in the IAP.	Targeted wildlife surveillance/reconnaissance needs to consider species known to occur in the impacted area, life-cycle stages, behaviour, and key risk periods. Wildlife reconnaissance should be undertaken in close consultation with personnel	❑

Responsibility		Task	Consideration	Complete
			undertaking relevant operational monitoring activities. Confirm best reconnaissance platform (e.g. vessel, aerial, shoreline). Consider ability to share resources (e.g. Monitor and Evaluate activities, Scientific Monitoring). Refer to the WA OWR Manual (DBCA, 2022b) for further information: • P1 OWR Procedure: Phase 1 Wildlife Reconnaissance • G-1: OWR Strategies by Fauna Group	
Ongoing Actions	Planning and Operations Section	Support Control Agency with any on-going OWR planning and resourcing support.		❑
General (to be coordinated by Control Agency and Pilot Energy IMT to provide support)				
IMT		Record relevant data e.g. equipment used, time deployed, weather conditions, JSA for all tasks.		❑
IMT		Hold pre-mobilisation team meeting, including communication of field schedules (provision for field personnel rotation).		❑
IMT		Obtain weather and tidal information from the Bureau of Metrology and on-scene observers.		❑
IMT		Assemble competent field team(s) (if required), including required PPE. Arrange any required inductions and/or permits.		❑
IMT		Arrange transportation (e.g. flights, vehicles), accommodation and food/equipment for field teams.		❑
IMT		Establish decontamination facilities (as required) for all equipment, vessels and personnel.		❑
IMT		Prepare a communications plan for field personnel.		❑

10.7 Oiled wildlife response – environmental performance

Table 10-4 indicates the environmental performance standards and measurement criteria for the following Environmental Performance Outcome:

- Support implementation of OWR tactics in accordance with relevant State Oiled Wildlife Response Plans to prevent or reduce impacts, and to humanely treat, house, and release or euthanise wildlife.

Table 10-4: Environmental Performance – Oiled wildlife response

Performance Standard	Measurement Criteria
Response Implementation	
OWR Plan developed and included in the IAP to provide oversight and management of OWR operations.	Records indicate IAP OWR Plan prepared prior to OWR operations commencing.

11. Scientific Monitoring

Pilot Energy has developed an OSM-BIP which describes a program of monitoring oil pollution that will be adopted in the event of a hydrocarbon spill incident (Level 2-3) to marine waters. It is aligned to the Joint Industry Operational and Scientific Monitoring Framework (APPEA, 2021) and describes how this Framework applies to the Eureka 3D MSS activities and spill risks in Australian waters.

The OSM-BIP is structured so that it can provide a flexible framework that can be adapted to individual spill incidents. A series of Operational Monitoring Plans (OMPs) and Scientific Monitoring Plans (SMPs) form part of the Joint Industry Framework and provide detail on monitoring design, standard operating procedures, data management and reporting. Details on personnel, resources, logistics and mobilisation times are outlined in the OSM-BIP. Table 11-1 lists the plans that are relevant to Pilot Energy's activities and the objective of each monitoring plan.

There are two types of monitoring that would occur following a Level 2-3 spill event:

- Operational Monitoring (OM) – which is undertaken during the course of the spill and includes any physical, chemical and biological assessments which may guide operational decisions such as selecting the appropriate response and mitigation methods and / or to determine when to terminate a response activity. The design of operational monitoring requires judgements to be made about scope, methods, data inputs and outputs that are specific to the individual spill incident, balancing the operational needs of the response with the logistical and time constraints of gathering and processing information. There is a need for information to be collected and processed rapidly to suit response needs, with a lower level of sampling and accuracy needed than for scientific purposes. For details on initiation and termination criteria for OM's refer to the OSM-BIP.
- Scientific Monitoring (SM) - which can extend well beyond the termination of response operations. Scientific monitoring has objectives relating to attributing cause-effect interactions of the spill or associated response with changes to the surrounding environment. The SMs will be conducted on a wider study area, extending beyond the spill footprint, will be more systematic and quantitative and aim to account for natural or sampling variation. For further details on the SM's refer to the OSM-BIP.
- Pilot Energy will review the initiation criteria for OMPs and SMPs (Provided in Table 5-1 (OMPs) and Table 6-1 (SMPs) of the Joint Industry Operational and Scientific Monitoring Framework (APPEA, 2021) during the preparation of the initial IAPs, and subsequent IAPs. If any initiation criteria are met, then that relevant OMP and/or SMP will be activated via the relevant Monitoring Service Provider.

Table 11-1: Operational and Scientific Monitoring Plans Relevant to Eureka 3D MSS

Monitoring Plan	Aim/Objective
Operational Monitoring	
Hydrocarbon properties and weathering behaviour at sea	To provide in field information on the hydrocarbon properties, behaviour and weathering of the spilled hydrocarbons to assist in determining suitability of spill response tactics and strategies
Shoreline clean-up assessment	Provide information on the physical and biological characteristics of shorelines within the predicted trajectory of the hydrocarbon spill or that have been exposed to the spill Conduct sectorisation of shorelines to aid in response planning and implementation of response activities Inform suitable pre-impact and post-impact response options/activities to minimise the threat posed to sensitive receptors from the spill, taking into account shoreline character Establish clean-up end points for the shoreline Monitor effectiveness of shoreline protection and/or clean-up activities Inform the IMT/EMT of any potential or actual impacts to sensitive receptors from response options/activities Inform the IMT/EMT of any sensitive receptors that may be relevant to scientific monitoring programs
Water quality assessment	To provide a rapid assessment of the presence, type, concentrations and character of hydrocarbons in marine water to assess the extent of spill contact and inform impact predictions for other monitoring plans
Sediment quality assessment	To provide a rapid assessment of the presence, type, concentrations and character of hydrocarbons in marine sediments to assess the extent of spill contact and inform impact predictions for other monitoring plans
Marine fauna assessment • Cetaceans (observational only) • Pinnipeds • Seabirds and shorebirds	To undertake a rapid assessment of marine fauna to understand the species, populations, habitats and geographical locations at greatest risk from potential spill impacts To provide the IMT/EMT with information that assists in deciding protection priorities and selecting response options that minimise the potential impact on marine fauna To provide the IMT/EMT with information on the effects of response activities on marine fauna Assess and document mortality of fauna during the spill event and response activities Establish the need for scientific monitoring of fauna affected by the spill event and/or response activities.
Marine fauna assessment • Fish	Identify, report and monitor potential impacts on fish, sharks and rays resulting from the hydrocarbon and/or response activities To provide the IMT/EMT with information that assists in deciding protection priorities and selecting response options that minimise the potential impact on fish Determine the extent and level of hydrocarbon contamination and tainting of fish Determine any mortality of fish species and document any fish-kills during the spill event

Monitoring Plan	Aim/Objective
	Determine if fish harvested from the spill area meets statutory limits for hydrocarbon residues and is marketable Provide regulatory agencies, fisheries managers and other spill responders with information to help them evaluate the likelihood that a hydrocarbon spill will contaminate seafood (fish) for commercial, aquaculture, recreational, traditional purposes Assist in the decision-making process to restrict, ban, close or re-open a fishery Establish the need for scientific monitoring of fish affected by the spill event and/or response activities.
Scientific Monitoring	
Water quality impact assessment	Detect and monitor the presence, concentration and persistence of hydrocarbons in marine waters following the spill and associated response activities. The specific objectives of this SMP are as follows: • Assess and document the temporal and spatial distribution of hydrocarbons and dispersants in marine waters of sensitive receptors; • Consider the potential sources of any identified hydrocarbons • Verify the presence and extent of hydrocarbons (both on water and in water) that may be directly linked to the source of the spill • Assess hydrocarbon/dispersant content of water samples against accepted environmental guidelines or benchmarks to predict potential areas of impact • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs
Sediment quality impact assessment	Detect and monitor the presence, concentration and persistence of hydrocarbons in marine sediments following the spill and associated response activities. The specific objectives of this SMP are as follows: • Assess and document the temporal and spatial distribution of hydrocarbons and dispersants in marine sediments of sensitive receptors • Consider the potential sources of any identified hydrocarbons; and • Verify the presence and extent of hydrocarbons that may be directly linked to the source of the spill • Assess hydrocarbon content of sediment samples against accepted environmental guidelines or benchmarks to predict potential areas of impact
Intertidal and coastal habitat assessment	To assess the impact (extent, severity, and persistence) and subsequent recovery of intertidal and coastal habitats and associated biological communities in response to a hydrocarbon release and associated response activities. The specific objectives of this SMP are as follows: • Collect quantitative data to determine short-term and long-term (including direct and indirect) impacts of hydrocarbon (and implementation of response activities) on intertidal and coastal habitats and associated biological communities, post-spill and post-response recovery

Monitoring Plan	Aim/Objective
	• Monitor the subsequent recovery of intertidal and coastal habitats and associated biological communities from the impacts of the hydrocarbon release and response activities
Seabirds and shorebirds	Document and quantify shorebird and seabird presence; and any impacts and potential recovery from hydrocarbon exposure and response activities. The objectives are to: • Identify and quantify, if time allows the post-spill/pre-impact presence and status (e.g. foraging and/or nesting activity) of shorebirds and seabirds in the study area • Observe, and if possible quantify and assess, the impacts from exposure of shorebirds and seabirds to hydrocarbons (i.e. post-impact) and to the response activities, including abundance, oiling, mortality, and sub-lethal effects • Identify, quantify and evaluate the post-impact status and if applicable, recovery of key behaviour and breeding activities of shorebirds and seabirds (e.g. foraging and/or nesting activity and reproductive success) over time and with regard to control sites
Marine mega-fauna assessment • Pinnipeds • Cetaceans	**Pinnipeds** Identify and quantify the status and recovery of pinniped populations (Australian sea lion, *Neophoca cinerea*) related to a hydrocarbon spill and response activities. The objectives are to: • Identify mortality of pinnipeds, where possible, that is directly related to the hydrocarbon spill or indirectly associated to spill-related impacts (including boat strike and/or use of dispersants) • Assess the impact of the hydrocarbon spill on pinniped species populations as recorded for breeding colonies and haul-out sites of hydrocarbon exposure/contact • Evaluate the recovery of pinniped breeding colonies **Cetaceans** Identify and quantify the status and recovery of whale sharks, dugongs and cetaceans related to a hydrocarbon spill and response activities. The objectives are to: • Observe and quantify the presence of whale sharks, dugongs and cetaceans within the area that may be affected by hydrocarbons • Where possible, assess and quantify lethal impacts and/or sub-lethal impacts directly related to the hydrocarbon spill or other indirect impacts (including vessel strike and/or use of dispersants and impacts to important habitats) • If applicable, evaluate recovery of key biological activities of impacted species following impacts due to a hydrocarbon spill and undertaking response options.

Monitoring Plan	Aim/Objective
Benthic habitat assessment	To assess the impact (extent, severity, and persistence) and subsequent recovery of subtidal benthic habitats and associated biological communities in response to a hydrocarbon release and associated response activities. The specific objectives of this SMP are as follows: • Collect quantitative data to determine short-term and long-term (including direct and indirect) impacts of hydrocarbon (and implementation of response options) on benthic habitats and associated biological communities, post-spill and post-response recovery • Monitor the subsequent recovery of benthic habitats and associated biological communities from the impacts of the hydrocarbon release
Marine fish and elasmobranch assemblages assessment	To assess the impacts to and subsequent recovery of fish assemblages associated with specific benthic habitats (as identified in SMP: Benthic Habitat Assessment) in response to a hydrocarbon release and associated response activities. The specific objectives of this SMP are as follows: • Characterise the status of resident fish populations associated with habitats monitored in SMP: Benthic Habitat Assessment that are exposed/contacted by released hydrocarbons • Quantify any impacts to species (abundance, richness and density) and resident fish population structure (representative functional trophic groups) • Determine and monitor the impact of the released hydrocarbons and potential subsequent recovery to residual demersal fish populations
Fisheries impact assessment	To monitor potential contamination and tainting of important finfish and shellfish species from commercial, aquaculture and recreational fisheries to evaluate the likelihood that a hydrocarbon spill will have an impact on the fishing and/or aquaculture industry. The specific objectives of this SMP are as follows: • Assess any physiological impacts to important fish and shellfish species and if applicable, seafood quality and safety • Assess targeted fish and shellfish species for hydrocarbon contamination • Provide information that can be used to make inferences on the health of fisheries and the potential magnitude of impacts to fishing industries (commercial, aquaculture and recreational)
Heritage features assessment	To detect changes in the integrity of significant shipwrecks as a result of a hydrocarbon release and/or associated response activities.
Social impact assessment	To assess the extent, severity and likely persistence of impacts on cultural, commercial, recreational and/or industrial users from a hydrocarbon release and associated response activities. The specific objective of this SMP is as follows:

Monitoring Plan	Aim/Objective
	• Determine direct and indirect impacts of a hydrocarbon or chemical spill and associated response activities on cultural, commercial, recreational and/or industrial users and identify areas where monitoring may need to continue for an extended period of time following termination of the response.

11.1 Scientific Monitoring - environmental performance

Table 11-2 indicates the environmental performance standards and measurement criteria for the following Environmental Performance Outcome:

- Implement monitoring programs to assess and report on the impact, extent, severity, persistence and recovery of sensitive receptors contacted by a spill or affected by spill response.

Table 11-2: Environmental Performance – Scientific Monitoring

Performance Standard	Measurement Criteria
Response Preparedness	
Maintain contracts with third-party providers to provide access to suitably qualified and competent personnel and equipment to assist in the implementation of monitoring	Contract with third party service providers maintained through duration of Eureka 3D MSS
	Vessel contracts in place for the duration of Eureka 3D MSS
Response Implementation	
OMPs and SMPs will be activated in accordance with the initiation criteria provided in Table 9-1 and 9-2 of the Joint Industry OSM Framework (APPEA, 2021)	Incident Action Plan and Incident Log confirm OMPs and SMPs are activated in accordance with the initiation criteria provided in Table 9-1 and 9-2 of the Joint Industry OSM Framework (APPEA, 2021)
Initiation criteria of OMPs and SMPs will be reviewed during the preparation of the initial Incident Action Plan (IAPs) and subsequent IAPs; and if any criteria are met, relevant OMPs and SMPs will be activated	Incident Action Plan/s
Monitoring to be conducted in accordance with the Operational and Scientific Monitoring Bridging Implementation Plan (Appendix H)	Incident log and monitoring records
Implementation of operational and scientific monitoring will comply with the Minimum Standards listed in Appendix A of the Joint Industry OSM Framework (APPEA, 2021)	Incident log and monitoring records

Performance Standard	Measurement Criteria
Once post-spill SMP monitoring reports are drafted they will be peer reviewed by an expert panel	Monitoring records
OMPs and SMPs will be terminated in accordance with the termination criteria provided in Table 6-1 of the Joint Industry OSM Framework (APPEA, 2021)	Incident Action Plan and Incident Log confirm OMPs and SMPs are terminated in accordance with the termination criteria provided in Table 6-1 of the Joint Industry OSM Framework (APPEA, 2021)

12. Response Termination

Terminating the spill response may involve demobilising personnel and equipment from response locations, post-incident reporting, identifying improvement opportunities, reviewing and updating plans and restocking equipment supplies. Planning to demobilise should occur ahead of time, during the response, to facilitate rapid demobilisation of resources that are no longer needed, and which can significantly reduce response costs.

The decision to terminate individual response strategies will be made by the relevant Control Agency (Table 2-2), according to the termination criteria shown for each strategy (Sections 6 - 9).

Scientific monitoring may continue after response operations have ceased and may be used to inform remediation activities.

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Appendix A Roles and responsibilities of Titleholder personnel in State MEECC/ DOT IMT/ FOB

Table A1-1 outlines the key roles and responsibilities of titleholder personnel potentially required to be positioned in the State Maritime Environmental Emergency Coordination Centre (MEECC)/ DoT IMT/ FOB in the event of a Level 2/3 spill that impacts WA waters or land. It should be noted the requirements outlines in Table A1-1 are the initial requirements, and not the minimum or maximum requirements.

Table A1-1: Roles and Responsibilities of Titleholder Personnel Positioned in State Maritime Environmental Emergency Coordination Centre (MEECC)/ DOT IMT/ FOB

Key Roles	Responsibilities
Crisis Management Team Liaison Officer (DoT MEEC)	• Provide a direct liaison between the Crisis Management Team and the State MEECC. • Facilitate effective communications and coordination between the Crisis Management Team Leader and the State SMEEC. • Offer advice to SMEEC on matters pertaining to titleholder crisis management policies and procedures.
Deputy Incident Officer (DoT IMT)	• Provide a direct liaison between the titleholder IMT and the DoT IMT. • Facilitate effective communications and coordination between the titleholder Incident Controller and the DoT Incident Controller. • Offer advice to the DoT Incident Controller on matters pertaining to the titleholder incident response policies and procedures. • Offer advice to the Safety Coordinator on matters pertaining to titleholder safety policies and procedures, particularly as they relate to titleholder employees or contractors operating under the control of the DoT IMT.
Deputy Intelligence Officer (DoT IMT)	• As part of the Intelligence Team, assist the Intelligence Officer in the performance of their duties in relation to situation and awareness. • Facilitate the provision of relevant modelling and predications from the titleholder IMT. • Assist in the interpretation of modelling and predictions originating from the titleholder IMT. • Facilitate the provision of relevant situation and awareness information originating from the DoT IMT to the titleholder IMT. • Facilitate the provision of relevant mapping from the titleholder IMT. • Assist in the interpretation of mapping originating from the titleholder IMT. • Facilitate the provision of relevant mapping originating from the DoT IMT to the titleholder IMT.
Deputy Planning Officer (DoT IMT)	• As part of the Planning Team, assist the Planning Officer in the performance of their duties in relation to the interpretation of existing response plans and the development of incident action plans and related sub plans. • Facilitate the provision of relevant IAP and sub plans from the titleholder IMT. • Assist in the interpretation of the titleholder OPEP from titleholder. • Assist in the interpretation of the titleholder IAP and sub plans from the titleholder IMT. • Facilitate the provision of relevant IAP and sub plans originating from the DoT IMT to the titleholder IMT. • Assist in the interpretation of titleholder's existing resource plans. • Facilitate the provision of relevant components of the resource sub plan originating from the DoT IMT to the titleholder IMT. *Note: this individual must have intimate knowledge of the relevant titleholder OPEP and planning processes.*

Key Roles	Responsibilities
Environmental Support Officer (DoT IMT)	• As part of the Intelligence Team, assist the Environmental Coordinator in the performance of their duties in relation to the provision of environmental support into the planning process. • Assist in the interpretation of the titleholder OPEP and relevant TRP plans. • Facilitate in requesting, obtaining and interpreting environmental monitoring data originating from the titleholder IMT. • Facilitate the provision of relevant environmental information and advice originating from the DoT IMT to the titleholder IMT.
Deputy Public Information Officer (DoT IMT)	• As part of the Public Information Team, provide a direct liaison between the titleholder Media team and DoT IMT Media team. • Facilitate effective communications and coordination between titleholder and DoT media teams. • Assist in the release of joint media statements and conduct of joint media briefings. • Assist in the release of joint information and warnings through the DoT Information & Warnings team. • Offer advice to the DoT Media Coordinator on matters pertaining to titleholder media policies and procedures. • Facilitate effective communications and coordination between titleholder and DoT Community Liaison teams. • Assist in the conduct of joint community briefings and events. • Offer advice to the DoT Community Liaison Coordinator on matters pertaining to the titleholder community liaison policies and procedures. • Facilitate the effective transfer of relevant information obtained through the Contact Centre to the titleholder IMT.
Deputy Logistics Officer (DoT IMT)	• As part of the Logistics Team, assist the Logistics Officer in the performance of their duties in relation to the provision of supplies to sustain the response effort. • Facilitate the acquisition of appropriate supplies through titleholder's private contract arrangements. • Collects Request Forms from DoT to action via the titleholder IMT. *Note: this individual must have intimate knowledge of the relevant titleholder logistics processes and contracts.*
Deputy Operations Officer (DoT IMT)	• As part of the Operations Team, assist the Operations Officer in the performance of their duties in relation to the implementation and management of operational activities undertaken to resolve an incident. • Facilitate effective communications and coordination between the titleholder Operations Section and the DoT Operations Section. • Offer advice to the DoT Operations Officer on matters pertaining to titleholder incident response procedures and requirements. • Identify efficiencies and assist to resolve potential conflicts around resource allocation and simultaneous operations of titleholder and DoT response efforts.
Deputy Waste Management Coordinator (DoT IMT)	• As part of the Operations Team, assist the Waste Management Coordinator in the performance of their duties in relation to the provision of the management and disposal of waste collected in State waters. • Facilitate the disposal of waste through titleholder's existing private contract arrangements related to waste management and in line with legislative and regulatory requirements. • Collects Waste Collection Request Forms from DoT to action via the titleholder IMT.
Deputy Finance Officer (DoT IMT)	• As part of the Finance Team, assist the Finance Officer in the performance of their duties in relation to the setting up and payment of accounts for those services acquired through titleholder's private contract arrangements. • Facilitate the communication of financial monitoring information to the titleholder to allow them to track the overall cost of the response.

Key Roles	Responsibilities
	• Assist the Finance Officer in the tracking of financial commitments through the response, including the supply contracts commissioned directly by DoT and to be charged back to titleholder.
Deputy Division Commander (DoT FOB)	• As part of the Field Operations Team, assist the Division Commander in the performance of their duties in relation to the oversight and coordination of field operational activities undertaken in line with the IMT Operations Section's direction. • Provide a direct liaison between titleholder's Forward Operations Base/s (FOB/s) and the DoT FOB. • Facilitate effective communications and coordination between titleholder On-Scene Commander and the DoT Division Commander. • Offer advice to the DoT Division Commander on matters pertaining to titleholder incident response policies and procedures. • Assist the Safety Coordinator deployed in the FOB in the performance of their duties, particularly as they relate to titleholder employees or contractors. • Offer advice to the Safety Coordinator deployed in the FOB on matters pertaining to titleholder safety policies and procedures.

Appendix B Visual Surveillance Logs

Vessel visual observer log

<table>
<tr><th colspan="10">Survey Details</th></tr>
<tr><td>Date</td><td colspan="2">Start time</td><td colspan="2">End Time</td><td colspan="5">Observers</td></tr>
<tr><td colspan="5">Incident</td><td colspan="5" rowspan="2">Area of Survey</td></tr>
<tr><td>Vessel type</td><td colspan="4">Call sign</td></tr>
<tr><th colspan="10">Weather Conditions</th></tr>
<tr><td colspan="4">Wind speed (knots)</td><td colspan="6">Wind direction</td></tr>
<tr><td colspan="4">Cloud cover (%)</td><td colspan="6">Visibility</td></tr>
<tr><td colspan="4">Time high water</td><td colspan="6">Current direction</td></tr>
<tr><td colspan="4">Time low water</td><td colspan="6">Current speed (nM)</td></tr>
<tr><th colspan="10">Slick Details</th></tr>
<tr><td colspan="4">Slick grid parameters by lat/long</td><td colspan="3">Slick grid parameters (vessel speed)</td><td colspan="3">Slick grid dimensions</td></tr>
<tr><td colspan="2">Length Axis</td><td colspan="2">Width Axis</td><td colspan="3">Length Axis</td><td>Width Axis</td><td>Length</td><td>nm</td></tr>
<tr><td colspan="2">Start Latitude</td><td colspan="2">Start Latitude</td><td colspan="2">Time (seconds)</td><td></td><td>Time (seconds)</td><td>Width</td><td>nm</td></tr>
<tr><td colspan="2">Start Longitude</td><td colspan="2">Start Longitude</td><td colspan="2"></td><td></td><td></td><td>Length</td><td>nm</td></tr>
<tr><td colspan="2">End Latitude</td><td colspan="2">End Latitude</td><td colspan="2">Vessel speed (knots)</td><td></td><td>Vessel speed (knots)</td><td>Width</td><td>nm</td></tr>
<tr><td colspan="2">End Longitude</td><td colspan="2">End Longitude</td><td colspan="2"></td><td></td><td></td><td>Grid area</td><td>km^2</td></tr>
<tr><th colspan="10">Visual appearance slick</th></tr>
<tr><td colspan="10">Colours, emulsification etc.</td></tr>
<tr><th colspan="10">Any marine fauna or other activities observed</th></tr>
<tr><td colspan="10"></td></tr>
</table>

Aerial surveillance observation log

Date	Incident	Aircraft type	Call sign	Start time	End time	Av altitude/ air speed
Wind speed (kts)	**Wind direction**	**Visibility (nm)**	**Cloud base (ft)**	**Sea state**	**Observer name/s**	**Spill source**
Survey start /end coordinates	**Survey start time**	**Survey end time**	**Time high tide**	**Time low tide**	**Current speed (nm)**	**Current direction**
Notes (e.g. remote sensing used, wildlife or sensitive receptors observed, any response activities observed):						

Slick details

Slick	Time local	Slick (centre or start)		Slick (end)		Slick Orient Degrees	Oil slick length			Oil slick width			Area km²	Coverage %	Oiled area km²
		LAT N/S	LONG E/W	LAT N/S	LONG E/W		SOG KT	Time seconds	Distance km	SOG KT	Time seconds	Distance km			
A															
B															
C															
D															
E															

Appendix C Shoreline Assessment Form

Department of Transport

When blank, this form is classed as **OFFICIAL**, when filled out, this form is classed as **OFFICIAL-SENSITIVE.**

Shoreline Assessment Form

This form should be submitted to the Shoreline Division Coordinator (SC). A summary of the information will be forwarded by the SC to the Operations Officer, Planning Officer and Management Support Unit.

Purpose

This form is for shoreline responders who are required to complete a shoreline assessment.

It is recommended that such responders have completed oiled shoreline training as a minimum. This form is not intended to be used in isolation.

Purpose

Human health and safety is **always** the number one priority in any incident.

Priorities

Protection priorities under Australia's National Plan to Combat Pollution of the Sea by Oil and other Noxious and Hazardous Substances (The National Plan) are:

- Human health and safety
- Habitat and cultural resources
- Rare and/or endangered flora and fauna
- Commercial resources
- Recreational and amenity areas

Complete

- Take Five and
- Job Safety Analysis (JSA)

Prior to and as part of your operations

What is a shoreline assessment?

A shoreline assessment:

- Is a simple and comprehensive survey of a shoreline
- Provides data to enable decision making for shoreline protection, clean-up and monitoring and
- Employs a systematic approach using standardised terminology

What information needs to be gathered?

Purpose

- Shoreline description
  - o Shoreline type, substrate and energy
  - o Biological character of shoreline
- Oil description
- Oil location, character and behaviour

Additional information that may be required:

- Access
- Site hazards and constraints
- Sensitive areas
- Features/landmarks
- Potential sites for
  - o Decontamination/waste
  - o Helicopter landing

Dividing the shoreline

Sectors

Where there is a geographical barrier and restricted access between two areas, they will be split into separate sectors. Different sectors may have separate field command centres, catering, ablutions, decontamination, etc. Sectors will be further spilt into segments.

Segments

A segment is a piece of shoreline that's a workable size for a team and could be defined based on:

- Shoreline type
- Substrate type
- Access points
- Features e.g. breakwater
- Jurisdiction e.g. shire boundaries
- Presence of particular flora and/or fauna
- Distance e.g. every 50m

Item Category	Item	Check
Recording	Camera	☐
Navigation	Maps and charts	☐
	GPS	☐
	Compass	☐
Communication	Mobile phone	☐
	Radio	☐
	Confirm phone/radio coverage	☐
Personal	First aid kit	☐
	Hat	☐
	Sun-cream	☐
	Drinking water	☐
	Rubber boots (non-slip)	☐
	Wet weather gear	☐
Documentation	Field booklet	☐
	Shoreline assessment forms	☐
	JSA forms	☐
	Log	☐
Other	Tape measure	☐
	Shovel	☐
	Sampling kit	☐

Ensure you advise command of your planned operation and establish reporting expectations for while you are in the field.

Shoreline descriptors:

Shoreline Type	Abbr.		Note
Cliff	Cl		Height and slope
Platform	Pl		Height relative to tide
Reef	Re		Reef is an intertidal platform
Beach	Be		
Dune	Du		
Flats	Fl		
Artificial	A		e.g. wharf, sea wall
Shoreline substrate	**Abbr.**	**Size**	**Note**
Bedrock or rock	R		
Boulder	B	Larger than head	
Cobble	C	Fist to head size	
Pebble	P	Pen diameter to fist size	
Gravel	G	2-4mm diameter	
Mud/silt/clay	M	Less than 0.6mm	Mix with water, if it goes cloudy = mud, if it sinks = sand
Earth	E		Usually cliffs only
Shellgrit	Sh		Usually with sand (i.e. Sh/S)
Coral	Co		Dead coral, i.e. coral rubble *(if corals are live, record as coral in both substrate type and biological character)*
Artificial	A		e.g. rip-rap

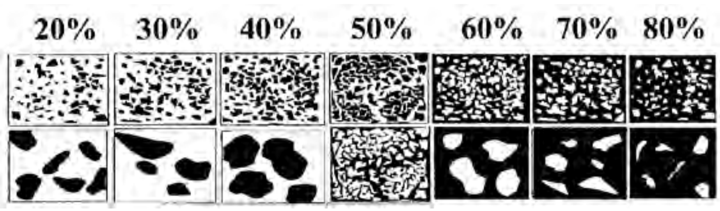
Note: S/B would indicate boulders and sand in equal amounts. S(B) would indicate sand was the dominant substrate.

Biological character
This is flora and fauna living on the shoreline. Document this and indicate location on sketch map.

Oil description/character

- **Colour**
- **Viscosity: Solid** *(doesn't flow)*, **Viscous** *(flow slowly)*, **Fluid** *(flows easily)*
- **Stickiness: Very sticky** *(can't be wiped/washed off)*, **Sticky** *(partly removed by wiping/washing)*, **Non sticky** *(wipes of easily)*

Percentage oil cover

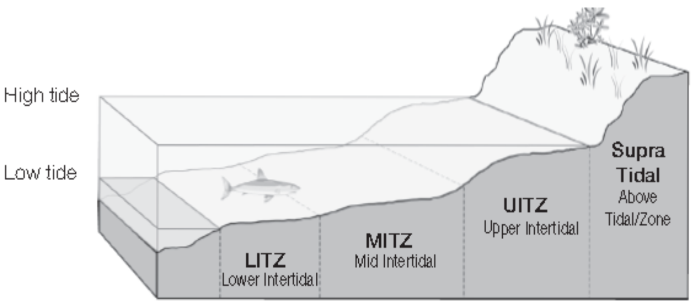


Oil thickness

Name	Abbr.	Thickness	Description
Pooled	Po	Can be measured in mm or cms	Pooled fresh or emulsified oil
Cover	Co	Over 1mm	Coverage of oil of measurable thickness but not pooled
Coat	Ct	Less than 1mm	This coach of oil that masks colour of substrate and can be scratched off with fingernail.
Stain	St	Less than 1mm	Very thin stain of oil which cannot be scratched off substrate with fingernail
Film or sheen	Fi or Shn	Extremely thin film or sheen	Substrate can usually be seen through oil. Can be described as brown, rainbow or silver.
Tar balls	Tb	Variety of sizes	Ball or clumps of weathered oil.

- To describe thickness of subsurface oil:
  - o Depth = distance from substrate surface to top of buried layer
  - o Thickness of lens = distance between top and bottom of buried layer

Shoreline tidal zones



Incident		Ref No.	

REPORTING DETAILS			
Assessment Team Leader		**Position/ Organisation**	
Team Members (name/org)			
Date Completed		**Time Completed**	
Reporting to		**Position/ Organisation**	
Date Received		**Time Received**	

LOCATION DETAILS			
Sector		**Segment**	
Name of Beach/Location		**Description (e.g. slope)**	
Topography/ Other Map		**Map Reference**	
Access Via	☐ Foot Only ☐ Road ☐ 4WD ☐ Boat ☐ Helicopter ☐ Gator/OUV		
Hazards			

TIMING			
First Assessment	☐ Yes ☐ No	**Last Assessment**	☐ Yes ☐ No
Timing	☐ Pre Impact ☐ Post Impact Before Clean-Up ☐ Post Impact After Clean-Up		
Time Since	Impact (days/hrs.):	Last Clean-up (days/hrs.):	

ASSESSMENT

Parameter	LITZ	MITZ	UITZ	Supratidal
Shoreline Description				
Shoreline type				
Substrate type				
Length of shoreline				
Width of shoreline				
Biological character				
Oil Distribution and Character				
Oil band length				
Oil band width				
% cover in band				
Surface oil thickness				
Oil appearance/character				
Depth of buried oil (from surface)				
Description of buried oil				
Other				
Un oiled debris				
Oiled debris				

Sketch Map

Please include North point and scale

Notes

Appendix F:
Operational and scientific monitoring plan

Eureka 3D MSS: OSM Bridging Implementation Plan

Revision	Date	Reason for issue	Reviewers	Approvers
A	16/03/2023	Internal Review		
B	09/08/2023	Internal Review		
0	06/12/2023	Issued for Use	RPS	RPS

Contents

List of Tables

List of Figures

Acronyms

Abbreviation/Acronym	Definition
AFMA	Australian Fisheries Management Authority
AIMS	Australian Institute of Marine Science
AIIMS	Australasian Integrated Incident Management System
ALA	Atlas of Living Australia
AMSA	Australian Maritime Safety Authority
AODN	Australian Ocean Data Network
APPEA	Australian Petroleum Production and Exploration Association
BTEXN	Benzene, toluene, ethylbenzene, xylene and naphthalene
BIA	Biologically Important Areas
CoC	Chain of Custody
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBCA	Western Australian Department of Biodiversity Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Cwth)
DWER	Western Australian Department of Water and Environmental Regulation
DoT	Western Australian Department of Transport
DPIRD	Western Australian Department of Primary Industries and Resource Development
EMBA	Environment that may be Affected
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Protection Act 1999* (Cwth)
EUL	Environment Unit Lead
GIS	Geographic Information System
GPS	Global Positioning System
IAP	Incident Action Plan
ICS	Incident Command System
IMOS	Integrated Marine Observing System
IMSA	Index of Marine Surveys for Assessments
IMT	Incident Management Team
IMT Leader	Incident Management Team Leader. Equivalent to an Incident Controller or Incident Commander.
IPIECA	International Petroleum Industry Environmental Conservation Association
KEF	Key Ecological Feature
MMO	Marine Mammal Observer
MSS	Marine Seismic Survey
OMP	Operational Monitoring Plan
OPEP	Oil Pollution Emergency Plan
OPGGS (Env)	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OSM	Operational and Scientific Monitoring

Abbreviation/Acronym	Definition
OSM-BIP	Operational and Scientific Monitoring – Bridging Implementation Plan
OSRA	Oil Spill Response Atlas
OSTM	Oil Spill Trajectory Modelling
PAH	Polycyclic Aromatic Hydrocarbons
PPE	Personal Protective Equipment
QA/QC	Quality Assurance and Quality Control
SIMA	Spill Impact Mitigation Assessment
SMP	Scientific Monitoring Plan
UWA	University of Western Australia
WAMSI	Western Australian Marine Science Institution

Part A – Preparedness

This Plan is presented in two parts. Part A outlines the relationship between the Pilot Energy's environmental management document framework and the Joint Industry Operational and Scientific Monitoring (OSM) Framework (APPEA, 2021). Part B provides operationally focussed guidance for Titleholder personnel and OSM Service Providers to coordinate the implementation of monitoring plans.

1. Introduction

Pilot Energy has elected to use the Joint Industry OSM Framework and supporting operational monitoring plans (OMPs) and scientific monitoring plans (SMPs) as the foundation of its operational and scientific monitoring approach. The Joint Industry OSM Framework is available on the APPEA Environment Publications Webpage. Use of the Joint Industry OSM Framework requires each Titleholder to develop a Bridging Implementation Plan (OSM-BIP) (this plan) that fully describes how the Framework interfaces with Titleholders own activities, spill risks and internal management systems.

Table 1-1 describes key documents that form Pilot Energy's environmental management document framework.

Activation of OSM should follow the process listed in Part B: Section 12 Activation Process.

Table 1-1: Key documents in Titleholder's environmental management framework

Document	Description
Eureka 3D Marine Seismic Survey (MSS) Environment Plan (EP)	The Eureka 3D MSS EP describes the activity and the location, the environment, the risks to the environment as a result of the activity and the associated management controls. Of particular relevance to this plan, it identifies sensitive receptors, potential impacts from hydrocarbon spills and the environment that may be affected (EMBA)
Eureka 3D MSS Oil Pollution Emergency Plan (OPEP) (Appendix E)	The OPEP outlines preparedness and response arrangements for the worst-case credible spill scenario that may occur as a result of the Eureka 3D marine seismic survey. It describes the relevant spill management arrangements for the various jurisdictions within the Environment that May be Affected, the process for selecting response strategies and the appropriateness of available response strategies for each scenario. The plan also provides response implementation guidance for each response strategy.
Emergency Response Procedure (PE-05-PRO-003)	Outlines the actions to be taken in the event of an emergency situation occurring at Pilot Energy's operations. This includes the arrangements for the planning, development and communication of emergency preparedness/ response procedures for the effective management of emergencies at Pilot projects.
Incident Management Procedure (PE-07-PRO-001)	Outlines the requirements for incident management at Pilot Energy including responsibilities, response procedures, reporting, incident classification, investigation, notifiable incidents and record management.
Emergency Management Contacts Directory (or similar)	Provide a summary of what is included in this document. **Worked example**: This document contains all relevant contact and communications information to enable effective communication amongst the response personnel and external stakeholders, including relevant OSM contacts. State frequency it is updated

Figure 1-1 illustrates how the OSM-BIP, OPEP and EP relate to each other during a spill response. Operational and scientific monitoring should commence when the initiation criteria outlined in Tables 5-1 and 6-1 of the Joint Industry OSM Framework are met.

Note: the monitor and evaluate strategy in the Eureka 3D MSS OPEP(Appendix E – Section 6) includes a wide range of tactics, including oil spill trajectory modelling that is often included in operational monitoring. Pilot Energy has retained spill modelling in the OPEP to ensure data inputs are managed by the Pilot Energy IMT and rapidly fed into the Common Operating Picture with other monitor and evaluate tactics during the initial stages of the spill.

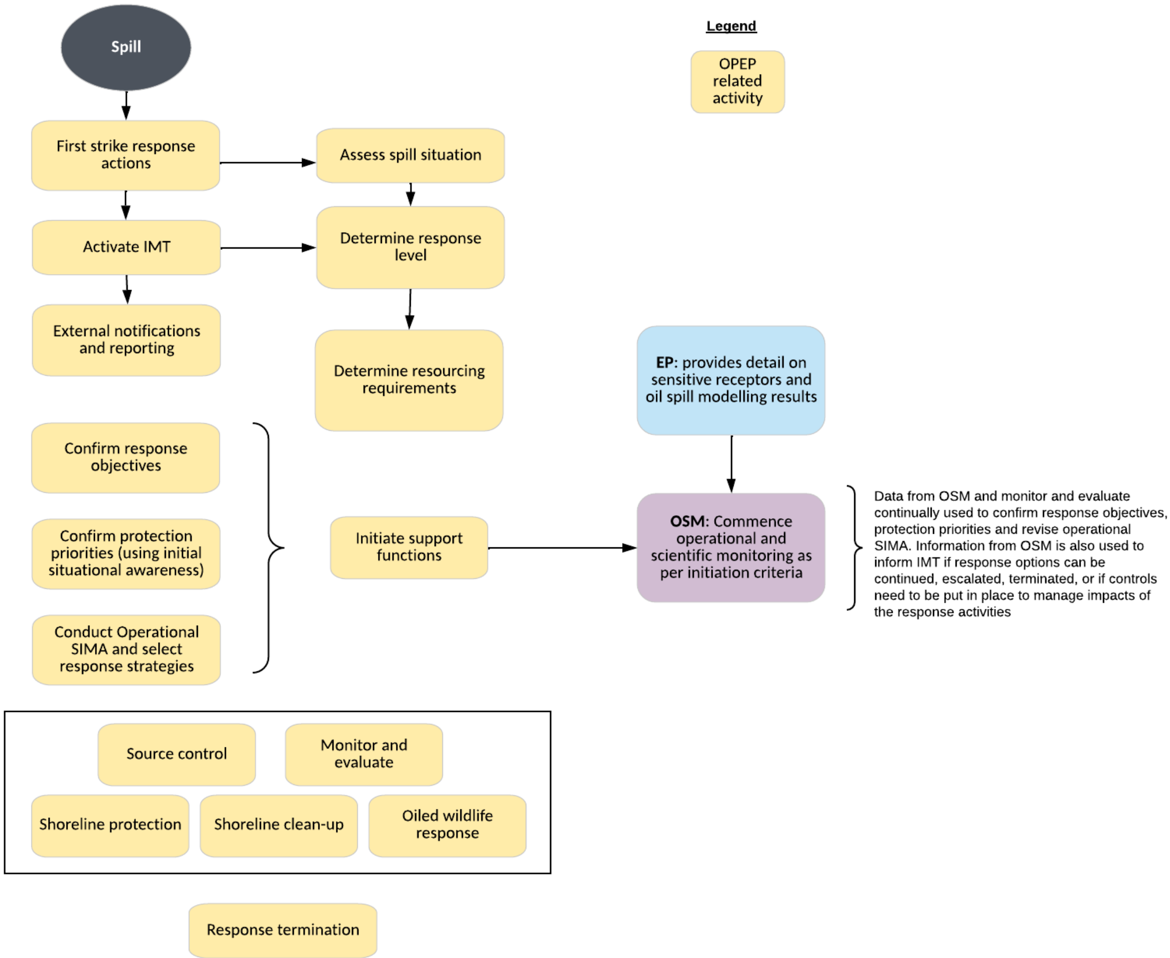


Figure 1-1: Relationship between the OSM-BIP, OPEP and EP during a Spill Response

2. EMBA and Monitoring Priorities

The EMBA is defined in the Eureka 3D MSS EP (Section 4) as the area potentially impacted by hydrocarbons from a spill event above impact concentration thresholds. The EMBA was determined using stochastic modelling results of oil spill trajectory modelling for a vessel spill in the south-east corner of the Operational Area (scenario 1) (RPS, 2023) from 100 simulations and applying the following thresholds:

- 1 g/m^2 floating oil thickness, which is considered to be below levels which would cause environmental harm and is more indicative of the areas perceived to be affected due to its visibility on the sea-surface
- 10 g/m^2 for accumulated (shoreline) oil, which represents the area visibly contacted by the spill
- 10 ppb for dissolved hydrocarbons corresponds generally with potential for exceedance of water quality triggers
- 10 ppb entrained hydrocarbons represents the low exposure zone and corresponds generally with potential for exceedance of water quality triggers.

Detailed information on the spill risks, modelling analysis of scenarios and response protection priorities is provided in the Eureka 3D MSS EP (Section 8.6) and Eureka 3D MSS OPEP (Appendix G – Section 3).

Monitoring priorities have been drawn from the stochastic modelling results (RPS, 2023). These priorities were identified through analysis of hydrocarbon spill modelling results against the location of key sensitive receptors with high conservation value; including habitat, species (e.g. State/Commonwealth protected areas, protected species), the sensitivity and/or recoverability of receptors to hydrocarbon impacts, and important socio-economic/heritage values. Monitoring priorities were identified as those sensitive receptors contacted by entrained hydrocarbons at the low threshold (≤10 ppb) and floating hydrocarbons at the low threshold (≤1 g/m^2) within 7 days at a probability > 5%, as listed in Table 2-2. Modelling did not predict any shoreline accumulation at the low threshold (≤10 g/m^2) at greater than 5% probability and at less than 7 days for the worst-case scenario.

In addition to these locations, there are receptors that are transient (i.e. cetaceans, seabirds) and others that are broadscale, such as managed fisheries with large spatial extents, Key Ecological Features (KEFs) and Biologically Important Areas (BIAs). These receptors are described in detail in the Eureka 3D MSS EP (Section 4). Table 2-1 lists the KEFs within the EMBA and describes how they may be affected by the MGO spill.

The monitoring protection priority areas identified (Table 2-2) and KEFs potentially contacted are listed for planning purposes and are based on stochastic modelling data. Therefore, it is unlikely that all of these receptors would be contacted, or contacted within 7 days, during a spill event. During a spill event, Pilot Energy will work with its monitoring providers and key stakeholders in the initial stages of the spill regarding priority receptors and to assist in the finalisation of the monitoring design. This process is outlined in Section 13.

Table 2-1: Key Ecological Features in the EMBA

Key Ecological Feature	Impact Description
Ancient coastline at 90-120 m depth contour	Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment (Department of Sustainability, Environment, Water, Population and Communities [DSEWPC] , 2012). Benthic receptors associated with this KEF would be at a low risk of exposure to hydrocarbons from a surface spill due to the depth of water they occur.
Commonwealth marine environment surrounding the Houtman Abrolhos Island	The Houtman Abrolhos Islands and surrounding reefs support a unique mix of temperate and tropical species. The Houtman Abrolhos Islands are the largest seabird breeding station in the eastern Indian Ocean. They support more than one million pairs of breeding seabirds, .and include a range of benthic habitats and associated fisheries resources (DSEWPC, 2012).

Key Ecological Feature	Impact Description
	Coral and fish surrounding the Houtman Abrolhos islands may be at risk from entrained hydrocarbons. Birds may be at exposed directly and indirectly to entrained hydrocarbons during foraging activities.
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	These lagoons are important for benthic productivity, including macroalgae and seagrass communities, and breeding and nursery aggregations for many temperate and tropical marine species. (McClatchie *et al.,* 2006) The lagoons are dominated by seagrass and epiphytic algae, which provide habitat and food for many marine species (directly and indirectly). Seagrass meadows occur in more sheltered areas and in the inter-reef lagoons along exposed sections of the coast while emergent reefs and small islands create a diverse topography. This mix of sheltered and exposed environments forms a complex mosaic of habitats. The lagoons are also important areas for the recruitment of commercially and recreationally important fishery species, including western rock lobster. Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor and Australian salmon (McClatchie *et al*., 2006). Exposure to hydrocarbons can be toxic to seagrasses and macroalgae. Fishes are most vulnerable to hydrocarbons during their embryonic, larval and juvenile life stages.
Western demersal slope and associated fish communities	The western continental slope provides important habitat for demersal fish communities. 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. Given demersal fish species are found at depths below 400 m they are at low risk of exposure to hydrocarbons from a surface spill.
Western rock lobster	The Western rock lobster is defined as a KEF due to its presumed ecological role as an important part of the food web on the west coast continental shelf. Impacts from a hydrocarbon spill will vary depending on the level of exposure and duration of exposure, life stage, and location (shallow versus deep water habitats). Larval life stages are likely the most vulnerable to the effects of hydrocarbons.
Perth Canyon and adjacent shelf break, and other west coast canyons	The Perth Canyon is the largest known undersea canyon in Australian waters (DSEWPaC 2012a). Deep ocean currents rise to the surface, creating upwelling zones which support larger aggregations of small fish, crustaceans and molluscs, as well as varying epibiota. The west coast canyons are believed to be associated with small periodic upwellings that locally increase productivity and attract aggregations of marine life (DSEWPaC 2012a). The high productivity of biota feeding other marine life would be vulnerable to the effects of hydrocarbons and disruptions in the foodchain.

Table 2-2: Spill Modelling Results for MGO spill with a Probability of Contact >5% and <7 days (RPS, 2023)

Priority Monitoring Areas	Key Sensitivities (specific to location)	Key Sensitivities (throughout area)	Probability (%) of contact of ≥10 ppb entrained hydrocarbon	Min. arrival time ≥10 ppb entrained hydrocarbon (days)	Probability (%) of contact of ≥1 g/m² floating hydrocarbon	Min. arrival time ≥1 g/m² floating hydrocarbon (days)
Clio Bank (submerged) (situated in the Abrolhos special purpose zone)	-	• Extensive meadows of seagrass that grow in shallow lagoons which provide an important nursery habitat for juvenile fish and western rock lobster (CALM, 2000) • Abalone occur on intertidal reefs • Macroalgal communities • Humpback whale and bottlenose dolphins (*Tursiops truncatus*) regularly seen in the area (CALM, 2000) • White shark foraging • Inshore islands between Cliff Head and Grey are important breeding areas for seabirds (Dunlop and Wooller, 1990; CALM, 2004) • Seabird foraging • Sea lion foraging • Cultural heritage-mainland areas have been identified as a significant area for Noongar people	14	6.8	<1	NC
Geelvink Channel Shoals (submerged) (situated between the Houtman Abrolhos Islands and the mainland between Horrocks and Geraldton)	• Humpback whale migration • Seabird foraging • Shipping channel to and from Geraldton		41	5.2	<1	NC
Cliff Head – White Point	-		12	0.5	<1	NC
Illawong – Cliff Head and Beagle Islands Nature Reserve	• Australian sea lion breeding on East Beagle Island (CALM, 2004)		44 (Beagle Islands Nature Reserve: 20)	0.1 (Beagle Islands Nature Reserve: 0.5)	13 (Beagle Islands Nature Reserve:1)	0.1 (Beagle Islands Nature Reserve:0.9)
Leeman - Coolimba	-		21	1.0	1	1.3
Green Head - Leeman	• Australian sea lion breeding on North Fisherman Island (CALM 2000)		20	1.5	<1	NC

Priority Monitoring Areas	Key Sensitivities (specific to location)	Key Sensitivities (throughout area)	Probability (%) of contact of ≥10 ppb entrained hydrocarbon	Min. arrival time ≥10 ppb entrained hydrocarbon (days)	Probability (%) of contact of ≥1 g/m^2 floating hydrocarbon	Min. arrival time ≥1 g/m^2 floating hydrocarbon (days)
	• Boullanger Island dunnart is only found on Boullanger Island (CALM, 2004) • Dibblers are found on Boullanger and Whitlock islands (CALM, 2004)	– The coast area between Greenhead and Jurien has the largest number of midden deposits in the south-west of WA (CALM, 2004) – Coast dunes in the Jurien Bay region were used as burial sites (CALM, 2004) • Several shipwrecks have been recorded between Cliff Head and Grey (CALM, 2004)				
Jurien Bay Marine Park	-		20	1.5	<1	NC
Booker Valley – Island Point*	• Dibblers are found on Boullanger and Whitlock islands (CALM, 2004)		13	2.7	<1	NC
Thirsty Point – Booker Valley*	• Australian sea lion breeding on Buller Island (CALM, 2004)		12	4.0	<1	NC
Grey – Thirsty Point*	-		11	4.9	<1	NC
North Tail Reef* (submerged)	-		9	3.1	<1	NC
Sand Knoll Ledge* (submerged)	-		6	6.0	<1	NC
Direction Bank (submerged) (situated in the Jurien special purpose zone)	-		18	3.8	<1	NC

** Locations within Jurien Bay Marine Park*

3. Relevant Existing Baseline Information Sources

Pilot Energy has access to a number of different baseline data sources that are relevant to the high value receptors in the EMBA. These include:

3.1 Australian Ocean Data Network

The Australian Ocean Data Network (AODN) is the primary access point for search, discovery, access and download of data collected by the Australian marine community. Data is presented as a regional view of all the data available from the AODN. Primary datasets are contributed to by Commonwealth Government agencies, State Government agencies, Universities, the Integrated Marine Observing System (IMOS - an Australian Government Research Infrastructure project), and the Western Australian Marine Science Institution (WAMSI).

Access is via the following link https://portal.aodn.org.au/search

3.2 Western Australian Oil Spill Response Atlas

The Western Australian Oil Spill Response Atlas (OSRA) is a spatial database of environmental, logistical and oil spill response data. Using a geographical information system (GIS) platform, OSRA displays datasets collated from a range of custodians allowing decision makers to visualise environmental sensitivities and response considerations in a selected location. Oil spill trajectory modelling (OSTM) can be overlaid to assist in determining protection priorities, establishing suitable response strategies and identifying available resources for both contingency and incident planning. OSRA is managed by the Oil Spill Response Coordination unit within Department of Transport (DoT) Marine Safety and is part funded through the National Plan for Maritime Environmental Emergencies and the Australian Maritime Safety Authority (AMSA).

Access is via the following link https://www.transport.wa.gov.au/imarine/oil-spill-response-and-planning-tools.asp

3.3 The Atlas of Living Australia

The Atlas of Living Australia (ALA) is a collaborative, online, open resource that contains information on all the known species in Australia aggregated from a wide range of data providers. It provides a searchable database when considering species within the EMBA. The ALA receives support from the Australian Government through the National Collaborative Research Infrastructure Strategy and is hosted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Access is via the following link https://www.ala.org.au/

3.4 Index of Marine Surveys for Assessment

The Index of Marine Surveys for Assessments (IMSA) is an online portal to information about marine-based environmental surveys in Western Australia. IMSA is a project of the WA Department of Water and Environmental Regulation (DWER) for the systematic capture and sharing of marine data created as part of an environmental impact assessment.

Access via the following link
https://biocollect.ala.org.au/imsa#max%3D20%26sort%3DdateCreatedSort

3.5 Other Sources

Reports and peer reviewed journal articles were also accessed via research and journal databases such as PubMed and Google Scholar.

Species recovery plans for various protected species and ecological communities can be found in using this link: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowallrps.pl

The Marine Bioregional Plan for the South-west Marine Region (DSEWPC, 2012) describes the marine environment and conservation values (protected species, protected places and key ecological features) of the South-west Marine Region, and can be accessed using this link: https://www.dcceew.gov.au/environment/marine/marine-bioregional-plans/south-west

The South-west Marine Parks Network Management Plan (Director of National Parks, 2018) describes the marine environment and conservation values (protected species, protected places and key ecological features) of the Australian Marine Parks in the South-west Marine Region, including the Abrolhos Marine Park and the Jurien Marine Park.

In addition, some receptors within the Jurien Bay Marine Park (State waters) are included in ongoing monitoring as part of the Department of Biodiversity Conservation and Attractions (DBCA) Marine Monitoring Program.

4. Baseline Data Review

Pilot Energy has compiled a list of available baseline data relevant to the high value receptors in the EMBA (Baseline data sources) and reviewed this information to assess the spatial and temporal relevance of this data and comparison of methods and parameters to those outlined in the Joint Industry SMPs. This review focused on priority monitoring locations with a minimum hydrocarbon contact timeframe of less than 7 days for the worst-case spill (Section 2).

The criteria used during the baseline data review is outlined in Table 4-1.

Table 4-1: Assessment Criteria for Baseline Data Review

Year of most recent data capture	Duration of monitoring program	Frequency of data capture	Similarity of methods to Joint Industry SMP	Similarity of parameters to Joint Industry SMP
High = 2015–2020	High = > 4 years	High = 4+ sampling trips per year	High	High
Medium = 2010–2014	Medium = 2–4 years	Medium = 2–3 sampling trips per year	Medium	Medium
Low = <2010	Low = <2 years	Low = one-off sampling trip	Low	Low

This assessment was then used to determine if the available baseline data could be used to detect change in receptors at priority monitoring locations in the event of a significant impact. Table 4-2 compares priority monitoring locations and receptors, and provides guidance on where post-spill, pre-impact monitoring should be prioritised.

The different categories are listed in Table 4-2 include:

- Not applicable (N/A) – this receptor and relevant SMP is not applicable to the priority monitoring location (i.e. shoreline habitat not present at submerged shoals);
- Survey – current monitoring/knowledge is considered sufficient (i.e. could be used to detect level of change in the event of a significant impact) and is considered a lower priority for post-spill, pre-impact data collection; and
- Priority survey – current monitoring/knowledge is not in place, not suitable or not practicable; and post-spill pre-impact baseline data collection should be prioritised.

It is noted that it is difficult to obtain absolute statistical proof of oil spill impacts, due to the variability (spatially and temporally) of the natural environment, the lack of experimental control due to the nature of spills and because suitable baseline data may not be available (Kirby et al., 2018). Alternative approaches exist for detecting impacts where post-spill, pre-impact monitoring may not be feasible. These include impact versus control design approaches and/or a gradient approach. The

Joint Industry OSM Framework provides guidance and considerations for survey designs to enable the acquisition of sufficiently powerful data during SMP implementation.

Once SMP monitoring reports are drafted (post-spill) they should be peer reviewed by an expert panel (Refer to Section 10.10 of the Joint Industry OSM Framework).

Table 4-2: Recommended Priority Monitoring Locations versus SMPs

Location	SMP									
	Water quality impact assessment	Sediment quality impact assessment	Intertidal and coastal habitat assessment	Seabirds and shorebirds	Marine mega-fauna assessment – Pinnipeds	Marine mega-fauna assessment – whale sharks, dugong and cetaceans	Benthic habitat assessment	Marine fish and elasmobranch assemblages assessment	Fisheries impact assessment	Heritage and social impact assessment
Jurien Bay Marine Park*	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Survey	Survey	Survey	Priority survey (Locations to be determined in consultation with key stakeholders)
Cliff Head – White Point	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Illawong – Cliff Head	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Leeman - Coolimba	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Green Head - Leeman	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Beagle Islands Nature Reserve	Priority survey	Priority survey	Priority survey	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Clio Bank (submerged)	Priority survey	Priority survey	N/A	Priority survey	Priority survey	Priority survey	Priority survey	Priority survey	Survey	
Direction Bank (submerged)	Priority survey	Priority survey	N/A	Priority survey	Survey	Priority survey	Priority survey	Priority survey	Survey	
Geelvink Channel Shoal (submerged)	Priority survey	Priority survey	N/A	Priority survey	Priority survey	Priority survey	Priority survey	Priority survey	Survey	

* *Including Booker Valley – Island Point; Thirsty Point – Booker Valley; Grey -Thirsty Point; North Tail Reef; Sand Knoll Ledge*

5. OSM Organisational Structure

The IMT structure for Pilot Energy is based on the IPIECA Good Practice Guidelines – Incident Management System for the Oil and Gas Industry (IPIECA, 2014). This system aligns with the international Incident Command System (ICS) and the Australasian Integrated Incident Management System (AIIMS). The Incident Management Team (IMT) will be responsible for coordinating OSM activities, which will be led by the Planning Section within the IMT, with support from each Section, in particular the Operations Section.

The Pilot Energy IMT structure is shown in Figure 5-1.

Figure 5-2 illustrates the structure of the OSM Management Team during the response phase. The IMT Leader is ultimately accountable for managing the response operation, which includes this plan. Depending on the scale of the event, individual people may perform multiple roles; similarly, multiple people may share the same role.

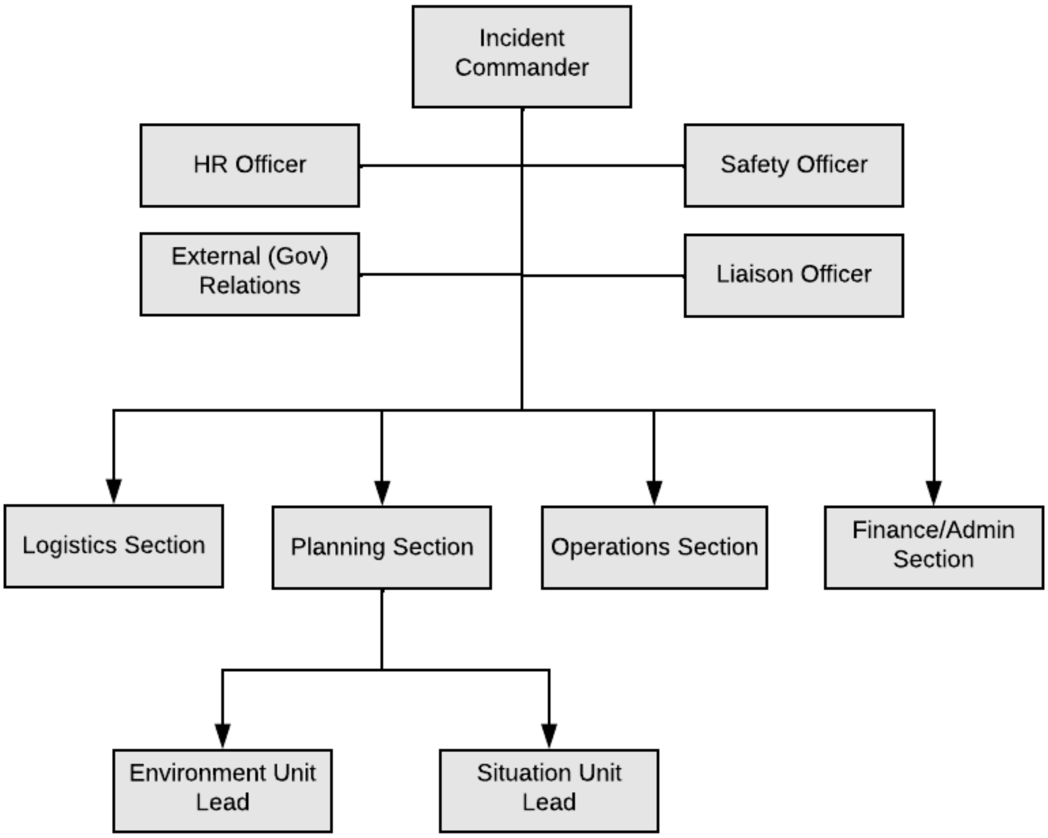


Figure 5-1: Pilot Energy IMT Structure

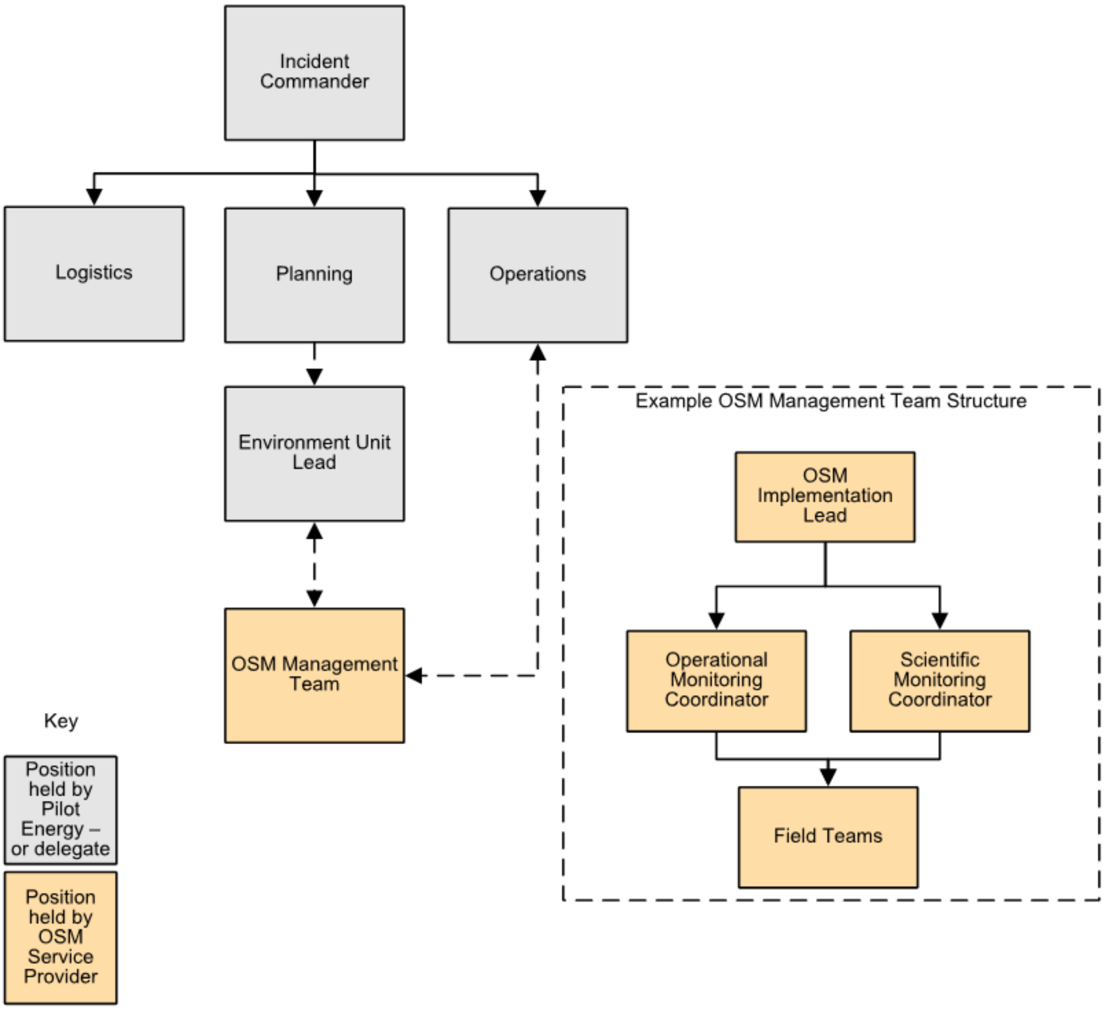


Figure 5-2: Pilot Energy IMT Structure with OSM Team

6. OSM Roles and Responsibilities

OSM roles and responsibilities are listed in Section 10.13.2 of the Joint Industry OSM Framework. Table 6-1 outlines the roles held by Pilot Energy and the OSM Services Provider.

During the post-response phase the Environment Unit Lead and the OSM Services Provider OSM Implementation Lead will continue to be responsible for the coordination and delivery of monitoring plans.

Table 6-1: Roles and Responsibilities for OSM

Role	Held by
Environment Unit Lead (EUL)	Environmental Consultants
Situation Unit Lead	Pilot Energy Planning Lead
OSM Implementation Lead	OSM Service Provider
Operational Monitoring Coordinator and Scientific Monitoring Coordinator	OSM Service Provider
OSM Field Operations Manager	OSM Service Provider
OSM Field Teams	OSM Service Provider

7. Mobilisation and Timing of OMP and SMP implementation

Table 7-1 provides an indicative implementation schedule for OMP and SMPs in the EMBA and adjacent waters. The locations listed are aligned to the initial monitoring priorities described in Section 2.

Table 7-1: Indicative OMP and SMP Implementation Schedule for OSM Activities if Initiation Criteria are Met

Proximity to spill source	Monitoring type	0–48 hours from OSM activation	Within 3-5 days of OSM activation	~5-7 days from OSM activation	>Two weeks from OSM activation
Spill site and surrounding waters	OM	• Activation of OMP Team Leads. • Finalise OMPs. • Commence activation and mobilisation of OM personnel.	• OMP: Hydrocarbon Properties And Weathering Behaviour, where resources are available (e.g. Supply Vessel with onboard sampling equipment). • OMP: Water Quality Assessment • OMP: Sediment Quality Assessment • OMP: Marine Fauna Assessment	-	As results from implemented OMPs are available, data are provided to relevant personnel in IMT (e.g. Planning) and used in the Incident Action Planning process for the next operational period. OMP is redesigned or reallocated according to the specifics of the actual spill.
	SM	• Commence activation and mobilisation process. • Activation of SMP Team Leads.	• Continue to activate and mobilise personnel. • Work on finalising SMPs.	• SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Marine fish and elasmobranch assemblages assessment • SMP: Marine mega-fauna assessment	Continue SMP monitoring until termination criteria are met
Sensitive receptors (including shorelines) where modelling shows contact within 72 hours (3 days) • Cliff Head – White Point (0.5 days)	OM	• Activation of OMP Team Leads. • Finalise OMPs. • Commence activation and mobilisation of OM personnel.	• OMP: Hydrocarbon properties and weathering behaviour at sea • OMP: Water quality assessment • OMP: Sediment quality assessment	-	As results from implemented OMPs are available, data are provided to relevant personnel in IMT (Situation Unit Lead) and used in the Incident Action Planning process for the next operational period. OMP is

Proximity to spill source	Monitoring type	0–48 hours from OSM activation	Within 3-5 days of OSM activation	~5-7 days from OSM activation	>Two weeks from OSM activation
• Illawong – Cliff Head (0.1 days) • Leeman – Coolimba (1.0 days) • Green Head – Leeman (1.5 days) • Beagle Islands Nature Reserve (0.5 days) • Booker Valley – Island Point (2.7 days)			• OMP: Shoreline clean-up assessment • OMP: Marine fauna assessment		redesigned or reallocated according to the specifics of the actual spill until termination criteria are met
	SM	• Activation of SMP Team Leads and finalisation of SMPs requiring reactive baseline monitoring data to be obtained pre-impact.	• Implementation of reactive baseline data monitoring (if applicable). • Finalisation of the remaining SMPs (where individual SMP initiation criteria are met).	• SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Intertidal and coastal habitat assessment • SMP: Seabirds and shorebirds • SMP: Marine mega-fauna assessment • SMP: Benthic habitat assessment • SMP: Marine fish and elasmobranch assemblages assessment • SMP: Commercial and recreational fisheries impact assessment • SMP: Heritage and social impact assessment	Continue SMP monitoring until termination criteria are met
Sensitive receptors (including shorelines) where modelling shows contact >3 days	OM	-	• Activation of OMP Team Leads. • Finalise OMPs.	• OMP: Hydrocarbon properties and weathering behaviour at sea	As results from implemented OMPs are available, data are provided to relevant personnel in IMT

Proximity to spill source	Monitoring type	0–48 hours from OSM activation	Within 3-5 days of OSM activation	~5-7 days from OSM activation	>Two weeks from OSM activation
• Thirsty Point – Booker Valley (4.0 days) • Grey – Thirsty Point (4.9 days) • Direction Bank (3.8 days) • North Tail Reef (3.1 days)			• Commence activation and mobilisation of OM personnel.	• OMP: Water quality assessment • OMP: Sediment quality assessment • OMP: Shoreline clean-up assessment • OMP: Marine fauna assessment	(Situation Unit Lead) and used in the Incident Action Planning process for the next operational period. OMP is redesigned or reallocated according to the specifics of the actual spill until termination criteria are met
	SM	-	• Commence activation and mobilisation process • Activation of SMP Team Leads and finalisation of SMPs	• SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Marine mega-fauna assessment - reptiles • SMP: Marine fish and elasmobranch assemblages assessment • SMP: Intertidal and coastal habitat assessment • SMP: Seabirds and shorebirds • SMP: Benthic habitat assessment • SMP: Commercial and recreational fisheries impact assessment	Continue SMP monitoring until termination criteria are met

Proximity to spill source	Monitoring type	0–48 hours from OSM activation	Within 3-5 days of OSM activation	~5-7 days from OSM activation	>Two weeks from OSM activation
				• SMP: Heritage and social impact assessment	
Sensitive receptors (including shorelines) where modelling shows contact >3 days • Geelvink Channel Shoals (5.2 days) • Sand Knoll Ledge (6.0 days) • Clio Bank (6.8 days)	OM	-	• Activation of OMP Team Leads. • Finalise OMPs. • Commence activation and mobilisation of OM personnel.	• OMP: Hydrocarbon properties and weathering behaviour at sea • OMP: Water quality assessment • OMP: Sediment quality assessment • OMP: Marine fauna assessment	As results from implemented OMPs are available, data are provided to relevant personnel in IMT (Situation Unit Lead) and used in the Incident Action Planning process for the next operational period. OMP is redesigned or reallocated according to the specifics of the actual spill until termination criteria are met
	SM	-	• Commence activation and mobilisation process • Activation of SMP Team Leads and finalisation of SMPs	• SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Marine mega-fauna assessment • SMP: Marine fish and elasmobranch assemblages assessment • SMP: Seabirds and shorebirds • SMP: Benthic habitat assessment • SMP: Commercial and recreational	Continue SMP monitoring until termination criteria are met

Proximity to spill source	Monitoring type	0–48 hours from OSM activation	Within 3-5 days of OSM activation	~5-7 days from OSM activation	>Two weeks from OSM activation
				fisheries impact assessment • SMP: Heritage and social impact assessment	

8. Resource Requirements

The resources required to assist the IMT in the coordination and management of OSM are outlined in Table 8-1. The resources required to implement operational and scientific monitoring components are presented in Table 8-1 and Table 8-2 respectively, which is based on the monitoring priorities in Section 2 and implementation schedule outlined in Table 7-1. This assessment is based on the vessel-based MGO spill (320 m^3) as listed in Table 3-1 of the Eureka 3D MSS OPEP (Appendix E). It should be noted that a single spill will not contact all locations and receptors listed in Table 7-1.

Table 8-1: Resources Required for Key OSM Coordination Roles

Role	Resources Required	Arrangement
OSM Implementation Lead (OSM Monitoring Provider/s)	1 x Principal Scientist	OSM contractor
Operational Monitoring Coordinator and Scientific Monitoring Coordinator (OSM Service Provider/s)		
OSM Field Operations Manager (OSM Service Provider/s)	1 x Senior Scientist	

Table 8-2: Resources Required for Implementing OMPs

OMP	Resources Required	Arrangement
Hydrocarbon properties and weathering behaviour at sea)*	1 team (spill site and surrounds) 1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll)	OSM contractor Marine contractors Laboratory arrangement

OMP	Resources Required	Arrangement
	1 team (Clio Bank, Geelvink Channel Shoals) Total 4 team leaders and 8 team members (3 personnel per team)	
Shoreline clean-up assessment	1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey) Total 2 team leaders and 4 team members (3 per team)	OSM contractor Marine contractors
Water quality assessment*	Refer to OMP: Hydrocarbon properties and weathering behaviour at sea resourcing* (all sites)	OSM contractor Marine contractors
Sediment quality assessment*	Refer to OMP: Hydrocarbon properties and weathering behaviour at sea resourcing* (all sites)	OSM contractor Marine contractors
Marine fauna assessment	1 team to conduct initial aerial surveys for all sites (2 observers per aircraft) Note: these resources may not be required if relevant scientific monitoring components initiation criteria have been triggered.	OSM contractor Marine contractors Aviation contractors

** Initial co-mobilisation between OMP: Hydrocarbon properties and weathering behaviour at sea, OMP: Water quality assessment and OMP: Sediment quality assessment*

Table 8-3: Resources Required for Implementing SMPs

SMP	Resources Required	Arrangement
Water quality impact assessment	1 team (spill site and surrounds) 1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll) 1 team (Clio Bank, Geelvink Channel Shoals) Total 4 team leaders and 8 team members (3 personnel per team) Note: can be performed by the same team as OMP: Water quality assessment. This SMP may replace OMP: Water quality assessment if the OMPs termination criteria are triggered	OSM contractor Marine contractors Laboratory arrangement
Sediment quality impact assessment	Refer to SMP: Water quality impact assessment* (all sites)	OSM contractor Marine contractors Laboratory arrangement

SMP	Resources Required	Arrangement
Intertidal and coastal habitat assessment	1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey) Total 2 team leaders and 2 team members (2 per team)	OSM contractor Marine contractors Laboratory arrangement
Seabirds and shorebirds	1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll) 1 team (Clio Bank, Geelvink Channel Shoals) Total 3 team leaders and 3 team members (2 per team) Note: can initially be performed by the same team as OMP: Marine fauna assessment – seabirds and shorebirds. This SMP may replace OMP: Marine fauna assessment – seabirds and shorebirds if the OMPs termination criteria are triggered	OSM contractor Marine contractors Laboratory arrangement
Marine mega-fauna assessment • Pinnipeds • Reptiles • Cetaceans	1 team (spill site and surrounds) 1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll) 1 team (Clio Bank, Geelvink Channel Shoals) Total 4 team leaders and 12 team members (4 per team) Note: Aerial surveillance aspects can initially be performed by the same team as the relevant OMP: Marine fauna assessment. This SMP may replace the relevant OMP: Marine fauna assessment if the OMPs termination criteria are triggered	OSM contractor Marine contractors Laboratory arrangement
Benthic habitat assessment	1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll) 1 team (Clio Bank, Geelvink Channel Shoals) Total 3 team leaders and 6 team members (3 per team)	OSM contractor Marine contractors Laboratory arrangement
Marine fish and elasmobranch assemblages assessment	1 team (spill site and surrounds) 1 team (Cliff Head, Illawong, Leeman, Green Head, Beagle Islands, Booker Valley) 1 team (Thirsty Point, Grey, Direction Bank, North Tail Reef, Sand Knoll) 1 team (Clio Bank, Geelvink Channel Shoals) Total 4 team leaders and 8 team members (3 per team) Note: can initially be performed by the same team as OMP: Marine fauna assessment – fish. This SMP may replace OMP: Marine fauna assessment – fish if the OMPs termination criteria are triggered	OSM contractor Marine contractors Laboratory arrangement

SMP	Resources Required	Arrangement
Fisheries impact assessment	1 team (Commonwealth fisheries with the potential to be impacted/are being impacted (e.g. Western Deepwater Trawl Fishery) Total 1 team leaders and 2 team members (3 per team) Note: can initially be performed by the same team as OMP: Marine fauna assessment – fish. This SMP may replace OMP: Marine fauna assessment – fish if the OMPs termination criteria are triggered	OSM contractor Marine contractors Laboratory arrangement
Heritage features assessment	1 team Total 1 team leader and 2 team members (3 per team)	OSM contractor Marine contractors Laboratory arrangement
Social impact assessment	1 team Total 1 team leader and 2 team members (3 per team)	OSM contractor

9. Capability Arrangements

Pilot Energy will engage an OSM Services Provider, providing standby OSM response and implementation services, prior to pre-mobilisation of the activity. Details of OSM services are provided in Table 9-1.

The OSM Services Provider is contracted to provide Pilot Energy with a Standby Capability and Competency Report at the commencement of the MSS, which details personnel requirements for OMPs/SMPs, numbers of available personnel and competencies for service provider and sub-contracted personnel.

Personnel listed on the report will be contactable via mobile phone during this period and accessible to a nearby port (i.e. Port Denison-Dongara or Fremantle) within 48 hours of Pilot Energy's initial activation of OSM Services.

Table 9-1: Worked Example – OSM Services Provider Standby and Implementation Services

Standby	Implementation
24/7 monitoring support accessed through 24 hour call out number	Provision of an OSM Implementation Lead to the Pilot Energy IMT within 12 hours of notification
Provision of a suitably trained personnel, which includes support from the service provider and its sub-contractors and suppliers	Provision of a first-strike scientific team within 24 hours of notification, available in Perth and ready to deploy
Report on personnel and equipment availability, prior to the commencement of the MSS	Development of scientific response and sampling plans (based on modelled hydrocarbon spill scenario)
Access to service providers network of scientific and engineering consulting expertise	Provision of a second-strike scientific team within 72 hours of notification, ready to deploy
Access to service providers local network of terrestrial consultants, laboratories and field service providers	Priority access to service providers staff and equipment

9.1 Personnel Competencies

Pilot Energy's OSM Service Contract specifies the competency requirements for key OSM personnel.

In addition and where practicable, Pilot Energy will engage its consultants in the initial stages of the monitoring program to help activate and mobilise monitoring teams, and finalise monitoring designs.

9.2 Equipment

Equipment requirements are listed in the individual OMPs and SMPs. A generalised breakdown of equipment types and the source is listed in Table 9-2.

In accordance with the OSM services contract, the OSM Services Provider will provide all specialised field monitoring equipment to implement individual OMPs and SMPs. Pilot Energy will remain responsible for support and field logistics, including monitoring platforms (e.g. vessels, vehicles and aircraft), flights and accommodation for personnel and transportation/couriers for samples to be sent back to laboratories.

Availability of field equipment will be listed in the OSM Services Provider's Standby Capability and Competency Report.

Table 9-2: OSM equipment

Equipment type	Source
Desktop equipment (e.g. Oil Spill Response Atlas, GIS)	Coordinated through OSM Service Provider
In-field specialised monitoring equipment (e.g. fluorometers, sample bottles, ROVs)	Coordinated through the OSM Services Provider's standby OSM response and implementation services
Logistical equipment (e.g. in-field accommodation, vessels, aircraft)	Marine contracts, aviation contracts.

9.3 Exercises

Testing of key service provider arrangements would be done as a standalone desktop test prior to the mobilisation of the activity, and would assess the capability and availability of resources by the service provider against the performance requirements. More information of exercise and testing arrangements is provided in Section 10 of the Eureka 3D MSS EP.

10. Capability Assessment

Table 10-1 demonstrates Pilot Energy's capability to implement each OMP and SMP, including an assessment of each monitoring plan, identification of likely monitoring platforms, major supporting infrastructure (e.g. offshore accommodation), reactive baseline monitoring requirements (Section 4.0), initial survey arrangements (e.g. aerial followed up with ground reconnaissance) and ability to combine with other monitoring plans. The personnel outlined is only relevant if the spill hits all receptors identified in table 8.3 at a high volume and threshold. Given the size and type of spill it is improbable that all personnel identified would be required and therefore activated.

Note that OMP: Surface chemical dispersant effectiveness and fate assessment and OMP: Subsea dispersant injection monitoring are not included in Table 10-1 as they have not been selected as suitable response strategies in the OPEP (Appendix E – Section 3.4).

Table 10-1: OSM Capability

Component	Total Personnel Required (Weeks 1–2) [1]	Personnel available via OSM Service Provider Standby Contract	Total Personnel Available
OSM Personnel embedded in IMT	1 OSM Implementation Lead (given nature/scale this person can also fill the role of OM and SM Coordinator) 1 Field Operations Manager	1 OSM Implementation Lead/ OM Monitoring Coordinator / SM Coordinator 1 Field Operations Manager	1 OSM Implementation Lead/ OM Monitoring Coordinator / SM Coordinator 1 Field Operations Manager
OMPs			
Hydrocarbon properties and weathering behaviour at sea*	4 team leaders 8 team members	4 team leaders 8 team members	4 team leaders 8 team members
Shoreline clean-up assessment	2 team leaders 4 team members	2 team leaders 4 team members	2 team leaders 4 team members
Water quality assessment*	Refer to OMP: Hydrocarbon properties and weathering behaviour at sea		
Sediment quality assessment*	Refer to OMP: Hydrocarbon properties and weathering behaviour at sea		
Marine fauna assessment	1 aerial team (including 1 Marine Mammal Observer (MMO) and 1 Aerial survey observer)	1 aerial team (including 1 Marine Mammal Observer (MMO) and 1 Aerial survey observer)	1 aerial team (including 1 Marine Mammal Observer (MMO) and 1 Aerial survey observer)
SMPs			
Water quality impact assessment	Note: can initially be performed by the same team as OMP: Water quality assessment. This SMP may replace OMP: Water quality assessment if the OMPs termination criteria are triggered		
Sediment quality impact assessment	Refer to SMP: Water quality impact assessment* (all sites)		

[1] If additional resources are required for week 3 onwards then this will be identified early in the monitoring process and Pilot Energy will activate additional contracted resources through its OSM Services Provider to increase capacity

Component	Total Personnel Required (Weeks 1–2) [1]	Personnel available via OSM Service Provider Standby Contract	Total Personnel Available
Intertidal and coastal habitat assessment	2 team leaders 2 team members	2 team leaders 2 team members	2 team leaders 2 team members
Seabirds and shorebirds	Note: can initially be performed by the same team as OMP: Marine fauna assessment – seabirds and shorebirds. This SMP may replace OMP: Marine fauna assessment – seabirds and shorebirds if the OMPs termination criteria are triggered		
Marine mega-fauna assessment	4 team leaders 12 team members	4 team leaders 12 team members	4 team leaders 12 team members
Benthic habitat assessment	3 team leaders 6 team members	3 team leaders 6 team members	3 team leaders 6 team members
Marine fish and elasmobranch assemblages assessment	4 team leaders 8 team members	4 team leaders 8 team members	4 team leaders 8 team members
Fisheries impact assessment	1 team leader 2 team members	1 team leader 2 team members	1 team leader 2 team members
Heritage features assessment	1 team leader 2 team members (including either ROV operator or marine diver/s)	1 team leader 2 team members (including either ROV operator or marine diver/s)	1 team leaders 2 team members (including either ROV operator or marine diver/s)
Social impact assessment	1 team leader 2 team members	N/A	1 team leader 2 team members

** Initial co-mobilisation between OMP: Hydrocarbon properties and weathering behaviour at sea and OMP: Water quality assessment and OMP: Sediment quality assessment*

11. Review of Plan

This document will be reviewed in the pre-mobilisation preoaration for the 3D MSS. Should any major changes have occurred this document will be revised. This could include changes required in response to one or more of the following:

- When major changes have occurred which affect Operational and/or Scientific Monitoring coordination or capabilities (e.g. change of service provider/s);
- Changes to the activity that affect Operational and/or Scientific Monitoring coordination or capabilities (e.g. a significant increase in spill risk);
- Changes to legislative context related to Operational and/or Scientific Monitoring (e.g. EPBC Act protected maters requirements);

The extent of changes made to this OSM Bridging Implementation Plan and resultant requirements for regulatory resubmission will be informed by the relevant Commonwealth regulations, i.e. the OPGGS (Env) Regulations.

Part B – Implementation

12. Activation Process

Pilot Energy's IMT Environment Unit Leader is responsible for activating OSM components, subject to approval from the IMT Leader. Table 12-1 outlines Pilot Energy's OSM activation process.

Table 12-1: OSM Activation Process

Responsibility	Task	Timeframe	Complete
Environment Unit Leader (Pilot Energy/ Environmental Consultants)	Review initiation criteria of OMPs and SMPs during the preparation of the initial Incident Action Plan (IAPs) and subsequent IAPs; and if any criteria are met, activate relevant OMPs and SMPs	Within 4 hours of spill notification	❑
	Obtain approval from Incident Commander Leader to initiate OSM	Within 4 hours of spill notification	❑
	Contact OSM Services Provider and notify on-call officer of incident, requesting provision of OSM Implementation Lead to the IMT	Within 4 hours of spill notification	❑
	Provide monitor and evaluate data (e.g. aerial surveillance, fate and weathering modelling, tracking buoy data) to OSM Services Provider	Within 1 hour of data being received by IMT	❑
	Liaise directly with OSM Services Provider to confirm which OMPs and SMPs are to be fully activated	Within 3 hours of monitor and evaluate data being received from IMT	❑
	Provide purchase order to OSM Services Provider (cross reference OSM Standby Services Scope of Work)	Within 72 hours of initial notification to OSM Services Provider	❑
	Record tasks in Personal Log	At time of completion of task	❑
OSM Services Provider	On-call officer to notify Service Provider Manager of activation and contact OSM Implementation Lead and Scientific Logistics Coordinator	Within 8 hours of notification being made to OSM Services Provider	❑
	Send OSM Implementation Lead and Scientific Logistics Coordinator to IMT	Within 12 hours of notification being made to OSM Services Provider	❑
	Liaise directly with EUL to confirm which OMPs and SMPs are to be fully activated	Within 4 hours of monitor and evaluate data being received from IMT	❑
	Confirm availability of initial personnel and equipment resources	Within 5 hours of monitor and evaluate data being received from IMT	❑

13. Monitoring Priorities

As described in Section 2, the available spill trajectory modelling has been analysed to understand the likely initial monitoring priorities for its activities in the EMBA. In addition, Table 4-2 lists comparability of available baseline data for receptors, to assist in identifying where post-spill, pre-impact monitoring should be prioritised.

The monitoring priorities provided in Section 2 and Table 4-2 are to be used for guidance when confirming monitoring priorities in consultation with key stakeholders and monitoring service providers (including subject matter experts, where available) at the time of the spill. Table 13-1 provides a checklist to assist in the confirmation of monitoring priorities for individual spills.

Table 13-1: Checklist for Determining Monitoring Priorities

Responsibility	Task	Timeframe	Complete
OSM Services Provider with input from Environment Unit Leader (EUL)	Confirm monitoring locations for activated OMPs and SMPs based on: • Current monitor and evaluate data (i.e. situational awareness data, including predicted time to receptor impact, aerial/vessel surveillance observations, tracking buoy data, satellite data); • Nature of hydrocarbon spill (i.e. surface release, hydrocarbon characteristics, volume, expected duration of release); • Seasonality and presence of receptors impacted or at risk of being impacted; • Current information on transient and broadscale receptors (surface and subsea); • Current operational considerations (e.g. weather, logistics); • Monitoring priorities identified in Section 2; and • Existing literature, baseline data, and monitoring programs.	Within 12 hours of monitor and evaluate data being received from IMT	❑
	Evaluate monitoring priorities in consultation with key stakeholders, including the appointed State Environment and Science Coordinator	Within 12 hours of monitor and evaluate data being received from IMT	❑
	Using the results of the baseline data analysis in Table 4-2 and the information above, determine priority locations for post-spill, pre-impact monitoring	Within 12 hours of monitor and evaluate data being received from IMT	❑
	Confirm the need for any additional reactive baseline monitoring data for SMPs and determine suitable locations, noting that suitable control or reference sites may be outside of the EMBA	Within 12 hours of monitor and evaluate data being received from IMT	❑
	Continually re-evaluate monitoring priorities in consultation with EUL and relevant key stakeholders throughout spill response	Ongoing	❑

14. Protected Matters Requirements

Table 14-1 provides a checklist to ensure monitoring personnel consider EPBC Act Protected Matters (MNES) and other protected matters requirements in the finalisation of OMPs and SMPs.

Appendix B outlines the management plans, recovery plans and conservation advice statements relevant for the protected matters within the EMBA that are likely to be relevant to the final design of the OMPs and SMPs. Appendix B also includes relevant priority monitoring locations where these receptors are known to occur in order to expedite consideration of relevant information into finalised monitoring designs.

Table 14-1: Checklist for Inclusion of Protected Matters into Monitoring Designs

Responsibility	Task	Complete
OSM Services Provider with input from EUL	Review Monitoring, Evaluation and Surveillance data and available OMP data to determine likely presence and encounter of protected species in predicted trajectory of the spill	❑
	Review the relevant recovery plan/wildlife conservation plan/conservation advice/management plan in Appendix B and determine if there have been any updates to the relevant conservation threats/actions. Integrate relevant considerations into the final monitoring design for affected OMPs and SMPs	❑
	Review restrictions on marine mammal buffer distances in SMP: Marine mega-fauna and ensure this is included in all relevant response and monitoring IAPs (e.g. Shoreline Protection Plan, Shoreline Clean-up Plan, OSM Plan), so that response and monitoring field teams maintain required buffer distances from fauna during operations	❑

15. Finalising Monitoring Design

The methods presented in the Joint Industry OMPs and SMPs are designed to allow Monitoring Providers with the flexibility to modify the standard operating procedures, so that the latest research, technologies, equipment, sampling methods and variables may be used. Monitoring designs may also be varied in-situ, according to the factors presented in Section 10.6 of the Joint Industry OSM Framework.

Pilot Energy's checklist for finalising monitoring designs post-spill is provided in Table 15-1. The OSM Implementation Lead will be responsible for approving the finalised monitoring design used in the OMPs and SMPs.

Table 15-1: Checklist for Finalising Monitoring Design

Responsibility	Task	Timeframe	Complete
OSM Services Provider	Confirm survey objectives, sampling technique, for each initiated OMP and SMP	Within 48 hours of initial monitoring priorities being confirmed by IMT	❑
	Determine suitable sampling frequency	Within 48 hours of initial monitoring priorities being confirmed by IMT	❑
	Finalise standard operating procedures	Within 48 hours of initial monitoring priorities being confirmed by IMT	❑
	Scientific monitoring: • Establish benchmarks and guidelines to be used • Confirm indicator species	Within 96 hours of initial monitoring priorities being confirmed by IMT	❑

Responsibility	Task	Timeframe	Complete
	• Confirm parameters and metrics		

16. Mobilisation

When the monitoring design has been finalised for each OMP and SMP, the OSM Services Provider shall work in conjunction with Pilot Energy to develop and execute a monitoring mobilisation plan, which will be incorporated into the Incident Action Planning process.

The OSM Services Provider will be required to coordinate the availability of personnel and equipment for all monitoring programs. Pilot Energy is responsible for flights, accommodation and victualing for field personnel. Pilot Energy will also be required to procure all vessels, aerial platforms and vehicles for OMP and SMP implementation.

A checklist for mobilising monitoring teams is provided in Table 16-1.

Table 16-1: Checklist for Mobilisation of Monitoring Teams

Responsibility	Task	Complete
OSM Services Provider with input from Environment Unit Leader	Confirm availability of all monitoring personnel (noting required competencies in Section 11.3 of the Joint Industry OSM Framework and individual OMPs/SMPs)	❑
	Allocate number of teams, personnel, equipment and supporting resource requirements	❑
	Undertake HAZIDs as required and consolidate/review field documentation including safety plans, emergency response plans, and daily field reports	❑
	Develop site-specific health and safety plans which is compliant with health safety and environment systems (including call in timing and procedures)	❑
	Conduct pre-mobilisation meeting with monitoring team/s on survey objectives, logistics, safety issues, reporting requirements and data management collection requirements	❑
	Determine data management delivery needs of the IMT/EMT and process requirements, including data transfer approach and frequency/timing	❑
	Confirm data formats and metadata requirements with personnel receiving data	❑
	Logistics	
	Confirm flights, accommodation, and car hire arrangements are in place	❑
	Develop field survey schedules, detailing staff rotation	❑
	Equipment	
	Confirm survey platform (vessel, vehicle, aircraft) has been secured to survey or access survey sites and ensure it is equipped with appropriate fridge and freezer space for transportation of samples (and carcasses if collecting)	❑
	Ensure vessels have correct fit-out specifications (e.g. winches, GPS, satellite, hi-ab, sufficient deck space, water supplies (fresh and/or salt), accommodation)	❑
	Confirm consumables (including personal protective equipment) have been purchased and will be delivered to required location	❑

Responsibility	Task	Complete
	Liaise with NATA-accredited laboratories to confirm availability, limits of detection, sampling holding times, transportation, obtain sample analysis quotes and arrange provision of appropriate sample containers, Chain of Custody (CoC) forms and suitable storage options for all samples. Make arrangements for couriers (if necessary)	❑
	Confirm specialist equipment requirements and availability (including redundancy)	❑
	Check GPS units and digital cameras are working and that sufficient spare batteries and memory cards are available	❑
	Confirm sufficient equipment to allow integration of survey software and navigational systems (e.g. GPS, additional equipment and adaptors), and additional GPS units prepared	❑
	Confirm GPS survey positions (where available) have been QA/QC checked and pre-loaded into navigation software/positioning system	❑
	Check field laptops, ensuring they have batteries (including spares), power cable, and are functional	❑
	Check if a first aid kit or specialist Personal Protective Equipment (PPE) is required	❑
	Confirm arrangements for freight to mobilisation port is in place	❑

17. Permits and Access Requirements

Permit and access requirements apply to marine parks, marine and terrestrial reserves, restricted heritage areas, operational areas of industrial sites, defence locations, certain fauna and managed fisheries. Table 17-1 lists relevant protected areas within the EMBA and the jurisdictional authority to be contacted to obtain the necessary permit or access permission.

The OSM Services Provider is responsible for submitting access and permit applications to all relevant Jurisdictional Authorities to conduct monitoring for OMPs and SMPs.

Table 17-1: Permits Required in EMBA

Receptor	Location	Jurisdictional Authority	Relevant information on permits
Permits for monitoring fauna	N/A	DCCEEW State government department with jurisdiction for fauna	Any interactions involving nationally listed threatened fauna may require approval from DCCEEW (http://www.environment.gov.au/biodiversity/threatened/permits) WA- appropriate permits can be found at: https://www.dpaw.wa.gov.au/plants-and-animals/licences-and-authorities?showall=&start=4
State Marine Protected Areas; Fish Habitat Protection Areas	• Jurien Bay Marine Park • Essex Rocks Nature Reserve • Buller, Whittell and Green Islands Nature Reserve • Cervantes Islands Nature Reserve • Beagle Islands Nature Reserve • Marmion Marine Park • Lipfert, Milligan, Etc Islands Nature Reserve • Sandland Island Nature Reserve • Ronsard Rocks Nature Reserve • Outer Rocks Nature Reserve • Fisherman Islands Nature Reserve	State government department with jurisdiction for parks and wildlife (DBCA) State government department with jurisdiction for fisheries (DPIRD)	No specific permitting requirements exist for monitoring in WA marine protected areas, but OSM Service Providers should contact DBCA and DPIRD prior to finalising monitoring design in protected areas. DBCA has a Marine Science Program for WA's Marine Protected Areas to undertake marine reaserach and monitoring that should be taken into account. Additional information is available at: https://www.dpaw.wa.gov.au/management/marine , https://www.dpaw.wa.gov.au/management/marine/marine-parks-and-reserves and https://www.fish.wa.gov.au/Sustainability-and-Environment/Aquatic-Biodiversity/Marine-Protected-Areas/Pages/default.aspx

Receptor	Location	Jurisdictional Authority	Relevant information on permits
	• Lancelin Island Lagoon Fish Habitat Protection • Abrolhos Islands Fish Habitat Protection		
Australian (Commonwealth) Marine Parks	• Abrolhos • Perth Canyon • Two Ricks • Jurien • South-west Corner	Director of National Parks Parks Australia	Permit and licence application information for Marine Protected Areas (including monitoring) can be found at: https://onlineservices.environment.gov.au/parks/australian-marine-parks and https://onlineservices.environment.gov.au/parks/australian-marine-parks/permits Additional information on permitting requirements in Australian Marine Parks can be obtained through Parks Australia via email marineparks@environment.gov.au or phone 1800 069 352 Information on permits to access biological resources in Commonwealth areas can be found at: http://www.environment.gov.au/topics/science-and-research/australias-biological-resources/access-biological-resources-commonwealth
Commonwealth Managed Fisheries	• Western Deepwater Trawl Fishery	Australian Fishing Management Authority (AFMA)	Commonwealth Managed Fisheries (scientific permit for research/monitoring in an Australian Fishing Zone) https://www.afma.gov.au/fisheries-services/fishing-rights-permits
Indigenous Cultural Heritage	Sites are located throughout EMBA	State government department with jurisdiction for indigenous heritage	Entry access permits to Aboriginal Lands in WA: https://www.wa.gov.au/service/aboriginal-affairs/aboriginal-heritage-conservation/apply-permit-access-or-travel-through-aboriginal-land Aboriginal heritage sites in WA: https://www.wa.gov.au/service/aboriginal-affairs/aboriginal-cultural-heritage/search-aboriginal-sites-or-heritage-places
Lancelin Defence Training Area	Lancelin	Department of Defence	Unexploded Ordanances (mapping information): https://www.defence.gov.au/UXO/default.asp Maritime military firing practice and exercise areas: https://www.hydro.gov.au/factsheets/FS_Navigation-Firing_Practice_and_Exercise_Areas.pdf
Industry (e.g. operational zone of offshore oil or gas platform)	• Triangle Energy Pty Ltd WA-31-L (29° 27’ 00.4” S 114° 52’ 12.1” E)	Operating company	Petroleum safety zones (up to 500 m from outer edge of well or equipment) – https://www.nopsema.gov.au/safety/safety-zones/

Receptor	Location	Jurisdictional Authority	Relevant information on permits
Shipwrecks	• Batavia Shipwreck Site	State/ or Commonwealth government department with jurisdiction for maritime cultural heritage/ archaeology	Underwater heritage protected zones (Commonwealth): www.environment.gov.au/heritage/underwater-heritage/protected-zones

18. Use of Data in Response Decision-making

18.1 Operational Monitoring to Inform Response Activities

The OSM Services Provider is responsible for the collection of data by field teams, which shall be QA/QC checked by the Field Team Lead in accordance with the requirements listed in the finalised OMPs and SMPs (where applicable). The Team Lead will be responsible for communicating data back to the OSM Management Team (led by the OSM Services Provider) via field reporting forms, debriefs and reports. Laboratory analysis reports should also be directed to the OSM Management Team.

The OSM Management Team is responsible for the interpretation and analysis of data. OMP data should be analysed rapidly so that it may be used to inform response planning and decisions in the current and/or next operating period. SMP data is designed to be more scientifically robust and long-term in nature and is not relied upon by the IMT for decision-making. Therefore, SMP data will be analysed more thoroughly by the OSM Management Team.

Once data is analysed and checked by the Field Team Lead, it will be provided to the IMT Situation Unit Lead, who will then distribute the data from each monitoring component to the relevant IMT Unit and/or Section. Table 18-1 provides guidance on the type of data generated from each OMP, which IMT Section/Unit requires the data and how the data may be used during a response.

Analysed data will then be incorporated into the Common Operating Picture (managed by the Situation Unit Lead) and used by the Environment Unit Lead during development of the operational Spill Impact Mitigation Assessment (SIMA), which would be included in the IAP for the current or next operating period.

As ultimately responsible for the IAPs, the Planning Section Chief will be required to determine if the response options can be commenced, continued, escalated, terminated, or if controls need to be put in place to manage impacts of the response activities. These decisions will be communicated to the broader IMT during regular situation debriefs.

Table 18-1: Data Generated from Each OMP and How this May be used by IMT in Decision Making

Operational Monitoring Plan	Data generated[2]	IMT Section requiring data	How data may be used by IMT
Hydrocarbon properties and weathering behaviour at sea	Hydrocarbon physical characteristics (e.g. viscosity, asphaltene content, fingerprinting, weathering ratios of hydrocarbon chains)	Planning Section to aid in response option selection / modification	Changes to the hydrocarbon properties will affect the window of opportunity for particular responses and the associated logistical requirements of these responses, such as use of chemical dispersants, recovery and pumping equipment suitability, hydrocarbon storage and hydrocarbon disposal requirements
Shoreline clean-up assessment	Assessment of shoreline character; assessment of shoreline oiling; recommendations for response activities; post-treatment surveys	Planning Section to aid in IAP development and response option selection / modification	Confirmation of shoreline character, habitats and fauna present which may influence selection of response tactics (e.g. no mechanical recovery if seabirds are known to be nesting); Oil deposition and/or removal rate for a shoreline sector will help determine effectiveness of relevant tactics (e.g. shoreline protection and/or clean-up operations); Assessment teams provide ground truthing of sites that are not possible via satellite imagery, therefore the IMT can rely on the recommendations of Assessment Teams (e.g. flagging access issues, suitable tactics, likely resourcing needs)
Water quality assessment	Distribution of oil in water column and change in hydrocarbon concentrations (e.g. total recoverable hydrocarbons; benzene, toluene, ethylbenzene, xylene and naphthalene [BTEXN], Polycyclic Aromatic Hydrocarbons [PAH]), physio-chemical parameters and dispersant detection	Situation Unit Lead to validate surveillance and modelling data; Planning Section for use in IAP	Confirm spatial extent of spill within the water column and verify spill modelling and surveillance data; extent of spill can in turn influence location of other OMP and SMP monitoring components and sites. Data can also influence ongoing use of dispersant through ongoing operational SIMA.
Sediment quality assessment	Distribution of oil in sediment and change in hydrocarbon concentrations (e.g. Total recoverable hydrocarbons, BTEXN, PAH)	Situation Unit Lead to validate surveillance and modelling data; Planning Section for use in IAP	Confirm spatial extent of spill; extent of spill can in turn influence location of other OMP and SMP monitoring components and sites

[2] Summary only. For additional detail, please refer to individual OMPs. Also note data outputs will be reliant on finalised monitoring design.

Operational Monitoring Plan	Data generated[2]	IMT Section requiring data	How data may be used by IMT
Marine fauna assessment • Pinnipeds • Cetaceans (observational only) • Seabirds and shorebirds • Fish	Rapid assessment of presence and distribution of marine fauna; evaluate impact of spill and response activities on fauna	Planning Section for use in IAP; Oiled Wildlife Unit/Division to help in developing Wildlife Response Sub-plan	Understanding of species, populations and geographical locations at greatest risk from spill impacts. IMT can use this information to help qualify locations with highest level of protection priority (e.g. factoring in seasonality of receptors); understanding the impacts of spill response activities can help IMT to modify or terminate activities if they are assessed as creating more harm than the oil alone (e.g. large shoreline clean-up teams and staging areas may disturb shorebird nesting resulting in adults abandoning chicks)

18.2 Impacts from Response Activities

Table 10-4 of the Joint Industry OSM Framework outlines the potential impacts from response activities and the relevant OMP/SMP for monitoring impacts. For example, if shoreline clean-up was being considered as a response option, then possible impacts resulting from that activity could include physical presence, ground disturbance, water/sediment quality decline and lighting/noise impacts to fauna.

When finalising monitoring designs, the OSM Implementation Lead shall review Table 10-4 of the Joint Industry OSM Framework to ensure potential impacts from response activities are considered and incorporated into relevant OMP/SMP designs.

18.3 Operational Monitoring of Effectiveness of Control Measures and to Ensure EPS are Met

The EPS relevant to spill response and OSM are included in the Eureka 3D MSS OPEP (Appendix E). When finalising monitoring designs, the OSM Implementation Lead and Environment Unit Lead (or delegate) shall review the Environmental Performance Standards listed in the Eureka 3D MSS OPEP (Appendix E) and integrate checks into the monitoring design that will help determine if relevant Environmental Performance Standards are being met.

19. Data Management

Minimum standards for data management are provided in Section 10.11 of the Joint Industry OSM Framework and will be adopted by Pilot Energy and the OSM Service Provider.

20. Quality Assurance and Quality Control

Refer to Section 10.11 of the Joint Industry OSM Framework for QA/QC minimum standards, which will be adopted by Pilot Energy and the OSM Service Provider.

21. Communication Protocols

21.1 OSM Services Provider/s

Communication protocols between Pilot Energy and its OSM Services Provider with respect to delivery of the OMPs and SMPs (during both preparedness and implementation) are intentionally defined to ensure clear and consistent information is provided in both directions.

The following communication protocols must be observed:

- During the preparedness phase (pre-spill) and during activation (prior to deployment) will be between a Pilot Energy Representative (or delegate) and the OSM Services Provider Lead respectively.
- During implementation (post deployment), primary communication occurs via two pathways:
  - Pilot Energy Representative and the OSM Services Provider Lead for contractual, management, scientific and general direction matters; and
  - Pilot Energy's IMT and the OSM Services Provider's Field Operations Manager for on-site matters.
- All OSM operational decisions should be logged in an OSM decision log by key personnel, including but not limited to the OSM Services Provider Implementation Lead, OSM Field

Operations Manager, Operational Monitoring Coordinator, Scientific Monitoring Coordinator and Field Team Leads.

- All OSM tasks, actions and requirements should be documented in an IAP during the response phase of the spill.
- The IMT Incident Commander/IMT Leader will keep the IMT Section Chiefs briefed of the OSM status as required.
- All correspondence (copies of emails and records of phone calls) between Pilot Energy and the OSM Services Provider during a response should be recorded and kept on file.
- All communication received by OSM Services Provider not in line with these protocols should be reported to the nominated Pilot Energy Representative who will seek guidance on the accuracy of the information received.
- Unless related to safety (e.g. evacuation), any direction or instruction received by the OSM Services Provider outside of these protocols should be confirmed via the nominated Pilot Energy Representative prior to implementation.

During the post-response phase all communications shall be between a nominated Pilot Energy Representative and the OSM Services Provider OSM Implementation Lead.

21.2 External Stakeholders

Results of OMPs and SMPs will be discussed with relevant stakeholders. Information will be shared with regulatory agencies/authorities as required and inputs received from stakeholders will be evaluated and where practicable, will be used to refine the ongoing spill response and/or ongoing operational and/or scientific monitoring.

Pilot Energy IMT will be the focal point for external engagement during the response operation .A focal point for post response communications will be assigned.

22. Stand Down Process

Monitoring for each component will continue until termination criteria for individual components are reached. Typically, OMPs will terminate when agreement has been reached with the Jurisdictional Authority relevant to the spill to terminate the response or a relevant SMP has been activated. SMPs will continue after the spill response has been terminated and until such time as their termination criteria are also reached. A list of criteria is provided in the OSM Framework.

After OMPs are terminated, the OMP monitoring teams will be advised to stand down. Following this stage, the OSM Services Provider will run a lessons-learnt meeting between Pilot Energy, all monitoring providers and other relevant stakeholders. It is the responsibility of Pilot Energy to ensure that lessons learnt are communicated to the relevant stakeholder groups. The lessons discussed should include both positive actions to be reinforced and lessons for actions that could be improved in future standby or response campaigns.

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Appendix A Baseline data sources

Table A-1: Baseline Data Sources

Receptor	Existing baseline monitoring	Source / Data Custodian	Spatial extent
Water and sediment quality	McAlpine, K. W., Wenziker, K. J., Apte, S. C., Masini, R. J. (2005) Background concentrations of selected toxicants in the coastal waters of the Jurien Bay Marine Park. Department of Environment, Perth, WA, Technical Series 119.	DWER (Link to report)	Jurien Bay Marine Park
	Department of Environment and Conservation (2007) Background quality of the marine sediments off the Western Australian mid west coast. Department of Environment and Conservation. Marine Technical	DWER (Link to report)	Jurien Bay Marine Park, Cliff Head, Champion Bay, Horrocks, Geraldton
	Rule, M. J., Bancroft, K. P., Kendrick, A. J. (2012) Baseline and quality of the Jurien Bay Marine Park: a benchmark for warm temperate Western Australia Conservation Science Western Australia, 8 (2): 241-249	DBCA (Link to report)	Jurien Bay Marine Park (Fisherman Islands, Hill River, Nambung Bay)
	Giraldo-Ospina A, Kendrick GA, Hovey RK. (2020) Depth moderates loss of marine foundation species after an extreme marine heatwave: could deep temperate reefs act as a refuge? Proc. R. Soc. B287: 20200709.http://dx.doi.org/10.1098/rspb.2020.0709	UWA (Link to report)	Jurien Bay and other areas in WA

Receptor	Existing baseline monitoring	Source / Data Custodian	Spatial extent
Benthic communities and fish assemblages	Sanderson PG (2000) A comparison of reef-protected environments in Western Australia: The central west and Ningaloo coasts. Earth Surface Processes and Landforms 25, 397–419.	Sanderson PG, UWA	Jurien Bay and other areas in WA
	Davidson, J. A., Bancroft, K. P. (2000) Broadscale habitat map and biological data of the major benthic habitats between Cervantes and Wedge Island in the proposed Jurien Bay Marine Conservation Reserve. Data Report: MRI/MW/JB-40/2000. February 2000. Marine Conservation Branch, Department of Conservation and Land Management, Fremantle, Western Australia. (Unpublished report).	DBCA (Link to report)	Cervantes to Wedge Island
	Klonowski, W.M., Fearns, P., Lynch, M. J. (2007) Retrieving key benthic cover types and bathymetry from hyperspectral imagery, Journal of Applied Remote Sensing 1(1), 011505	Curtin University	Jurien Bay Marine Park
	AIMS (2016). WAMSI 1 - Node 4.2.2a - Establishment of indicators for ecosystem based fisheries management - Benthic assemblages. Unpublished report prepared for WAMSI.	AIMS (Link to metadata)	Jurien Bay and other areas in WA
	Fairclough, D. V., Potter, I. C., Lek, E., Bivoltsis, A. K., Babcock, R. C. (2011). The fish communities and main fish populations of the Jurien Bay Marine Park	Murdoch University (Link to report)	Jurien Bay Marine Park
	Bellchambers, L.M. and Pember, M. B. 2014. Assessing the ecological impact of the western rock lobster fishery in fished and unfished areas FRDC Project 2008/013. Fisheries Research Report No. 254. Department of Fisheries, Western Australia. 108pp.	Fisheries Research Division (Link to report)	Jurien and Leeman
	Stat, M., John, J., DiBattista, J.D., Newman, S.J., Bunce, M. and Harvey, E.S. (2019), Combined use of eDNA metabarcoding and video surveillance for the assessment of fish biodiversity. Conservation Biology, 33: 196-205. https://doi.org/10.1111/cobi.13183	Macquarie University (Link to report)	Jurien Bay Marine Park
	Giraldo-Ospina A, Kendrick GA, Hovey RK. 2020 Depth moderates loss of marine foundation species after an extreme marine heatwave: could deep temperate reefs act as a refuge? Proc. R. Soc. B287: 20200709.http://dx.doi.org/10.1098/rspb.2020.0709	UWA (Link to report)	Jurien Bay and other areas in WA
	Goldsworthy DS, Saunders BJ, Parker JRC, Harvey ES (2020) Spatial assemblage structure of shallow-water reef fish in Southwest Australia. Mar Ecol Prog Ser 649:125-140. https://doi.org/10.3354/meps13445	Curtin University	Jurien Bay and other areas in WA
	Mulders YR, Wernberg T (2020) Fifteen years in a global warming hotspot: changes in subtidal mobile invertebrate communities. Mar Ecol Prog Ser 656:227-238.	UWA (Link to report)	Jurien Bay and other areas in WA

Receptor	Existing baseline monitoring	Source / Data Custodian	Spatial extent
	Wernberg, T. (2021). Marine Heatwave Drives Collapse of Kelp Forests in Western Australia. In: Canadell, J.G., Jackson, R.B. (eds) Ecosystem Collapse and Climate Change. Ecological Studies, vol 241. Springer, Cham. https://doi.org/10.1007/978-3-030-71330-0_12	UWA	Jurien Bay and other areas in WA
	Ross, C.L.; French, B.;Lester, E.K.;Wilson, S.K.; Day, P.B.;Taylor, M.D.; Barrett, N. (2021). Coral Communities on Marginal High-Latitude Reefs in West Australian Marine Parks. Diversity, 13, 554. https://doi.org/ 10.3390/d13110554	DBCA (Link to reference)	Jurien Bay Marine Park and other areas in WA
Seabirds and shorebirds	Dunlop, J. N. & Wooller, R. D. (1990). The breeding seabirds of south-western Australia: trends in species, populations and colonies. Corella 14:107-112.	(Link to reference)	Inshore Islands from Dongara to Mandurah and other areas in WA
	Dunlop, JN. (2009) The population dynamics of tropical seabirds establishing frontier colonies on islands off south-western Australia. Marine Ornithology 37: 99-105.	(Link to reference)	North Fisherman Island, Green Islets and other areas in WA
	Harrison, S. A. (2006). The influence of seabird-derived nutrients on island ecosystems in the oligotrophic marine waters of south-western Australia. https://ro.ecu.edu.au/theses/68	Edith Cowan University (Link to reference)	Favourite Island, Boullanger Island, Whitlock Island, North and South Cervantes Island and other areas in WA
Marine mammals	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, Western Australia, 42 p	Department of Fisheries (Link to reference)	Jurien Bay (North Fisherman Island, Beagle Island, Buller Island) and other locations in WA
	Möller, L.M., Attard, C.R.M., Bilgmann, K. et al. (2020) Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. Sci Rep 10, 21165. https://doi.org/10.1038/s41598-020-78143-2	Flinders University (Link to reference)	WA coastline
	Goldsworthy, S. D. , Shaughnessy, P. D., Mackay, A. I., Bailleul, F., Holman, D., Lowther, A. D., Page, B., Waples, K., Raudino, H., Bryars, S., Anderson, T. (2021). Assessment of the status and trends in abundance of a coastal pinniped, the Australian seal lion *Neophoca cinerea*. Endangered Species Research, 44: 421-437.	Goldsworth, S. D, University of Adelaide (Link to reference)	Jurien Bay (North Fisherman Island, Beagle Island, Buller Island) and other locations in WA and SA
Commercial fisheries	Caputi N, Kangas M, Chandrapavan A, Hart A, Feng M, Marin M and de Lestang S (2019) Factors Affecting the Recovery of Invertebrate Stocks From the 2011 Western Australian Extreme Marine Heatwave. Front. Mar. Sci. 6:484. doi: 10.3389/fmars.2019.00484	DPIRD (Link to reference)	Jurien region and others

Receptor	Existing baseline monitoring	Source / Data Custodian	Spatial extent
	Commercial Fisheries data collected by WA Department of Fisheries (WA DoF) and Australian Fishing Management Authority (AFMA)	WA Department of Fisheries / Australian Fishing Management Authority	Australia wide

Appendix B Protected Matters in the EMBA

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
***Mammals* (refer to Section 4 of EP for additional description of key receptors)**				
Southern right whale	Draft National Recovery Plan for the Southern Right Whale (*Eubalaena australis*) (DCCEEW, 2022)	• Relevant threats: anthropogenic underwater noise, vessel collision • Relevant management actions: Minimise vessel strike and assess and address anthropogenic noise.	• OMP: Marine fauna assessment – Cetaceans • SMP: Marine mega-fauna assessment – Whale sharks, dugongs and cetaceans	• 0.04 days to migration BIA
Sei whale	Approved Conservation Advice *Balaenoptera borealis* (sei whale) (TSSC, 2015a)	• Relevant threats: pollution, vessel disturbance • Relevant management actions: report vessel strikes		-
Humpback whale	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (TSSC, 2015b)	• Relevant threats: habitat degradation, vessel disturbance or strike. • Relevant management actions: Minimise vessel collisions.		• 0.04 days to migration BIA
Blue whale	Conservation Management Plan for the Blue Whale 2015 to 2025 (DoE, 2015a)	• Relevant threats: habitat degradation, vessel disturbance or strike. • Relevant management actions: Minimise vessel collisions and report vessel strikes		• 5.2 days to foraging IA

[3] Unless otherwise noted, all results are entrained hydrocarbon timeframes to contact.

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
Australian Sea Lion	Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*) (DSEWPC, 2013a)	• Relevant threats: habitat degradation, boating activities and aircraft can cause disturbance, human presence at sensitive sites • Relevant management actions: mitigation to prevent undue disturbance	• OMP: marine fauna assessment - Pinnipeds	• Illawong – Cliff Head (Australian sea lion breeding on East Beagle Island): 0.1 days • Green Head – Leeman (Australian sea lion breeding on North Fisherman Island): 1.5 days • Thirsty Point – Booker Valley (Australian sea lion breeding on Buller Island) • 0.4 days to Foraging areas
***Reptiles* (refer to Section 4 of EP for additional description of key receptors)**				
Loggerhead turtle, green turtle, leatherback turtle, hawksbill turtle, flatback turtle	Recovery Plan for Marine Turtles in Australia (DoEE, 2017)	• Relevant threats: chemical and terrestrial discharge, light pollution, vessel disturbance, habitat modification • Relevant management actions from recovery plan: **Chemical and terrestrial discharge**	• OMP: Marine fauna assessment – Reptiles • SMP: Marine mega-fauna assessment – Reptiles	N/A (presence associated with foraging [no breeding sites])

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
		– Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs. – Quantify the impacts of decreased water quality on stock viability. – Quantify the accumulation and effects of anthropogenic toxins in marine turtles, their foraging habitats and subsequent stock viability.		
Sharks and rays **(refer to Section 4 of EP for additional description of key receptors)**				
White shark	Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPC, 2013b)	• Relevant threats: habitat modification. • Relevant management objectives: Continue to identify and protect habitat critical to the survival of the white shark and minimise the impact of threatening processes within these areas	• OMP: Marine fauna assessment – Fish • SMP: Marine mega-fauna assessment – Marine fish and elasmobranch assemblages assessment	• 0.04 day to foraging BIA
Scalloped hammerhead	No recovery plan in place	-		-
Grey nurse shark	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (DoE, 2014)	• Relevant threats: pollution		-

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
Seabirds and Migratory Shorebirds **(refer to Section 4 of EP for additional description of key receptors)**				
Marine and migratory seabirds	Wildlife Conservation Plan for Seabirds (DoE, 2020)	• Relevant threat/s: shipping, marine debris, light pollution	• OMP: Shoreline clean-up assessment • OMP: Marine fauna assessment – Seabirds and shorebirds • SMP: Seabirds and shorebirds	-
Red knot, knot	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b) Approved Conservation Advice for *Calidris canutus* (red knot) (TSSC, 2016)	• Relevant threat/s: damage to nesting habitat, pollution • Relevant management actions: manage disturbance at important sites which are subject to anthropogenic disturbance when red knot are present – e.g. discourage or prohibit vehicle access, implement temporary site closures	• OMP: Shoreline clean-up assessment • OMP: Marine fauna assessment – Seabirds and shorebirds • SMP: Seabirds and shorebirds	-
Great knot	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b)	• Relevant threats: habitat modification, acute pollution, anthropogenic disturbance • No relevant management actions identified		-
Northern Siberian bar-tailed godwit, Russkoye bar-tailed godwit	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b)	• Relevant threats: habitat modification, acute pollution, anthropogenic disturbance • No relevant management actions identified		-
Curlew Sandpiper	-	-		-

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
Lesser sand plover	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b)	• Relevant threats: habitat modification, acute pollution, anthropogenic disturbance • No relevant management actions identified		-
Australian lesser noddy	-	-		• 7.3 days to foraging BIA
Great sand plover	Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b)	• Relevant threats: habitat modification, acute pollution, anthropogenic disturbance • No relevant management actions identified		-
Australian fairy tern	National Recovery Plan for the Australian fairy tern (*Sternula nereis nereis*) (Commonwealth of Australia, 2020)	• Relevant threats: habitat degradation and loss of breeding habitat, disturbance • Relevant management actions: reduce, or eliminate threats at breeding, non-breeding and foraging sites		• 1.5 days Jurien Bay Marine Park (breeding known to occur) • 0.4 days to foraging BIA
Threatened Ecological Communities **(refer to Section 4 of EP for additional description of key receptors for each location)**				
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Sedgelands in Holocene Dune Swales Recovery Plan, (DEC, 2011)	• Relevant threats : Clearing (shoreline clean-up and/or shoreline based monitoring activities) • Relevant management actions: Protect and conserve remaining areas of the ecological community	• OMP: Shoreline clean-up assessment • SMP: Intertidal and Coastal Habitat Assessment	-

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
Australian Marine Parks **(refer to Section 4 of EP for additional description of key receptors for each location)**				
Abrolhos MP	South-west Marine Parks Network Management Plan 2018 (Director of National Parks, 2018)	• Relevant management actions: Park protection and management—timely and appropriate preventative and restorative actions to protect natural, cultural and heritage values from impacts	• OMP: Water quality assessment • OMP: Sediment quality assessment • OMP: Marine fauna assessment – Seabirds and shorebirds • Cetaceans • Pinnipeds • OMP: Marine fauna assessment - fish • SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Seabirds and shorebirds • SMP: Marine mega-fauna assessment – Whale sharks, cetaceans and dugongs Pinnipeds • SMP: Benthic habitat assessment • SMP: Marine fish and elasmobranch	• 3.8 days
Perth Canyon MP				• 12.0 days
Two Rocks MP				• 11.9 days
Jurien MP				• 1.8 days
South-west Corner MP				• 27.8 days

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
			assemblages assessment • SMP: Commercial and recreational fisheries impact assessment • SMP: Heritage and social impact assessment	
***Western Australian Marine Parks* (refer to Section 4 of EP for additional description of key receptors for each location)**				
Essex Rocks Nature Reserve[4]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls	• OMP: Water quality assessment • OMP: Sediment quality assessment • OMP: Shoreline clean-up assessment • OMP: Marine fauna assessment – Seabirds and shorebirds Cetaceans Pinnipeds • OMP: Marine fauna assessment - fish • SMP: Water quality impact assessment	-
Buller, Whittell and Green Islands Nature Reserve[5]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		-

[4] Within Jurien Bay Marine Park

[5] Within Jurien Bay Marine Park

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
Abrolhos Islands Fish Habitat Protection	N/A	-	• SMP: Sediment quality impact assessment • SMP: Intertidal and Coastal Habitat Assessment • SMP: Seabirds and shorebirds • SMP: Marine mega-fauna assessment – Whale sharks, cetaceans and dugongs Pinnipeds • SMP: Benthic habitat assessment • SMP: Marine fish and elasmobranch assemblages assessment • SMP: Commercial and recreational fisheries impact assessment • SMP: Heritage and social impact assessment	-
Cervantes Islands Nature Reserve[6]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		-
Jurien Bay Marine Park	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		• 1.5 days
Beagle Islands Nature Reserve	N/A	-		• 0.5 days
Marmion Marine Park	Marmion Marine Park Management Plan 1992-2002 No. 23 (CALM, 1992)	• Relevant management issues: oil spills, damage to reef habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models		• 20.0 days

[6] Within Jurien Bay Marine Park

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
		for oil spills, apply appropriate anchoring controls		
Lancelin Island Lagoon Fish Habitat Protection	N/A	-		-
Lipfert, Milligan, Etc Islands Nature Reserve[7]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		-
Sandland Island Nature Reserve[8]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		-
Ronsard Rocks Nature Reserve[9]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring		-

[7] Within Jurien Bay Marine Park

[8] Within Jurien Bay Marine Park

[9] Within Jurien Bay Marine Park

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
		• Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		
Outer Rocks Nature Reserve	N/A	-		-
Fisherman Islands Nature Reserve[10]	Jurien Bay Marine Park Management Plan 2005-2015 No. 49 (CALM, 2005)	• Relevant management issues: oil spills, damage to seagrass habitats by indiscriminate mooring and anchoring • Relevant management actions: ensure the values of the park are fed into predictive models for oil spills, apply appropriate anchoring controls		-
Commonwealth Heritage Places **(refer to Section XX of EP for additional description of key receptors for each location)**				
Lancelin Defence Training Area	N/A	-	• OMP: Water quality assessment • OMP: Sediment quality assessment • MP: Water quality impact assessment • SMP: Sediment quality impact assessment	-

[10] Within Jurien Bay Marine Park

Receptor	Recovery plan / wildlife conservation plan / conservation advice / management plan (date issued)	Relevant threats and conservation actions	Relevant OMPs and SMPs	Relevant priority monitoring locations (quickest modelled time to contact[3])
National Heritage Places **(refer to Section XX of EP for additional description of key receptors for each location)**				
Batavia Shipwreck Site	N/A	-	• OMP: Water quality assessment • OMP: Sediment quality assessment • SMP: Water quality impact assessment • SMP: Sediment quality impact assessment • SMP: Heritage and social impact assessment • SMP: Benthic habitat assessment	-

Appendix G:
Underwater noise modelling

Eureka 3D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

JASCO Applied Sciences (Australia) Pty Ltd

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Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences (JASCO) performed numerical modelling to derive underwater sound levels for the proposed Eureka 3D Marine Seismic Survey (MSS) to predict the potential impacts on key regional receptors including marine mammals, fish, turtles, benthic invertebrates, sponges, coral, and plankton. JASCO's specialised Airgun Array Source Model (AASM) was used along with complementary underwater acoustic propagation models to estimate sound levels at six sites, to account for variable coastal features and water depth.

The modelling considered source directivity and range-dependent environmental properties likely to be encountered within the survey area. Estimated acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

For the accumulated sound exposure scenarios, the SEL_{24h} is a cumulative metric that reflects the dosimetric effect of noise levels within 24 hours. It assumes a receiver (e.g., an animal) is consistently exposed to the noise at a fixed position. More realistically, marine animals would not stay in the same location for 24 hours. Therefore, a radius for the SEL_{24h} criteria does not mean that marine fauna within this radius will be impaired, but rather that the animal could be exposed to the sound level associated with impairment, either Permanent Threshold Shift (PTS) or Temporary Threshold Shift (TTS), if it remained at that location for 24 hours.

Marine mammals – Results

- Maximum distance for behavioural response based on NOAA (2019) criterion of 160 dB re 1 µPa (SPL) varied between 9.20 and 6.51 km depending on the site.
- The results for marine mammal injury considered the criteria from Southall et al. (2019). These criteria contain two metrics (PK and SEL_{24h}), both required for the assessment of marine mammal PTS and TTS. The longest distance associated with either metric is required to be applied for assessment; Table 1 summarises the maximum distances, along with the relevant metric.

Table 1. Maximum horizontal distance (R_{max}) for behavioural response thresholds, permanent threshold shift (PTS) and temporary threshold shift (TTS) for marine mammals. Maximum extents are in the broadside direction.

Hearing group	Maximum modelled distance to effect threshold (R_{max})		
	Behavioural response[1]	Impairment (km): PTS[2]	Impairment (km): TTS[2]
LF cetaceans (Baleen whales)	9.20	3.08 (SEL_{24h})	43.0 (SEL_{24h})
HF cetaceans (Dolphins, plus toothed, beaked, and bottlenose whales)		–	–
VHF cetaceans (*Kogia*, cephalorhynchid, and *L. australis*)		0.41 (PK)	0.84 (PK)
Other Carnivores in Water (Australian sea lion, Australian fur seal)		–	0.06

Noise exposure criteria: [1] NOAA (2019) and [2] Southall et al. (2019).
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Sea turtles

- The PK sea turtle impairment criteria from Finneran et al. (2017) were not exceeded beyond the modelled resolution of 20 m.

- The maximum distance for PTS onset was 0.06 and 2.10 km for TTS onset for the seismic source (Finneran et al. 2017).
- Behavioural response of turtles are shown in Table 2, based on 166 dB re 1 µPa and 175 dB re 1 µPa (SPL) (McCauley et al. 2000).

Table 2. Maximum horizontal distance (in km) to turtle behavioural response criteria, temporary threshold shift (TTS), and permanent threshold shift (PTS).

Hearing group	Maximum modelled distance (in km) to effect threshold (R_{max})			
	Behavioural response[1]	Behavioural disturbance[1]	Impairment: TTS[2]	Impairment: PTS[2]
Sea turtles	4.90 (166 dB re 1 µPa - SPL)	1.58 (175 dB re 1 µPa - SPL)	2.10 (SEL_{24h})	0.06 (SEL_{24h})

Noise exposure criteria: [1] McCauley et al. (2000) and [2] Finneran et al. (2017).

Fish, fish eggs, and fish larvae

This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics (water column) associated with mortality and potential mortal injury as well as impairment in the following groups:

- Fish without a swim bladder (also appropriate for sharks in the absence of other information),
- Fish with a swim bladder that do not use it for hearing,
- Fish that use their swim bladders for hearing,
- Fish eggs and fish larvae.

Table 3 summarises distances to effect criteria for fish, fish eggs, and fish larvae along with the relevant metric. Seafloor sound levels were assessed at nine different depths within the survey area. Assessment was based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics (water column) associated with mortality, potential mortal injury and impairment.

Table 3. Maximum onset distances for single impulse and 24 hour sound exposure level (SEL_{24h}) for fish, fish eggs, and larvae injury and temporary threshold shift (TTS).

Relevant hearing group	Effect criteria	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Recoverable injury	PK	0.15
	TTS	SEL_{24h}	4.06
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Recoverable injury	PK	0.27
	TTS	SEL_{24h}	4.06
Fish eggs, and larvae (relevant to plankton)	Injury	PK	0.27

Benthic invertebrates, Cephalopods, Sponges, and Coral

To assist with assessing the potential effects on these receptors, the following results were determined:

- Crustaceans (representative of southern rock lobsters and crabs): The distance to no effect was reached between 206 and 292 m, based on 202 dB re 1 µPa PK-PK level from Payne et al. (2008).

- Bivalves (representative of scallops and mussels): The distance to no effect was reached between 58 and 7 m, based on a particle acceleration limit of 37.57 ms^{-2} at the seafloor as presented in Day et al. (2016a).
- Squid: The distance to the per–pulse SEL (L_E) startle (inking) response level of 162 dB re 1 $\mu Pa^2 s$ for squid (Fewtrell and McCauley 2012) was reached between 2.90 and 2.03 km.
- Sponges and coral: The threshold was reached at a maximum of 15 m, based on the PK sound level criteria of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018).

Divers

An SPL human health assessment of 145 dB re 1 µPa (SPL; L_p) derived from Parvin (2005) was considered for people swimming and diving. The sound level was reached at ranges between 36.4 and 24.1 km depending on the modelled site. This is the maximum range over all modelled azimuths, and it is typically in orientated offshore. This maximum range should not be used as an offset distance to the coast and the sound field contour maps should be used to inform any such offset.

1. Introduction

JASCO Applied Sciences (JASCO) performed numerical modelling to calculate underwater sound levels for the proposed Eureka 3D Marine Seismic Survey (MSS) to predict the potential impacts on key regional receptors including marine mammals, fish, turtles, benthic invertebrates, sponges, coral, and plankton. In total, six sites were used for modelling across the proposed survey area to account for variable coastal features and for small changes in sound propagation that could occur in the shallow coastal waters.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict acoustic signatures and spectra for the source. AASM accounts for individual airgun volumes, airgun bubble interactions, and array geometry to yield accurate source predictions.

Complementary underwater acoustic propagation models were used in conjunction with the selected array signature to estimate sound levels considering environmental effects. Single-impulse sound fields were predicted at each of the defined locations, and accumulated sound exposure fields were predicted for each scenario. A worst-case sound speed profile that would be most supportive of sound propagation conditions for the potential survey period was defined and applied throughout.

The modelling considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), peak acceleration magnitude, and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

1. Modelling Scenarios

Two nominal acquisition scenarios were considered using both acoustic propagation modelling, are presented in Table 4. Acoustic source and propagation modelling was conducted at six individual single-impulse sites. The single impulse sites and the accumulated SEL scenarios were determined based on proposed survey line plans with lines orientated either at 0/180°. The locations of the modelled sites are provided in Table 5 and presented in Figure 1 . This study considered a 2495 in^3 seismic source towed in a double array configuration at an assumed speed of ~4.5 knots with an impulse interval (inter-pulse interval) of 12.5 m and a crossline array separation of 50 m. The acoustic propagation modelling utilised an August sound speed profile as this month will likely result in favourable propagation conditions within potential acquisition time periods for the proposed survey.

The single impulse sites and accumulated SEL scenarios were chosen to be representative of the range of water depths and the potential sound propagation characteristics within the Active Source Area. Seafloor sound levels were assessed at eight different representative water depths within the Active Source Area (10,12.5,15, 20, 25, 30, 40, and 50 m).

Table 4. Parameters for modelled scenarios

Scenario	Source volume (in^3)	Tow depth (m)	Tow direction (°)	Source configuration	Impulse interval (m)	Discharged impulses
1	2495	6	0 & 180	Double	12.5	11351
2						8558

Table 5. Location details for the single impulse modelled sites.

Site	Latitude (°S)	Longitude (°E)	MGA[1] Zone 50		Water depth (m)
			X (m)	Y (m)	
1	29° 28' 49.64"	114° 51' 05.04"	291676	6736859	25.0
2	29° 31' 38.47"	114° 51' 01.47"	291676	6731659	33.0
3	29° 37' 54.69"	114° 50' 53.49"	291676	6720072	30.0
4	29° 23' 08.13"	114° 40' 10.60"	273835	6747035	45.0
5	29° 30' 13.53"	114° 40' 17.24"	274276	6733941	47.0
6	29° 22' 53.53"	114° 38' 08.87"	270544	6747419	48.0

[1] Map Grid of Australia (MGA)

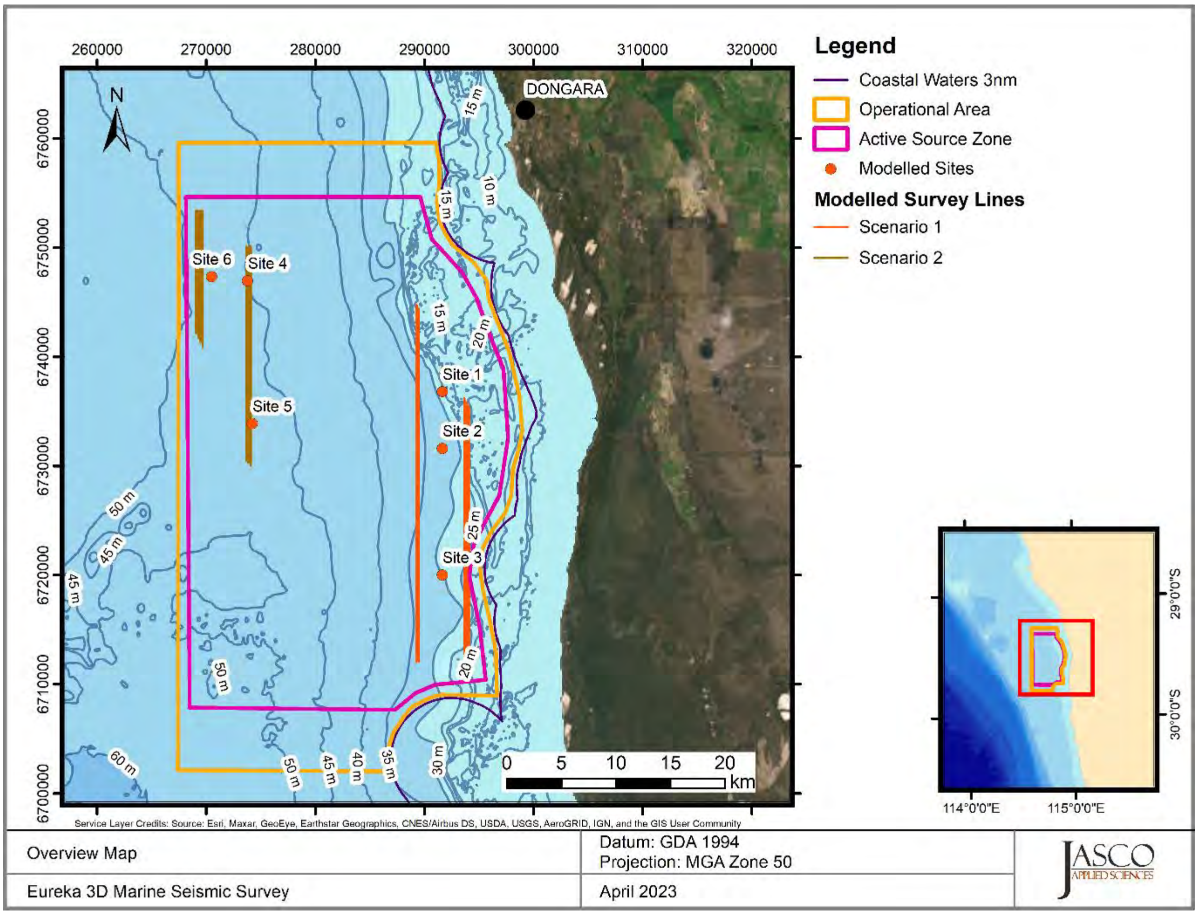

Figure 1. Overview of key survey features, modelled locations and the two survey scenarios.

2. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as that from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a “per pulse” assessment or over 24 hours. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that have investigated the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

The following noise criteria and sound levels for this study were chosen because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in literature for species with no suggested thresholds (Sections 2.1–2.4 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Southall et al. (2019) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals.
2. Marine mammal behavioural threshold based on the current US National Oceanic and Atmospheric Administration (NOAA 2019) criterion for marine mammals of 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs and larvae (including plankton) (Popper et al. 2014).
4. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in turtles.
5. Sea turtle behavioural response threshold of 166 dB re 1 µPa (SPL; L_p) for impulsive noise, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL; L_p) (McCauley et al. 2000).
6. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) and peak particle acceleration magnitude (ms^{-2}) at the seafloor to help assess effects of noise on crustaceans through comparing to results in Day et al. (2016a), Day et al. (2019), Day et al. (2016b), Day et al. (2017) and Payne et al. (2008).
7. A sound level of 226 dB re 1 µPa (PK; L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals.
8. A startle (inking) response sound level of 162 dB re 1 µPa^{2}s per–pulse SEL (L_E) for squid from Fewtrell and McCauley (2012).
9. An SPL human health assessment threshold of 145 dB re 1 µPa (SPL; L_p) for sound exposure to people swimming and diving derived from Parvin (2005), and considering Ainslie (2008).

Additionally, to assess the size of the low-power zone required under the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA 2008), the distance to an unweighted per-pulse SEL of 160 dB re 1 µPa^2·s (L_E) is reported.

2.1. Marine Mammals

There are two categories of auditory threshold shifts or hearing loss: permanent threshold shift (PTS), a physical injury to an animal's hearing organs; and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea fatigue.

To help assess the potential for the possible injury and hearing sensitivity changes in marine mammals, this report applies the criteria recommended be Southall et al. (2019), considering both PTS and TTS. These criteria, along with the applied behavioural criteria (NOAA 2019), are summarised in Table 6, with descriptions included in Appendix A.4.1 (auditory impairment) and Appendix A.4.2 (behavioural response), with frequency weighting explained in Appendix A.5. Whilst the newly published Southall et al. (2021) includes recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals.

Table 6. Unweighted sound pressure level (SPL), weighted 24-hour sound exposure level (SEL_{24h}), and peak pressure (PK) thresholds for acoustic effects on marine mammals.

Hearing group	NOAA (2019)	Southall et al. (2019)			
	Behaviour	PTS onset thresholds[1] (received level)		TTS onset thresholds[1] (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL (L_E; dB re 1 µPa² s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL (L_E; dB re 1 µPa² s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans (baleen whales)	160	183	219	168	213
High-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)		185	230	170	224
Very-high-frequency cetaceans (*Kogia*, cephalorhynchid, and *L. australis*)		155	202	140	196
Pinnipeds[2] (Australian sea lion, Australian fur seal, New Zealand fur seal)		203	232	188	226

[1] Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS onset.
[2] Listed as pinnipeds but equivalent to other marine carnivores in water in the Southall et al. (2019) criteria.
L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

2.2. Fish, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a panel convened by NOAA two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.

- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report and are included in Table 7 for completeness only. Because the presence or absence of a swim bladder has a role in hearing, a fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately. Table 7 lists relevant effects thresholds from Popper et al. (2014).

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. Popper et al. (2014) recommend applying a standard period, where this is either defined as a justified fixed period or the duration of the activity; however Popper et al. (2014) also included caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 hours has been applied in this study for SEL, which is similar to that applied for marine mammals in NMFS (2016, 2018).

Additional information is provided in Appendix A.4.

Table 7. Criteria for seismic noise exposure for fish, adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae (relevant to plankton)	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

2.3. Sea Turtles

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. Popper et al. (2014) suggested thresholds for onset of mortal injury (including PTS) and mortality for sea turtles and, in absence of taxon-specific information, adopted the levels for fish that do not hear well (suggesting that this likely would be conservative for sea turtles).

Finneran et al. (2017) presented revised thresholds for sea turtle injury and hearing impairment (TTS and PTS). Their rationale is that sea turtles have best sensitivity at low frequencies and are known to have poor auditory sensitivity (Bartol and Ketten 2006, Dow Piniak et al. 2012). Accordingly, TTS and PTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000) observed the behavioural response of caged sea turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the sea turtles increased their swimming activity, and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy et al. 2017) acknowledges the 166 dB re 1 µPa SPL reported (McCauley et al. 2000) as the level that may result in a behavioural response to marine turtles. The 175 dB re 1 µPa level from (McCauley et al. 2000) is recommended as a criterion for behavioural disturbance. These are shown in Table 8.

Table 8. Acoustic effects of impulsive noise on sea turtles: Unweighted sound pressure level (SPL), 24 hour sound exposure level (SEL_{24h}), and peak pressure (PK) thresholds.

Effect type	Criterion	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} (L_{E24h}; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	McCauley et al. (2000)	166	NA	
Behavioural disturbance		175		
PTS onset thresholds[1] (received level)	Finneran et al. (2017)	NA	204	232
TTS onset thresholds[1] (received level)			189	226

[1] Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

L_p denotes sound pressure level period and has a reference value of 1 µPa.

$L_{pk,flat}$ denotes peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.

L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa²s.

2.4. Invertebrates

2.4.1. Benthic Invertebrates (Crustaceans and Bivalves)

Research is ongoing into the relationship between sound and its effects on crustaceans (including southern rock lobsters and crabs), including the relevant metrics for effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves (including scallops, abalone, mussels, squid, and octopus).

At the seafloor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Including recent research, such as Day et al. (2016b), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, we cannot propose authoritative thresholds to inform the impact assessment. However, levels can be determined for pressure metrics presented in literature to assist the assessment.

The pressure and acceleration examples provided in Day et al. (2016a) (Figures 11 and 12 in report) indicate that the acceleration and pressure signals occurred simultaneously, which was interpreted as an indication that the waterborne sounds were responsible for the accelerations measured by the geophones. For clarity, it is important to distinguish that the acceleration from waterborne sound energy is *not* ground roll, which Day et al. (2016a) correctly define as the sound that propagates along the interface at a speed lower than the shear wave speed of the sediment. However, the report subsequently uses ground roll for all further discussions of particle acceleration. While Day et al. (2016a) discuss that they chose the simplest measure of ground roll, it should have been referring to as ‘the acceleration from waterborne sound energy’, or ‘waterborne acceleration’ for short.

For crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no effect, and therefore applied in the assessment. Additionally for context related to different levels of potential impairment, the PK-PK sound levels determined for crustaceans in Day et al. (2016b), 209–212 dB re 1 µPa and 213 dB re 1 µPa from Day et al. (2019), are also included.

For bivalves, PK-PK sound levels of 212, and 213 are presented to allow comparison to the maximum sound levels measured in Day et al. (2016a) and Day et al. (2017) for scallops and pearl shell oyster.

Literature does not present a sound level associated with no impact, and as particle motion is the more relevant metric, particle acceleration from the seismic source has been presented for comparing the results in Table 7 of Day et al. (2016a). The maximum particle acceleration assessed for scallops was 37.57 ms^{-2}.

2.4.2. Plankton

To assess effects on plankton, there are only a few studies to base threshold criteria on. Popper et al. (2014) cites many of the references and studies on potential impacts of noise emissions on fish eggs and larvae prior to 2014. Results presented in Day et al. (2016b) for embryonic lobsters and Fields et al. (2019) for copepods align with those presented in Popper et al. (2014), which is that mortality and sub-lethal injury are limited to within tens of metres of seismic sources. Additionally, the Popper et al. (2014) criteria (Table 7), are extrapolated from simulated pile driving signals which have a more rapid rise time and greater potential for trauma than pulses from a seismic source.

Other research, such as McCauley et al. (2017), has indicated the potential for effects at longer range and at levels of 178 dB PK-PK, however, Fields et al. (2019) noted that it was difficult to reconcile the high mortality reported by McCauley et al. (2017) with the low mortalities reported in the greater previous body of earlier research and their experiment. They recommended further research into whether it is the sound pulse itself (i.e., the energy, peak pressures, or particle acceleration), the (turbulent) fluid flow occurring more slowly (i.e., not related to the sound pulse), or other effects such as the bubble cloud that which might cause higher mortality near the seismic source.

2.4.3. Squid

The responses of squid to airgun signals were investigated by Fewtrell and McCauley (2012). The authors conducted a number of experiments and examined the received per–pulse SEL for caged squid. They found that in one trial, where the received level of the first airgun impulse was 162 dB re 1 $\mu Pa^2 \cdot s$, the squid inked. This response was not observed again within this trial, however the authors stated that it was unknown if this was due to depleted ink reserves or habituation. In two other trials, the initial received levels were lower (132 and 146 dB re 1 $\mu Pa^2 \cdot s$ per–pulse SEL), and although the cumulative received levels did exceed 162 dB re 1 $\mu Pa^2 s$, no inking behaviour was observed. The authors hypothesised that the results also suggest that a gradual increase in received levels and prior exposure to air gun impulses decreases the severity of the alarm responses in this species. This aligns with findings of general habituation in response to predators in squid (Long et al. 1989). Recent work (Jones et al. 2020) supports these findings as well, indicating potential rapid, short–term habituation by squid to impulsive noise, however, similar response rates were seen 24 h later, which indicated that squid might re–sensitise to the noise.

The results presented in by Fewtrell and McCauley (2012) were stated by the authors to be preliminary, and while they stated that while it is possible that noise levels greater than 147 dB re 1 µPa²·s are required to induce avoidance behaviour, the level associated with inking, of 162 dB re 1 µPa²·s per–pulse SEL, has been considered as a startle response level for squid. In the absence of additional studies and thresholds this level may be considered for other cephalopods; however, it may be limited when applied to other species.

2.5. Human Health Assessment Threshold

Underwater, the human ear is about 20 dB less sensitive than it is in air at low frequencies (20 Hz), increasing to 40 dB at mid–frequencies (less than 1 kHz), and increasing to 70–80 dB less sensitive at higher frequencies (Parvin 1998). Divers who wear neoprene hoods have even higher hearing thresholds (lower sensitivity) above 500 Hz because the hood material absorbs high–frequency sounds (Sims et al. 1999). Exposure studies related to divers have typically focused on military sonar exposure, with little information on seismic surveys, and as such care is required when considering thresholds for recreational divers and swimmers, particularly for impulsive sounds such as seismic surveys (Ainslie 2008).

The auditory threshold of hearing under water was lowest at 1 kHz (70 dB re 1 µPa SPL) and increased for lower and higher frequencies to around 120 dB re 1 µPa at 20 Hz and at 20 kHz (Parvin 1998). Fothergill et al. (2000) and Fothergill et al. (2001) conducted controlled acoustic exposure experiments on military divers under fully controlled conditions at a US Ocean Simulation Facility and an US Open water test facility; in all tests, the diver were covered with soft or hard shell dive suits and their position and distance relative to sound source, signal characteristics and received levels were controlled and documented (Pestorius et al. 2009). A total of 89 male Navy divers were exposed to pure tone signals and sweeps between 160–320 Hz at SPLs up to 160 dB re 1 µPa. The divers were exposed to these sounds over 100 seconds at depths from 10 to 40 metres. The divers rated the sounds on a severity scale. For frequencies between 100 and 500 Hz, at a received SPL of 130 dB re 1 µPa, divers and swimmers detected body vibration. None of the divers tested rated levels of 140 dB re 1 µPa as “very severe”; however, at 157 dB re 1 µPa, sound was rated as “very severe” 19 % of the time. No physiological damage was observed at the highest levels tested: 160 dB re 1 µPa (Fothergill et al. 2001). In a subsequent study, recreational divers were exposed to tonal signals or 30 Hz sweeps at frequencies between 100 and 500 Hz at received levels of 130–157 dB re 1 µPa (Pestorius et al. 2009). Each exposure lasted for 7 s. Nine female and 17 male scuba divers were tested, all wearing full body neoprene wetsuits. Diver aversion and perception of body vibration were used as test parameters. The results showed no sex–specific differences. The results differed as a function of frequency – while test results showed a strong overall variation between subjects, signals at 100 Hz elicited the strongest aversion in all tests and even at 148 dB a few diver ratings indicated extreme aversion. Due to this and the strong variation between test subjects, the following exposure limit for both military and recreational divers was suggested as a conservative measure: For frequencies between 100 and 500 Hz, the maximum SPL should be 145 dB re 1 µPa over a maximum continuous exposure of 100 seconds or with a maximum duty cycle of 20 % and a maximum daily cumulative total of 3 h. The trading relation between the maximum SPL and duration was 4 dB per doubling of duration (e.g., 141 dB SPL for a 200 second exposure) (Pestorius et al. 2009).

Considering only frequencies between 100 and 500 Hz, Parvin (2005) suggested 145 dB re 1 µPa as a safety criterion for recreational divers and swimmers. Seismic impulses are broadband sources, and therefore, to be precautionary, the 145 dB re 1 µPa SPL suggested by Fothergill et al. (2001) and Parvin (2005) has been applied in this study as a broadband SPL and as a human health assessment threshold for recreational divers and swimmers. This does not imply that this level is associated with the onset of injury.

3. Methods

3.1. Parameter Overview

The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendix D. A single sound speed profile for August was considered in this modelling study; this was identified as the seasonal period that would provide the farthest propagation (Appendix D.3.2); as such it was selected to as part of a conservative approach to estimating distances to received sound level thresholds.

The propagation models used in this study consider a single geoacoustic profile. Several papers describe potential geoacoustic models estimated via acoustic inversion (Duncan et al. 2008, Fan et al. 2009). These models consist of a thin sand layer underlain by a semi-cemented limestone/calcarenite bottom. A nominal three layer representation of the seabed has been proposed based on this information; however, the studies all give slightly different geoacoustic values and layer thicknesses. The seabed model consists of sand/calcarenite/limestone basement where the geoacoustic parameters were averaged to obtain representative geoacoustic values.

3.2. Acoustic Source Model

The pressure signature of the individual airguns and the composite decidecade-band point-source equivalent directional levels (i.e., source levels) of the 2495 in^3 seismic source was modelled with JASCO's Airgun Array Source Model (AASM). Although AASM accounts for notional pressure signatures of each seismic source with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

All seismic sources considered were modelled over AASM's full frequency range, up to 25 kHz. Appendix B.1 details this model.

3.3. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and Gaussian beam acoustic ray-trace model (MONM-BELLHOP, 10 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 10 to 1024 Hz).
- Wavenumber integration model (VSTACK, 10 to 1024 Hz).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK. Appendix C details each model. MONM-BELLHOP was used to calculate SEL of a 360° area around each source location. FWRAM was used to model synthetic seismic pulses and to generate a generalised range-dependent SEL to SPL conversion function. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM-BELLHOP to estimate SPL values. FWRAM was also used to calculate water column PK and PK-PK levels.

VSTACK was used to calculate close range PK, PK-PK, and particle motion levels along 4 transects at the seafloor along the endfire and broadside directions at 15, 20, 25, 30, 40, and 50 m water depths.

3.4. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances of 80 km from the source in each cardinal direction, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta = 2.5°$ for a total of $N = 144$ radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 2600 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using BELLHOP for frequencies from 1.25 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency range of interest.

FWRAM was run to 80 km along four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency. This was done to compute SEL-to-SPL conversions (Appendix D.2) but also to quantify water column PK and PK-PK. The horizontal range step begins at 20 m and increases with range from the source.

The maximum modelled range for VSTACK was 1000 m, and a variable receiver range increment that increased away from the source was used, which increased from 10 to 25 m. Received levels were computed for receivers at 5 and 50 cm above the seafloor to assist in the assessment on invertebrates and fish respectively.

3.5. Accumulated SEL

New sound energy is introduced into an environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the marine mammal and fish SEL criteria (Section 2), account for the total acoustic energy marine fauna is subjected to over a specified duration, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic impulse but also on the number of impulses delivered in a duration and the relative positions of the impulses.

When there are many seismic impulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, such that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth were calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (see Equation A-5) to produce the cumulative sound field grid with cell sizes of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields.

The unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

4. Results

4.1. Acoustic Source Levels and Directivity

AASM (Section 3.2) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the 2495 in^3 source array (Table 9), with additional results provided in Appendix B.3 along with the horizontal directivity plots for this source.

Table 9. Far-field source levels for 2495 in^3 source at 2 m depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$; dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$; dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25000 Hz
Broadside	249.2	224.5	184.0
Endfire	245.3	222.4	187.3
Vertical	255.2	228.0	194.6
Vertical (surface affected source level)	255.2	230.5	197.6

4.2. Per-pulse Sound Fields

This section presents the per-pulse sound fields in terms of maximum-over-depth SPL, SEL, PK, and seafloor PK and PK-PK. The different metrics are presented for the following reasons:

- SPL sound fields were used to determine the distances to marine mammal and turtle behavioural thresholds.
- Per-pulse SEL sound fields are used as inputs into the 24 h SEL scenario and to provide context for the range to 160 dB re 1 µPa^2·s, relevant for the EPBC Act Policy Statement 2.1 (DEWHA 2008).
- Per-pulse SEL sound fields are used as inputs into the 24 h SEL scenario and to provide context for the range to 160 dB re 1 µPa^2·s, relevant for the EPBC Act Policy Statement 2.1 (DEWHA 2008).
- Per-pulse SEL sound fields to determine the distances to the level associated with squid startle (inking) response (Fewtrell and McCauley 2012).
- PK metrics within the water column are relevant to thresholds and guidelines for marine mammals, sea turtles, fish, fish eggs and larvae (as well as plankton)
- PK metrics at the seafloor are relevant to guidelines for fish, fish eggs and larvae and the sound level for no effect on corals and sponges.
- PK-PK metrics at the seafloor are relevant to sound levels used in the assessment of effect on benthic invertebrates.

The maximum and 95% distances to per-pulse SEL and SPL metrics are presented in Tables 10 and 18. The SPL sound fields, and distances to relevant isopleths can be visualised on the contour maps presented in Figures 2–7. The SPL sound fields are also presented as vertical slices for selected azimuths along the endfire and broadside directions out to 20 km, with the airgun array in the centre (Figures 8–11).

Maximum distances to maximum-over-depth water column PK thresholds were calculated for three modelled single impulse sites, Sites 1, 4, and 6, and presented in Table 12. Seafloor sound levels were assessed at eight different representative depths and Tables 13–14 present the PK and PK-PK results. At these eight depths particle motion was also calculated.

4.2.1. Tabulated Results

4.2.1.1. Entire Water Column

Table 10. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth (also maximised over tow modelled tow direction) unweighted per-pulse sound exposure level (SEL) isopleths from the modelled single impulse sites, with water depth indicated.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (25 m)		Site 2 (33 m)		Site 3 (30 m)		Site 4 (45 m)		Site 5 (47 m)		Site 6 (48 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.08	0.07	0.07	0.06	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06
180	0.30	0.26	0.30	0.26	0.30	0.26	0.28	0.22	0.30	0.23	0.26	0.23
170	1.10	0.87	1.20	0.95	1.22	1.00	1.14	0.91	1.06	0.92	1.12	0.92
162[1]	2.80	2.18	2.66	2.03	2.56	2.03	2.90	2.36	2.62	2.09	2.58	2.06
160[2]	3.38	2.70	3.24	2.44	3.20	2.38	3.38	2.80	3.22	2.54	3.20	2.52
150	7.70	6.21	8.12	6.72	8.31	6.74	9.52	7.44	8.08	6.28	8.21	6.27
140	19.2	14.9	17.8	14.6	19.1	15.7	22.9	17.7	23.8	19.0	23.2	18.7
130	54.4	48.4	49.6	40.9	51.2	43.2	48.0	36.8	46.9	40.7	49.7	41.5
120	73.1	61.0	98.6	62.4	75.8	61.6	82.4	65.8	99.2	72.9	99.4	69.7

[1] Startle response level for squid (Fewtrell and McCauley 2012).
[2] Low power zone assessment criteria DEWHA (2008).

Table 11. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the seismic source to modelled maximum-over-depth (also maximised over tow modelled tow direction) per-pulse sound pressure level (SPL) isopleths from the modelled single impulse sites, with water depth indicated.

SPL (L_p; dB re 1 µPa)	Site 1 (25 m)		Site 2 (33 m)		Site 3 (30 m)		Site 4 (45 m)		Site 5 (47 m)		Site 6 (48 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.06	0.06	0.06	0.06
190	0.28	0.23	0.26	0.22	0.26	0.22	0.22	0.20	0.24	0.20	0.24	0.20
180	0.90	0.76	0.90	0.76	0.94	0.78	0.86	0.68	0.80	0.70	0.82	0.68
175[1]	1.52	1.19	1.56	1.24	1.58	1.25	1.28	1.03	1.26	1.06	1.28	1.01
170	2.86	2.30	2.72	2.17	2.74	2.16	2.18	1.70	2.02	1.64	2.00	1.59
166[2]	4.90	4.02	4.26	3.22	4.14	3.14	3.78	3.07	3.50	2.71	3.34	2.63
160[3]	9.20	7.68	7.64	6.32	7.65	6.32	8.04	6.54	6.51	5.10	6.58	5.05
150	19.9	16.6	16.7	13.6	17.7	14.6	20.7	16.2	20.7	16.0	20.5	16.4
145[4]	30.0	25.0	24.1	19.2	27.9	22.1	29.8	23.8	36.4	31.2	35.4	29.7
140	53.6	45.1	41.1	33.1	48.3	39.9	46.5	33.3	44.8	40.1	47.9	40.8
130	98.4	65.2	70.8	60.0	70.6	58.2	72.9	58.5	98.7	61.7	99.0	62.1

[1] Threshold for turtle behavioural disturbance from impulsive noise.
[2] Threshold for turtle behavioural response to impulsive noise (NSF 2011).
[3] Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
[4] Human health assessment threshold derived from (Parvin 2005).

Table 12. Maximum (R_{max}) horizontal distances (in km) from the seismic source to modelled maximum-over-depth (also maximised over tow modelled tow direction) peak pressure level (PK) thresholds based on Southall et al. (2019) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for sea turtles, Sites 3 and 5), with water depth indicated.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)	
		Site 4 (30 m)	Site 6 (47 m)
Low-frequency cetaceans (PTS)	219	0.06	0.04
Low-frequency cetaceans (TTS)	213	0.15	0.11
High-frequency cetaceans (PTS)	230	–	–
High-frequency cetaceans (TTS)	224	–	–
Very-high-frequency cetaceans (PTS)	202	0.41	0.39
Very-high-frequency cetaceans (TTS)	196	0.84	0.76
Other Carnivores in Water (PTS)	232	–	–
Other Carnivores in Water (TTS)	226	–	–
Sea Turtles (PTS)	232	–	–
Sea Turtles (TTS)	226	–	–
Fish: No swim bladder (also applied to sharks)	213	0.15	0.11
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.27	0.24

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

4.2.1.2. Seafloor

Ranges presented at the seafloor (50 and 5 cm above the interface) provided in Tables 13 and 14 are different to those for the maximum-over-depth modelling results presented in Table 12. This is because the model used for the water column results, calculated using FWRAM do not represent the maximum sound levels at the seafloor close to the array. This is because FWRAM is based on a wide-angle parabolic equation (PE) algorithm which is valid to only approximately 70° down angle from the horizontal, and while it provides accurate predictions in the horizontal direction, it cannot predict sound levels directly under the array. The VSTACK model is used to determine the levels at the seafloor directly under the array, and due to seafloor interactions, these can be greater than those elsewhere in the water column.

Table 13. Maximum (R_{max}) horizontal distances (in m) from the seismic source to modelled seafloor (receiver located 50 cm above seafloor) peak pressure level thresholds (PK) at three water depths within the Operational Area.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Water Depth							
		10 m	12.5 m	15 m	20 m	25 m	30 m	40 m	50 m
		Distance R_{max} (m)							
Sound levels for sponges and corals[1]	226	6	7	9	15	13	13	*	*
Fish: No swim bladder (also applied to sharks)	213	50	48	59	66	70	57	65	71
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	98	126	93	104	113	105	117	120

[1] Heyward et al. (2018)
An asterisk indicates that the sound level was not reached.

Table 14. Maximum (R_{max}) horizontal distances (in m) from the seismic source to modelled seafloor (receiver located 5 cm above seafloor) peak-peak pressure levels (PK-PK) at three water depths within the Active Source Area. Results included in relation to benthic invertebrates.

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Water Depth							
	10 m	12.5 m	15 m	20 m	25 m	30 m	40 m	50 m
	Distance R_{max} (m)							
213[1,2,3]	83	73	85	90	92	94	103	86
212[2,3]	86	88	89	103	100	100	111	121
210[1,2]	101	130	123	110	122	136	120	133
209[1,2]	112	132	150	124	126	141	167	145
202[4]	206	251	292	228	247	254	276	228

[1] Day et al. (2019), lobster
[2] Day et al. (2016a), lobster and scallops
[3] Day et al. (2017), scallops.
[4] Payne et al. (2008), lobster

4.2.1.2.1. Particle Motion Metrics

Table 15. Maximum (R_{max}) horizontal distances (in m) from the 2495 in^3 to particle motion threshold: Peak acceleration magnitude level (m/s^2) threshold for benthic invertebrates 5 cm above the seafloor, with water depth indicated. Results included in relation to benthic invertebrates (Section 2.4.1).

Hearing group/animal type	Peak Acceleration Magnitude (m/s^2)	Water Depth							
		10 m	12.5 m	15 m	20 m	25 m	30 m	40 m	50 m
		Distance R_{max} (m)							
Benthic invertebrates	37.57	58	48	44	40	43	47	54	7

4.2.2. Sound Field Maps and Graphs

4.2.2.1. Sound Level Contour Maps

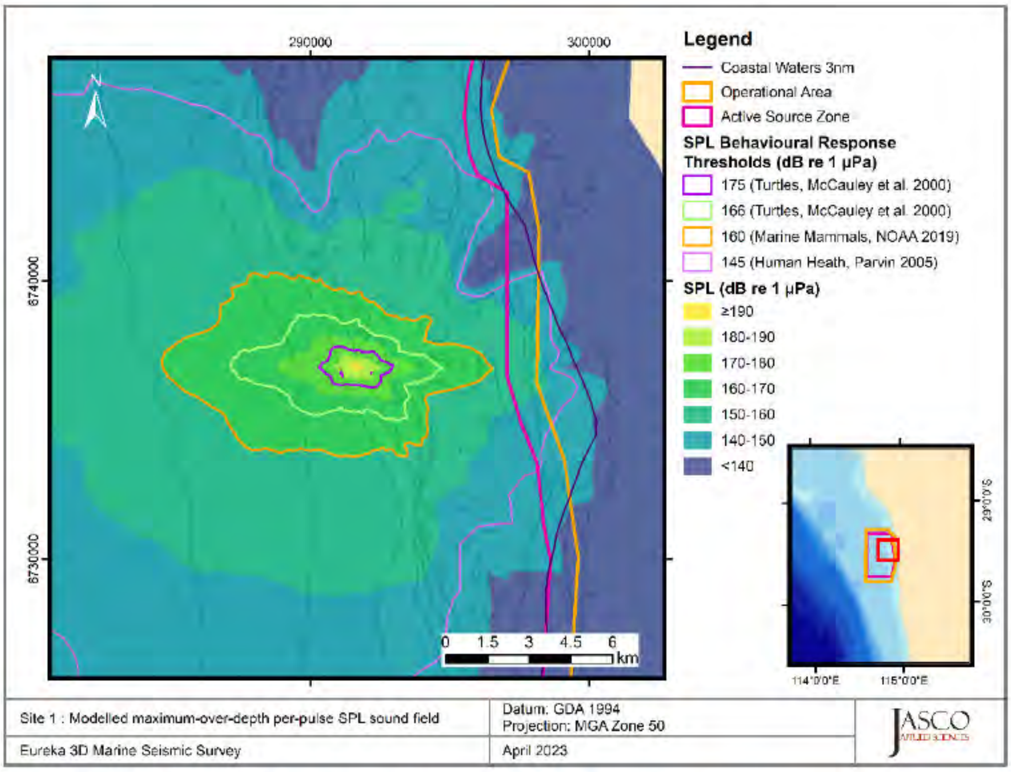

Figure 2. *Site 1, SPL, 2495 in^3 source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

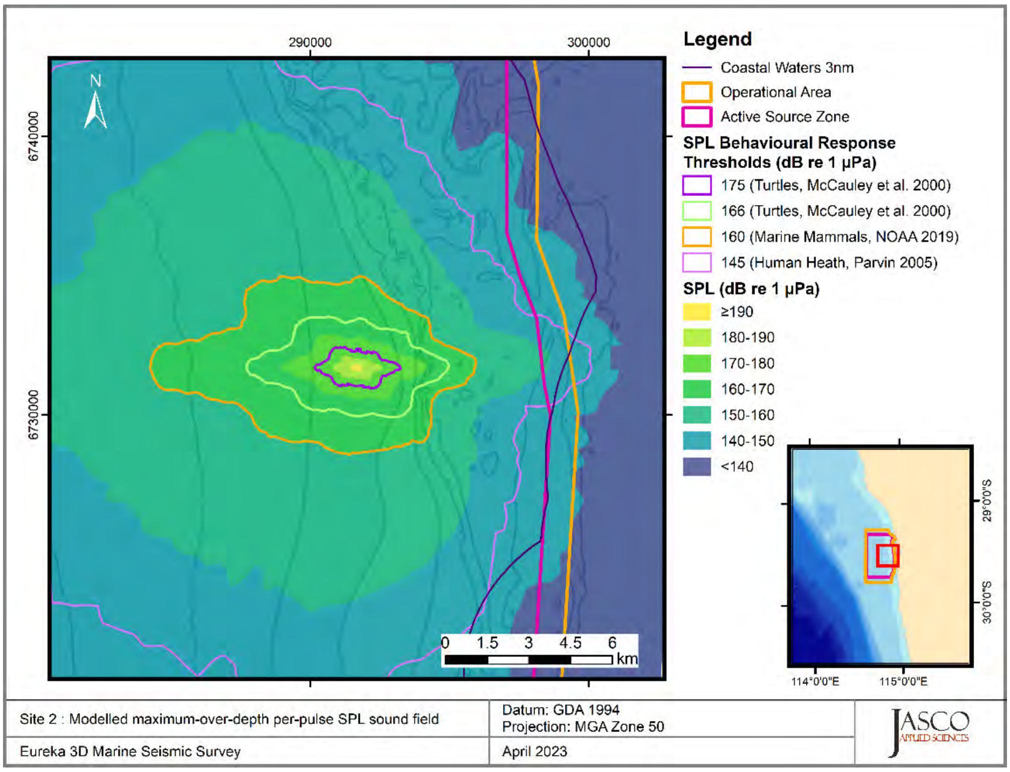

Figure 3. *Site 2, SPL, 2495 in³ source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

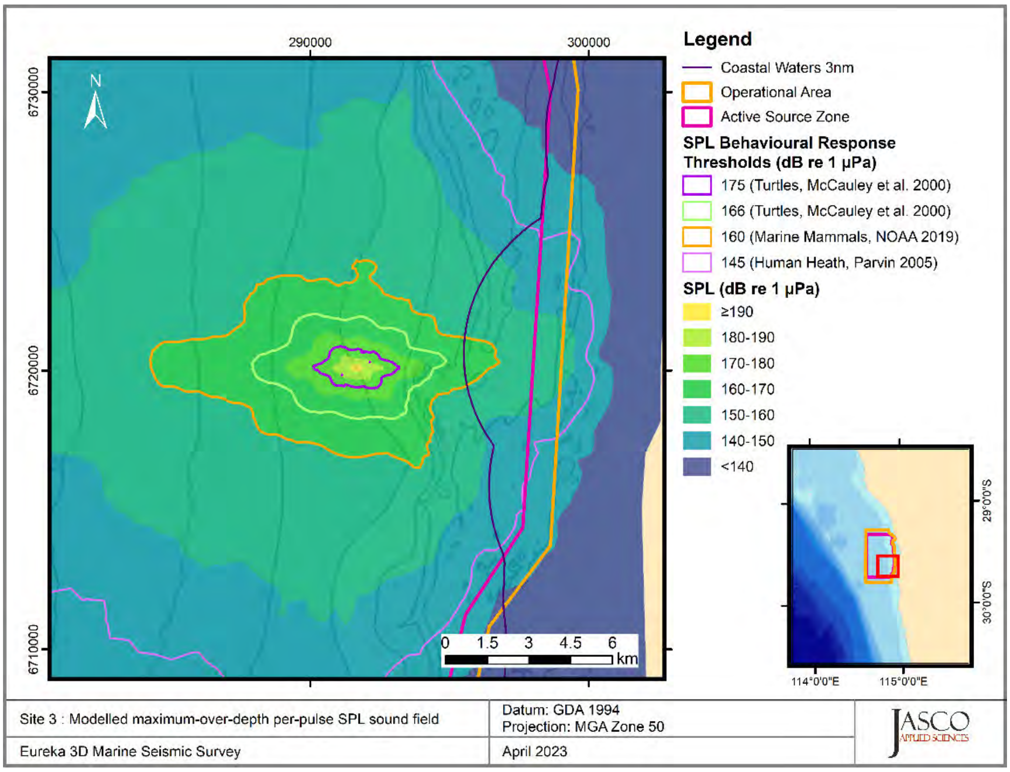

Figure 4. *Site 3, SPL, 2495 in³ source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

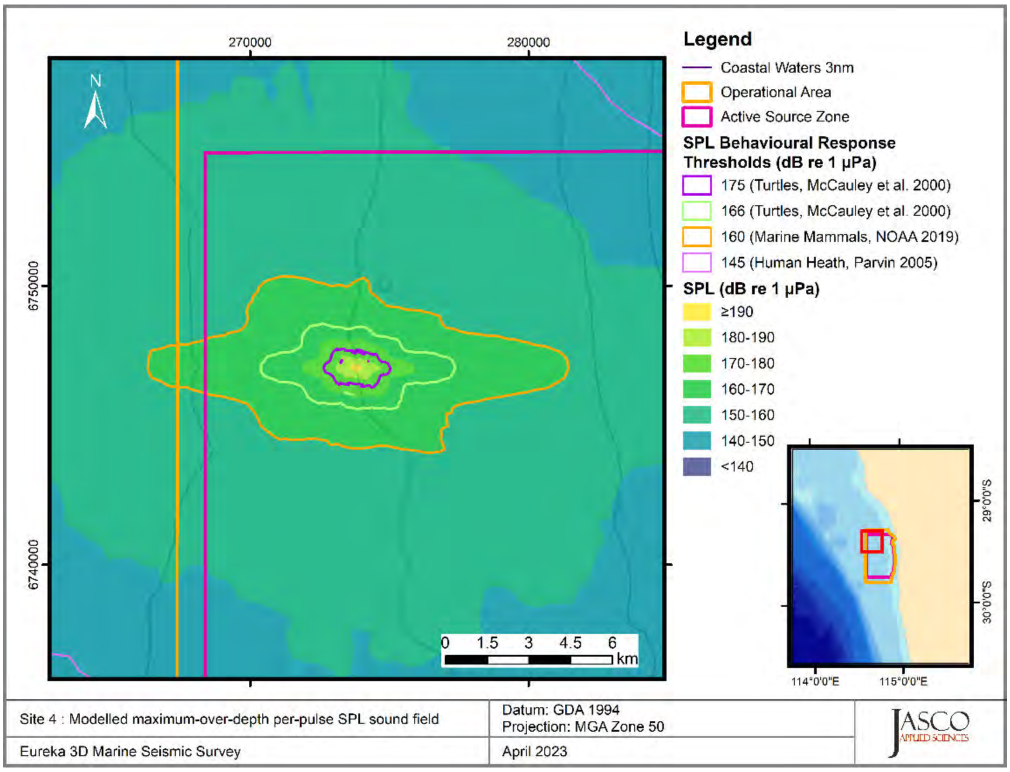

Figure 5. *Site 4, SPL, 2495 in³ source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

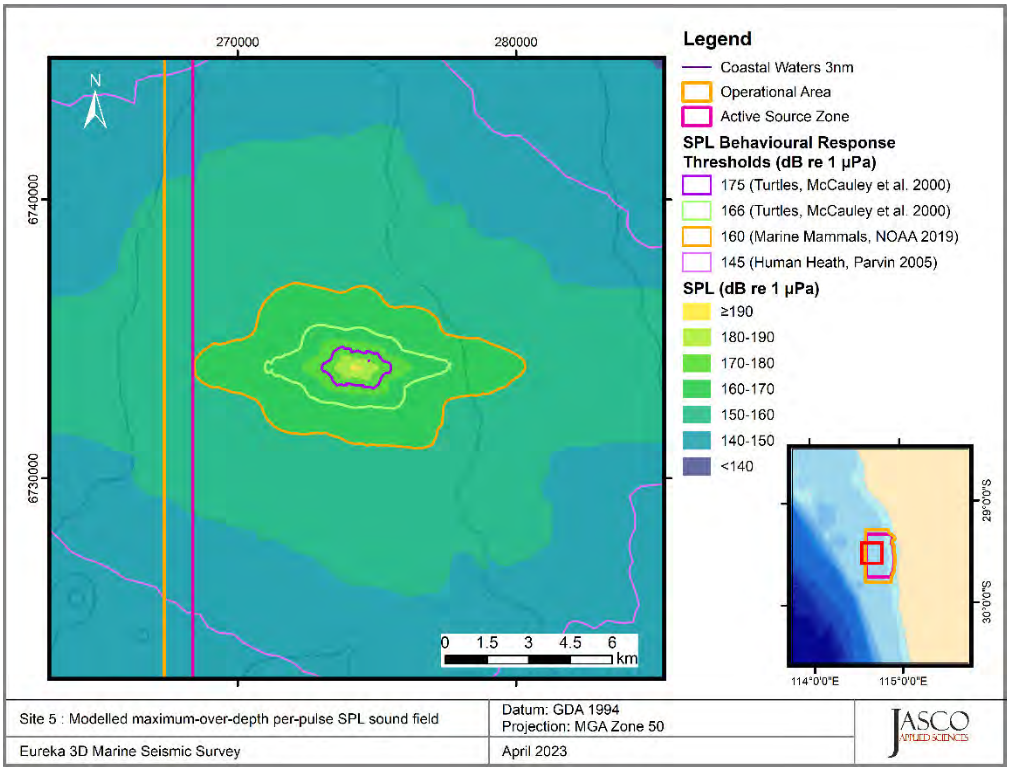

Figure 6. *Site 5, SPL, 2495 in³ source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

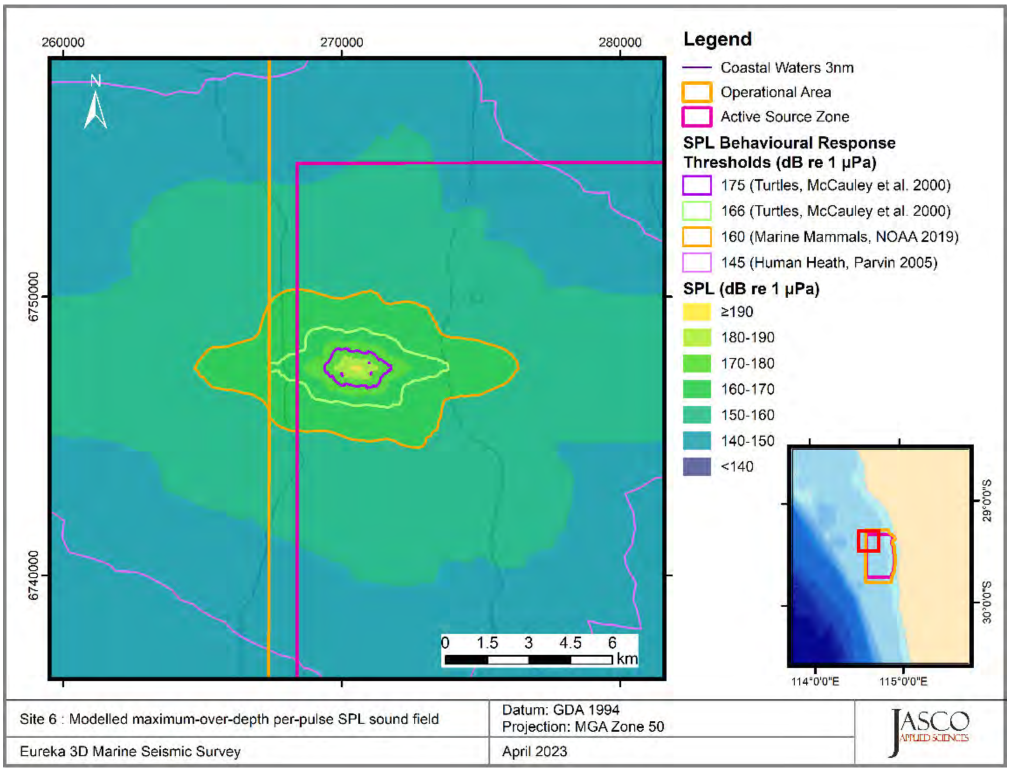

Figure 7. *Site 6, SPL, 2495 in³ source, tow azimuth 0°*: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals and turtles.

4.2.2.2. Sound Level Vertical Slices

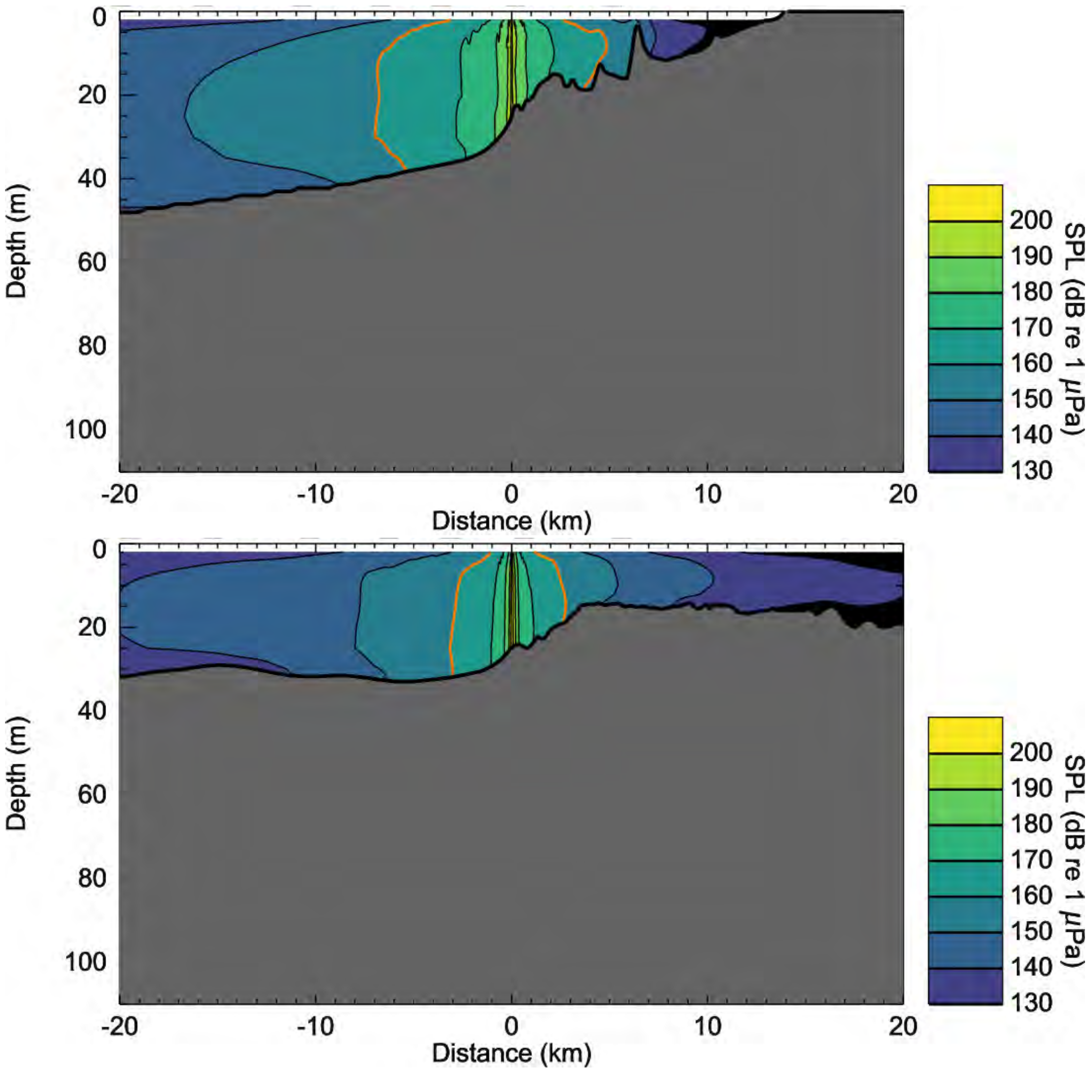

Figure 8. *Site 1, Scenario 1, tow azimuth 0°, SPL*: Sound level contours (vertical slice), perpendicular to (broadside, top) and along the tow direction (endfire, bottom). For context the behavioural response threshold for marine mammals is highlighted in orange. The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

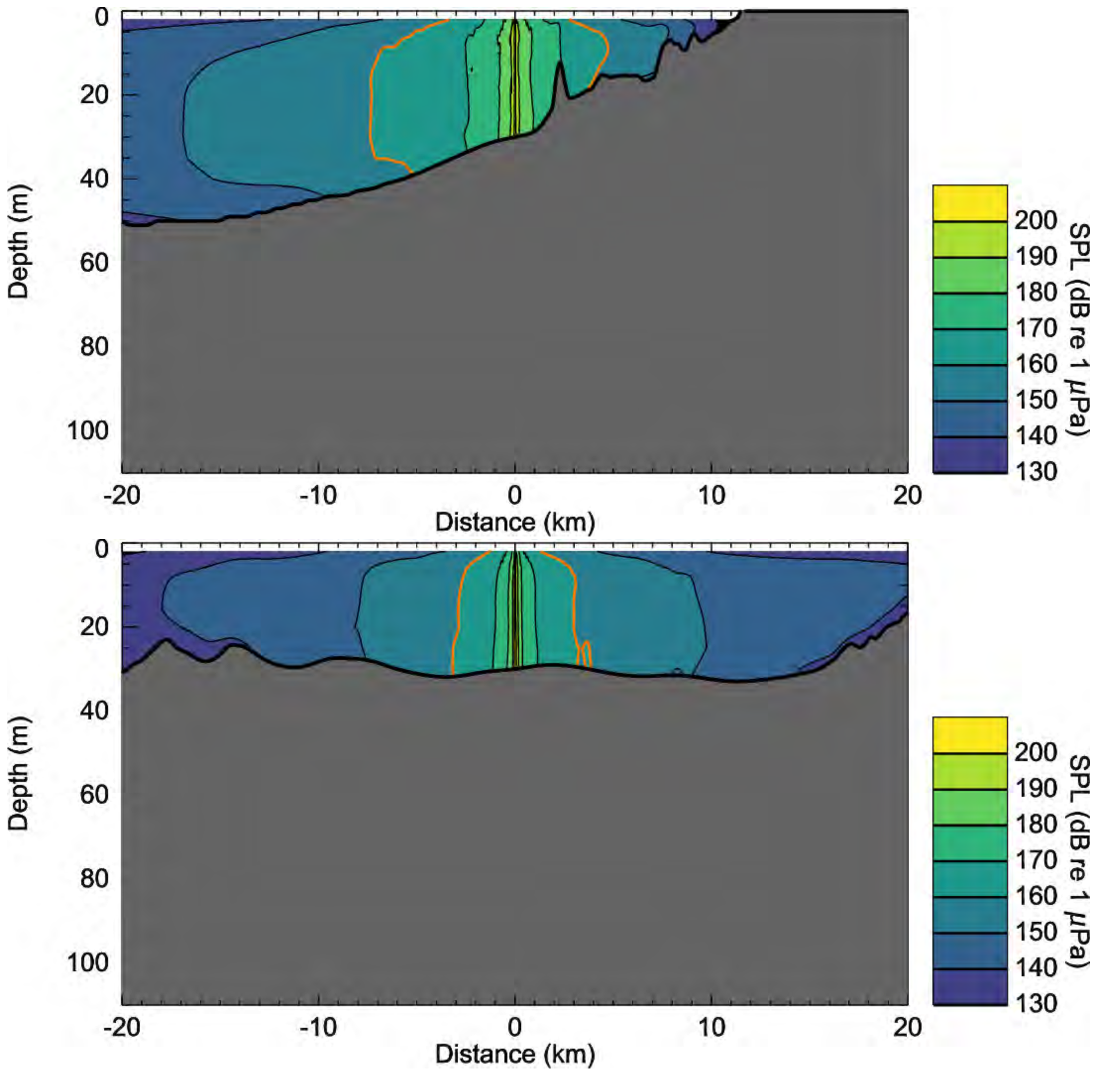

Figure 9. *Site 3, Scenario 1,tow azimuth 0°, SPL*: Sound level contours (vertical slice), perpendicular to (broadside, top) and along the tow direction (endfire, bottom). For context the behavioural response threshold for marine mammals is highlighted in orange. The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

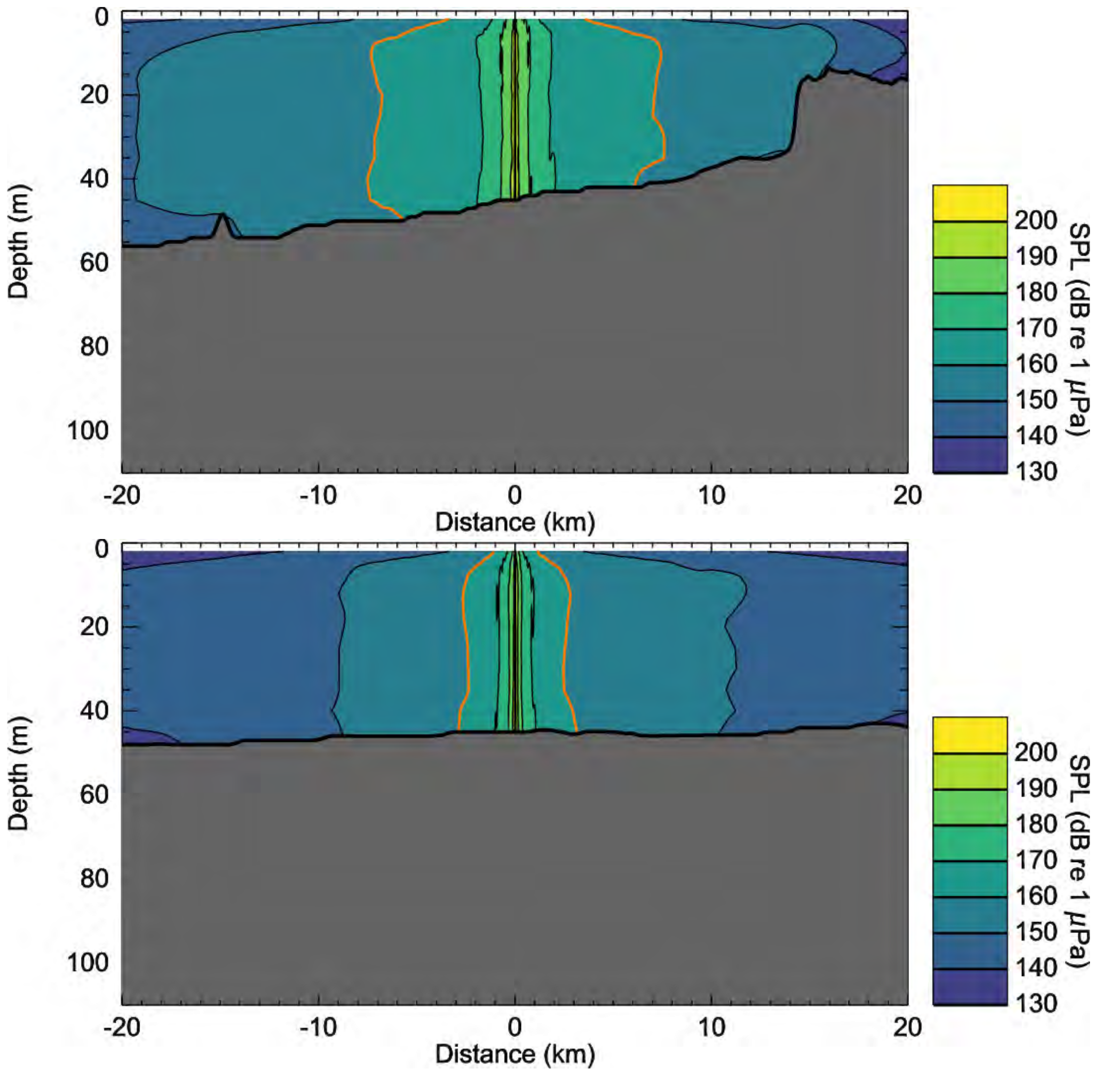

Figure 10. *Site 4, Scenario 2,tow azimuth 0°, SPL*: Sound level contours (vertical slice), perpendicular to (broadside, top) and along the tow direction (endfire, bottom). For context the behavioural response threshold for marine mammals is highlighted in orange. The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

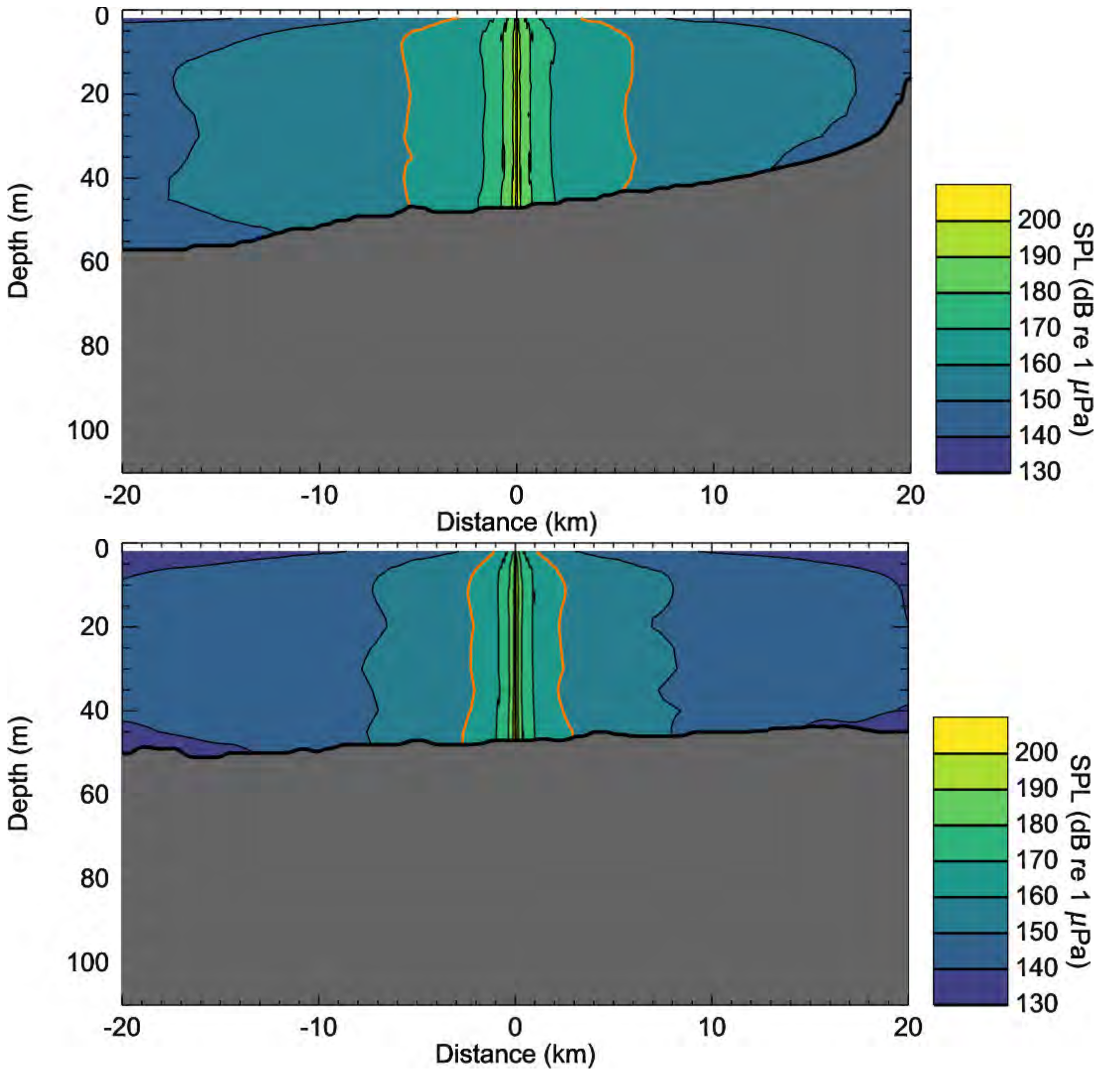

Figure 11. *Site 5, Scenario 2,tow azimuth 0°, SPL*: Sound level contours (vertical slice), perpendicular to (broadside, top) and along the tow direction (endfire, bottom). For context the behavioural response threshold for marine mammals is highlighted in orange. The positive distance direction in each slice is 90° clockwise from the tow azimuth for broadside, and the tow azimuth for the endfire slice.

4.3. Multiple Source Fields

This section presents the sound fields in terms of SEL accumulated over 24 hours of survey, for the two modelled scenarios (Section 1). Frequency-weighted SEL_{24h} sound fields were used to estimate the maximum horizontal distances (R_{max}) to marine mammal and sea turtle PTS and TTS thresholds (listed in Table 6), and to estimate maximum distance and the area for injury and TTS guidelines for fish (Tables 16–17).

The SEL_{24h} sound fields are presented as contour maps in Figures 12 and 13. These figures present the unweighted SEL_{24h} in 10 dB steps, as well as the isopleths corresponding to thresholds or guidelines for which R_{max} is greater than 20 m.

4.3.1. Tabulated Results

Table 16. Marine mammal and sea turtle criteria: Maximum (R_{max}) horizontal distances (in km) and ensonified area (km²) from the survey lines to permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds considering 24 hours of survey activity (maximum-over-depth).

Hearing group	Weighted SEL thresholds ($L_{E,24h}$; dB re 1 µPa²·s)	Scenario 1		Scenario 2	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
PTS					
Low-frequency cetaceans	183	2.72	272	3.08	167
High-frequency cetaceans	185	-	-	–	–
Very-high-frequency cetaceans	155	0.06	5.68	0.06	6.19
Pinnipeds	203	-	-	–	–
Sea Turtles	204	0.06	5.68	0.06	6.19
TTS					
Low-frequency cetaceans	168	34.8	1884	43.0	2220
High-frequency cetaceans	170	0.06	3.91	0.06	5.56
Very-high-frequency cetaceans	140	0.44	58.7	0.42	37.2
Pinnipeds	188	0.06	4.71	0.06	5.56
Sea turtles	189	2.10	204	2.00	119.8

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 17. *Fish criteria*: Maximum horizontal distances (R_{max}, in km) from the survey lines and area (km^2) to injury and temporary threshold shift (TTS) thresholds considering 24 h of survey activity.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	Scenario 1		Scenario 2	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
Mortality and potential mortal injury					
I	219	0.06	4.71	0.06	4.75
II, fish eggs and larvae	210	0.06	5.68	0.06	6.19
III	207	0.06	5.68	0.06	6.19
Fish recoverable injury					
I	216	0.06	5.31	0.06	5.8
II, III	203	0.10	25.8	0.10	19.3
Fish TTS					
I, II, III	186	4.06	339	4.66	256

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
An asterisk indicates that the sound level was not reached.

4.3.2. Sound Level Contour Maps

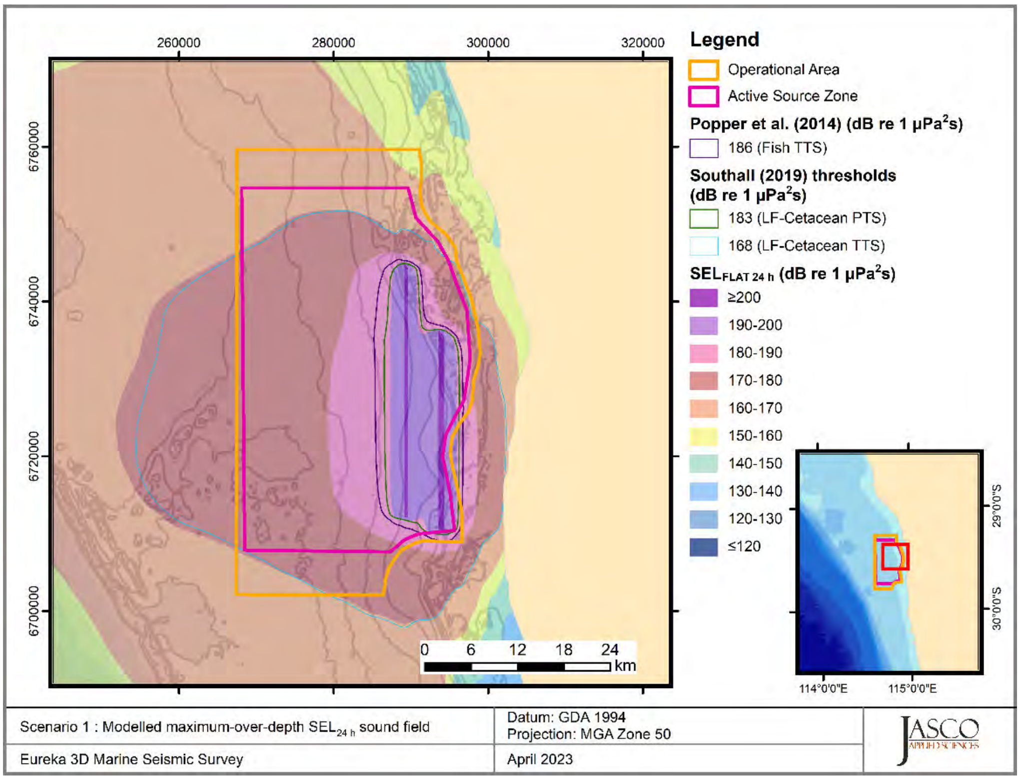

Figure 12. *Scenario 1*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h}, along with thresholds for LF-cetaceans and fish. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Tables 16 and 17 for tabulated radii.

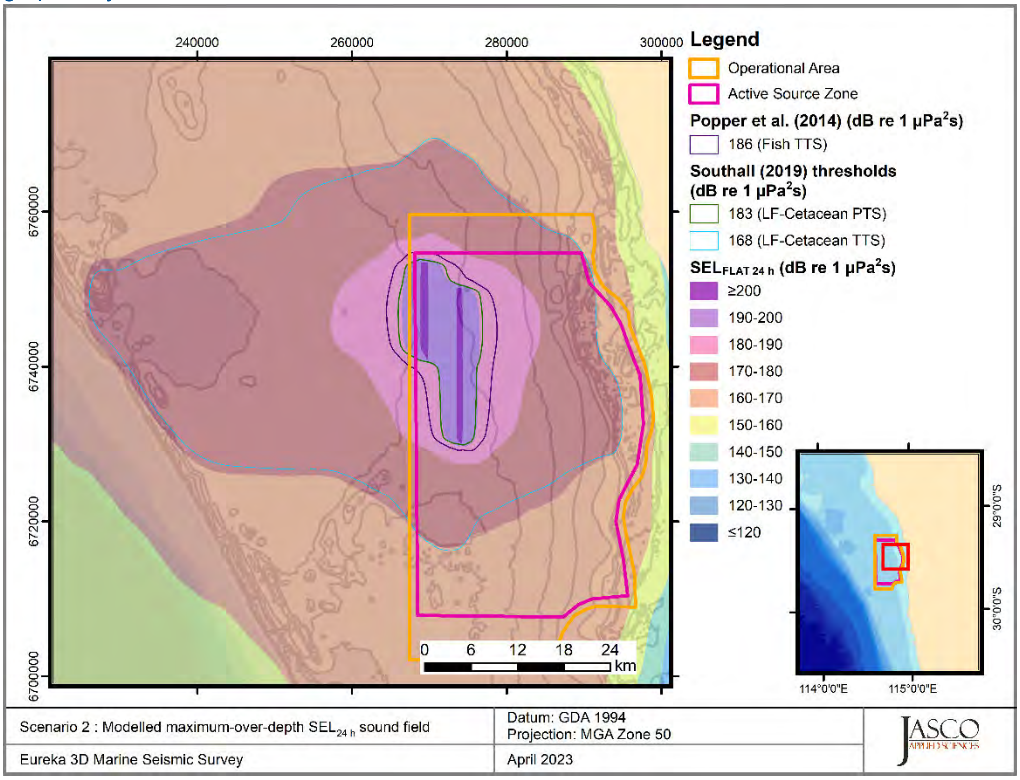

Figure 13. Scenario 2: Sound level contour map showing unweighted maximum-over-depth SEL_{24h}, along with thresholds for LF-cetaceans and fish. Thresholds omitted here were not reached or not large enough to display graphically. Refer to Tables 16 and 17 for tabulated radii.

5. Discussion and Summary

The modelling study predicted underwater sound levels associated with the planned Eureka 3D MSS. The underwater sound field was modelled for a 2495 in^3 seismic source within the active source area.

Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz. Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz. The modelled array had a pronounced broadside directivity for decidecade bands between ~100 to 400 Hz (Appendix B.3), which caused a noticeable axial bulge in the modelled acoustic footprints.

5.1. Per-Pulse Sound Fields

The Eureka 3D MSS covers an area that is close to the Western Australia coastline; this required specifically selected sites to capture the propagation effects associated with shallow water depths and bathymetric features. The per-pulse modelled sites span water depths from about 25 to 48 m across an assumed single geological region. Seafloor sound levels were assessed at eight different representative water depths. The bathymetry within vicinity of the active source area varied approximately between 10–60 m; however, along a westward transect the environment generally transitions from coastal shallow waters to relatively deeper waters of the continental shelf and then the continental slope. The frequency content of the seismic source coupled with the bathymetry had a considerable effect on propagation at longer distances, with larger lobes of sound energy extending into the deeper waters. The maximum-over-depth sound footprint maps and vertical slice plots (Sections 4.2.2.1 and 4.2.2.2) assist in demonstrating the influence of the bathymetry and seabed interactions on the sound field.

Furthermore, sites located in deeper water have a lower “cut-off frequency (f_c)” than sites in shallower coast water. The cut-off frequency is a single number that describes how much acoustic energy can propagate with minimal loss between the sea-surface and seafloor interfaces. For a given acoustic signal, frequencies below f_c are subject to higher loss compared to frequencies above the f_c (Jensen et al. 2011). For sources in waters greater than 30 m deep (i.e. sites associated with Scenario 2) the cut off frequency was less than 20 Hz. For these sites a comparatively larger amount of low-frequency energy can propagate in the water column compared to sources in shallow water below 30 m (i.e. sites associated with Scenario 1).

Based on available literature of the area, the seabed was modelled as a sand layer underlain by semi-cemented limestone/calcarenite. Acoustic propagation over calcarenite seabeds generally displayed higher rates of loss at distance away from the source as compared to seabeds that contain thick packages of unconsolidated sediments (Duncan et al. 2009). Literature suggests that the thickness of this layer is variable and could be on the order of several metres thick or in some locations non-existent(Duncan et al. 2008, Duncan et al. 2009, Fan et al. 2009). The distribution of sand layer is not well known and if the thickness of the sand layer is not as uniform as modelled then this variability could potentially lead to smaller radii if thinner or larger radii if thicker.

5.2. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic source operation was modelled considering representative scenarios with a realistic acquisition pattern for the marine portion of the Eureka 3D MSS. The model methodology predicted the accumulation of sound energy, considering the change in location and the azimuth of the source at each pulse point, which was used to assess possible injury in marine mammals and the SEL_{24h} based fish and marine mammal criteria. The results were presented as maps of the accumulated exposure levels and tabulated values of ranges to threshold levels and exposure areas for the given effects criteria (Section 2).

The footprints and range maxima for all SEL_{24h} criteria are substantially influenced by the location of single impulse modelled sites. As discussed above, the footprints and range maxima for all accumulated SEL thresholds within the survey area are primarily influenced by the high levels in the offshore direction due to deepening waters. This results in generally different isopleth and threshold distances for Scenarios 1 and 2.

5.3. Summary

A summary of predicted distances to criteria from acoustic modelling are presented below.

Marine mammals

The maximum distance for behavioural response based on NOAA (2019) criterion of 160 dB re 1 µPa (SPL) varied between 9.20 and 6.51 km depending on the site. All results can be found in Section 4.2.1.1. The results for marine mammal injury considered the criteria from Southall et al. (2019). These criteria contain two metrics (PK and SEL_{24h}), both required for the assessment of marine mammal PTS and TTS. The longest distance associated with either metric is required to be applied for assessment; Table 18 summarises the maximum distances, along with the relevant metric. Results for PK thresholds can be found in Section 4.2.1.1 and SEL_{24h} can be found in Section 4.3.1.

Table 18. Summary of maximum horizontal distance (R_{max}) for behavioural response thresholds, permanent threshold shift (PTS) and temporary threshold shift (TTS) for marine mammals. Maximum extents are in the broadside direction.

Hearing group	Maximum modelled distance to effect threshold (R_{max})		
	Behavioural response[1]	Impairment (km): PTS[2]	Impairment (km): TTS[2]
LF cetaceans (Baleen whales)	9.20	3.08 (SEL_{24h})	43.0 (SEL_{24h})
HF cetaceans (Dolphins, plus toothed, beaked, and bottlenose whales)		–	–
VHF cetaceans (*Kogia*, cephalorhynchid, and *L. australis*)		0.41 (PK)	0.84 (PK)
Pinnipeds (Australian sea lion, Australian fur seal, New Zealand fur seal)		–	0.06

Noise exposure criteria: [1] NOAA (2019) and [2] Southall et al. (2019).
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Sea turtles

The PK sea turtle impairment criteria from Finneran et al. (2017) were not exceeded beyond the modelled resolution of 20 m. The maximum distance for PTS and TTS onset associated with the SEL_{24h} (Finneran et al. 2017) were respectively 0.06 and 2.10 km, and the behavioural response of turtles (McCauley et al. 2000) are summarised in Table 19. Results for PK and behavioural response thresholds can be found in Section 4.2.1.1 and SEL_{24h} can be found in Section 4.3.1.

Table 19. Summary of maximum horizontal distance (in km) to turtle behavioural response criteria, temporary threshold shift (TTS), and permanent threshold shift (PTS).

Hearing group	Maximum modelled distance (in km) to effect threshold (R_{max})			
	Behavioural response[1]	Behavioural disturbance[1]	Impairment: TTS[2]	Impairment: PTS[2]
Sea turtles	4.90 (166 dB re 1 µPa - SPL)	1.58 (175 dB re 1 µPa - SPL)	2.10 (SEL_{24h})	0.06 (SEL_{24h})

Noise exposure criteria: [1] McCauley et al. (2000) and [2] Finneran et al. (2017).

Fish, fish eggs, and fish larvae

This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics (water column) associated with mortality and potential mortal injury as well as impairment in the following groups:

- Fish without a swim bladder (also appropriate for sharks in the absence of other information),
- Fish with a swim bladder that do not use it for hearing,
- Fish that use their swim bladders for hearing,
- Fish eggs and fish larvae.

Table 20 summarises distances to effect criteria for fish, fish eggs, and fish larvae along with the relevant metric. Seafloor sound levels were assessed at nine different depths within the survey area. Assessment was based on Popper et al. (2014) and considered both PK (seafloor and water column, Sections 4.2.1.1 and 4.2.1.2) and SEL_{24h} metrics (water column, Section 4.3.1) associated with mortality, potential mortal injury and impairment.

Table 20. Summary of maximum onset distances for single impulse and 24 hour sound exposure level (SEL_{24h}) for fish, fish eggs, and larvae injury and temporary threshold shift (TTS).

Relevant hearing group	Effect criteria	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Recoverable injury	PK	0.15
	TTS	SEL_{24h}	4.06
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Recoverable injury	PK	0.27
	TTS	SEL_{24h}	4.06
Fish eggs, and larvae (relevant to plankton)	Injury	PK	0.27

Benthic invertebrates, Cephalopods, Sponges, and Coral

A full set of tabulated results can be found in Section 4.2.1.2; however, to summarise the potential effects on these receptors, the following results are provided:

- Crustaceans (representative of southern rock lobsters and crabs): The distance to no effect was reached between 206 and 292 m, based on 202 dB re 1 µPa PK-PK level from Payne et al. (2008).
- Bivalves (representative of scallops and mussels): The distance to no effect was reached between 54 and 7 m, based on a particle acceleration limit of 37.57 ms^{-2} at the seafloor as presented in Day et al. (2016a).
- Squid: The distance to the per–pulse SEL (L_E) startle (inking) response level of 162 dB re 1 $\mu Pa^2 s$ for squid (Fewtrell and McCauley 2012) was reached between 2.90 and 2.03 km.
- Sponges and coral: The threshold was reached at a maximum of 15 m, based on the PK sound level criteria of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018).

Divers

An SPL human health assessment of 145 dB re 1 μPa (SPL; L_p) derived from Parvin (2005) was considered for people swimming and diving. The sound level was reached at ranges between 36.4 and 24.1 km depending on the modelled site. This is the maximum range over all modelled azimuths, and it is typically in orientated offshore. This maximum range should not be used as an offset distance to the coast and the sound field contour maps should be used to inform any such offset.

Glossary

1/3-octave

One third of an octave. *Note*: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

1/3-octave-band

Frequency band whose bandwidth is one one-third octave. *Note*: The bandwidth of a one-third octave-band increases with increasing centre frequency.

absorption

The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

audiogram

A graph or table of hearing threshold as a function of frequency that describes the hearing sensitivity of an animal over its hearing range.

auditory frequency weighting

The process of applying an auditory frequency weighting function. In human audiometry, C-weighting is the most commonly used function, an example for marine mammals are the auditory frequency weighting functions published by Southall et al. (2007).

auditory frequency weighting function

Frequency weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity. Example hearing groups are low-, mid-, and high-frequency cetaceans, phocid and otariid pinnipeds.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

bandwidth

The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI S1.13-2005 (R2010)).

bar

Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^5 Pa or 10^{11} μPa.

broadband level

The total level measured over a specified frequency range.

broadside direction

Perpendicular to the travel direction of a source. Compare with endfire direction.

cetacean

Any animal in the order Cetacea. These are aquatic species and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

conductivity-temperature-depth (CTD)

Measurement data of the ocean's conductivity, temperature, and depth; used to compute sound speed and salinity.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006).

decidecade

One tenth of a decade. *Note*: An alternative name for decidecade (symbol ddec) is "one-tenth decade". A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a "one-third octave".

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Unit: dB.

endfire direction

Parallel to the travel direction of a source. Also see **broadside direction**.

energy source level

A property of a sound source obtained by adding to the sound exposure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2 s$.

energy spectral density

Ratio of energy (time-integrated square of a specified field variable) to bandwidth in a specified frequency band f_1 to f_2. In equation form, the energy spectral density E_f is given by:

$$E_f = \frac{2\int_{f_1}^{f_2} |X(f)|^2 \, \mathrm{d}f}{f_2 - f_1},$$

where $X(f)$ is the Fourier transform of the field variable $x(t)$

$$X(f) = \int_{-\infty}^{+\infty} x(t) \exp(-2\pi i f t) \, \mathrm{d}t \, .$$

The field variable $x(t)$ is a scalar quantity, such as sound pressure. It can also be the magnitude or a specified component of a vector quantity such as sound particle displacement, sound particle velocity, or sound particle acceleration. The unit of energy spectral density depends on the nature of x, as follows:

- If x = sound pressure: Pa^2 s/Hz
- If x = sound particle displacement: m^2 s/Hz
- If x = sound particle velocity: $(m/s)^2$ s/Hz
- If x = sound particle acceleration: $(m/s^2)^2$ s/Hz

The factor of two on the right-hand side of the equation for E_f is needed to express a spectrum that is symmetric about $f = 0$, in terms of positive frequencies only. See entry 3.1.3.9 of ISO 18405 (2017).

energy spectral density level

The level ($L_{E,f}$) of the **energy spectral density** (E_f). Unit: decibel (dB).

$$L_{E,f} := 10 \log_{10}\left(E_f / E_{f,0}\right) \text{dB} .$$

The frequency band and integration time should be specified.

As with **energy spectral density**, energy spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($E_{f,0}$) for energy spectral density level depends on the nature of field variable.

energy spectral density source level

A property of a sound source obtained by adding to the energy spectral density level of the sound pressure measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2 s/Hz$.

ensonified

Exposed to sound.

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

Fourier transform (or Fourier synthesis)

A mathematical technique which, although it has varied applications, is referenced in the context of this report as a method used in the process of deriving a spectrum estimate from time-series data (or the reverse process, termed the inverse Fourier transform). A computationally efficient numerical algorithm for computing the Fourier transform is known as fast Fourier transform (FFT).

flat weighting

Term indicating that no frequency weighting function is applied. Synonymous with unweighted.

frequency

The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function. For sound of a given frequency, the frequency weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency weighting function*: compensatory frequency weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency weighting function*: frequency weighting function describing the sensitivity of an acoustic acquisition system, typically consisting of a hydrophone, one or more amplifiers, and an analogue to digital converter.

functional hearing group

Category of animal species when classified according to their hearing sensitivity, hearing anatomy, and susceptibility to sound. For marine mammals, initial groupings were proposed by Southall et al. (2007), and revised groupings are developed as new research/data becomes available. Revised groupings proposed by Southall et al. (2019) include low-frequency cetaceans, high-frequency cetaceans, very high-frequency cetaceans, phocid carnivores in water, other carnivores in water, and sirenians. See auditory frequency weighting functions, which are often applied to these groups. Example hearing groups for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

geoacoustic

Relating to the acoustic properties of the seabed.

hearing threshold

The sound pressure level for any frequency of the hearing group that is barely audible for a given individual for specified background noise during a specific percentage of experimental trials.

hertz (Hz)

A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean

See **functional hearing** group.

impulsive sound

Qualitative term meaning sounds that are typically transient, brief (less than 1 s), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Examples of impulsive sound sources include explosives, seismic airguns, and impact pile drivers.

isopleth

A line drawn on a map through all points having the same value of some quantity.

knot

One nautical mile per hour. Symbol: kn.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. Examples include sound pressure level, sound exposure level, and peak sound pressure level. For example, a value of sound exposure level with reference to 1 μPa^2 s can be written in the form x dB re 1 μPa^2 s.

low-frequency (LF) cetacean

See **functional hearing** group.

Monte Carlo simulation

The method of investigating the distribution of a non-linear multi-variate function by random sampling of all of its input variable distributions.

mysticete

A suborder of cetaceans that use baleen plates to filter food from water. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The skulls of toothed whales are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid

A common term used to describe members of the Otariidae, eared seals, commonly called sea lions and fur seals. Otariids are adapted to a semi-aquatic life; they use their large fore flippers for propulsion. Their ears distinguish them from phocids. Otariids are one of the three main groups in the superfamily Pinnipedia; the other two groups are phocids and walrus.

otariid pinnipeds in water (OPW)

See **functional hearing** group.

other marine carnivores in air (OCA)

See **functional hearing** group.

other marine carnivores in water (OCW)

See **functional hearing** group.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of propagation loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

particle acceleration

See **sound particle acceleration**.

particle displacement

See **sound particle displacement**.

particle motion

See **sound particle motion**.

particle velocity

See **sound particle velocity**.

peak sound pressure level (zero-to-peak sound pressure level)

The level ($L_{p,pk}$ or L_{pk}) of the squared maximum magnitude of the sound pressure (p_{pk}^2). Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

$$L_{p,\mathrm{pk}} := 10 \log_{10}\left(p_{\mathrm{pk}}^2 / p_0^2\right) \mathrm{dB} \ = 20 \log_{10}\left(p_{\mathrm{pk}} / p_0\right) \mathrm{dB}$$

The frequency band and time window should be specified. Abbreviation: PK or Lpk.

peak-to-peak sound pressure

The difference between the maximum and minimum sound pressure over a specified frequency band and time window. Unit: pascal (Pa).

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

phocid

A common term used to describe all members of the family Phocidae. These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves. Phocids are one of the three main groups in the superfamily Pinnipedia; the other two groups are otariids and walrus.

phocid pinnipeds in water (PPW)

See **functional hearing** group.

pinniped

A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source

A source that radiates sound as if from a single point.

power spectral density

Generic term, formally defined as power in a unit frequency band. Unit: watt per hertz (W/Hz). The term is sometimes loosely used to refer to the spectral density of other parameters such as squared sound pressure. ratio of **energy spectral density**, E_f, to time duration, Δt, in a specified temporal observation window. In equation form, the power spectral density P_f is given by:

$$P_f = \frac{E_f}{\Delta t}.$$

Power spectral density can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement).

power spectral density level

The level ($L_{P,f}$) of the **power spectral density** (P_f). Unit: decibel (dB).

$$L_{P,f} := 10 \log_{10}(P_f / P_{f,0}) \text{ dB} .$$

The frequency band and integration time should be specified.

As with **power spectral density**, power spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($P_{f,0}$) for power spectral density level depends on the nature of field variable.

pressure, acoustic

The deviation from the ambient pressure caused by a sound wave. Also called sound pressure. Unit: pascal (Pa).

pressure, hydrostatic

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, PL(x) = SL − L(x).

received level

The level measured (or that would be measured) at a defined location. The type of level should be specified.

reference values

standard underwater references values used for calculating sound **levels**, e.g., the reference value for expressing sound pressure level in decibels is 1 µPa.

Quantity	Reference value
Sound pressure	1 µPa
Sound exposure	1 µPa^2 s
Sound particle displacement	1 pm
Sound particle velocity	1 nm/s
Sound particle acceleration	1 µm/s^2

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called a secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium.

sound exposure

Time integral of squared sound pressure over a stated time interval. The time interval can be a specified time duration (e.g., 24 h) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: Pa^2 s.

sound exposure level

The level (L_E) of the sound exposure (E). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 µPa^2 s.

$$L_E := 10 \log_{10}(E/E_0)\,\text{dB} \;= 20 \log_{10}\left(E^{1/2}/E_0^{1/2}\right)\,\text{dB}$$

The frequency band and integration time should be specified. Abbreviation: SEL.

sound exposure spectral density

Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum. Unit: Pa^2 s/Hz.

sound field

Region containing sound waves.

sound intensity

Product of the sound pressure and the sound particle velocity. The magnitude of the sound intensity is the sound energy flowing through a unit area perpendicular to the direction of propagation per unit time.

sound particle acceleration

The rate of change of sound particle velocity. Unit: metre per second squared (m/s^2). Symbol: *a*.

sound particle motion

smallest volume of a medium that represents its mean physical properties.

sound particle displacement

Displacement of a material element caused by the action of sound, where a material element is the smallest element of the medium that represents the medium's mean density.

sound particle velocity

The velocity of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: *v*.

sound pressure

The contribution to total pressure caused by the action of sound.

sound pressure level (rms sound pressure level)

The level ($L_{p,\text{rms}}$) of the time-mean-square sound pressure (p_{rms}^2). Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

$$L_{p,\text{rms}} := 10 \log_{10}(p_{\text{rms}}^2/p_0^2)\,\text{dB} \;= 20 \log_{10}(p_{\text{rms}}/p_0)\,\text{dB}$$

The frequency band and averaging time should be specified. Abbreviation: SPL or Lrms.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

A property of a sound source obtained by adding to the sound pressure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2$.

spectrum

An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

surface duct

The upper portion of a water column within which the sound speed profile gradient causes sound to refract upward and therefore reflect off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity. TTS can be caused by noise exposure.

thermocline

The depth interval near the ocean surface that experiences temperature gradients due to warming or cooling by heat conduction from the atmosphere and by warming from solar heating.

unweighted

Term indicating that no frequency weighting function is applied. Synonymous with flat weighting.

very high-frequency (VHF) cetacean

See **functional hearing** group.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow the American National Standard Institute and International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI R2013), but these standards are not always consistent.

The zero-to-peak sound pressure, or peak sound pressure (PK or $L_{p,pk}$; dB re 1 μPa), is the decibel level of the maximum instantaneous acoustic pressure in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,\mathrm{pk}} = 10\log_{10}\frac{\max|p^2(t)|}{p_0^2} = 20\log_{10}\frac{\max|p(t)|}{p_0} \quad \text{(A-1)}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of an acoustic event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure (PK-PK or $L_{p,pk\text{-}pk}$; dB re 1 μPa) is the difference between the maximum and minimum instantaneous sound pressure, possibly filtered in a stated frequency band, attained by an impulsive sound, $p(t)$:

$$L_{p,\mathrm{pk\text{-}pk}} = 10\log_{10}\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2} \quad \text{(A-2)}$$

The sound pressure level (SPL or L_p; dB re 1 μPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt \Big/ p_0^2\right) \quad \text{(A-3)}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,fast}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,boxcar\ 125ms}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results are referred to as 90% SPL ($L_{p,90\%}$).

The sound exposure level (SEL or L_E; dB re 1 μPa²·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right) \quad \text{(A-4)}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\sum_{i=1}^{N}10^{\frac{L_{E,i}}{10}} \quad \text{(A-5)}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LF,24h}$; see Appendix A.5) or auditory-weighted SPL ($L_{p,ht}$). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should also be specified.

A.2. Particle Acceleration and Velocity Metrics

Since sound is a mechanical wave, it can also be measured in terms of the vibratory motion of fluid particles. Particle motion can be measured in terms of three different (but related) quantities: displacement, velocity, or acceleration. Acoustic particle velocity is the time derivative of particle displacement, and likewise acceleration is the time derivative of velocity. For the present study, acoustic particle motion has been reported in terms of acceleration and velocity.

The particle velocity (v) is the physical speed of a particle in a material moving back and forth in the direction of the pressure wave. It can be derived from the pressure gradient and Euler's linearised momentum equation where ρ_0 is the density of the medium:

$$v = -\int \nabla p(t)dt/\rho_0 \quad \text{(A-6)}$$

The particle acceleration (a) is the rate of change of the velocity with respect to time, and it can be obtained from equation A-6 as:

$$a = \frac{dv}{dt} = -\frac{\nabla p(t)}{\rho_0} \quad \text{(A-7)}$$

Unlike sound pressure, particle motion is a vector quantity, meaning that it has both magnitude and direction: at any given point in space, acoustic particle motion has three different time-varying components (x, y, and z). Given the particle velocity in the x, y, and z, directions, v_x, v_y, and v_z, the particle velocity magnitude $|v|$ is computed per the Pythagorean equation:

$$|v| = \sqrt{v_x + v_y + v_z} \quad \text{(A-8)}$$

The magnitude of particle acceleration is calculated similarly from the particle acceleration in the *x*, *y*, and *z* directions.

A.3. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. They are approximately one third of an octave (base 2) wide and are therefore often referred to as 1/3-octave-bands. Each octave represents a doubling in sound frequency. The centre frequency of the ith band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{\frac{i}{10}}\ \text{kHz} \tag{A-9}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{lo,i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{hi,i} = 10^{\frac{1}{20}} f_c(i) \tag{A-10}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band 7 ($f_c(7)$ = 5 Hz) to band 44 ($f_c(44)$ = 25 kHz).

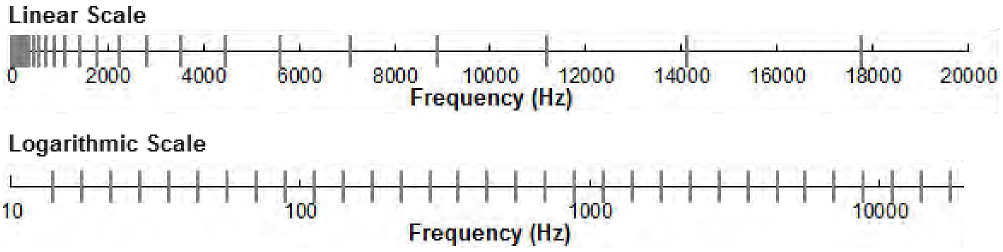


Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{lo,i}$ and $f_{hi,i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{lo,i}}^{f_{hi,i}} S(f)\, df \tag{A-11}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{\frac{L_{p,i}}{10}} \tag{A-12}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient noise signal. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

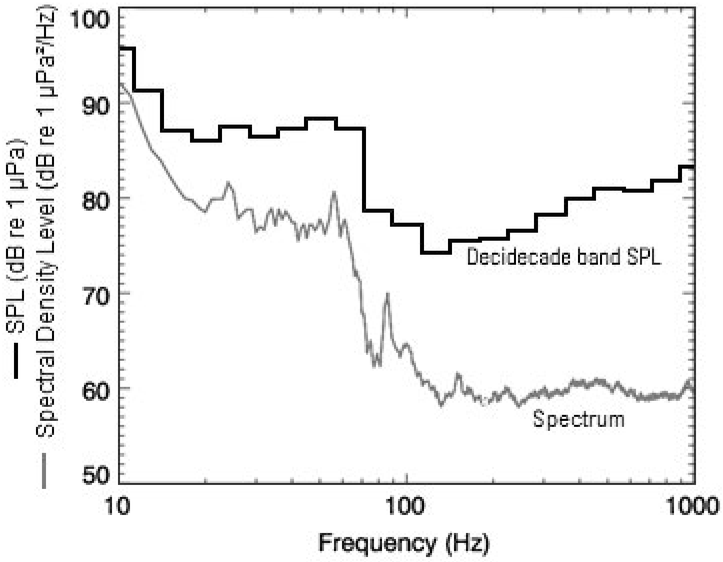


Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

A.4. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.4.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.4). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 µPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 µPa^2·s.

As of present, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; with the criteria defined in NMFS (2018). The latest criteria are from Southall et al. (2019) which is applied in this report.

A.4.2. Behavioural Response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

For impulsive noise, NMFS currently uses step function thresholds of 160 dB re 1 µPa SPL (unweighted) to assess and regulate noise-induced behavioural impacts for marine mammals (NOAA 2018, NOAA 2019). The threshold for impulsive sound is derived from the High-Energy Seismic Survey (HESS) panel (HESS 1999) report that, in turn, is based on the responses of migrating mysticete whales to airgun sounds (Malme et al. 1984). The HESS team recognised that behavioural responses to sound may occur at lower levels, but significant responses were only likely to occur above a SPL of 140 dB re 1 µPa. Southall et al. (2007) found varying responses for most marine mammals between a SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions.

A.5. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.5.1. Marine Mammal Frequency Weighting Functions

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-13)}$$

Finneran (2015)Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses acoustic impacts on marine mammals (NMFS 2018), and in the latest guidance by Southall (2019). The updates did not affect the content related to either the definitions of frequency-weighting functions or the threshold values. Table A-1 lists the frequency-weighting parameters for each hearing group. Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by Southall et al. (2019).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
High-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
Very-high-frequency cetaceans (*Kogia*, cephalorhynchid, and *L. australis*)	1.8	2	12,000	140,000	1.36
Other marine carnivores in water (Australian sea lion, Australian fur seal, New Zealand fur seal)	2.0	2	940	25,000	0.64

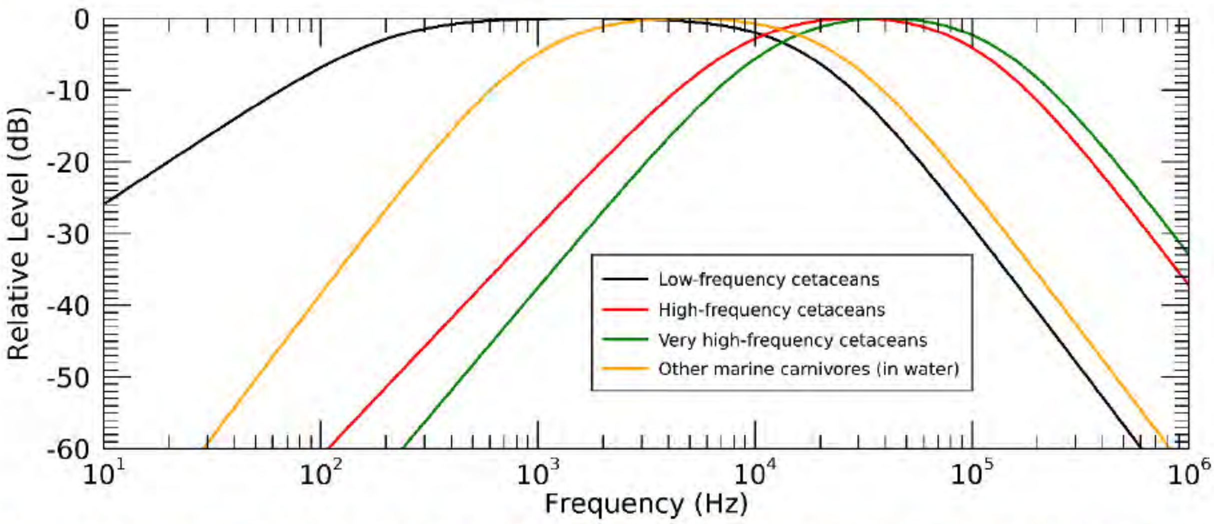


Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by Southall et al. (2019).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed Dragoset (1984), Laws et al. (1990), and Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

While airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (800−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into decidecade-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered a directional point source in the far field.

A seismic array consists of many sources and the point source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \quad \text{(B-1)}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Seismic Source

The layout of the seismic source used for modelling in this study is provided in Figure B-1 and details of the airgun parameters are provided in Table B-1.

For the modelled array, the layout is presented in a nominal cartesian coordinate system. In this coordinate system the direction of vessel travel determines the relative position of the array elements as plotted and tabulated. The layout used for acoustic modelling was produced by transforming the coordinates of client supplied layouts such that the resultant layouts correspond to a vessel travel direction along the positive X-axis and the array is centred on the X-Y origin. When used with an acoustic model the positive X-axis in this nominal coordinate system aligns with the vessel tow direction or survey line azimuth.

Table B-1. Layout of the modelled 2495 in^3 array. Tow depth is 6 m. Firing pressure for all guns is 2000 psi. Also see Figure B-1.

Gun	*x* (m)	*y* (m)	*z* (m)	Volume (in^3)	Gun	*x* (m)	*y* (m)	*z* (m)	Volume (in^3)
1	7.5	-4.4	6.0	90	13	7.5	3.6	6.0	60
2	7.5	-3.6	6.0	90	14	7.5	4.4	6.0	60
3	4.5	-4.5	6.0	250	15	4.5	3.5	6.0	250
4	4.5	-3.5	6.0	250	17	1.5	3.5	6.0	250
6	1.5	-3.5	6.0	250	18	1.5	4.5	6.0	250
8	-1.5	-3.6	6.0	100	19	-1.5	3.6	6.0	120
9	-4.5	-4.4	6.0	70	20	-1.5	4.4	6.0	120
10	-4.5	-3.6	6.0	70	21	-4.5	3.6	6.0	100
11	-7.5	-4.4	6.0	150	23	-7.5	3.6	6.0	70
12	-7.5	-3.6	6.0	150	24	-7.5	4.4	6.0	70

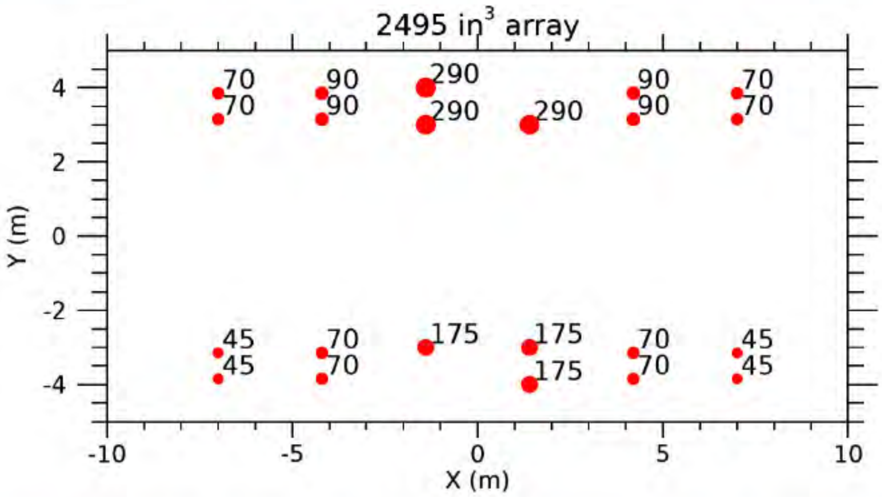


Figure B-1. Layout of the modelled 2495 in^3 array. Tow depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table B-1.

B.3. Array Source Levels and Directivity

Figure B-2 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction) and vertical overpressure signature and corresponding power spectrum levels for the seismic source (Appendix B.2). Horizontal decidecade-band source levels are shown as a function of band centre frequency and azimuth in Figure B-3.

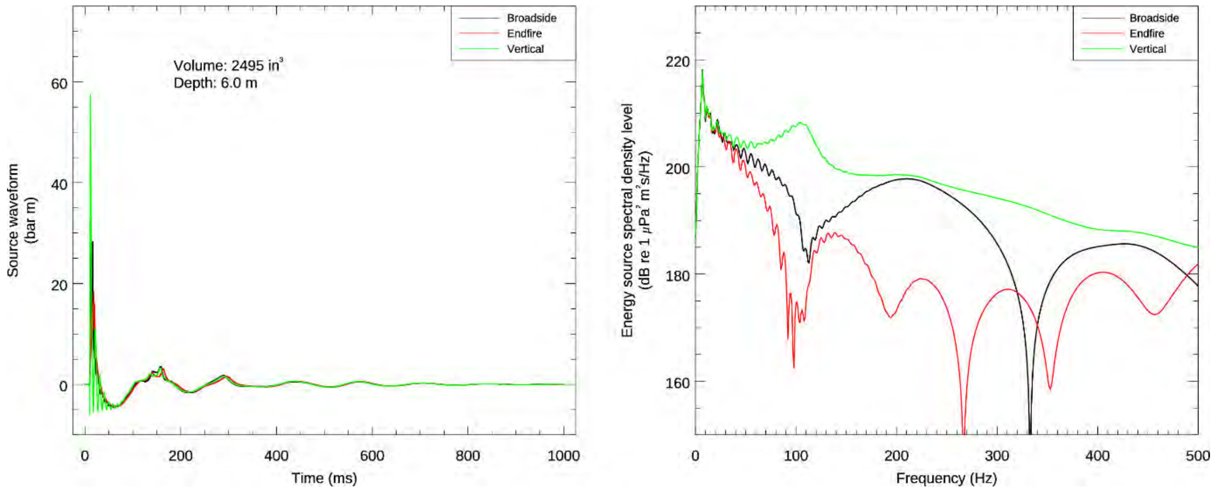


Figure B-2. Predicted source level details for the 2495 in^3 seismic source with a 6 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

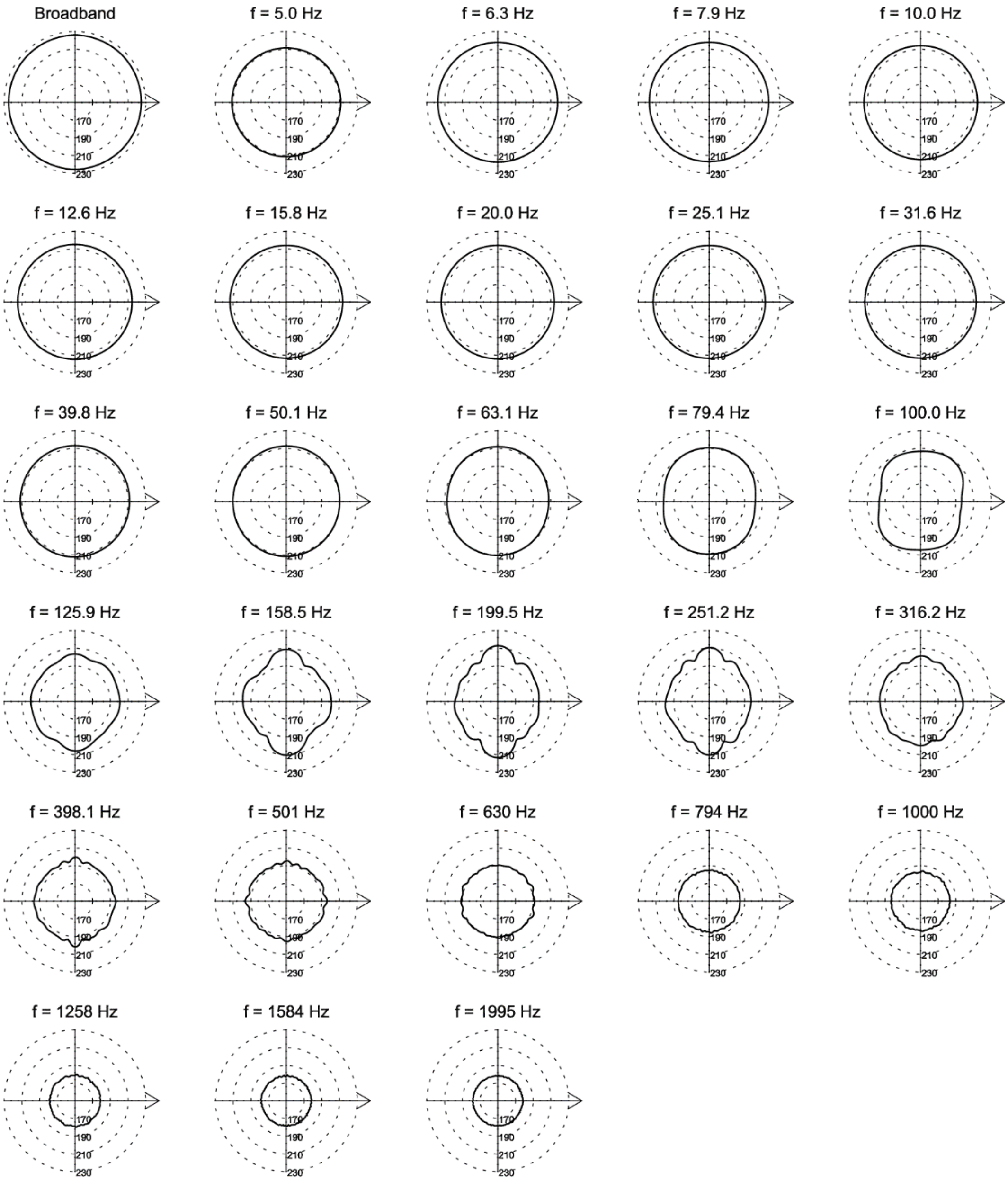


Figure B-3. Directionality of the predicted horizontal source levels for the 2495 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 $\mu Pa^2 \cdot s\ m^2$) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 6 m.

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 5 Hz to 1 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the US Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies >1 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

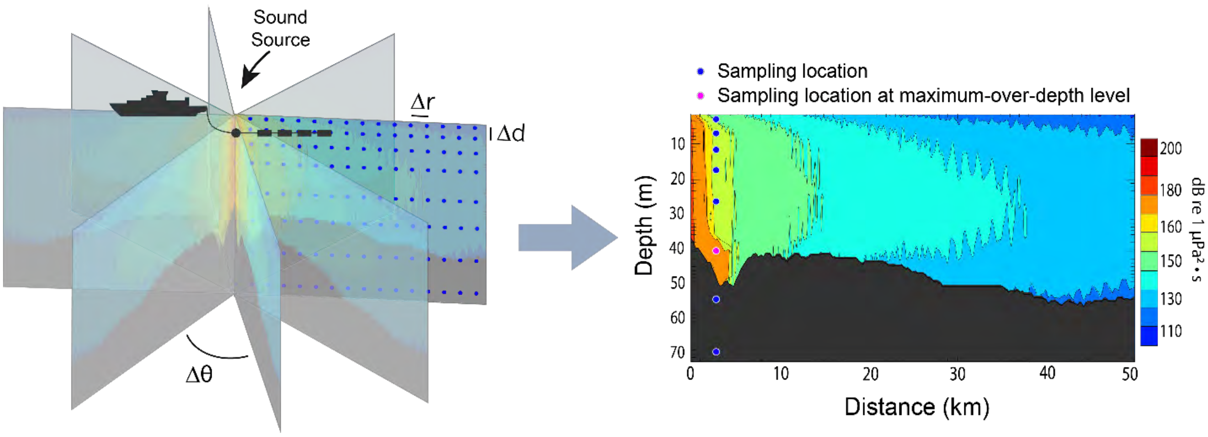


Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many decidecade bands, starting at 5 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The decidecade band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received decidecade band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. The maximum received per-pulse SEL at many sampling depths are taken over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as contours around the source.

C.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

C.3.1. Particle Motion

VSTACK was also used to compute estimates of particle acceleration and velocity for two sites (100 and 200 m water depth) for both airgun arrays. Particle motion waveforms were modelled, and pulse metrics were computed from the time-domain traces. VSTACK uses the wavenumber integration approach to solve the exact acoustic wave equation for arbitrarily layered range-independent acoustic environments.

The VSTACK model setup for the particle velocity scenarios was identical to that for the peak pressure scenarios in terms of source treatment, frequency range and environmental model. The particle acceleration and velocity waveforms were computed to a maximum distance of 1000 m in the broadside and endfire directions from the centre of the airgun array for a receiver 5 cm above the seafloor.

As discussed above in Appendix A.2, particle velocity (v) is the physical speed of a particle in a material. It can be derived from the pressure gradient and Euler's linearised momentum equation where ρ_0 is the density of the medium. Since the wavenumber integration kernel is a product of analytic expressions in terms of range and depth, VSTACK computes particle velocity by computing the spatial gradient of the pressure field analytically in the frequency domain. Fourier synthesis is applied to compute time series synthetic pressure and/or velocity waveforms at depth and range receivers by convolving the source waveforms with the impulse response of the waveguide. Particle velocity metrics at each receiver location were calculated from the modelled particle motion along three perpendicular axes (horizontal and along the source-receiver path, horizontal and perpendicular to the source-receiver path, and vertical).

The particle velocity results were converted to acceleration by time differentiation. The peak particle acceleration and velocity were calculated from the maximum of the predicted acceleration and velocity magnitude, defined as "peak magnitude" and are presented as plots of peak value versus range.

C.3.2. Limestone Seabed Propagation Loss

For all modelled sites, an additional broadband correction was applied to the propagation loss results from MONM to better account for the additional propagation loss associated with a calcarenite/limestone seabed. The differences between the broadband per-pulse SEL from MONM and VSTACK were extracted at the same modelled ranges and depths for corresponded range independent environments. The 90th percentile of the resultant dB differences in range bins were selected to generate a correction function for representative sites to be modelled. The conversion functions were applied after to the summed decidecade band levels from MONM, but before gridding, and radii calculations for each modelled site in each modelled scenario considered.

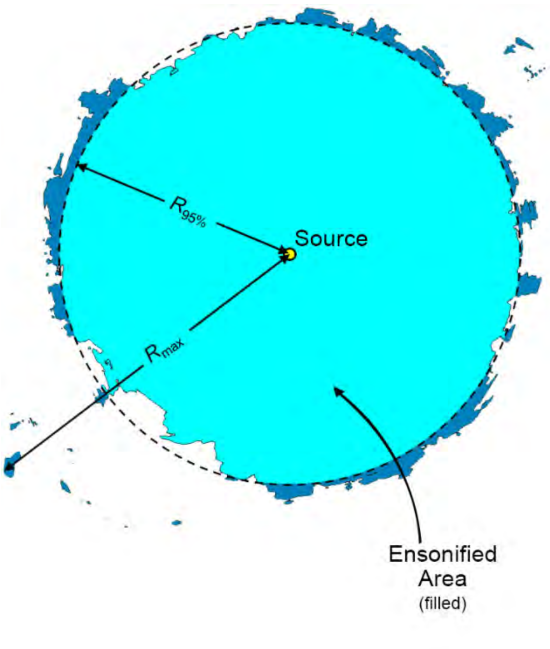
Appendix D. Methods and Parameters

This section the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.



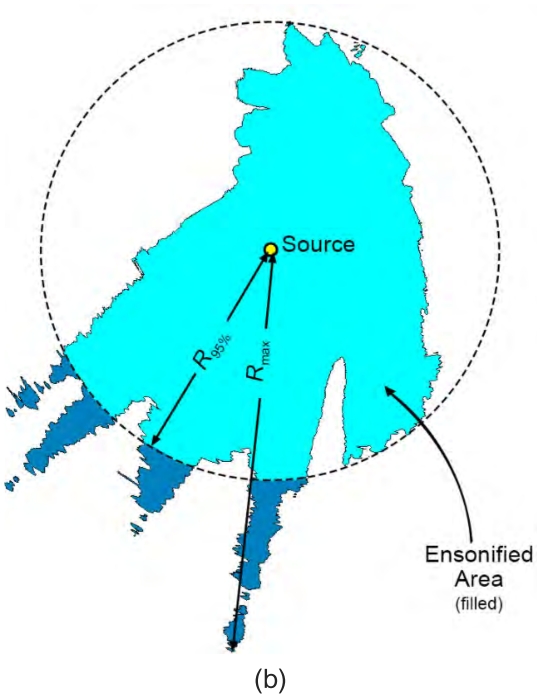


Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017b). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 10–1024 Hz. This was performed along all broadside and endfire radials at three sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL-to-SPL offsets were averaged in 0.02 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM to model SPL values. Figures D-2 and D-3 show the conversion offsets for Sites 3 and 5 for the 2495 in^3 array; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source.

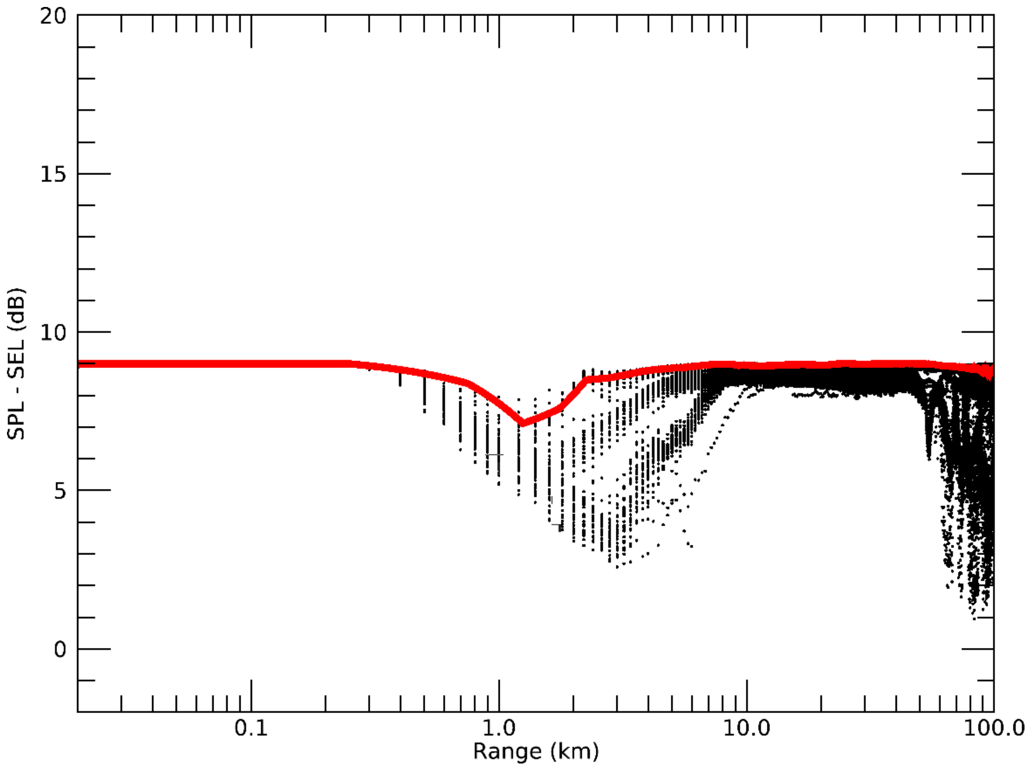


Figure D-2. *Site 3*: Range-and-depth-dependent conversion offsets for converting sound exposure level (SEL) to sound pressure level (SPL) for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

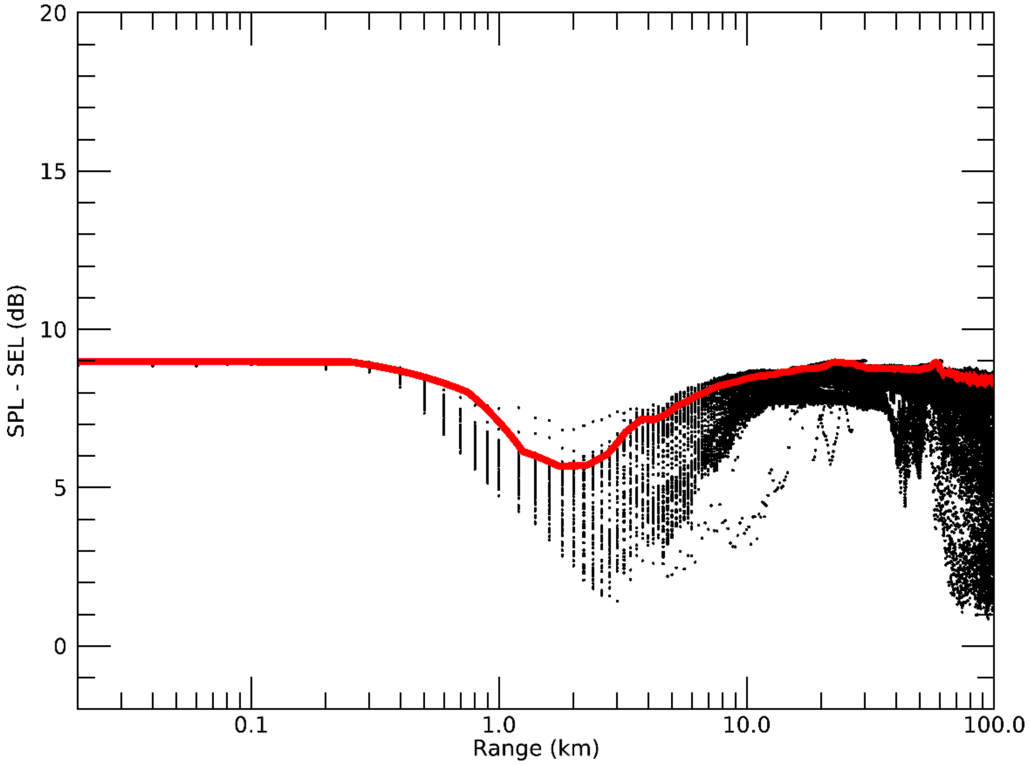


Figure D-3. *Site 5*: Range-and-depth-dependent conversion offsets for converting sound exposure level (SEL) to sound pressure level (SPL) for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from high resolution bathymetry data supplied by the client and. The Australian Bathymetry and Topography Grid is a 9 arc-second grid rendered for Australian waters (Whiteway 2009). Re-rendering and merging of these two data sets was conducted by re-gridding and averaging the fine resolution bathymetry with the larger scale Australian Bathymetry and Topography Grid. The final dataset was grid onto a Map Grid of Australia (MGA) coordinate projection (Zone 50) with a regular grid spacing of 200 × 200 m to generate the bathymetry in Figure D-4. This process may result in some water depth mismatch between higher resolution data and the Australian Bathymetry and Topography Grid; however, care was taken to reduce the potential for edge artefacts in merged data corrupting numerical predictions.

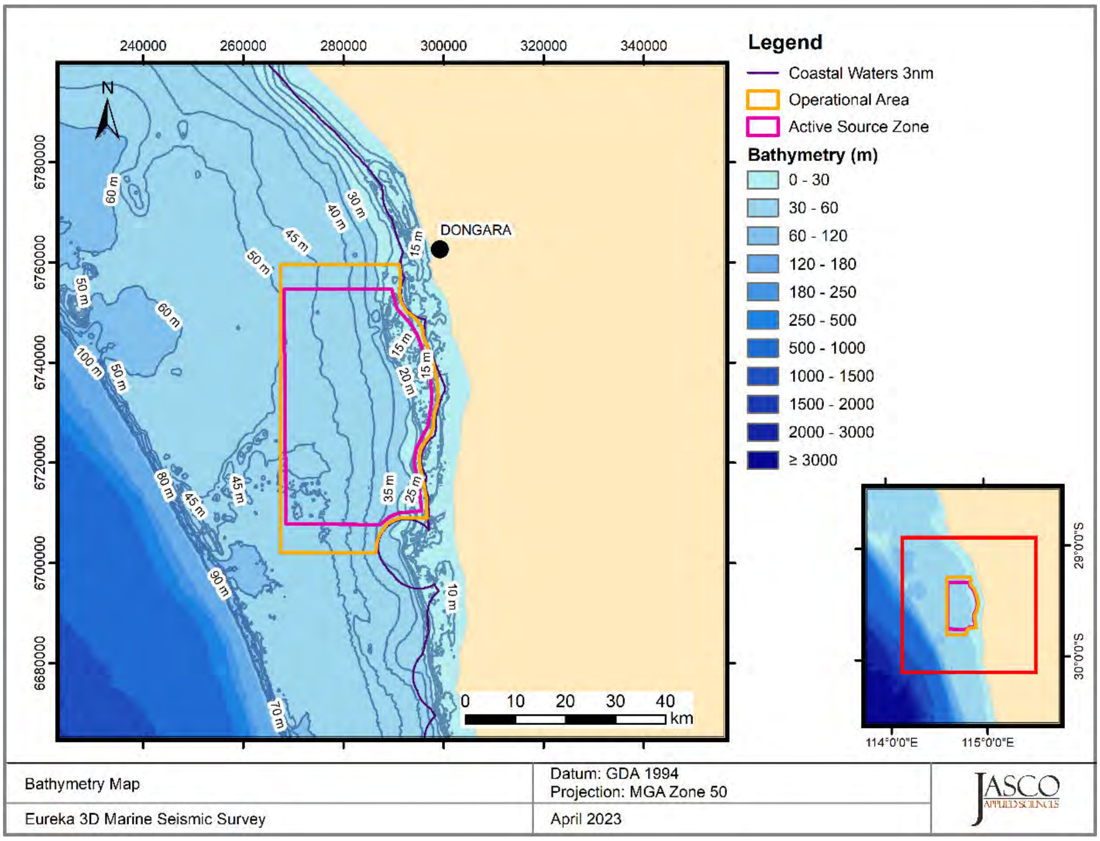


Figure D-4. Bathymetry map of the modelling area for the Eureka Marine Seismic Survey.

D.3.2. Sound Speed Profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the US Naval Oceanographic Office's Generalized Digital Environmental Model V 3.0 (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the US Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles within a 100 km box radius encompassing all modelled sites. The August sound speed profile is expected to be most favourable to longer-range sound propagation during the proposed survey time frame. As such, August was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Figure D-5 shows the resulting profile used as input to the sound propagation modelling.

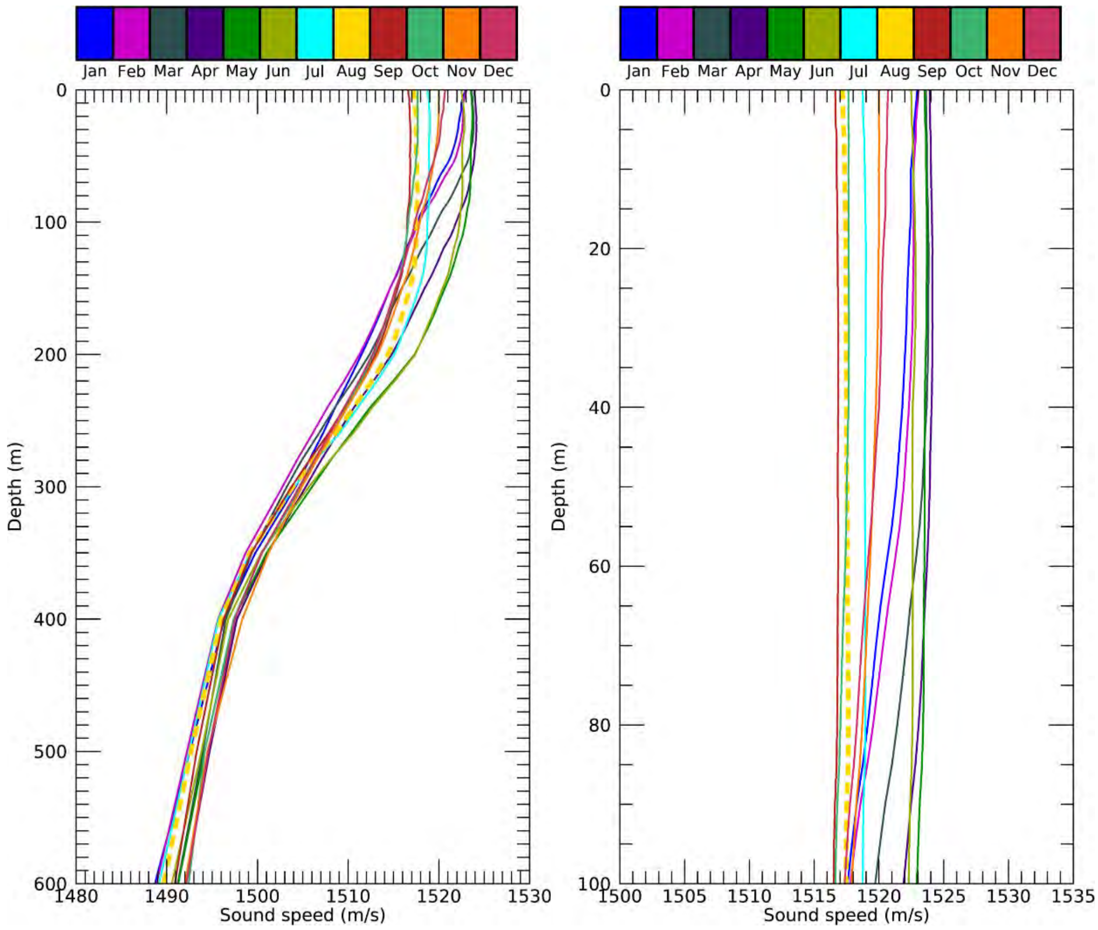


Figure D-5. The sound speed profile used for sound propagation modelling at all sites (August).

D.3.3. Geoacoustics

The propagation models used in this study consider a single geoacoustic profile. Several papers describe a potential geoacoustic models estimated via acoustic inversion (Duncan et al. 2008, Fan et al. 2009). These models consist of a thin sand layer underlain by a semi-cemented limestone/calcarenite bottom. A nominal three-layer representation of the seabed has been proposed based on this information; however, the studies all give slightly different geoacoustic values and layer thicknesses. The seabed model consists of sand/calcarenite/limestone basement where the geoacoustic parameters were averaged and adjusted slightly to obtain representative geoacoustic values. The selected seabed profile is indicative of benthic an environment located on the continental shelf and are consistent with larger scale geological data and interpretations of the Australian continental shelf environment (James and Bone 2010).

Acoustic propagation over calcarenite seabeds generally results in higher rates of loss at distance away from the source as compared to seabeds that contain thick packages of unconsolidated sediments (Duncan et al. 2009), as such additional modelling was conducted to account for the propagation loss associated with a limestone seabed (See Appendix C.3.2). The geoacoustic parameters considered for modelling are provided in Table D-1.

Table D-1. Geoacoustic profile for modelled sites.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–1	Sand	1.73	1848	0.43		
1–451	Semi-cemented Calcarenite	2.37	2672	0.21	400	0.5
>451	Limestone Basement	2.40	3550	0.2		

Appendix E. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

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Technical Memo

DATE: 20 December 2023

FROM: (JASCO Applied Sciences (Australia) Pty Ltd)

TO: RPS

DOCUMENT 03171

VERSION 1.0

Subject: Animal Movement Modelling for the Eureka 3D MSS

JASCO Applied Sciences (JASCO) previously conducted modelling for the Eureka 3D Marine Seismic Survey (MSS) and considered a seismic source array with a volume of 2495 in^3. A change has been requested to include animal movement and exposure modelling for the 2495 in^3 scenario with a shot point interval (12.5 m). Foraging and northbound migrating pygmy blue whales *(Balaenoptera musculus brevicauda)* have been considered. The acoustic and animal movement modelling has been conducted with particular focus on the amount of ensonification of biologically important areas (BIAs) for pygmy blue whales. The migration and known foraging areas for pygmy blue whales are considered herein.

1. Modelling Scenarios

One acquisition scenario was considered using animal movement and exposure modelling. The previous acoustic modelling consisted of both source and propagation modelling, which was conducted at three individual single-impulse sites (Koessler and McPherson 2023). The single impulse sites and the accumulated SEL scenarios were determined based on proposed survey line plans. This study considered a 2495 in^3 seismic source towed in a double array configuration at an assumed speed of ~4.5 knots with an impulse interval (inter-pulse interval) of 12.5 m and a crossline array separation of 50 m.

Table 1 presents the particulars of the scenario and Table 2 presents the sites used in the modelling. Figure 1 presents a map of the spatial extent of the modelled survey lines, sites, and BIAs.

Table 1. Parameters for modelled scenario

Scenario	Source volume (in^3)	Tow depth (m)	Tow direction (°)	Source configuration	Impulse interval (m)	Discharged impulses
2†	2495	6	0 & 180	Double	12.5	8558

† As presented in Koessler and McPherson (2023).

Table 2. Location details for the single impulse modelled sites

Site	Latitude (°S)	Longitude (°E)	MGA[1] Zone 50		Water depth (m)
			X (m)	Y (m)	
4	29° 23' 08.13"	114° 40' 10.60"	273835	6747035	45.0
5	29° 30' 13.53"	114° 40' 17.24"	274276	6733941	47.0
6	29° 22' 53.53"	114° 38' 08.87"	270544	6747419	48.0

[1] Map Grid of Australia (MGA)

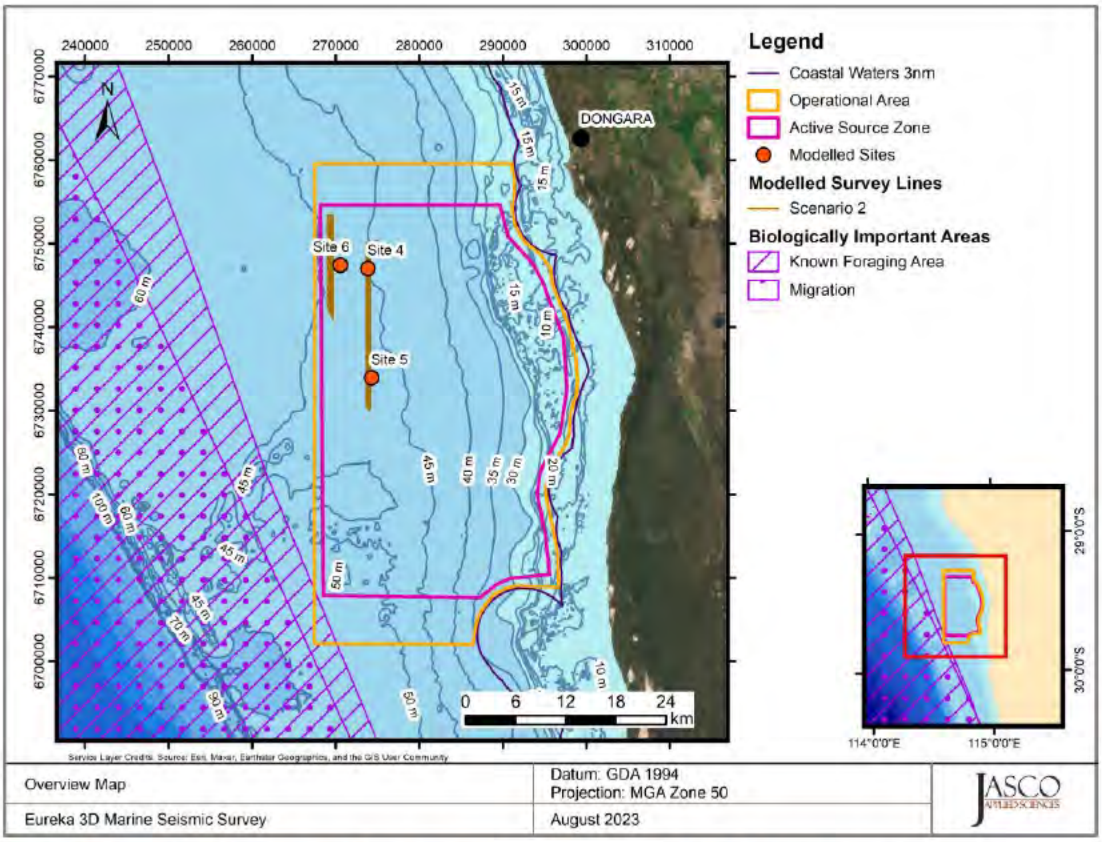

Figure 1. Overview of key survey features, modelled locations, and the survey scenario.

2. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as that from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that have investigated the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

The following noise criteria were chosen because they include standard thresholds, thresholds suggested by the best available science:

1. Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Southall et al. (2019) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals as applied to pygmy blue whales (low-frequency cetaceans, baleen whales).

Further detail on noise effect criteria is provided in Koessler and McPherson (2023).

3. Methods

The methods for acoustic modelling applied herein are the same as presented in Koessler and McPherson (2023). For completeness, the methods employed for animal movement modelling are presented below in Section 3.1.

3.1. Animal Movement and Exposure Modelling

3.1.1. Methodology

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats to sound arising from the seismic activity. JASMINE integrates the predicted sound field with biologically meaningful movement rules for each marine mammal species (pygmy blue whales for the current analysis) that results in an exposure history for each animat in the model. An overview of the exposure modelling process using JASMINE is shown in Figure 2.

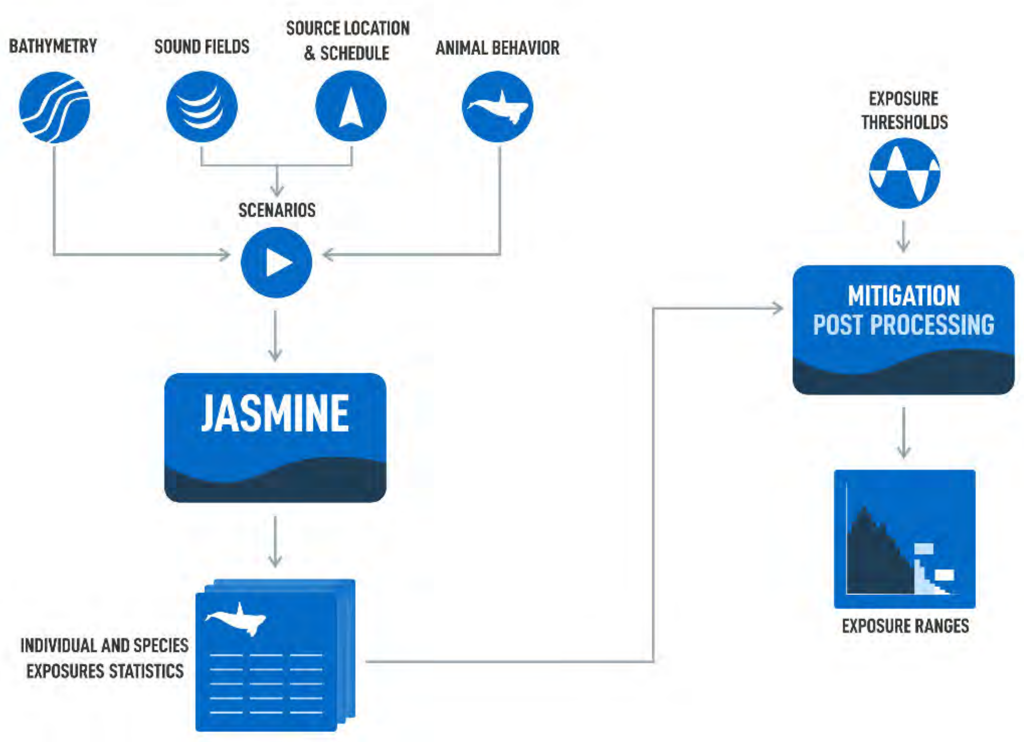

Figure 2. Exposure modelling process overview.

In JASMINE, the sound received by the animats is determined by the proposed seismic operations. As illustrated in Figure 3, animats are programmed to behave like the marine animals that may be present in an area. The parameters used for forecasting realistic behaviours (e.g., diving and foraging depth, swim speed, surface times) are determined and interpreted from marine mammal studies (e.g., tagging studies) where available, or reasonably extrapolated from related or comparable species. For cumulative metrics, an individual animats sound exposure levels are summed over a 24 h duration to determine its total received energy, and then compared to the relevant threshold criteria. For single-exposure metrics, the maximum exposure is evaluated against threshold criteria for each 24 h period. For additional information on JASMINE, see Appendix A.

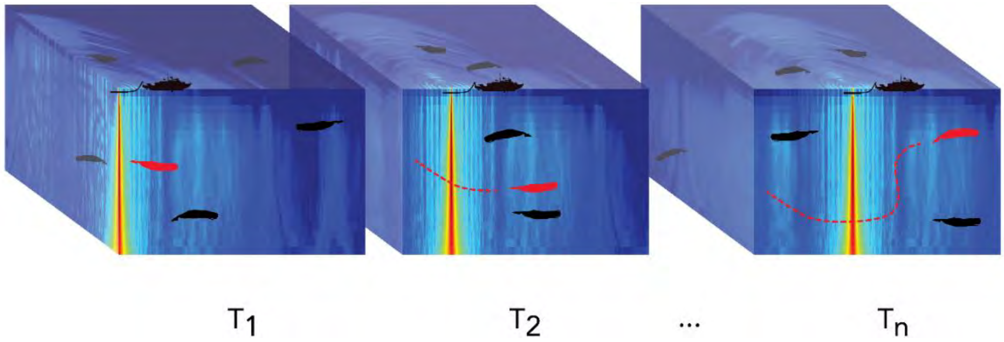

Figure 3. Depiction of animats in a moving sound field. Example animat (red) shown moving with each time step (T_n). The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

The exposure criteria for impulsive sounds (described in Koessler and McPherson (2023)) were used to determine the number of animats that exceeded thresholds. To generate statistically reliable probability density functions, model simulations were run with animat sampling densities of 4 animats/km^2. The modelling results are not related to real-world density estimates for pygmy blue whales within BIAs or known core range area, as the density of animals is not known. To evaluate PTS and TTS, exposure results were obtained using detailed behavioural information for pygmy blue whales (Section 3.1.3.1).

The seismic source was modelled as a vessel towing an airgun array at a speed of 4.5 knots, with an impulse interval of 12.5 m. The simulated source tracks followed a racetrack configuration with no acquisition occurring during turns. At the time and location of each seismic pulse, the modelled source location with the closest distance was selected for exposure modelling. The track lines, along with the acoustic modelling locations, are shown in Figure 1.

Figure 4 shows an example animat track (generated for information purposes only and not related to the results presented in this report) with associated received levels from a stationary point source. The top panel displays the animat track relative to the point source, and the bottom panel displays the accumulation of SEL_{24h} for TTS and PTS criteria. At approximately 50 seconds, the animat is exposed so that the TTS threshold is exceeded, and at approximately 700 seconds the animat is exposed so that the PTS threshold is exceeded.

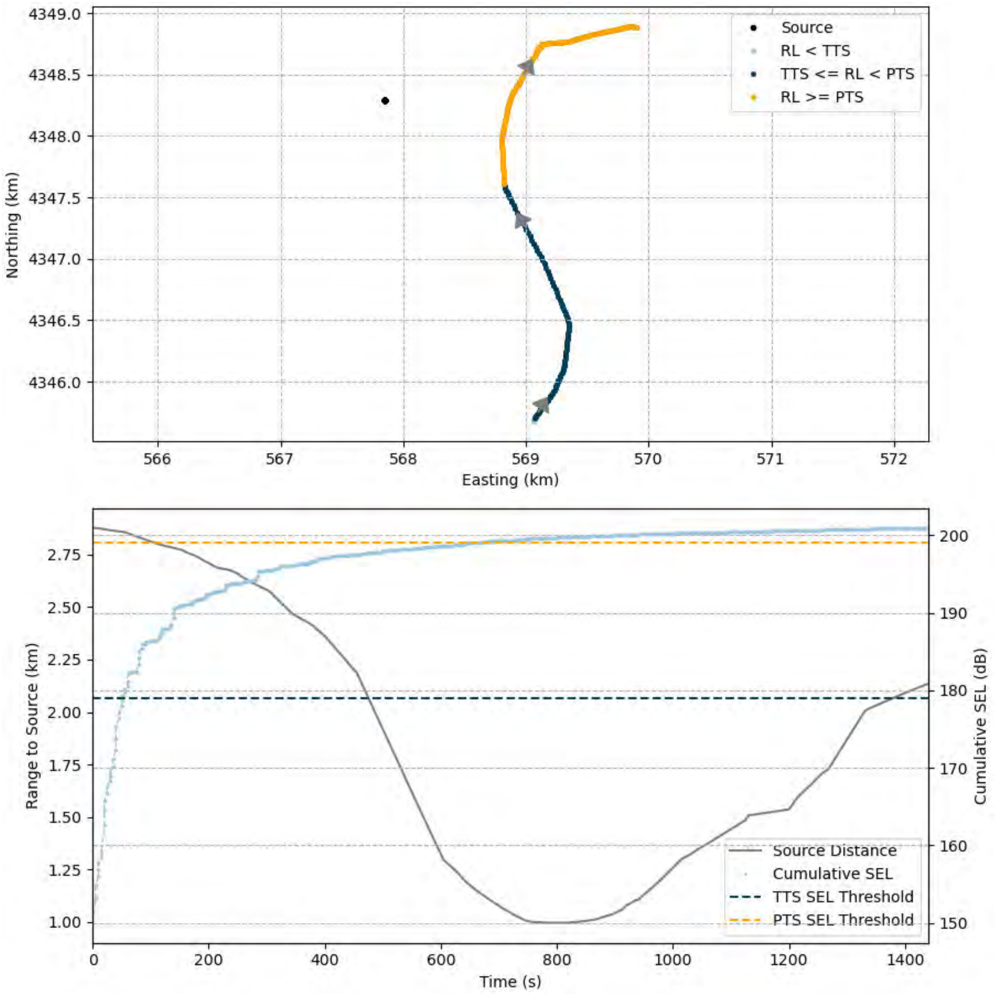

Figure 4. Animat track from an example simulation showing northward movement over a 1400 s duration. The upper panel shows a plan view of both a stationary point source and a foraging animat. Animat steps are coloured to indicate whether the accumulated sound energy at that point has exceeded either TTS or PTS threshold criteria. The lower panel shows horizontal distance in kilometres to the source (grey line; left y-axis) and cumulative 24-h SEL ($L_{E,24h}$, dB re 1 µPa²·s; right y-axis) as a function of time. Note that this example does not use data from the current study.

3.1.2. Exposure–based Radial Distance Estimation

The results from the animal movement and exposure modelling provided a way to estimate radial distances to effect thresholds. The distance to the closest point of approach (CPA) for each of the animats was recorded. The $ER_{95\%}$ (95% Exposure Range) is the horizontal distance that includes 95% of the animat CPAs that exceeded a given effect threshold. Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed threshold criteria. This occurs for several reasons, including the spatial and temporal characteristics of the sound field and the way in which animats sample the sound field over time, both vertically and horizontally. The sound field varies as a function of range, depth, and azimuth based on a variety of factors such as bathymetry, sound speed profile, and geoacoustic parameters. The way the animats sample the sound field depends upon species-typical swimming and diving characteristics (e.g., swim speed, dive depth, surface intervals, and reversals). Furthermore, even within a particular species definition, these characteristics vary with behavioural state (e.g., feeding, migrating). As this results in some animats not exceeding threshold criteria even within the $ER_{95\%}$, the probability that an animat within that distance was exposed above threshold within the $ER_{95\%}$ was also computed (P_{exp}) to provide additional context.

Acoustic ranges are reported for both $R_{95\%}$ and R_{max} (see Appendix D, Koessler and McPherson (2023)), however, exposure ranges are reported for $ER_{95\%}$ only since, statistically, ER_{max} is not defined. JASMINE is a Monte Carlo simulation, and the results are probabilistic in nature. This is in contrast with acoustic modelling, where there is a specific maximum isopleth range for a given source/environment setup.

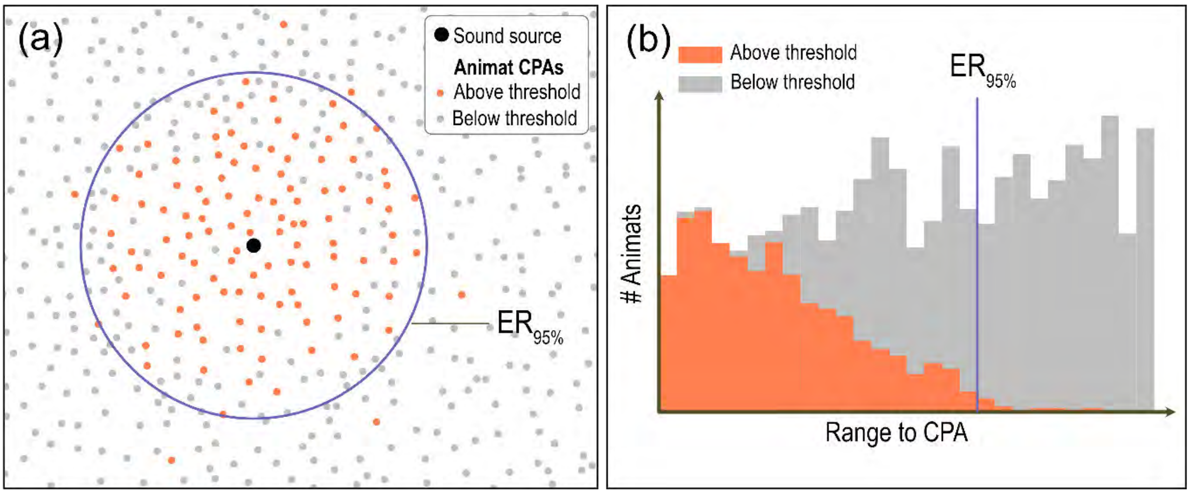

Figure 5. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animats near a sound source. Panel (b) shows the distribution of distances to animat CPAs. The 95% exposure range ($ER_{95\%}$) is indicated in both panels.

3.1.3. Species Specific Behaviour Profile Parameterisation

3.1.3.1. Pygmy Blue Whale Behaviour Profile

The project area is adjacent to the known foraging BIA for pygmy blue whales (DoE (AU) 2015-2025), as well as to the pygmy blue whale migratory BIA (Figure 1). Therefore, animat modelling was undertaken for both foraging and migrating behaviours.

Fine-scale data on foraging behaviour are not currently available for pygmy blue whales. Therefore, data from multi-sensor tags deployed on blue whales (B. musculus) in the North Pacific were used to inform the feeding behaviours. Using intermediate-duration archival tags (SPLASH MK10) attached to eight blue whales off the coast of California, Irvine et al. (2019) determined two primary feeding behaviours: shallow and deep feeding. These two feeding behaviours differed between male and female blue whales, with females generally diving deeper than males during both shallow and deep feeding. In order to account for these differences, foraging female and male pygmy blue whales were modelled separately, with values derived from Irvine et al. (2019). The remaining parameters for feeding behaviour were primarily sourced from Goldbogen et al. (2011b), who deployed 25 multi-sensor suction cup tags (DTAGs) on blue whales off the coast of California. The exceptions were the values for travel speed, which was derived from satellite tags deployed on pygmy blue whales off southern Australia (Möller et al. 2020), and surface interval, which was derived from a satellite tag deployed on a pygmy blue whale off western Australia (Davenport et al. 2022).

The migratory pygmy blue whale behaviour profile was not split by gender as there is no evidence for sex-related differences in migratory behaviour. The migratory profile included both migratory and exploratory dives (i.e., shallow dives with no indication of feeding) based on detailed information from Owen et al. (2016), who equipped a sub-adult pygmy blue whale with a multi-sensor tag off Western Australia. Migrating pygmy blue whales were not modelled undertaking feeding behaviour, as per the findings of Owen et al. (2016). In the migratory profile, the two dive types were modelled together such that the animats were migrating 95% of the time and engaged in exploratory dives 5% of the time (Owen et al. 2016). Using data from Owen et al. (2016), the approximate length of a bout of exploratory dives could be determined, as well as the average (± SD) depth of this dive type. The analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. The mean depth of migratory dives was 14 ± 4 m while the mean maximum depth of exploratory dives was 107 ± 81 m. Additional parameters regarding pygmy blue whale behaviour were derived from sources that used multi-sensor tags to record fine-scale dive and movement data (Owen et al. 2016, Möller et al. 2020). Where information was unavailable for pygmy blue whales, parameters were derived from blue whale tagging data (Goldbogen et al. 2011a), as per the foraging profile.

The behaviour of migrating pygmy blue whales was modelled to reflect animats transiting through the modelling area on a 334° track during the northbound migration. This represents the animals migrating along the west coast of Australia to Indonesia (Double et al. 2014, DoE (AU) 2015-2025). The speed of travel for migratory behaviour (1.17 ± 0.60 m/s) and exploratory dives (0.88 ± 0.14 m/s) were calculated from data presented in Möller et al. (2020).

4. Results

Details of the acoustic modelling results can be found in Koessler and McPherson (2023).

4.1. Animal Movement Exposure Ranges

A summary of radial distances to exposure thresholds for pygmy blue whales, along with probability of exposure for each modelled scenario (Section 1) are included below. Table 3 shows results for scenarios for foraging and migrating pygmy blue whale animats. Results include $ER_{95\%}$ exposure ranges calculated for the SEL_{24h} thresholds for both TTS and PTS, and the probability of an animat being exposed above the threshold within the $ER_{95\%}$.

Section 4.1.1 includes histograms of CPA ranges to SEL_{24h} PTS and TTS with results in Table 3.

Table 3. Summary of animat simulation results for pygmy blue whales. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided. The modelled array volume and inter-pulse interval are also provided in brackets below.

Noise Effect Criteria Description	Scenario 2 (2495 in^3, 12.5 m)					
	Foraging				Migrating	
	Female		Male			
	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
PTS (SEL_{24h})[1]	0.89	63	0.82	66	0.63	54
TTS (SEL_{24h})[2]	14.5	57	13.7	59	8.47	70

[1] LF-weighted SEL_{24h} (183 dB re 1 $\mu Pa^2 \cdot s$) (Southall et al. (2019))
[2] LF-weighted SEL_{24h} (168 dB re 1 $\mu Pa^2 \cdot s$) (Southall et al. (2019))

4.1.1. Exposure Range Histograms: Pygmy Blue Whales

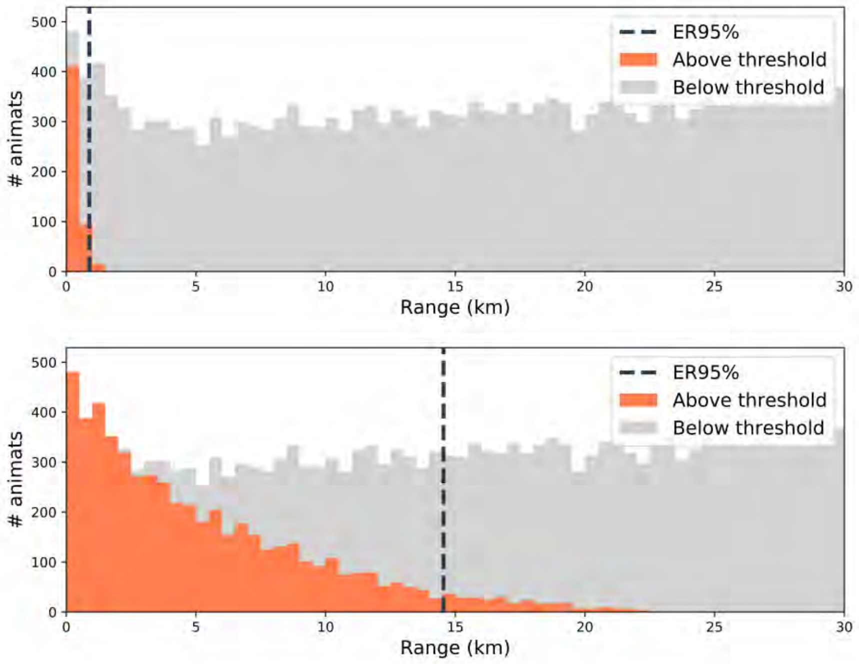

Figure 6. *Scenario 2*, *foraging female pygmy blue whale animats*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel) and SEL_{24h} TTS threshold (bottom panel).Bar colours indicate whether the animats exceeded the threshold.

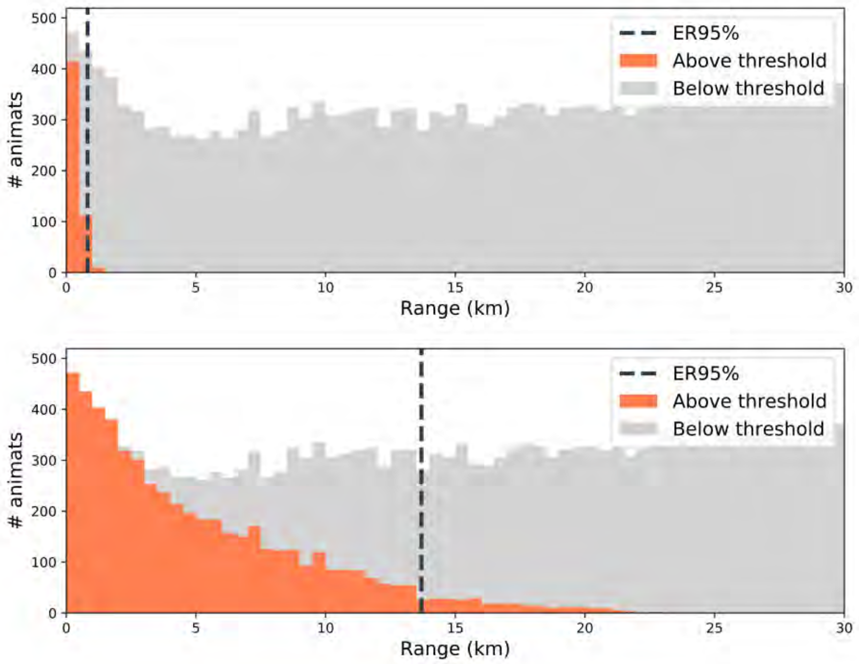

Figure 7. *Scenario 2, foraging male pygmy blue whale animats*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel) and SEL_{24h} TTS threshold (bottom panel).Bar colours indicate whether the animats exceeded the threshold.

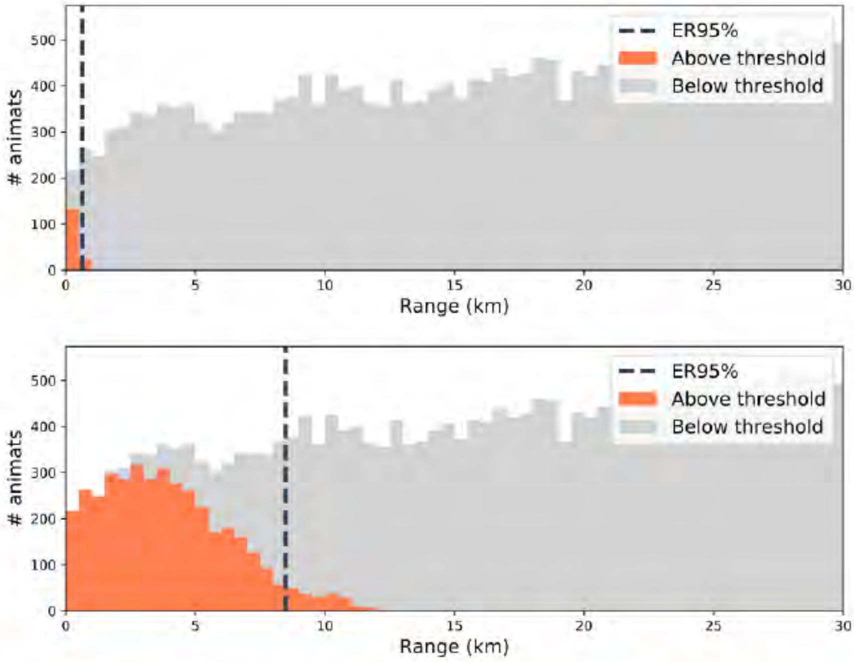

Figure 8. *Scenario 2, migrating pygmy blue whale animats*: CPA range histogram for animats, SEL_{24h} PTS threshold (top panel) and SEL_{24h} TTS threshold (bottom panel).Bar colours indicate whether the animats exceeded the threshold.

5. Discussion

5.1. Animal Movement Modelling

The estimated sound fields produced by source and propagation models for the planned Eureka MSS were incorporated into an animat sound exposure model for pygmy blue whales to estimate the radial distance within which 95% of exposure exceedances occur ($ER_{95\%}$), along with the probability that an animat with its closest point of approach within that distance would be exposed above the relevant threshold (P_{exp}).

For this exposure analysis, one nominal acquisition scenario with an impulse interval of 12.5 m was run for foraging and northbound migrating pygmy blue whales. The nominal acquisition scenario is located approximately 13.5 and 18.5 km outside of the known core range area and the migrating BIA, respectively. Animats were not restricted to the known core range area or BIA.

Section 5.1.1 summarises the PTS and TTS exposure range results, with the summarised results presented in Table 4.

Table 4. Summary of animat simulation results for PTS and TTS criteria for pygmy blue whales. Maximum exposure ranges show $ER_{95\%}$ (km) first and probability of exposure of animats travelling within the $ER_{95\%}$ (P_{exp} (%)) in parentheses.

Species	Scenario	TTS (SEL_{24h})[2]	PTS (SEL_{24h})[2]
		168[1]	183[1]
Pygmy blue whale	2 (2495 in^3,12.5 m)	14.5	0.89

[1] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)

[2] Southall et al. (2019) criteria for marine fauna.

5.1.1. PTS and TTS

Exposure ranges from animal movement modelling for PTS and TTS criteria are typically shorter than those predicted using acoustic propagation modelling because moving animats generally accumulate sound energy over a shorter time ('dwell time'). In this study, PTS and TTS exposure ranges were substantially shorter than acoustic ranges to threshold.

All considered scenarios with unrestricted animat seeding resulted in exposures above the PTS and TTS thresholds. The maximum $ER_{95\%}$ for PTS and TTS were 0.89 and 14.5 km, respectively, with corresponding exposure probabilities for animats travelling within that range of 63% and 57%, indicating that 37% and 43% of animats that travelled within the 95th percentile range were not exposed above threshold. This is because the modelled animats move in and out of the ensonified area and change their vertical position in the water column, thereby influencing the length of time they are within the exposure radius. For example, an animat might approach within the predicted exposure range but if they are traveling more quickly on average than other animats, they may not accumulate as much sound exposure, or they may spend more time at depths where sound levels are lower.

The animal movement and exposure modelling presented herein is a more realistic estimate of the dosimetric impact potential for accumulated sound exposure compared to static receiver accumulated sound exposure modelling scenarios presented in Koessler and McPherson (2023) .

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Appendix A. Animal Movement and Exposure Modelling

Animal movement and exposure modelling considers the movement of both sound sources and animals over time. Acoustic source and propagation modelling are used to generate 3-D sound fields that vary as a function of distance to source, depth, and azimuth. Sound sources are modelled at representative sites and the resulting sound fields are assigned to source locations using the minimum Euclidean distance. The sound received by an animal at any given time depends on its location relative to the source. Because the true locations of the animals within the sound fields are unknown, realistic animal movements are simulated using repeated random sampling of various behavioural parameters. The Monte Carlo method of simulating many animals within the operations area is used to estimate the sound exposure history of the population of simulated animals (animats).

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an events occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more simulated animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is typically much higher than real-world animal density to ensure good representation of the PDF. The resulting PDF can be scaled using real-world density when such data are available.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behaviour. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behaviour model (3MB, Houser 2006) and used to predict the exposure of animats to sound arising from the anthropogenic activities. Animats are programmed to behave like the species likely to be present in the survey area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animats modelled sound exposure levels are summed over the total simulation duration to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as 3MB (Houser, 2006), but has been extended to be directly compatible with JASCO's Marine Operations Noise Model (MONM) and Full Waveform Range-dependent Acoustic Model (FRAWM) acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioural states based on time and space dependent modelled variables such as received levels for aversion behaviour, although aversion was not considered in this study.

A.1.1. Animal Movement Parameters

JASMINE uses previously measured behaviour to forecast behaviour in new situations and locations. The parameters used for forecasting realistic behaviour are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behaviour of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behaviour states. The probability of an animat starting out in or transitioning into a given behaviour state can in turn be defined in terms of the animats current behavioural state, depth, and the time of day. In addition, each travel parameter and behavioural state has a termination function that governs how long the parameter value or overall behavioural state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

- **Direction**– determines an animats choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviours with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).
- **Travel rate**–defines an animats rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate**–defines an animats rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate**–defines an animats rate of travel in the vertical plane during the descent portion of a dive.
- **Depth**–defines an animats maximum dive depth.
- **Reversals**–determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behaviour is used to emulate the foraging behaviour of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval**–determines the duration an animat spends at, or near, the surface before diving again.

A.1.2. Exposure Integration Time

The interval over which acoustic exposure (LE) should be integrated and maximal exposure (Lp) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behaviour collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. For this study, a representative 24-hour period was simulated.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the source during an operation is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

A.1.3. Seeding Density and Scaling

Seeding density refers to the spatial sample rate, in units of animats/km^2, used in the simulation. It is not related to the real-world animal density, but rather is a model parameter that controls how samples are drawn from the model space. The minimum required seeding density for any given project depends on several factors such as bathymetry, source characteristics, and the behavioural profile of the animats, with the main constraint being computation time and resources. Seeding density is adjusted as needed based on model conditions specific to a project or project area.

In the present study, the exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 4 animat/km^2 over the entire simulation area. The modelling results are not related to real-world animal densities as this data is not available, and the number of real-world animals potentially exposed could not be calculated.