EUREKA 3D MARINE SEISMIC SURVEY

ENVIRONMENT PLAN

Rev 6

EUK-EP-001:5

3 October 2025

Document Status					
Version	**Purpose of document**	**Authored by**	**Reviewed by**	**Approved by**	**Review date**
Draft A	Draft for internal review	RPS	RPS	NA	26/01/2024
Rev 0	Final for issue	RPS	RPS	RPS	31/01/2024
Rev 1	Revised for Issue	RPS	RPS	RPS	13/05/2024
Rev 2	Revised for Issue	RPS	RPS	RPS	12/06/2024
Rev 3	Revised for Issue	Klarite	Klarite	Pilot Energy	8/05/2025
Rev 4	Revised for Issue	Klarite	Klarite	Pilot Energy	15/08/2025
Rev 5	Revised for Issue	Klarite	Klarite	Pilot Energy	17/09/2025
Rev 6	Revised for Issue	Klarite	Klarite	Pilot Energy	3 October 2025

Approval for issue	
Klarite	3 October 2025

Acknowledgement
This report builds upon the initial work prepared by RPS, who provided the foundational drafts and technical inputs. We acknowledge their contribution and thank them for their efforts in developing the earlier drafts of this document.

Prepared by:

Klarite Pty Ltd

Prepared for:

Pilot Energy Limited

Michael Lonergan
Head of Upstream

Suite 2, 100 Havelock Street
West Perth, WA, 6005

T: +61 448 080 177
E: mlonergan@pilotenergy.com.au

Contents

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 titleholder's environmental performance	Section 10
Response arrangements in the Oil Pollution Emergency Plan	Appendix E
Consultation undertaken	Section 0 and Appendix D
Details of the titleholders nominated liaison person for the activity	Section 1.3.

1.2 Scope of this environment plan

Pilot Energy Limited (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 Titleholder and Nominated Liaison Person

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.

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 Limited ABN: 86 115 229 984	Mike Lonergan Business Address: Suite 2, 100 Havelock Street West Perth, WA, 6005 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 WA State legislation

Given the proximity of the planned Eureka 3D MSS to the Western Australia state boundary Pilot Energy had regard for the following WA State legislation:

1. Fisheries Resource Management Act 1994 (WA) – this act regulates the management and conservation of fish and fish habitats. The WA Department of Primary Industries and Regional Development (DPIRD) is the regulatory body for this Act, and they were consulted as a relevant person for this EP.
2. Environmental Protection Act 1986 (WA) – This Act provides the framework for environmental protection in Western Australia. It includes provisions for assessing the environmental impact of proposed activities in WA state areas. The Office of the EPA was consulted as a relevant person for this EP.
3. Biodiversity Conservation Act 2016 (WA) – this Act focuses on the conservation of biodiversity, including threatened species and ecological communities. The list of threatened fauna for WA has been checked and there are no additional species that would be relevant to the EMBA or OA. The Department of Biodiversity, Conservation and Attractions (DBCA), as the management agency for this Act, has been consulted as a relevant person for this EP.
4. Aboriginal Heritage Act 1972 (WA) – this Act protects Aboriginal heritage sites in Western Australia. DPLH, as the management agency, has been consulted as a relevant person for this EP.
5. Emergency Management Act 2005 – This Act provides for the DoT functions as the Hazard Management Agency for marine spills.

2.3 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: To provide for managing the following: Biosecurity risks The risk of contagion of a listed human disease 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 Risks related to ballast water Biosecurity emergencies and human biosecurity emergencies To give effect to Australia's international rights and obligations, including under the International Health Regulations, the SPS Agreement and the Biodiversity Convention. Biosecurity Amendment (Biofouling Management) Regulation 2023 served to amend the Biosecurity Regulation 2016 with the following insertion (after paragraph 48(2)(o)): 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.	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

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
	Details of any inspections of the vessel for biofouling, cleaning of biofouling or treatment for biofouling intended while the vessel is in Australian territory. Practices included in any plan of biofouling management for the vessel that is currently in use. Details of the voyage history of the vessel in the past 12 months.		
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 to comply with the Biosecurity Act.	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 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: Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations 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 The principle of inter-generational equity -- that the present generation should ensure that the health, diversity and productivity of the	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
	environment is maintained or enhanced for the benefit of future generations The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making 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. 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.	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 sources to whales in biologically important habitat areas or during critical behaviours.	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 policy statement outlines standard management procedures, which include: Pre-start-up visual observations Soft-start procedures	

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
	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.	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 4.4.9 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	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.	NOPSEMA

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
(Environment) Regulations 2023		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 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	AMSA

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
		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.	
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. Section 8 details where the applicable requirements apply to the survey.	AMSA
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'	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

Requirements	Scope (as relevant to this EP)	Application to Eureka 3D MSS	Administering authority
Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) 2011			
Australian Biofouling Management Requirement, Version 2 (DAFF, 2023)	The Australian Biofouling Management Requirements set out vessel operator obligations for the management of biofouling when operating vessels under biosecurity control within Australian territorial seas. These requirements reduce the risk of introducing harmful aquatic organisms into Australia's marine environment through biofouling from 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
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 except for 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*.
China-Australia Migratory Bird Agreement (CAMBA) 1988	Signatories to CAMBA, JAMBA and ROKAMBA are committed to cooperating and taking appropriate measures to preserve and enhance the environment of	The survey is designed, sited and managed such that there is no measurable disruption in the lifecycle (breeding, feeding, migration

Agreement	Scope (as relevant to this EP)	Relevance
Japan-Australia Migratory Bird Agreement (JAMBA) 1981 Republic of Korea Migratory Bird Agreement (ROKAMBA) 2007	migratory birds by seeking means to prevent damage to such birds and their environment. These agreements recognise the existence of special international concern for the protection of migratory birds and those species that are known to migrate between each of the countries.	or resting behaviour) of an ecologically significant proportion of the population of a migratory species or their habitats.
Agreement on the Conservation of Albatrosses and Petrels (ACAP) 2004	A multilateral agreement which seeks to conserve albatrosses and petrels by coordinating international activity to mitigate known threats to their populations. The Agreement provides a focus for international cooperation, exchange of information and expertise and the implementation of conservation measures for these threatened seabirds on land and at sea.	The survey is designed, sited and managed such that activities are not inconsistent with the ACAP and conservation measures for identified in Article III of the Agreement.
Convention on the Conservation of Migratory Species of Wild Animals (CMC or Bonn Convention) 1980	An environmental treaty of the United Nations that provides a global platform for the conservation and sustainable use of terrestrial, aquatic and avian migratory animals and their habitats.	The survey is designed, sited and managed such that activities are not inconsistent with the Fundamental Principles identified in Article II of the Agreement.

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.

Standard / guideline	Description
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.
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 are:

- ASA: Range for the active source within the streamer area from approximately 20m – 52m and the Nodal area ranging from approximately 11 – 35m, although the source will not be activated in depths of less than 10m.
- Operational area: Range from approximately 1–65 m.

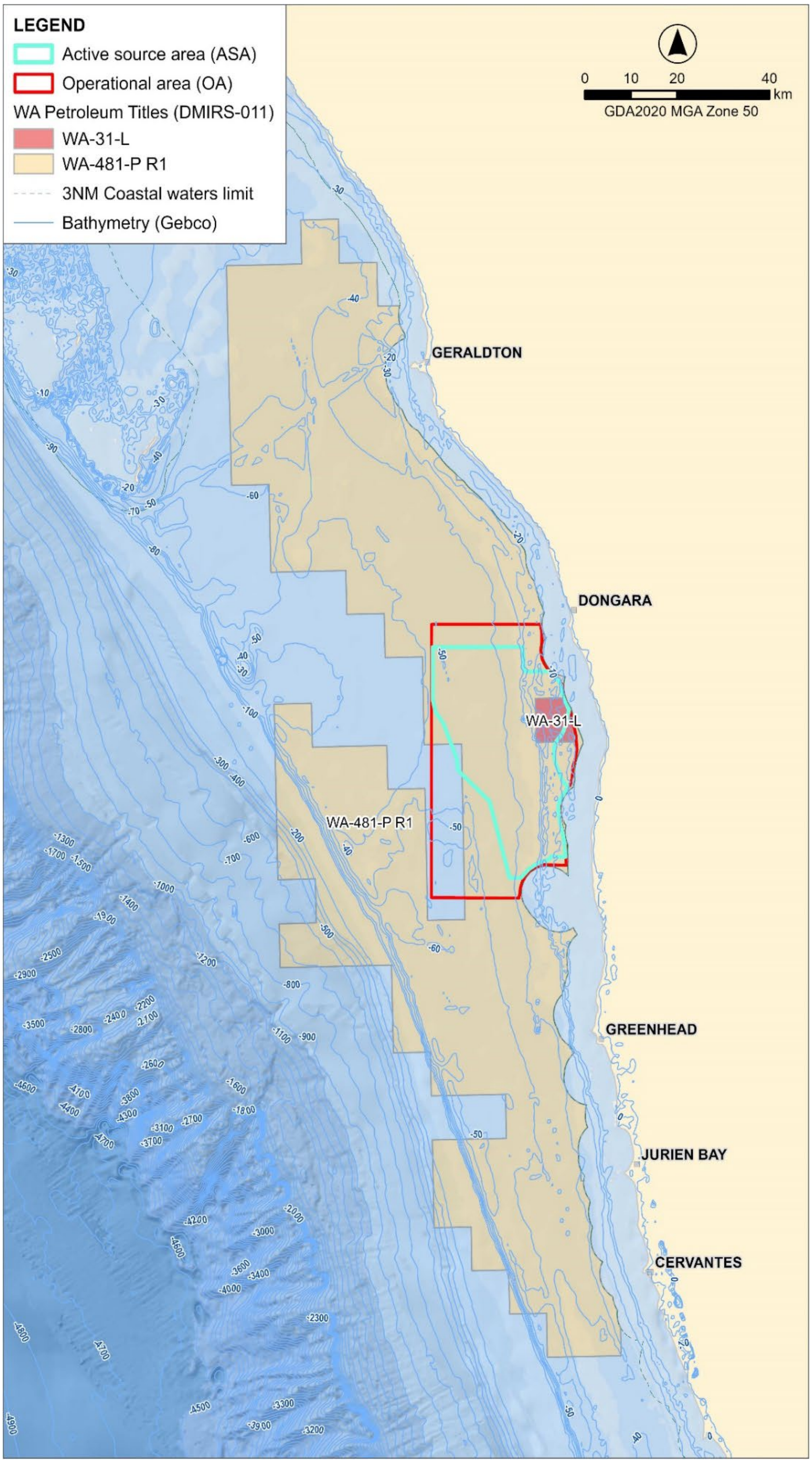


Figure 3-1: Eureka 3D MSS Active Source Area and Operational Area overlapping Petroleum Titles

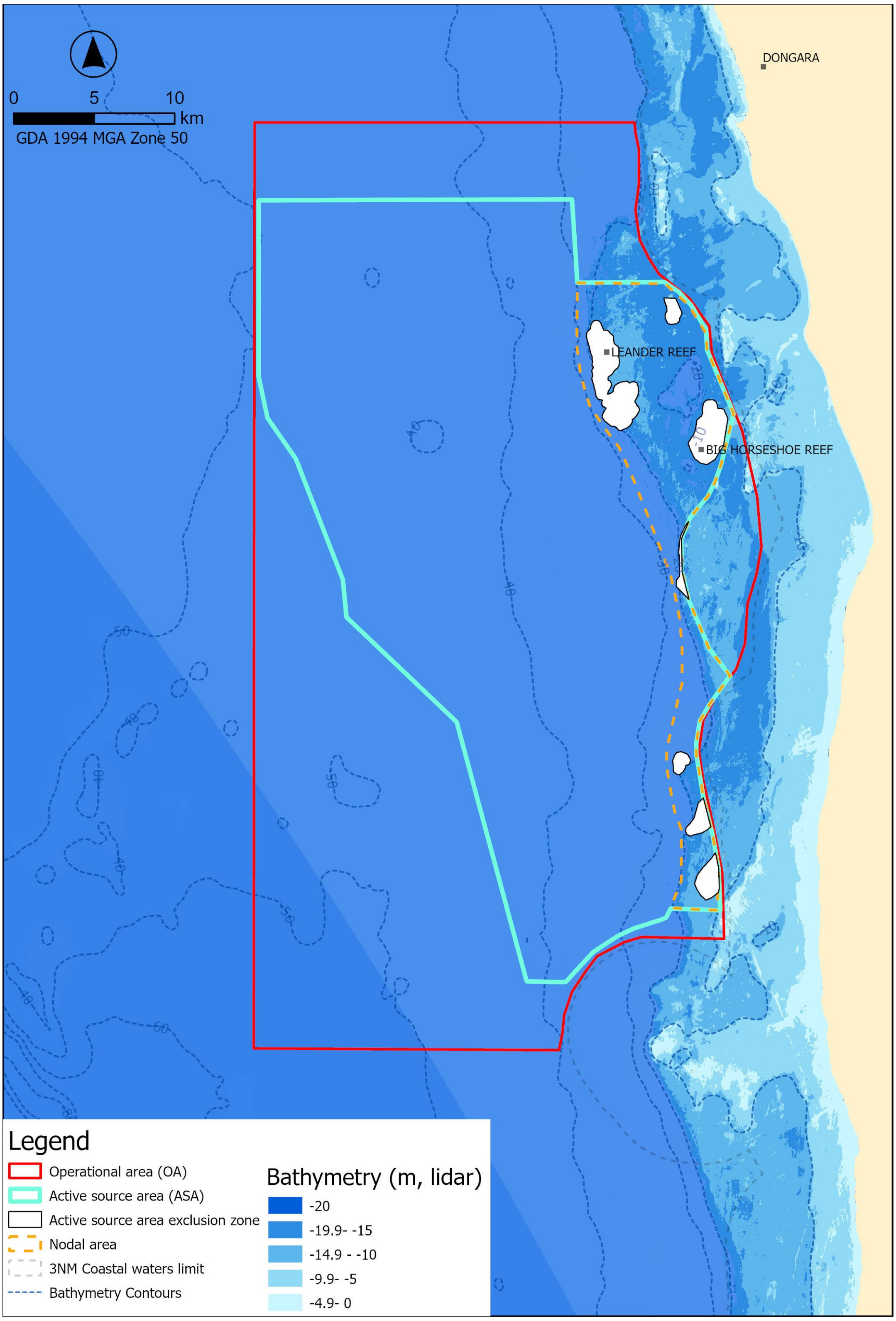


Figure 3-2: Eureka 3D MSS Active Source Area and Operational Area

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 runouts, 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 streamer acquisition will take place, where data will be acquired by a vessel towing the seismic source and streamers, and an inshore area (called the nodal area), where nodal acquisition will take place, 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 20 m.

Within the nodal area there are designated exclusion zones (Figure 3-2). These are areas that the seismic source will not be discharged due to proximity to known large 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. Whilst other shallow water areas are not specifically identified within the defined ASA, the seismic source will not be discharged in water depths of less than 10m.

Within the active source area, a shallow reef is characterized as a spatial feature with an area exceeding 0.25 square kilometers, rising more than 10 meters from the sea floor, located in water depths of 20 meters or less, and having a clearly defined edge, is defined as significant.

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.

Given the multiple shallow areas within the OA, and the potential tidal variations affecting known bathymetry databases, all vessels will operate with a minimum under keel clearance of 2m for a support vessel (unless specifically scouting water depths), and 5m for the seismic vessel at all times. Any vessel operating in water depths of less than 12m will be fitted with sonar and depth sounders.

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
		-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 2026 to 31 March 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 in 2 phases, one phase utilising 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 the source will not be operated in depths of less than 20m. The other phase will utilise a source vessel towing the seismic source at a depth of 5m below the sea surface, whilst the receivers are comprised of nodes located on the sea floor in water depths of up to 30m. The seismic source for this phase will consist of an array of airguns varying in volume, with a total volume not exceeding 1420cuin, and will not be activated in water 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. The conservative case for streamers is for there to be six as a minimum which results in a 300m sail line separation. If the contractor were to suggest an eight-streamer vessel, line separation would increase to 400m.

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)	100 m shotpoint interval (per source line), 50 m effective interval due to flip-flop shooting on staggered 50 m sail lines. 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 towed streamer / 1420 in^3 nodal
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 towed streamer/5 m nodal
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

Parameter	Eureka 3D MSS
Other vessels	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 like 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 three areas, a western and eastern portion, and the nodal area. The western portion is currently planned to be completed first, followed by the eastern portion with the nodal area being acquired last (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. There may be some concurrent activities with nodes being laid in the nodal area whilst the western portion commences acquisition, however this will depend on vessel availability and weather conditions.

During line runouts, 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.

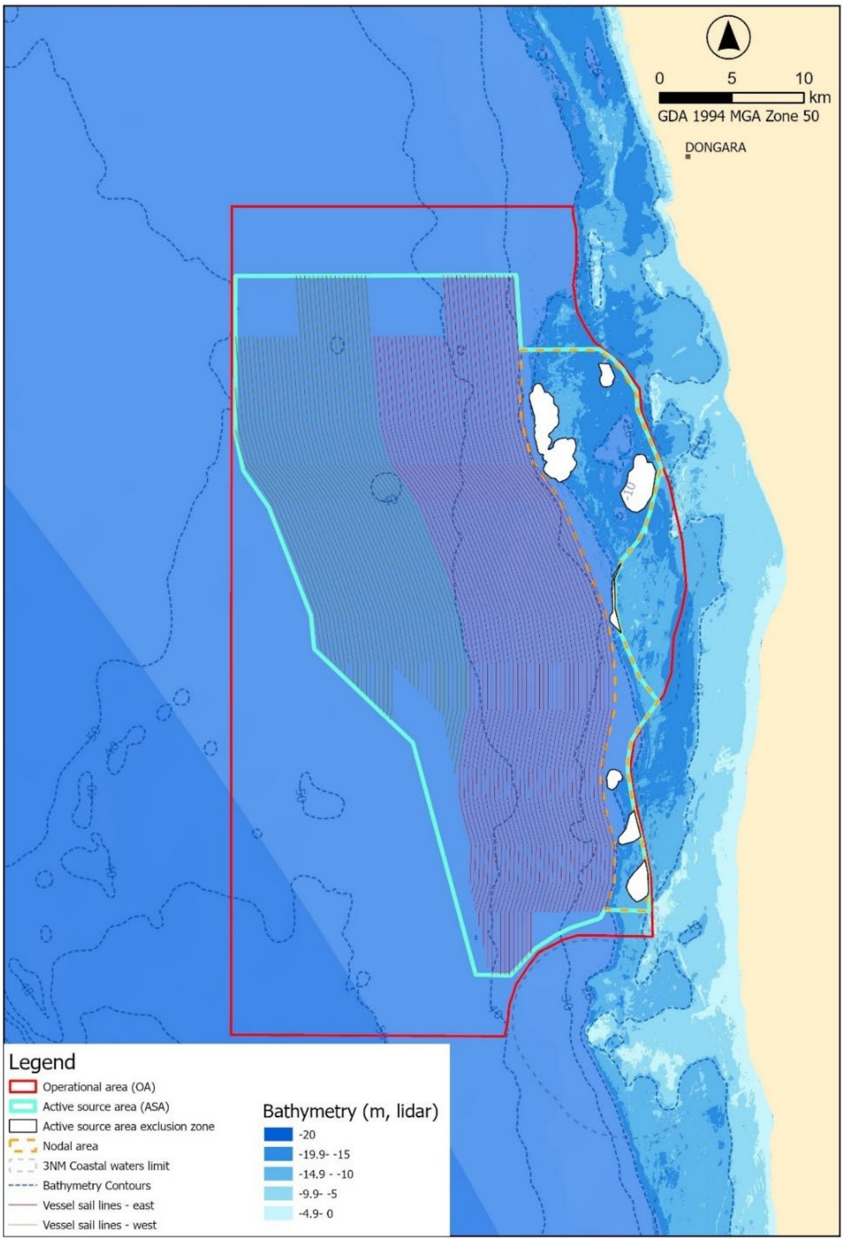


Figure 3-3: Sail lines in the east and west and nodal area showing exclusion zones

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 for nodal acquisition (Figure 3-2 and Figure 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 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 node density of approximately 200/km^2. Pilot will use a smaller source, of max volume 1420 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. While the shot point interval along each individual source line is 100 m, the use of staggered source lines and flip-flop shooting results in an effective shot point interval of 50 m across the area. This firing pattern aligns with the assumptions used in the acoustic modelling by JASCO and reflects the expected operational approach. 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.

Whilst it is expected that the streamer component of the survey will be acquired prior to the nodal phase, given the short acquisition window, the final decision on order of acquisition will be dependant on environmental factors such as weather forecasts. Regardless of the order of acquisition, the nodes are expected to be deployed for the majority of the survey duration. 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, with the nodal deployment being expanded into these deeper waters.

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 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 bara-vanes, 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.

3.3.6 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

Pilot Energy acknowledges the Traditional Owners of the lands and seas connected to the survey area and recognises their enduring cultural authority and connection to Country. We respect that all living beings, places, and natural features may hold cultural significance, and that totemic species, sacred sites, and Dreaming tracks form part of the cultural and spiritual fabric of Traditional Owners' lives. Accordingly, all species, habitats and places described in this chapter are recognised as potentially carrying cultural values in addition to their ecological roles. This acknowledgement reflects Pilot Energy's commitment to respectful engagement and ensures that new or previously unrecorded cultural values identified during consultation are given due consideration.

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 a 6-hour surface 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.

4.1.1 Regional context –South-west Marine Region

The OA is 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).

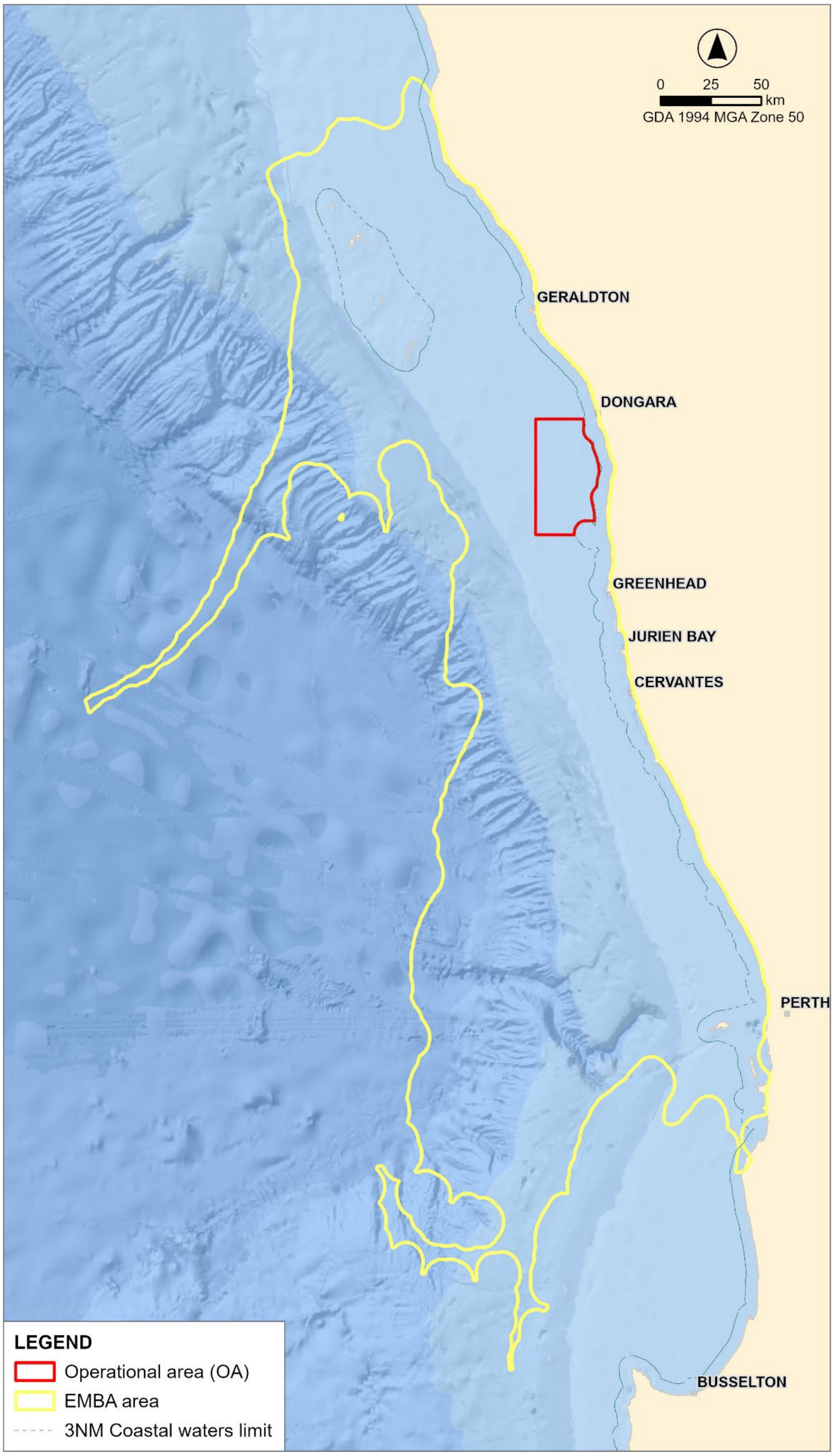


Figure 4-1: Operational area and EMBA for the Eureka 3D MSS

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.

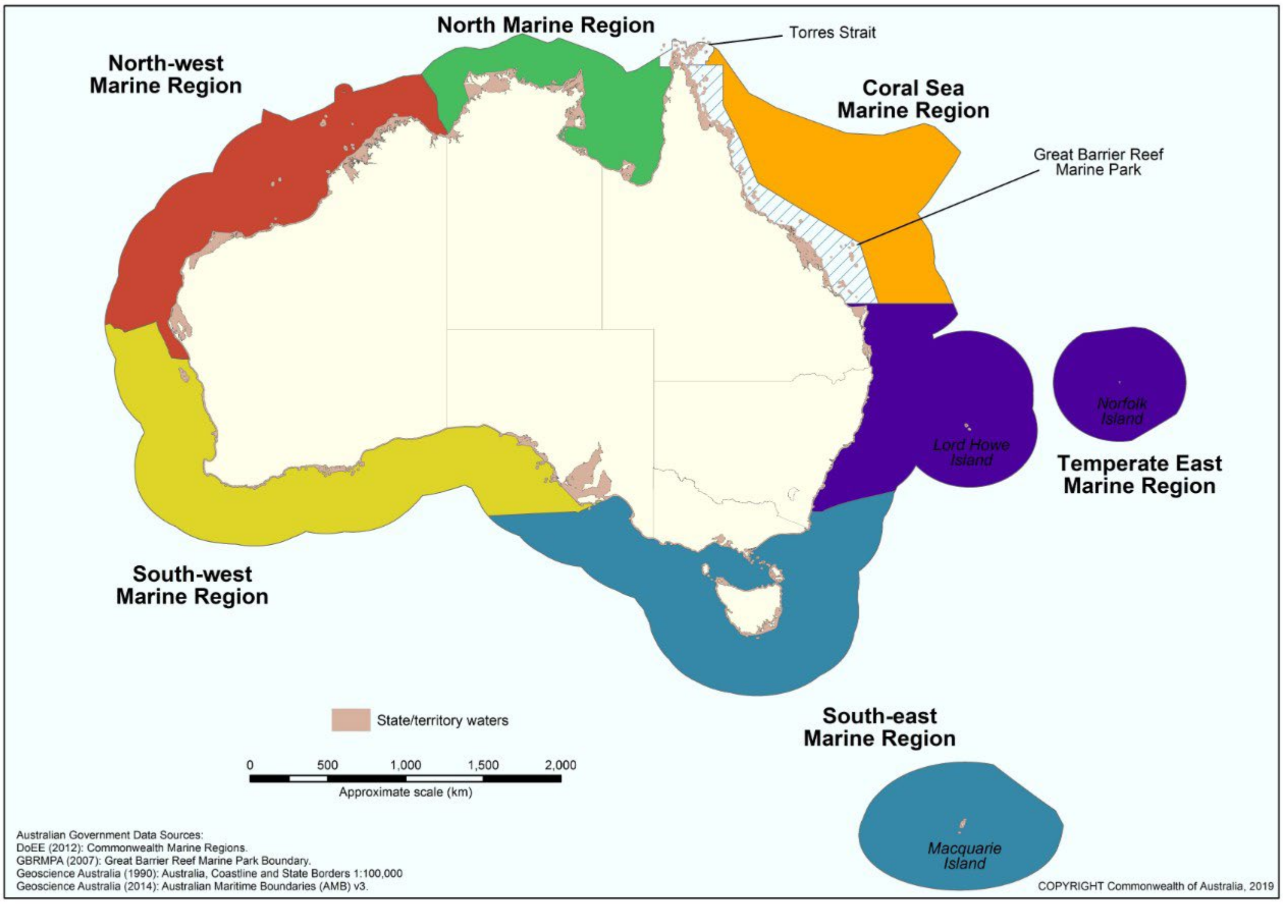


Figure 4-2: Marine bioregions of Australia (Source: DCCEEW 2019a)

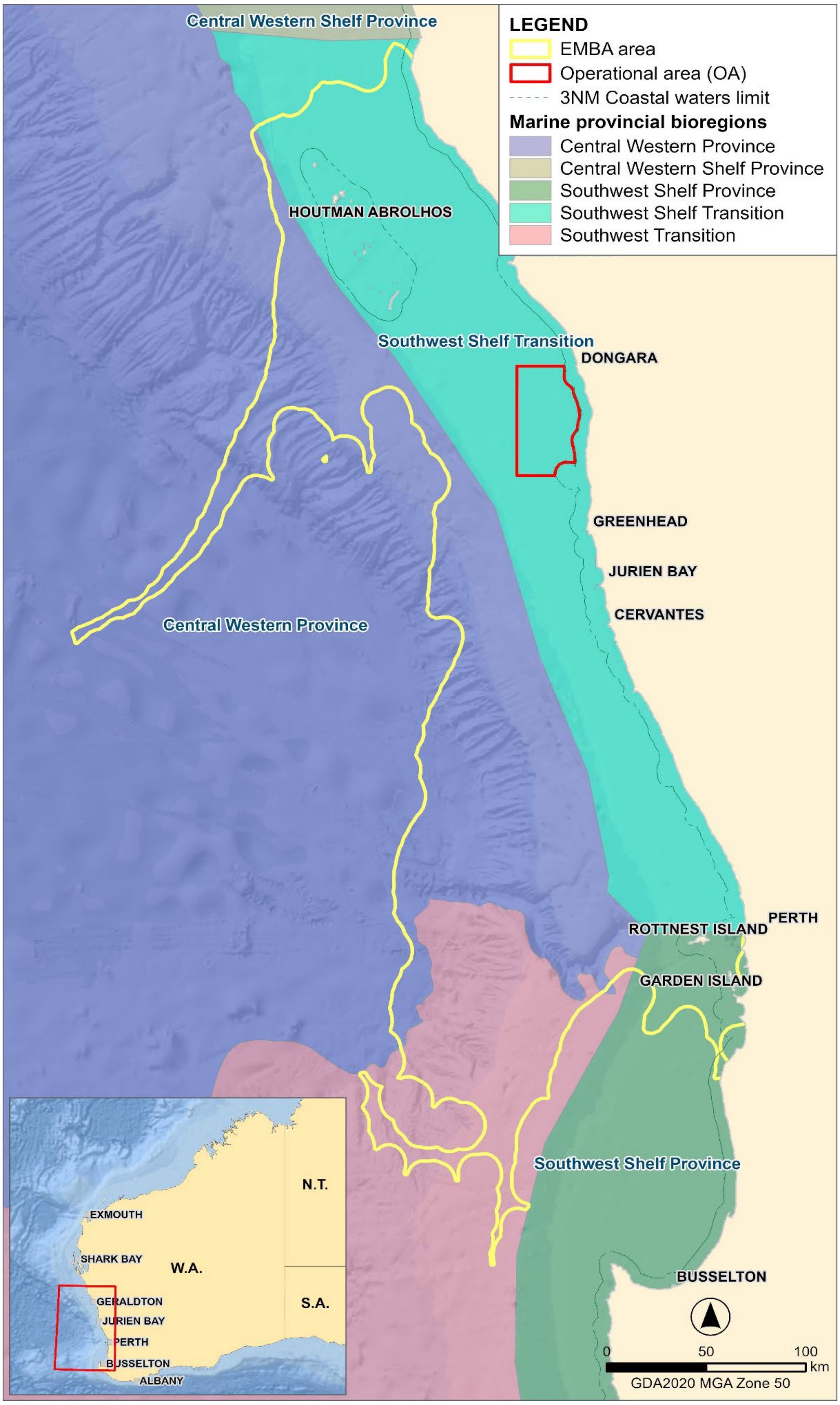


Figure 4-3: Provincial bioregions (IMCRA v4.0) (source: North-West Atlas/DCCEEW 2023)

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 is a significant feature in the bioregion. Eddies detach from the LC and spin anticlockwise, 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).

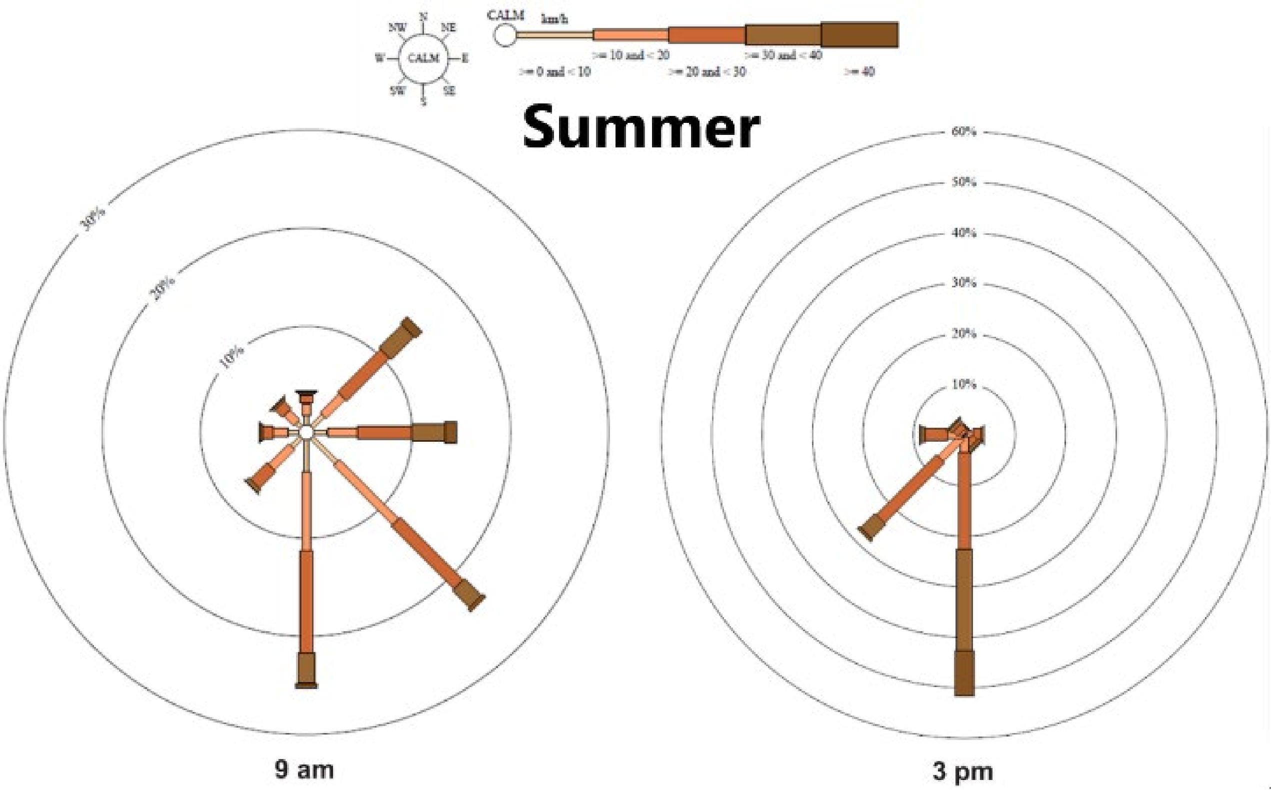


Figure 4-4: Wind roses for Geraldton, showing direction (%) vs wind speeds (km/h) at 9.00 am and 3.00 pm in summer 1941–2014 (source: BoM 2022b)

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.

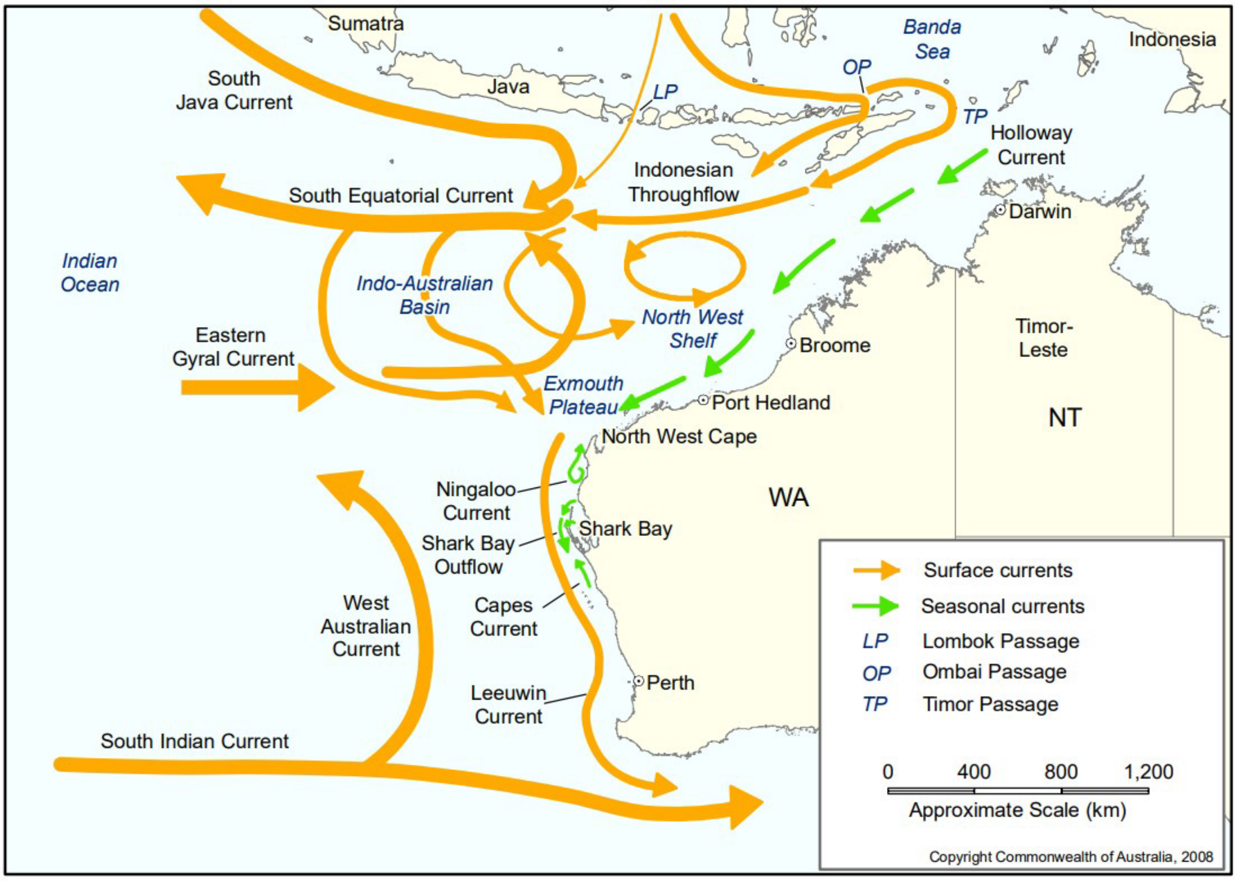


Figure 4-5: Surface currents in Western Australian waters. Source: DEWHA (2007)

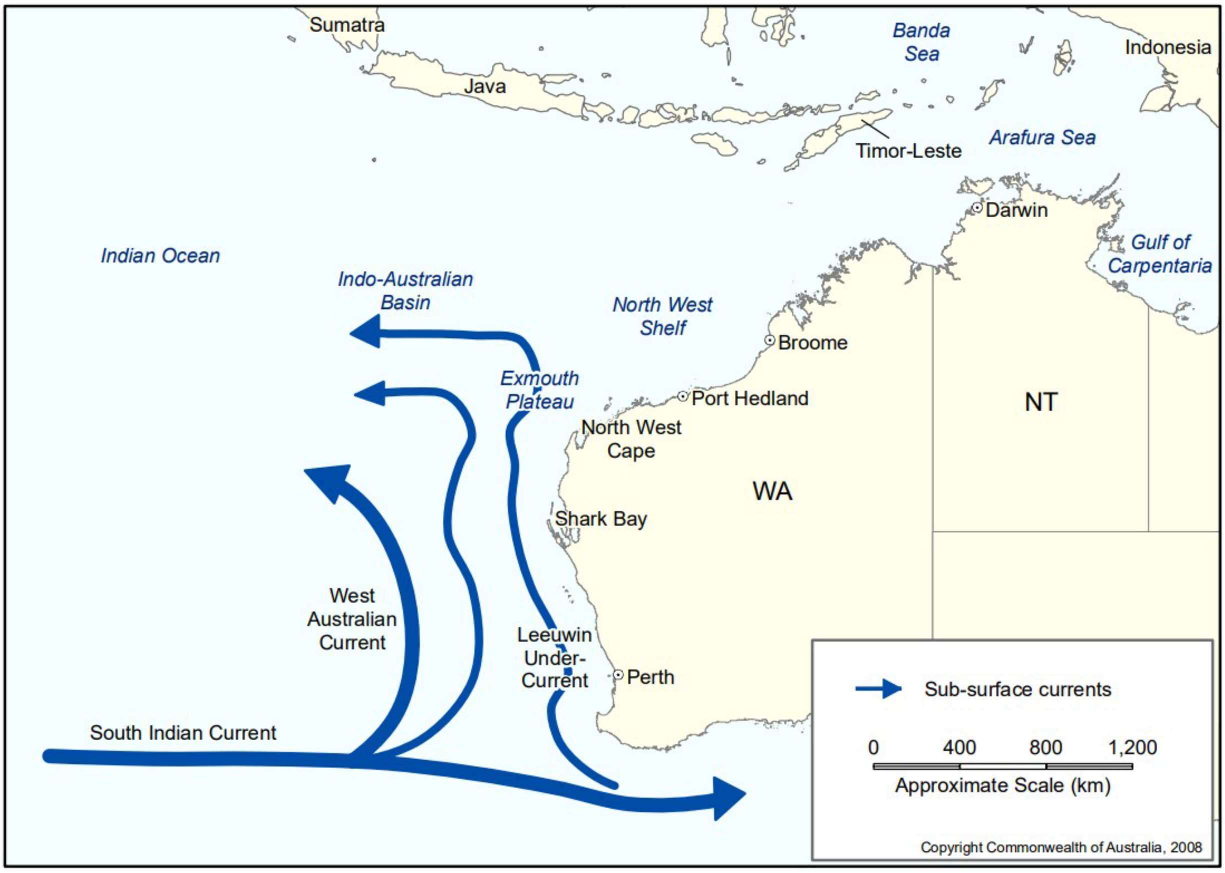


Figure 4-6: Subsurface currents in WA waters (Source: DEWHA 2007)

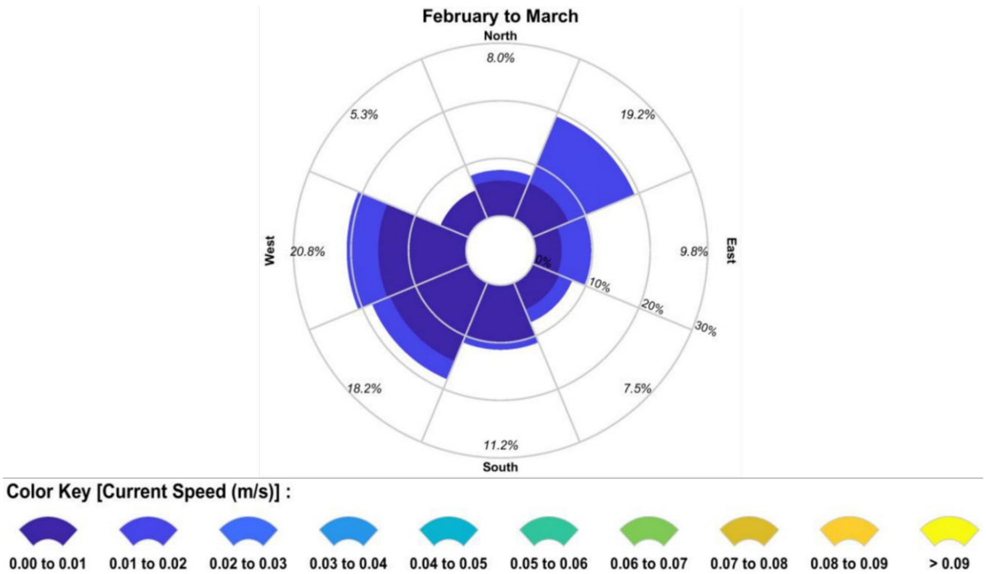


Figure 4-7: Typical seasonal current distributions (2006 – 2015, inclusive) in the OA. The colour key shows the current magnitude, the compass direction provides the direction towards which the current is flowing, and the size of the wedge gives the percentage of the record (Source: RPS 2023)

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 (shallower over reefs) to approximately 60 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 (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.

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).

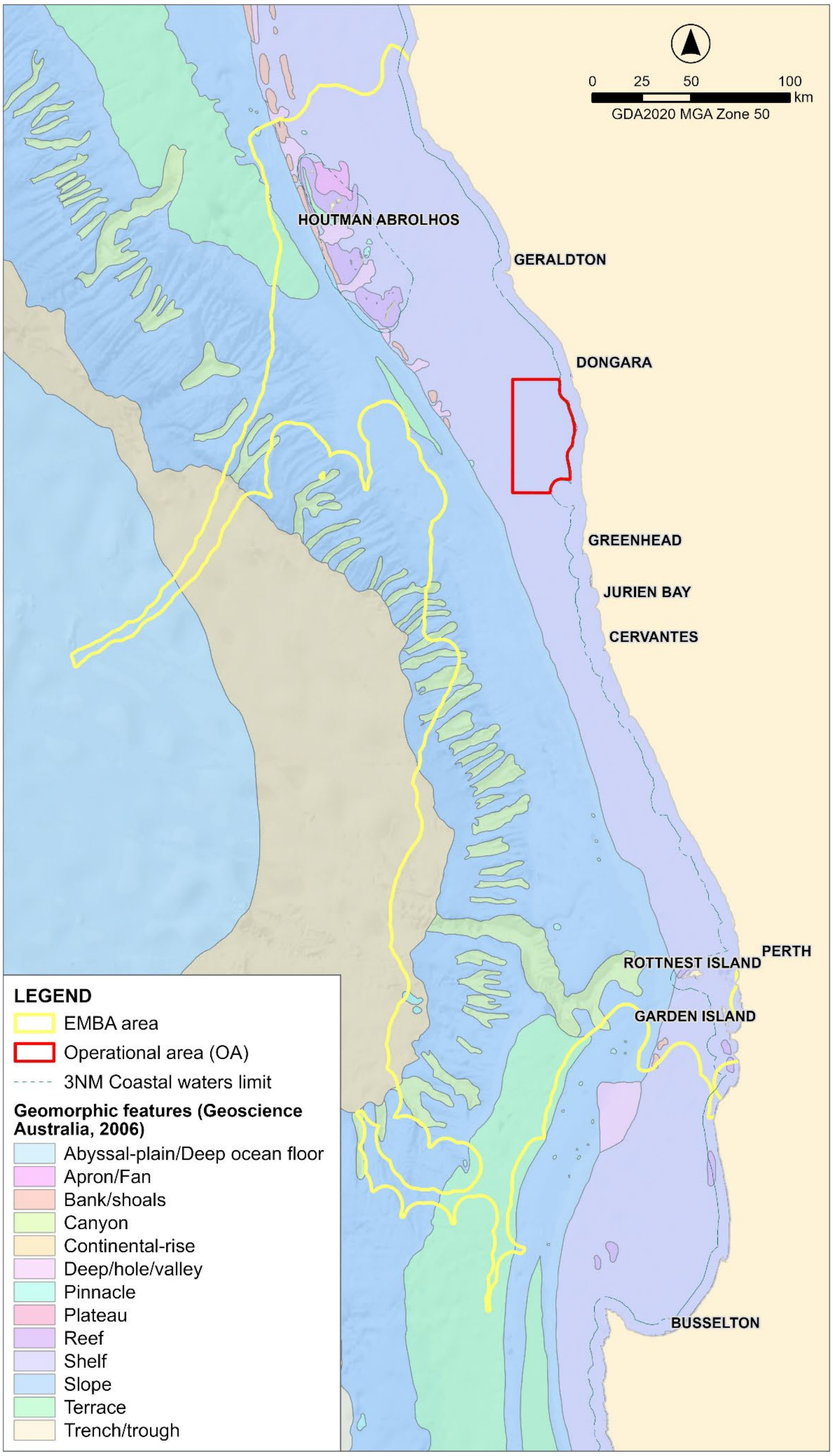


Figure 4-8: Geomorphic features of the OA and EMBA

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 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 4.3.6.

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 souths 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 4-5). 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 4-5.

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.

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.

4.3.5 Commercially targeted invertebrates

The SWMR supports commercial fisheries that target a variety of invertebrate species. Table 4-4 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 4-2: Listed threatened fishes potentially occurring within the EMBA

Common name	Habitat, distribution, and seasonality	Presence in EMBA
Orange roughy	Habitat and distribution	May occur
	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).	

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). Typically occur in 20 – 50 m (Bray & Gomon, 2023; DoF 2011). 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 over isolated reef outcrops and weed-covered sandy areas (DPIRD 2023a). WA dhufish with spawning and recently spent gonads have been captured in water depths ranging from 10 to 150 m, indicating spawning is not restricted to any particular water depth (Hesp et al. 2002) 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 4-12).
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 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).	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 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).	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 is 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 4-12).
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 is 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.

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
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). 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).	Baldchin gropers 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 48–55 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 gropers 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).	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 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 (*Hyperoglyphe antarctica*)	Blue-eye trevalla are widespread in oceans of the southern hemisphere (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).	Recent studies have identified four adult blue-eye 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).	250–650 m	Blue-eye trevalla are serial spawners. Females reach reproductive maturity at 11–12 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).	November to May (Fairclough & Fisher 2023).	Given their distribution, habitat, 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.

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
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.
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.

Table 4-4: Key commercial invertebrate 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
Western rock lobster	Western rock lobster (WRL; *Panulirus cygnus*) are a temperate species that are endemic to WA. The WRL range extends along the continental shelf from Northwest Cape to Albany, with the highest densities between Perth and Geraldton (de Lestang et al. 2016; DPIRD 2020b). WRL are demersal invertebrates that nocturnally forage by walking through seagrass and algal beds (de Lestang et al. 2024). Juveniles inhabit shallow coastal reefs and seagrass beds, which provide shelter and abundant food sources, while adults prefer deeper offshore reefs and rocky substrates, often found at depths ranging from 0 to 200 m (de Lestang et al. 2016; Bellchambers et al. 2017).	WRL are considered a single biological stock, which extends along the mid to lower west coast of WA, from Northwest Cape to Cape Leeuwin (de Lestang et al. 2016).	Juveniles 0-40 m Adults 0-80 m (de Lestang et al 2016).	WRL reproduce by males attaching a sperm packet ("tarspot") to the underside of females in late winter and spring. Females then release eggs and sperm simultaneously, fertilizing the eggs, which are carried under the female's tail for 4 to 8 weeks until they hatch, depending on water temperature (DPIRD 2020b). WRL recruitment is highly variable and influenced by environmental factors, particularly the strength of the LC. Spawning and egg hatching occur at depths below 40 m in spring-summer. The phyllosoma larvae are then transported offshore into the Indian Ocean via the LC, where they spend 9 to 11 months, aggregating at depths of 50 to 120 m (Hayes et al. 2008). Late-stage larvae metamorphose into pueruli beyond the continental shelf before they return to the coast and settle on shallow near-shore reefs (de Lestang et al. 2016). They remain there for 3 to 4 years before migrating to deeper waters to spawn, completing their life cycle (MacArthur et al. 2007).	September to February with a peak in October and November (de Lestang et al. 2016).	Given their distribution, habitat, and principal depth ranges, adult and juvenile WRL are likely to occur in the OA and/or EMBA. The proposed acquisition window (February–March) overlaps with one month of the six-month WRL spawning period (Table 4-12).

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
Roe's abalone	Roe's abalone (*Haliotis roei*) is primarily found along the coast of WA, from Shark Bay to Victoria (DPIRD 2016; Hart et al. 2017), although they are not uniformly distributed throughout this range and are most abundant on the south-west coast around Perth and Cape Naturaliste (Strain et al. 2019). They inhabit shallow limestone reefs, particularly around Perth and Geraldton, preferring rocky areas, crevices, caves, and under rocks in shallow coastal waters (DPIRD 2016). Roe's abalone are generally found in shallow coastal waters on intertidal reef platforms and shallow adjoining subtidal reef to about 10 m depth (Strain et al. 2019). Their populations occur on semi-continuous reef complexes, typically less than 10 km in coastal length, occupying intertidal reef platforms and adjoining subtidal reefs up to 30 to 40 m beyond the reef platforms (Hart et al. 2017).	The biological stock range of Roe's abalone extends from Shark Bay in WA to western Victoria. Genetic evidence indicates high levels of connectivity and gene flow across their geographic range (Hancock 2004; Sandoval-Castillo et al. 2015).	Principal depth range 0-10 m (Strain et al. 2019) and typically < 5 m (DoF, 2011). May occur in depths up to 30 m (Hart et al. 2017).	Roe's abalone are broadcast spawners, releasing gametes (sperm and eggs) into the water column where fertilisation occurs. The ova develop into veliger larvae, which settle onto suitable habitats around 8 to 10 days post-hatching (Hart et al. 2017). The length at which 50% of Roe's abalone attain maturity is estimated to be 40 mm, at approximately two and a half years old (DoF 2011). Roe's abalone in the Perth metropolitan area have major spawning events in winter (Wells and Keesing 1989; DoF 2011). The fertilized eggs develop into free-swimming larvae, which settle onto suitable rocky substrates after a few days. Recruitment is influenced by environmental factors, including water temperature and habitat availability. Juveniles grow in shallow coastal waters before moving to deeper areas as they mature (Hart et al. 2017).	Roe's abalone mostly spawn in winter and larvae are in the water column for approximately one week only (Wells and Keesing 1989; DoF 2011).	Given their distribution, habitat, and principal depth range, Roe's abalone are likely to occur in the shallowest areas of the OA only (around 10 m deep), but may occur in water depths up to 30 m. Roe's abalone are likely to occur in the EMBA in water depths less than 10 m, but may also occur in depths up to 30 m.

Species	Distribution and habitat	Biological stock range	Principal depth range	Reproduction and recruitment	Spawning season	Relevance to EP
Western rock octopus	Western Rock Octopus (WRO; *Octopus djinda*) is endemic to the temperate waters of WA from Shark Bay to Esperance. WRO complete their life cycle in a range of nearshore habitats, including rocky reefs, seagrass meadows and sandy substrates, typically using limestone reefs around 20 m deep (Hart et al. 2018).	The species has an extended pelagic larval phase and are assumed to be a single stock over their distribution in WA (Hart et al. 2018).	0-70 m (Hart et al. 2018)	WRO is short-lived (up to 1.5 years), with early maturity and year-round spawning (Hart et al. 2018). WRO has a merobenthic life cycle; females lay ~100,000 eggs that take ~30 days to hatch then spend ~50 days in the water column as paralarvae before settling on the benthos (Hart et al. 2016). After settlement, octopuses are believed to move to protected inshore waters, with females later migrating to rocky temperate reefs to mature and find suitable lairs for brooding their eggs (Leporati et al. 2015).	Year-round. The greatest frequency of spawning is during periods of transitional temperature in autumn and spring (Leporati et al. 2015).	Given their distribution, habitat, and principal depth range, adult and juvenile WRO are likely to occur in the OA and/or EMBA.
Crystal crab	The crystal crab (*Chaceon albus*) is endemic to WA and distributed from Northwest Cape to Esperance. They inhabit deep water sand, mud or broken shell habitats (DPIRD 2020d).	There is little information available regarding the biological stock range of crystal crabs. Most of the catch (> 95%) comes from a small geographic area, and it is considered a single stock for the purpose of fisheries assessment (de Lestang 2023).	300-1450 m (DPIRD 2020d)	There is little information available regarding the reproduction and recruitment of crystal crabs. Tagging studies indicate crystal crabs are slow-growing and long-lived with a likely maximum age of 25 to 30 years. Preliminary studies indicate that maturity in males is attained at 12 years (DPIRD 2020d).	Year-round. There is little evidence of seasonality in the crystal crab reproductive cycle (Smith et al. 2004; Melville-Smith et al. 2007).	Given their distribution, habitat, and principal depth range, crystal crabs are unlikely to occur in the OA, but may occur in the EMBA.

4.3.6 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.

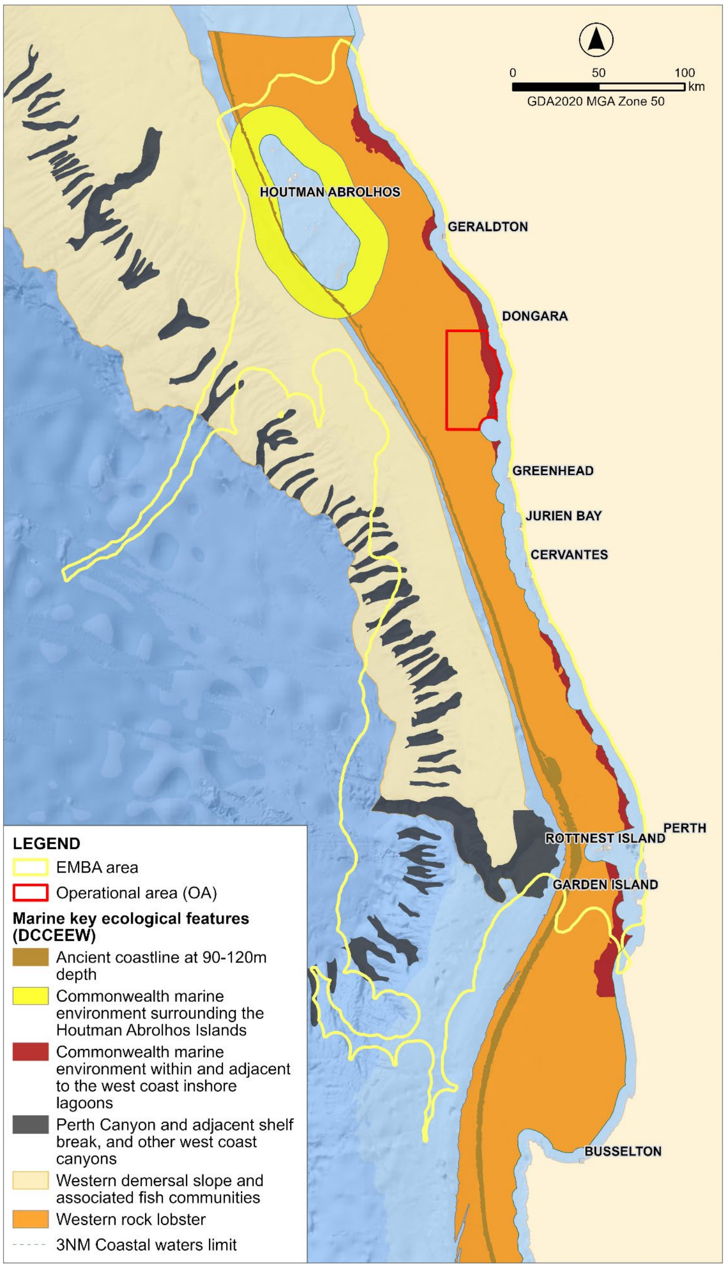


Figure 4-9: KEFs overlapping the OA and EMBA

4.3.6.1 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).

4.3.6.2 Western rock lobster

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). 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.

Within the SWMR, western rock lobsters (WRL; *Panulirus cygnus*) can be found north of Cape Leeuwin to a depth of 150 m and 40-60 km seaward of the coast (DSEWPC 2012a; Peinado et al, 2024). Both the OA and EMBA overlap the Western rock lobster KEF. The EMBA overlaps 57.85% of the KEF, and the OA overlaps the KEF by 3.94% (Figure 4-9). Within this area, WRL are largely confined to limestone reef systems where they inhabit caves and ledges, and foraging occurs within adjacent seagrass meadows. Fine scale tracking studies have found that WRL generally forage at night within 500 m of their den, with 90% of WRL foraging activity within 60 m of the nearest reef (MacArthur et al. 2008). There are several shallow reef areas within the OA that are likely to provide suitable habitat for WRL. Unvegetated areas such as those in deeper waters of the OA are likely to be utilised by juveniles during offshore migrations (see below).

To inform the evaluation of impacts, it is important to understand the spatio-temporal overlap of WRL habitats and life stages with the timing and location of the proposed Eureka MSS in more detail. As stated above, the shallow reef areas of the Eureka MSS OA are likely to provide habitat for juvenile WRL prior to migration into deeper waters. The migration of juvenile WRL from shallow water to deeper waters (>40 m) is commonly known as the 'whites' migration due to their pale colour post moulting (Bellchambers et al., 2012). This migration occurs in November through to mid-January each year (Melville-Smith & Beale, 2009; Caputi et al. 2009; Miller et al. 2023) when they migrate from coastal reefs to the edge of the continental shelf. A small percentage of WRL makes a longer migration to the north along the edge of the continental shelf (DoF, 2011). This northerly migration typically occurs between late January to February towards the big bank area, north of the Houtman Abrolhos (deep water between Kalbarri and Onslow).

Once in deeper water, breeding females prefer limestone or coral reef habitats and breeding grounds are between 40 and 100 m deep (de Lestang et al., 2016). Mating of WRL occurs in August – September and the females generally release fertilised eggs between September and February (Peinado et al. 2024). 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 (Peinado et al. 2024). 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 (Peinado et al. 2024). The settlement of puerulus larvae on inshore reefs can occur throughout the year (Miller et al. 2023), with peaks from late-winter to mid-summer (Caputi et al. 2009). There is therefore some potential for the MSS to overlap with the hatching and puerulus settlement period on inshore reefs, but there is no temporal overlap with the peak puerulus settlement period.

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. 2008).

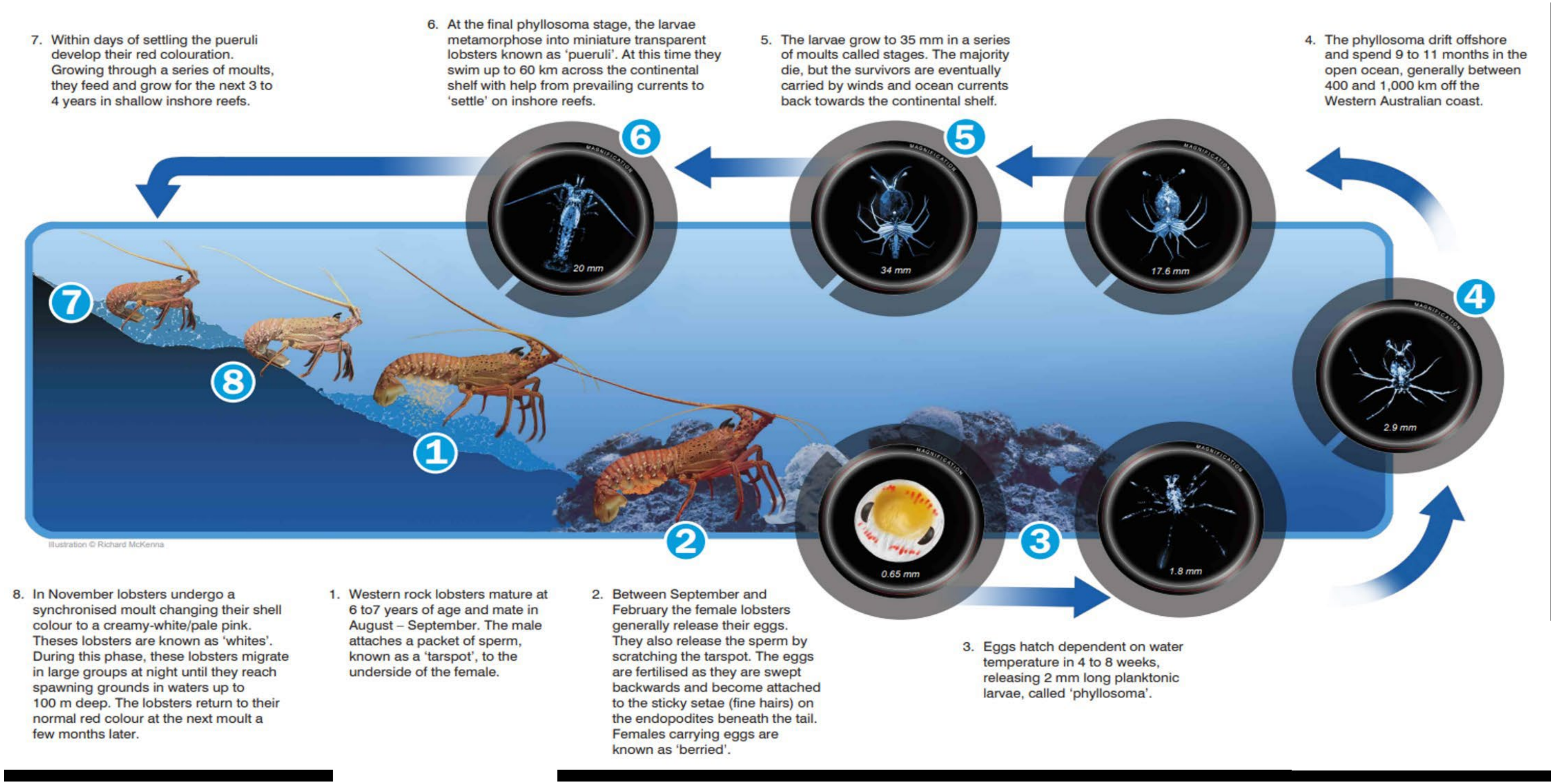


Figure 4-10: Western rock lobster life cycle (Western Australian Department of Primary Industries and Regional Development)

4.3.6.3 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 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).

4.3.6.4 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.

4.3.6.5 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.

4.3.6.6 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).

4.3.7 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/or EMBA. The results of the search inform the assessment of planned events in Section 7 and 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 potentially occur.

The PMST identified 32 EPBC Act listed Threatened species and 43 listed migratory species that potentially occur within the OA. Of those listed, a total of 49 individual species were identified as Threatened and/or migratory under the EPBC Act, consisting of eight mammals, four reptiles, 26 birds, and 11 sharks and rays ().

The PMST identified 109 EPBC Act listed Threatened species and 85 listed migratory species that potentially occur within the EMBA. Of those listed, 107 individual species were identified as Threatened and/or migratory that occur within the EMBA but outside of the OA, consisting of 11 mammals, three reptiles, 50 birds, and two sharks and rays (Table 4-5).

Numerous species (e.g., grey wagtail; Motacilla cinerea, Balston's pygmy perch; Nannatherina balstoni, and various land animals) were identified by the PMST as potentially occurring within the EMBA have been excluded from further assessment due to the lack of a credible impact scenario.

The complete list of species identified by the PMST is provided in Table 4-5 contains species that are deemed likely to occur within 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 4-5: 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					
Balaenoptera musculus	Blue whale	Endangered	✓	✓	✓
Eubalaena australis	Southern right whale	Endangered	✓	✓	✓
Neophoca cinerea	Australian sea lion	Endangered	X	✓	✓
Balaenoptera borealis	Sei whale	Vulnerable	✓	✓	✓
Balaenoptera physalus	Fin whale	Vulnerable	✓	✓	✓
Balaenoptera bonaerensis	Antarctic minke whale, Dark-shoulder minke whale	N/A	✓	X	✓
Balaenoptera edeni	Bryde's whale	N/A	✓	✓	✓
Caperea marginata	Pygmy right whale	N/A	✓	X	✓
Lagenorhynchus obscurus	Dusky dolphin	N/A	✓	X	✓
Megaptera novaeangliae	Humpback whale	N/A	✓	✓	✓
Orcinus orca	Killer whale, Orca	N/A	✓	✓	✓
Physeter macrocephalus	Sperm whale	N/A	✓	X	✓
Marine reptiles					
Caretta	Loggerhead turtle	Endangered	✓	✓	✓
Dermochelys coriacea	Leatherback turtle	Endangered	✓	✓	✓
Chelonia mydas	Green turtle	Vulnerable	✓	✓	✓
Natator depressus	Flatback turtle	Vulnerable	✓	✓	✓
Sharks and rays					
Centrophorus uyato	Little gulper shark	Conservation Dependent	X	X	✓
Galeorhinus galeus	School shark, Eastern school shark	Conservation Dependent	X	X	✓
Sphyrna lewini	Scalloped hammerhead	Conservation Dependent	X	✓	✓
Carcharias taurus	Grey nurse shark (west coast population)	Vulnerable	X	✓	✓
Carcharodon carcharias	White shark, Great white shark	Vulnerable	✓	✓	✓
Pristis	Freshwater sawfish	Vulnerable	✓	✓	✓
Rhincodon typus	Whale shark	Vulnerable	✓	✓	✓
Carcharhinus longimanus	Oceanic whitetip shark	N/A	✓	✓	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Isurus oxyrinchus	Shortfin mako, Mako shark	N/A	✓	✓	✓
Isurus paucus	Longfin mako	N/A	✓	✓	✓
Lamna nasus	Porbeagle, Mackerel shark	N/A	✓	✓	✓
Mobula alfredi	Reef manta ray, coastal manta ray	N/A	✓	✓	✓
Mobula birostris	Giant manta ray	N/A	✓	✓	✓
Fish					
Hoplostethus atlanticus	Orange roughy, Deep-sea perch	Conservation Dependent	X	X	✓
Avifauna					
Calidris ferruginea	Curlew sandpiper	Critically Endangered	✓	✓	✓
Numenius madagascariensis	Eastern curlew, Far Eastern curlew	Critically Endangered	✓	✓	✓
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	✓	X	✓
Diomedea amsterdamensis	Amsterdam albatross	Endangered	✓	✓	✓
Diomedea dabbenena	Tristan albatross	Endangered	✓	X	✓
Diomedea sanfordi	Northern royal albatross	Endangered	✓	X	✓
Limosa	Black-tailed godwit	Endangered	✓	X	✓
Macronectes giganteus	Southern giant-petrel	Endangered	✓	✓	✓
Rostratula australis	Australian painted snipe	Endangered	X	X	✓
Thalassarche cauta	Shy albatross	Endangered	✓	✓	✓
Tringa nebularia	Common greenshank	Endangered	✓	X	✓
Anous tenuirostris melanops	Australian lesser noddy	Vulnerable	X	✓	✓
Ardenna grisea	Sooty shearwater	Vulnerable	✓	X	✓
Arenaria interpres	Ruddy turnstone	Vulnerable	✓	X	✓
Calidris acuminata	Sharp-tailed sandpiper	Vulnerable	✓	✓	✓
Calidris canutus	Red knot, Knot	Vulnerable	✓	✓	✓
Calidris tenuirostris	Great knot	Vulnerable	✓	X	✓
Charadrius leschenaultii	Greater sand plover, large sand plover	Vulnerable	✓	X	✓
Diomedea epomophora	Southern royal albatross	Vulnerable	✓	✓	✓
Diomedea exulans	Wandering albatross	Vulnerable	✓	✓	✓
Halobaena caerulea	Blue petrel	Vulnerable	X	X	✓
Macronectes halli	Northern giant petrel	Vulnerable	✓	✓	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Phoebetria fusca	Sooty albatross	Vulnerable	✓	X	✓
Pluvialis squatarola	Grey plover	Vulnerable	✓	X	✓
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	X	✓	✓
Sternula nereis	Australian fairy tern	Vulnerable	X	✓	✓
Thalassarche carteri	Indian yellow-nosed albatross	Vulnerable	✓	✓	✓
Thalassarche impavida	Campbell albatross	Vulnerable	✓	✓	✓
Thalassarche melanophris	Black-browed albatross	Vulnerable	✓	✓	✓
Thalassarche steadi	White-capped albatross	Vulnerable	✓	✓	✓
Xenus cinereus	Terek sandpiper	Vulnerable	✓	X	✓
Actitis hypoleucos	Common sandpiper	N/A	✓	✓	✓
Anous stolidus	Common noddy	N/A	✓	✓	✓
Apus pacificus	Fork-tailed swift	N/A	✓	✓	✓
Ardenna carneipes	Flesh-footed shearwater	N/A	✓	✓	✓
Ardenna pacifica	Wedge-tailed shearwater	N/A	✓	X	✓
Calidris alba	Sanderling	N/A	✓	X	✓
Calidris melanotos	Pectoral sandpiper	N/A	✓	✓	✓
Calidris pugnax	Ruff	N/A	✓	X	✓
Calidris ruficollis	Red-necked stint	N/A	✓	X	✓
Calidris subminuta	Long-toed stint	N/A	✓	X	✓
Charadrius bicinctus	Double-banded plover	N/A	✓	X	✓
Fregata ariel	Lesser frigatebird, Least frigatebird	N/A	✓	X	✓
Gallinago megala	Swinhoe's snipe	N/A	✓	X	✓
Gallinago stenura	Pin-tailed snipe	N/A	✓	X	✓
Glareola maldivarum	Oriental pratincole	N/A	✓	X	✓
Hydroprogne caspia	Caspian tern	N/A	✓	✓	✓
Limicola falcinellus	Broad-billed Sandpiper	N/A	✓	X	✓
Limosa lapponica	Bar-tailed Godwit	N/A	✓	X	✓
Motacilla cinerea	Grey wagtail	N/A	✓	X	✓
Numenius minutus	Little curlew	N/A	✓	X	✓
Numenius phaeopus	Whimbrel	N/A	✓	X	✓
Onychoprion anaethetus	Bridled tern	N/A	✓	✓	✓
Pandion haliaetus	Osprey	N/A	✓	X	✓

Scientific name	Common name	Threatened	Migratory	Relevance to EP	
				OA	EMBA
Phaethon lepturus	White-tailed tropicbird	N/A	✓	X	✓
Phaethon rubricauda	Red-tailed tropicbird	N/A	✓	X	✓
Phalaropus lobatus	Red-necked phalarope	N/A	✓	X	✓
Pluvialis fulva	Pacific golden plover	N/A	✓	X	✓
Sterna dougallii	Roseate tern	N/A	✓	✓	✓
Sternula albifrons	Little tern	N/A	✓	X	✓
Thalasseus bergii	Greater crested tern	N/A	✓	X	✓
Tringa brevipes	Grey-tailed tattler	N/A	✓	X	✓
Tringa glareola	Wood sandpiper	N/A	✓	X	✓
Tringa stagnatilis	Marsh sandpiper, Little greenshank	N/A	✓	X	✓
Tringa totanus	Common redshank	N/A	✓	X	✓

4.3.7.1 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 4-6 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 4-6: 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	National Recovery Plan for the Southern Right Whale (DCCEEW 2024)	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.	Minimise light pollution No specific actions for vessel disturbance are identified by the plan. The Australian Government has	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
		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 that individuals are affected, but there is no effect at stock level.	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. 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

Species	Recovery plan / conservation advice	Key threats identified in the plan/ advice	Actions relevant to the Eureka 3D MSS	Environmental risk assessment section
Leatherback turtle	Recovery plan for marine turtles in Australia (Commonwealth of Australia 2017) Approved conservation advice for *Dermochelys coriacea* (leatherback turtle) (DEWHA 2008c)	Vessel disturbance	Minimising vessel collisions.	Section 8.2
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* (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 and shorebirds				
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
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)	Marine infrastructure interactions – Threats from interactions with offshore installations and ships, including artificial lighting. Marine pollution - Threats from marine pollution, contamination and debris, including plastics and microplastics.	Minimise light pollution No specific actions for artificial light are identified by the plan. The IAATOs Guidelines to Minimize Seabirds Landing on Ships including seabirds landing on ships capture, handling and release procedure should be considered for the survey. Contribute to long-term prevention of marine debris, through waste management and resource recovery.	Section 7.1 Section 7.4 Section 8.5 Section 8.6 Section 8.7
Seabirds	Wildlife Conservation Plan for seabirds (Commonwealth of Australian 2020)	No threats identified that are applicable to this EP	N/A	Section 7.1 Section 7.4 Section 8.6 Section 8.7

4.3.7.2 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 4-7 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 4.3.8 and Section 4.3.9).

Table 4-7: 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 OA and ASA	✓
Pygmy blue whale	Migration	<1 km (~19km to ASA)	✓
	Known Foraging	Overlaps (~19km to ASA)	✓
Southern right whale	Seasonal calving (calving buffer)	185 km	✓

Species	BIA	Distance from OA	Overlaps EMBA
	Migration	<1 km to OA and ASA	✓
Sperm whale	Foraging	215 km	✓
Australian sea lion	Foraging	Overlaps OA and ASA	✓
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	✓

4.3.8 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 4-8.

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 Australian Marine Spatial Information System (AMSIS). 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 minor overlap of the OA with the pygmy blue whale foraging BIA and the adjacent migration BIA and 'most important foraging area' and 'most important migration area' 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 ~2585 animals in 2020 and a south-eastern population of ~268 animals in 2018 (Stamation et al. 2020, Smith et al. 2021). 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. The shallow coastal waters near Albany in WA and Head of the Bight in SA host the greatest concentrations of the western population during their breeding season (Bannister 2001, Charlton et al. 2022). While the main aggregation of individuals is along the southern coastline, they have been recorded further north, with the northern extremity of their distribution being Exmouth / Ningaloo on the west coast (Bannister 2001, Sprogis et al. 2022). However there have been few recorded observations this far north (Bannister 2001), with the latest published sighting in 2021 of a single cow calf pair in Exmouth Gulf (Sprogis et al. 2022). As the populations increase in abundance there has been an expansion and re-occupation of historic breeding grounds, notably Geographe Bay in south-western Australia, Fowlers Bay and Encounter Bay in SA (Charlton et al. 2019, Kemper et al. 2022, Salgado Kent et al. 2022).

Right whales are capital breeders relying on stored fat to sustain long fasting periods on breeding grounds. Recent studies have identified a body condition threshold (~40% below average, ~3% blubber) beyond which survival is compromised. An average southern right whale can endure ~17 months of fasting in good condition, but calves and lactating females have limited reserves (a 4 m calf may only survive ~20 days without nutrition). Notably, North Atlantic right whales – often already in poorer body condition – have much reduced fasting endurance; a severely entangled 5-year-old could only survive ~1–2 months without feeding. These findings underscore the very narrow survival margin for any right whale in suboptimal condition, such as an underweight or entangled individual, highlighting their heightened vulnerability to any prolonged loss of feeding opportunities or added energetic stress (Christensen et al. 2025).

There are currently no identified historic high use areas (locations where intensive shore-based whaling effort occurred, and southern right whales occupied the area) within WA (DSEWPAC, 2012c). The recent publication of the National Recovery Plan for the Southern Right Whale (DCCEEW, 2024) identifies the migratory BIA as a continuous coastal path between Hervey Bay in QLD extending along the southern coastline of Australia and up Western Australia to Exmouth Gulf (DCCEEW, 2024). The temporal extent of southern right whale presence in this migratory BIA is approximately May to October, with the peak abundance occurring late July to August. Between season variation can occur with the possibility of early and late individuals between April and November (Department of the Environment, 2024). The most recent recovery plan includes the addition of a reproductive BIA in Exmouth Gulf (approximately May to September) (DCCEEW, 2024). The single sighting of the cow calf pair in Exmouth Gulf occurred late July (Sprogis et al. 2022). Aerial surveys conducted between 1999 to 2010 to identify cetaceans utilising Shark Bay, North-West Cape, Exmouth Gulf and Anketell Point recorded no observations of southern right whales (Jenner et al. 2010, Jenner and Jenner 2011).

A 2025 report on the western population of SRW surveyed calving areas south of Perth, including Albany, Esperance and the Head of Bight, and found a slowing trajectory in the population recovery at these locations. These results are consistent with existing knowledge already reflected in this EP, namely that calving occurs in southern Western Australia. The findings do not alter the understanding of SRW distribution in the northern Perth Basin (Smith et al. 2025). It is therefore highly unlikely that southern right whales will utilise the migratory BIA inshore of the OA during the MSS period of February to March.

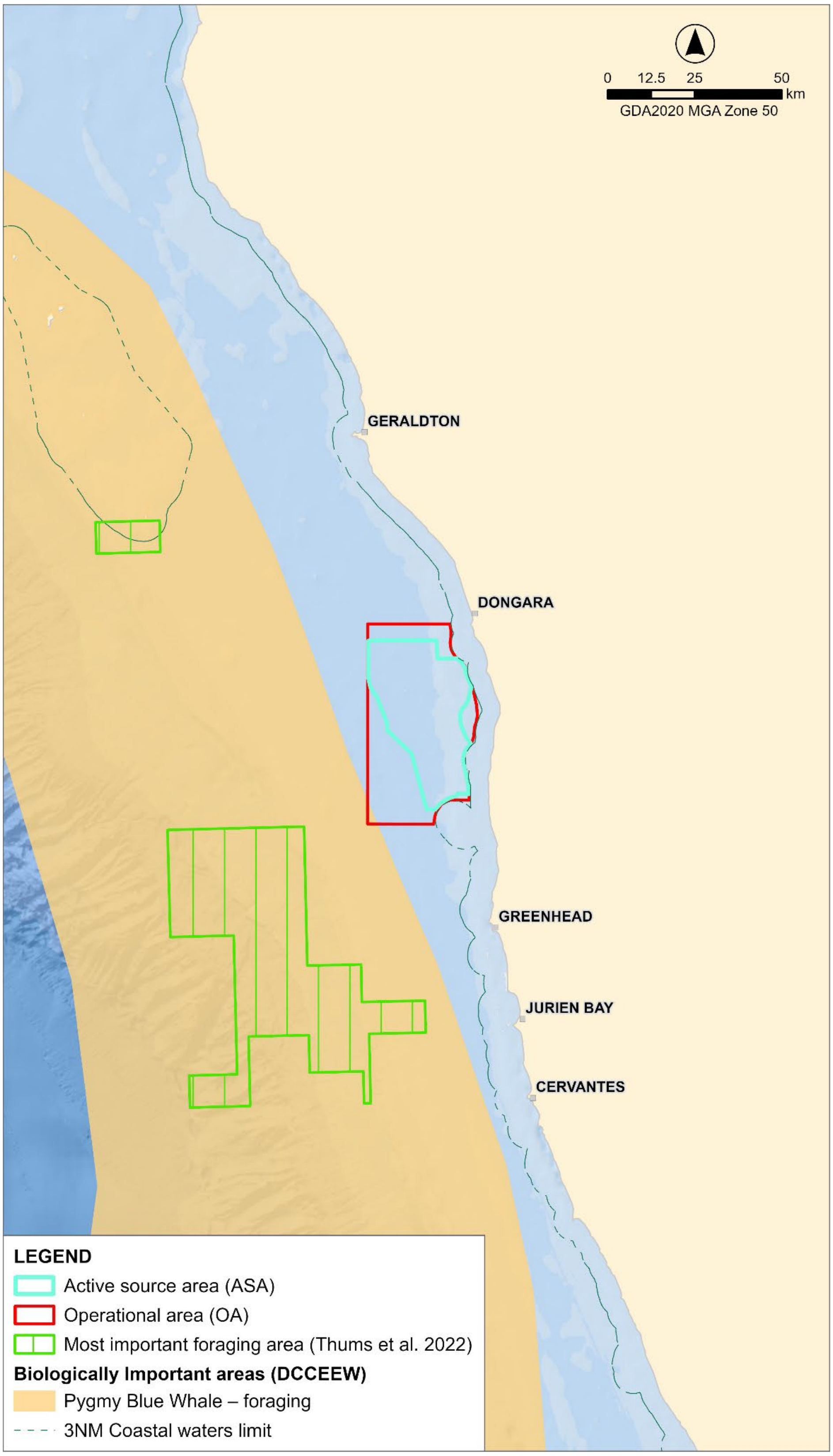


Figure 4-11: Pygmy blue whale known foraging BIA and most important foraging area, as detailed in Thums et al. (2022)

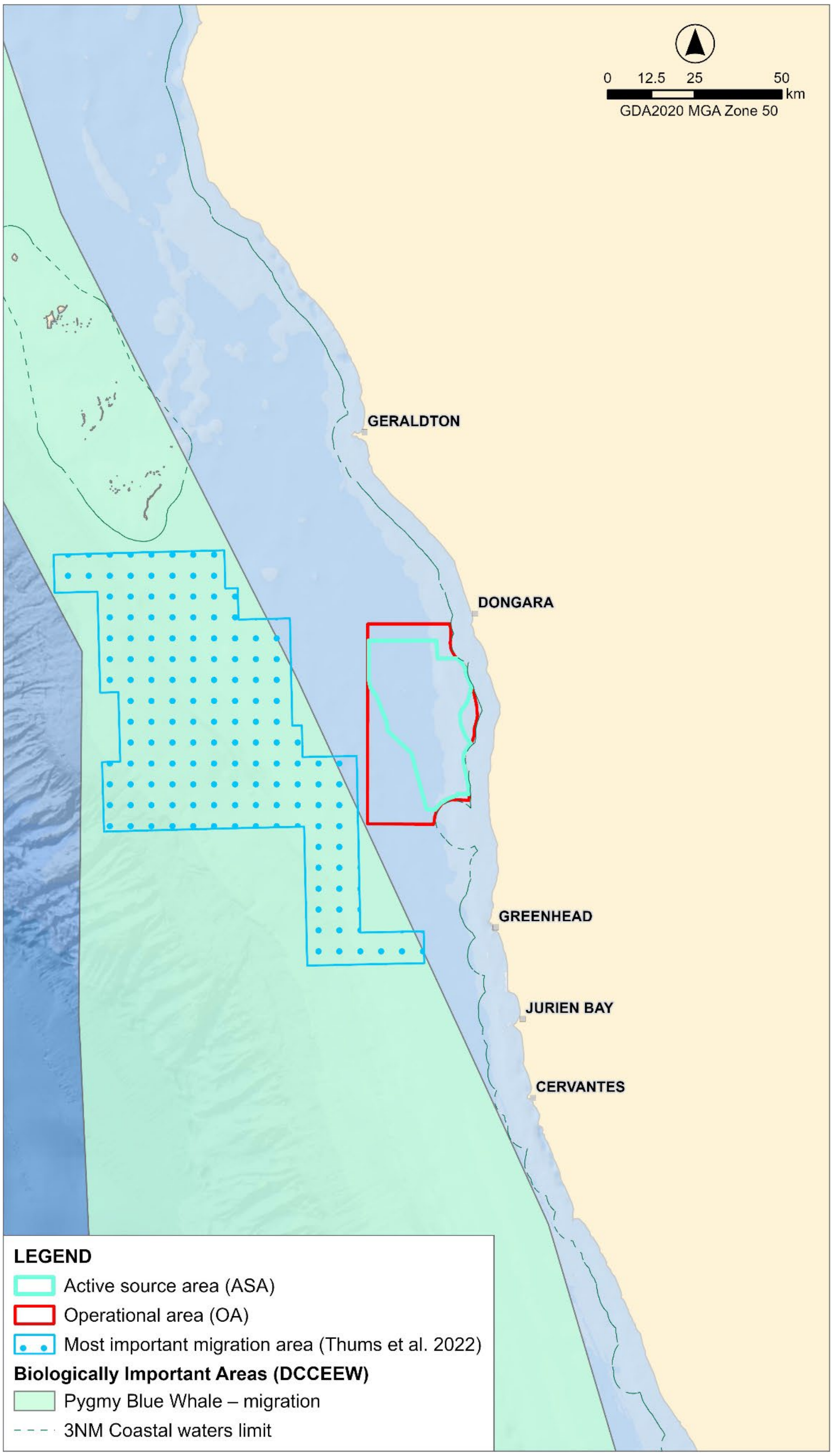


Figure 4-12: Pygmy blue whale migration BIA and the most important migration path, as detailed in Thums et al. (2022)

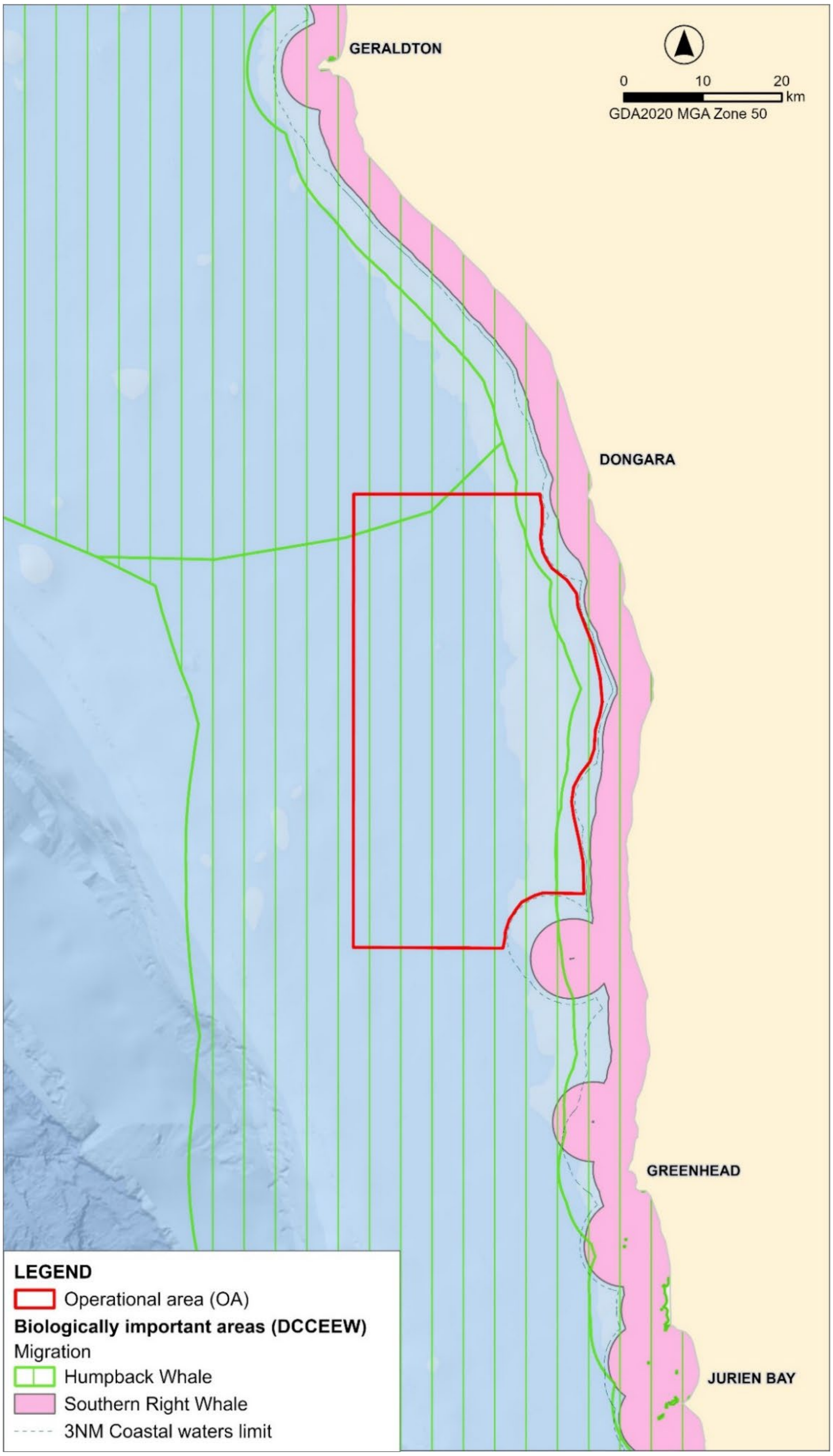


Figure 4-13: Humpback and southern right whale migration BIAs

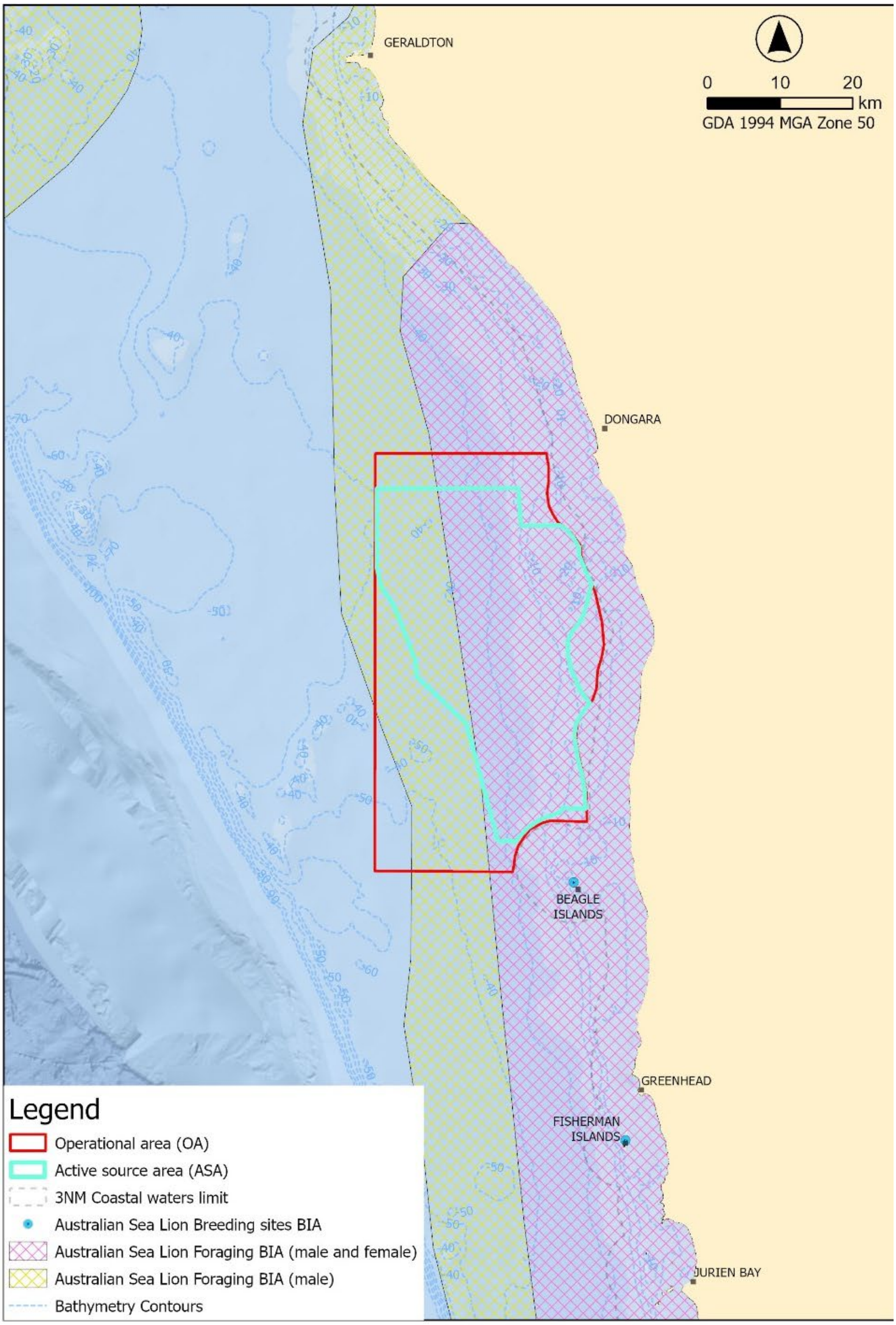


Figure 4-14: Australian sea lion foraging BIA

Table 4-8: Threatened and Migratory mammals potentially occurring within the OA and EMBA during February and March

Common name	Habitat, distribution and seasonality	Presence
Marine mammals potentially occurring within the OA		
Blue whale	Habitat and distribution	May Occur
	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; Möller et al. 2020; Thums et al. 2022).	
Humpback whale	Habitat and distribution	Unlikely
	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	May occur
	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	Unlikely
	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 2001). 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. Southern right whales are seasonally present in Australian water from as early as April and as late as November (Department of the Environment, 2024), outside of the Eureka MSS period of February to March.	
	Seasonality	

Common name	Habitat, distribution and seasonality	Presence
	Southern right whales migrate to more temperate coastal waters to calve from April to November with peak abundance typically occurring in July and August (Watson et al. 2021, DCCEEW 2024). The closest calving area to the study area is approximately 400 km away near Mandurah; 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 (DCCEEW, 2024).	
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 47-79 pups per breeding cycle (AMSIS). The foraging BIAs 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 for a survey conducted during the 2025 period, however there is no overlap of breeding with the 2026 period. 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	

Common name	Habitat, distribution and seasonality	Presence
	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).	
Sperm whale	Habitat and distribution	Likely
	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	May Occur
	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).	

4.3.9 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 4-5).

A description of the identified threatened and/or migratory sharks, sawfish and rays is provided in Table 4-9, 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).

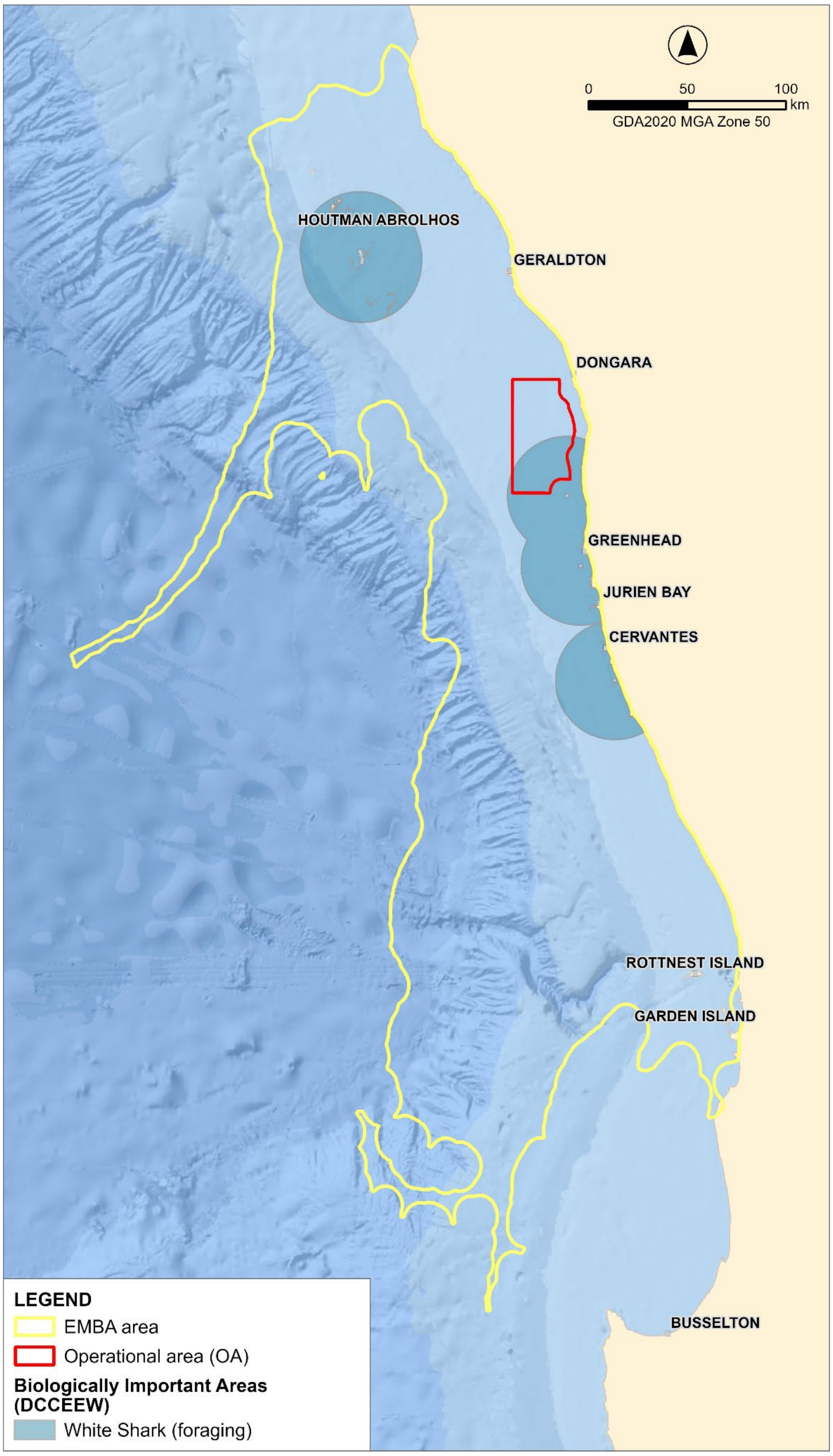


Figure 4-15: White shark foraging BIA overlap with the OA and EMBA

Table 4-9: 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.	
	Seasonality	
	There is insufficient data to determine seasonal distribution, migration times and routes in the region.	

Common name	Habitat, distribution and seasonality	Presence
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).	

Common name	Habitat, distribution and seasonality	Presence
Grey nurse shark (west coast population)	Habitat and distribution	Known
	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).	
Porbeagle, Mackerel shark	Habitat and distribution	May occur
	Porbeagle sharks are found circumglobally in the Southern Hemisphere between 30° and 60°S, and in the North Atlantic (Bray & Gomon, 2023). In Australia, they inhabit southern Western Australia, South Australia, Tasmania, Victoria, New South Wales, and southern Queensland (Last & Stephens, 2009). They typically inhabit cold oceanic waters (below 18°C) off the continental shelf although they occasionally enter coastal waters. Porbeagle sharks undertake daily vertical migrations, diving to 600 meters during the day with a maximum recorded depth of 1024 meters, and spending most of their nights at depths of 200–600 meters in the open ocean (Francis et al. 2015).	
	Seasonality	
	Porbeagle sharks exhibit seasonal migration patterns, although the timing and details of these movements are not well-understood. Individuals have been tracked moving large distances (i.e., 1500-1800 km along continental shelves and crossing the Atlantic Ocean between Europe and North America) (Francis et al. 2002). In the Southern Hemisphere, they likely give birth off New Zealand and Australia in winter (Francis & Stevens 2000). They also perform daily vertical migrations, diving deeper during the day and staying at mid-depths at night.	
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.	
	Habitat and distribution	Likely

Common name	Habitat, distribution and seasonality	Presence
Little gulper shark, Southern dogfish	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).	

4.3.10 Marine reptiles

4.3.10.1 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 4-10 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 4-10: 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	Known
	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).	
Green turtle	Habitat and distribution	Known
	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).	

Common name	Habitat, distribution and seasonality	Presence
Leatherback turtle	Habitat and distribution	Known
	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).	
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).	

4.3.11 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 4-11). 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 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 4-7).

Table 4-11: Threatened and Migratory birds potentially occurring within the EMBA and OA

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
Common noddy	Habitat and distribution 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. It is possible individuals of the species may pass through the OA, but the area is not considered an important foraging habitat.	Likely	May Occur
Roseate tern	Habitat and distribution	Likely	May Occur

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	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	Unlikely
	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	Unlikely
	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). The primary habitat of the northern giant petrel during the non-breeding period is deep pelagic waters, although first year birds may spend more time on the continental shelf, slope and cold eastern boundary currents off Australia (BirdLife 2024)		
	Seasonality		
	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 (rare)	May occur (rare)
	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		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	survey area in October-March. The northern migration from southern Australia occurs in April (DoEE 2019).		
Southern giant petrel	Habitat and distribution	May occur	Unlikely
	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	Unlikely
	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	May occur
	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. It is possible individuals of the species may pass through the OA but as the OA occurs well inshore off the shelf edge, it is not a primary foraging habitat.		
	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	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 Abrolhos. These birds are likely to be largely sedentary or		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	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	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	Unlikely
	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	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).		
Pacific gull	Habitat and distribution	Known	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		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	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		
	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	May occur
	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	May occur
	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	Unlikely
	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.		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
Great-winged petrel	Habitat and distribution The great-winged petrel inhabits offshore islands and waters, and nests in burrows on islands with steep rocky slopes or cliffs off the southern coast of Western Australia (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.	Known	May occur
White-faced storm petrel	Habitat and distribution 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 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).	Known	May occur
Little shearwater	Habitat and distribution 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).	Known	May occur
Far eastern curlew	Habitat and distribution 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	Unlikely	Unlikely

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	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	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 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	Unlikely
	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		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	(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	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	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	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. 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		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	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	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	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	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	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.		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence 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).		
Amsterdam albatross	Habitat and distribution	Unlikely	Unlikely
	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).		
Campbell albatross	Habitat and distribution	Unlikely	Unlikely
	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).		
Bar-tailed godwit	Habitat and distribution	Unlikely	Unlikely
	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).		
Soft-plumaged petrel	Habitat and distribution	May occur	May occur
	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.		

Common name	Habitat, distribution and seasonality	Presence EMBA	Presence OA
	Seasonality		
	The movement patterns of soft-plumaged petrels are poorly documented. Breeding occurs during summer, whereafter the species migrates north-west (Burbidge & Fuller 1989).		

4.3.12 Timing of biological sensitivities

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

Table 4-12 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 4-12: Timing of key biological sensitivities relevant to the OA and EMBA

Sensitivity	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
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	■	■	■	■	■	■	■	■	■	■	■	■
WRO spawning[8]	■	■	■	■	■	■	■	■	■	■	■	■
WRO commercial fishing season	■	■	■	■	■	■	■	■	■	■	■	■
Roe's abalone spawning[9]						■	■	■				
Roe's abalone 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]									■	■	■	■
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), 8 (Source: Leporati et al. 2015, Hart et al. 2018), 9 (Source: Wells and Keesing 1989, DoF 2011)

* 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

WCDS = West coast demersal scale fish, WRL = Western rock lobster, WRO = Western rock octopus

Peak period		Mammals	Fish	Invertebrates	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 4-14.

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.

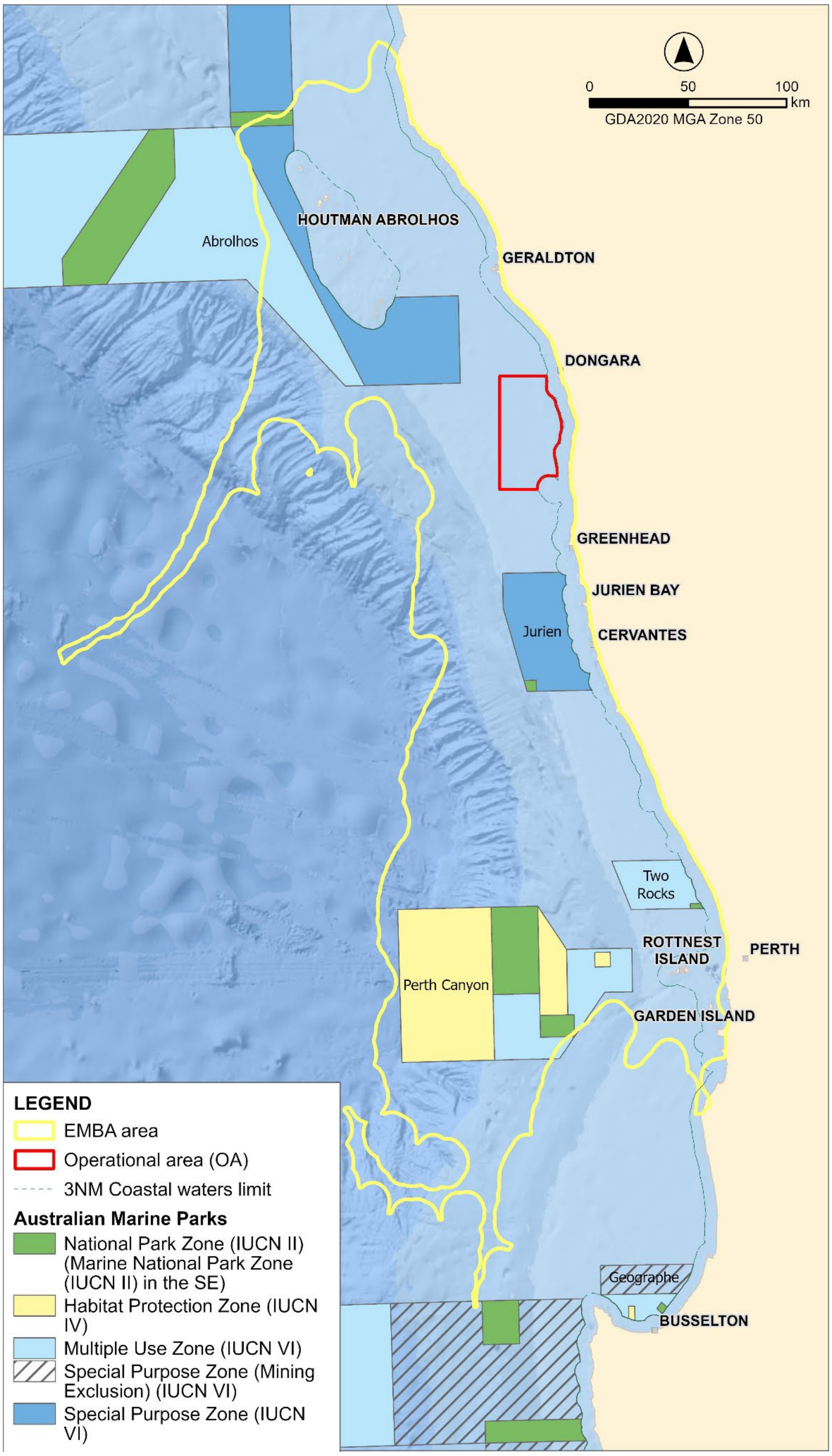


Figure 4-16: Commonwealth protected areas overlapping and adjacent to the OA and EMBA

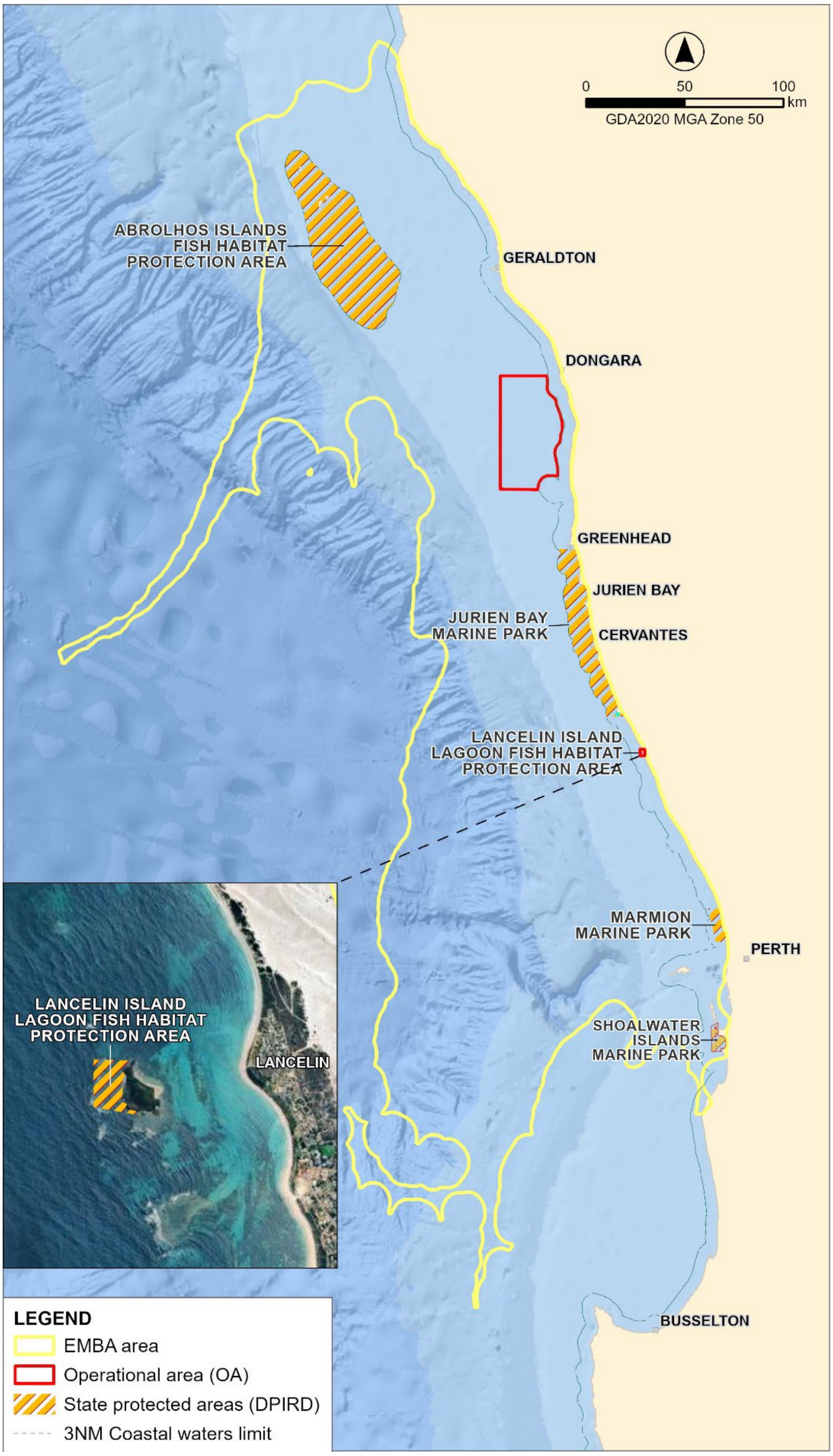


Figure 4-17: State protected areas within the EMBA

Table 4-13: 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)

Reserve	Distance from OA	IUCN categories	Key values
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 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			

Reserve	Distance from OA	IUCN categories	Key values
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 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 Proximity to Perth City, providing local area to explore nature 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*)
Buller, Whittell and Green Islands	90 km S		
Cervantes Islands	75 km S		
Sandland Island	40 km S		
Outer Rocks	65 km S		

Reserve	Distance from OA	IUCN categories	Key values
Fisherman Islands	35 km S	Nature Reserves part of Turquoise Coast	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)
Ronsard Rocks	70 km S		
Beagle Islands	10 km S		
Lipfert, Milligan, Etc Islands	25 km S		

Table 4-14: 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 4-15.

Table 4-15: 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.

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
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 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, and only 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). The fishery predominantly uses pelagic long-line fishing gear that are many kilometres long. Each line usually takes several hours to deploy and retrieve and has the potential to be entangled with the seismic survey streamers.	✓	✓	Low catch or effort occurs in WA. Seismic activity may affect fishing activities 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 4.4.4.1)
- 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 4-16. The activity of these fisheries is described in the following sections.

Table 4-16: 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). Off the west coast of WA, the AMF primarily targets Roe's abalone (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.

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
Open Access Fishery (OAF)	✓	✓	The OA overlaps with 1575 km² (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.
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 km² (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.

Fishery	Licence to fish		Description	Historical catch / effort		Relevance to EP
	OA	EMBA		OA	EMBA	
West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF)	✓	✓	The OA overlaps with 1575 km² (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 km² (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.
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 km² (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.

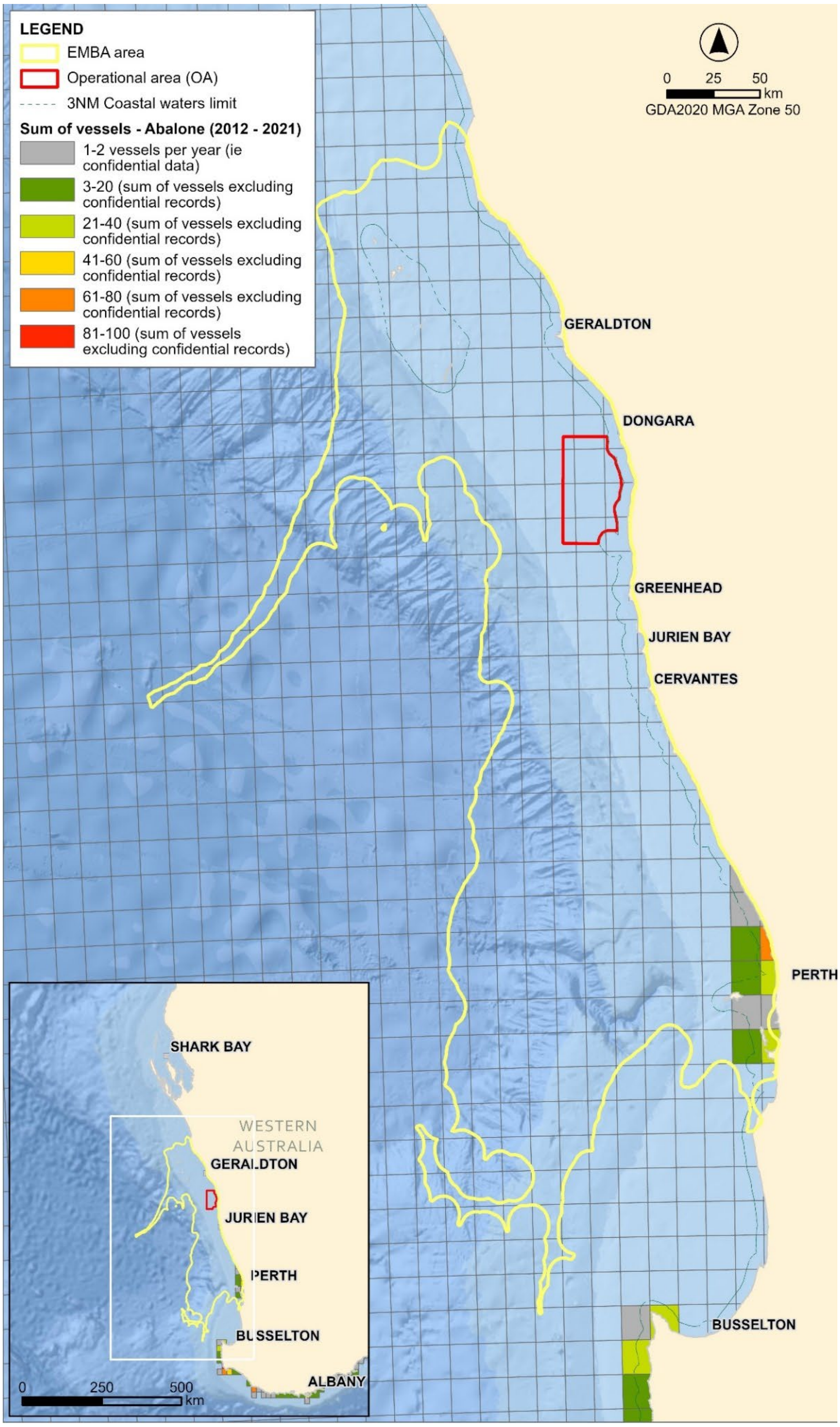


Figure 4-18: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the AMF for 2012–2021 combined

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.

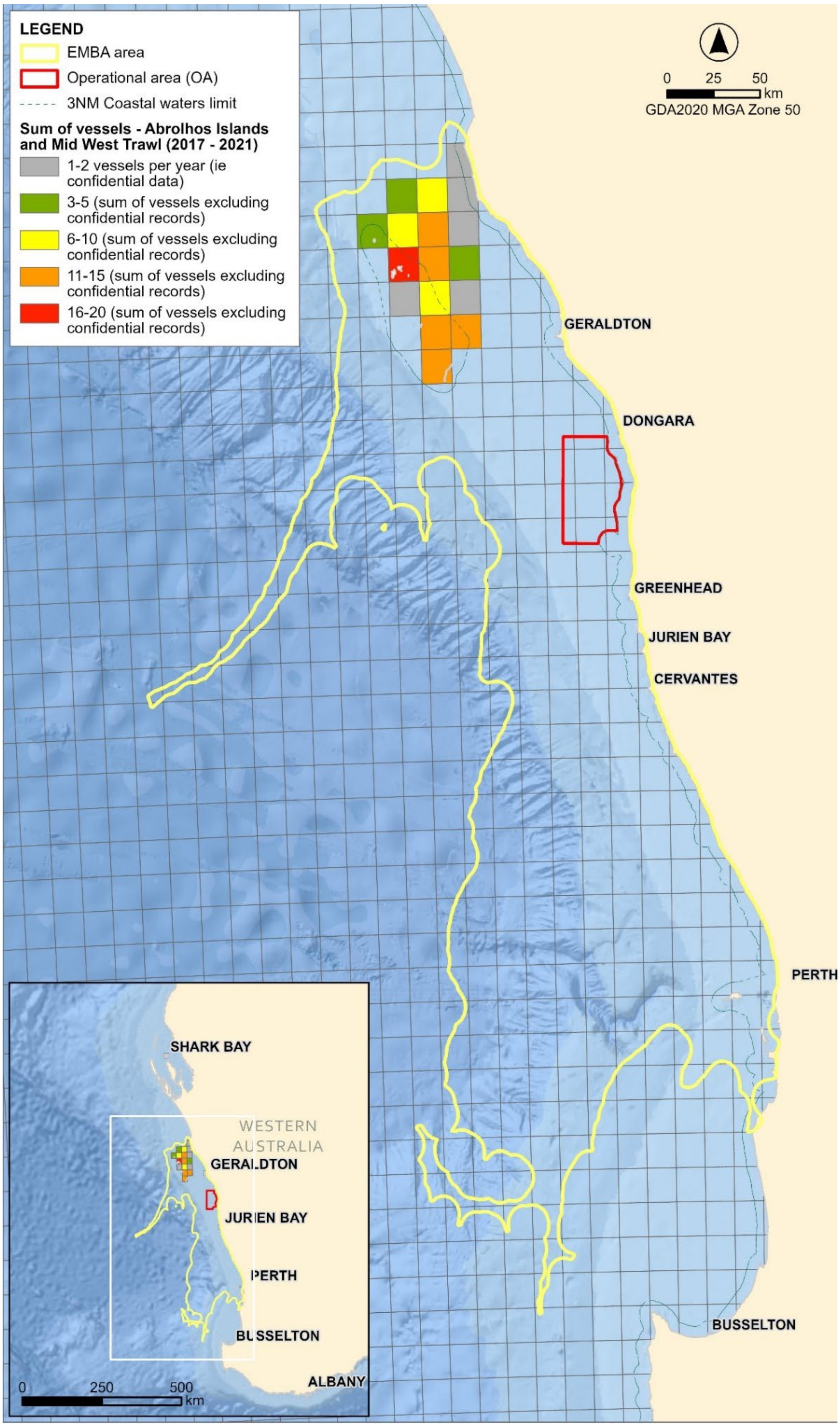


Figure 4-19: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the AIMWTMF for 2017–2021 combined

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.

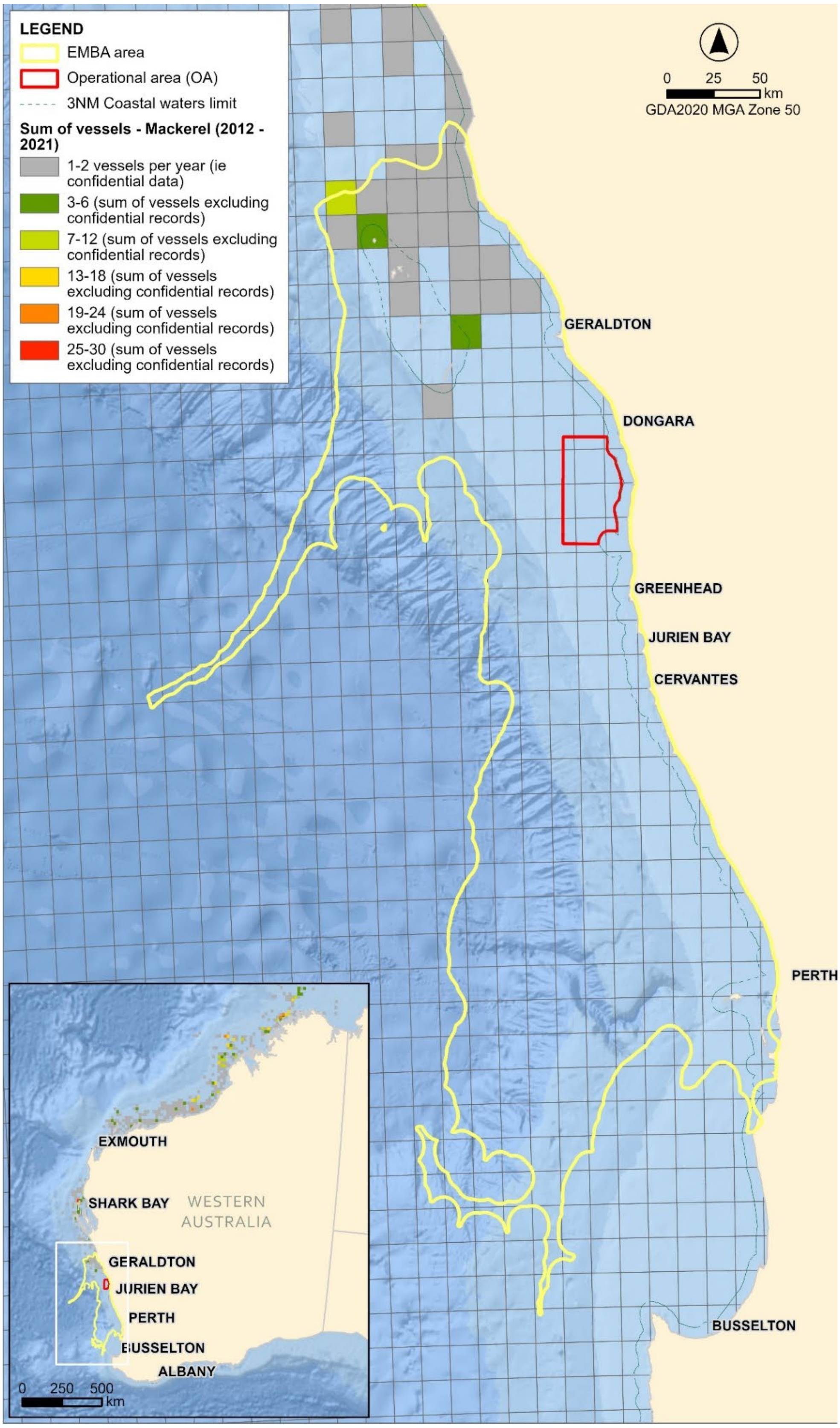


Figure 4-20: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MMF for 2012–2021 combined

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.

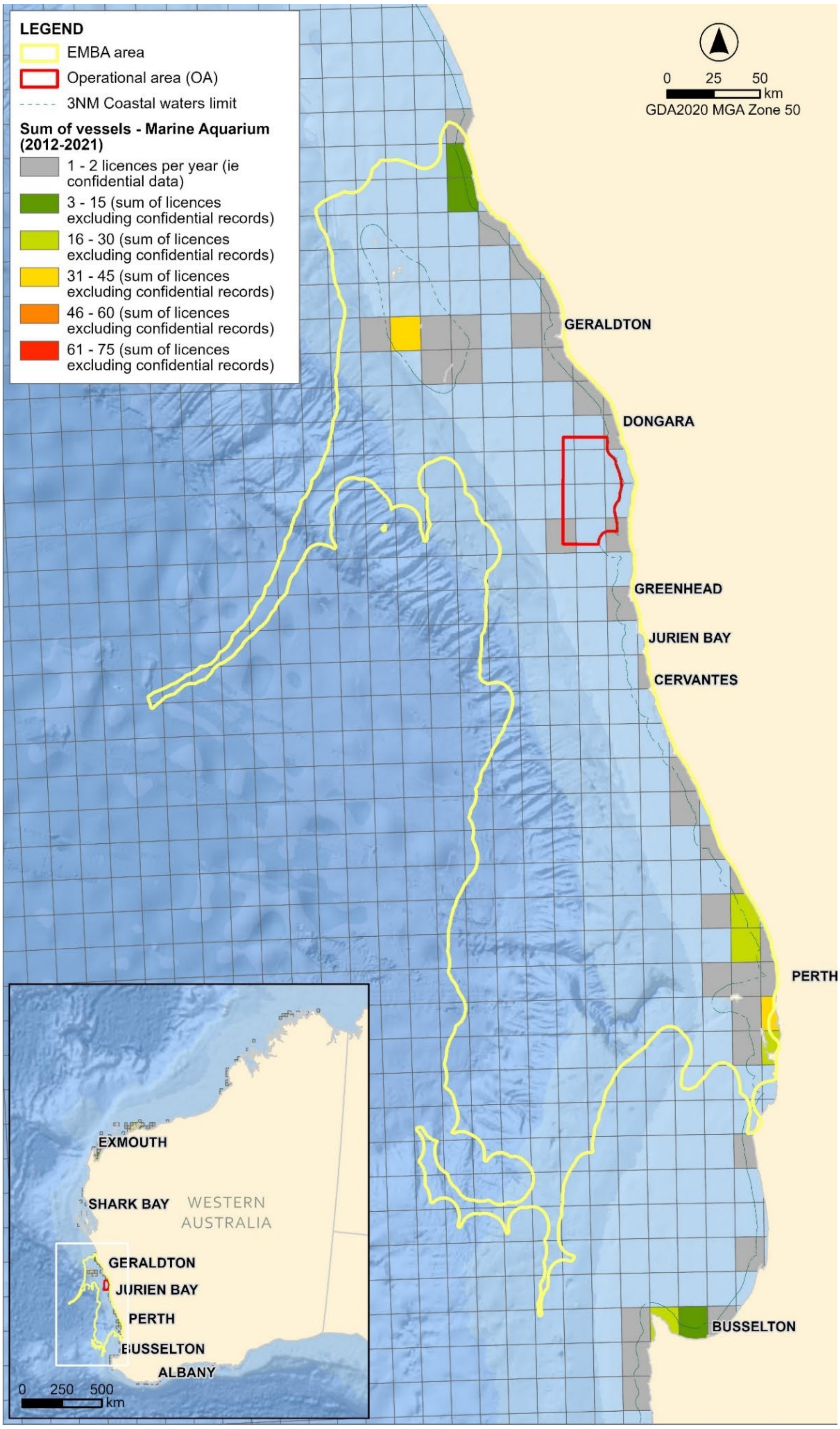


Figure 4-21: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MAFMF for 2012–2021 combined

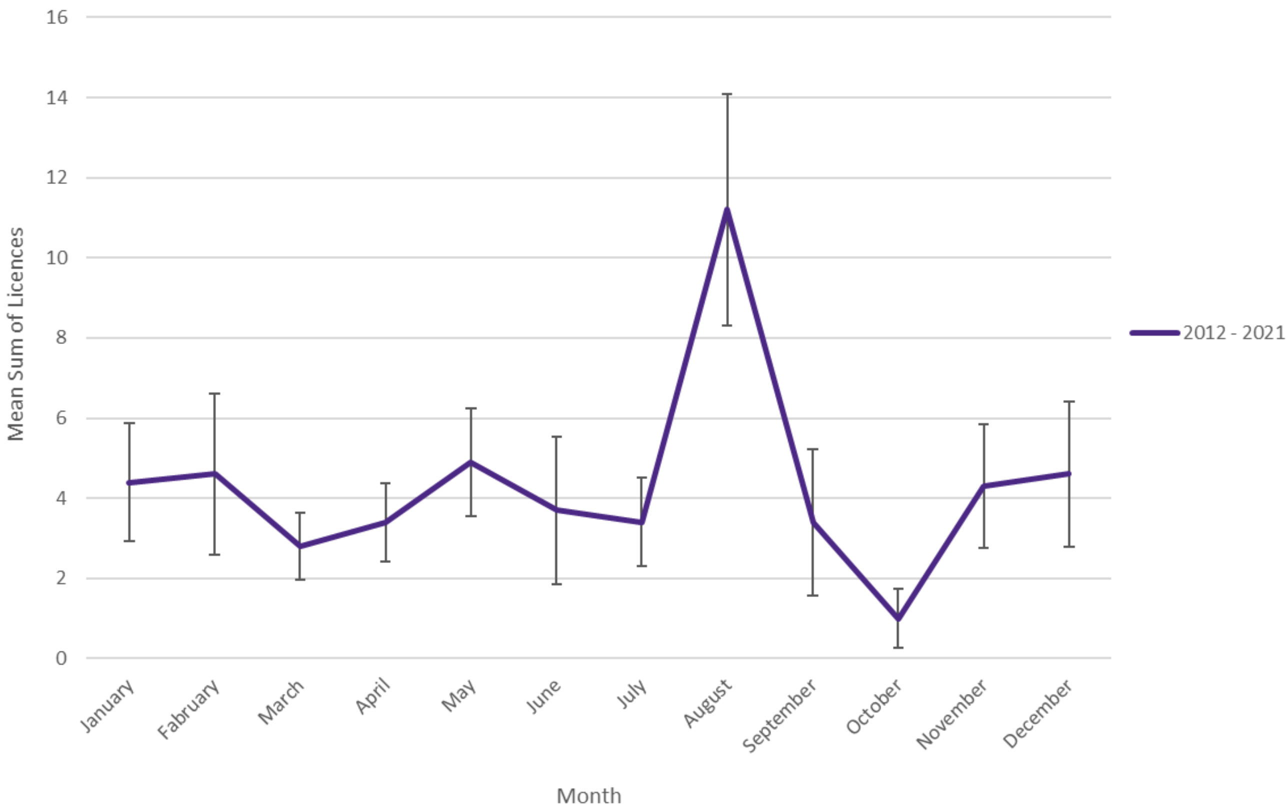


Figure 4-22: Mean monthly sum of licences (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the MAFMF for 2012–2021 combined

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).

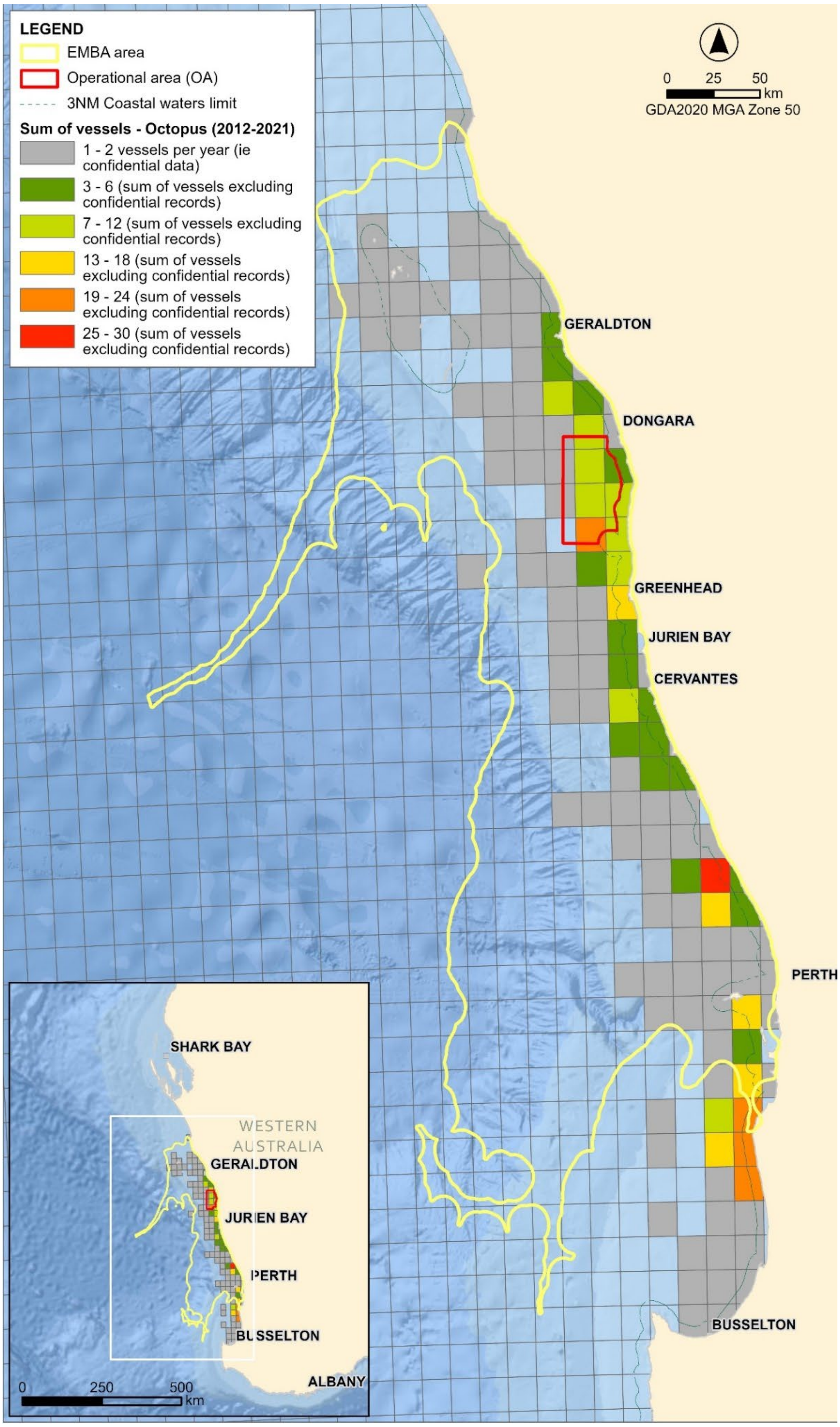


Figure 4-23: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the OIMF for 2012–2021 combined

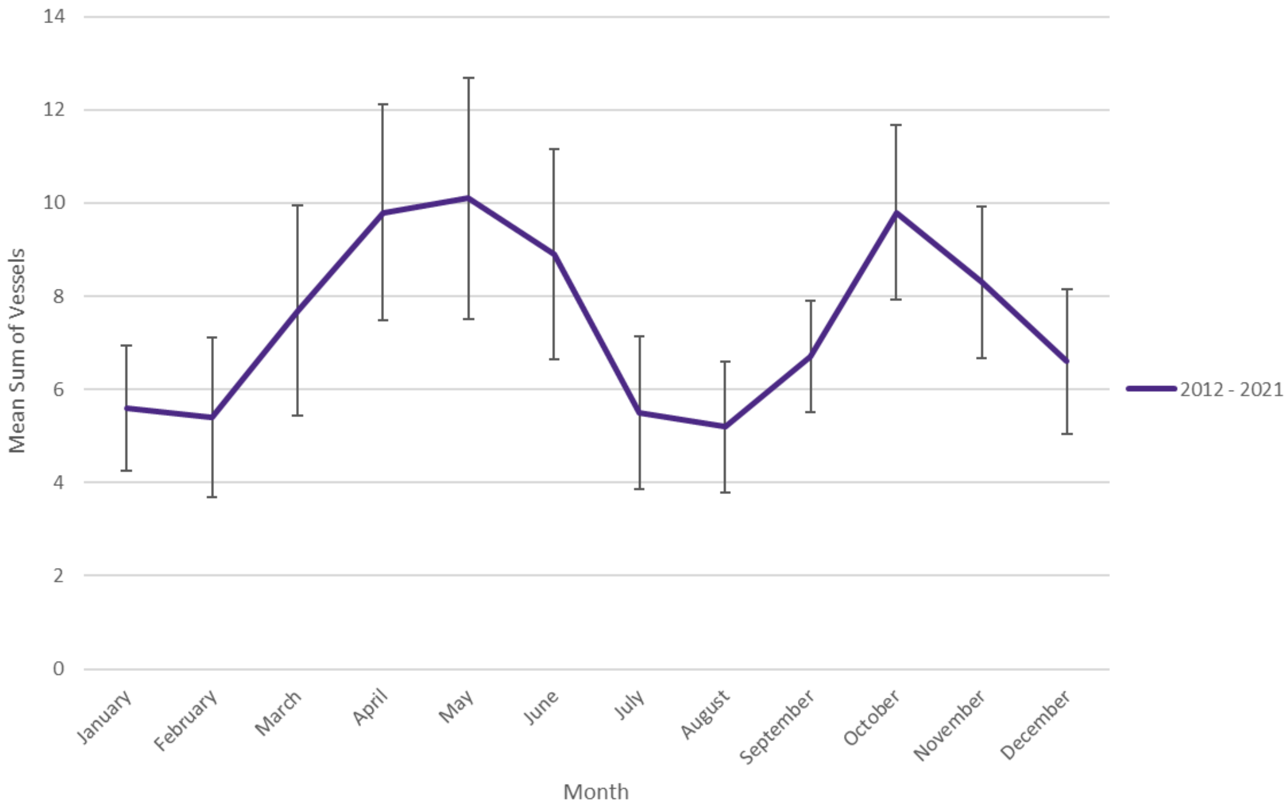


Figure 4-24: Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the OIMF for 2012–2021 combined

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.

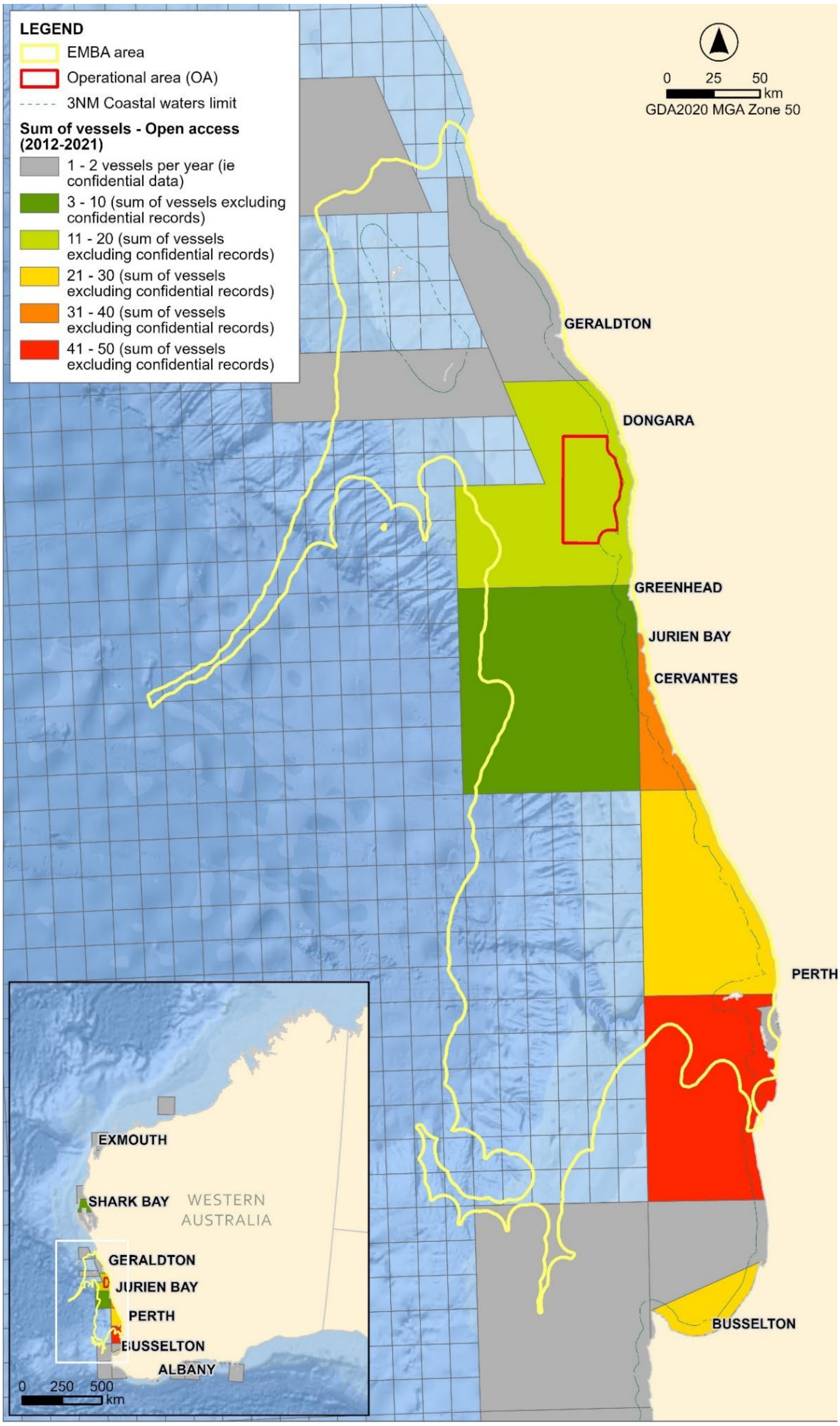


Figure 4-25: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the OAF for 2012–2021 combined

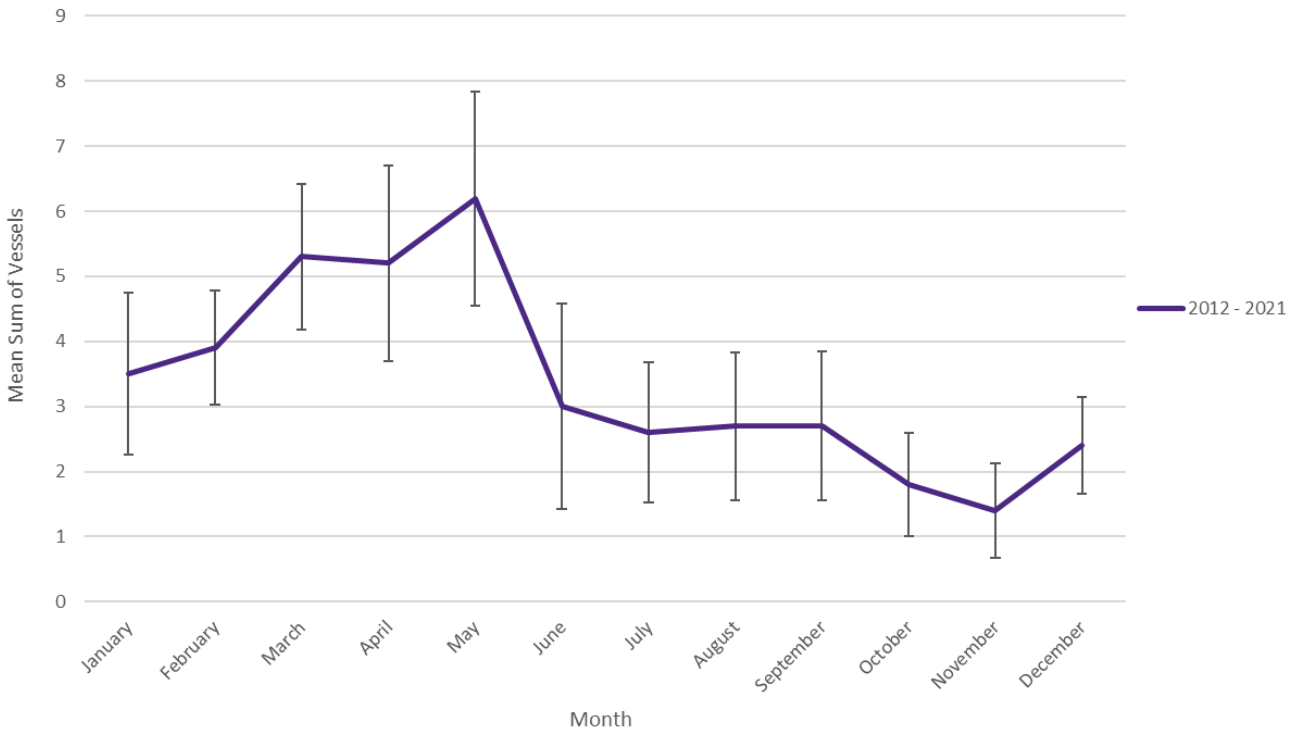


Figure 4-26: Mean monthly sum of vessels (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the OAF for 2012–2021 combined

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.

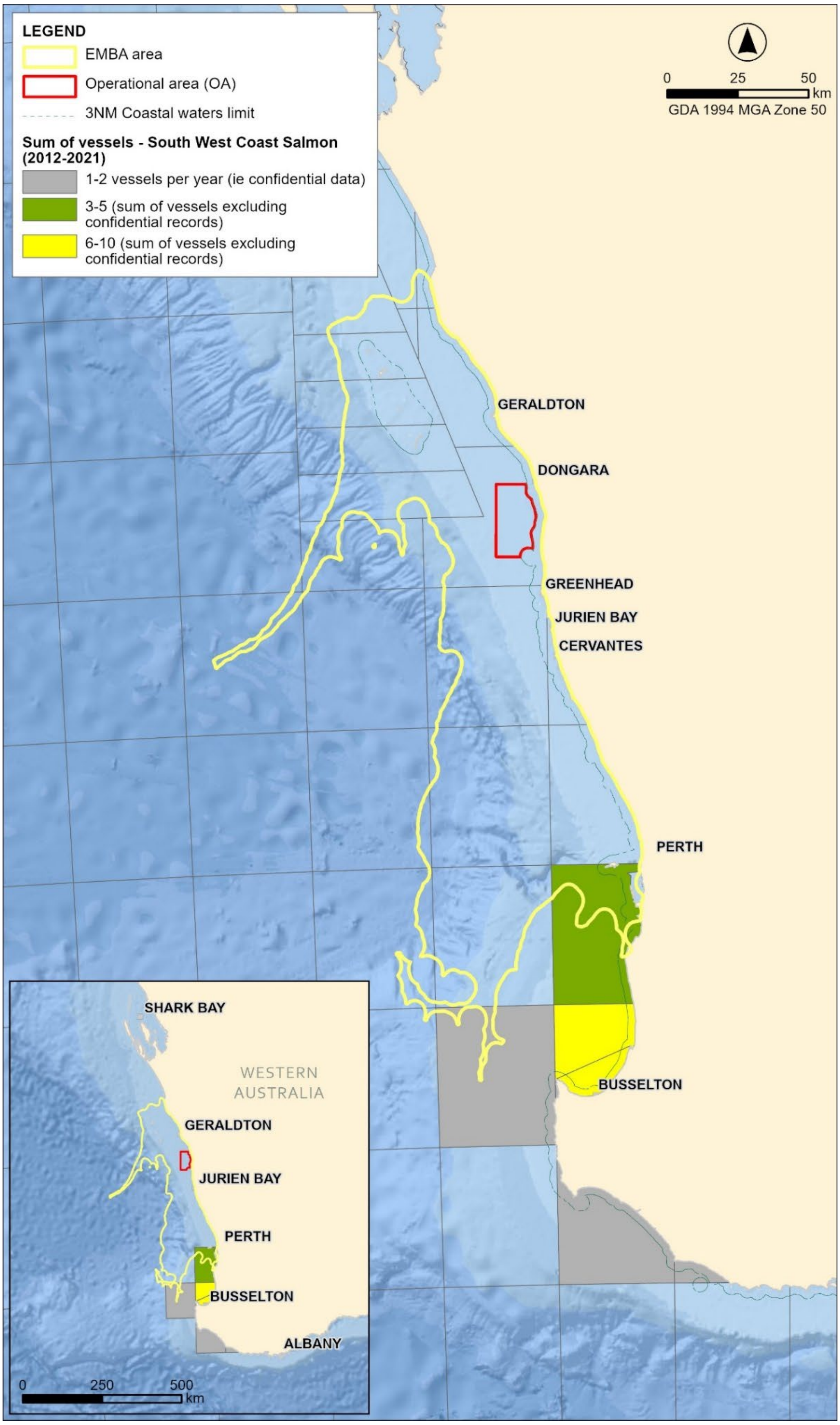


Figure 4-27: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the SWCSMF for 2012–2021 combined

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.

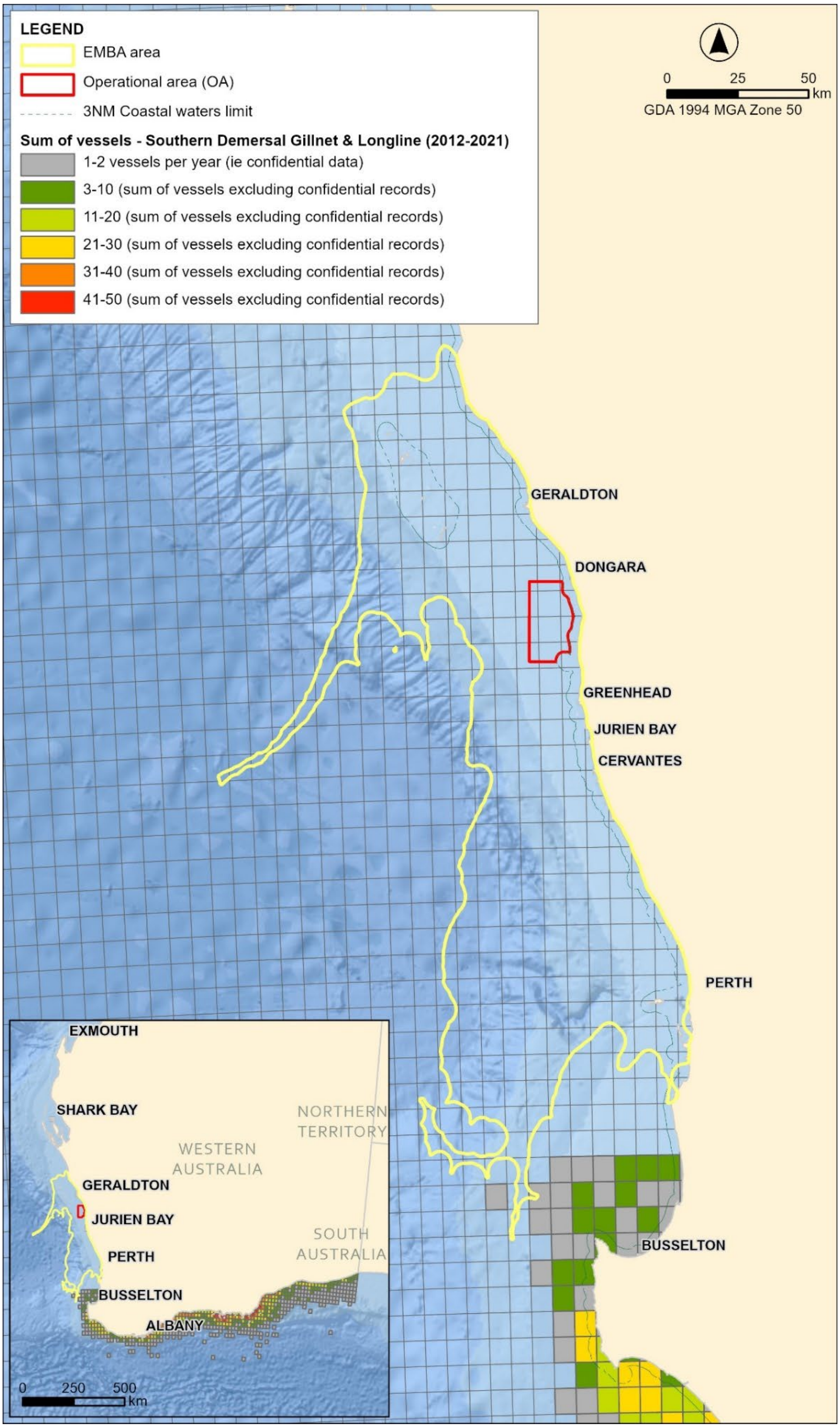


Figure 4-28: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the SDGDLMF for 2012–2021 combined

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.

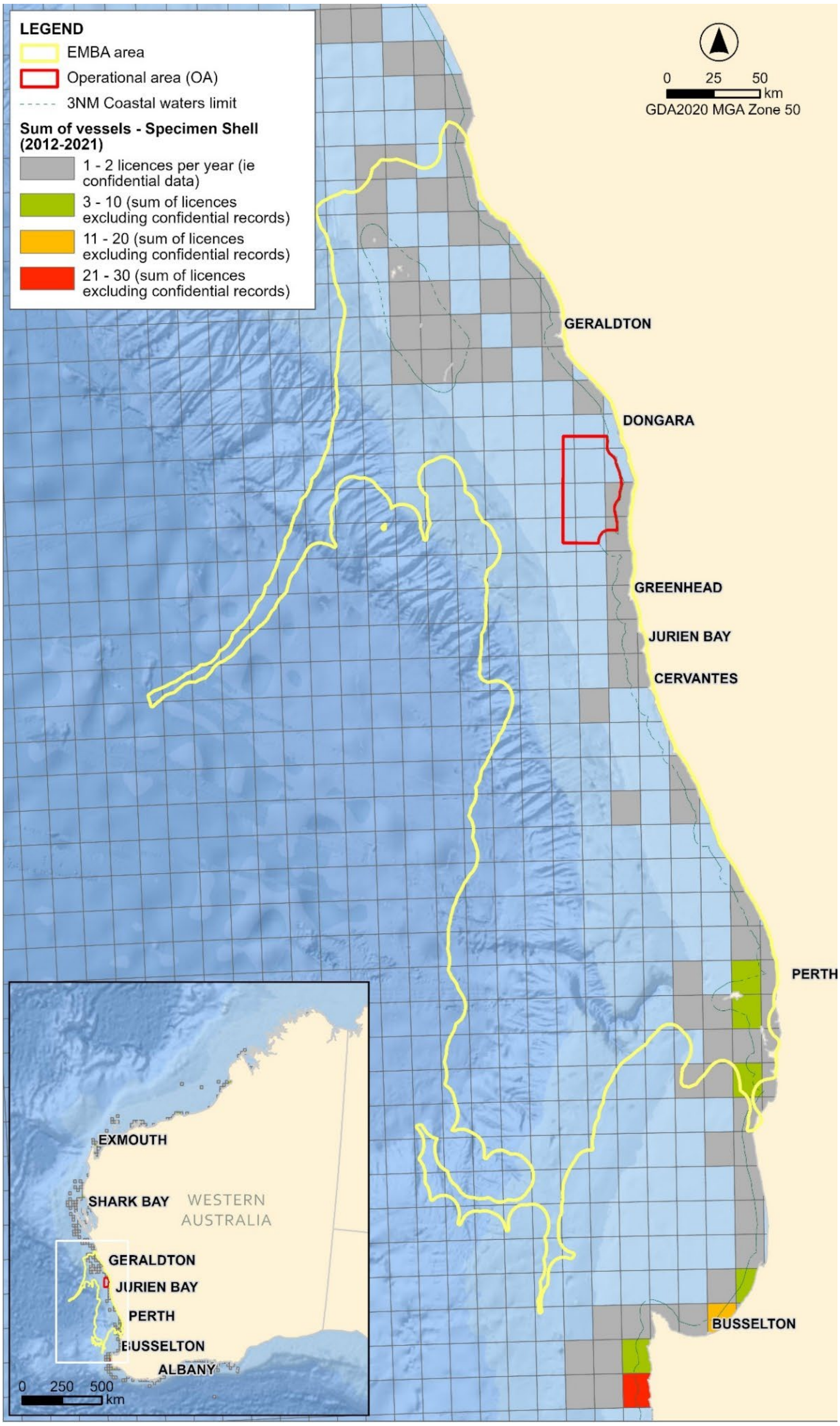


Figure 4-29: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the SSMF for 2012–2021 combined

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.

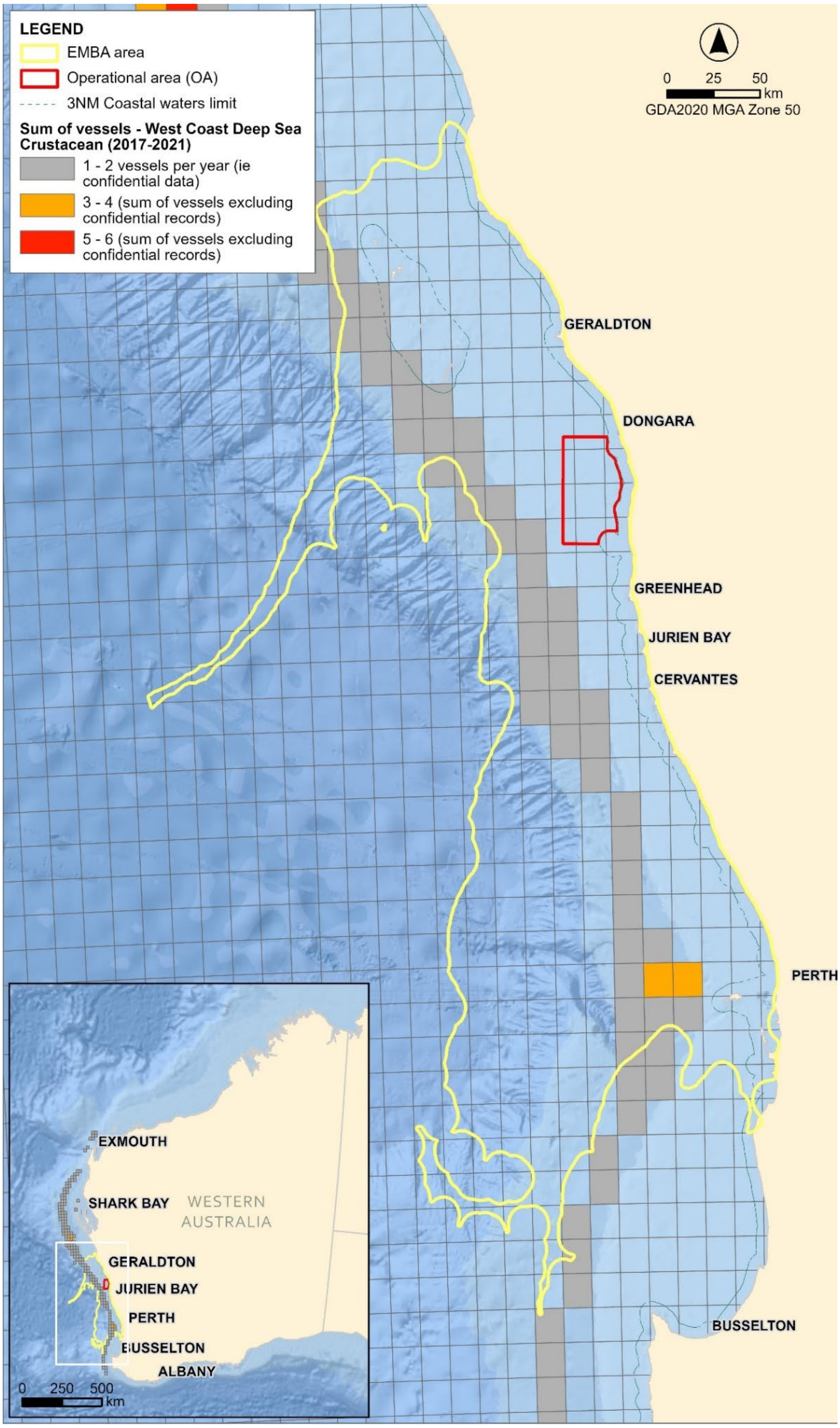


Figure 4-30: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSCMF for 2012–2021 combined

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.

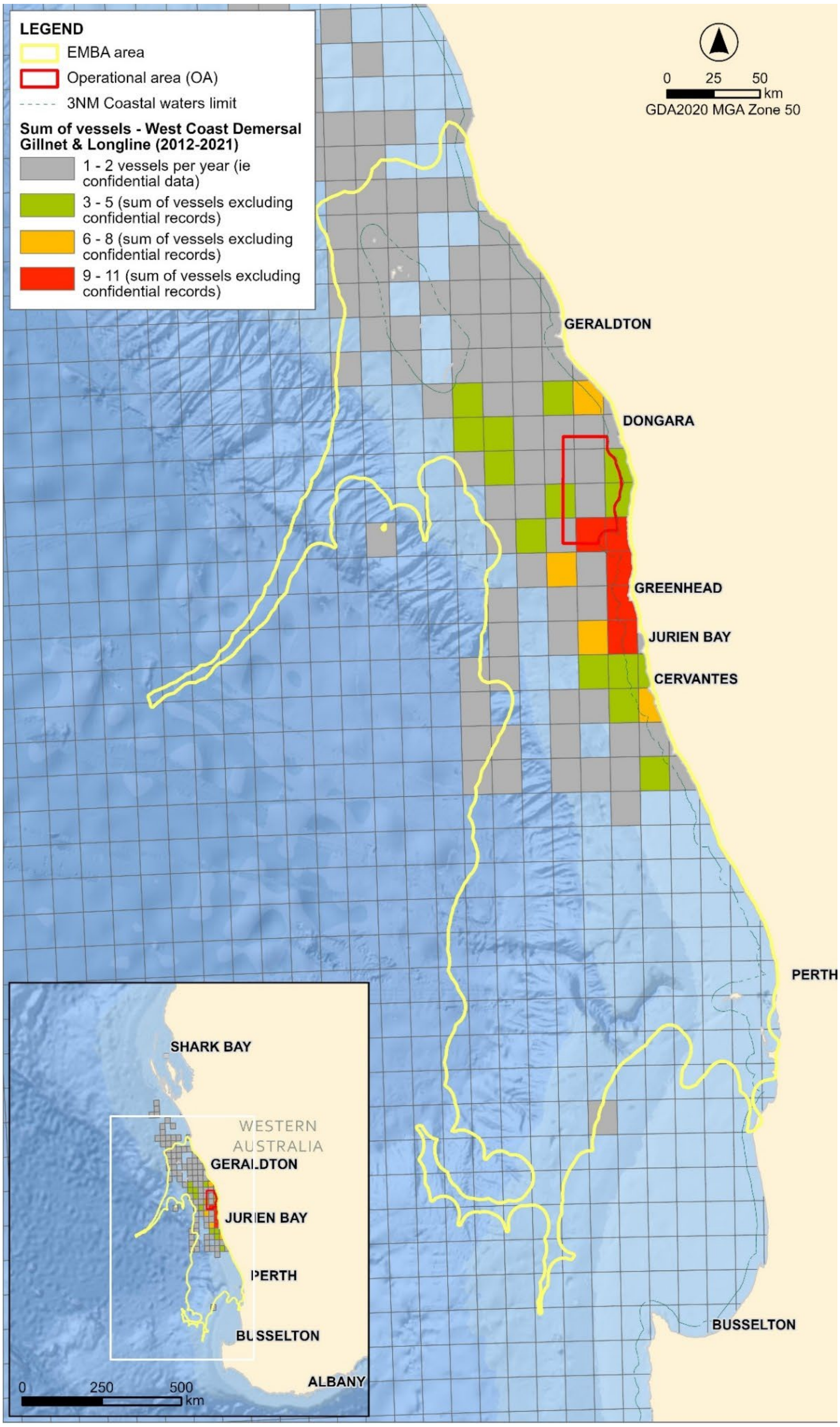


Figure 4-31: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDGDLMF for 2012–2021 combined

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, 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).

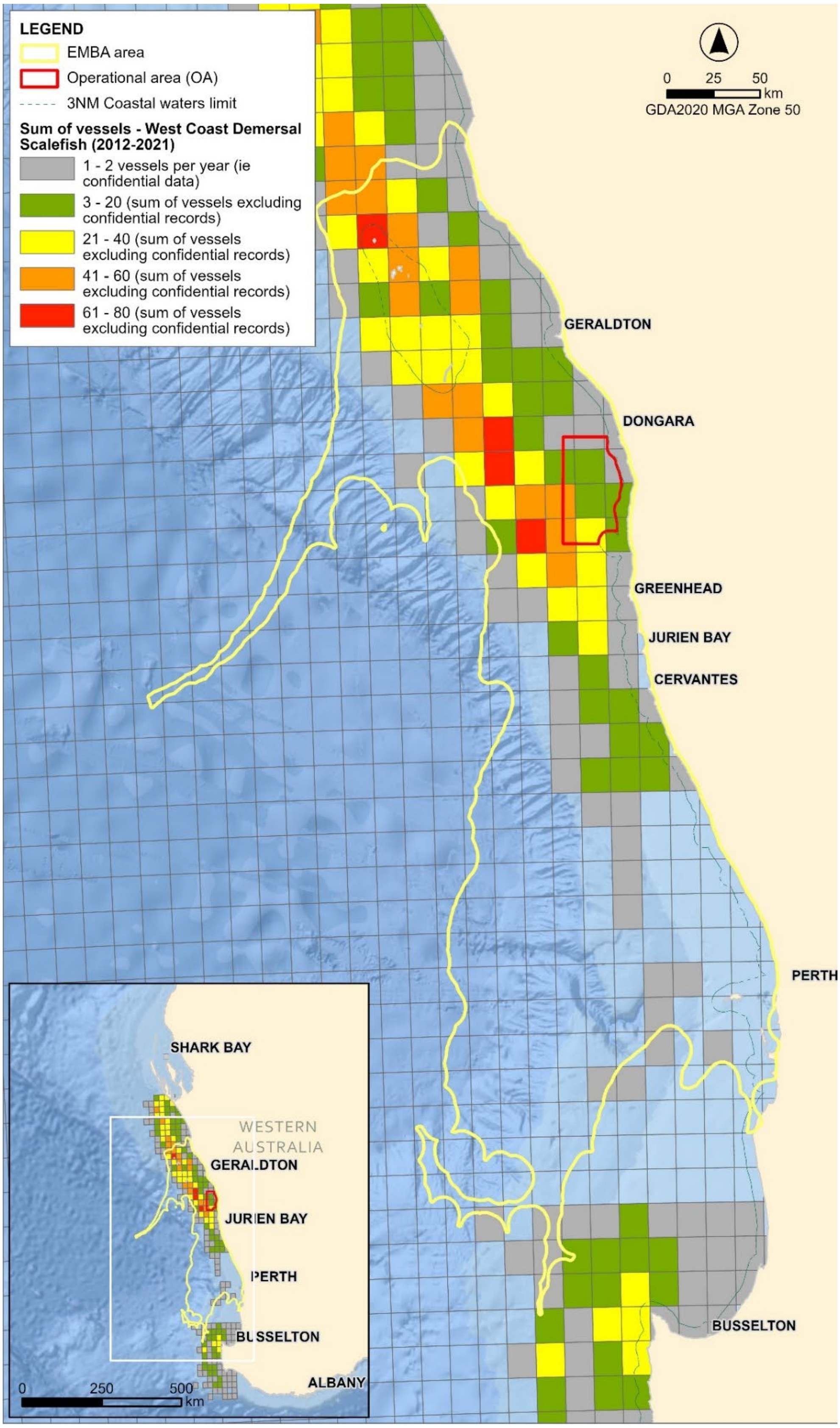


Figure 4-32: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSIMF for 2012–2021 combined

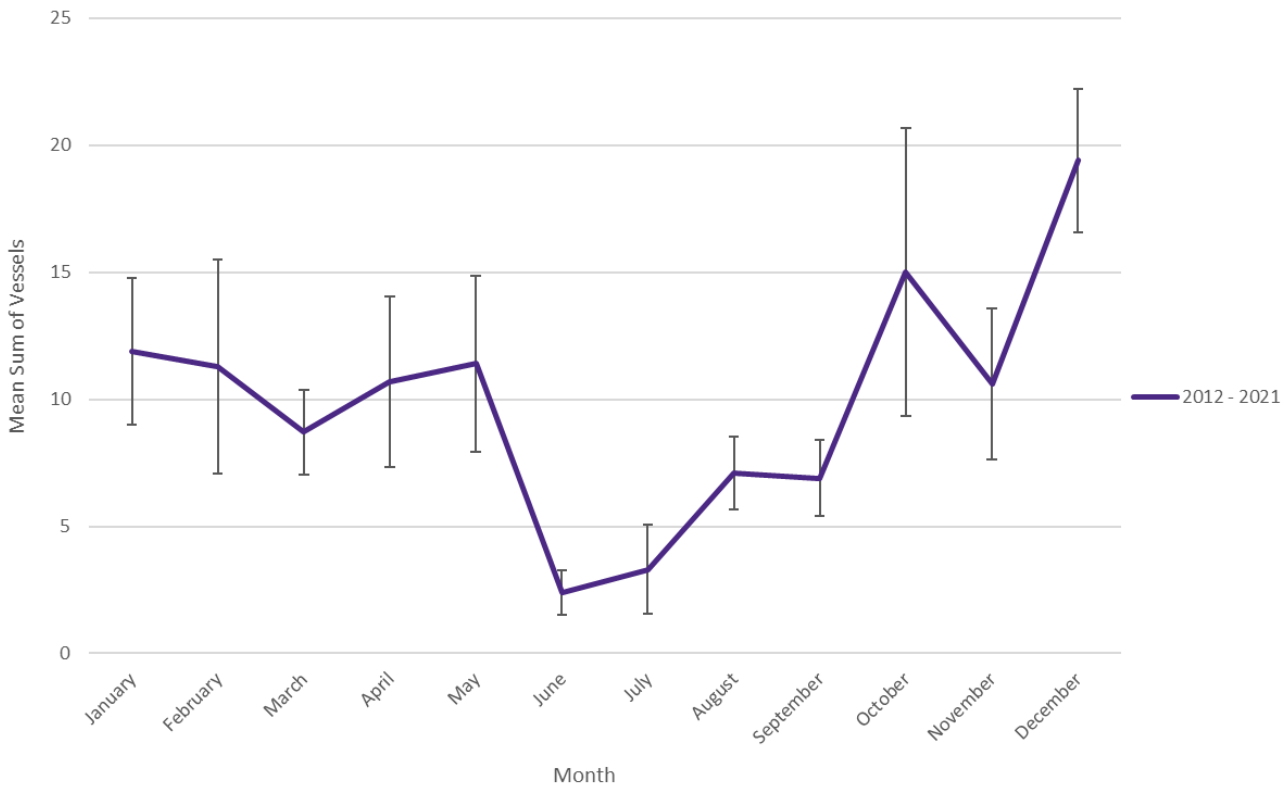


Figure 4-33:Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCDSIMF for 2012–2021 combined

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.

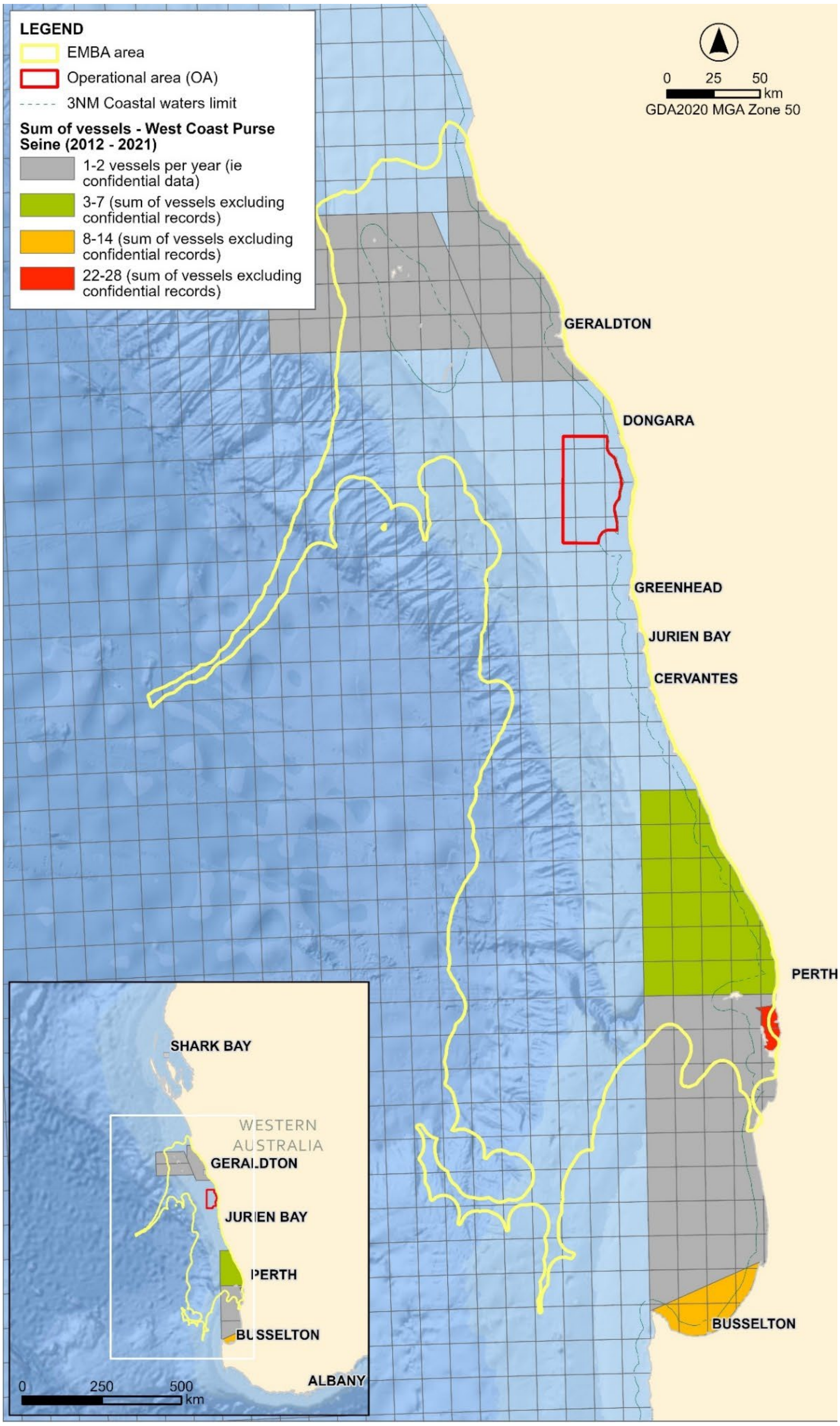


Figure 4-34: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 60 × 60 nm CAES blocks recorded in the WCPSMF for 2012–2021 combined

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).

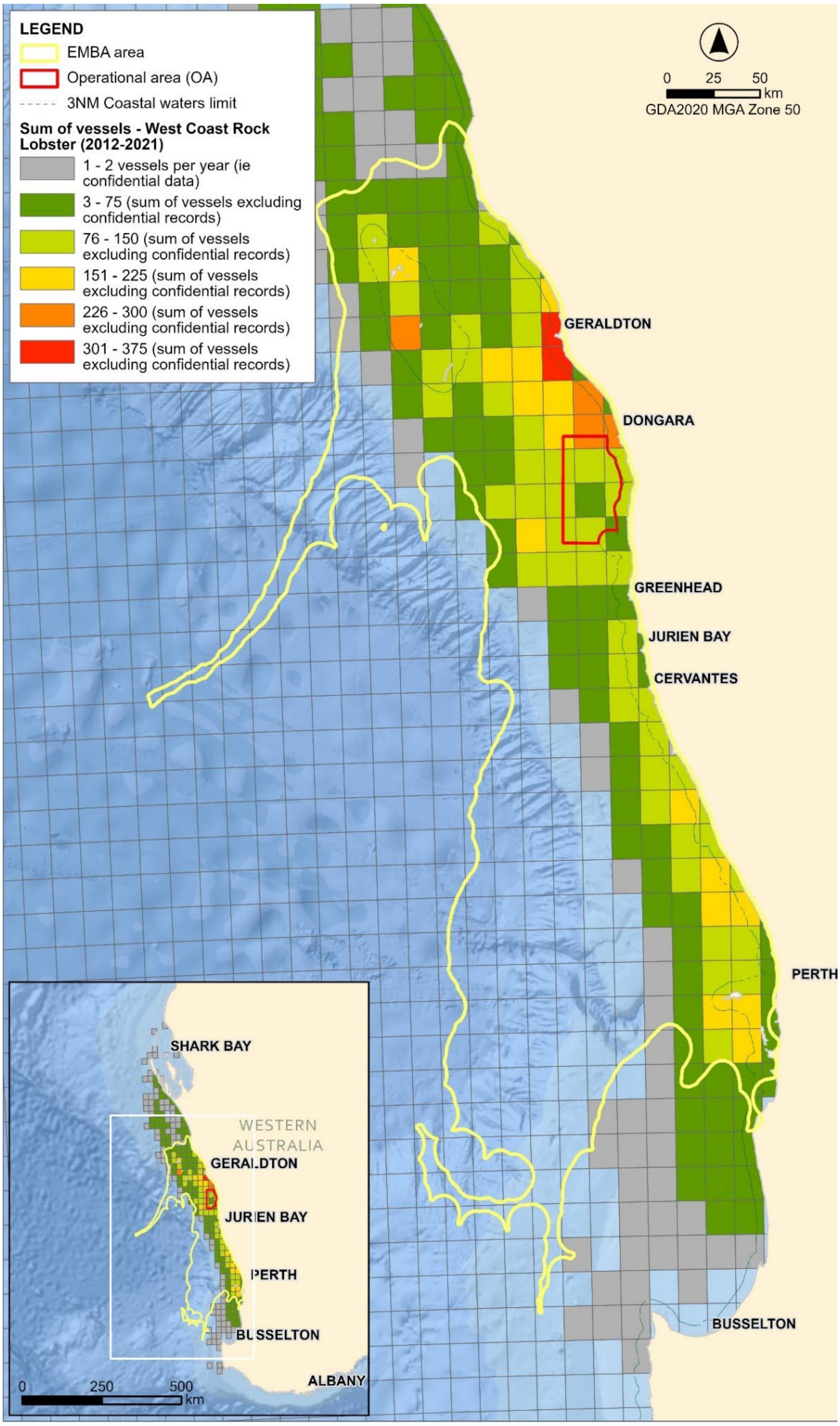


Figure 4-35: Spatial distribution and sum of annual vessel counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCRLMF for 2012–2021 combined

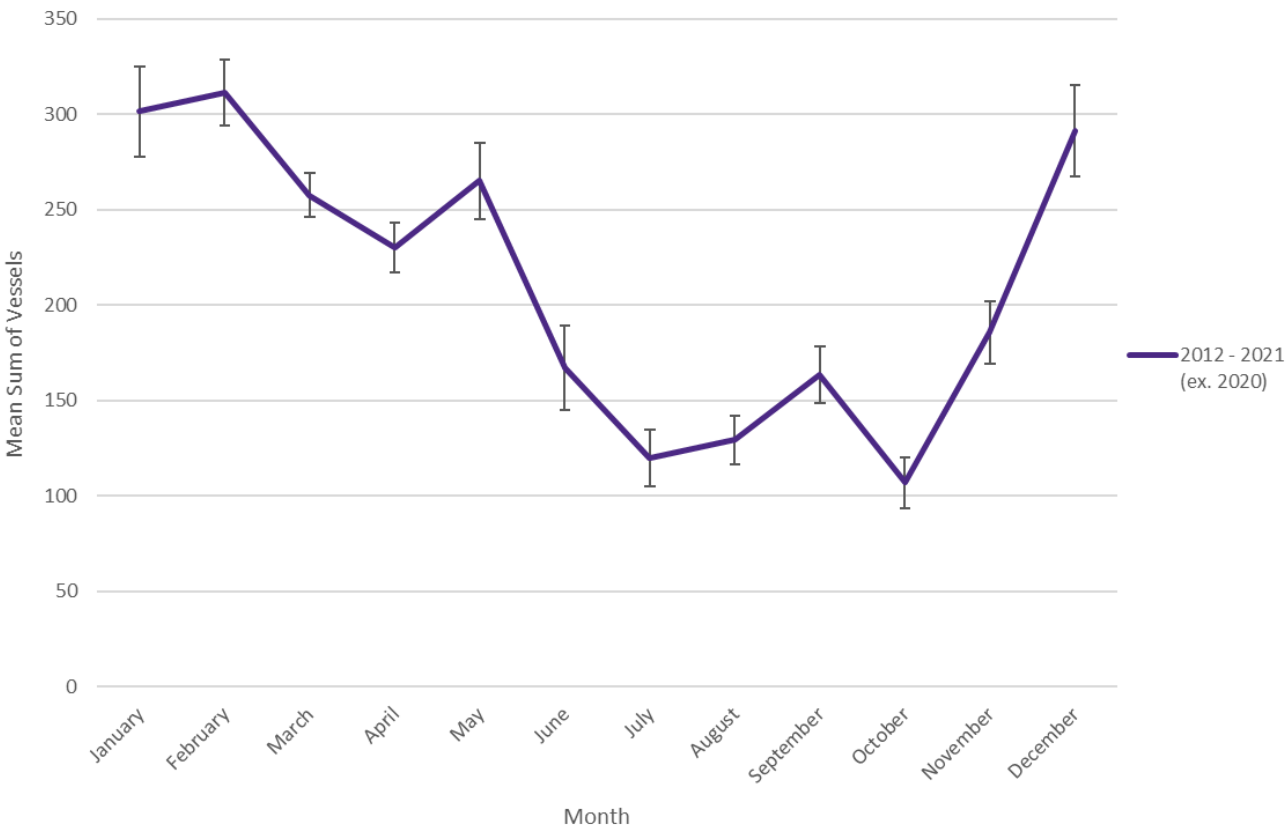


Figure 4-36: Mean monthly sum of vessels (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the WCRLMF for 2012–2021 combined, excluding 2020

4.4.3 Tourism

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 0.

4.4.4 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 4.4.4.1).

4.4.4.1 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, 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.

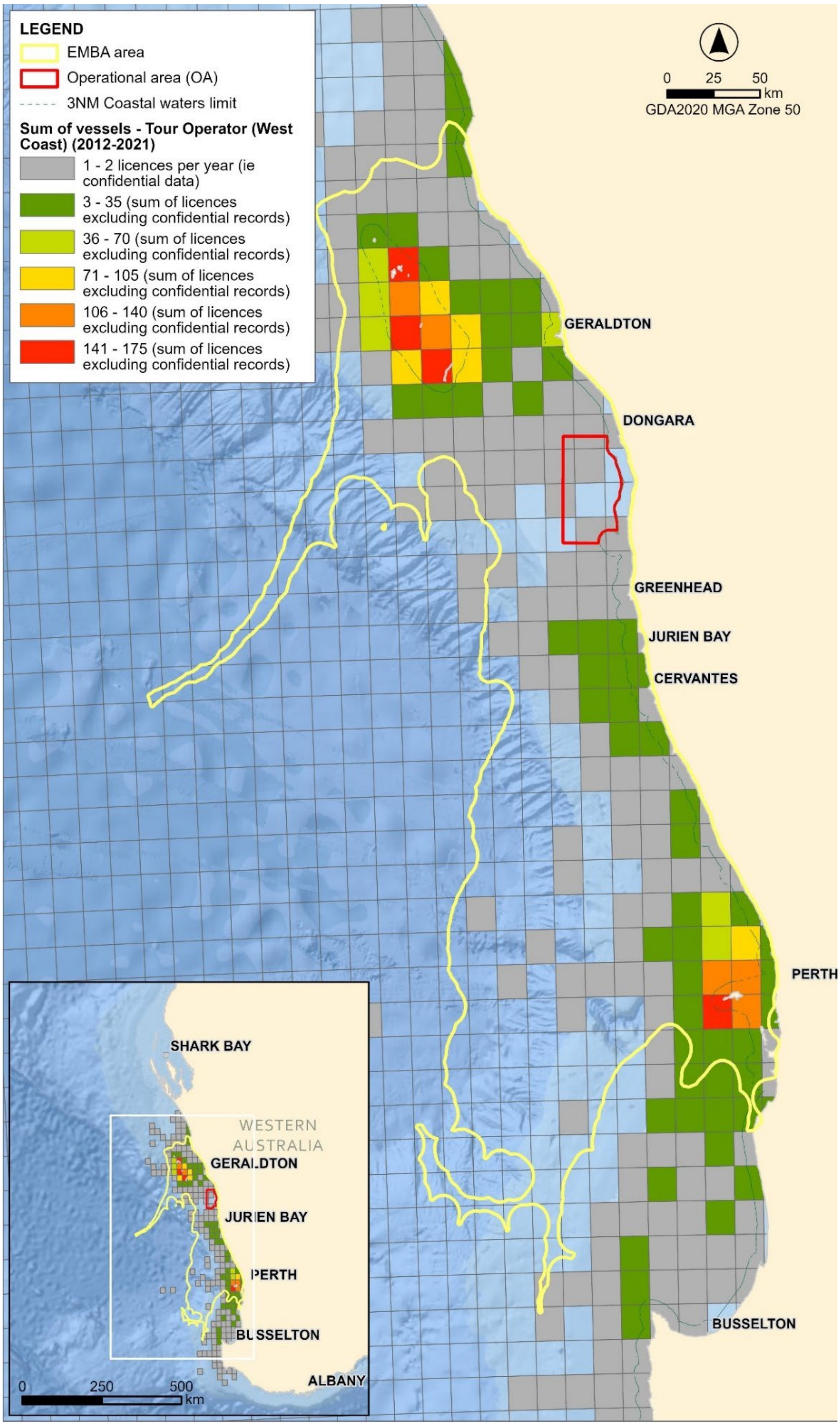


Figure 4-37: Spatial distribution and sum of annual licence counts (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the TOFWC for 2012–2021 combined

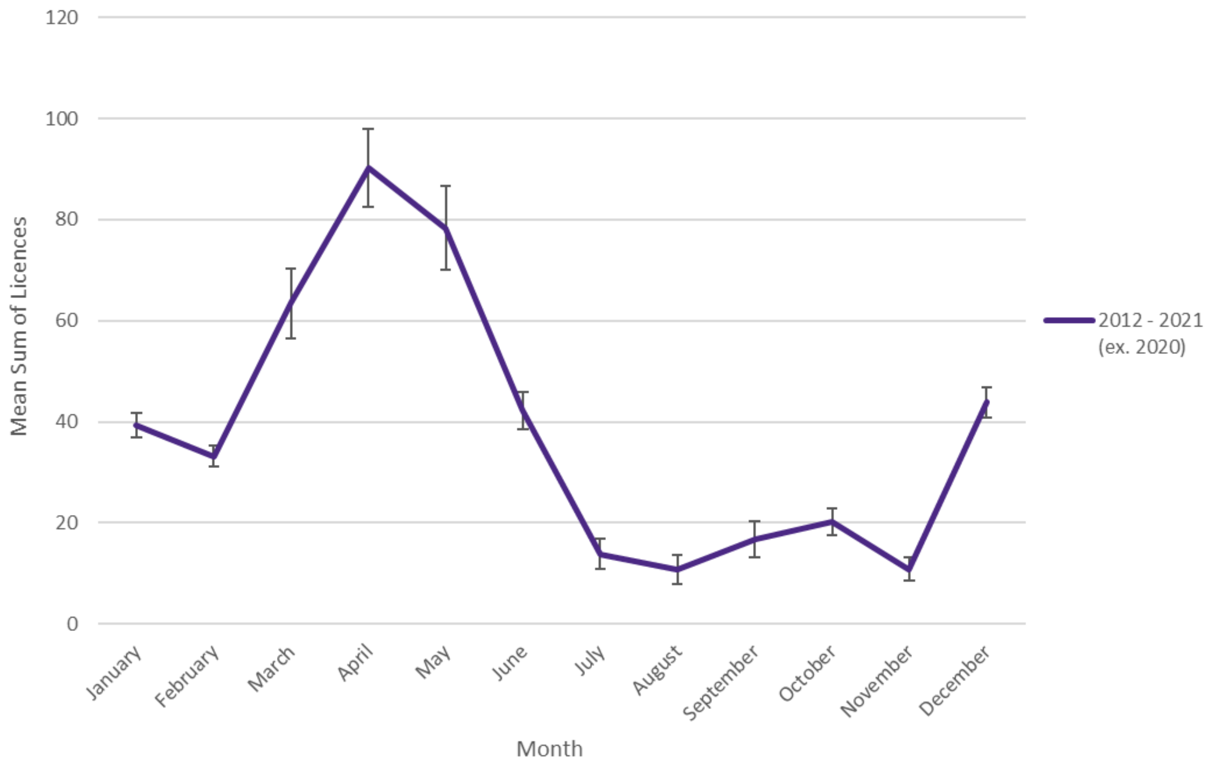


Figure 4-38: Mean monthly sum of licences (excluding confidential records) in 10 × 10 nm CAES blocks recorded in the TOFWC for 2012–2021 combined, excluding 2020

4.4.5 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.

There is only one petroleum title adjacent to the proposed activity. WA-31-L is a production licence that partially overlaps the OA and its operator is Triangle Energy (Operations) Pty Ltd.

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.

4.4.6 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). *Batavia* is located approximately 117 km northwest of the OA.

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.

4.4.7 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 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, which have been confirmed through research and/or consultation. 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.

4.4.7.1 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).

There is geographical overlap between the Operational Area and the Yamatji Nation Indigenous Land Use Agreement (ILUA) area. However, the ILUA's obligations under the Native Title Act 1993 (Cth) primarily bind the Western Australian Government and Yamatji Nation entities, and do not impose direct compliance requirements on petroleum titleholders for activities governed by the Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Cth). All consultation obligations under the OPGGS (Environment) Regulations 2023 continue to be addressed through the EP's existing stakeholder engagement processes.

The Yamatji Nation claim is made up of five claimant groups – Hutt River, Southern Yamatji, Yamatji Nation, Mullewa Wadjari and Widi Mob. The Yamatji People are represented by the Bundi Yamatji Aboriginal Corporation, Yamatji Southern Regional Corporation and the Yamatji Marlpa Aboriginal Corporation. A Yamatji Proponent Standard Heritage Agreement (YPSHA) is in place between TEO and Yamatji Southern Regional Corporation as of February 2021.

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.

4.4.7.2 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 Southern Yamatji people are currently consulting on the development of an Indigenous Protected Area (IPA) at the Houtman Abrolhos Islands and have commenced drafting their Sea Country Management Plan. 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.

4.4.7.3 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). Pilot also recognises that the Beagle Islands have also been submitted as a site of cultural heritage by the Wattandee Littlewell Aboriginal Corporation (WLAC) to the Aboriginal Heritage Committee, though this is not reflected on the ACHIS website at the time of submission. 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 several 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 (KMAC) have identified their interests for the Sea Country around Wedge Island (within the Yued ILUA area) and within the EMBA, with the presence of both songlines and totemic species identified for the group. Discussion with members of WLAC have identified important cultural areas and heritage around the Irwin River mouth, the Beagle Islands and adjacent Sea Country. Pilot Energy acknowledges and recognises the totemic species: Sea Lion, Shark, Dolphin, Whales and their spiritual and ecological significance to WLAC peoples and Elders and the sacred sites and Dreaming tracks across the shelf and marine zones.

They have identified strong cultural connections to sea lions in Irwin River mouth and suggested that a songline regarding sea lions is shared along the coast amongst different tribes. However, there was no identification of who the knowledge holders of this songline would be for that area.

Pilot Energy understands from WLAC that it has and will continue to make submissions to have cultural heritage registered under the Aboriginal Cultural Heritage Act 1972 (WA) and produce maps of these places. As part of ongoing consultation with all relevant persons, Pilot Energy will update this EP to reflect information provided by any Traditional Owner group to ensure ongoing recognition and acknowledgement of their cultural heritage values.

There are references to totemic animals and songlines associated with various animals in publicly available literature. Whadjuk Noongar people have strong affiliations with whales, 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.

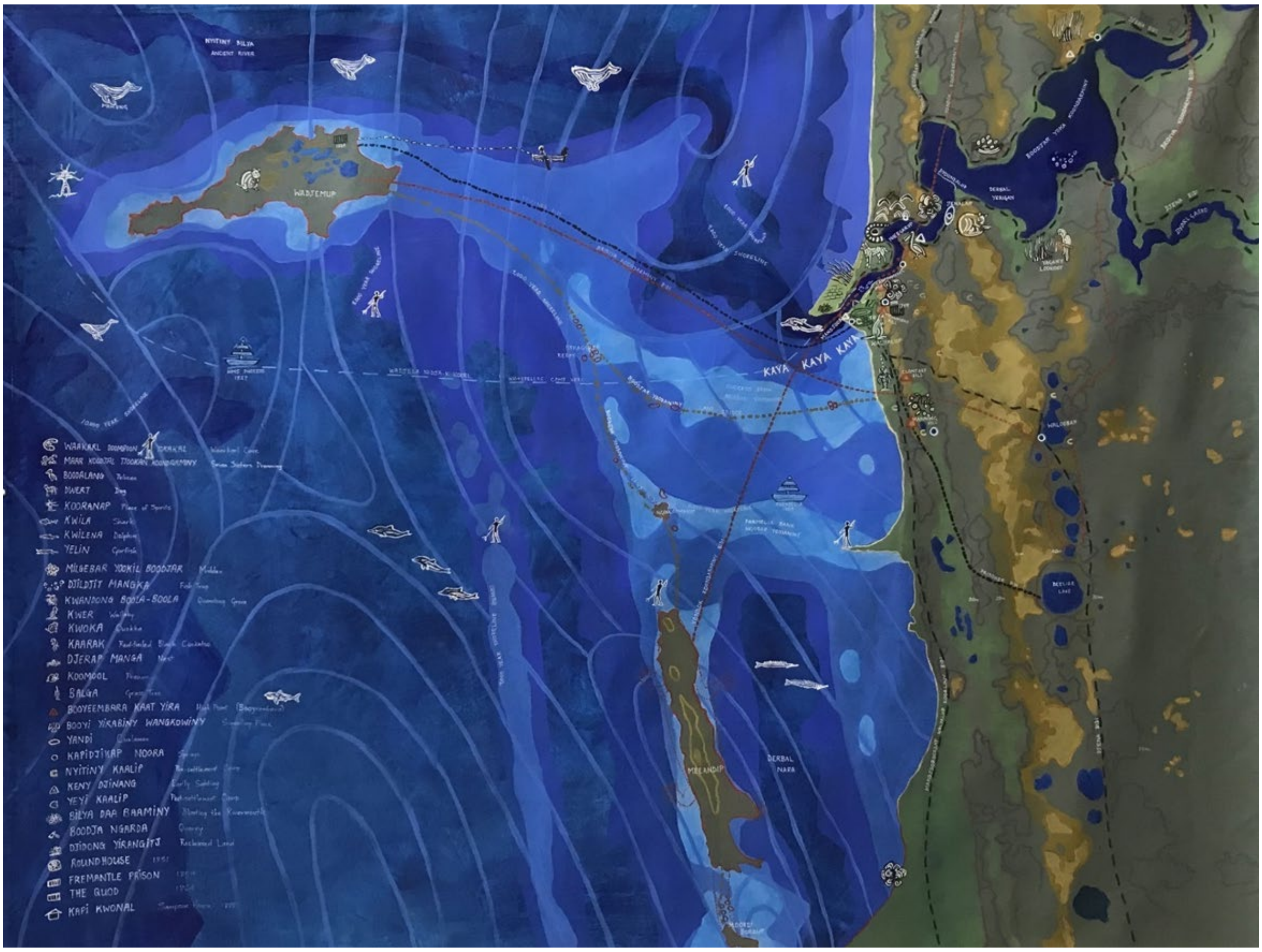


Figure 4-39: Sea Country cultural values around Sea Country of Whadjuk Noongar. Reproduced from Mapping Walyalup Boodja (Collard et al 2021)

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 River mouth, Beagle Island and surrounding waters, across the shelf and throughout their Sea Country. As well as sharks and whales being a species of cultural significance.	Relevant person consultation	Yes	Yes, Sea Country cultural values exist
Kwelena Mambakort Wedge Island Aboriginal Corporation	Sea Country values and totemic species including mullet, shark, dolphin, whales and abalone around Wedge Is.	Relevant person consultation	Yes	Yes, Sea Country cultural values exist

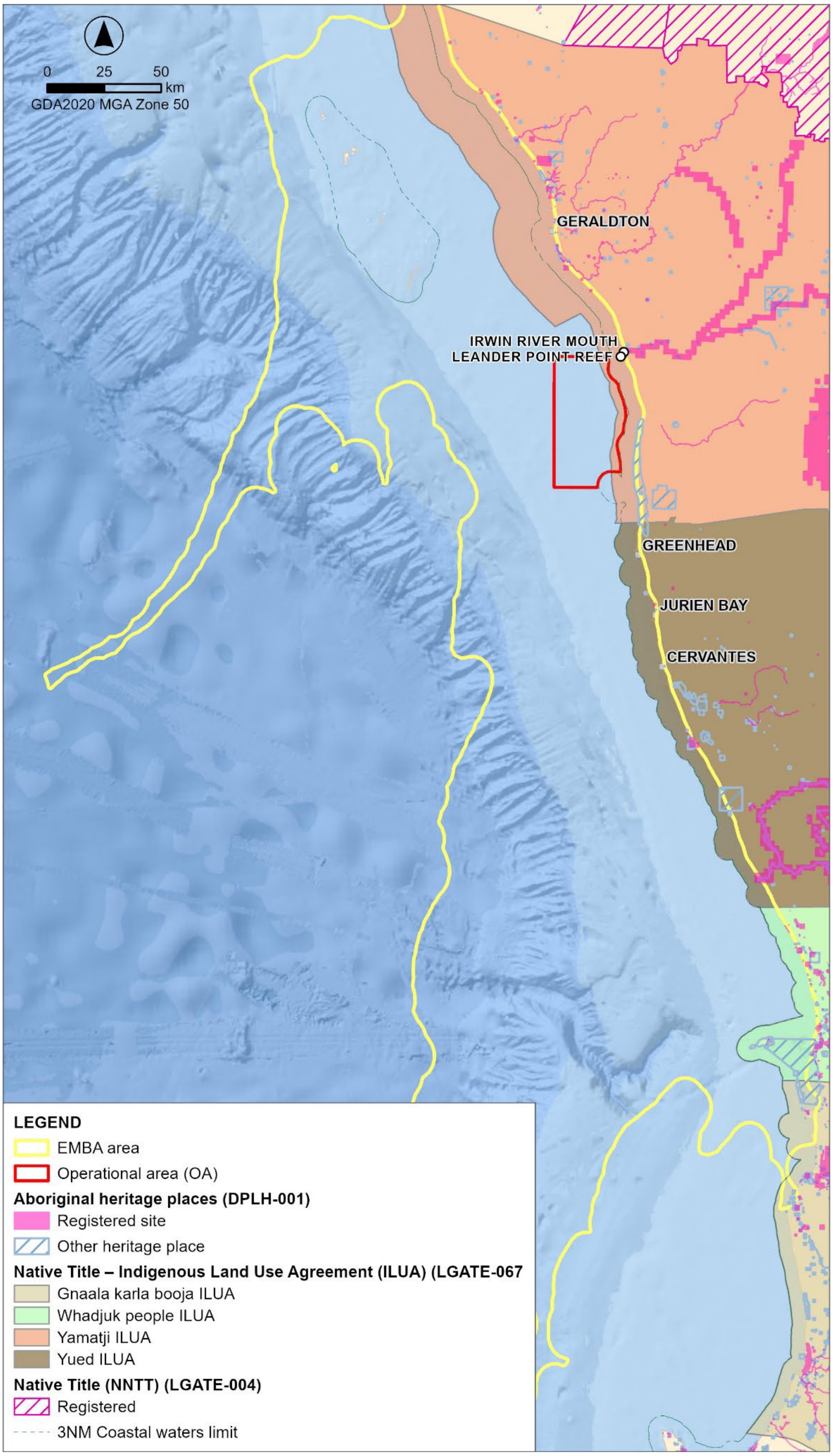


Figure 4-40: Native title and cultural heritage areas in and adjacent to the OA and EMBA

4.4.8 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.

4.4.9 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 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

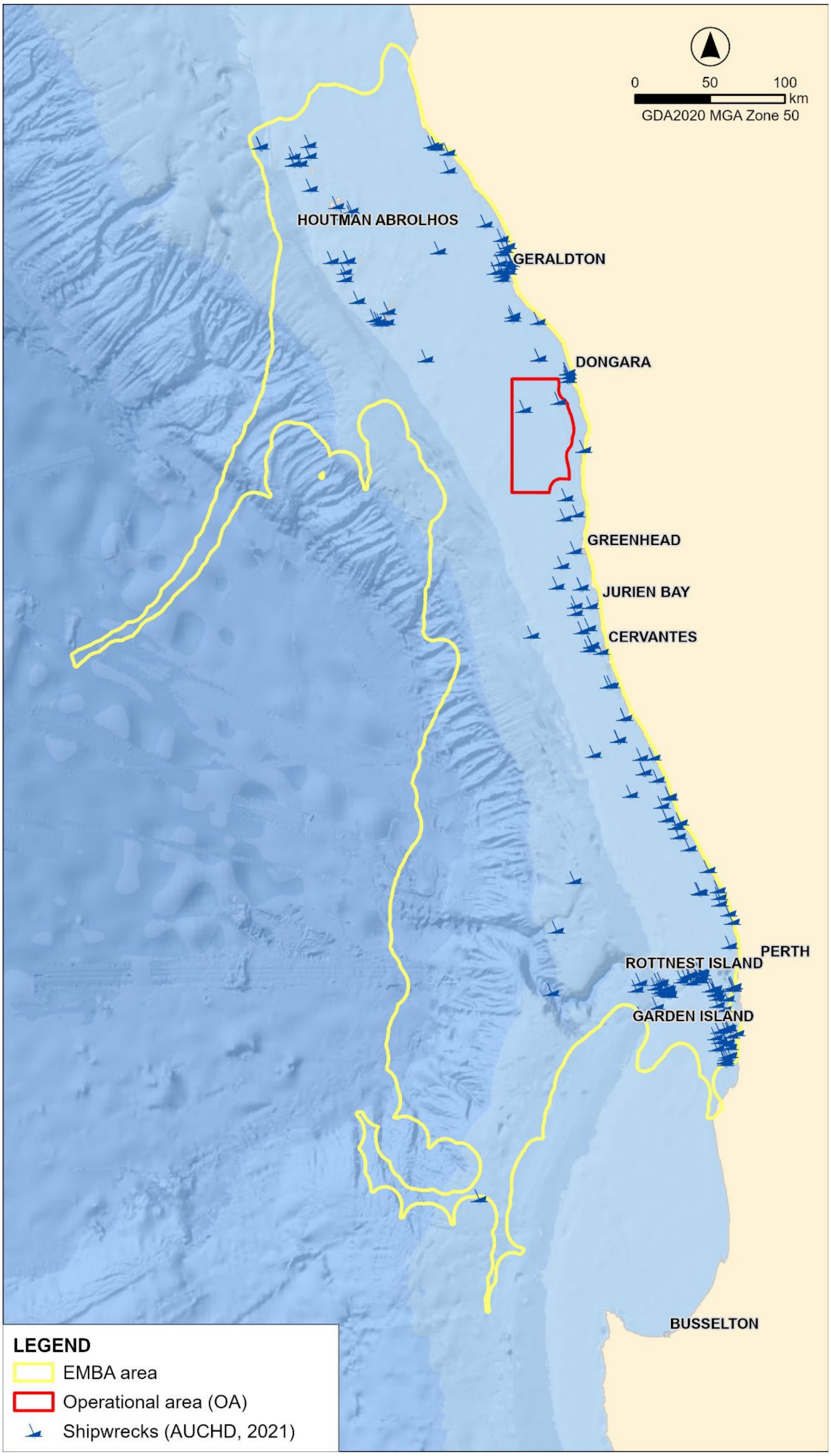


Figure 4-41: Recorded shipwrecks within the OA and EMBA (AUCHD, 2021 database)

4.4.10 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. The activity is limited to the months of February and March, so analysis of the craft tracking system is narrowed to this period.

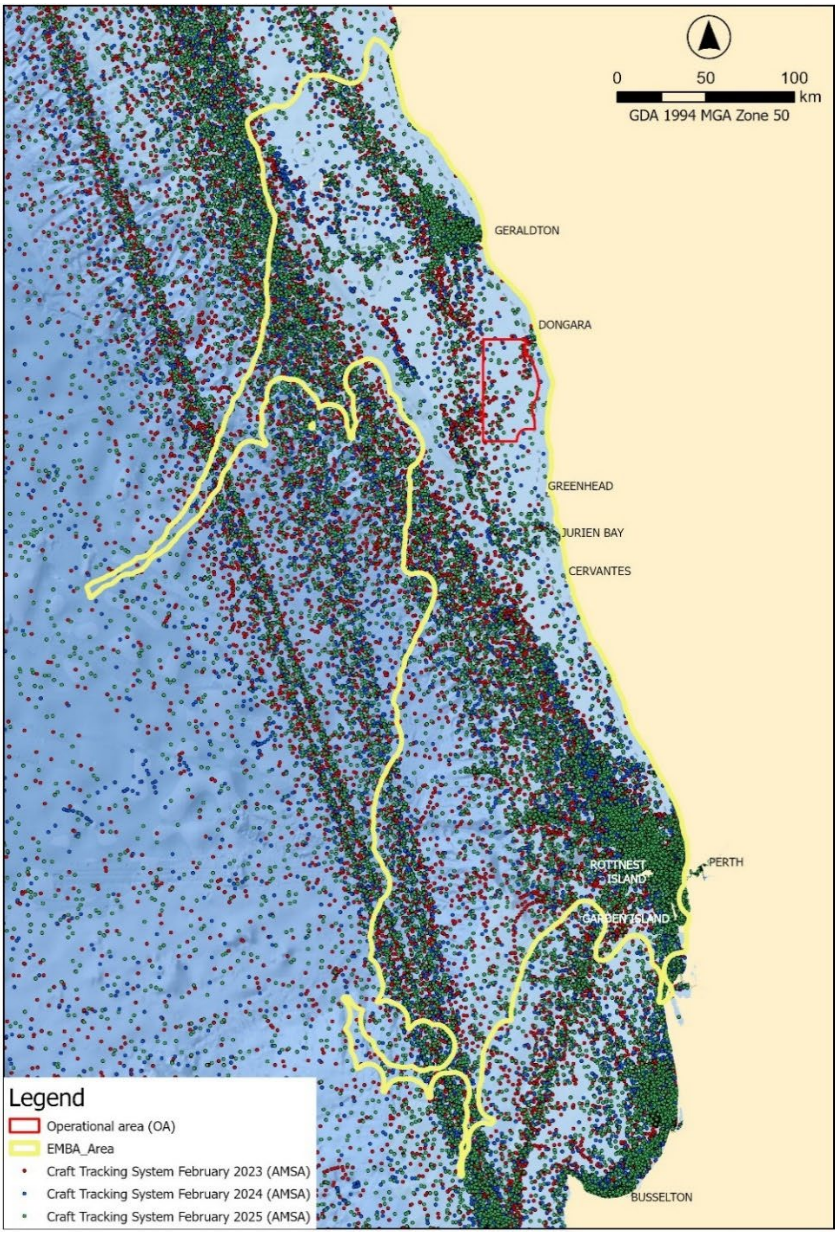


Figure 4-42: Commercial shipping tracks within and adjacent to the OA and EMBA

4.4.11 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).

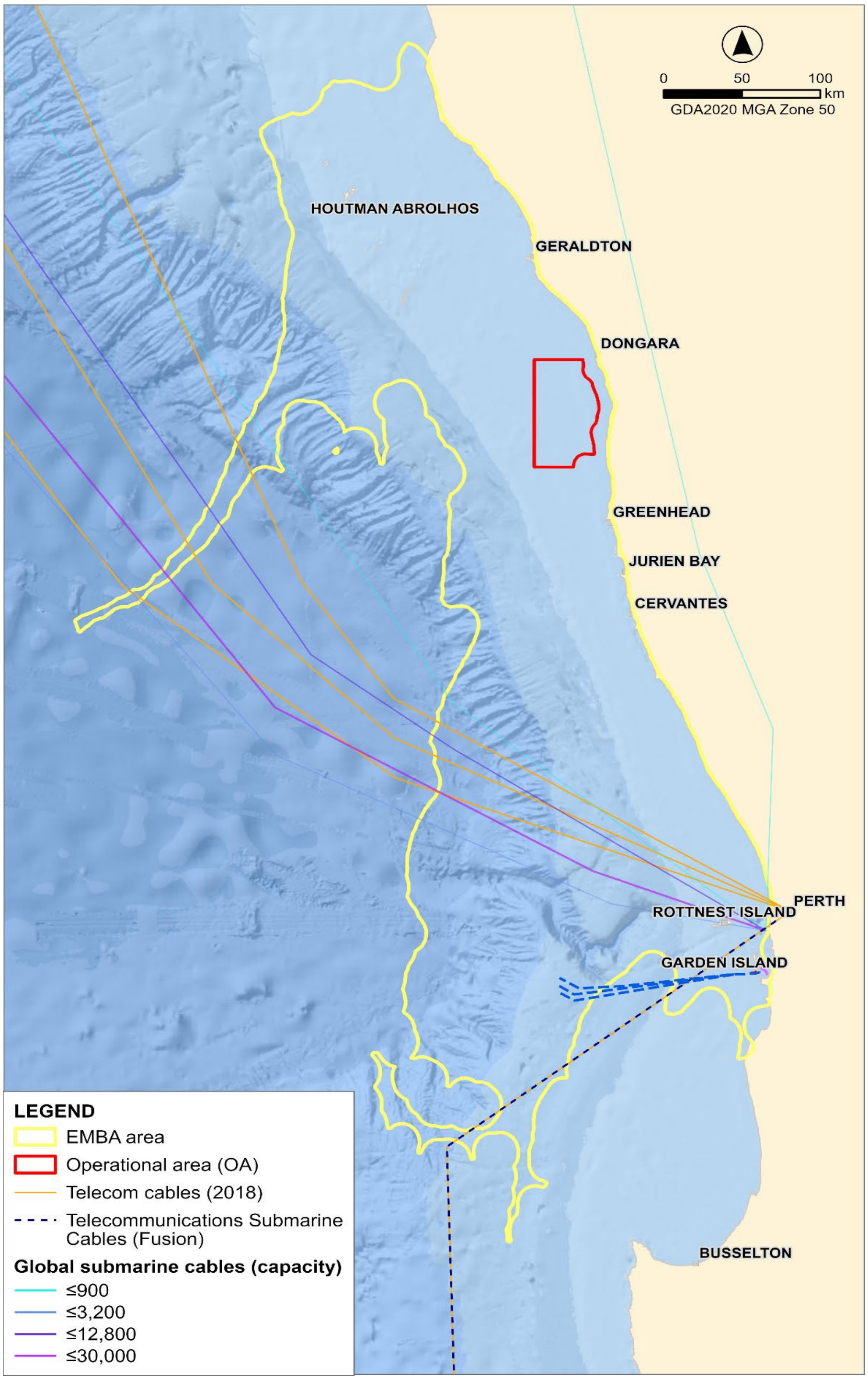


Figure 4-43: Communication lines overlapping the EMBA

4.4.12 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).

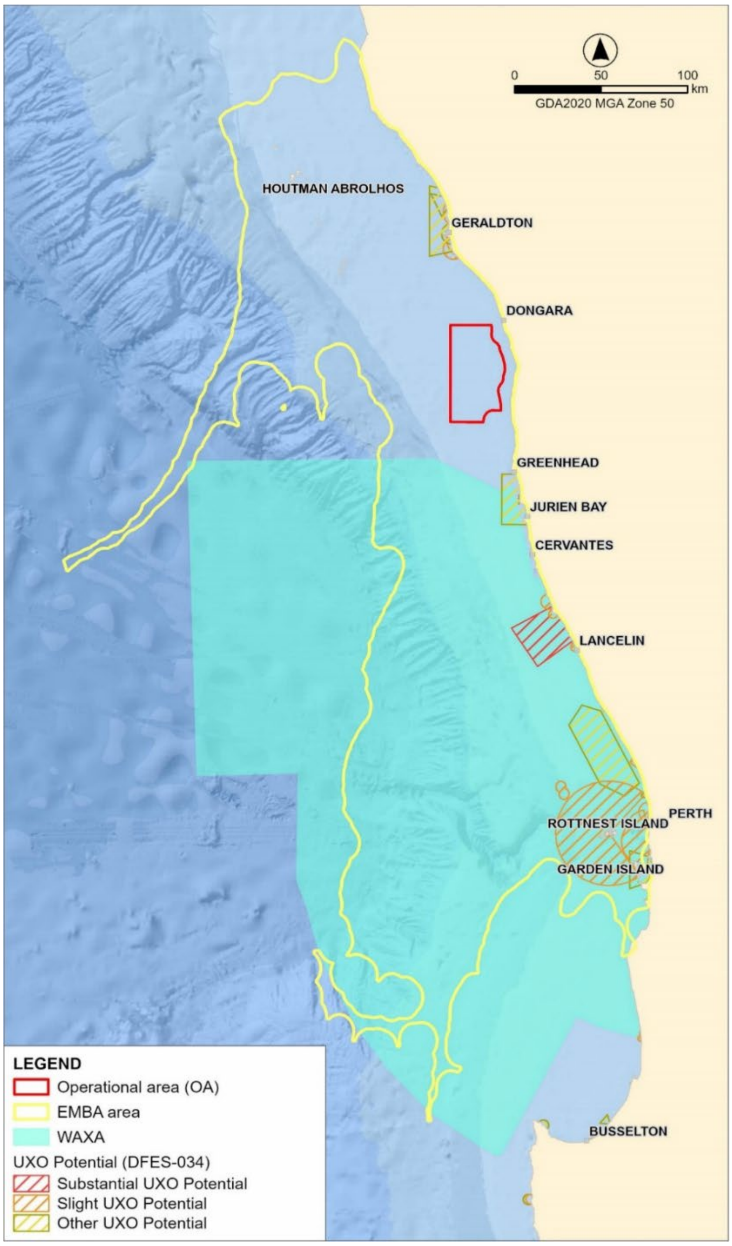


Figure 4-44: Defence areas adjacent to the OA and overlapping the EMBA

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 desktop research, community outreach events and various targeted media and advertising techniques, Pilot implemented a consultation process capable of identifying all ascertainable relevant persons.[1] Once identified, relevant persons were 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: Eureka Marine Seismic Survey Commercial Fisher Compensation Protocol (EMSSCFCP)

Pilot has implemented the EMSSCFCP to provide a practical, evidence-based process and reasonable monetary adjustment claims process for by commercial fishers who may be impacted by loss of catch, displacement and/or fishing gear loss/damage because of the seismic survey operations, as well as other commercial marine operators that may be affected. The protocol is based up on the National Energy Resources Australia (NERA) Commercial Fishing Industry Adjustment Protocol and has underdone further review during consultation with Western Rock Lobster Council to ensure that the protocol is fit for purpose to the application of Western Rock Lobster pot fishing, previously unaccounted for.

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 organisations and persons, so each specific case by case 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.

---

[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.

This appendix also highlights the extent to which consultation was undertaken with relevant persons and organisations and the mediums by which each relevant person were discovered, including self-identification through the Eureka website (https://klarite.mysocialpinpoint.com.au/eureka3d/).

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.

5.1 Legislation and requirements

The methodology for consultation for this activity is informed by various guidelines, legislation and published guidance that are relevant for consultation on offshore petroleum activities, including:

- *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
- *Environmental Protection and Biodiversity Conservation Act 1999.*
- NOPSEMA Guideline GL2086 – Consultation while 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).
- *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.
- 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

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.
- Pilot's method for identifying relevant persons, in accordance with Section 25 and the NOPSEMA guidelines is based on the understanding of:
- Our planned activities in the Operational Area, being the area in which our planned activities are proposed to occur (See Section 3)
- Our geographical extent for consultation was based on the Environmental Planning Area but was in no way limited to this area as Pilot acknowledge that relevant persons may not be geographically constrained, but that some groups are likely to be proximate to the activity.

Pilot used an iterative approach which 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.

The National Energy Resource Australia (NERA) *Consequence Analysis of an Accidental Release of Diesel* reference case (RC 1003) formed the primary technical basis for defining the *Environmental Planning Area* (EPA) for the Eureka 3D MSS EP. Consistent with the modelling outputs and aggregated industry data presented in the reference case, the maximum credible extent of surface hydrocarbon concentrations above the ecological effects threshold (10 g/m^2) was identified as 150 km from the release point. For the purposes of the Eureka EP, an additional precautionary buffer of 5 km was applied to this radius, resulting in a total *Environmental Planning Area* extent of 155 km. This conservative adjustment was adopted to ensure that all potentially affected coastal sensitivities were captured within the spatial extent used for stakeholder identification and consultation searches.

While subsequent oil spill modelling for the Eureka 3D MSS indicated that, under certain conditions, entrained hydrocarbons could occur beyond the 155 km EPA, this does not invalidate the original methodology used to define the consultation area. The EPA was established primarily to ensure comprehensive capture of coastal and surface-water sensitivities for stakeholder identification purposes and was not intended to act as a strict geographical limit on engagement. In practice, consultation for the Eureka EP was undertaken without rigid spatial restriction, and relevant persons whose functions, interests, or activities may have been affected regardless of their location relative to the EPA were identified and consulted.

Pilot identified several subject-centred groups in its planning process and the consultation methodology was tailored to the cultural, social, and economic features of these people and communities. The discussion in the subsequent sections applies to all subject-centred groups. Through the consultation process two, subject-centred groups (Commercial Fishers and First Nations Australians) warranted elevated tailoring of the consultation method.

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

- Maximising the broad capture of relevant persons.
- 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 a reasonable period for relevant persons and encouraging feedback and queries.
- Providing a response to each objection or claim made by a relevant person where appropriate.
- 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 principles outlined in Table 5-1 from the former Ministerial Council and Mineral and Petroleum Resources 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 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 5.3.1).

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 and webinars.
- 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. This survey helped self-identification as it enabled individuals to provide their functions, interests, and activities, or request more information to determine if they were relevant.

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. In total, the website reached over 1941 unique users, with over 4175 total visits, 421 document downloads, the consultation survey was taken 24 times, and in addition to 7 website feedback interactions identified 28 unique relevant persons with some interacting through both means.

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.

The search for persons or organisations deemed relevant persons initially takes a broad, global approach, as the definitions of functions, interests and activities are not geographically constrained. However, certain groups, such as other marine users, are likely to be in proximity to the activity.

By categorising people within the community, engagement was tailored to specific subject-centred groups. The legislation provides guidelines for four key classifications: the public, authorities, organisations, and persons. As outlined in Section 25 of the OPGGS (E) Regulations, relevant persons – including organisations, authorities, and individuals – are distinct from the public and are mandatory consultees in EP preparation.

Pilot has assessed all potential environmental impacts and risks based on the identified information and relevant persons. Should new data or relevant persons emerge, Pilot has established change management procedures, detailed within our ongoing consultation strategy (see Section 5.6).

5.3.2.1 Methods for identification

Pilot used the following methods to find authorities, organisations, and persons who may be affected by the proposed activities. Table 5-2 offers additional insights into the methods Pilot utilized to identify relevant persons and engage them through customized, subject-centred consultation approaches. Annex D shows Pilot's record of engagements.

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. NOPSEMA guidelines for "Consultation with Commonwealth agencies with responsibilities in the marine area" were utilised to identify relevant Government Departments that may have functions, interests or activities that may be impacted by the survey operations.
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. Online searches performed for local indigenous groups that may operate independently to the main land councils, and aboriginal corporations that claim may sovereignty over their land within the existing Native Titles.
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 environmental 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.

Method	Aim	Result
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 and tourism.
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 to establish if they 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 organisations 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. Self-identification was a successful method in capturing relevant persons that may have received information through other mediums such as social media and community events.
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.	Community events were advertised and attended along the coastal region of the EPA to engage with local communities. These events were well attended and resulted in consultation and engagement with many relevant persons that fall outside of the main sub-centre category groups. Shire of Irwin Expo was attended to speak with the 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.

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 Section 5.3.2.3.

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 Table 5-4.

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 and peak representative bodies	Assessed overlap of State and Commonwealth fisheries that have the licence to operate within the Operational Area and Environmental Planning Area. If they have the licence to operate within the EMBA, then they were considered relevant and contacted as part of Pilot Energy's consultation efforts unless directed otherwise by the representative body's own consultation guidelines. One state commercial fishing association had their own consultation guidelines that were adhered to, which included only consulting with fisheries that had the right to fish within the OA, in addition to having historical catch data within the OA. Fisheries that overlapped with the EMBA only or did not have evidence of fishing within the OA were to be removed from consultation efforts to reduce consultation fatigue with state fisheries. 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.
Traditional Custodians	Traditional custodians are First Nations Australians who hold cultural rights and interest or have cultural functions or perform cultural activities over land and waters. Desktop searches for local traditional owner groups were undertaken, to establish if there were other miscellaneous indigenous organisations or tribes outside of the main Native Title structure that would be considered relevant for the Eureka project
Native title representative bodies (traditional owners and First Nations peoples) and nominated representative corporations	An approach including desktop research, databases of registered native title claims, indigenous government agencies and lists of local land councils in and around the EPA was undertaken. Contact details of land councils were sourced from the National Native Title Council. Contacted registered Aboriginal Corporations and Prescribed Body Corporates. 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.

Subject-centred group	Tailored identification strategies
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, PBCs and aboriginal corporations 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.

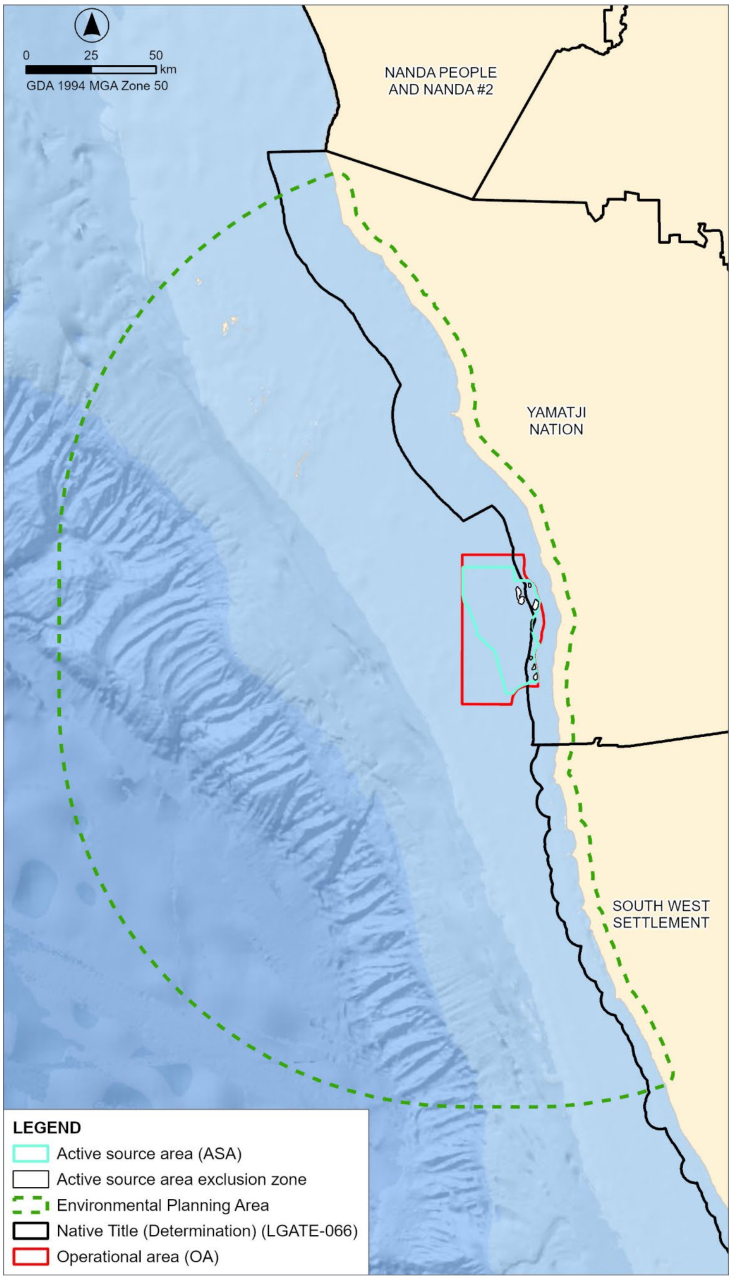


Figure 5-1: Native title determinations within the environmental planning area

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 Environmental Planning Area (EPA) overlaps the Yamatji 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. YSRC later restructured their organisation and internal procedures, which resulted in consultation being streamlined directly with the organisation instead of with cultural committees to improve efficiency.

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 has been enthusiastic engaging from the initial contact and has included attendance at their Elders Connect Day with an opportunity to consult with the WLAC community and Cultural Awareness training to understand matters of significance to their tribe. Pilot has since attended online meetings, a multi-tribe (WLAC & KMAC) group meeting on country with the traditional owners in Green Head and completed a Sea Country Management Program with a representing tribal consultant, to identify the tangible and intangible cultural values.

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. After a restructuring within the organisation, Pilot Energy were asked to resend information including a board paper which helped the organisation triage the urgency of meetings with their cultural committees. This was then re-requested 12 months later. 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. Email was used as the primary and initial form of contact (as per NOPSEMA guideline GL1887). Other forms of communication such as phone calls, links to online resources, meetings and presentations were used when requested. DPIRD limits provision of contact details (under the FRMA 1994) from the register to the name and business address of licence holders, limiting Pilot to an initial contact format of letters. Alternative forms of communications are at the licence holder's discretion once communication has been established. Maps and videos were also used as tools to provide sufficient information in digestible media formats. 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, where possible, to allow them to make an informed assessment of possible consequences.
- 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.

A diverse range of communication strategies was implemented by Pilot, customized to suit different audiences, preferred mediums, and available technology. Consultation was conducted as a two-way dialogue, ensuring relevant persons received adequate information through their chosen medium to make informed decisions regarding the potential impact of the Eureka MSS on their functions, activities, or interests. These communication channels included emails, phone calls, face-to-face meetings, tailored presentations, webinars, and website interactions.

The assessment of effectiveness of a communication channel included consideration of the following:

- Accessibility to the communication channel.
- Accessibility of information.
- Clarity and quality of conveyed information.
- Least burden on the person.
- Opportunity to provide feedback.
- Demonstrated thoughtful consideration of perspectives before decision-making.

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. This included information packs to traditional owner groups, commercial fisher fact sheets, and recreational fisher fact sheets.
- 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. YouTube videos were produced at the request of Traditional Owner groups, to help the communities who may be less proficient in reading to receive and digest the information.

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, calls were made, if possible, to connect with the correct team within the department to confirm receipt of the information. If there was still no response 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.

At the relevant organisation's request, 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). Information slides were built for the Western rock lobster fishers were also presented and later made available to the public and relevant persons via social media and the project website in June 2023.

The NERA protocol was adopted as a control measure to compensate commercial fishers and commercial marine users where interferences was unavoidable. This protocol was initially developed in consultation with fishers on the North West Shelf, and was not fit for purpose for use in the Mid West region due to its lack and applicability to Western Rock Lobster pot fishing. Pilot provided an open comment forum on the NERA protocol 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 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 (eureka3dmss.com.au) 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 Environmental 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 (if joining the live webinar), 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:
    - Community Consultation and Engagement Plan
    - 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 sessions for commercial fishers in Fremantle, Geraldton and Cervantes and one more session specific to traditional owners in Mingenew. These sessions introduced the Eureka project, with an explanation of a seismic survey, activity description, how to register as a relevant person, environmental impacts and controls measures. 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 public. They were used to introduce the project and provide links to the website, email address and phone number. Invitation to the 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 therefore has applied different interpretations of the term 'reasonable period' to different subject-centred groups.

A reasonable period is inherently flexible, adapting to the iterative nature of consultation. Defining it as a strict timeframe risks misuse by relevant persons or the titleholder, undermining the consultation process. Pilot, therefore, considered multiple engagement attempts, along with project updates and the provision of additional information, as constituting a reasonable period.

Pilot also considered the subjective context affecting a relevant person's communication important to determining what a reasonable period might be as shown in Table 5-5 below.

All identified potentially relevant persons were contacted on a minimum of two separate occasions, with timeframes adjusted on a case-by-case basis. Given the variability in consultation and response times among relevant persons, establishing a standard period is challenging to conclude. However, as a baseline, all relevant persons were granted a minimum of 30 days for consultation.

If an identified or self-identified relevant person was unresponsive, Pilot attempted follow-up contact using an alternative communication method where available, such as email or SMS for Commonwealth Fishers. If no additional contact method was found despite further desktop research, a follow-up was conducted using the initial method. If a response remained outstanding, Pilot continued to provide project updates, fostering engagement and ensuring the relevant person stayed informed of developments.

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. Up to 60 days depending on time frame (WAFIC guideline)	Professional nature of these industries, direct relevance of the proposed activity and the depth of knowledge and experience required in these types of roles. Times of year and relevant person's activities may impact on duration of reasonable period.
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 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.

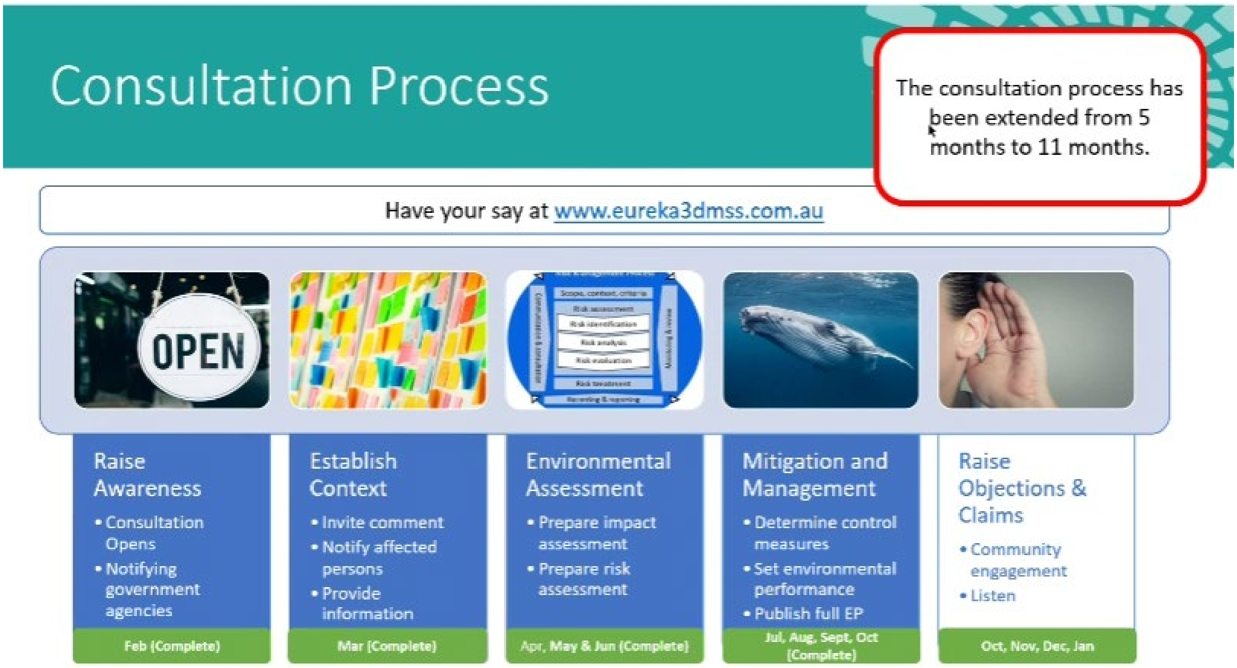


Figure 5-2: Eureka consultation phases

In Phase four, detailed information on the existing environment within the operational area and the finalised EMBA were made available to relevant persons and the 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 or claim.
- An assertion or concern.
- Information requests.
- Information received
- 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 does not 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 (see Table 5-6), 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:
   - Information from a relevant person for input into the EP; or
   - 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 – g above, 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
F2211, F4123, F4045, F4004, F4041	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 7-19, Performance standard PS13
F2165	Is it possible to 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

Feedback IDs	Feedback, objection or claim	Measures adopted
F4121, F4000, F4028, F4170	Western rock lobster is 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 7.1.6.2 to ensure the impact assessment addresses the unique life history of this species.
F4122, F4278, F2197, F4051, F4165	Commercial fishers will be worse off because 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 refers to a commercial fishing industry adjustment protocol to manage claims in Section 7.3. The control is assessed in Table 7-17 and a performance standard (PS 37) is added to Table 7-19.
F1482, F4039, F4004	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 7-17 and performance standards (PS 1, 2 and PS 109) are added to Table 7-19.
Feedbacks received during Public Comment relating to Event ID 4691.	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.
Feedback received during Public Comment relating to Event ID 4690.	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. 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 7-32; 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.

Feedback IDs	Feedback, objection or claim	Measures adopted
F4278, F4155	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 7-22), 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.
F2138	Seismic activity will impact whales in the area.	Control measures are in place to manage impacts to whales from underwater noise (see Table 7-17) 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 November), and no seismic acquisition during the humpback whale migration period (June to November).
F4116	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.
F4157, F4032	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. The adopted control measures for the activity described in Sections 7 and 8 are implemented to reduce the impact to the ecosystem.

Feedback IDs	Feedback, objection or claim	Measures adopted
F4168, F4185	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.
F2190	Request of actions taken if dolphins are observed in the area during seismic operations (Event 2888).	As described in Table 7-17 of the EP, in addition to the requirements of EPBC Policy 2.1, Pilot Energy will initiate a power-down or shut-down of the seismic source if dolphins' approach within 500 m of the source, except for those bow riding. As well as the use of seismic vessel soft starts.

5.4 Discharge of consultation requirement under regulation 25

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.

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 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) 31000:2018 Risk Management – 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 are carried out during all stages of the 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 0.

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 0, 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 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
- If 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 31000:2018 Risk Management – Guidelines (last reviewed and confirmed in 2023), 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 (Table 6-1), including the extent, duration, timing and potential for recovery, and assessing the likelihood or probability that those consequences may occur (Table 6-2).

Potential maximum quantities released, timescale 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 medium-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
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 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, 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 0.

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.

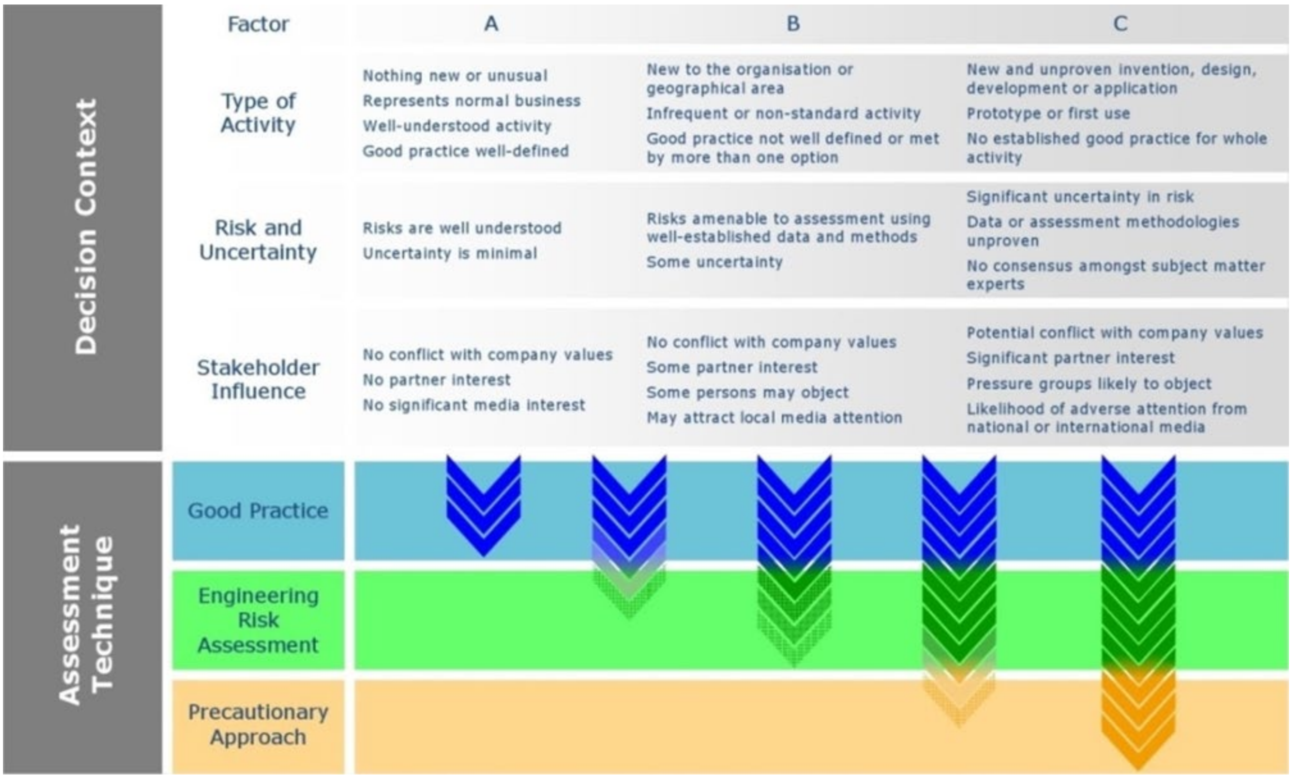


Figure 6-2: Risk related decision support framework (source: OGUK 2014)

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, considering:

- 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 (if 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 ALARP and 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.

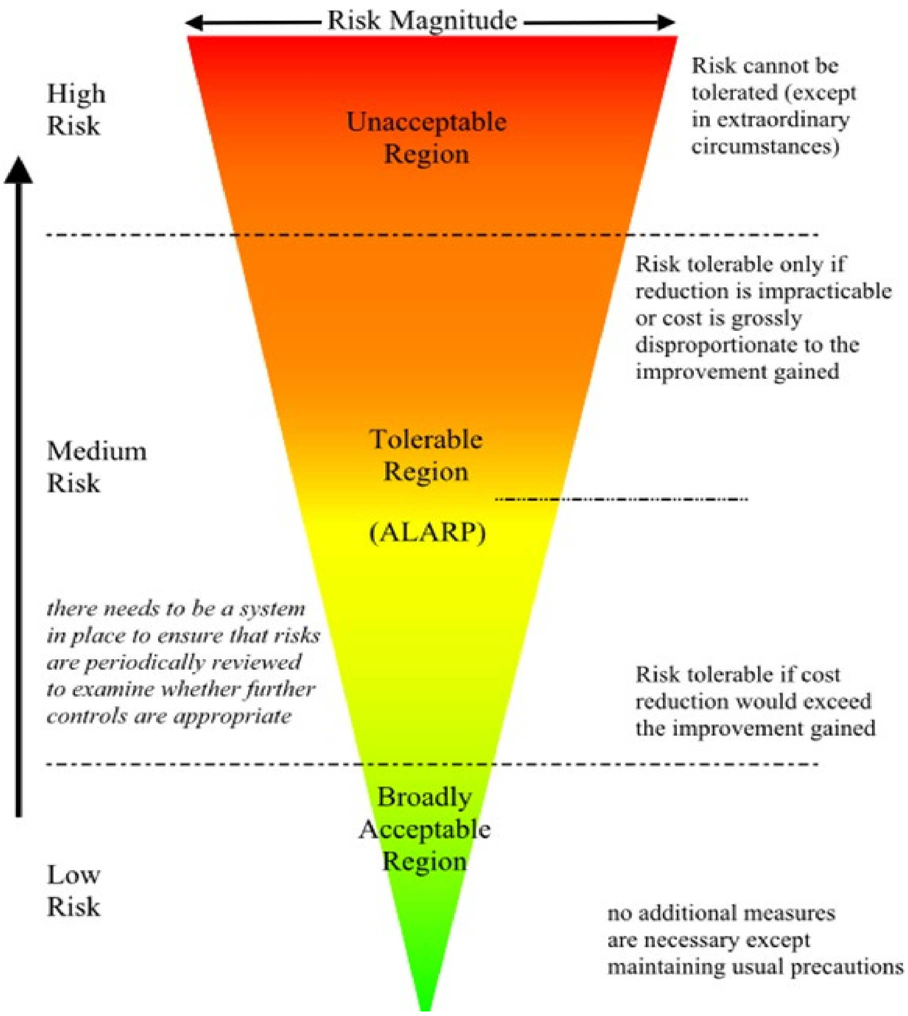


Figure 6-3: Approach to demonstrating ALARP and acceptable levels (source: IEC 31010:2019 Risk management – risk assessment techniques)

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 in Sections 7 and 8 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 31010:2018 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 Principles of ESD

For all impacts and risks identified in Sections 7 and 8 an assessment was conducted to determine if the Seismic activity was consistent with the relevant principles of ESD. The assessment determined that the activity is consistent with principles of ESD a, b, c, and d. Principle e is not relevant to the activity.

6.8 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 IMPACT 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as higher order. Therefore, an additional assessment and detail is required to demonstrate this impact is of an acceptable level.

7.1.1 Identification of hazard and extent

Hazard	The activity is a typical 3D survey like most 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 in the streamer area and 1420in^3 in the nodal area During the proposed activity, the seismic survey streamer vessel will traverse a series of pre-determined sail lines at approximately 300m apart, within the ASA at a speed of approximately 4.5 knots (8 km/hr), with a 50m source line spacing on the nodal component as a similar vessel speed. Seismic data will be acquired with the source active in water depths of between 10 to 52 m for up to 40 days. The seismic array is highly directional, focussing sound energy on 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 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 several 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 acoustic 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(i) & (ii)) applied to this assessment. These areas are defined by the following distances from the source: • Plankton – up to 280 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 – potentially up to 9.2 km from the source (behavioural response) • Very high-frequency cetaceans – 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 Defined acceptable levels

Pilot Energy's risk assessment methodology for demonstrating that impacts and risks are at an acceptable level distinguishes between higher-order and lower-order impacts and risks. For lower-order impacts and risks, acceptability is demonstrated when the impact or risk has been shown to be reduced to as low as reasonably practicable (ALARP). However, for the underwater sound impact from seismic operations, an additional demonstration is required. Before the assessment, acceptable levels of impact are defined (below). Once the assessment is complete, the predicted impact levels are compared with these predefined acceptable levels. If the predicted levels are lower than the defined thresholds, the impact is at an acceptable level.

Marine receptors (general)

AL 1. Seismic operations (including soft starts / ramping up) are limited to within the OA

AL 2. Seismic discharge intensities are always limited to the minimal levels while performing operational objectives

AL 3. Soft starts of airgun array will be used every time the array is first started

AL 4. Zoning of ASA to reduce potential impacts on BIAs and to avoid intense sonification of any one area for the duration of the survey.

Plankton (incl. fish larvae, eggs)

AL 5. Minimise overlap of seismic acquisition with spawning activity in important areas for fish/ invertebrates

AL 6. No long-term impact to zooplankton communities or zooplankton biomass resulting in alteration to ecosystem functioning or population effects.

Fishes (incl. spawning)

AL 7. Survey has negligible effects on the spawning output of commercially important species likely to be present within the OA

AL 8. 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)

AL 9. No population or ecosystem level effects

AL 10. No impacts to fish populations that would impact the sustainability of fish stocks within the OA

Invertebrates (incl. spawning)

AL 11. Survey has negligible effects on the spawning output of commercially important species likely to be present within the OA

AL 12. No population or ecosystem level effects

AL 13. No injury to cephalopod populations which would affect the sustainability of commercially fished cephalopod stocks.

Marine turtles

AL 14. Predicted effects limited to behavioural disturbance of a small number of individuals

AL 15. 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)

AL 16. No predicted impacts on breeding, migration or foraging of marine turtles

AL 17. No population level effects.

Cetaceans

AL 18. 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

AL 19. No displacement or exclusion of foraging, aggregating, calving/breeding, migrating cetaceans from BIAs

AL 20. This activity is not inconsistent with the relevant management actions in the Conservation Management Plan for the Blue Whale (Commonwealth of Australia 2015a):

a. PBWs will continue to use BIAs without injury and are not displaced from foraging areas

b. 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

c. Behavioural impacts are to be considered when assessing the effect of anthropogenic noise on PBW

AL 21. This activity is not inconsistent with the relevant recovery actions in the Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2024a):

a. The activity will not prevent any SRW from utilising a BIA, or cause injury (TTS and PTS) and/or disturbance

b. Apply the measures specified in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales

c. Behavioural impacts are to be considered when assessing the effect of anthropogenic noise on SRW

AL 22. This activity aligns with the management actions of the humpback whale Conservation Advice by:

a. Performing site-specific underwater acoustic modelling to assess the impacts from noise on cetaceans

b. 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)

AL 23. This activity aligns with the management actions of the sei whale and fin whale Conservation Advice for an assessment of noise impacts

AL 24. No population level effects.

Australian sea lion

AL 25. Predicted effects limited to short term behavioural disturbance of a small number of individuals

AL 26. This activity is not inconsistent with the relevant management actions in the Recovery Plan for the Australian Sea Lion (DSEWPC 2013a)

AL 27. Australian sea lions continue to forage within foraging BIAs

AL 28. 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

AL 29. No population level effects.

Commercial and recreational fisheries

AL 30. ASA reduced to as small an area as possible to minimise overlap with habitats for adult rock lobster, but some habitat overlap is acceptable

AL 31. 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

AL 32. Some short-term disruption of fishers with fixed equipment within the ASA (i.e. WRL and octopus fishers) is acceptable

AL 33. Some short-term displacement of other commercial and recreational fishing activities from the Safe Navigation Area (SNA) during seismic acquisition is acceptable

AL 34. No ongoing impact on catchability as fishes/invertebrates predicted to recover in the short-term after survey completion.

Protected areas and KEFs

AL 35. No impacts on the values of the Abrolhos Marine Park

AL 36. No impacts on the values of the Jurien Marine Park

AL 37. No impacts on the values of the Western rock lobster KEF

AL 38. No impacts on the values of the Commonwealth marine environment within and adjacent to the west coast inshore lagoons.

Tourism and recreation

AL 39. No long-term impacts on local tourism and recreational activities (e.g. Diving, snorkelling, spearfishing, sea lion tours)

AL 40. Some short-term disruption during seismic acquisition is acceptable.

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 micro pascal (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}).

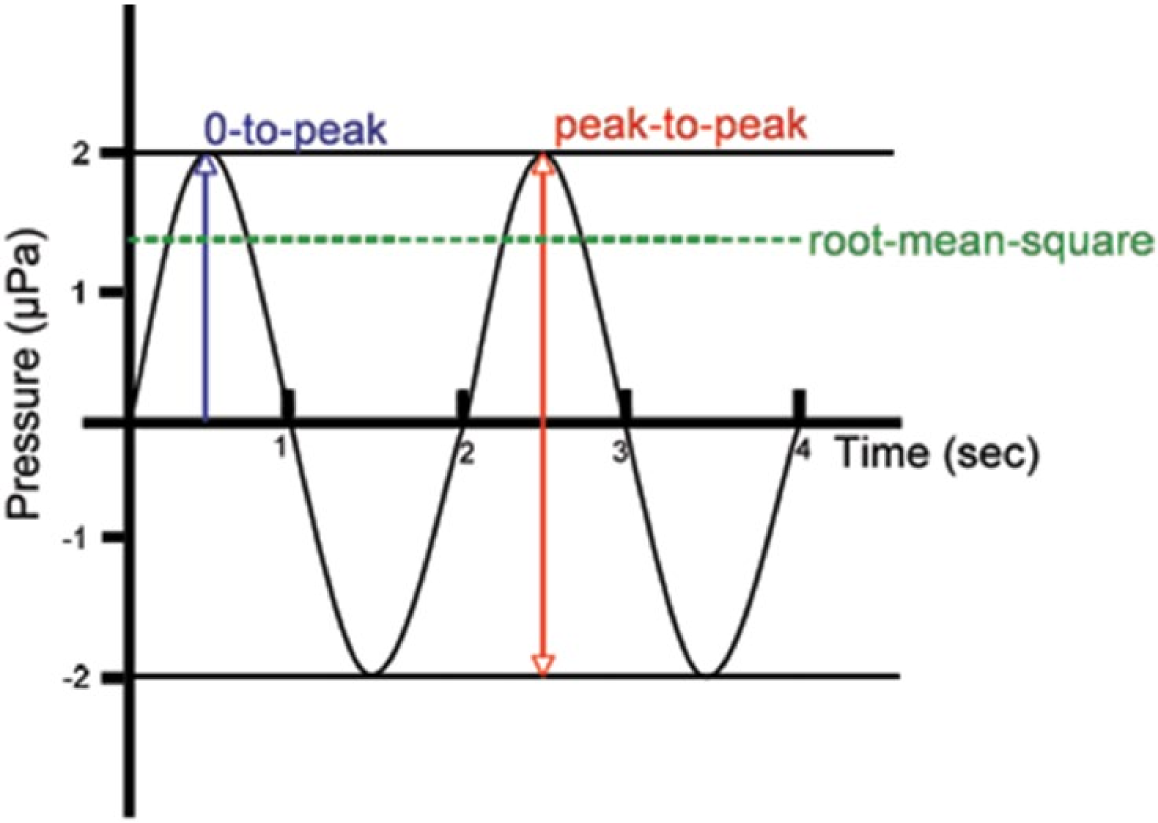


Figure 7-1: Simplified sound wave and sound pressure metrics (DOSITS1)

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 µm/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 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(i)).

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 source and propagation modelling to evaluate accumulated sound exposure. Acoustic source and propagation modelling was also 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 period (February–March) for the survey.

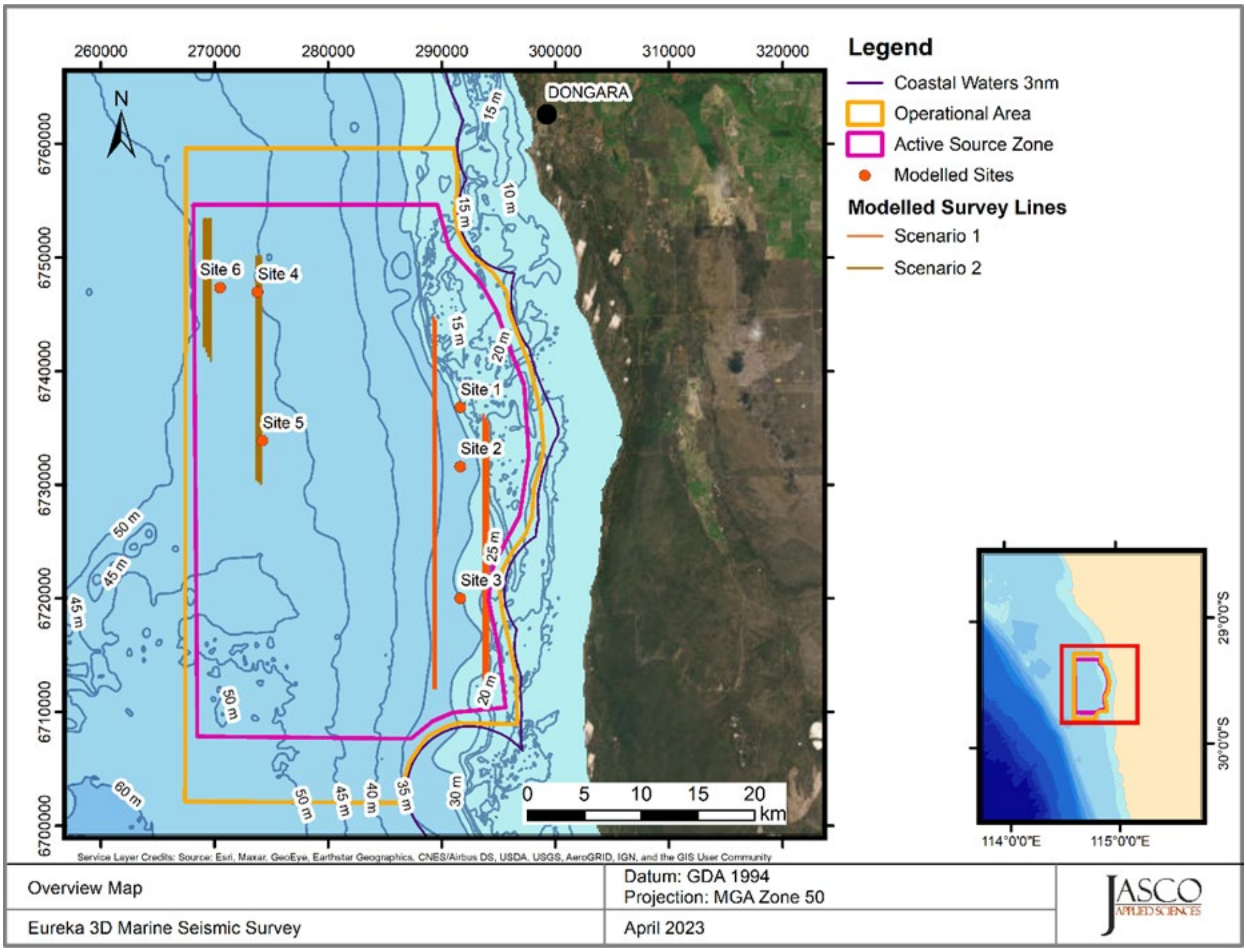


Figure 7-2: Overview of key survey features, modelling locations and the two survey scenarios (Appendix G(i))

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(i)).

Due to changes in seismic data acquisition plans in the nodal area, Pilot commissioned JASCO to undertake additional modelling in the nodal area, the full report available to view in Appendix G(ii). This modelling includes an additional acquisition scenario that reflects the acquisition plan within the nodal area, i.e., a smaller 1440 in^3 airgun array towed in a double array configuration at an assumed speed of ~5 knots with a 50 m shot point interval and 50 m line spacing. This secondary modelling study also included a new single pulse site at a depth of 15 m located between several reef exclusion zones relevant to the activity (Figure 7-3). The accumulated SEL over 24 hours of seismic source operation was modelled considering representative scenarios with realistic acquisition patterns for shallow sections of the Eureka 3D MSS. Compared to the original acoustic modelling, a smaller array volume and larger inter-pulse intervals reduced the maximum ranges to all relevant SEL24h thresholds.

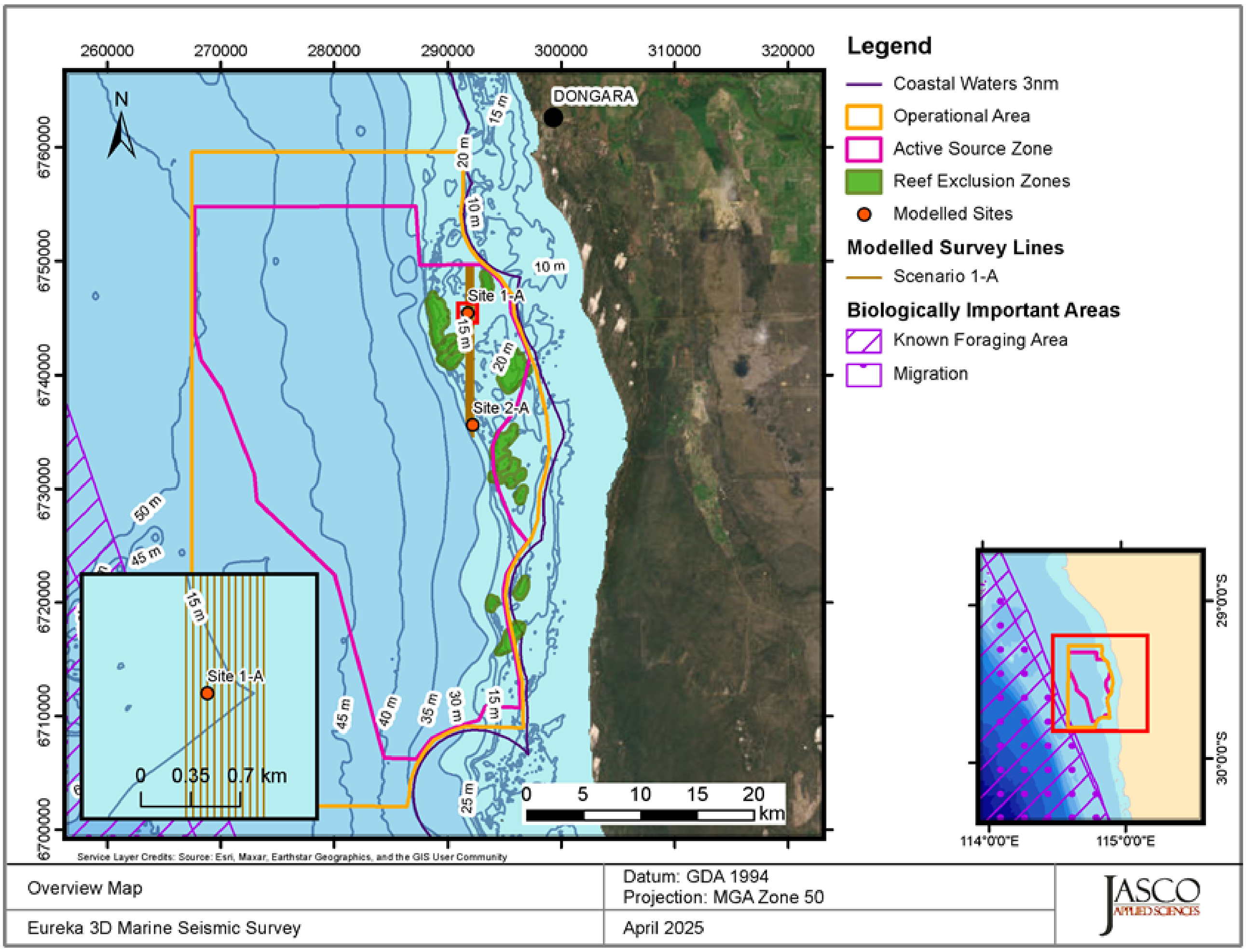


Figure 7-3: Overview of key survey features, modelled locations, and the survey scenario (Appendix G(ii))

The National Marine Fisheries Service (NMFS) recently released an updated version of its technical guidance titled "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0)" (NMFS, 2024). This guidance provides revised underwater and in-air criteria for the onset of auditory-related impacts to marine mammals exposed to anthropogenic sound and includes the introduction of a new approach for assessing injury. The thresholds for permanent (PTS) and temporary (TTS) threshold shifts have been updated to reflect the onset of auditory injury for different marine mammal hearing groups. Auditory injury, as defined by NMFS, includes but is not limited to PTS and TTS. TTS is described as a temporary, reversible elevation in the hearing threshold at a specific frequency or within a portion of an animal's hearing range, relative to a baseline level. While TTS is acknowledged in the guidance, NMFS does not classify it as a true auditory injury. This position is supported by studies indicating that TTS falls within normal physiological variability and does not cause structural damage. The temporary hearing reduction following exposure to loud noise is attributed primarily to fatigue of cochlear hair cells and supporting structures rather than cell loss, and is fully reversible (Ward, 1997; Southall et al., 2007, 2019, as cited in NMFS 2024).

Among the key changes, for Otariid Pinnipeds, both the peak sound pressure level (PK) and the cumulative sound exposure level (SELcum) thresholds for this group have been slightly lowered, indicating the potential for greater sensitivity to both immediate and prolonged noise exposure at greater distances from the sound source.

By contrast, the cumulative sound exposure level (SELcum) injury thresholds for the HF and VHF cetacean groups have been slightly lowered in the updated technical guidance. The peak sound pressure level (PK) thresholds for both groups have remained unchanged in the 2024 update. As a result, the revised SELcum criteria may theoretically result in a slightly reduced modelled effect distances for cumulative exposure scenarios, where animals are exposed repeatedly or over extended periods. The distances based on PK exposure, which are central to protecting marine mammals from immediate auditory injury, remain unchanged and therefore unaffected. To summarise, the modelled SELcum distances for HF and VHF cetaceans are likely more conservative than they would be if based on the updated thresholds.

Cumulative sound exposure level (SELcum) thresholds have remained unchanged for LF cetaceans, and the PK thresholds for this group have increased. As a result, the modelled PK distances for LF cetaceans are likely more conservative than they would be if based on the updated thresholds.

The changes to auditory injury and TTS thresholds introduced in this new guidance introduce an element of uncertainty regarding the effectiveness of control measures established in the Eureka EP. Adjustments to exposure levels, particularly for the Otariid Pinniped group, may alter the modelled distances at which relevant thresholds are exceeded. This uncertainty highlighted the need for Pilot's revision and consideration of the updated criteria in impact assessments and relevant control measures. Despite these revisions, Pilot is confident that existing control measures remain robust. Under the previous NMFS thresholds, no peak sound pressure level (PK) exposures approached auditory injury/PTS thresholds. Consequently, any recalculated distances using the updated 2024 thresholds are expected to be minor — likely within tens of meters. Given this scale, any such adjustments would be operationally insignificant and would not materially affect the overall effectiveness of Pilot's mitigation strategy, with Pilot's approach continuing to provide sufficient and conservative protection for marine mammals.

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. 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 G, 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 based on 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 several 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

7.1.5.1.1 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 several 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 like 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):

- 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 1.2 km is substantially lower than at the source.
- 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.
- 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 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 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 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 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}.

7.1.5.1.2 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 7-2). 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 7-2: 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) – Streamer Acquisition	R_{max} distance (km) – Nodal Acquisition
210 dB re 1 µPa².s (SEL_{24h})	0.06	0.07
207 dB re 1 µPa (PK)	0.27	0.28

As shown in Table 7-2, 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 for streamer acquisition and 280 m for nodal acquisition.

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.

7.1.5.1.3 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 7-2, the maximum predicted distance to mortality/PMI thresholds in the water column for zooplankton (including coral eggs and larvae) is 270 m for streamer acquisition and 280 m for nodal acquisition. 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. The 300 m exclusion distance provides some additional conservatism against the reported R_{max} for mortality/PMI for coral eggs and larvae.

7.1.5.1.4 Zooplankton – impact assessment conclusion

The potential impacts of noise emissions from the seismic source on zooplankton during the seismic acquisition are '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

7.1.5.2.1 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 can. 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(i)).

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

7.1.5.2.2 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, except for 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 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).

7.1.5.2.2.1 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 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 like 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 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 lobsters 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 because 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).

A more recent study by de Lestang et al. (2024) investigated the short, medium- and long-term effects of seismic exposure on wild western rock lobster, *Panulirus cygnus,* in a similar environment to the proposed Eureka MSS. Two hundred and twenty lobsters (carapace lengths ranging from 64 to 78 mm) were collected from commercial lobster vessels fishing in shallow waters (0 – 20 m) in the Fremantle region. Lobsters in the intermoult phase were retained, marked with anchor tags and held in aquaria for ~30 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. However, recorded sound levels when the hydrophone was deployed directly under a firing location (equivalent to position of treatment lobster baskets) are likely to replicate the sound level received by the treatment lobster. The sound levels recorded in these instances were ≳220 dB re 1 µPa peak-to-peak sound pressure level.

An additional 100 control lobsters were held in the same conditions 10 km north of the survey area in similar habitat, depth and swell conditions. All baskets of treatment lobsters were retrieved ~30 minutes after direct exposure and baskets of control lobsters were retrieved immediately after this. All baskets of lobsters were then suspended in the water column above their final release location for 20 hours (overnight). The final release was located ~5 km offshore and central to the control and treatment locations over an isolated patch reef of ~0.5 km^2. This reef was surrounded by a sand habitat in ~ 14 m water depth.

Of the 200 lobsters deployed for the trial, only six died during the trials, four from the treatment group and two from the control group and this difference was not statistically significant. The surviving lobsters were examined for leg loss, righting time, blood protein concentration and release behaviour. Most lobsters examined after the trial had all legs present (77 and 76 % of control and treatment lobsters, respectively). However, more treatment lobsters than control lobsters had lost one or more legs, and this result was statistically significant. Like studies on southern rock lobster, treatment lobsters took significantly longer to right themselves (average of 13.6 s and 6.5 s for treatment and control lobsters, respectively). (Appendix H). No significant difference was observed in blood protein concentrations but there was a statistically significant difference in release behaviour. Release behaviour was classified on a scale of 1 – 3, with 1 representing very slow descent (no attempt by the lobster to expedite its descent); 2 representing slow descent (lobster made some attempt to speed up its descent); and 3 representing normal descent (lobster immediately tail-flicked and descended). The differences in release behaviours were as follows:

- 27% of treatment lobsters were classified as very slow, compared to 16% of control lobsters.
- 36% of treatment lobsters were classified as slow, compared to 27% of control lobsters.

Following these initial tests, all lobsters were then released at the same reef location (described above) and subject to the same commercial fishing activity. Of the 190 lobsters released, only 35 lobsters were recaptured by commercial fishers resulting in a small sample size for comparisons. This may have partly been due to some lobsters being below legal size and able to evade pots via escape gaps and the paper states there were equal numbers of undersize lobsters within the treatment and control groups. Nineteen lobsters were initially caught (11 control and 8 treatment) and 10 of these were retained by the fisher (3 control and 7 treatment). There were no further recorded instances of tagged lobsters being retained. The recapture rate from commercial fishing rapidly declined after this initial fishing effort with all subsequent fishing trips at this location yielding between zero and four tagged lobsters.

Analysis of the recapture data showed a lower recapture rate for lobsters exposed to seismic signals for the first month post seismic survey. Based on this recapture data, a model estimated an initial mortality experienced by the treatment lobsters of 22.1 %. However, the 95% confidence interval associated with this mortality estimate (0.06 – 0.68) indicates a low precision for this estimate. The cause of this reduction was not determined by the study, but reduced survival is put forward as the most likely cause. It is suggested that this mortality is associated with slower release behaviours for treatment lobsters making them more vulnerable to predation. Recapture rates for treatment and control lobsters after the first month did not indicate any long-term effects on lobster survival or catchability.

de Lestang et al. (2024) state that the 22% reduction in recapture of exposed lobsters should be measurable through a reduction in catch rates following the seismic survey. However, potential impacts on commercial fishing catch rates were not able to be examined as part of this study due to:

- Lack of fishing activity prior to the survey to serve as a baseline for comparison with post survey catch rates.
- The high abundance of small lobster that can escape commercial lobster pots.
- The highly variable nature of catchability within the WRL fishery.

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. These exclusion zones are designed to minimise the potential for close range sound exposure as experienced by treatment lobsters in the de Lestang et al. (2024) study. 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. In the first period of the migration between late November and mid-December, the 'whites' occur in the shallower waters <40m. From late December to late February, the migration continues, however in waters >40m out to around 100m deep. The survey will occur outside the period when 'whites' are in the shallowest waters <40m (de Lestang et al 2022). 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. It should also be noted that the natural reef ledge habitat of WRL will afford some protection from transmission loss before sound reaches the lobster.

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.

Most of the puerulus/phyllosoma larvae spawned in the months leading up to the seismic survey will be highly dispersed once the survey is undertaken. Estimates of puerulus and phyllosoma larval densities in the water column are highly variable and change diurnally and with water column depth. Density estimates range from 0.04 – 0.7/1000m^3 for phyllosoma and 0.04 – 0.1/1000m^3 for puerulus (Ritz 1972). This is also likely to vary among years with changes in metocean conditions and spawning stock.

The science on noise impacts to plankton indicates that within the area of ensonification there will be a highly variable and sliding scale of impacts which will range from mortality to those individuals very close to the seismic source through to minimal disturbance to those individuals farthest from the source and/or exposed to seismic for a minimal time period. .. There are no specific studies on impacts to puerulus/phyllosoma from seismic surveys hence the assessment is informed from multiple studies on other invertebrates/crustaceans . Our assessment is further informed by the highly variable and inconsistent effects of seismic surveys on individuals, the spatially and temporally variable patterns of recruitment and settlement of WRL and the panmictic nature of the WA Rock Lobster population.

Larval distribution extends across a broad area of the west coast of Western Australia (Figure 7-4), from Exmouth to Augusta (de Lestang et al. 2016), encompassing oceanic and coastal waters far exceeding the spatial footprint of the proposed survey. Based on this range and the relatively small survey area, the overlap between the modelled phyllosoma distribution and the survey footprint is expected to be less than 1% of the total range. This greatly limits the proportion of the larval population potentially exposed to elevated sound levels.

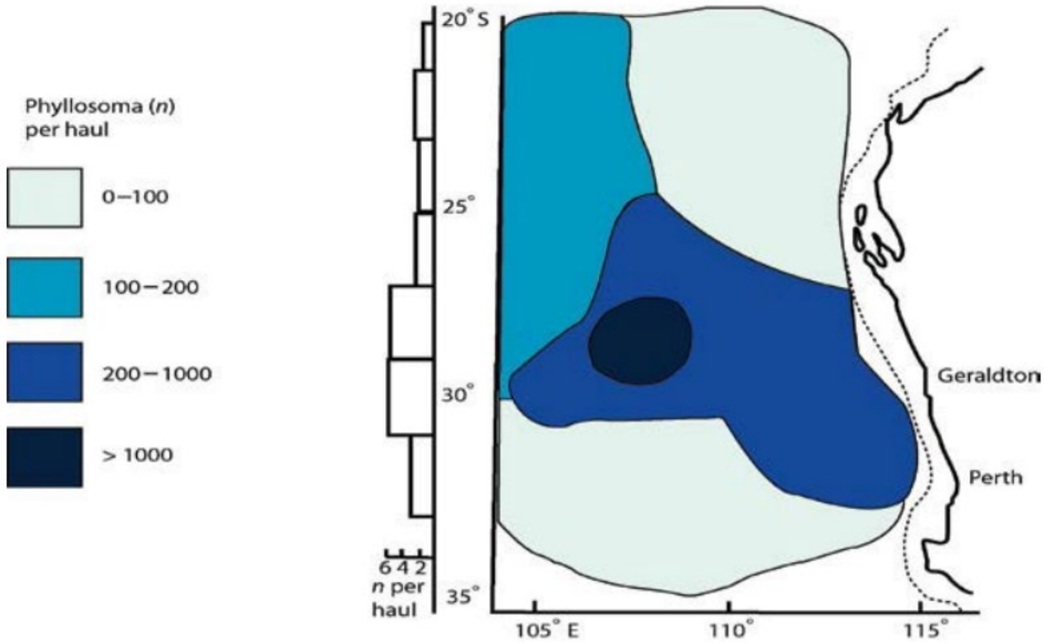


Figure 7-4: Distribution of western rock lobster phyllosoma larvae (Figure 5-7 in de Lestang et al. 2016)

The timing of the proposed survey (February–March) occurs after the main period of WRL puerulus settlement, which peaks during late spring to early summer and is largely complete by this time of year (Figure ; de Lestang 2016). These data have changed in recent years with the 2024 Stock Assessment report indicating a shift in settlement to later in the year, though the peak settlement still occurs well before the proposed survey window. Consequently, most puerulus will have already settled before the commencement of seismic operations, reducing the potential for exposure during this sensitive life stage.

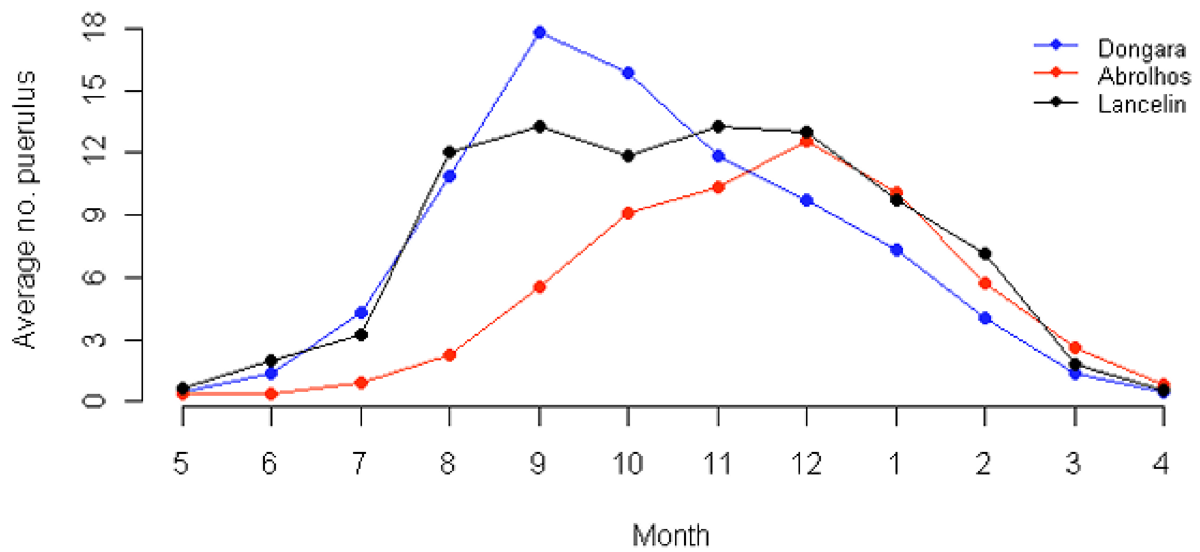


Figure 7-5: Average long-term (per 2007) puerulus settlement by month for sites in the northern (Dongara), southern (Lancelin) and offshore (Abrolhos Islands) zones of the WRL fishery (Figure 8-9 from de Lestang 2016).

Long-term puerulus monitoring shows that inter-annual settlement variability at Dongara, and at other monitoring sites along the coast, is substantial. For example, Figure 3.1 of the 2024 Stock Assessment report indicates that annual average settlement has ranged from well below 20 to over 200 puerulus per collector at Dongara in different years — more than a tenfold difference — with similar variability observed elsewhere. Despite these large fluctuations in settlement, effects on subsequent biomass, egg production, landed catch, and catch rates have been comparatively muted, indicating resilience to variation at the settlement stage. Furthermore, the 2024 Stock Assessment notes that there is currently no stock–recruitment relationship known for this stock, and that variation in puerulus settlement is primarily driven by environmental factors (de Lestang 2024).

Given the survey's timing outside the main settlement period, the very small spatial overlap with the larval distribution range, the naturally high inter-annual variability in settlement, and the absence of a demonstrated stock–recruitment relationship, any reduction in larval abundance potentially associated with the proposed survey is expected to be negligible in the context of the WRL population.

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. It is expected that most 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.

The analysis of seismic activity in the Dongara area and rates of puerulus settlement over the past 13 years shows that no relationship exists between the level of seismic activity and rates of settlement (Figure 7-6). Nine seismic surveys have been conducted in fishing area A and the southern half of fishing area B over the past 13 years. A scatter plot analysis of the rate of survey frequency against the rate of settle shows a very weak but insignificant positive correlation (i.e., rate of settlement increases with rate of surveys). Puerulus settlement is highly variable among years and is likely influenced by many biotic and abiotic environmental factors, but seismic activity does not appear to influence puerulus settlement.

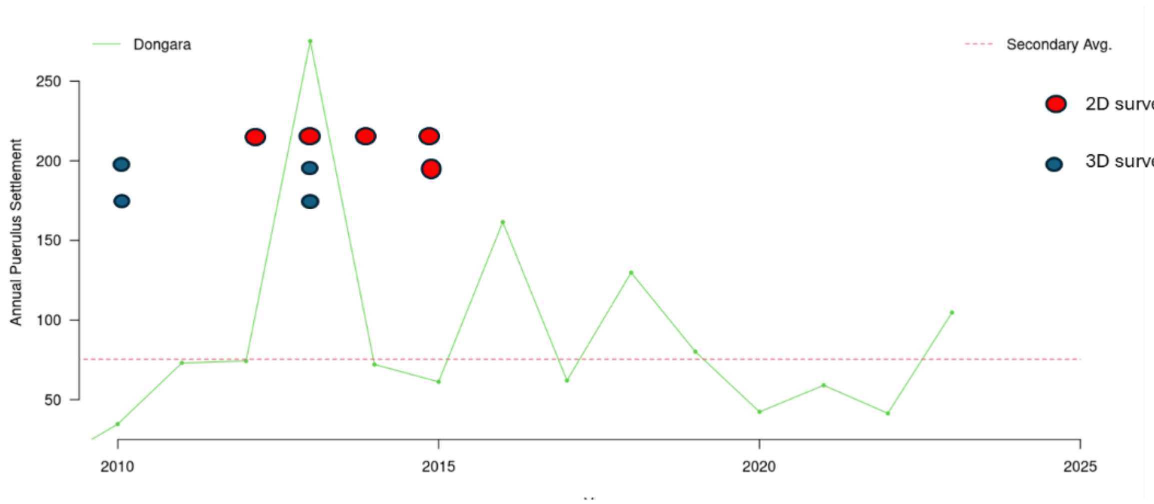


Figure 7-6: Rates of puerulus settlement and 2D and 3D seismic activity between 2010 and 2023

Finally, the above impact assessment draws heavily on research conducted on the effects of seismic noise on southern rock lobster (SRL). Stakeholders raised concerns regarding the applicability of these studies for assessing potential impacts of seismic noise on western rock lobster. Therefore, Pilot commissioned a study by the University of Tasmania's Institute for Marine and Antarctic Studies to assess the transferability of the knowledge between the two species for the purposes of the impact assessment (Peinado et al. 2024). While the study found that species specific data is preferable where feasible., it did highlight several similarities between the species in relation to hearing anatomy and susceptibility to noise impacts. These include:

- While there is significantly less information available for WRL on the potential impacts of seismic signals compared to SRL, one similarity is that air guns signals cause righting impairments for both species (Day et al., 2019; Day et al., 2022; de Lestang et al., 2024)
- In crustaceans, the basic structure of the statocyst is similar across species, consisting of a sac-like epidermal invagination of the cuticle (Finley and MacMillan, 2000). However, the location of the statocyst varies between groups; for example, in lobsters, it is in the basal segment of each antennule. To the best of our knowledge, the statocyst in WRL has not yet been examined. However, due to the similarities across different crustacean species, as well as the similarities between lobsters, it is likely that the WRL and SRL statocysts are similar. This suggests that the seismic impact observed on the SRL statocyst could be extrapolated to WRL.

In the absence of specific studies on WRL, the use of data from studies on SRL is considered a reasonable surrogate. However, further research specific to WRL would assist in greater certainty in the impact assessment.

7.1.5.2.2.2 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 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).

Several 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 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 G). 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 several 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 µPa²·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 µPa²·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 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.

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 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 several 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. (2024) 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 $\mu Pa^2 \cdot s$. 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. (2024) found no conclusive evidence of an impact of the seismic source survey on oyster mortality or pearl production.

In the absence of noise effect criteria on abalone, the body of research described above for other molluscs has been used to assess impacts of seismic noise form the Eureka survey. Therefore, noise levels capable of producing sub-lethal effects to abalone could extend approximately a few hundred meters from the source. Hart et al (2017) shows that Roe's abalone on the west coast predominantly inhabit waters between 1-40m depth and are generally limited to rocky reef habitats within those depths. As such, there is the potential that abalone on the reef areas, in waters less than 40m depth within the survey area, could be exposed to sub-lethal levels of seismic noise.

The ASA is in Abalone Management Area 8 for Roe's abalone, and in 2010/2011 a marine heat wave significantly reduced the population. The level of reduction/mortality in areas south of Port Gregory were uncertain, but likely less than waters further north where mortality levels were up to 99.9% north of Kalbarri and were between 20%-90% in waters between Port Gregory and Kalbarri (Strain et al 2019, Figure 3.6). This is most likely due to waters further south being cooler (Strain et al 2019, Figure 3.5) and therefore it logical to predict that mortality levels were lower in the ASA than further north.

Furthermore, Sandoval-Castillo et al. (2015) showed that Roe's abalone have three genetically distinct population clusters, which shows each population can repopulate through breeding and dispersal of larvae within its defined geographical range. The abalone in the ASA are in cluster two which occupies the coastal waters between Greenough and Augusta. This cluster likely suffered less depletion than cluster one to the north (Kalbarri Cliff to Lucky Bay) where waters were warmer and given their genetic connectivity, are likely to have greater recovery potential than abalone further north in Abalone Management Area 8.

Approximately, 51% of the active source area has waters less than 40m deep and the survey is restricted to waters deeper than 15m, but not all that area contains the rocky habitat used by abalone. Without a dedicated benthic habitat survey of the ASA, it is not possible to quantitatively assess the amount of rocky habitat in the ASA. However, the proportion of habitat within the ASA is only a very small proportion of the habitat available to abalone within the greater bioregion and fishery. Since the survey is scheduled to occur during the summer/autumn period, concerns have been raised regarding the combined effect of elevated water temperatures and noise exposure if another marine heatwave occurred during the survey. Unfortunately, no studies have been conducted to evaluate the effects of simultaneous seismic noise and elevated water temperatures on abalone. Therefore, for the purpose of this impact assessment, it is conservatively assumed that all the abalone could die due to cumulative exposure (noting that an extreme heatwave alone could cause significant mortality). The ASA is within genetic cluster two, which extends south to Augusta, occupies less than 1% of the geographical range of this genetic cluster. Even if there was complete mortality of abalone on the rocky reef areas in the ASA, most of the population, including those further south that have been less affected by historical marine heat waves, could potentially re-populate the abalone in the ASA. The evidence from previous marine heat waves shows that mortality rates can be extremely high, and if similar extreme temperatures were repeated during the survey, any additional stress from seismic noise exposure is unlikely to have significant additional mortality when the heat alone has caused near total mortality. Conversely, if temperatures are only slightly elevated and the combined effect of elevated temperature and noise exposure induce some additional mortality in the ASA, the evidence from genetic analysis shows that abalone from the surrounding waters can repopulate the ASA. As such, there is not expected to be any long-term or large spatial scale impacts on the Roe's abalone population within genetic cluster two because of the seismic survey.

Roe's abalone are known to reproduce through the winter months in the waters around Perth and have an estimated larval duration of about 10 days (Hart et al 2017). Since the survey will be conducted in February to March there is not anticipated to be a direct impact on reproductive behaviour, larvae or settlement. Other molluscs have exhibited physiological changes that are consistent with a stress response (as described above). For abalone exposed to noise levels that elicit a sub-lethal response it is possible that an associated stress response could alter reproductive performance or fecundity. In the worst-case scenario if reproduction is impacted, this will only occur for the few abalone within the ASA, which is a very small proportion of the spawning population and is unlikely to affect the broader population merely because the numbers impacted would be too small. However, there is great uncertainty in this prediction and any sublethal effects may have no effect on reproduction at all.

7.1.5.2.3 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).

7.1.5.2.4 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).

7.1.5.2.5 Impact assessment

7.1.5.2.5.1 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 7-3, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, the maximum predicted R_{max} distance was 167 m for streamer acquisition, and 103 m for nodal acquisition. 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 for streamer acquisition, and 70 m at 10 m water depth for nodal acquisition. 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) for streamer acquisition and 4 m (15 m water depth) for nodal acquisition. 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 7-3: Maximum predicted distances (R_{max}) to effect thresholds for benthic crustaceans at the sea floor

Sound exposure threshold (PK-PK)	R_{max} distance (m) – Streamer Acquisition	Water depth (m)	R_{max} distance (m) – Nodal Acquisition	Water depth (m)
213 dB re 1 µPa	103	40	70	10
212 dB re 1 µPa	121	50	75	10
210 dB re 1 µPa	136	30	93	10
209 dB re 1 µPa	167	50	103	10
202 dB re 1 µPa	292	15	212	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 for streamer acquisition and 103 m for nodal acquisition, 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 most 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 for streamer acquisition and 70 m from the source for nodal acquisition.

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 for streamer acquisition and between 2.3 and 2.56 km for nodal acquisition.

7.1.5.2.5.2 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(i)).

As described above, for crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is 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 G). 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. For the streamer acquisition modelling, 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. For the nodal acquisition modelling, a maximum distance of 42 m was reached at 10 m water depth.

7.1.5.2.6 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 7-7).

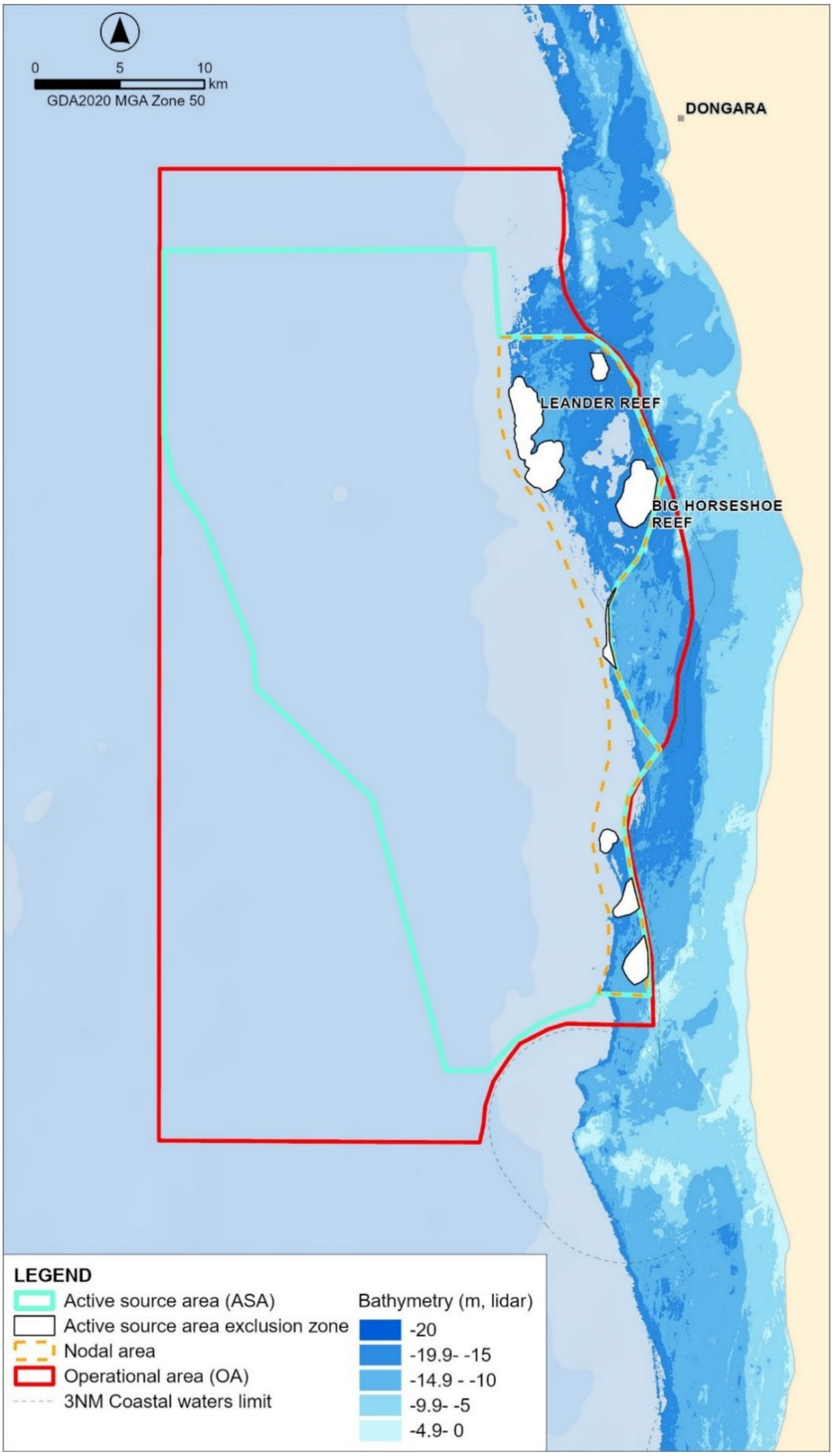


Figure 7-7: Proposed seismic source exclusion zones

7.1.5.2.7 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 timescales, 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 '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

7.1.5.3.1 Species sensitivity and sound exposure thresholds

Every species of fish studied to date can 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). Most 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 except for 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 can detect 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, most marine fish species do not have this hearing specialisation.

A great many fishes 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 scale fish, 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 7-4 and explained in more detail in the acoustic modelling report (Koessler & McPherson 2023; Appendix G(i)). 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 7-4: 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).

7.1.5.3.2 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 can 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.

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 because 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 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.

7.1.5.3.3 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 7-4 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 7-4 includes a level of conservatism as:

- Most 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 because 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).

7.1.5.3.4 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 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, like 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 uPa².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 µPa² 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 µPa² 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 more than 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 because 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 was 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 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 9.7 m from the speaker were 164 dB re 1 µPa and 101 dB re 1 nm/s^2, respectively. At 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 7-4). 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.

7.1.5.3.5 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 this 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) because of high sound levels at close range to the seismic source, or behavioural disturbance impacts at greater distances.

Table 7-5 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 7-5: 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		Rmax distance (km) – Streamer Acquisition		Rmax distance (km) – Nodal Acquisition	
				MOD	Sea floor	MOD	Sea floor
I Fish: No swim bladder	Mortality/PMI	219 dB re 1 µPa2·s (SEL24h)	<0.06	<0.06	0.06		0.06
		213 dB re 1 µPa (PK)	0.15	0.07	0.11		0.045
	Recoverable injury	216 dB re 1 µPa2·s (SEL24h)	<0.06	<0.06	0.07		0.07
		213 dB re 1 µPa (PK)	0.15	0.07	0.11		0.045
	TTS	186 dB re 1 µPa2·s (SEL24h)	4.66	4.66	2.46		2.46
II Fish: Swim bladder not involved in hearing	Mortality/PMI	210 dB re 1 µPa2·s (SEL24h)	<0.06	<0.06	0.07		0.07
		207 dB re 1 µPa (PK)	0.27	0.13	0.28		0.094
	Recoverable injury	203 dB re 1 µPa2·s (SEL24h)	0.10	0.10	0.07		0.07
		207 dB re 1 µPa (PK)	0.27	0.13	0.28		0.094
	TTS	186 dB re 1 µPa2·s (SEL24h)	4.66	4.66	2.46		2.46
III Fish: Swim bladder involved in hearing	Mortality/PMI	207 dB re 1 µPa2·s (SEL24h)	<0.06	<0.06	0.07		0.07
		207 dB re 1 µPa (PK)	0.27	0.13	0.28		0.094
	Recoverable injury	203 dB re 1 µPa2·s (SEL24h)	0.10	0.10	0.07		0.07
		207 dB re 1 µPa (PK)	0.27	0.13	0.28		0.094
	TTS	186 dB re 1 µPa2·s (SEL24h)	4.66	4.66	2.46		2.46

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.

7.1.5.3.6 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 reef 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 7-5, 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 for streamer acquisition, and 45 – 94 m for nodal acquisition, from a single impulse. Further detailed modelling of SEL_{24h} levels received at the sea floor was undertaken by Koessler & McPherson (2023; Appendix G), 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 for streamer acquisition, and 70 m for nodal acquisition (refer Table 7-4).

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 (streamer acquisition) and 280 m (nodal acquisition) from the seismic source (refer Table 7-5). 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. 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 and 280 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. 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).

7.1.5.3.7 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 7-5, 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 (streamer acquisition) or 110 m (nodal acquisition). 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 (streamer acquisition) or 280 m (nodal acquisition). 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 for streamer acquisition, or 2.5 km for nodal acquisition. 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 4.7/2.5 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 because of potential disturbance to more sound-sensitive prey species, such as herrings, sardine's, sprat and shads.

7.1.5.3.8 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 $\mu Pa^2 \cdot s$ (SEL_{24h}); and TTS (186 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}), have been used for this assessment.

As shown in Table 7-5, 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 150/110 m. TTS thresholds across the water column for fish without a swim bladder could be reached within 4.7/2.5 km. It is important to appreciate that individual sharks would have to remain within a range of 4.7/2.5 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.

7.1.5.3.9 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 'localised' and 'short-term' and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area near 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).

7.1.5.4.1 Impact assessment

This impact assessment is focused on fish spawning and recruitment for relevant key indicator commercial fish stocks.

Sections 4.3.4 and 4.4.4 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
- The natural variability in fish distribution, spawning biomass and recruitment
- 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.

7.1.5.4.2 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 several assumptions have been applied to the analysis 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:

The spatial overlap with each stock is represented by 24-hours of 3D acquisition with a 10 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 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 10 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 10 km buffer also accounts for the predicted R_{max} distance to TTS onset in all fish hearing groups (4.66 km; refer Table 7-5 above) and provides an additional 5km buffer as a conservative measure that aligns with the upper limit of the qualitative threshold for behaviour set by Popper et al. (2014) (Table 7-6).

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.

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.

The spatial-temporal analysis is a simplistic approach that assumes that fish spawning in the area and period of exposure will be compromised.

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 7-6 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 7-6: Spatial overlap with spawning ranges of key indicator fish species

Acquisition scenario	Spatial overlap			
	Dhufish (10–150 m)	Snapper (1–200 m)	Redthroat emperor (5–100 m)	Spanish mackerel (1–50 m)
24-hours 3D + 10 km buffer (maximum 620 km^2)	3.9%	2.4%	3.0%	1.4%

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 7-7). It is important to note that the temporal overlap may also over-represent what will likely 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 7-7: 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 30-day duration Feb–Mar survey period	24%	0%	33%	0%

The combined spatial-temporal overlap with the spawning areas and times of the key commercial indicator fish species is presented in Table 7-8.

Table 7-8: Combined spatial-temporal overlap with spawning periods and ranges of key indicator fish species

Acquisition scenario	Spatial / temporal overlap			
	Dhufish (10–150 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 30-day duration	0.94%	0%	0.99%	0%

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 overlap with the Spanish mackerel stock is less than 0.2% of its WA stock range and does not overlap with the spawning period.

7.1.5.4.3 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; for example, long-term monitoring data for indicator species show interannual variation in recruitment and biomass indices of more than an order of magnitude (Fisher et al. 2023; DPIRD 2023), 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 driven primarily by environmental factors and fishing pressure (Marriott et al., 2012; Newman et al., 2003; Fisher et al., 2023) 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). DPIRD (ID 4682) highlighted that dhufish pair spawn and published studies show that waters of 10 to 150 m are inhabited by recently spawned dhufish (Hesp et al. 2002), suggesting their spawning could occur in these depths. In the absence of further studies delineating the specific locations or depths of spawning dhufish, they are assumed to be capable of spawning at any depth within their range where there is suitable habitat. Furthermore, the distribution of spawning fish is unlikely to be evenly distributed either within or outside the seismic survey area. Given the survey area spans a representative depth range of their natural distribution, the proportional level of impact (<1%) is considered a conservative and representative assessment.

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 most spawning groups in the region at any point in time will be undisturbed. For species with high dispersal and connectivity, such spatially and temporally restricted disturbances are within the range of population fluctuations observed under natural conditions (Fisher et al., 2023; Hesp et al., 2002). 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 because 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 because of a seismic survey would have impacts many orders of magnitude smaller than regional scale environmental/climatic events that would affect entire stocks and are within the bounds of the year-to-year variability documented for these fisheries (Fisher et al., 2023; DPIRD 2023).

7.1.5.4.4 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, and any such effect would be indistinguishable from natural variation in spawning and recruitment observed over the long term (Fisher et al., 2023; DPIRD 2023), 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).

7.1.5.5.1 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 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).

7.1.5.5.2 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.

7.1.5.5.3 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, most 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 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 after 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 4-15) 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. If 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).

7.1.5.5.4 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 ‘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

7.1.5.6.1 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 7-9. The peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL) presented in Table 7-9 are as reported in Finnernan et al. (2017) for PTS and TTS effects in turtles. The behavioural response threshold presented in Table 7-9 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 7-9: 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 µPa²s.

7.1.5.6.2 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) because of high sound levels at close range to the seismic source, or behavioural disturbance impacts.

As described in Section 4.3.10.1, the OA does not overlap any marine turtle BIA, and the nearest nesting beaches are 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 7-10 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 7-10: 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) – Streamer Acquisition	R_{max} distance (km) – Nodal Acquisition
Marine turtles	**Behavioural response**		
	166 dB re 1 µPa (SPL)	4.90	3.37
	175 dB re 1 µPa (SPL)	1.58	1.28
	PTS		
	232 dB re 1 µPa (PK)	-	-
	204 dB re 1 µPa².s (SEL_{24h})	0.06	0.07
	TTS		
	226 dB re 1 µPa (PK)	-	-
	189 dB re 1 µPa².s (SEL_{24h})	2.10	1.72

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 for streamer acquisition and 70 m for nodal acquisition. 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 for streamer acquisition and 1.72 km for nodal acquisition, 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(i)).

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 for streamer acquisition and 3.37 km for nodal acquisition. Based on the 175 dB re 1 µPa SPL behavioural threshold criterion a behavioural disturbance could occur within 1.58 km for streamer acquisition and 1.28 km for nodal acquisition. 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.

7.1.5.6.3 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 'localised' and 'short-term'. Impacts are likely to be restricted to temporary behavioural changes (avoidance) to transient turtles that may pass within 4.9/3.37 km (streamer/nodal acquisition) 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

7.1.5.7.1 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 7-11). 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 7-11: 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

7.1.5.7.2 Impact assessment - cetaceans

Biologically important periods for key cetaceans in the region are shown in Table 7-12.

Table 7-12: Biologically important periods for cetaceans

Species	January	February	March	April	May	June	July	August	September	October	November	December	Notes
Survey timing													
Humpback whale													September to October – cows/calves
Pygmy blue whale													Species typically prefers deeper waters
Southern right whale													Occasional sightings north of Geographe Bay

Peak period		Shoulder period	

Marine mammals use sound for foraging, orientation, communication, navigation, echolocation of prey and predator avoidance (Richardson et al. 1995, Reckendorf et al. 2023) and therefore are sensitive to underwater noise. High levels of anthropogenic underwater sound can 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, Gordon et al. 2003, Brandt et al. 2018, Palmer et al. 2021).

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 (Southall et al. 2019). 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 (Southall et al. 2019).

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, Weilgart 2007, Southall et al. 2021). 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^3/1440 in^3 (in nodal areas) predicted distances to received sound levels compared with noise effect criteria threshold levels in Table 7-13.

Table 7-13: Summary of modelled impact ranges for cetaceans

Hearing group / effect	Sound effect threshold	R_{max} distance (km) – Streamer Acquisition	R_{max} distance (km) – Nodal Acquisition
LF cetaceans			
PTS	219 dB re 1 uPa (PK)	0.06	0.06
	183 dB re 1 uPa^2·s (SEL_{24h})	3.08	1.72
TTS	213 dB re 1 uPa (PK)	0.15	0.11
	168 dB re 1 uPa^2·s (SEL_{24h})	43.0	11.9
HF cetaceans			
PTS	230 dB re 1 uPa (PK)	-	-
	185 dB re 1 uPa^2·s (SEL_{24h})	-	-
TTS	224 dB re 1 uPa (PK)	-	-
	170 dB re 1 uPa^2·s (SEL_{24h})	0.06	0.1
VHF cetaceans			
PTS	202 dB re 1 uPa (PK)	0.41	0.45
	155 dB re 1 uPa^2·s (SEL_{24h})	0.06	0.07
TTS	196 dB re 1 uPa (PK)	0.84	0.85
	140 dB re 1 uPa^2·s (SEL_{24h})	0.44	0.07
All cetaceans			
Behavioural response	160 dB 1 uPa (SPL)	9.2	5.53

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 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.

7.1.5.7.2.1 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) due to the multiple airguns arranged in a specific pattern which spreads the sound energy over a larger area reducing the intensity of the sound pressure waves at any given point compared to a single point source, and therefore 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 (for both streamer and nodal acquisition) of the airguns and VHF cetaceans within 410 m (streamer acquisition) or 450 m (nodal acquisition). The PTS onset threshold was not reached within the limits of the model (20 m) for HF cetaceans (Table 7-13). 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 peak 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 (streamer acquisition) or 1.72 km (nodal acquisition) of the source (Table 7-13). This prediction included close exposure whereby most of the sound energy "dose" would have occurred, and 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 4.3.8). 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 7-13). The noise modelling for VHF cetaceans predicted that prolonged exposure over 24-hours could cause PTS out to a maximum of 60 m (streamer acquisition) or 70 m (nodal acquisition) of the source (Table 7-13). 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 (streamer acquisition) or 110 m (nodal acquisition) of the airgun array and within 840 m (streamer acquisition) or 850 m (nodal acquisition) 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 MFOs 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 (streamer acquisition) or 11.9 km (nodal acquisition), 60 m (streamer acquisition) or 100 m (nodal acquisition) for HF cetaceans and 440 m (streamer acquisition) or 70 m (nodal acquisition) for VHF cetaceans (Table 7-13). 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.

While no physical injury is expected, any significant avoidance or prolonged disturbance of whales can carry energetic consequences. New bioenergetics research shows that higher activity levels measurably reduce fasting endurance in right whales. A lactating female or an individual in marginal condition may have little capacity for extra energy expenditure. Therefore, even a temporary displacement or increased travel distance to evade seismic noise could erode a whale's energy reserves, potentially affecting its condition, survival or reproductive success if feeding opportunities are delayed. This risk is highest for mother-calf pairs and any whales already in poor body condition or entangled (Christensen et al. 2025.

The timing of the survey (early February to end of March) is prior to the period of known presence of whales adjacent to 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. EPBC Policy Statement PS 2.1 Parts A and B are being implemented as precautionary measures in case some individuals are encountered, and 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 7-14, 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 7-14: 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. Based on an approximate bridge height of 4m above sea surface for the support vessel, and 20m for the seismic vessel giving viewable distances to the horizon of 7km and 16km respectively. These combined distances provide observation distances more than the 14.5km required (Figure 7-8). 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 Table 7-19).

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 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.

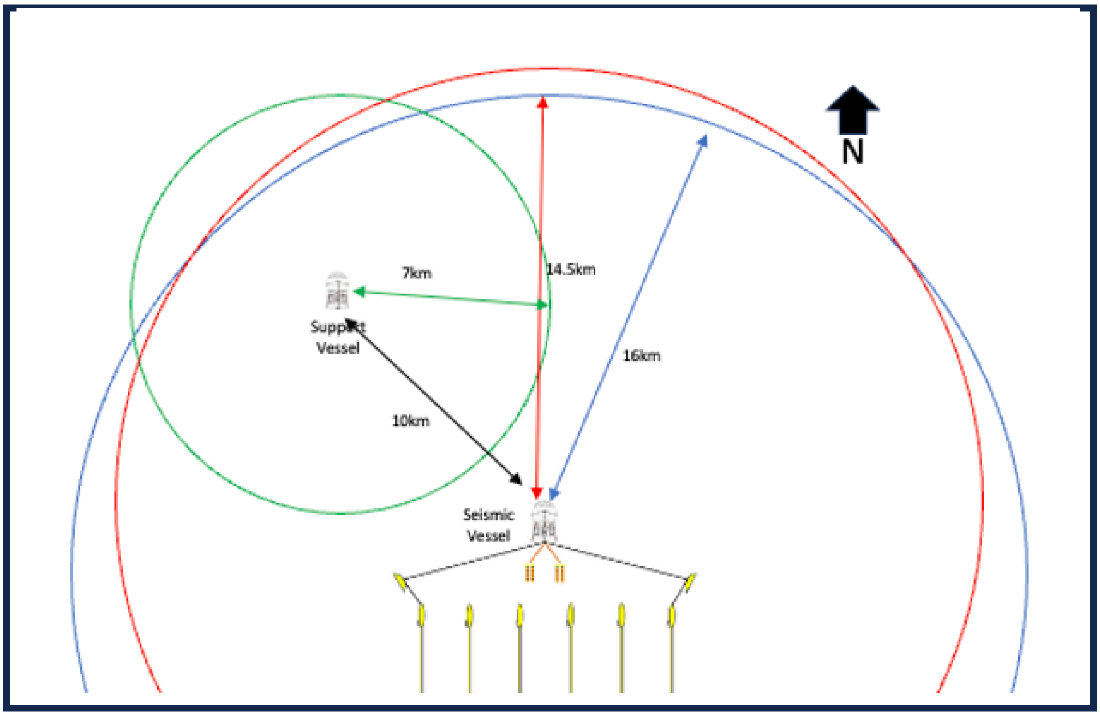


Figure 7-8: Dual-Vessel MFO Deployment Ensures >14.5 km PBW Coverage

7.1.5.7.2.2 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 (streamer acquisition) or 5.53 km (nodal acquisition) from the source (Table 7-13). 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 unlikely, or in the case of PBW, limited to transient individuals during this time. In particular, the OA is extending toward the northern extremity of SRW distribution with only a few recorded sightings and strandings north of Perth. These records all fall within the expected temporal scale of SRW migration and reproduction within Australian waters and do not extend into the period of the survey. There is a lack of temporal overlap for SRWs, and the closest reproduction BIAs are approximately 100 km south of Perth (400 km south of the OA), and 1000 km north of the OA in Exmouth Gulf, SRW presence is considered unlikely in the areas adjacent to the OA at this time of year.

Other whales that may be encountered during the survey in the OA include the minke, sei, fin and Bryde's whale. These species may also exhibit a behavioural response out to the modelled ranges of 9.2/5.53 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 9.2/5.53 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.

7.1.5.7.2.3 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 280 m from the ASA, and consequently these effects will not extend into the PBW foraging BIA.

7.1.5.7.3 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 4.3.8, 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 7-11). 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 7-15). 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 (streamer acquisition) or 980 m (nodal acquisition) of the source (Table 7-15). 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 are expected to occur.

However, it is possible that sea lions could exhibit some behavioural disturbance within 9.2 km (streamer acquisition) or 5.53 km (nodal acquisition) 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 7-15: Summary of modelled impact ranges for pinnipeds

Effect	Sound effect threshold	R_{max} distance (km) – Streamer Acquisition	R_{max} distance (km) – Nodal Acquisition
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	0.98
Behavioural response	160 dB 1 uPa (SPL)	9.2	5.53

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 7.1.6.3): 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 7.1.6.2): 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 7.1.6.2): Benthic invertebrates such as WRL cannot move large distances in response to acoustic sound. Sub-lethal impacts to WRL may be observed because 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 near 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).

7.1.5.7.4 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 '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

7.1.5.8.1 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. However, little penguins are rarely observed north of Perth, and the OA is not an important foraging area for this species. The primary foraging habitats are south of Perth, in Cockburn Sound.

7.1.5.8.2 Impact assessment

A total of 27 species of marine birds were identified as potentially occurring in the OA (Section 4.3.11), 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.

7.1.5.8.3 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 7-16). Protected areas and their conservation values that could be affected by seismic sound from the Eureka 3D MSS are summarised in Table 7-16. 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 0).

Table 7-16: 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 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 Abrolhos AMP is located 20 km west 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).
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(i)). 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 known commercial diving operations that periodically occur in the OA as part of the commercial fishing activities for the Marine Aquarium Managed Fishery and the Specimen Shell Managed Fishery, typically diving at depths of 10-50m, in addition to recreational diving activities likely 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 0.

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 (Day et al 2017), however overall changes in benthic community composition and structure are expected to be negligible in the context of natural variability in mortality and recruitment (Parry and Gason 2006, Blanchard et al 2022).

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 0 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 7-17). 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 7-17).

Table 7-17: 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	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			

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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) 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.	Benefits outweigh cost	Yes	Yes
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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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
Additional control measures for pygmy blue whales			

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Use of passive acoustic monitoring (PAM) to detect vocalising whales	Pilot Energy has implemented a mitigation strategy that reduces risks to baleen whales through a combination of seasonal timing, visual monitoring, and adaptive management. The survey is scheduled for February to March, outside the peak migration periods for humpback, pygmy blue, and southern right whales in the Dongara region. This timing aligns with known seasonal whale movements and relevant EPBC Act guidance. Although Passive Acoustic Monitoring (PAM) could, in theory, help detect whales at night, its practical value is limited in this context. Furthermore, the cost and operational complexity of PAM are not justified given the seasonal timing of the survey. The high cost and operational burden of PAM make it a disproportionate and unnecessary measure. Pilot Energy's current approach achieves appropriate protection without unjustified expenditure.	`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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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). Significant cost of commercial drones and licensed pilots.	Limited	No
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 hires.	Limited	No
Other control measures			
If 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 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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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 will not be directly impacted because 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 are 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, particularly the blue whale (refer Table 4-11).	No	No
No seismic acquisition during the pygmy blue whale northbound or southbound peak 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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
No seismic acquisition during the peak commercial fishing periods and peak sensitive periods for fish and invertebrates	Pilot Energy has scheduled the seismic survey for February and March to minimise environmental and operational risks. This timing avoids peak periods for whale migration, foraging, and Australian sea lion breeding, based on current observations for 2026. It also reduces the likelihood of weather-related delays that could prolong operations and increase risk. Environmental assessments support the low likelihood of ecological impact during this period. Western Rock Lobster hatching mostly occurs outside the seismic area, and only one month of the six-month puerulus settlement period overlaps with the survey. Fish spawning overlap is minimal—less than 1% for key species such as dhufish, snapper, red throat emperor, and Spanish mackerel—making population-level impacts unlikely when considering natural variability and fishing pressures. To minimise disruption to commercial fishing, Pilot Energy will maintain regular communication with fishers, provide forward notice of survey vessel movements, and support access to alternative fishing areas. A compensation protocol is in place to address any losses incurred.	No	No
Seismic source validation: If a seismic source is selected for the Eureka 3D MSS that is any larger size (see Table 3-2) 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
All discharges of the seismic source (including soft starts and bubble tests) will occur only within the ASA.	Benefits outweigh cost	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Seismic vessel will adopt lowest possible seismic source size while still achieving operational outcomes	The chosen source sizes (2495 cu.in. in deeper areas and 1440 cu.in. in the nodal area areas) are the minimum necessary to achieve required data quality for operational objectives, thereby reducing potential impacts on marine fauna. Further reduction in source size would compromise data quality and operational objectives.	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 45 km, Pilot will notify divers/snorkellers of the planned activity where practicable. Where diving and seismic activity will occur within 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
In addition to the requirements of EPBC Policy 2.1, Pilot Energy will initiate a power-down or shut-down of the seismic source if dolphins' approach within 500 m of the source, except for those observed bow riding.	Measure adopted from consultation. (Event 2888).	Yes	Yes
Nodal Source and Reef Exclusion Zones ALARP Analysis			
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 200 m from the exclusion zones in the nodal area	Benefits outweigh cost	Yes	Yes

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Complete the nodal source lines no closer than 300m from the reef during day and night.	This control reduces the acquisition area which reduces the quality of the geophysical data, however the data collected will still be sufficient to meet the survey objectives. There is no additional survey costs associated with this control. This control provides protection to adult lobsters that reside in the reef habitats where lobsters are potentially at greatest densities. This control has been adopted because the cost is not grossly disproportionate to the environmental benefit gained.	Yes	Yes
Complete the nodal source lines within 500m of the 300m exclusion zone only during daylight hours to provide protection to nighttime foraging lobsters.	This control adds significant cost to the survey due to an additional week required to conduct the survey and approximately $3 million in additional survey costs. The additional 500m exclusion zone excludes 1.3 times the area of the 300m zone alone. Other costs associated with extending the duration of the survey include greater seismic noise exposure to other environmental receptors and revision of the entire EP to extend the survey. The evidence shows that seismic exposure is not lethal to adult lobsters, but sublethal effects may occur. While foraging may be impacted for the few nights that acquisition is active in the 500m zone, the impacts to lobster health and foraging behaviour are temporary. Therefore, the additional commercial costs to the survey are grossly disproportionate to the small sublethal protections that the control would provide.	Yes	No

Control measures	Cost benefit analysis	Impact reduction	Control adopted
Complete the nodal source lines no closer than 800m from the reef structures at any time (day and night).	Though this is more protective for all life cycle stages of lobsters, this would result in the geophysical data objectives for the survey not being completed and invalidate survey. As a result, the survey would not be commercial viability. The environmental benefit gained would be the reduction in sublethal effects on a small number of foraging lobsters. Therefore, the additional commercial costs to the survey are grossly disproportionate to the small sublethal protections that the control would provide.	Yes	No

Control measures	Cost benefit analysis	Impact reduction	Control adopted
No operation of the seismic source over areas of seabed with seagrass to protect the puerulus that may be residing in the seagrass.	This control would result in the survey not being economically feasible because the full extent of seagrass in the OA is not known. A dedicated seabed mapping study would be required that would cost millions of dollars and months of additional work prior to the seismic survey commencing. These areas would then be excluded from the survey area and would likely result in the geophysical data objectives for the survey not being completed and invalidate the survey. The evidence shows that puerulus exposed at very close proximity to seismic noise resulted in sublethal effects (Day et al. 2021, 2022, 2023). Therefore, excluding seismic acquisition over seagrass beds is not going to prevent large mortality events of peurulus and at most may reduce some sublethal effects and some possible mortality. As such, the environmental benefit of adopting this control is consider minor, especially in the context of the broader peurulus recruitment. Therefore, the additional commercial costs to the survey are grossly disproportionate to the small sublethal protections that the control would provide	Yes	No

7.1.6.2 Residual impact evaluation

Residual impact	Consequence	Likelihood	Risk ranking	Decision type
	Low – Plankton	Possible – Plankton	Low – Plankton	B
	Minor – Invertebrates	Unlikely – Invertebrates	Low – Invertebrates	
	Low to Minor – Lobster/octopus	Unlikely to Possible – Lobster/octopus	Low to Moderate – Lobster/octopus	
	Minor – Fishes	Unlikely – Fishes	Low – Fishes	
	Minor – Fisheries	Unlikely – Fisheries	Low – Fisheries	
	Low – Turtles	Possible – Turtles	Low – Turtles	
	Minor – Cetaceans	Unlikely – Cetaceans	Low – Cetaceans	
	Minor – Pinnipeds	Unlikely – Pinnipeds	Low – Pinnipeds	
	Minor - Seabirds	Unlikely - Seabirds	Low - Seabirds	
	Minor – Protected areas	Unlikely – Protected areas	Low – Protected areas	
	Minor – Tourism/Divers/snorkellers	Unlikely – Tourism/Divers/snorkellers	Low – Tourism/Divers/snorkellers	

7.1.6.3 Demonstration of acceptability

The Activity is consistent with Pilots corporate policies, culture, processes, standards, structure and system as outlined in the Demonstration of ALARP and Environmental Performance Outcomes including:

- Alignment with Pilots Environmental and Sustainability Policy for the Eureka 3D MSS described in Appendix A.
- Alignment with Pilots Hazard Identification and Risk Management Procedure.
- Adherence to Pilots impact/risk treatment (section 0).

These principles are integral to Australia's environmental legislation, including the federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). They guide the evaluation of projects, ensuring that they align with the principles of ESD, protect biodiversity, and promote sustainable development. Consistent adherence to these principles is essential for responsible and sustainable environmental management in Australia. ESD is a foundational concept in environmental decision-making and management, with its principles deeply rooted in international agreements and enshrined in Australian legislation. The core tenet of ESD is to ensure that the needs of the present generation are met without compromising the ability of future generations to meet their own needs. There follows and assessment of each principle of ESD having regard to the Eureka MSS and the preparation process of the EP. The impact assessment has considered the following relevant principles of ESD:

- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.

Impacts are considered consistent with these principles given controls adopted, and that impacts will be limited to a range of low-moderate indicating ether ‘negligible impact’ to ‘short term effect with recovery from months to one year’ (See section 6.4.2). Other principles of ESD were not considered relevant to underwater noise emissions from seismic source.

The proposed activity and control measures are not inconsistent with the requirements of recovery plans or wildlife conservation plans/advice. 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 31010:2018 Risk

Management, Standards Australia / Standards New Zealand Risk Management Guidelines). The impact assessment and control measures are also consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev 2 Dec 2018). Extensive consultation has been undertaken, and all stakeholder concerns and feedback has been assessed and addressed appropriately.

The newly published southern right whale aerial survey report (Smith et al., 2025) reinforces that calving continues to occur in southern Western Australia and that population growth rates in those areas have slowed in recent years. This information does not change the assessment for the Eureka 3D MSS, as the survey area lies approximately 350 km north of Perth and outside of known calving habitat. The primary protective measure for SRW in this EP remains the February–March timing of the activity, which avoids periods when SRWs are present in Western Australian waters.

Additionally, to the criteria presented above, Table 7-18 below further exhibits the reasonings why predicted impacts to relevant receptors, and by extension the activity, will be conducted in an environmentally acceptable manner, and impacts will be reduced to an acceptable level.

Table 7-18: Statement of Acceptability

Statement of Acceptability		
Receptor	Acceptability Criteria & Assessment Summary	Environmental Performance Considerations
Plankton, Fish, Invertebrates (incl. spawning)	The predicted level of impact for Plankton, fish and invertebrates (including spawning) is of an acceptable level because: 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 focus was that both species have a mechanosensory organ called a statocyst that is potentially 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. Impacts to adult and juvenile lobster are expected to be sublethal and recoverable and are therefore not expected to have population and ecosystem level effects. The survey will not result in changes to spawning biomass or changes in recruitment of important species that may be discernible from normal natural variation and will therefore not have population or ecosystem level effects. The survey will be managed in a manner that is consistent with management objectives for relevant AMPS's, recovery plans and conservations plans/advice. 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). Recovery of fish expected within 12 to 24-hours based on Stadler & Woodbury (2009) and Popper (2018).This demonstration of acceptability meets acceptable levels AL 1,2,3,5,6,7,8,9, 10, 11, 12, and 13.	EPO 2 - 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. EPO 3 - Undertake seismic acquisition in a manner that prevents injury and reduces the potential for TTS in site-attached fishes and invertebrates.

Statement of Acceptability		
Receptor	Acceptability Criteria & Assessment Summary	Environmental Performance Considerations
Marine Fauna (turtles, cetaceans, ASL, seabirds)	The predicted level of impact for migratory and threatened cetaceans is of an acceptable level given the following: 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. The survey will be managed in a manner that prevents physical injury or displacement of PBW, HBW, SRW and ASL from migration and foraging BIA's. Additionally, it will be managed in a manner that reduces potential biologically significant behavioural disturbances to PBW, SRW, HBW, ASL and other cetacean species. The survey will be managed in a manner that is consistent with management objectives for relevant AMPS's, recovery plans and conservations plans/advice. The predicted level of impact has been reduced to ALARP. By scheduling the seismic survey between early February to end of March, the migration periods for PBWs, SRWs and HBWs are avoided. This demonstration of acceptability meets acceptable levels AL 1,2,3,4, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30 and 31.	EPO 1 - Undertake seismic acquisition in a manner that prevents injury and biologically significant behavioural disturbance to whales and ASLs. Implementation of EPBC Policy Statement 2.1 Part B.6 Adaptive Management Measures to minimise the minimum potential impacts to pygmy blue whales. 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.

Statement of Acceptability		
Receptor	Acceptability Criteria & Assessment Summary	Environmental Performance Considerations
KEFs & Protected Areas	The predicted level of impact for KEF's and protected areas is of an acceptable level because: The survey will be undertaken in a manner that is consistent with the principles and management objectives of the south-west marine reserves network management plan. The survey will be undertaken in a manner that is consistent with the objectives of the commonwealth and (Abrolhos and Jurien AMP) and state protected areas (Jurien Bay Marine Park). This demonstration of acceptability meets acceptable levels AL 37, 38, 39, and 40.	EPO 1 - Undertake seismic acquisition in a manner that prevents injury and biologically significant behavioural disturbance to whales and ASLs.

Statement of Acceptability		
Receptor	Acceptability Criteria & Assessment Summary	Environmental Performance Considerations
Commercial & Recreational Fisheries	The predicted level of impact for commercial and recreational fisheries is of an acceptable level given the following: Claims were raised that there may be future financial impacts to commercial fishing because 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 because of survey activities. 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 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 relevant stakeholders. This demonstration of acceptability meets acceptable levels AL 32, 33, 34, 35, and 36.	EPO 2 - 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. EPO 3 - Undertake seismic acquisition in a manner that prevents injury and reduces the potential for TTS in site-attached fishes and invertebrates. EPO 6 - 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 - Implementation of the Eureka Marine Seismic Survey Commercial Fisher Compensation Protocol (EMSSCFCP) to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch because of survey activities.

Tourism & Recreation	The predicted level of impact for tourism and recreation is of an acceptable level given the following: The proposed controls and consequence level are consistent with the DMAC 12 (Rev 2) 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. This demonstration of acceptability meets acceptable levels AL 41 and 42.	EPO 2 – 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 - 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 45 km, Pilot will notify divers/snorkellers of the planned activity where practicable. Where diving and seismic activity will occur within 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. PS - Direct communication with local dive shops and Port Denison Volunteer Sea Search & Rescue will be used to identify and notify the public of planned survey operations. Local newspaper advertisements and signs posted at local boat ramps and beaches will also be used to notify the public of the planned survey operations.

Statement of Acceptability		
Receptor	Acceptability Criteria & Assessment Summary	Environmental Performance Considerations
		EPO 4 - Undertake seismic acquisition in a manner that prevents injury to any scuba divers or snorkellers. EPO 6 - 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 - 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. PS - Survey timing will be limited to February – March 2026.

7.1.6.4 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 7-19.

Table 7-19: 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 and biologically significant behavioural disturbance to whales, dolphins, and ASLs EPO 2 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 for a minimum of 30 minutes 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 Dolphin shut-down – The seismic source will be powered down if any dolphin enters the 500 m shut-down zone.	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	MC 3 Records demonstrate two dedicated MFOs per observing vessel (survey vessel and support vessel) are

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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) 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.	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
	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:	MC 8 Records demonstrate compliance with pygmy blue whale adaptive management measures as described

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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 10 Records confirm no incidents when vessels less than 40 km apart and actively acquiring data
	PS 6 No seismic acquisition during the pygmy blue whale northbound or southbound migration periods (i.e., April to July; and October to January)	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 7 No seismic acquisition during the southern right whale migration period (i.e., April to October)	
	PS 8 No seismic acquisition during the humpback whale migration period (June to November)	
	PS 9 Seismic source validation: If a seismic source is selected for the Eureka 3D MSS that is a larger size (see Table 3-2) 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 10 If 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 MC 13 Records demonstrate compliance with the 40 km separation distance.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
		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 11 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.
	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 3 Undertake seismic acquisition in a manner that prevents injury and reduces the potential for TTS in site-attached fishes and invertebrates	PS 12 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.	
	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 the Eureka Marine Seismic Survey Commercial Fisher Compensation Protocol (EMSSCFCP) to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch because of survey activities.	MC 43 Commercial Fishing Industry Adjustment Protocol implemented with relevant commercial fishers prior to commencement of survey activities.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	This Protocol originated from the National Energy Resources Australia (NERA) Commercial Fishing Industry Adjustment Protocol (NERA, 2021). The Protocol has been amended following feedback from fishers and fishing associations who Pilot Energy have consulted with. The (EMSSCFCP) will have the following features: As a minimum, claims processes for direct losses from: Accidental damage or loss of deployed fishing equipment caused by the presence of the seismic vessel (either repair or replace). Displacement for increased transit times, which result in increased fuel and crewing costs from moving fishing locations, Reduced catch per unit effort if survey acquisition timing directly overlaps a previously fished area, within the fishing season, demonstrated by the reported data. The claims process will require a fisher to provide evidence (or authorisation to access evidence) for claimed losses that enables a calculation of how much compensation may be due. Details about the role, responsibilities, and instructions for nominated claims assessors who will be third parties to the titleholder. An assessment report on each claim will be provided by the claim assessor to the titleholder and the claimant. The assessment report will include the details and methodology used to conclude the claim and an Outcome Notification. There will be a dispute mechanism requiring additional assessment by a different assessor. Applies to fishing cooperatives who can provide evidence of commercial losses because of the survey. A loss of adjustment claim can be lodged up to 6 months s after the completion of the activity. Subject to a claim being lodged, a suitably experienced/qualified independent person/organisation will be engaged by the titleholder as the assessor of the claim, in consultation with the claimant. Appropriately documented claims will be assessed, in accordance with the processes outlined in the protocol, and a report will be provided to the claimant within 30 days of the lodgement date of the claim Successful claims will receive compensation within 10 working days of the Outcome Notification being executed. The claim assessor(s) will be suitably experienced and qualified and is defined as a person or organisation with proven demonstrated experience in data analysis and data auditing processes and procedures	

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	within the fishing industry. Nominees for claims assessors can be made by titleholders and claimants and then agreed upon before the commencement of a claim. There is a claims process specified in the protocol, which will be followed by the titleholder and the claims assessor. If a claimant disagrees with a claim assessment outcome, and an agreement cannot be reached between the titleholder and the claimant, the claimant may, within 30 days of receipt of the Outcome Notification, request that a suitably experienced/ qualified independent third-party is engaged to review and determine the outcome of the claim. The independent expert reviewer must provide a view as to whether the claim assessment process has been conducted in line with the requirements of the protocol. The independent expert reviewer may also consider any additional information deemed appropriate by them, including information provided by either the claimant or the titleholder. An independent expert review decision may differ from the initial assessment outcome. A copy of the Protocol has been included in Appendix C.	
EPO 4 Undertake seismic acquisition in a manner that prevents injury to any scuba divers or snorkellers	PS 13 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 45 km, Pilot will notify divers/snorkellers of the planned activity where practicable. Where diving and seismic activity will occur within 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as lower order.

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 shutdowns). 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 Defined acceptable level

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to ALARP. This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks at this level are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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. Most 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) near 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 because 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 0.

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 7-20), 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 7-20: 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

The impact assessment has concluded that, with the implemented control measures, project vessel noise disturbance is expected to result in no more than localised and temporary disruption to a small proportion of the population. These impacts are anticipated to have no lasting effects and no impact on critical habitats or activities.

Pilot has thoroughly evaluated additional opportunities to further mitigate impacts and risks associated with vessel noise. The adopted control measures are in line with good industry practice and fully comply with the requirements set forth in Part 8 (Division 8.1) of the EPBC Regulations 2000.

The planned seismic activity has been assessed to be consistent with relevant Recovery and Threat Abatement Plans and aligns with the principles of ESD. No specific concerns regarding underwater sound impacts from project vessels have been raised by relevant stakeholders.

Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks of underwater sound from project vessels to a level that is broadly acceptable.

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 7-21: Environmental performance outcomes, standards and measurement criteria for underwater sound from vessel operations

.

Table 7-21: Environmental performance outcomes, standards and measurement criteria for underwater sound from vessel operations

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 5 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 20 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as higher order. Therefore, an additional assessment and detail is required to demonstrate this impact is of an acceptable level.

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 km^2 (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) 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 Defined acceptable levels

Pilot Energy's risk assessment methodology for demonstrating that impacts and risks are at an acceptable level distinguishes between higher-order and lower-order impacts and risks. For lower-order impacts and risks, acceptability is demonstrated when the impact or risk has been shown to be reduced to as low as reasonably practicable (ALARP). However, for the interactions with other marine users, an additional demonstration is required. Before the assessment, acceptable levels of impact are defined (below). Once the assessment is complete, the predicted impact levels are compared with these predefined acceptable levels. If the predicted levels are lower than the defined thresholds, the impact is at an acceptable level.

AL 41. Survey activity and equipment are limited to within the OA and only during the survey period

AL 42. 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

AL 43. Vessel operations will be compliant with relevant legislation and guidelines relating to navigation and safety at sea

AL 44. Third parties are always made aware of the presence and movements of the seismic and support/chase vessels through the ongoing relevant person notification program

AL 45. Fishers receive sufficient notification of survey operations in each zone through the ongoing relevant person notification program for planning of fishing trips

AL 46. 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.

AL 47. 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 4-15 and Table 4-16 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 0. 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 0. 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 0). 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. If 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. Potential impacts are predicted on the value of these cultural features, particularly songlines, but no spatial or temporal impacts are predicted.

Inherent impact evaluation				
Inherent impact	**Consequence**	**Likelihood**	**Risk ranking**	**Decision type**
Rock lobster, octopus and demersal scale fish 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	

The potential for interference with commercial and tourism fishing activities has been assessed on a fishery-by-fishery basis, focusing on operational interactions that may arise. For State managed fisheries this assessment includes only those where both the fisheries licensed area and historical commercial catch data directly overlap with the Eureka MSS operational area. This dual-filter approach was the requested consultation approach by the Western Australian Fishing Industry Council ensuring that the analysis is focused on fisheries with a demonstrable and spatially relevant history of activity in proximity to the proposed survey, thereby reducing consultation fatigue for fishers and prioritising resources and consultation efforts where there is a reasonable potential for operational interaction. This filtering method is applied using Table 4-15 (Commonwealth-managed fisheries) Table 4-16 (WA State-managed fisheries).

However, there are some limitations of employing this methodology. Historical fishing effort is only a snapshot of past activity and may not fully capture the dynamic nature of commercial fishing operations, particularly for mobile fisheries or those with flexible effort distribution across their licence area. In theory, some operators could choose to relocate into the MSS area in the future, even if they have not done so historically. Furthermore, the spatial granularity at which the fishing effort is reported, prevents the identification of effort within and adjacent to the MSS. Therefore, comprehensive consultation was undertaken to identify fishers that could be affected by the survey. The consultation has revealed some fishers that could be affected which is analysed and evaluated below.

7.3.3.1 Western Tuna and Billfish Fishery (WTBF)

This line-based fishery is mobile and operates across broad offshore zones throughout northern, western and southern Australia. Historical effort within the MSS area is very low with no known recent fishing activity within the OA. Therefore, fishing effort and CPUE is unlikely to be affected. Consultation did not identify any active fishing in the OA. This combined with the lack of historical fishing in the OA, means it is highly unlikely that the seismic gear could be entangled with a long-line or that fishers will be displaced. The MSS will be conducted in a way that avoids unnecessary interference and has ongoing control measures to minimise loss to fishers.

7.3.3.2 Marine Aquarium Fish Managed Fishery (MAFMF)

This small-scale, dive-based fishery operates primarily in inshore reef environments. Although historical fishing effort has occurred within the MSS area, consultation identified one active fisher who has historically fished in the MSS. Pilot continues to consult with this fisher through the ongoing consultation process and impacts will be managed through the measures provided in Section 7.3.4.3(e.g. the look ahead notification procedure and compensation protocol). As such, there is potential for some impacts to an individual fisher, these impacts are expected to be low.

7.3.3.3 Octopus Interim Managed Fishery (OIMF)

This pot-based fishery operates in inshore and shelf waters. The pots use a triggered trapdoor and are generally deployed for up to 11 days and are retrieved and re-deployed in similar locations. While some effort has occurred near the OA area in past years, these gear types are easily relocated, and current fishing intensity in the area is limited. Outside the MSS, 96.7% of the fishery remains available to fishers and with relatively mobile fishing pots the gear can be relocated with sufficient notice to fishers. Consultation did not identify the OA as being intensively fished or as being a more important area than the rest of the fishery, however some fishers routinely fish the MSS area with their pots remaining deployed for long periods of time. As such, there is the potential for engagement with their pots or the potential to displace these fishers during the survey period. Pilot has identified mitigation options that include notifications to enable fishers to remove pots prior to the survey and redeployment post survey with appropriate compensation or the seismic contractor removes and redeploys pots on behalf of the fishers with appropriate compensation or fishers could move pots outside of the OA with appropriate compensation. Pilot continues to consult with affected fishers and will manage impact to acceptable levels through the ongoing consultation process.

7.3.3.4 Open Access Fishery (OAF)

This category includes small-scale commercial single drop wet-line fishing activities with variable spatial effort. Historical data shows minimal fishing in the OA area, though it is acknowledged that fishing locations may shift over time. However, consultation did not identify any open access fishery likely to operate in the survey area during the MSS timeframe. Fishing is primarily conducted by small coastal vessels that can deploy their single drop wet-lines at a range of locations along the coast. Interference with fishing activity is not anticipated.

7.3.3.5 Specimen Shell Managed Fishery (SSMF)

This fishery involves hand collection of shells in shallow, reef-associated habitats. No historical effort has been recorded within the MSS area. Although effort could relocate, no intention to operate in the survey area was identified during consultation. Therefore, interference is not expected.

There has been one fisher identified who has previously fished in the area. Their lowest level of fishing effort is conducted in the OA during the time of year the survey period is scheduled. The SIMOPS plan will be used to manage impacts to divers, and the compensation plan will be used to offset any loss of fishing effort and therefore impacts are expected to be low.

7.3.3.6 Tour Operator Fishery West Coast (TOFWC)

This non-extractive fishery supports licensed tourism operations such as diving and marine wildlife tours. No tourism activity is known to occur in the MSS area. Consultation confirmed no tour operators will be affected, and advance notifications will be issued to ensure operations can continue without interference.

7.3.3.7 West Coast Demersal Gillnet and Demersal Longline Managed Fishery (WCDGDLMF) and West Coast Demersal Scalefish Managed Fishery (WCDSMF)

This fishery uses passive gear and targets demersal species and the WCDSMF is subject to recent management reforms and closely monitored for CPUE. Some historical effort has occurred near the MSS area and consultation has identified two fishers who claim to have historically fished in the OA. The extent and locations of historical fishing by these fishers has not been disclosed. The gear types used in these fisheries are typically relocated with ease, and consultation did not identify any expected interference. Pilot continues to consult with affected fishers and will manage impact through the ongoing consultation process, look ahead notification procedure and compensation protocol. Therefore, impacts to fishers due to physical interactions is expected to be low.

7.3.3.8 West Coast Rock Lobster Managed Fishery (WCRLF)

The West Coast Rock Lobster Managed Fishery (WCRLF) is a pot-based fishery that operates widely along the west coast. While some lobster pots may be set inside and near the OA area, they can be retrieved and redeployed with enough notice and planning. Consultation identified 12 fishers that could potentially be affected by the seismic survey. It is unclear as to the exact level of effort that these fishers have historically undertaken within the OA. There is the potential for both the streamers and seismic source to become entangled with the pot floats and lines, causing damage and loss to their gear. However, Pilot continue to consult with affected fishers through the ongoing consultation process and will manage impacts to fishers with the look ahead notification procedure and compensation protocol. Therefore, impacts to fishers due to physical interactions is expected to be low. .

7.3.3.9 Mackerel Managed Fishery (MMF)

During consultation, the Western Australian Fishing Industry Council (WAFIC) requested that the Mackerel Managed Fishery (MMF) be included in the list of WA State Fisheries with historical activity in the Operational Area (OA). However, no publicly available data has been identified to verify historical effort by the MMF within the OA. The manager of the MMF at DPIRD confirmed the fishery can be deemed historically inactive in the OA. Therefore, the MMF will be considered historically inactive in the OA for the purposes of this assessment.

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 to reduce the overall size of the OA and ASA 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 7-22).

Table 7-22: 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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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
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

Control measures	Cost benefit analysis	Impact reduction	Control adopted
No seismic acquisition during the peak commercial fishing periods and peak sensitive periods for fish and invertebrates	Pilot Energy has selected February and March as the timing for the seismic survey based on a range of overarching environmental and operational considerations. This period was chosen to avoid peak sensitivities for key marine species, such as whale migration and foraging patterns, and to minimise overlap with Australian sea lion breeding, which is expected to fall outside February and March in 2026 based on current observations. Operational constraints also played a role in this decision, as conducting the survey during other times of the year could increase risks associated with prolonged operations due to adverse weather conditions affecting acoustic acquisition. Specific temporal assessments of environmental sensitivities further support this timing. For Western Rock Lobster (WRL), egg hatching occurs predominantly in deeper waters, outside the area of seismic acquisition (ASA). Additionally, the overlap between WRL puerulus settlement and the survey period is limited to one month out of six. An analysis of spatial and temporal overlap with fish spawning for key indicator species is detailed in Section 7.1.5.4. The findings indicate minimal overlap: less than 0.50% of the Western Australian stock range and spawning period for dhufish and snapper, slightly higher at 0.53% for redthroat emperor, and less than 0.2% for Spanish mackerel. These highly conservative assessments conclude that potential disturbances to approximately 0.5% of indicator fish stocks within the West Coast Bioregion fisheries management area during one season are unlikely to result in population-level impacts. This conclusion considers natural variability in spawning and recruitment as well as stock depletion caused by fishing mortality. Regarding commercial fishing, Pilot Energy recognizes the importance of minimizing disruption to fishers during the survey period. To assist fishers in reducing impacts to their operations, constant communication will be maintained regarding the location of survey vessels, along with lookahead planning to provide advance notice of vessel movements. Additionally, alternative viable fishing grounds are expected to be available during the survey period. If losses are incurred by fishery groups because of the survey, a compensation protocol will be implemented to address them.	Yes	No

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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

The impact assessment has been conducted in alignment with the relevant principles of ESD and has that, with the implemented control measures, the physical interaction of project vessels and towed seismic equipment is expected to have no more than a moderate impact on rock lobster, octopus, and recreational fisheries. These impacts are anticipated to be localised and temporary, lasting from days to weeks. For other receptors, the impact is assessed as low with negligible effects. This will ensure AL 48 is met.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks. All vessel operations will strictly adhere to relevant legislation and guidelines concerning navigation and maritime safety, including Marine Orders 21, 27, and 30, as well as the International Convention for the Safety of Life at Sea (SOLAS). This will ensure AL 45 is met.

The activity will be confined to the Operational Area and the survey timeframe. This will ensure AL 43 will be met.

Stakeholders have raised concerns about the potential displacement of commercial fishers during the survey period. While fishing activities will remain possible in areas of the survey zone where the seismic vessel is not currently operating, Pilot acknowledges the potential for displacement impacts. To address this, Pilot has implemented a Commercial Fishing Industry Adjustment Protocol to formally manage and address claims from affected commercial fishers. To minimise interactions with other marine users including entanglement in fishing gear, Pilot will provide ongoing notifications about vessel locations. This will ensure AL 44, 46, 47, and 49 are met.

The adopted control measures are in line with good industry practice and meet the expectations of the Australian Maritime Safety Authority (AMSA) and the Australian Hydrographic Office (AHO). Pilot believes these measures are appropriate and sufficient to manage the impacts and risks associated with physical interactions of project vessels to an acceptable level.

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 7-23. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted above.

Table 7-23: Environmental performance outcomes, standards and measurement criteria for physical interactions with other marine users

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 6 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 16 Vessel to maintain appropriate lighting, navigation and communication always 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 17 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 18 Continuous (24-hour) survey operations with multiple trained crew (STCW95/Elements of Shipboard Safety) and monitoring of vessel position (radar) and depth always during seismic acquisition.	MC 23 Records confirm bridge was manned continuously during survey operations, visual and radar watches always maintained, and that vessel crew have appropriate qualifications.
	PS 19 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 20 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 21 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	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

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	(including INMARSAT-C and satellite telephone), area of operation and requested clearance from other vessels.	
	PS 22 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.
	PS 23 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 24 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 25 Tail buoys clearly marked to identify streamer ends to other users.	MC 31 Records confirm all tail buoys marked to identify streamer ends.
	PS 26 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 27 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 28	MC 35

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	An Access Authority (AA) will be agreed with the Titleholder for WA-31-L.	Records of AA for data acquisition in permit areas within the Operational Area.
	PS 29 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 30 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 31 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.
	PS 32 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 33 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 34 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 35 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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 36 Implementation of the Eureka Marine Seismic Survey Commercial Fisher Compensation Protocol (EMSSCFCP) to formally manage claims by commercial fishers for lost/damaged gear, costs due to displacement/relocation and loss of catch because of survey activities.	MC 43 Commercial Fishing Industry Adjustment Protocol implemented with relevant commercial fishers prior to commencement of survey activities.
	PS 113 If 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 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 38 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 Minimise survey activity in areas where there is known fishing activity.	MC 44 Survey consultation records show merit assessment and consideration of controls in response to relevant person feedback prior to and during survey.
	PS 39 Resupplying sites will not be in shipping channels or high traffic areas	MC 45 Logs show all resupplying occur away from shipping lanes and high traffic areas
	PS 40 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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	PS 41 Survey timing will be limited to February – March 2026.	MC 46 Records show no activity in months outside of February - March 2026.

7.4 Impact 4: Light emissions – vessels

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as lower order.

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 decreasing 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 Defined acceptable level

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to ALARP. This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks at this level are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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). Vessels are a dynamic source of light pollution in the marine environment, often brightly lit and temporarily increasing light levels in otherwise relatively dark areas (Austad et al.2023). Burrow-nesting Procellariiformes (petrels, storm-petrels and shearwaters) are the species most affected by artificial light through attraction and grounding. Fledglings are more commonly impacted during maiden flights as they disperse from their natal colonies (Rodríguez et al. 2017), particularly where light pollution sources occur at close range (Rodríguez et al. 2017; Atchoi et al. 2024). However, under specific meteorological conditions such as fog or light precipitation, lighting may increase the potential for attraction and/or disorientation of juvenile and/or adult seabirds. There are no records of surface nesting Procellariform seabird fallout or light attraction events at sea (Atchoi et al. 2020).

	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 4.3.11). 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. The wedge-tailed shearwater, little shearwater and white-faced storm-petrel are locally breeding species that may be attracted to artificial light on vessels at night, become disorientated and become grounded on the vessel's deck. 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). A protocol for the capture, handling and release of any grounded seabirds may be implemented to minimise impacts to seabirds (IAATO Guidelines to Minimize Seabirds Landing on Ships). 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 or under conditions of high humidity, cloud and fog that lead to poor visibility. 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).		
	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.		
	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.		
Inherent impact	Consequence	Likelihood	Risk ranking
	Minor	Unlikely	Low

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 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 7-24).

Table 7-24: 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 near 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
Guidelines to Minimize Seabirds Landing on Ships including seabirds landing on ships capture, handling and release procedure	Benefit outweighs cost	Yes. These guidelines provide information on how to help prevent birds from landing on the ships. They also provide information on how to safely handle any birds that do land which assists to minimise impacts to birds that have landed.	Yes
Design and implement a rescue program for grounded birds.	Evidence from previous seismic surveys indicates extremely low incidence of grounded seabirds, therefore the cost of establishing a rescue programme is grossly disproportionate to the minor benefit potentially gained.	Limited benefit due to very low incidence of grounded seabirds.	No
Prevent indoor lighting reaching outdoor environment by closing window blinds to shield internal lights.	Benefit outweighs cost	Yes	Yes
ALARP assessment technique – EIA			

Control measures	Cost benefit analysis		Impact reduction	Control adopted
No night-time operations.	Limiting seismic activities to daylight hours would significantly extend the time required to acquire data for individual activities. Most 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 near 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

The impact assessment has concluded that routine light emissions from project vessels may result in detectable but insignificant localised changes to ecosystems, habitats, and local species populations. These impacts are expected to be temporary, with full recovery anticipated within days to weeks.

Pilot has thoroughly explored opportunities to further reduce the impacts associated with light emissions, as discussed in previous sections. The assessment has given due consideration to relevant conservation advice, wildlife conservation plans, and the NLPG.

The impact assessment has been conducted in alignment with the relevant principles of ESD. No specific concerns regarding light emissions have been raised by relevant stakeholders. Given these factors, Pilot believes that operations conducted in accordance with the identified standards and implemented control measures are sufficient to manage the risks associated with light emissions to a level that is broadly acceptable.

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 7-25. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.6.4.2.

Table 7-25: Environmental performance outcomes, standards and measurement criteria for light emissions

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 7 External vessel lighting conforms to that required by maritime safety standards	PS 42 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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 8 Minimise potential for adverse impacts on light sensitive marine fauna	PS 43 Non-essential vessel lighting will be switched off when not in use, and blinds will be shut at night.	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, and closing of blinds at night.
	PS 44 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.
	PS 45 Vessel crew to follow guidelines to Minimize Seabirds Landing on Ships including seabirds landing on ships capture, handling and release procedure: – Keep deck lights and ice lights at the minimum necessary for safety. – Use blackout blinds on all portholes and windows where possible. – Keep deck lights to a minimum when at anchor or close inshore overnight. – Check every morning to see if birds have landed on the ship. – When possible, let one person coordinate the handling and taking care of these birds. – Handle the birds as little as possible. – Keep the birds in a warm, dry, dark room until ready for release. – Use one box/container for each bird. If not, enough boxes are available, put same bird species in one box. Do not mix bird species. – Record the birds found and report the event to IAATO. – Release the birds when the deck lights are off, or at first light the next day. – Ensure there are no Skuas or Gulls around during the release. – To release, stand at the railing on the windward side of the ship. Sit the bird in the palms of the outstretched hands – if the bird does not take off on its	MC 128 Fauna interactions documented in MFO datasheets

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	own then gently throw the bird up in the air.	

7.5 Impact 5: Routine discharges – vessels

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as lower order.

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:** Comprising 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:** Includes 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 parts of the OA to the shoreline and shallow water depths, no discharges of liquid and solid waste will occur within the nodal area of the OA.
Extent	OA
Duration	Duration of survey – up to 40 days in early February to the end of March

7.5.2 Defined acceptable levels

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to ALARP. This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks at this level are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 desalination 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 7-26).

Table 7-26: Demonstration of ALARP – routine discharges – vessels

Control measures	Cost benefit analysis	Impact reduction	Control adopted
ALARP assessment technique – legislative requirements, good practice			

Control measures	Cost benefit analysis	Impact reduction	Control adopted
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. Industry standard	Yes	Yes
Deck drains 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 contaminated 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 waste outside of the nodal area will be treated as per Marine Orders.	Yes	Yes
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

The impact assessment has determined that given the adopted controls, planned discharges from project vessels are unlikely to result in a potential impact great than a temporary contamination above background levels. Further opportunities to reduce risks have been explored above and Pilot has committed to an additional control in limiting discharges in the shallower nodal area of the OA. Therefore, the adopted controls are considered good industry practice, are aligned with the principals of ESD and meet the legislative requirements under Marine Orders 91, 95 and 96. With no specific relevant person concerns raised, Pilot considers that the controls will manage the impacts of discharges to a level that is broadly acceptable.

The impact assessment has concluded that, with the implemented control measures, planned discharges from project vessels are expected to result in no more than temporary contamination above background levels. These impacts are anticipated to be limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate risks associated with planned discharges. In response to these investigations, Pilot has committed to an additional control measure, specifically limiting discharges in the shallower nodal area of the OA.

The adopted control measures are in line with good industry practice and fully comply with the legislative requirements set forth in Marine Orders 91, 95, and 96. Furthermore, these measures align with the principles of ESD.

No specific concerns regarding planned discharges from project vessels have been raised by relevant stakeholders. Given these factors, Pilot believes the adopted control measures, including the additional commitment to limit discharges in sensitive areas, are appropriate and sufficient to manage the impacts of planned discharges to a level that is broadly acceptable.

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 7-27. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted above.

Table 7-27: Environmental performance outcomes, standards and measurement criteria for routine vessel discharges

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 9 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

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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.
	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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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 10 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.
	PS 55 No discharge of liquid and solid waste within the nodal area	MC 129 Records show location where liquid and solid waste discharged
EPO 11 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 56 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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 12 The marine crew is competent in spill response and have appropriate response resources to respond to a spill.	PS 57 The vessel crew is competent in spill response and has appropriate response resources to prevent or minimise hydrocarbon or chemical spills discharging overboard.	MC 72 Training records verify that vessel crews receive spill response training.

7.6 Impact 6: Atmospheric emissions – vessels

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as lower order.

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 Defined acceptable levels

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to ALARP. This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks at this level are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 7-28. The activity is like 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

Table 7-28: Potential emissions calculations for Eureka 3D MSS

Results	Volume in t CO_2-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

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 7-29).

Table 7-29: 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

The impact assessment has determined that given the adopted controls atmospheric emissions during the seismic activity will not result in a potential impact greater than negligible impact to the localised area. Further opportunities to reduce the impacts and risks are investigated above. The adopted controls are considered, good industry practice, in line with the principles of ESD, and meet legislative requirements. Pilot has not received comments or concerns from relevant persons and considers that the adopted controls manage the impacts of atmospheric emissions in the OA to a level that is broadly acceptable.

The impact assessment has concluded that, with the implemented control measures, atmospheric emissions during the seismic activity are expected to result in no more than negligible impacts to the localised area. These impacts are anticipated to be minimal and limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with atmospheric emissions, as discussed in previous sections. The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements. Furthermore, these measures align with the principles of ESD

Pilot has not received any comments or concerns from relevant stakeholders regarding atmospheric emissions from the project activities. Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts of atmospheric emissions in the Operational Area to a level that is broadly acceptable.

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 7-30. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.6.4.1.

Table 7-30: Environmental performance outcomes, standards and measurement criteria for atmospheric emissions

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 13 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
	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.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 14 Fuel use will be restricted to the minimum required to undertake the seismic survey	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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this impact is classified as lower order.

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 Defined acceptable levels

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to ALARP. This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks at this level are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 7-9, 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 7-9). 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

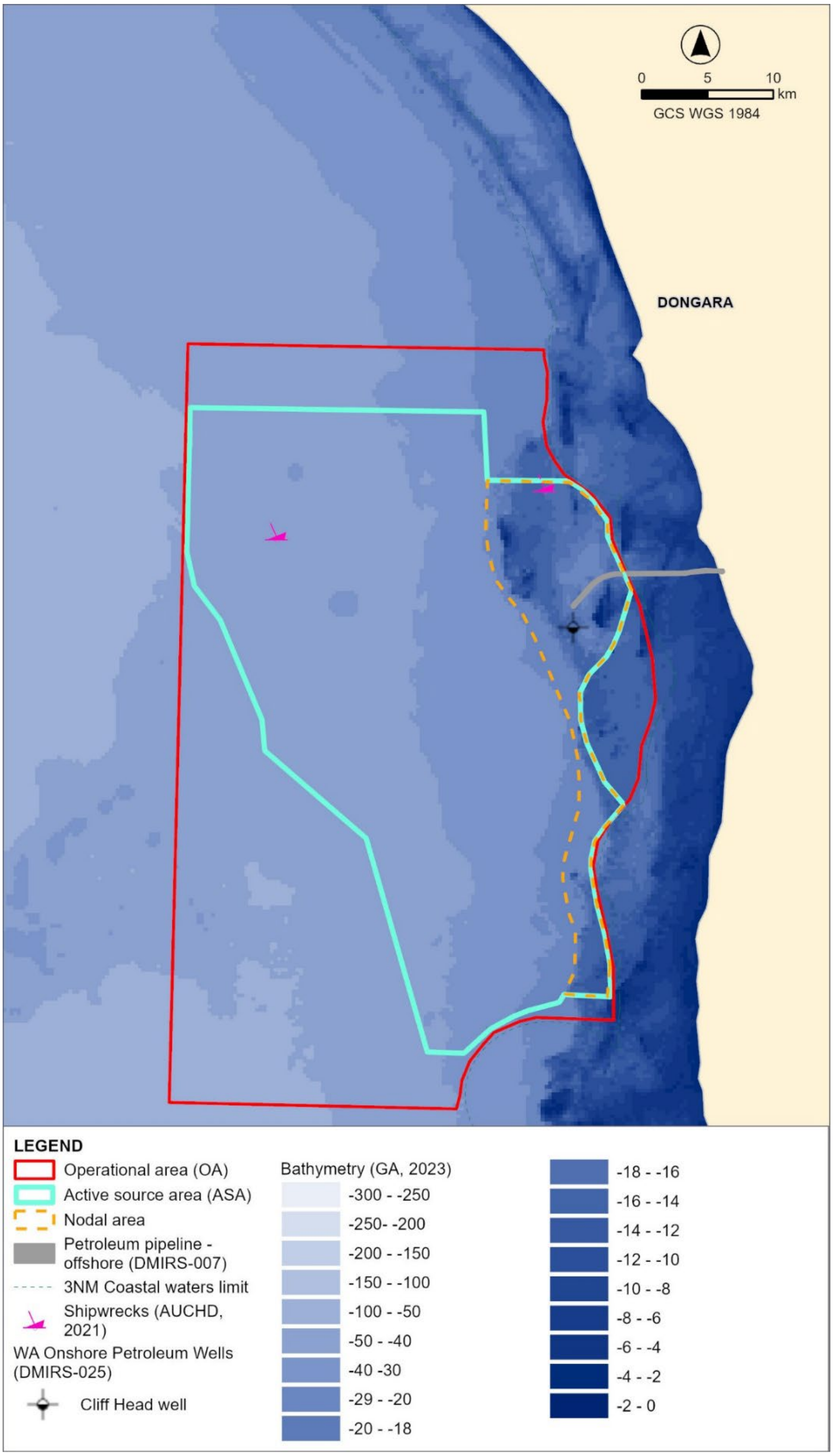


Figure 7-9: Submerged features within the OA

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 7-31).

Table 7-31: 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 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
Vessels will contain geospatial information on exclusion zone areas, ASA, OA and relevant significant features (shipwrecks, BIA's etc)	Industry standard	Yes	Yes
Support vessels will always maintain a 2m depth under keel (except when scouting water depths).	This control ensures awareness of grounding risks and reduces risks to benthic habitats.	Yes	Yes
The seismic vessel will always maintain a 5m depth under keel.	This control ensures awareness of grounding risks and reduces risks to benthic habitats.	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

Nodes will not be placed within the 12m contour of Leander Reef, Big Horseshoe Reef or other unnamed reef areas in the Node Survey Area	Although the control would reduce the impacts to the seabed, this would result in the inability to acquire seismic data underneath these reefs which are the prospective areas of the survey and would compromise the geophysical objectives of the survey.	Yes	No
Nodes will not be placed shallower than 6m water depth from LAT.	This control measure is the optimum balance of proximity from reefs and geophysical objectives that can be achieved to minimise benthic disturbance and protect the shallow reef areas.	Yes	Yes
Nodal placement and retrieval procedures to ensure location of nodes avoids sensitive benthic habitat.	Although the reef areas are expected to be hard limestone outcrops, there is a possibility of corals, seagrasses, or epifauna in the region making clear procedural measures for placement and retrieval protective of the environment at little additional cost.	Yes	Yes

Residual impact evaluation				
Residual impact	Consequence	Likelihood	Risk ranking	Decision type
	Low	Unlikely	Low	A

7.7.4.2 Demonstration of acceptability

The impact assessment has determined that given the adopted controls seabed disturbance from the placement of nodes are unlikely to result in a potential impact greater than localised and temporary disruption. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good industry practice, meet legislative requirements and are aligned with the principles of ESD. An additional control was added, in response to relevant person feedback, to demonstrate that standard industry equipment (ECDIS, depth sounder, sonar) will be utilised to ensure awareness of water depth in shallow areas. Marine order 27 was also referenced in the performance standards. Pilot considers that the adopted standard and additional controls appropriate to manage the impacts and risks of seabed disturbance to a level that is broadly acceptable.

The impact assessment has concluded that, with the implemented control measures, seabed disturbance from the placement of nodes is expected to result in no more than localised and temporary disruption. These impacts are anticipated to be limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with seabed disturbance, as discussed in previous sections. The adopted control measures are in line with good industry practice, fully comply with relevant legislative requirements, and align with the principles of ESD.

In response to feedback from relevant stakeholders, Pilot has implemented an additional control measure. This measure demonstrates that standard industry equipment, including Electronic Chart Display and Information System (ECDIS), depth sounders, and sonar, will be utilised to ensure awareness of water depth in shallow areas. Furthermore, Marine Order 27 has been explicitly referenced in the performance standards to enhance regulatory compliance.

Given these factors, Pilot believes the adopted standard and additional control measures are appropriate and sufficient to manage the impacts and risks of seabed disturbance to a level that is broadly acceptable.

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 7-32. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.4.4.1.

Table 7-32: Environmental performance outcomes, standards and measurement criteria for seabed disturbance – placement of ocean bottom nodes

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 15 Seabed disturbance to be limited to planned activities and impacts described as part of the Seismic Activity and will not occur outside the Operational Area. EPO15A No significant damage to sensitive benthic habitats (corals, seagrass or reef communities) because of node deployment and retrieval.	PS 64 Operational procedures will be in place for deployment and retrieval of OBNs that ensures minimal seabed disturbance where nodes will be lowered in a controlled manner (not freely dropped) to avoid impact damage, positioned only on bare substrate (avoiding live corals or significant epifauna), and retrieved vertically to prevent dragging across the seabed. Nodes must not be placed shallower than 6m water depth (from LAT).	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 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	MC 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	MC 117 Vessel inspection shows inclusion of sonar and depth sounder equipment in working order.
	PS 116 Vessels will contain geospatial information on exclusion zones	MC 130 Vessel logs will show areas traversed

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
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 - Moderate
Oil spill response	Low

8.2 Risk 1: Physical interaction – vessel collision with marine fauna or entrapment by equipment

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as lower order.

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 Defined acceptable level

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to as low as reasonably practicable (ALARP). This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks for this lower order risk are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 is 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 faunae 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 (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 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, with the humpback and pygmy blue whale migration BIA overlapping 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 faunae 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

	Moderate – collision Moderate – entrapment	Unlikely – collision Unlikely– entrapment	Moderate – collision Moderate – 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 0 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, regarding 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 8-2).

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 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 (except for 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 vessels 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			

Control measures	Cost benefit analysis			Risk reduction	Control adopted
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
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 is 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	Very unlikely	Low – collision	A	
	Low – entrapment	Unlikely	Low – entrapment	A	

8.2.4.2 Demonstration of acceptability

The impact assessment has concluded that, with the implemented control measures, the potential for collision or entrapment of marine species represents a low residual risk to marine fauna.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with collision and entrapment of marine fauna, as discussed in previous sections. The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements and recovery plans. Furthermore, these measures align with the principles of ESD.

No specific concerns regarding the potential for collision or entrapment of marine fauna have been raised by relevant stakeholders. Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks from seabed disturbance caused by potential loss of equipment and unplanned anchoring to a level that is broadly acceptable.

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 8-3 in Section 7.3.4.1.

Table 8-3: 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 16 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 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 (except for 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 4.5 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as lower order.

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 Defined acceptable level

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to as low as reasonably practicable (ALARP). This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks for this lower order risk are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 large numbers of vessel movements, vessels are stationary for an extended period 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). These conditions will not be found in the OA during the timeframe of the activity. 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 several 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	Unlikely	Moderate

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 regarding 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 Australian Biofouling Management Requirements (version 2, 2023). 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 8-4).

Table 8-4: 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 the Australian Biofouling Management Requirements Biofouling risk assessment shows low risk of IMS presence prior to entry to the Operational Area. 'Low risk' result is achieved when the following criteria are met: • Vessel Biofouling Management Plan is implemented and is consistent with IMO Guidelines • Biofouling record book is kept and must demonstrate implementation of the vessels Biofouling Management Plan • If the Biofouling record book does not demonstrate implementation of the vessels Biofouling Management Plan, relevant information such as recent inspection, dry dock / clean, operational history, and functional MGPS, should be sought to inform/manage marine pest risk. • If this information is not available, an inspection should be undertaken by suitably experienced marine pest inspector and / or appropriately manage biofouling risk. 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			

Control measures	Cost benefit analysis	Risk reduction	Control adopted
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 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 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 is limited project vessels based in Australian waters and sourcing Australian-based vessels only will cause increases in cost due to pressures of vessel availability. Sourcing vessels from within Australia will reduce the likelihood of IMS introduction from outside Australian waters; however, it does not reduce the likelihood of introducing species native to Australia but alien to the Operational Area. It also does not prevent the translocation of IMS that have established elsewhere in Australia. Therefore, the consequence is unchanged.	No	No

Residual risk evaluation				
Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Moderate	Unlikely	Moderate	A

8.3.4.2 Demonstration of acceptability

The impact assessment has concluded that, with the implemented control measures, the introduction of IMS to the OA through ballast water or biofouling on vessels or in-water equipment represents a risk that is unlikely to result in a potential impact greater than moderate to species in the benthic community.

The adopted control measures are in line with good industry practice and fully comply with relevant biosecurity legislative requirements. Furthermore, these measures align with the principles of ESD.

Pilot has implemented all practicable control measures to mitigate the risks associated with IMS introduction. These measures encompass comprehensive management of both ballast water and biofouling, in accordance with current best practices and regulatory standards.

No specific concerns regarding the potential introduction of IMS have been raised by relevant stakeholders.

Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the risks of IMS introduction to a level that is acceptable.

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 8-5. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.3.4.1.

Table 8-5: Environmental performance outcomes, standards and measurement criteria – introduction and establishment of IMS

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 17 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 (except for 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. Ballast water will be managed in full compliance with Australian Ballast Water Management Requirements – no high-risk ballast water discharge will occur in Australian waters. If any ballast exchange is necessary, it will only be conducted in mid-ocean, >12 nm from land and in water >200 m deep, per the Biosecurity Act standards.	MC 92 Ballast water exchange records show No recorded occurrence of a ballast water exchange during the survey (except for 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 the Australian Biofouling Management Guidelines Biofouling Record Book kept A vessel specific Biofouling management plan outlining marine fouling management actions Biofouling risk assessment shows low risk of IMS presence prior to entry if outside Australian waters Recent hull inspections (if required based on biofouling risk assessment) Each project vessel will undergo a biofouling risk assessment consistent with Biosecurity Regulation 2016, Reg 48(2), prior to commencing the activity. Any vessel that does not meet the 'low risk' criteria (clean hull, recent anti-fouling, etc.) will be cleaned or treated as required before entry to the Operational Area. The following key factors will be considered in the determination of whether the project vessels present the 'low risk' criteria for the introduction of IMS: • Timing of marine pest risk assessment relative to vessel selection and movement to the offshore activity area to ensure there is sufficient time to implement necessary control measures in cases where management is warranted to reduce the risk.	MC 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. Biofouling risk assessment report confirming risk assessment completion date as being ≥30 days before vessel mobilisation into the Operational Area. Prior to survey a copy of the International Anti-fouling System Certificate is sighted and is in date.

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	• History of the vessel, including time spent in ports of call since last dry dock, cleaning regime or marine pest inspection results. • Time between a biofouling inspection and mobilisation to an offshore activity to inform exposure risk following the last inspection and justify the relevance of biofouling inspection findings. • Presence of an appropriate biofouling management plan and effective implementation of the plan (e.g. demonstrated implementation of external and internal marine growth prevention systems, an understanding of the effectiveness of antifouling coatings and functionality of internal treatment systems). • Level of existing biofouling and the presence of species of concern (in particular the presence of marine pests) within biofouling communities on the vessel associated with the activity (often informed by biofouling record books, maintenance records, cleaning results or inspection programs). • Operational profile relevant to biosecurity risk such as operating speed, time alongside a facility and the need for ballast exchanges while engaged in an offshore activity. • Receiving environment including temperature, salinity and the presence of shallow water sensitivities within proximity to the offshore activity. • Qualifications and competency of personnel undertaking biofouling inspections associated risk assessments and making management decisions. The IMS risk assessment process must be applied to determine residual risk of introducing or spreading marine pests at least 30 days before the start of the activity. 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.	
	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).	MC 94 Evidence / records confirm submersible equipment inspected and found free of biofouling prior to commencing the activity. If 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as lower order.

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 Defined acceptable level

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to as low as reasonably practicable (ALARP). This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks for this lower order risk are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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 if 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 60 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 4-41). 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 or steering, the likely course of action will be for the seismic vessel to immediately drop anchor, quickly followed by the supply vessel towing it to safety. Should a support/chase vessel lose power or steering, 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 8-6).

Table 8-6: 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

The impact assessment has concluded that, with the implemented control measures, the potential loss of seismic equipment to the seabed represents a minor consequence to benthic communities and habitats, with no lasting effects anticipated. These impacts, should they occur, are expected to be limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with potential equipment loss and unplanned anchoring, as discussed in previous sections. The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements. Furthermore, these measures align with the principles of ESD.

No specific concerns regarding the potential loss of seismic equipment or unplanned anchoring have been raised by relevant stakeholders. Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks from seabed disturbance caused by potential loss of equipment and unplanned anchoring to a level that is broadly acceptable.

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 8-7. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.4.4.1.

Table 8-7: 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 18 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	MC 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 indicate 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 112 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 19	PS 79	MC 99

Environmental performance outcomes	Environmental performance standards	Measurement criteria
Avoid objects being dropped overboard	The crane handling and transfer procedure is in place and implemented by crane operators (and others, such as dogmen) to prevent dropped objects.	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.
	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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as lower order.

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 Defined acceptable levels

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to as low as reasonably practicable (ALARP). This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks for this lower order risk are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

8.5.3 Risk analysis and evaluation

8.5.3.1 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.

8.5.3.2 Predicted Effects

8.5.3.2.1 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 if the vessel Garbage Management Plan (GMP) is followed correctly.

8.5.3.2.2 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 assessed for merit 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 8-8).

Table 8-8: 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
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 near 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

Control measures	Cost benefit analysis	Risk reduction	Control adopted
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

The impact assessment has concluded that, with the implemented control measures, the accidental release of hazardous and non-hazardous materials represents a low-risk rating that is unlikely to result in potential impacts beyond localised effects with no lasting consequences. These impacts, should they occur, are expected to be limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with accidental releases, as discussed in previous sections. The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements. Furthermore, these measures align with the principles of ESD.

The control measures implemented by Pilot address both the prevention of accidental releases and the management of any potential impacts should such an event occur. These measures are designed to minimize the risk of releases and to ensure prompt and effective response in the unlikely event of an incident.

No specific concerns regarding the potential accidental release of hazardous and non-hazardous materials have been raised by relevant stakeholders. Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks from accidental release of hazardous and non-hazardous materials to a level that is broadly acceptable.

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 8-9. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 7.5.4.1.

Table 8-9: 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 20 Hazardous and non-hazardous wastes are stored, handled, disposed of in a manner that prevents marine pollution. EPO 20A No release of hazardous and non-hazardous wastes to the marine environment.	PS 82 Compliance with MARPOL 73/78 Annex V, the *Protection of the Sea (Prevention* 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 127 Inspection prior to commencement of survey confirms solid streamers used.
EPO 21 Oily wastes and chemicals are stored, handled, disposed of and cleaned up in a manner	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	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

Environmental performance outcomes	Environmental performance standards	Measurement criteria
that prevents marine pollution.	Survey vessel holds a valid IOPP certificate, where 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.
	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

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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 114 Survey vessel crew are inducted in their responsibilities under the SOPEP and is competent in spill response and has appropriate response resources 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.
	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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as higher order. Therefore, an additional assessment and detail is required to demonstrate this risk is of an acceptable level.

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) 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 control measures 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 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 8.7. 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 Defined acceptable level

Pilot Energy's risk assessment methodology for demonstrating that impacts and risks are at an acceptable level distinguishes between higher-order and lower-order impacts and risks. For lower-order impacts and risks, acceptability is demonstrated when the impact or risk has been shown to be reduced to as low as reasonably practicable (ALARP). However, for accidental oil spills from vessel collision or grounding, an additional demonstration is required. Before the assessment, acceptable levels of impact are defined (below). Once the assessment is complete, the predicted impact levels are compared with these predefined acceptable levels. If the predicted levels are lower than the defined thresholds, the impact is at an acceptable level.

•

AL 48. 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

AL 49. There will be no predicted long-term unrecoverable effects on fish stocks or commercial fishing

AL 50. No specific relevant person claims or objectives have been raised that have not been addressed. There are no outstanding merited claims or objections.

AL 51. 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

8.6.3.1 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.

8.6.3.2 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 encounter 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 8-10), means the fuel will spread quickly and will thin out to a film; increasing the initial rate of evaporation.

Table 8-10: 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 (%)
	Non-persistent			Persistent
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	-

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 exposure's opportunities considered over the timescale 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 8-11).

Table 8-11: 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, Figure 8-2 and Figure 8-3.

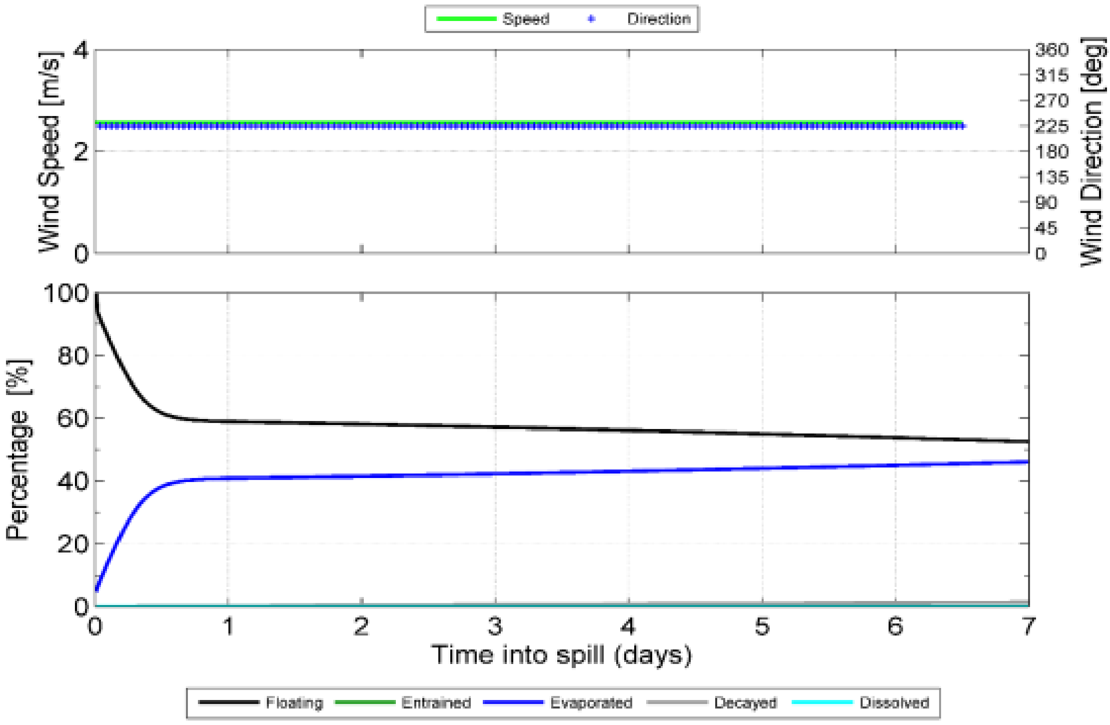


Figure 8-1: Proportional mass balance plot representing weathering of a surface release of 320 m3 of MGO under theoretical conditions

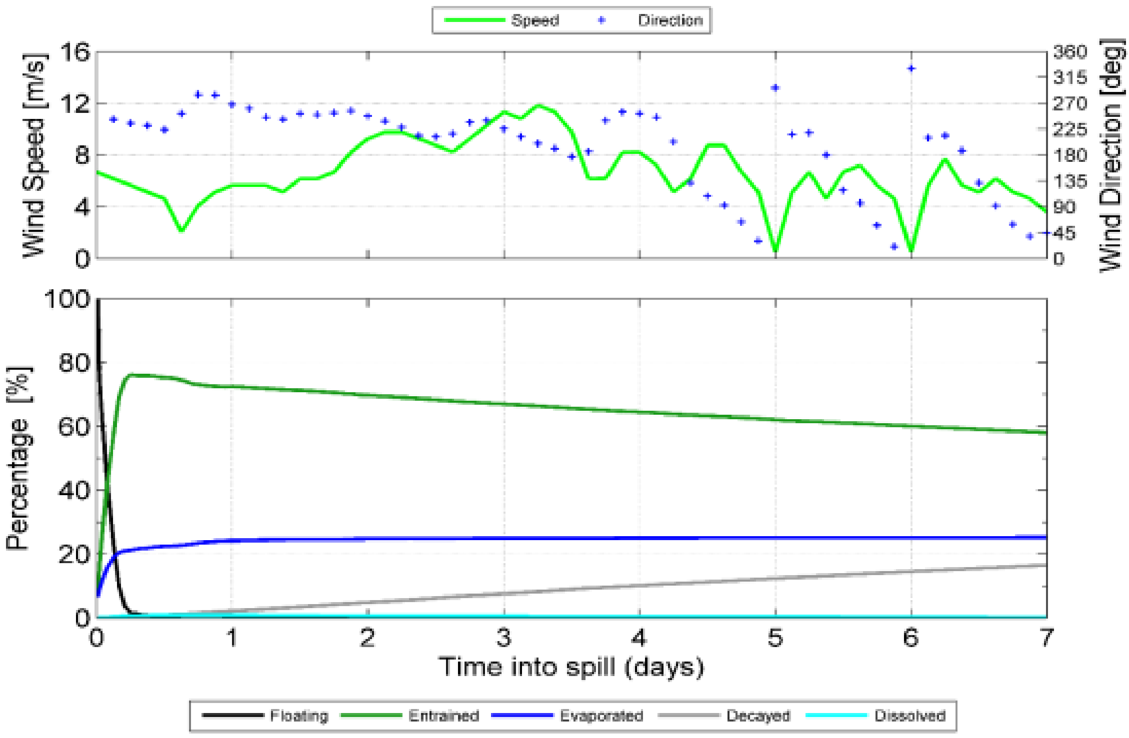
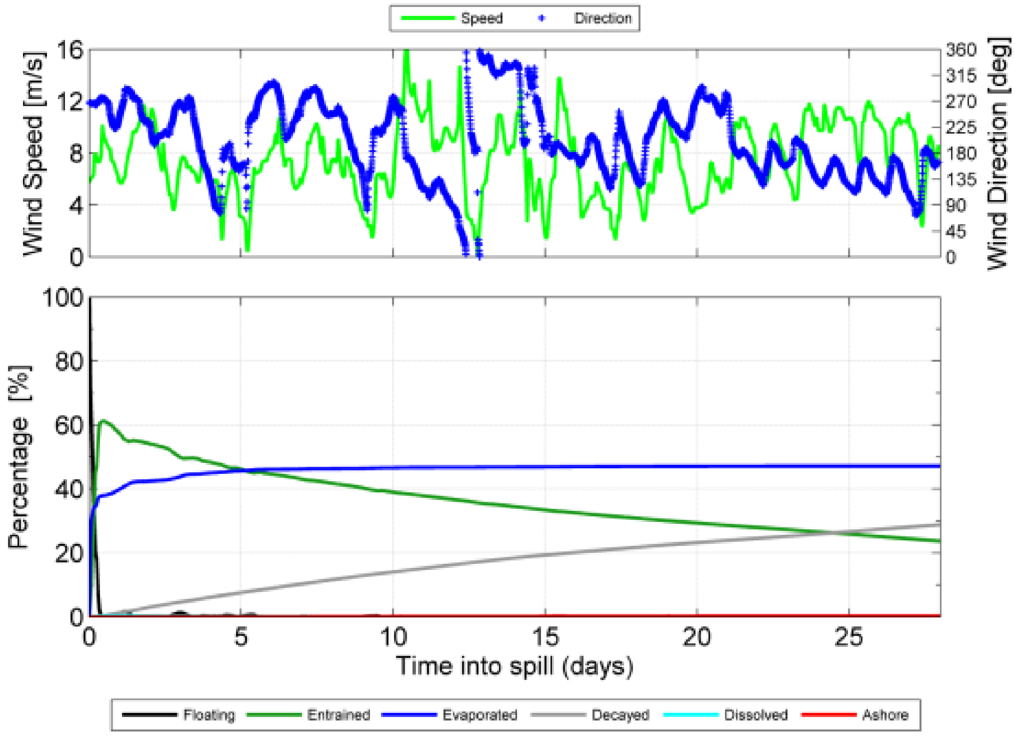


Figure 8-2: Proportional mass balance plot representing weathering of a surface release of 320 m3 of MGO weathering and fates graph, as a function of volume, under 5, 10 and 15 knot static wind conditions



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

8.6.3.2.1 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 hindcasting 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 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 because 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 8-12 include a short discussion on their basis with details provided in the spill modelling study report (RPS 2023).

Table 8-12: 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.

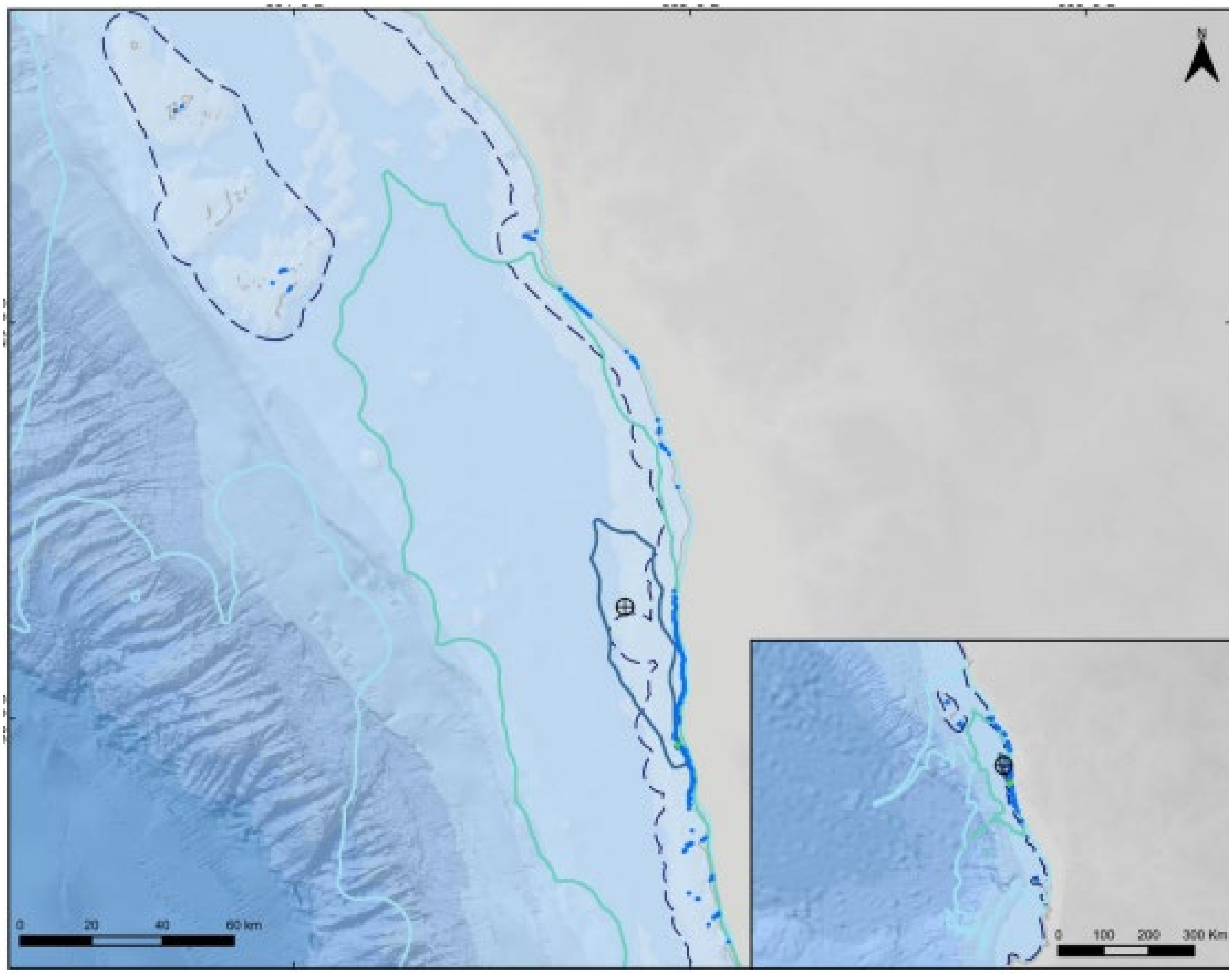


Figure 8-4: Predicted annualised zones of potential contact with surface floating oil, shoreline, entrained, and dissolved from a 320 m3 accidental spill of MGO

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. 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 exposure's opportunities considered over the timescale 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 8-11), 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.

8.6.3.3 Potential impacts and probability of exposure to sensitive receptors

8.6.3.3.1 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.

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 because 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/m2. 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.

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.

8.6.3.3.2 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.

8.6.3.3.3 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).

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.

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.

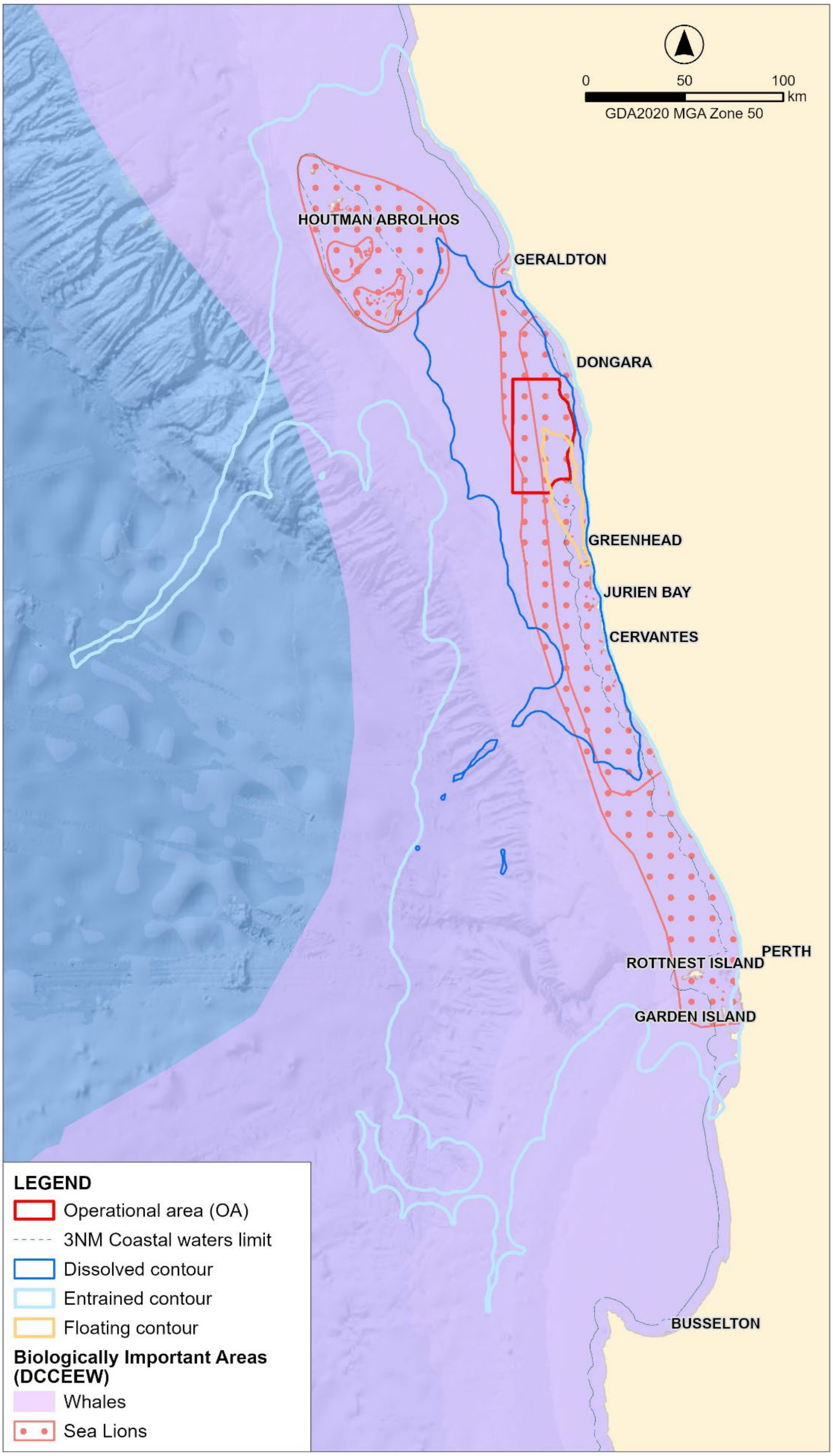


Figure 8-5: Marine mammal BIAs with areas overlapped by dissolved (≤10 ppb), entrained (≤10 ppb), and floating oil (≤1 ppb)

8.6.3.4 Marine mammals – cetaceans

A description of the cetaceans within the EMBA is provided in Section 4.3.8.

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. 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.

8.6.3.5 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.

8.6.3.6 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 encounter 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.

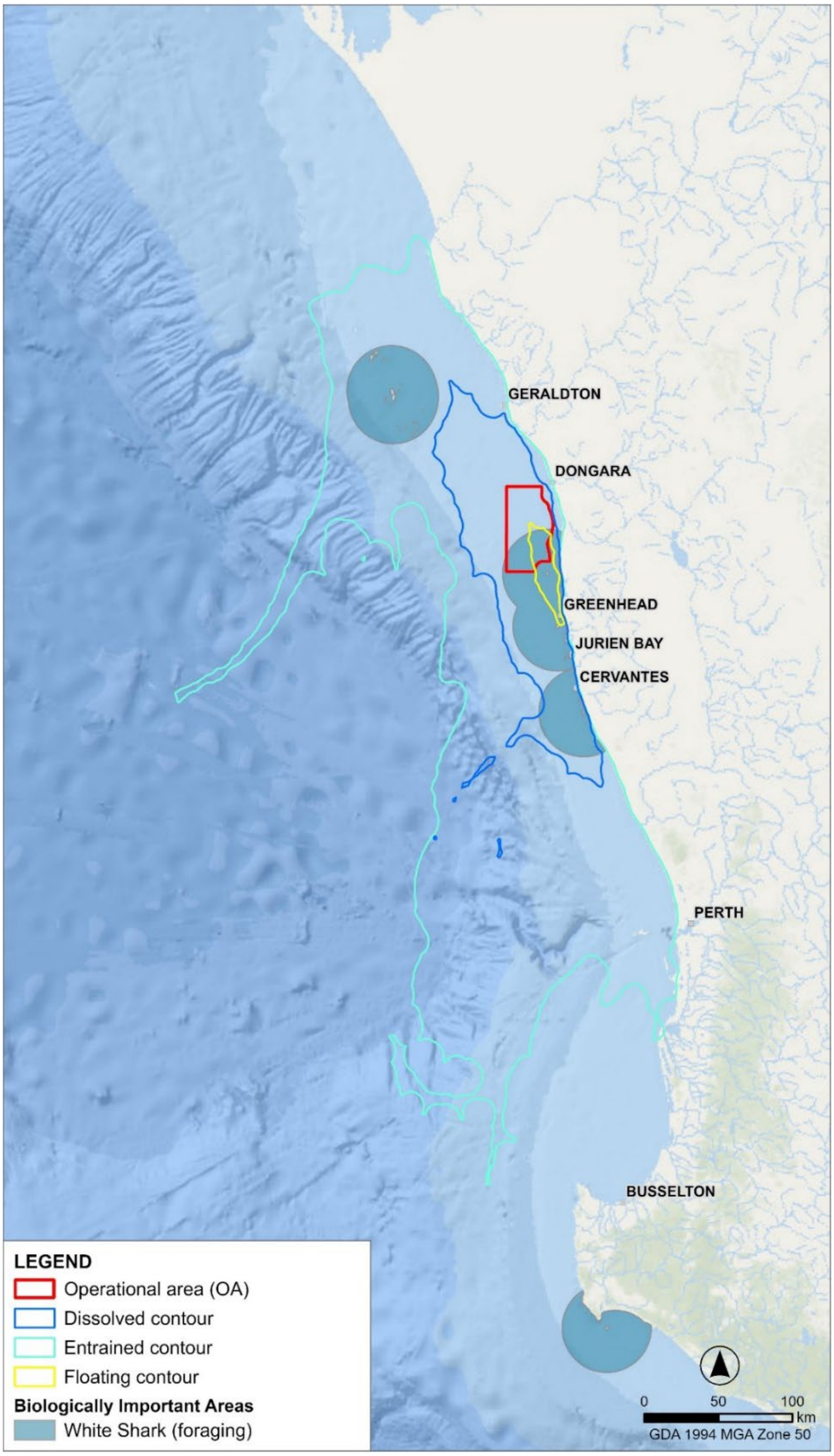


Figure 8-6: White shark foraging BIA with areas overlapped by dissolved (≤10 ppb), entrained (≤10 ppb), and floating oil (≤1 ppb)

Most fish are mobile and unlikely to incur sufficient exposure over a period long enough to be impacted above harm thresholds. Most 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.

8.6.3.7 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 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).

If 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).

Modelling indicates that, in the unlikely event of a vessel collision or grounding resulting in a loss of marine diesel, there is potential for hydrocarbon contact with the shoreline via dissolved, entrained, and floating oil pathways (Figure 8-7). While dissolved hydrocarbons are primarily confined to offshore waters, modelling shows they may approach or reach the shoreline at several locations along the Western Australian coast. Potential shoreline contact is predicted at Jurien Bay, Green Head, Leeman, Dongara, and Glenfield Beach, particularly where low-energy environments and nearshore currents may facilitate accumulation. Although dissolved concentrations are expected to be low, there remains a risk of sub-lethal effects to sensitive coastal habitats such as seagrass meadows, macroalgal beds, and intertidal reef systems. These habitats form part of the West Coast Inshore Lagoons Key Ecological Feature (KEF) and support the western rock lobster fishery. Impacts may include physiological stress or reduced reproductive success in marine flora and invertebrates, particularly in sheltered embayments or lagoon systems with limited water circulation.

The entrained hydrocarbon contour, which represents dispersed oil droplets in the water column, spans a broad stretch of coastline between Mandurah and Kalbarri, encompassing sections of the West Coast Inshore Lagoons KEF and areas critical to the western rock lobster fishery. Entrained oil may be retained longer in nearshore lagoons, reef platforms, and embayments, increasing the potential for shoreline interaction. If present, entrained hydrocarbons could temporarily affect shoreline flora and fauna through both toxic and physical mechanisms, particularly in environments with limited natural flushing.

Due to the volatile nature of MGO, only limited shoreline contact by floating oil is predicted. The areas potentially exposed to surface oiling greater than 10 g/m² include Glenfield Beach (3 km), Green Head (8 km), and Leeman (2 km) on the mainland, and 3 km of shoreline each at the Houtman Abrolhos Islands and the Pelsaert Group. Where floating oil does strand, short-term toxic and smothering effects may occur to intertidal flora and fauna. Several of these sites, including Green Head and Leeman, lie within or adjacent to the Jurien Bay Marine Park, and portions of the predicted contact zone overlap with habitat important to the Western Rock Lobster Fishery and the West Coast Inshore Lagoons KEF. Shallow reef platforms and lagoon environments in these locations may enhance oil retention on the shoreline, although overall impacts are expected to be temporary given the high volatility and rapid weathering characteristics of MGO.

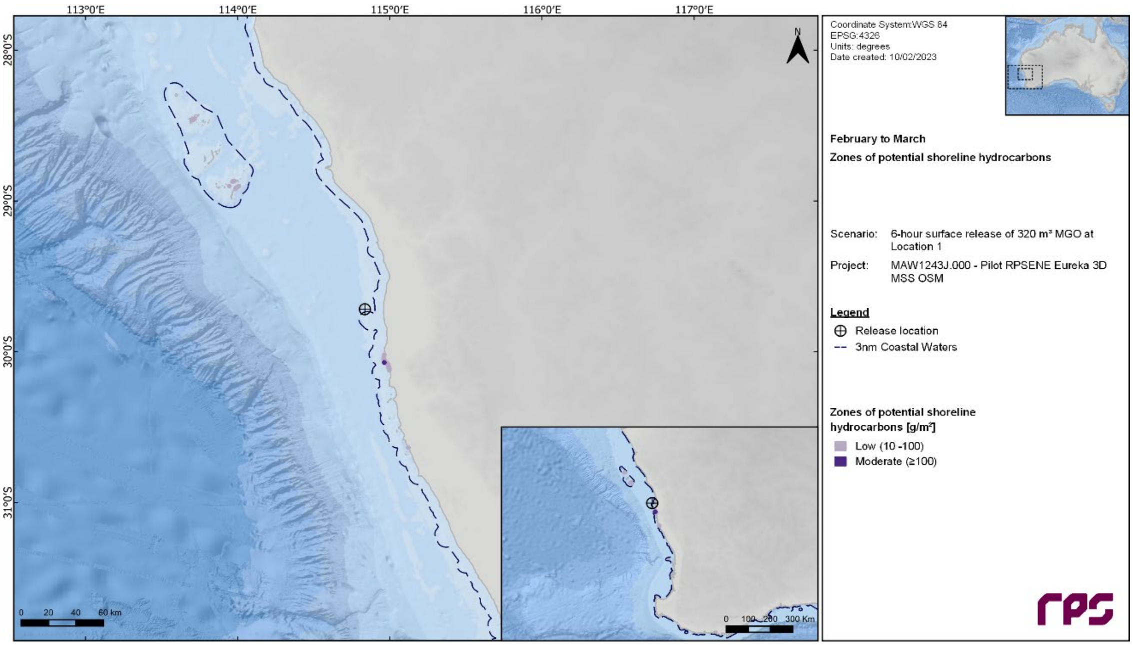


Figure 8-7: Areas of shoreline that could potentially be contacted by hydrocarbons

8.6.3.7.1 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 LC50 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. These 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.

8.6.3.8 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 cannot contact 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 (except for 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.

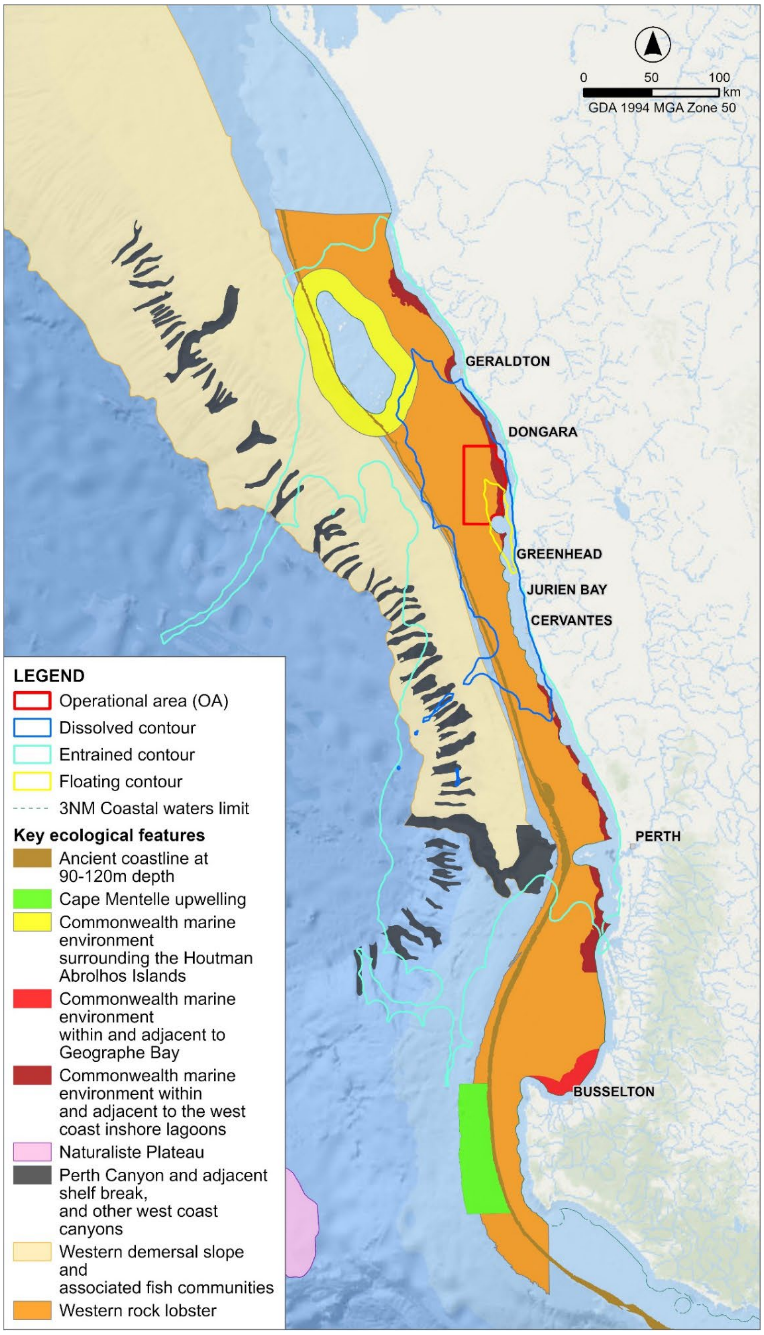


Figure 8-8: Overlap of KEFs with dissolved, entrained and floating oil

8.6.3.8.1 Macroalgal and coral communities

A description of macroalgal communities is provided in Section 4.3.2.

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 because 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 because 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.

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 1g/m2 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%).

8.6.3.8.2 Commercial fisheries

A description of commercial fisheries in the EMBA is provided in Section 4.4.2. Table 8-13 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 8-13: Overlap between each WA-managed commercial fishery and floating at ≤1g/m2, dissolved at ≤10 ppb, and entrained oil

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, most 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). 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 because 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 several 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.

8.6.3.8.3 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.

8.6.3.8.4 Places of heritage and cultural Indigenous importance, and Commonwealth and State marine protected areas

A description of shipwrecks and other heritage sites is provided in Sections 4.4.6 and 4.4.7 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 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 41 shows the quantity and location of shipwrecks that could potentially be contacted by entrained oil.

No Commonwealth heritage listed sites (see Section 4.4.7) 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).

Table 8-14 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 8-14: 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
	Moderate	Unlikely	Moderate

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 8-15).

Table 8-15: 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 retrofitting 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
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 always 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

Control measures	Cost benefit analysis	Risk reduction	Control adopted
Continuous (24-hour) survey operations, with survey team and bridge crew monitoring for weather and metocean conditions and other vessels always during seismic acquisition	Benefits outweigh costs	Yes	Yes
No refuelling of vessels to occur within the OA	Benefits outweigh costs	Yes	Yes
Vessels with fuel tank more than 320m3 will not be contracted to undertake the activity	This may result in inability to contract a vessel to undertake activity. If a vessel does have a fuel tank more than 320m3 there are other mitigations that could be implemented to ensure no increase in risk	No	No
Vessels will be limited to 10m depth	This may result in an inability to acquire parts of the survey area, depending on tide action and local bathymetry. Vessels will have navigational equipment and experienced personnel to deem safe depths for the local conditions.	No	No
In an emergency event where there is a loss of propulsion or steering on any vessel, anchors should be deployed immediately to reduce grounding risks and awaiting towing support.	This control ensures a timely response to a loss of propulsion or steering event.	Yes	Yes
Support vessels will always maintain a 2m depth under keel (except when scouting water depths).	This control ensures awareness of grounding risks and reduces risks to benthic habitats.	Yes	Yes
The seismic vessel will always maintain a 5m depth under keel.	This control ensures awareness of grounding risks and reduces risks to benthic habitats.	Yes	Yes

Residual risk evaluation				
Residual risk	Consequence	Likelihood	Risk ranking	Decision type
	Moderate	Unlikely	Moderate	B

8.6.4.2 Demonstration of acceptability

The demonstration of acceptability for lower-order impacts and risks is achieved by showing that they have been reduced to ALARP. This involves evaluating the effectiveness of all identified control measures, considering functionality, availability, reliability, survivability, compatibility, and cost–benefit factors. Where this evaluation confirms that no further reduction in impact or risk can reasonably be achieved, the ALARP threshold has been met. In accordance with NOPSEMA's Environment Regulations and guidance, once ALARP is demonstrated for a lower-order impact or risk, it is deemed to be of an acceptable level.

The risk assessment has concluded that an accidental hydrocarbon release resulting from a vessel collision represents a moderate risk rating that may result in medium-scale, medium-term impacts on ecosystems, species, and habitats. These potential impacts have been carefully evaluated in the context of their extent and duration.

The risk assessment concluded potential risks to commercial fish species and fish stocks as a result of a hydrocarbon spill were unlikely to result in measurable effects on fishery catch returns and risks to commercial stocks and fishermen would to be minor, ensuring AL 49 is met.

In conducting this assessment, Pilot has given due consideration to EPBC Act listed MNES, Marine Reserve Management Plan Values and Threatened Species Recovery Plans / Conservation Advice ensuring AL 48 has been met. . The assessment also considers compliance with MARPOL 73/78 Annex I, Marine Orders 21, 27, 30, and 91, as well as requirements set forth by AMSA and the AHO, ensuring AL 51 is met.

The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements. Furthermore, these measures align with the principles of ESD. Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with potential vessel collisions and subsequent hydrocarbon releases, as discussed in previous sections.

It is noted that while oil spill concerns were raised during the public comment period for the EP, no specific feedback has been received from relevant persons regarding this aspect of the project. This demonstration ensures AL 50 has been met.

Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks from vessel collision and potential hydrocarbon release to a level that is acceptable.

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 8-16.

Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 8.5.4.1.

Table 8-16: Environmental performance outcomes, standards and measurement criteria –accidental oil spill – vessel collision/grounding

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 22 Vessel crews are prepared to respond to a spill, including Vessel master initiating action to reduce fuel loss EPO 22A No release of hydrocarbons to the marine environment.	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 23 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

Environmental performance outcomes	Environmental performance standards	Measurement criteria
	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
	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 111 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 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 110 Continuous (24 hour) survey operations, with survey team and bridge crew monitoring for weather and metocean conditions and other vessel position and depth always during seismic acquisition	MC 23 Records confirm bridge was manned continuously during survey operations, and that survey vessel crew have appropriate qualifications

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 24 Vessels contracted will ensure compliance with modelled fuels and volumes	PS 115 Activity vessels will not use heavy fuel oil	MC 76 Bunkering records demonstrate volume of MGO or MDO used on all vessels
	PS 117 Activity vessel fuel tanks will not hold more than modelled amount fuel.	
EPO 25 No refuelling in the Operational Area	PS 118 Activity vessels will not undertake refuelling or vessel-to-vessel bunkering in the Operational Area.	MC 130 Records will show locations that refuelling occurred
EPO 26 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

In accordance with the Pilot Energy risk assessment methodology (Section 6) this risk is classified as lower order.

8.7.1 Identification of hazard and extent

Hazard	In the event of an oil spill, several 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 Defined acceptable levels

For lower-order impacts and risks, Pilot Energy defines the acceptable level as the point at which the residual impact or risk has been reduced to as low as reasonably practicable (ALARP). This means that all relevant control measures have been identified and implemented to the extent that no additional practicable measures are available without costs being grossly disproportionate to the environmental benefit gained. In this context, the acceptable level is inherently linked to the ALARP outcome, recognising that residual impacts and risks for this lower order risk are tolerable, consistent with legislative requirements, and aligned with relevant environmental and stakeholder expectations.

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).		
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 8-17). 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).

8.7.4.2 Demonstration of acceptability

Pilot Energy's risk assessment methodology requires that the demonstration of acceptability for lower-order impacts and risks is achieved by showing that they have been reduced to ALARP. This involves evaluating the effectiveness of all identified control measures, considering functionality, availability, reliability, survivability, compatibility, and cost–benefit factors. Where this evaluation confirms that no further reduction in impact or risk can reasonably be achieved, the ALARP threshold has been met. Once ALARP is demonstrated for a lower-order impact or risk, it is deemed to be of an acceptable level.

This assessment has concluded that, with the implemented control measures, Oil Spill Response activities represent a low-risk rating that is unlikely to result in potential impacts beyond localised effects with no lasting consequences. These impacts, should they occur, are expected to be limited in both extent and duration.

Pilot has thoroughly explored additional opportunities to further mitigate impacts and risks associated with Oil Spill Response activities, as discussed in previous sections. The adopted control measures are in line with good industry practice and fully comply with relevant legislative requirements. Furthermore, these measures align with the principles of ESD.

No specific concerns regarding Oil Spill Response activities have been raised by relevant stakeholders. Given these factors, Pilot believes the adopted control measures are appropriate and sufficient to manage the impacts and risks from Oil Spill Response activities to a level that is broadly acceptable.

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 8-18. Environmental performance standards and relevant measurement criteria have been developed for each control measure adopted in Section 8.7.4.1.

Table 8-17: 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)	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

Table 8-18: Environmental performance outcomes, standards and measurement criteria – oil spill response

Environmental performance outcomes	Environmental performance standards	Measurement criteria
EPO 27 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 Table 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)	MC 123 Records of verbal communications and copies of marine pollution report (POLREP) report and situation reports (SITREPs) as per Section 8.7
	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)
- National Recovery Plan for the Southern Right Whale (DCCEEW 2024)
- 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)
- National Recovery Plan for albatrosses and petrels (DCCEEW 2022b)
- 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 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 to Table 9-10.

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			

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
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		
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	
National Recovery Plan for the Southern Right Whale			

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
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 to facilitate recovery of southern right whales.	Y	Y	Y
Population dynamics, including demographics, distribution, residency, and coastal movement across the species range are monitored and quantified using robust, standardised, best-practice methodology to assess population recovery.	Y		
The population structure of southern right whales in Australian waters is clearly characterised, including the level of interchange of individuals among coastal reproductive areas, to evaluate the degree to which the western and eastern populations are separate populations and inform the degree of connectivity with other southern right whale populations (e.g., New Zealand).	Y		
Capability of First Nation Australians, 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 legislative and management protection for southern right whales	Y		
A.2: Address habitat degradation impacts from coastal and offshore marine infrastructure developments within the species' range	Y		
A.3: Understand impacts of climate variability and anthropogenic climate change on the species biology and population recovery	Y		
A.4: Manage and mitigate the threat of entanglements from commercial active or discarded fishing gear throughout the species' range in Australian waters	Y		
A.5: Assess, manage, and mitigate impacts from anthropogenic underwater noise.	Y	Y	Y
A.6: Manage, minimise, 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		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
B.3: Determine migratory paths and offshore distribution	Y		
B.4: Improve capability of First Nation Australians, 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 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:			

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
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		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
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		
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 10: Promote community education and awareness in relation to grey nurse shark conservation and management	Y		
National recovery Plan for albatrosses and petrels			
Overarching Objective:			
To improve the conservation status of albatrosses and petrels so that these species are on a trajectory towards no longer being threatened in Australia's jurisdiction.	Y	Y	Y
Overarching actions:			
A1: Ongoing protection of albatross and petrel species breeding sites and habitats in Australia's jurisdiction	Y	Y	Y
A2: Prevent introduction of alien species to breeding islands in Australia's jurisdiction	Y		
A3: Identify whether competition with native species is causing population declines	Y		
A4: Identify diseases likely to have a population-level effect on breeding populations	Y		
A5: Avoid or minimise incidental catch (or bycatch) of seabirds during fishing operations in Australia's jurisdiction	Y		
A6: Advocate for effective international measures for conserving albatrosses and petrels	Y		
A7: Minimise the effects of marine debris, plastics and pollution	Y	Y	Y
B1: Monitor population and conservation status of breeding populations in Australia's jurisdiction	Y		
B2: Monitor the effects of fishing on albatrosses and petrels in Australia's jurisdiction	Y		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
B3: Increase community understanding of and involvement in the conservation of albatrosses and petrels	Y		
B4: Increase understanding of the effects of climate change on albatrosses and petrels in Australia and identify ways to increase the resilience of the species to these effects.	Y		
B5: Implement statutory requirements	Y		
Strategies to measure the effectiveness of the recovery plan and progress towards the objective of the plan:			
Strategy 1: Ensure ongoing protection of albatross and petrel breeding sites and habitats in Australia's jurisdiction.	Y		
Strategy 2: Improve the understanding of the size, structure and population trends for albatrosses and petrels breeding in Australia's jurisdiction.	Y		
Strategy 3: Improve effectiveness of management measures that reduce land-based threats to albatrosses and petrels breeding in Australia's jurisdiction.	Y		
Strategy 4: Improve effectiveness of management measures that reduce marine-based threats to albatrosses and petrels foraging in Australia's jurisdiction.	Y	Y	Y
Strategy 5: Improve understanding of generalised threats to albatrosses and petrels breeding and foraging within Australia's jurisdiction.	Y		
Strategy 6: Improve community awareness of the conservation of albatrosses and petrels.	Y		
Strategy 7: Achieve substantial progress towards global conservation of albatrosses and petrels in international conservation and fishing forums.	Y		
Wildlife Conservation Plan for Seabirds			
Overarching Objective:			
The Plan aims to provide a national framework for the research and management of listed marine and migratory seabirds and to outline national activities to support the conservation of listed seabirds in Australia and beyond.			
Objectives:			
Objective 1: International cooperation and collaboration continue to support the survival of seabirds and their habitats outside Australian jurisdiction.	Y		
Objective 2: Seabirds and their habitats are identified, protected and managed in Australia.	Y	Y	
Objective 3: The long-term survival of seabirds and their habitats is achieved through supporting priority research programs, coordinated monitoring, on-ground management and conservation.	Y		

EPBC Act Part 13 statutory instrument	Applicable to government	Titleholder	This activity
Objective 4: Increase the awareness of the importance of conserving seabirds and their habitats through community education and capacity building to support monitoring and on-ground 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 8-7
	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 recover habitats', e.g., nesting habitat,	Refer Sections 8.5, 8.6. **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 8-7. Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the activity are present Appendix E.

Part 13 statutory instrument	Relevant action areas/objectives	Relevant actions	Evaluation	EPO, PS and MC
		seagrass meadows or coral reefs		
	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 in Shark Bay, a least 350 km north of the Operational Area.	Table 7-25
	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 7.2 **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 in Shark Bay, a least 350 km north of the Operational Area	Table 7-4 and Table 7-21: Environmental performance outcomes, standards and measurement criteria for underwater sound from vessel operations
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 proximity to a known	Table 7-19

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
			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. 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 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 8-3
Assessment summary				

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
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 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 National Recovery Plan	**Action Area A5:** Assess, manage, and mitigate impacts from anthropogenic underwater 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 auditory impairment **Action 3:** Actions within and adjacent to southern right whale BIA and HCTS should demonstrate that the risk of behavioural disturbance is minimised **Action 4:** 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 5:** Quantify risks of anthropogenic underwater noise to southern right whales, including studies aimed to measure physiological effects, behavioural disturbance, and changes to acoustic communication (e.g., masking of vocalisations) 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 because the 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 Recovery Plan for the Southern Right Whale.	Table 7-5 and Table 7-8
	Action Area A6: Manage, minimise, 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 and HCTS	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	Refer to Table 8-3

	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	overlap the defined migration period for southern right whales in the region (April to October).	

Assessment summary

The 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 8-7
	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 8.7 **Not inconsistent assessment:** The assessment of vessel strikes, 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 8-3, Table 8-7 Table 8-9 and to Sections 8.2 and 8.7. Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the activity are presented in Appendix E.

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 soon, 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 4-5: Threatened and migratory marine species listed potentially occurring within the OA and EMBA
			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 4-6 Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the activity are presented in Appendix E.
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 National recovery Plan for albatrosses and petrels

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
National Recovery Plan for albatrosses and petrels	The focus of the recovery plan is on biosecurity and human disturbance at breeding sites, critical habitats, monitoring of breeding populations, land-based threats at breeding colonies, fisheries and bycatch, climate change and climate change resilience, ingestion and entanglement and community awareness. There are no specific actions identified in the recovery plan that are relevant to the threat from interactions with offshore installations and ships, including artificial lighting, despite this marine threat being listed in the recovery plan. Additionally, no species' affected or prioritised within Australian jurisdiction were identified as being associated with this threat, as assessed in the recovery plan. Actions relevant to this threat therefore do not require assessment.			
	Strategy 4 defined in this recovery plan: "Improve effectiveness of management measures that reduce marine-based threats to albatrosses and petrels foraging in Australia's jurisdiction", is assigned to fishery-based actions with no link observed between this strategy and any aspect relevant to the Eureka MSS. This strategy is therefore not assessed.			
	Overarching Action A1: Ongoing protection of	**Action 1a**: Rigorous biosecurity measures are	Refer Section 8.3.	Table 8-5

	albatross and petrel species breeding sites and habitats in Australia's jurisdiction	implemented to reduce the risk of introduction of invasive species.	**Not inconsistent assessment:** This EP includes an assessment of the impacts from accidental introduction of invasive marine species on marine species.	
	Overarching Action A7: Improve understanding of and reduce the effects of marine debris, plastics and pollution on albatrosses and petrels.	**Action 5c**: Risk based response strategies for marine pollution incidents are developed.	Refer Sections 8.5, 8.6 and 8.7. **Not inconsistent assessment:** The assessments of accidental release of solid hazardous and non-hazardous wastes, and of accidental release of chemicals / hydrocarbons have considered the potential risks to seabirds.	Table 8-9, Table 8-16, Table 8-18.

Assessment summary

The National Recovery Plan for albatrosses and petrels 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 9-9: Assessment against relevant actions of the Assessment against relevant actions of the Wildlife Conservation Plan for Seabirds

Part 13 statutory instrument	Relevant action areas/ objectives	Relevant actions	Evaluation	EPO, PS and MC
Wildlife Conservation Plan for Seabirds	**Objective 2:** Seabirds and their habitats are identified, protected and managed in Australia.	Action 2D: Ensure all areas of important habitat for seabirds are considered appropriately and consistently in the development assessment process.	**Not inconsistent assessment:** The impact assessment has considered the potential impacts and risks to seabirds, including important habitats and BIAs. The activity is not inconsistent with the identification, protection and management of seabirds and their habitats in Australia.	Table 4-5, Table 4-6, Table 9-8.
Assessment summary The Wildlife Conservation Plan for Seabirds 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 9-10: 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 8-7
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 0).

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 0). Roles and responsibilities for oil-spill incidents are outlined in 10.7.1 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. Member of the Incident Management Team for Emergency Response
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
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.

Role	Key environmental responsibilities
	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. Ensure geospatial information is uploaded and accurate and communicated to the vessel master. 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, including operational discharges and emissions. Ensures geospatial information is uploaded and accurately verified with the client site representative 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. Records relating to seismic source emissions, vessel discharges and fuel consumption will be kept.
- 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.
- A review of the WA Aboriginal Cultural Heritage Inquiry System (ACHIS) one month prior to the survey commencing to check for any new submissions under the Aboriginal Cultural Heritage Act (WA).

Due to the short duration of the survey, conformance will be monitored daily by the client site representative with inspections undertaken once per week during survey operations.

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 environmental performance are considered non-conformances (non-compliance). Non-conformances may be identified during an audit, inspection, crew observation or because 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), including seabird capture and handling procedures.
- 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.

For oil pollutions emergencies, Table 10-2 identifies the role and the minimum training requirements for the person undertaking the role. Pilot Energy will have access to person with these qualifications for the duration of the activity either through our own staff, from our JV partners in other projects, and from subcontractors.

Table 10-2: Eureka 3D MSS IMT Roles and Relevant Competencies

IMT role	Competency
IMT Leader	Oil Spill Command and Control (IMO 3)
Logistics	Oil Spill Management Course (IMO 2)
Planning	Oil Spill Management Course (IMO 2)
Operations	N/A
Environment Unit Lead	Bachelor's degree in environmental management / science >10 years' experience in environmental management Spill Management course like IMO2 Participation in one incident management exercise every three years
Finance and Admin	Oil Spill Response Familiarisation Workshop or similar
Tactical response team leader	Oil Spill Command and Control (IMO 2)
Client site representative	None

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 shutdowns 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 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 are 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 10-3 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 'vessels' and not a petroleum activity. 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.

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. Table 10-4 identifies the roles that support the execution of the activity, the roles they may have in an oil pollution emergency, and their responsibilities in an emergency. Additional resources will be required to fill all the roles identified in the IMT noting that depending on the size and scale of the event that individuals may fulfil multiple emergency roles.

Table 10-3: 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

Table 10-4: Roles and Responsibilities during emergencies or potential emergencies

Day to Day Role	Oil Pollution Emergency Role	Responsibilities during emergencies or potential emergencies
Project Manager	IMT Leader	Commit resources to facilitate an emergency response strategy in the event of an incident.
		Complete the notifications detailed within the OPEP.
		Review and send incident reports to regulators and others as defined in the OPEP.
		Manage the emergency response strategy in the event of an incident.
Environment Advisor	Environment Support Officer	Manage any oil spill monitoring requirements as per the OSMP.
		Confirm the high priority protection areas.
Client Site Representative (Primary Vessel-based Contact)	Operations Lead	Immediately alert the Acquisition Operations 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.
Vessel Masters	No change	Notify AMSA, Site Representative and Vessel Manager in the event of a notifiable oil spill or the accidental release of waste overboard.
		Implement the vessel's SOPEP procedures in the event of an oil spill, including first response to an incident using the resources immediately available to the vessel.

[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.

	Immediately notify the 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.

•

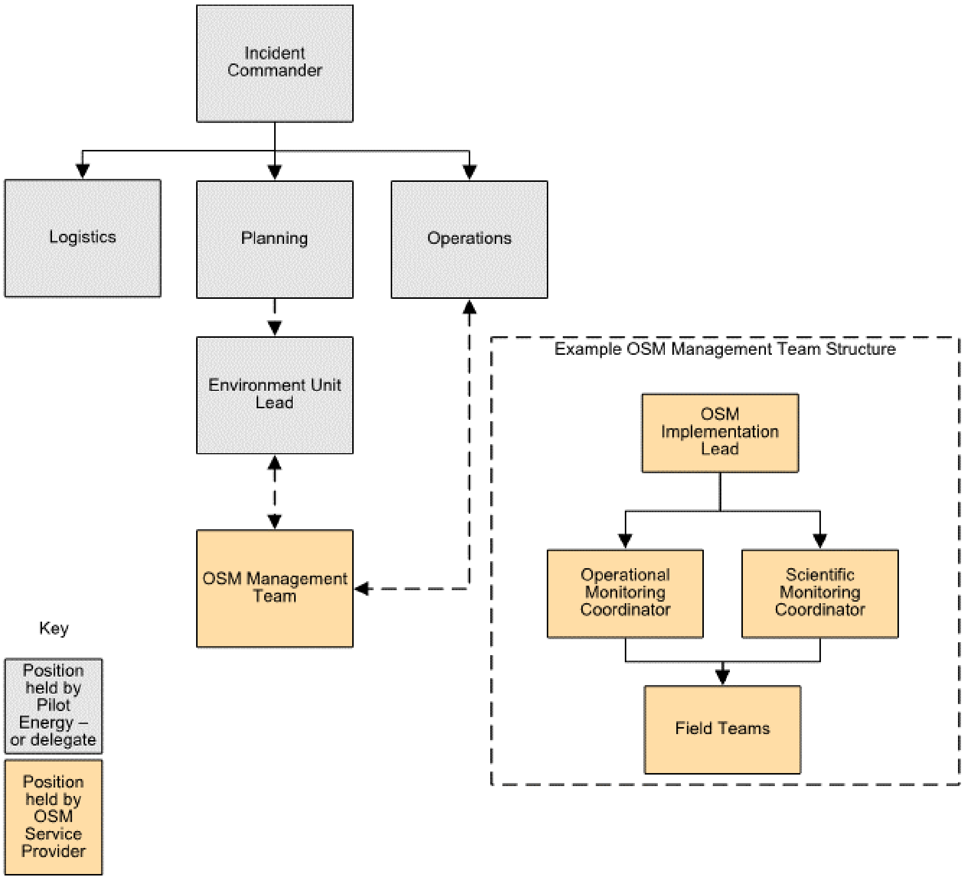


Figure 10-1: Pilot IMT structure with OSM team

The responsibilities associated with these roles can be found in Table 10-5.

Table 10-5: IMT Roles and Responsibilities

IMT role	Responsibility
IMT Leader	Responsible for ensuring that an effective immediate response is mounted and that it is ongoing until termination is determined. Supports relevant control agency
Logistics	Act as a focal point for materials and logistical requirements. Organise the supply and transportation of contractor personnel, materials and equipment required for oil spill response as required by the IMT.
Planning	Provide a focal point for developing the Incident Action Plan for sign off by the IMT if requested by control agency. Work with the control agency to get environmental and scientific inputs to the IAP. Monitor the IAP progress against the IAP objectives.
Operations	Responsible to the IMT and control agency for response operational activities
Environment Unit Lead	Advising on the environmental priorities and thorough implementation of the NEBA assessment, the preferred response options considering the significance, sensitivity and possible recovery of the resources likely to be affected. To implement the Oil Spill Monitoring Plan (operational and scientific)

Finance and Admin	Ensure Implementation of the Administration and Finance strategies
Tactical response team leader	Ensure the safety of personnel and the management of the vessel. Notifies the Pilot onsite representative of the incident Implements the SOPEP and emergency response plans
Client site representative	Represents Pilot and point of contact between IMT and tactical response team leader and vessel master.

10.7.2 Drill and training (OPEP/SOPEP)

The OPEP will be desktop tested prior to commencing the Eureka 3D MSS. This will only occur once in the immediate pre-mobilisation phase and will not be repeated during the survey as the time frame of the activity is too short for additional testing to be warranted.

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, considering 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 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 6.6) 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 10-6.

Table 10-6: 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 registers 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 10-7.

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 10-7: Routine and incident reporting requirements

Requirements	Timing
Recordable incident reporting	

Requirements	Timing
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 incident: • Collision with large marine fauna (cetaceans, pinnipeds, marine turtles) causing injury or death. • Any Oil Spill • Introduction of invasive marine species	
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 has 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
Reportable incident – written notification	
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).	As soon as practicable following verbal notification to NOPSEMA Email NOPSEMA: submissions@nopsema.gov.au Email NOPTA: info@nopta.gov.au

Requirements	Timing
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 has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident • The action that has been taken, or is proposed to be taken, to prevent similar recordable incidents occurring in the future.	As soon as practicable, and not later than three days following the first occurrence of the incident Email NOPSEMA: submissions@nopsema.gov.au
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).	Within seven days of providing a written report to NOPSEMA Email NOPTA: info@nopta.gov.au
Notify the DCCEEW of any impacts to MNES specifically injury to or death of EPBC Act listed Threatened or Migratory species	Within seven days of the incident protected.species@environment.gov.au or compliance@environment.gov.au
Notify the DCCEEW and AMSA of a vessel strike with a cetacean	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

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 shutdowns 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 because 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
- 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
- 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.
- In the event of any reportable incident that has the potential to affect the functions, interests, or activities of any relevant person.

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 10-8.

Table 10-8: 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 around the 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

Requirement	Timing
Notify the AHO and AMSA (JRCC) of altered information during the survey to enable a Notice to Mariners (NTM) to be issued, in addition to progress updates	Email the AHO fortnightly (if required) to report altered information at: datacentre@hydro.gov.au and JRCC at: rccaus@amsa.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 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

In addition to the above notifications, and for the avoidance of doubt, Pilot Energy will provide the following notifications to relevant persons:

- A pre-start notification to all relevant persons (including DEMIRS, etc.) at least 2 weeks before commencement of the survey, confirming the expected start date.
- A completion notification within 10 days after the survey concludes.
- Incident notifications: if any reportable environmental incident occurs, directly notify those relevant persons whose functions, interests or activities may be affected, including DEMIRS, DBCA, WAFIC and any fishing co-ops in the region, as soon as practicable.
- Traditional Owner groups to be notified at weekly intervals of any marine Fauna observations made by MFOs, in addition to a report at the end of operations detailing observations made, and any actions taken as a result.
- Tourists and divers: direct communication with local dive shops and Port Denison Volunteer Sea Search & Rescue will be used to identify and notify the public of planned survey operations. Local newspaper advertisements and signs posted at local boat ramps and beaches will also be used to notify the public of the planned survey operations.

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).

11 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)

Name	Description
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
DBCA	Department of Biodiversity, Conservation and Attractions
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

Name	Description
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
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

Name	Description
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
OIW	Oil in Water
OPGGS	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*

Name	Description
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 Limited
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

Name	Description
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
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

Name	Description
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

12 REFERENCES

[AFMA] Australian Fisheries Management Authority, 2022. Southern Bluefin Tuna Fishery. Australian Government, Canberra. Available from: https://www.afma.gov.au/fisheries/southern-bluefin-tuna-fishery. Accessed 4 October 2022.

[AFMA] Australian Fisheries Management Authority, 2023a. Western Deepwater Trawl Fishery. Australian Government, Canberra. Available at: https://www.afma.gov.au/fisheries/western-deepwater-trawl-fishery.

[AFMA] Australian Fisheries Management Authority 2023b. Small Pelagic Fishery. Australian Government, Canberra. Available at: https://www.afma.gov.au/fisheries/small-pelagic-fishery.

[AGDD] Australian Government Department of Defence, 2023. Unexploded ordnance. Accessed from https://www.defence.gov.au/UXO/Where/Default.asp Accessed on 17 May 2023.

[AMSA] Australian Maritime Safety Authority, 2015. Technical guidelines for preparing contingency plans for marine and coastal facilities. Australian Government. [ANZECC & ARMCANZ] Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, 2000. Water Quality Guidelines. https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000

[BoM] Bureau of Meteorology, 2022a. Climate statistics for Australian locations. Australian Government, Canberra. Available from: http://www.bom.gov.au/climate/averages/tables/cw_008050.shtml. Accessed Nov 2022.

[BoM] Bureau of Meteorology 2022b. Wind Roses for Selected Locations in Australia. Australian Government, Canberra. Available from: http://www.bom.gov.au/climate/averages/wind/selection_map.shtml. Accessed November 2022.

[BoM] Bureau of Meteorology 2023a. Tide Predictions for Australia, South Pacific and Antarctica. Australian Government, Canberra. Available from: http://www.bom.gov.au/australia/tides. Accessed January 2023.

[BoM] Bureau of Meteorology 2023b. Sea Temperature and Currents: West Western Australia. Australian Government, Canberra. Available from: http://www.bom.gov.au/oceanography/forecasts.

[BoM] Bureau of Meteorology 2023c. Climate influences. Australian Government, Canberra. Available from: http://www.bom.gov.au/climate/outlooks/#/overview/influences.

Christiansen, F., Dawson, S. M., Bejder, L., New, L. F., Harcourt, R., Miller, C. A., Rolland, R. M., & Parks, S. E. (2025). Starvation threshold and fasting endurance of right whales. *Marine Ecology Progress Series, 768,* 99–118. https://doi.org/10.3354/meps15851

[CoA] Commonwealth of Australia, 2014. Streamlining Offshore Petroleum Environmental Approvals. Program Report. Australian Government, February 2014. 60 pp.

[CoA] Commonwealth of Australia, 2015a. Conservation Management Plan for the Blue Whale–A Recovery Plan under the Environment Protect and Biodiversity Conservation Act 1999. Canberra: Department of the Environment. Available at http://www.environment.gov.au/biodiversity/threatened/publications/recovery/blue-whale-conservation-management-plan. In effect under the EPBC Act from 03-Oct-2015.

[CoA] Commonwealth of Australia, 2015b. Sawfish and River Sharks Multispecies Recovery Plan. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity /threatened/publications/recovery/sawfish-river-sharks-multispecies-recovery-plan. In effect under the EPBC Act from 07-Nov-2015.

[CoA] Commonwealth of Australia, 2015c. Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Department of the Environment. Available at: http://www.environment.gov.au/biodiversity/publications/wildlife conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

[CoA] Commonwealth of Australia, 2017. Recovery Plan for Marine Turtles in Australia 2017-2027. Department of the Environment and Energy. Canberra.

[CoA] Commonwealth of Australia, 2018. Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Canberra, ACT: Commonwealth of Australia. Available from: https://www.dcceew.gov.au/sites/default/files/documents/tap-marine-debris-2018.pdf

[CoA] Commonwealth of Australia, 2020. National light pollution guidelines for wildlife including marine turtles, seabirds and migratory shorebirds. Department of the Environment and Energy. Canberra.

[DAFF] Department of Agriculture, Fisheries and Forestry, 2022. Fishery status reports 2022. https://www.agriculture.gov.au/abares/research-topics/fisheries/fishery-status#:~:text=The%20fisheries%20 assessed%20in%20the,fisheries%20GVP%20of%20%241.39%20billion.

[DAWE] Department of Agriculture, Water and Environment. 2020a. Australian Ballast Water Management Requirements: Version 8. Available from: https://www.agriculture.gov.au/sites/default/files/ documents/Australian-ballast-water-management-requirements.pdf. Accessed on 12 July 2022.

[DAWE] Department of Agriculture, Water and the Environment. 2020b. Wildlife Conservation Plan for Seabirds. Department of Agriculture, Water and the Environment, Canberra. Available from: http://www.dcceew.gov.au/environment/biodiversity/publications/wildlife-conservation-plan-seabirds-2022. In effect under the EPBC Act from 16-Jun-2022

[DAWE] Department of Agriculture, Water and Environment, 2021a. *Sterna dougallii* — Roseate Tern. Accessed from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?showprofile=Y&taxon_id=817. Accessed on 10 June 2021.

[DAWE] Department of Agriculture, Water and Environment, 2022. Underwater Cultural Heritage Act 2018. Accessed from https://www.environment.gov.au/heritage/underwater-heritage/underwater-cultural-heritage-act. Accessed on 10 June 2021.

[DBCA] Department of Biodiversity, Conservation and Attractions, n.d. Marine Panning. Parks and Wildlife Service. https://www.dbca.wa.gov.au/management/marine-planning. Accessed 7/10/2023.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water, n.d. Species Profile and Threats Database: Key Ecological Features. Australian Government, Canberra. Available from https://www.environment.gov.au/sprat-public/action/kef/search.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water, 2019a. Australia's Marine Regions. Australian Government, Canberra. Available from: https://www.waterquality.gov.au/anz-guidelines/your-location/australia-marine-regions. Accessed January 2023.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2022b. National Recovery Plan for albatrosses and petrels. Department of Climate Change, Energy, the Environment and Water, Canberra. Recovery Plan approved and in the process of being published on the department's website. In effect under the EPBC Act from 01-Oct-2022.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2022c. 'Assessment of the Commonwealth Southern Bluefin Tuna Fishery November 2019, Commonwealth of Australia.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2022d. 'Assessment of the Commonwealth Western Tuna and Billfish Fishery, November 2022. Australian Government, Canberra.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2023. Protected Matters Search Tool. Australian Government, Canberra.

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2023. Conservation Advice for Numenius madagascariensis (far eastern curlew), December 2023. Australian Government, Canberra Conservation Advice for Numenius madagascariensis (far eastern curlew) (environment.gov.au)

[DCCEEW] Department of Climate Change, Energy, the Environment and Water 2024. National Recovery Plan for the Southern Right Whale. Australian Government, Canberra.

[DEC] Department of Environment and Conservation, 2007. Rowley Shoals marine Park Management Plan 2007-2017, Management Plan No 56. Prepared by the Department of Environment and Conservation on behalf of the Marine Parks and Reserves Authority (MPRA), Perth, Western Australia.

[DEWHA] Department of the Environment, Water, Heritage, and the Arts, 2007. A Characterisation of the Marine Environment of the North-west Marine Region: A summary of an expert workshop convened in Perth, Western Australia, 5-6 September 2007. Australian Government, Canberra. Available at: https://parksaustralia.gov.au/marine/pub/scientific-publications/archive/nw-characterisation.pdf.

[DEWHA] Department of the Environment, Water, Heritage, and the Arts, 2008a. EPBC Act Policy Statement 2.1 - Interaction Between Offshore Seismic Exploration and Whales. In: Australian Government. Department of the Environment, Water, Heritage and the Arts. 14 pp.

[DEWHA] Department of the Environment, Water, Heritage and the Arts, 2008b. The South-west Marine Bioregional Plan: Bioregional Profile. Australian Government, Canberra. Available at: https:// parksaustralia.gov.au/marine/pub/scientific-publications/archive/south-west-marine-bioregional-plan.pdf.

[DEWHA] Department of the Environment, Water, Heritage and the Arts, 2008c. Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1768-conservation-advice.pdf. In effect under the EPBC Act from 08-Jan-2009.

[DEWR] Department of Environment and Water Resources 2007. A Characterisation of the Marine Environment of the South-west Marine Region: a summary of an expert workshop convened in Perth, Western Australia, September 2006. Australian Government, Canberra. Available at: https://parksaustralia.gov.au/marine/pub/scientific-publications/archive/sw-characterisation.pdf.

[DFO] Department of Fisheries and Oceans. 2004. Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals. Canadian Science Advisory Secretariat (CSAS), Habitat Status Report 2004/002, 15 pp.

[DMAC] Diving Medical Advisory Committee, 2020. Safe Diving Distance from Seismic Surveying Operations. DMAC 12 Rev 2.1. https://www.dmac-diving.org/guidance/DMAC12.pdf

[DNP] Director of National Parks, 2018. South-west Marine Parks Network Management Plan, 2018. Director of National Parks. Canberra. 186 pp. https://parksaustralia.gov.au/marine/pub/plans/south-west-management-plan-2018.pdf

[DoAFF] Department of Agriculture, Fisheries and Forestry, 2021. Assessment of the Western Australian West Coast Demersal Gillnet and Demersal Longline Interim Managed Fishery and Southern Demersal Gillnet and Demersal Longline Managed Fishery August 2021. Australian Government, Canberra. Available from: https://www.dcceew.gov.au/sites/default/files/env/pages/ad594b82-7fc1-4de2-a43b-be56dd6df129/files/wa-temperate-shark-assessment-2021.pdf. Accessed 11th Oct 2022.

[DoE] Department of the Environment, 2014a. Approved Conservation Advice for *Pristis* (largetooth sawfish). Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf. In effect under the EPBC Act from 11-Apr-2014.

[DoE] Department of the Environment, 2014b. Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*). Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/resource/recovery-plan-grey-nurse-shark-carcharias-taurus. In effect under the EPBC Act from 14-Aug-2014.

[DoE] Department of the Environment, 2015a. Conservation Advice *Calidris ferruginea* curlew sandpiper. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf. In effect under the EPBC Act from 26-May-2015.

[DoE] Department of the Environment, 2015b. Conservation Advice *Numenius madagascariensis* eastern curlew. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf. In effect under the EPBC Act from 26-May-2015.

[DoE] Department of the Environment 2024. *Eubalaena australis* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: https://www.environment.gov.au/sprat. Accessed Fri, 18 Oct 2024.

[DoEE] Department of the Environment and Energy, n.d. Recovery Plans. Available from: https://www.environment.gov.au/biodiversity/threatened/recovery-plans. Accessed 23/05/2019

[DoEE] Department of the Environment and Energy, n.d. Biologically important areas of regionally significant marine species. Commonwealth of Australia. Available from: https://www.environment.gov.au/marine/marine-species/bias. Accessed 29/05/2019

[DoEE] Department of the Environment and Energy, 2017. National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna. Available from: https://www.dcceew.gov.au/sites/default/files/documents/vessel-strike-strategy.pdf.

[DoEE] Department of the Environment and Energy, 2019. Species profile and threats database. http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl. Accessed 04/04/2019

[DoEE] Department of Environment and Energy, 2021a. The Ramsar Convention on Wetlands. Available at https://www.environment.gov.au/water/wetlands/ramsar Accessed 13 May 2019

[DoEE] Department of the Environment and Energy, 2021b. Australian National Shipwreck Database. Available at https://www.environment.gov.au/heritage/historic-shipwrecks/Australian-national-shipwreck-database. Accessed 13 May 2019.

[DoEE] Department of the Environment and Energy, 2023. Australia's National Heritage List. Available at https://www.environment.gov.au/heritage/places/national-heritage-list Accessed 20 May 2019

[DoF] Department of Fisheries, 2013. Guidance statement on undertaking seismic surveys in Western Australian waters. Fisheries Occasional Publication No. 112, Government of Western Australia. 20 pp.

[DoF] Department of Fisheries, 2011. Fisheries Fact Sheet: Abalone. Government of Western Australia. Available at: https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_abalone.pdf

[DoF] Department of Fisheries, 2011. Fisheries Fact Sheet: West Australian Dhufish. Government of Western Australia. Available at: https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet__dhufish.pdf

[DoT] Department of Transport, 2020. State Hazard Plan–Maritime Environmental Emergencies (MEE). Available at https://www.transport.wa.gov.au/mediaFiles/marine/MAC_P_StateHazardPlanMaritimeEnviroEmergMEE.pdf

[DoT] Department of Transport, 2023. Coastal data and charts: Tide data (real time). Government of Western Australia, Perth. Available from: https://www.transport.wa.gov.au/imarine/tide-data-real-time.asp. Accessed January 2023.

[DPC] Department of the Premier and Cabinet, 2018. South West Native Title Settlement. March 14. Accessed June 18, 2019. Available at: https://www.dpc.wa.gov.au/swnts/Noongar-Heritage-and-History/Pages/Noongar-History.aspx.

[DPIRD] Department of Primary Industries and Regional Development, 2014. West Coast Rock Lobster Harvest Strategy and Control Rules 2014 - 2019. Fisheries Management Paper No. 264. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

[DPIRD] Department of Primary Industries and Regional Development, 2016. Fisheries: Abalone. Available at: https://www.fish.wa.gov.au/Species/Abalone/Pages/default.aspx

[DPIRD] Department of Primary Industries and Regional Development, 2018. Commercial Fishing Guide. Available at https://www.fish.wa.gov.au/Fishing-and-Aquaculture/Commercial-Fishing/Pages/Commercial-Fishing-Guide.aspx Accessed 20 May 2019.

[DPIRD] Department of Primary Industries and Regional Development 2020a. Fisheries. https://www.fish.wa.gov.au/fishing-and-aquaculture/commercial-fishing/Pages/default.aspx

[DPIRD] Department of Primary Industries and Regional Development, 2020b. Fisheries: Rock lobster. Available at: https://www.fish.wa.gov.au/Species/Rock-Lobster/Pages/default.aspx

[DPIRD] Department of Primary Industries and Regional Development, 2020c. Fisheries Management Paper No. 303. Estuarine and Nearshore Finfish Resource of South-West Western Australia Harvest Strategy: 2020-2025. Government of Western Australia, Perth. Available from: https://library.dpird.wa.gov.au/cgi/viewcontent.cgi?article=1327&context=fr_fmp. Accessed Nov 2022.

[DPIRD] Department of Primary Industries and Regional Development 2020d. West Coast Deep Sea Crustacean Resource Harvest Strategy 2020-2025. Government of Western Australia, Perth. Available from: https://library.dpird.wa.gov.au/cgi/viewcontent.cgi?article=1326&context=fr_fmp. Accessed 10th Oct 2022.

[DPIRD] Department of Primary Industries and Regional Development, 2020e. Fisheries Management Paper No. 299: Saucer Scallop Resource of the Abrolhos Islands Harvest Strategy 2020 – 2025. Available from: https://www.fish.wa.gov.au/Documents/management_papers/fmp299.pdf

[DPIRD] Department of Primary Industries and Regional Development 2021. Fisheries Management Paper No. 305: West Coast Demersal Scalefish Resource Harvest Strategy 2021-2025. Available from: https://www.fish.wa.gov.au/Documents/management_papers/fmp305.pdf. Accessed: 11 Oct 2022.

[DPIRD] Department of Primary Industries and Regional Development, 2022a. Abalone Management. Available at: https://www.fish.wa.gov.au/Species/Abalone/Pages/Abalone-Management.aspx. Accessed October 2022.

[DPIRD] Department of Primary Industries and Regional Development, 2022b. Mackerel Management. Available at: https://www.fish.wa.gov.au/Species/Spanish-Mackerel/Pages/Mackerel-Management.aspx

[DPIRD] Department of Primary Industries and Regional Development, 2022c. Salmon Commercial Fishing. Available from: https://www.fish.wa.gov.au/Species/WA-Salmon/Pages/Salmon-Commercial-Fishing.aspx. Accessed 10th Oct 2022.

[DPIRD] Department of Primary Industries and Regional Development 2023a. Dhufish, West Australian. Government of Western Australia, Perth. Available at: https://www.fish.wa.gov.au/species/wa-dhufish/Pages/default.aspx. Accessed April 2023.

[DPIRD] Department of Primary Industries and Regional Development 2023b. Pink snapper. Government of Western Australia, Perth. Available at: https://www.fish.wa.gov.au/species/pink-snapper/pages/default.aspx. Accessed April 2023.

[DPIRD] Department of Primary Industries and Regional Development 2023c. Fisheries Fact Sheet: Baldchin Groper. Government of Western Australia, Perth. Available at: https://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_baldchin_groper.pdf. Accessed April 2023.

[DPIRD] Department of Primary Industries and Regional Development 2023d. West Coast Demersal Scalefish Resource. Government of Western Australia, Perth. Available at: https://www.fish.wa.gov.au/Fishing-and-Aquaculture/demersal/Pages/default.aspx.

[DSEWPC] Department of Sustainability, Environment, Water, Population and Communities, 2012a. Marine bioregional plan for the South-west Marine Region. Australian Government, Canberra. Available from: https://www.dcceew.gov.au/sites/default/files/env/pages/a73fb726-8572-4d64-9e33-1d320dd6109c/files/south-west-marine-plan.pdf

[DSEWPC] Department of Sustainability, Environment, Water, Population and Communities, 2012b. Commonwealth marine environment report card. Supporting the marine bioregional plan for the South-west Marine Region. Australian Government, Canberra. Available from: https://www.dcceew.gov.au/sites/default/files/env/pages/a73fb726-8572-4d64-9e33-1d320dd6109c/files/south-west-report-card-commonwealth.pdf.

[DSEWPC] Department of Sustainability, Environment, Water, Population and Communities, 2012c. Conservation Management Plan for the Southern Right Whale. *A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999*. Available from: https://www.dcceew.gov.au/sites/default/files/documents/e-australis-2011-2021.pdf

[DSEWPC] Department of Sustainability, Environment, Water, Population and Communities, 2013a. Recovery Plan for the Australian Sea Lion (*Neophoca cinerea*). Australian Government, Canberra. Available from: http://www.environment.gov.au/resource/recovery-plan-australian-sea-lion-neophoca-cinerea. In effect under the EPBC Act from 05-Jul-2013.

[DSEWPC] Department of Sustainability, Environment, Water, Population and Communities, 2013b. Recovery Plan for the White Shark (*Carcharodon carcharias*). Australian Government, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/recovery-plan-white-shark-carcharodon-carcharias. In effect under the EPBC Act from 06-Aug-2013 as *Carcharodon carcharias*.

[ERM] Environmental Resources Management, 2017. Bethany 3D Survey Environment Plan - Seismic Airguns and Fish Mortality Literature Review. Final Report to Santos, Reference No. 0436696. 1 December 2017. 39 pp.

[FWA] Fisheries Western Australia, 2001. Final Plan of Management for the Lancelin Island Lagoon Fish Habitat Protection Area. Fisheries Management Paper No. 149.

[IAGC] International Association of Geophysical Contractors. 2017. Plankton Study Speculative and Needs Better Data. News Release, June 22, 2017. 2 pp.

[IMCRA] Interim Marine and Coastal Regionalisation for Australia, 1997. Interim Marine and Coastal Regionalisation for Australia: an ecosystem based classification for marine and coastal environments, Interim Marine and Coastal Regionalisation for Australia Technical Group, Environment Australia, Canberra

[IMOS] Integrated Marine Observing System, 2023. IMOS OceanCurrent: Four hour SST. Available from: http://oceancurrent.imos.org.au. Accessed January 2023.

[IPIECA] International Petroleum Industry Conservation Association, 1995. Volume 7: Biological impacts of oil pollution: Rocky shores. https://www.amn.pt/DCPM/Documents/RockyShores.pdf

[IPIECA] International Petroleum Industry Conservation Association, 1999. Volume 7: Biological impacts of oil pollution: Sedimentary shores. https://www.amn.pt/DCPM/Documents/SedimentaryShores.pdf

[IPIECA] International Petroleum Industry Conservation Association, 2019. Oil spill preparedness and response: An introduction (2019). https://www.ipieca.org/resources/oil-spill-preparedness-and-response-an-introduction-2019

[ITOPF] International Tanker Owners Pollution Federation, 2011. Effects of Oil Pollution on the Marine Environment. Technical Information Paper. Technical paper No. 13. The International Tank Owners Pollution Federation Limited.

[IUCN] International Union for Conservation of Nature, 2016. Effective planning strategies for managing environmental risk associated with geophysical and other imaging surveys: A resource guide for managers. 42 pp. https://portals.iucn.org/library/sites/library/files/documents/2016-053.pdf

[MPSC] Marine Pest Sectoral Committee. 2018. National Biofouling Management Guidance for the Petroleum and Exploration Industry, http://www.marinepests.gov.au/marine_pests/publications/Documents/Biofouling_guidance_petroleum.pdf. Viewed 18 Oct 2023.

[MSC] Marine Stewardship Council, 2022. Western Australia Octopus. Available from: https://fisheries.msc.org/en/fisheries/western-australia-octopus/. Accessed 10th Oct 2022.

[NESP] National Environmental Science Program, 2018. An eco-narrative of Perth Canyon Marine Park. Available at: https://maps.northwestatlas.org/files/montara/Perth_Canyon_narrative_FINAL%20(1).pdf

[NMFS] National Marine Fisheries Service. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55. 189 pp.

[NMFS] National Marine Fisheries Service, 2018. 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 pp.

[NMFS] National Marine Fisheries Services, 2024. Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (version 3.0): Underwater and In Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-71, 182 p.

[NOAA] National Oceanic and Atmospheric Administration. 2002. Final Restoration Plan and Environmental Assessment for the M/V Kuroshima Oil Spill, Summer Bay, Unalaska, Alaska. Available: http://www.darrp.noaa.gov/northwest/kuro/admin.html

[NOAA] National Oceanic and Atmospheric Administration, 2013a. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals. Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. Draft 23 December 2013. 83 pp.

[NOAA] National Oceanic and Atmospheric Administration, 2013b. Shoreline assessment manual. Office of Response and Restoration, Emergency Response Division. https://response.restoration.noaa.gov/sites/default/files/manual_shore_assess_aug2013.pdf

[NOAA] National Oceanic and Atmospheric Administration, 2019. ESA Section 7 Consultation Tools for Marine Mammals on the West Coast. Available at: https://www.fisheries.noaa.gov/westcoast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west

[NOPSEMA] National Offshore Petroleum Safety and Environmental Management Authority, 2023a. Consultation in the course of preparing an environment plan. Available at: https://www.nopsema.gov.au/sites/default/files/documents/Consultation%20in%20the%20course%20of%20preparing%20an%20Environment%20Plan%20guideline_1.pdf.

[NRDA] Natural Resource Damage Assessment. 2012. Status update for the Deepwater Horizon oil spill. National Oceanic and Atmospheric Administration. https://www.gulfspillrestoration.noaa.gov/wp-content/uploads/FINAL_NRDA_StatusUpdate_April2012.pdf

[NSF] National Science Foundation (U.S.), Geological Survey (U.S.), and NOAA National Oceanic and Atmospheric Administration (U.S.). 2011. Final Programmatic Environmental Impact Statement/Overseas. Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey. National Science Foundation, Arlington, VA, U.S.A.

[OGP/IAGC] International Association of Oil & Gas Producers and International Association of Geophysical Contractors, 2011. An overview of marine seismic operations. Report No. 448. International Association of Oil and Gas Producers and the International Association of Geophysical Contractors. 50 pp [OGUK] Oil and Gas UK, 2014. Guidance on risk related decision making (Issue No. 2). United Kingdom Offshore Operators Association, London.

[TSSC] Threatened Species Scientific Committee, 2015a. Conservation Advice *Balaenoptera borealis* sei whale. Canberra: Department of the Environment. Available at http://www.environment.gov.au/biodiversity/threatened/species/pubs/34-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

[TSSC] Threatened Species Scientific Committee, 2015b. Conservation Advice *Balaenoptera physalus* Fin whale. Canberra: Department of the Environment. Available at http://www.environment.gov.au/ biodiversity/threatened/species/pubs/37-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

[TSSC] Threatened Species Scientific Committee, 2015c. Conservation Advice *Rhincodon typus* whale shark. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/ threatened/species/pubs/66680-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

[TSSC] Threatened Species Scientific Committee, 2015d. Conservation Advice *Papasula abbotti* Abbott's booby. Canberra: Department of the Environment. Available at: http://www.environment.gov.au/ biodiversity/threatened/species/pubs/59297-conservation-advice-01102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

[TSSC] Threatened Species Scientific Committee, 2015e. Conservation Advice *Megaptera novaeangliae* Humpback whale. Canberra: Department of the Environment. Available at http://www.environment.gov. au/biodiversity/threatened/species/pubs/38-conservation-advice-10102015.pdf. In effect under the EPBC Act from 01-Oct-2015.

[TSSC] Threatened Species Scientific Committee, 2016a. Conservation advice *Calidris canutus* red knot. Canberra: Department of the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/ pubs/855-conservation-advice-05052016.pdf. In effect under the EPBC Act from 05-May-2016

[TSSC] Threatened Species Scientific Committee, 2016b. Conservation advice *Charadrius leschenaultii* greater sand plover. Canberra: Department of the Environment. Available at: http://www. environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf

[WAFIC] Western Australian Fishing Industry Council 2022. Temperate Demersal Gillnet and Demersal Longline Fishery. Available from: https://www.wafic.org.au/fishery/temperate-demersal-gillnet-and-demersal-longline-fishery/. Accessed 11th Oct 2022.

[WAM] Western Australian Museum, 2024. Shipwreck database. Available at
https://www.museum.wa.gov.au/maritime-archaeology-db/wrecks. Accessed 7th March 2024.

Aguilar de Soto, N. Delorme, N. Atkins, J. Howard, S. Williams, J. and Johnson, M. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. Scientific Reports 3: 2831.

Ainslie, M.A. 2008. Review of published safety thresholds for human divers exposed to underwater sound. TNO Defence, Security and Safety Report. TNO-DV 2007 A598.

Alsabah, N.J, 2017 Impact of Sewage Discharge on Coral Reefs, The International Journal of Engineering and Science, Vol 6, Iss 6 PP09-13, B0606020913.pdf (theijes.com)

Amoser, S. and Ladich, F. 2003. Diversity in noise-induced temporary hearing loss in otophysine fishes. Journal of the Acoustical Society of America 113: 2170–2179.

André, M. Kaifu, K. Solé, M. van der Schaar, M. Akamatsu, T. Balastegui, A. Sánchez, A.M. and Castell, J.V. 2016. Contribution to the understanding of particle motion perception in marine invertebrates. pp. 47–55, in Popper, N.A. Hawkins, A. (eds.), The effects of noise on aquatic life II. Springer, New York, USA.

Armstrong, A.J, Armstrong, A.O. McGregor, F. Richardson, A.J. Bennett, M.B. Townsend, K.A. Hays, G.C. van Keulen, M. Smith, J. Dudgeon, C.L. 2020. Satellite Tagging and Photographic Identification Reveal Connectivity Between Two UNESCO World Heritage Areas for Reef Manta Rays.

Atchoi, E., Mitkus, M., & Rodríguez, A. 2020. Is seabird light-induced mortality explained by the visual system development?. *Conservation Science and Practice*, *2*(6), e195.

Aulich, M. G. McCauley, R. D. Saunders, B. J. & Parsons, M. J. 2019. Fin whale (*Balaenoptera physalus*) migration in Australian waters using passive acoustic monitoring. *Scientific Reports*, 9(1), pp.1-12.

Aulich, M. G. McCauley, R. D. Miller, B. S. Samaran, F, Giorli, G, Saunders, B. J. & Erbe, C, 2022. Seasonal Distribution of the Fin Whale (*Balaenoptera physalus*) in Antarctic and Australian Waters Based on Passive Acoustics. *Frontiers in Marine Science*, vol. 9, https://doi.org/10.3389/fmars.2022.864153.

Austad, M., Oppel, S., Crymble, J., Greetham, H.R., Sahin, D., Lago, P., Metzger, B.J. and Quillfeldt, P., 2023. The effects of temporally distinct light pollution from ships on nocturnal colony attendance in a threatened seabird. *Journal of Ornithology*, *164*(3), pp.527-536.

Australian Government 2022. Supporting cooperative coexistence of seismic surveys and commercial fisheries in Australia's Commonwealth marine area, Commonwealth of Australia, Canberra, October. CC BY 4.0.

Baker, G.B. Double, M.C. Gales, R. Tuck, G.N. Abbott, C.L. Ryan, P.G. Petersen, S.L. Robertson, C.J. and Alderman, R. 2007. A global assessment of the impact of fisheries-related mortality on shy and white-capped albatrosses: conservation implications. *Biological Conservation*, vol. 137(3), pp.319-333.

Ball, A. O. Sedberry, G. R. Zatco, M. S. Chapman, R. W. & Carlin, J. L. 2000. Population structure of the wreckfish Polyprion americanus determined with microsatellite genetic markers. *Marine Biology*, vol. 137: 1077 – 1090.

Ballou TG, Hess SC, Dodge RE, Knap AH, Sleeter TD. 1989. Effects of untreated and chemically dispersed oil on tropical marine communities: a long-term field experiment. International Oil Spill Conference Proceedings, (1): 447–454. doi: https://doi.org/10.7901/2169-3358-1989-1-447

Bannister, A. Kemper, C.M. and Warnecke, R.M.1996. The Action Plan for Australian Cetaceans. Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

Bannister, J. L. 2001. Status of Southern Right Whales (*Eubalaena Australis*) Off Australia. *Journal of Cetacean Research and Management* Special Issue 2, 103–110. DOI: https://doi.org/10.47536/jcrm.vi.273.

Bannister, J. L. P. S. Hammond, and M. C. Double, 2010. Population trend in right whales off southern Australia. *Reports of the International Whaling Commission*.

Bannister, J. L. 2017. Project A7—Monitoring population dynamics of south-western right whales off southern Australia 2015–2018. Final report to National Environment Science Program, Australian Commonwealth Government.

Barrett, G. Silcocks, A. Cunningham, R. Oliver, D. Weston, M. and Baker, J. 2007. Comparison of atlas data to determine the conservation status of bird species in New South Wales, with an emphasis on woodland-dependent species. *Australian Zoologist*, 34(1), pp.37-77.

Barter, M. A. 2002. Shorebirds of the Yellow Sea: importance, threats and conservation status. Wetlands International Global Series 9. International Wader Studies 12. (Canberra, Australia). Wetlands International, Wageningen, the Netherlands.

Bartol, S.M. Musick, J.A. 2003. Sensory biology of sea turtles. In: Biology of Sea Turtles, Vol. 2 (ed. Lutz, P.L. Musick, J.A. Wyneken, J.), pp. 79-102. Boca Raton, FL: CRC Press.

Bartol, S.M. Ketten D. 2006. Tuna and Turtle Hearing. In Swimmer Y. and Brill R. (eds.) Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries, NOAA Technical Memorandum NMFS-PIFSC-7.

Bellchambers L, Mantel P, Chandrapavan A, Pember M and Evans S, 2012. Western Rock Lobster Ecology – The State of Knowledge Marine Stewardship Council Principle 2: Maintenance of Ecosystem. Fisheries Research Report No. 236. Department of Fisheries. Government of Western Australia, Perth.

Bellchambers LM, How J, Evans SN, Pember MB, de Lestang S and Caputi N, 2017. Ecological Assessment Report: Western Rock Lobster Resource of Western Australia. Fisheries Research Report No. 279. Department Primary Industries and Regional Development. Government of Western Australia, Perth.

Benjamin, J et al. 2023. Stone artefacts on the seabed at a submerged freshwater spring confirm a drowned cultural landscape in Murujuga, Western Australia. *Quat. Sci. Rev*. vol. 313 (2023), p. 108190. Available at: https://doi.org/10.1016/j.quascirev.2023.108190

Berry, O, England, P, Fairclough, D Jackson, G and Greenwood, J, 2012. Microsatellite DNA analysis and hydrodynamic modelling reveal the extent of larval transport and gene flow between management zones in an exploited marine fish (*Glaucosoma hebraicum*). *Fisheries Oceanography*, vol. 21 (4), pp. 243 – 254.

Bertram, A, Fairclough, D, Sandoval-Castillo, J, Brauer, C, Fowler, A, Wellenreuther, A, & Beheregaray, L. B. 2022. Fisheries genomics of snapper (*Chrysophrys auratus*) along the west Australian coast. *Evolutionary Applications*, vol. 15(7), pp. 1099 – 1114.

Best, P. B. Butterworth, D. S. & Rickett, L. H, 1984. An Assessment Cruise for the South African Inshore Atock of Bryde's Whales (*Balaenoptera edeni*). Report of the International Whaling Commission, vol. 34, pp. 403-423.

BirdLife International 2023. Data Zone: Houtman Abrolhos Important Bird Area. http://datazone.birdlife.org/site/factsheet/houtman-abrolhos-iba-australia Accessed 15 May 2023.

Blanchard, A.L., Demchenko, N.L., Aerts, L.A.M. *et al.* Benthic studies adjacent to Sakhalin Island, Russia, 2015 I: benthic biomass and community structure in the nearshore gray whale feeding area. *Environ Monit Assess* **194** (Suppl 1), 743 (2022). https://doi.org/10.1007/s10661-022-10017-8

Blazeski, S, Norriss, J, Smith, K. A, & Hourston, M, 2021. Ecological Risk Assessment for the State-Wide Small Pelagic Scalefish Resource. Fisheries Research Report 320. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Blumer, M. 1971. Scientific aspects of the oil spill problem. 1 B.C. Envtl. Aff. L. Rev. 54. http://lawdigital commons.bc.edu/ealr/vol1/iss1/4

Boeger, W.A. Pie, M.R. Ostrensky, A. and Cardoso, M.F. 2006. The Effect of Exposure to Seismic Prospecting on Coral Reef Fishes. Brazilian Journal of Oceanography 54(4): 235-239.

Bolle, L.J. de Jong, C.A.F. Bierman, S.M. van Beek, P.J.G. van Keeken, O.A. et al. 2012. Common Sole Larvae Survive High Levels of Pile-Driving Sound in Controlled Exposure Experiments. PLoS ONE 7(3): e33052. doi:10.1371/journal.pone.0033052.

Booman, C. Dalen, J. Leivestad, H. Levsen, A. van der Meeren, T. and Toklum, K. 1996. Effekter av luftkanonskyting på egg, larver og yngel. Undersøkelser ved Havforskningsinstituttet og Zoologisk laboratorium, UIB. [In Norwegian with English Summary]. 89 pp.

Boyer, T. P, Garcia, H. E, Locarnini, R. A, Zweng, M. M, Mishonov, A. V, Reagan, J. R, Weathers, K. A, Baranova, O. K, Seidov, D and Smolyar, I. V 2018a. World Ocean Atlas 2018, Annual temperature objectively analyzed mean at the surface. NOAA National Centers for Environmental Information. Dataset: https://www.ncei.noaa.gov/archive/accession/NCEI-WOA18. Accessed January 2023.

Boyer, T. P, Garcia, H. E, Locarnini, R. A, Zweng, M. M, Mishonov, A. V, Reagan, J. R, Weathers, K. A, Baranova, O. K, Seidov, D and Smolyar, I. V 2018b. World Ocean Atlas 2018, Annual salinity at the surface. NOAA National Centers for Environmental Information. Dataset: https://www.ncei.noaa.gov/access/world-ocean-atlas-2018f/bin/woa18f.pl. Accessed January 2023.

Braccini, M. Blay, N. Hesp, A. & Molony, B, 2018. Resource Assessment Report Temperate Demersal Elasmobranch Resource of Western Australia. Fisheries Research Report No. 294. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Bradley, J, & Yanyuwa families, 2010. Singing saltwater country: Journey to the songlines of Carpentaria. Allen and Unwin, Sydney Australia.

Brandt, M. J., Dragon, A. C., Diederichs, A., Bellmann, M. A., Wahl, V., Piper, W., ... & Nehls, G. (2018). Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. *Marine Ecology Progress Series*, *596*, 213-232.

Braun, C.B. Grande, T. 2008. Evolution of peripheral mechanisms for the enhancement of sound reception. In: Webb, J.F. Fay, R.R. Popper, A.N. (eds.) Fish bioacoustics. Springer, New York, USA. pp. 99–144.

Bray, D. J. & Gomon, M. F. (eds), 2023. Fishes of Australia. Museums Victoria and OzFishNet. Available at: http://fishesofaustralia.net.au.

Brewer, D, Lyne, V, Skewes, T and Rothlisberg, P, 2007. Trophic Systems of the North-West Marine Region. Report to the Department of Environment, Water, Heritage and the Arts. CSIRO Marine and Atmospheric Research, Cleveland, Australia.

Brothers, N. Gales, R. Hedd, A. and Robertson, G. 1998. Foraging movements of the shy albatross *Diomedea cauta* breeding in Australia; implications for interactions with longline fisheries. Ibis, 140(3), pp.446-457.

Bruce, B. Bradford, R. Foster, S. Lee, K. Lansdell, M. Cooper, S. and Przeslawski, R. 2018. Quantifying fish behaviour and commercial catch rates in relation to a marine seismic survey. Marine Environmental Research 140: 18-30.

Bruintjes, R. Simpson, S.D. Harding, H. Bunce, T. Benson, T. Rossington, K. Jones, D. 2016. The impact of experimental impact pile driving on oxygen uptake in black seabream and plaice. Proc. Mtgs. Acoust 10 July 2016; 27 (1): 010042.

Burbidge, A. and Fuller, P. 1989. Numbers of breeding seabirds on Pelsaert Island, Houtman Abrolhos, Western Australia. Corella, 13, pp.57-61.

Cailliet, G. M. Cavanagah, R. D. Kulka, D. W. Stevens, J. D. Soldo, A, Clo, S, Macias, D, Baum, J, Kohin, S, Duarte, A, Holtzhausen, J. A, Acuña, E, Amorim, A, & Domingo, A, 2009. *Isurus oxyrinchus* – IUCN Red List of Threatened Species. Available at https://www.iucnredlist.org/species/39341/2903170#population. Accessed 15 May 2019.

Caltrans, 2001. Fisheries impact assessment for the Pile Installation Demonstration Project, San Francisco – Oakland Bay Bridge East Span Seismic Safety Project. State of California Department of Transportation, San Francisco.

Campbell, R. Holle, D. Collin, P. and Armstrong, S. 2014. Changes in the abundance and distribution of the New Zealand fur seal (*Arctocephalus forsteri*) in Western Australia: are they approaching carrying capacity? Australian Journal of Zoology, 62: 261-267.

Campbell, R. and Holley, D., 2007. Foraging ecology of Australian sea lions and their relationship with commercial fishing and marine protected areas. Report to the Department of Environment and Heritage, Department of Fisheries, Perth.

Caputi, N, de Lestang, S, Reid, C, Hesp, A, How, J, 2014. Maximum economic yield of the western rock lobster fishery of Western Australia after moving from effort to quota control. *Marine Policy*, vol. 51, (452-464).

Caputi, N, Melville-Smith, R, de Lestang, S, Pearce, A, and Feng, M. 2009, The effect of climate change on the western rock lobster (Panulirus cygnus) fishery of Western Australia. *Canadian Journal of Fisheries and Aquatic Sciences, 67* (1), 85-96.

CarbonNet, 2018. Geotechnical and Geophysical Investigations Environment Plan Summary. Department of Jobs, Precincts and Regions, Melbourne. https://info.nopsema.gov.au/home/underway_offshore

Cariton, J & Geller, J. 1993. Ecological Roulette: The Global Transport of Nonindigenous Marine Organisms. Science (New York, N.Y.). 261. 78-82. 10.1126/science.261.5117.78.

Carroll, A.G. Przeslawski, R. Duncan, A. Gunning, M. and Bruce, B. 2017. A critical review of the potential impacts of marine seismic surveys on fish and invertebrates. Marine Pollution Bulletin 114: 9-24.

Casper, B.M. Halvorsen, M.B. Popper, A.N. 2012. Are sharks even bothered by a noisy environment? Advances in Experimental Medicine and Biology 739: 93–97.

Challenger, GE, Mauseth, G. 2011. Seafood safety an oil spills. Oil Spill Science and Technology, pp 1083-1100. https://www.sciencedirect.com/science/article/abs/pii/B9781856179430100322?via%3Dihub

Chapman, C. and Hawkins, A. 1969. The importance of sound in fish behaviour in relation to capture by trawls. Fisheries and Aquaculture Report 62 (3): 717–729.

Charlton, C. Ward, R. McCauley, R.D. Brownell Jr, R.L. Guggenheimer, S. Salgado Kent, C.P. and Bannister, J.L. 2019. Southern right whales (*Eubalaena australis*) return to a former wintering calving ground: Fowlers Bay, South Australia. Marine Mammal Science, 35(4), pp.1438-1462.

Charlton C, McCauley R. D, Brownell Jr R. L, Ward R, Bannister J. L, Salgado Kent C and Burnell S. 2022. Southern right whale (*Eubalaena Australis*) population demographics at major calving ground Head of Bight, South Australia, 1991–2016. *Aquatic Conservation: Marine and Freshwater Ecosystems* 32, 4, 671-686. DOI: https://doi.org/10.1002/aqc.3771.

Chen, M, Pattiaratchi, C. B, Ghadouani, A, Hanson, C, 2019. Seasonal and inter-annual variability of water column properties along the Rottnest continental shelf, south-west Australia. *Ocean Science*, (15), pp: 333–348.

Childerhouse, S., Douglas, L., Kennedy, J. and Burns, D. 2016. Report: Analysis of Marine Observer data from New Zealand seismic surveys. Blue Planet Marine, New Zealand.

Christian, J.R. Mathieu, A. Thompson, D.H. White, D. and Buchanan, R.A. 2003. Effect of seismic energy on snow crab (*Chionoecetes opilio*). Environmental Funds Project No. 144. Fisheries and Oceans Canada, Calgary, Canada.

Cintron, G. Lugo, A. E. Marinez, R. Cintron, B. B. and Encarnacion, L. 1981. Impact of oil in the tropical marine environment. Technical Publication, Division of Marine Research, Department of Natural Resources, Puerto Rico.

Clarkson, C. Jacobs, Z. Marwick, B. et al. 2017. Human occupation of northern Australia by 65,000 years ago. *Nature*, vol. 547, 306–310. Available at: https://doi.org/10.1038/nature22968

Clapham, P. J. S. B. Young,and Brownell, R. L. Jr. 1999. Baleen whales: conservation issues and the status of the most endangered populations. Mammal Review 29: 35–60.

Collard, N, Bropho, H, Farlett, F, et al. 2021. Mapping Boodjar Walyalup. Curtin Research Publications, DOI 10.25917/vz9m-6j04

Colman, J. G, 1997. A Review of the Biology and Ecology of the Whale Shark. The Fisheries society of British Isles, *Journal of Fish Biology*, vol. 51, no. 6, pp. 1219-1234.

Connell, D. W. and G. J. Miller. 1981a. Petroleum hydrocarbons in aquatic ecosystems—behaviour and effects of sublethal concentrations. Part 1. Crit. Rev. Environ. Control 11:37-104

Cote, D. Morris, C.J. Regular, P.M. Piersiak, M.G. 2020. Effects of 2D seismic on snow crab movement behaviour. Fisheries Research 230 (2020) 105661.

Cresswell, G. R and Domingues, C. M. 2009: The Leeuwin Current south of Western Australia. *Journal of the Royal Society of Western Australia*, (92), pp: 83-100.

Currey-Randall, L. M. Galaiduk, R, Stowar, M, Vaughan, B. I. Miller, K. J, 2021. Mesophotic fish communities of the ancient coastline in Western Australia. *PLoS ONE*, vol 16(4): e0250427. Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0250427.

Dalen, J. and Knutsen, G. 1987. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. pp. 93–102 in Merklinger, H.M (ed.), Progress in underwater acoustics. Plenum Publishing Corporation, New York, USA.

Daley, R.K. Williams, A. Green, M. Barker, B. Brodie, P. 2015. Can marine reserves conserve vulnerable sharks in the deep sea? A case study of *Centrophorus zeehaani* (Centrophoridae), examined with acoustic telemetry. Deep Sea Research Part II: Topical Studies in Oceanography, 115, pp.127-136.

Dambacher, J.M. Rochester, W. Dutra, L. 2009. Addendum to ecological indicators for the exclusive economic zone waters of the South-west Marine Region. Report for the Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Davenport, J, Angel, MV, Gray, JS, Crisp, DJ, Davies, JM. 1982. Oil and planktonic ecosystems. Vol. 297, No. 1087, The Long-Term Effects of Oil Pollution on Marine Populations, Communities and Ecosystems, pp. 369-384

Davenport, A.M. Erbe, C. Jenner, M.-N.M. Jenner, K.C.S. Saunders, B.J. McCauley. R.D. 2022. Pygmy Blue Whale Diving Behaviour Reflects Song Structure. Journal of Marine Science and Engineering 10(9): 1227.

Davidsen, J. Dong, H. Linné, M. Andersson, M. Piper, A. Prystay, T. Hvam, E. Thorstad, E. Whoriskey, F. Cooke, S. Sjursen, A. Rønning, L. Netland, T.C. and Hawkins, A. 2019. Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe. Conservation Physiology. 7. 10.1093/conphys/coz020.

Davis, HK, Moffat, CF, Shepherd, NJ. 2002. Experimental Tainting of Marine Fish by Three Chemically Dispersed Petroleum Products, with Comparisons to the Braer Oil Spill. Spille Science and Technology Bulletin, 7(5-6), pp 257-278. https://doi.org/10.1016/S1353-2561(02)00043-9

Day, R.D. McCauley, R.D. Fitzgibbon, Q.P. Hartman, K. Semmens, J.M. 2016a. Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries. FRDC Project No 2012/008. University of Tasmania, Hobart, Tasmania.

Day, R.D. McCauley, R.D. Fitzgibbon, Q.P. Semmens, J.M. 2016b. Seismic air gun exposure during early-stage embryonic development does not negatively affect spiny lobster *Jasus edwardsii* larvae (Decapoda: Palinuridae). Scientific Reports, 6: 22723.

Day, R.D. McCauley, R.M. Fitzgibbon, Q.P. Semmens, J.M. 2017. Exposure to seismic air gun signals causes physiological harm and alters behaviour in the scallop Pecten fumatus. Proceedings of the National Academy of Sciences 114(40): E8537-E8546.

Day, R.D, McCauley, R.D. Fitzgibbon, Q.P. Hartmann, K. Semmens, J.M. 2019. Seismic air guns damage rock lobster mechanosensory organs and impair righting reflex. Proc. R. Soc. B. 286(1907): pp10.

Day, R. Fitzgibbon, Q. McCauley, R. Hartmann, K. Semmens, J. 2020. Lobsters with pre-existing damage to their mechanosensory statocyst organs do not incur further damage from exposure to seismic air gun signals. Environmental Pollution. 267. DOI: 10.1016/j.envpol.2020.115478.

Day, R.D. Fitzgibbon, Q.P. McCauley, R.D. and Semmens, J.M. 2021. Examining the potential impacts of seismic surveys of octopus and larval stages of southern rock lobster – Part A: southern rock lobster. FRDC project 2019-051. The Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania.

Day, R.D. Fitzgibbon, Q.P. McCauley, R.D. Baker, K.B. Semmens, J.M. 2022. The impact of seismic survey exposure on the righting reflex and moult cycle of Southern Rock Lobster (*Jasus edwardsii*) puerulus larvae and juveniles. Environmental Pollution, 309: 119699.

Day, R.D. McCauley, R.D. Leon, R. Fitzgibbon, Q.P. Baker, K. Hartmann, K. Semmens, J.M. 2023. Examining the potential impacts of seismic surveys on octopus and larval stages of southern rock lobster. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, CC BY 3.0.

de Lestang, S, Caputi, N, & How, J, 2016. Resource Assessment Report Western Rock Lobster Resource of Western Australia. Western Australian Marine Stewardship Council Report Series No. 9. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

de Lestang, S., Hoenig, J. and How, J., 2022. Development of an individual-based tag recapture model to benchmark biomass and harvest rates in an iconic lobster fishery. Bulletin of Marine Science, 98(1), pp.27-50.

de Lestang, 2023. Crystal Crab. Fisheries Research and Development Corporation (FRDC) report. Available at: https://fish.gov.au/report/415-Crystal-Crab-2023.

de Lestang, S. How, J. Erbe, C. & Rushworth, K. in prep. Impacts of a seismological survey on western rock lobsters. Presented at the 12th International Conference & Workshop on Lobster Biology and Management 2023, 22-27 October 2023, The Esplanade Hotel Fremantle, Western Australia.

De Lestang, S. Tuffley, EJ. Stock Assessment, TAC Advice and MSC Audit Reporting for West Coast Deep Sea Crustacean Resource. June 2024. Accessed online via https://westernrocklobster.org/wp-content/uploads/2024/10/2024-West-Coast-Rock-Lobster-Resource-Stock-Assessment.pdf

de Lestang. S, How. J, Rushworth. K, and Erbe. C. 2024. Boom, shake the room: Seismic surveys affect behaviour and survival of western rock lobster. Fisheries Research, 277 (107072). https://doi.org/ 10.1016/j.fishres.2024.107072DNV Energy. 2007. Effects of seismic surveys on fish, fish catches and sea mammals. Report by Det Norske Veritas Energy, Hovik, Norway for Cooperation group - Fishery Industry and Petroleum Industry, Stavanger. Report no.: 2007-0512. 33 pp.

Double, M. C. Jenner, K. C .S. Jenner, M-N. Ball, I, Childerhouse, S, Laverick, S, & Gales, N, 2012. Satellite tracking of northbound Humpback whales (Megaptera novaeangliae) off Western Australia. Australian Marine Mammal Centre. Available at: http://www.wamsi.org.au/sites/wamsi.org.au/files/Final%20report%20-%20Satellite%20tracking%20WA%20Humpback%20whales%202011.pdf

Double, M. C. Andrews-Goff, V, Jenner, K. C. S. Jenner, M-N, Laverick, S. M. Branch, T. A. & Gales, N. J. 2014. Migratory Movements of Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as revealed by Satellite Telemetry. *PLoS One*, vol. 9, no. 4.

Dow Piniak, W.E. Mann, D.A. Eckert, S.A. Harms, C.A. 2012. Amphibious hearing in sea turtles. In: Popper, A.N. Hawkins, A. (eds.). The Effects of Noise on Aquatic Life, Advances in Experimental Medicine and Biology 730, pp. 83-87, doi:10.1007/978-1-4419-7311-5_18.

Duncan, EM, Botterell, ZLR, Broderick, AC, Galloway, TS, Lindeque, PK, Nuno, A, Godley, BJ. 2017. A global review of marine turtle entanglement in anthropogenic debris: a baseline for further action. Endang Species Res, 34: 431–448

Dunlop, J. N. & Greenwell, C. N. 2022. A long tern view: distribution of small terns (Sternula) in Western Australia and implications for their conservation. *Pacific Conservation Biology*. Online Early.

Dunlop, R.A. Noad, M.J. McCauley, R.D. Kniest, E. Slade, R. Paton, D. and Cato, D.H. 2017. The behavioural response of migrating humpback whales to a full seismic airgun array. Proc. R. Soc. B284: 20171901.

Ebert, D.A. Fowler, S. and Compagno, L. 2013. Sharks of the World. A Fully Illustrated Guide. Wild Nature Press, Plymouth, United Kingdom.

Edgar GJ, Barrett NS. 1995. Effects of the Iron Barren oil spill – impact and recovery of sub tidal reefs. Marine Research Laboratories, Department of Primary Industry and Fisheries Tasmania.

Edmonds, N.J. Firmin, C.J. Goldsmith, D. Faulkner, R.C. and Wood, D.T. 2016. A review of crustacean sensitivity to high amplitude underwater noise: data needs for effective risk assessment in relation to UK commercial species. Marine Pollution Bulletin 108: 5–11.

Eliot, M 2018. Western Australian Sea Level Variability. PhD thesis. School of Civil, Environmental, and Mining Engineering, University of Western Australia.

Eliot, M & Pattiaratchi, C 2010. Remote forcing of water levels by tropical cyclones in southwest Australia. *Continental Shelf Research*, vol. 30 (14), pp. 1549-1561.

Elliott, D. and Tang, K. 2011. Influence of carcass abundance on estimates of mortality and assessment of population dynamics in Acartia tonsa. Marine Ecology Progress Series 427: 1–12.

Engås, A. and Løkkeborg, S. 2002. Effects of seismic shooting and vessel-generated noise on fish behaviour and catch rates. Bioacoustics 12(2-3): 313–316.

Engås, A. Løkkeborg, S. Ona, E. Soldal, A.V. 1993. Effects of seismic shooting on catch and catch-availabilty of cod and haddock. Havforskningsinsituttet, Institute of Marine Research. August 1993. 117 pp.

Engås, A. Løkkeborg, S. Ona, E. and Soldal, A.V. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences 53: 2238–2249.

Epstein, N. Bak, R.P.M. & Rinkevich, B. 2000. Toxicity of 3rd generation dispersants and dispersed Egyptian crude oil on Red Sea coral larvae. Marine Pollution Bulletin, 40: 497-503.

Fairclough, D. V, Edmonds, J. S, Lenanton, R. C. J, Jackson, G, Keay, I. S, Crisafulli, B. M, Newman, S. J 2011. Rapid and cost-effective assessment of connectivity among assemblages of *Choerodon rubescens* (Labridae), using laser ablation ICP-MS of sagittal otoliths. *Journal of Experimental Marine Biology and Ecology*, vol. 403 (1 – 2), pp. 46 – 53.

Fairclough, D. V, Edmonds, J. S, Jackson, G, Lenanton, R. C. J, Kemp, J, Molony, B. W, Keay, I. S, Crisafulli, B. M, Wakefield, C. B, 2013. A comparison of the stock structures of two exploited demersal teleosts, employing complementary methods of otolith element analysis. *Journal of Experimental Marine Biology and Ecology*, Vol. 439, pp. 181 – 195.

Fairclough, D.V. Hesp, S.A. Denham, A. Fisher, E.A. Marks, R. Ryan, K.L. Lek, E. Allen, R. Crisafulli, B.M, 2021a. 2021 assessment of the status of the West Coast Demersal Scalefish Resource. Fisheries Research Report No. 316. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Fairclough, D.V. 2021b. Partitioning of marine transition zone reefs among temperate, sub-tropical and tropical fishes is related more to depth and habitat than temperature. Marine Ecology Progress Series, 672: 175-192 doi:https://doi.org/10.3354/meps13778.

Fairclough, D. V. & Fisher, E, 2023. DPIRD Fisheries Research. Personal communication. February 2023.

Falkner, I. Whiteway, T. Przeslawski, R. and Heap, A.D. 2009. Review of Ten Key Ecological Features (KEFs) in the Northwest Marine Region, Geoscience Australia Record 2009/13. A report to the Department of the Environment, Water, Heritage and the Arts, Geoscience Australia, Canberra, Australian Capital Territory.

Felder, DL, Thoma, BP, Schmidt, WE, Sauvage, T, Self-Krayesky, SL, Chistoserdov, A, Bracken-Grissom, HD, Fredericq,, S. 2014. Seaweeds and Decapod Crustaceans on Gulf Deep Banks after the Macondo Oil Spill, BioScience, Volume 64, Issue 9, Pages 808–819, https://doi.org/10.1093/biosci/biu119

Fewtrell, J. and McCauley, R. 2012. Impact of air gun noise on the behaviour of marine fish and squid. Marine Pollution Bulletin 64 (5): 984-993.

Fields, D. M. Handegard, N. O. Dalen, J. Eichner, C. Malde, K. Karlsen, Ø. Skiftesvik, A. B. Durif, C. M. F. and Browman, H. I. 2019. Airgun blasts used in marine seismic surveys have limited effects on mortality, and no sublethal effects on behaviour or gene expression, in the copepod Calanus finmarchicus.–ICES Journal of Marine Science, doi:10.1093/icesjms/fsz126.

Finneran, J.J. Hastings, M.C. 2000. A mathematical analysis of the peripheral auditory system mechanics in the goldfish (Carassius auratus). Journal of the Acoustical Society of America 108(3): 3035–3043.

Finneran, J.J. Henderson, E. Houser, D. Jenkins, K. Kotecki, S. and Mulsow, J. 2017. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Technical report by Space and Naval Warfare Systems Center Pacific (SSC Pacific). 183 pp.

Fisher, E. Fairclough, D. Walters, S. 2023. West Coast Demersal Scalefish Resource Status Report 2022. In: Status Reports of the Fisheries and Aquatic Resources of Western Australia 2021/22: The State of the Fisheries eds. Newman, S.J. Wise, B.S. Santoro, K.G. and Gaughan, D.J. Department of Primary Industries and Regional Development, Western Australia. pp. 43-49.

Fitzgibbon, Q.P. Day, R.D. McCauley, R.D. Simon, C.J. Semmens, J.M. 2017. The impact of seismic air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, Jasus edwardsii, Marine Pollution Bulletin, 125, (1–2): 146-156.

Fletcher, W.J. Shaw, J. Gaughan, D.J. and Metcalf, S.J. 2011. Ecosystem based fisheries management case study report – West Coast Bioregion. Fisheries Research Report, 225.

Fogden, SCL. 1971. Mother-young behavior at grey seal breeding beaches. J. Zool. 164: 61-92.

Ford, J. K. B. Ellis, G. M. Matkin, D. R. Balcomb, K. C. Briggs, D, & Morton, A. B, 2005. Killer whale Attacks on Minke Whales: Prey Capture and Antipredator Tactics, *Marine Mammal Science*, vol 21, no. 4, pp 603-618.

Fothergill, D.M. Waltz, M.D. Forsythe, S.E. 2000. Diver aversion to low frequency underwater sound phase II: 600 – 2500 Hz. Undersea and Hyperbaric Medicine 27 (Supplement): 18.

Fothergill, D.M. Sims, J.R. Curley, M.D. 2001. Recreational SCUBA divers' aversion to low frequency underwater sound. Undersea and Hyperbaric Medicine 28(1): 9-18.

Francis, M, Natanson, L & Campana, S, 2002. The Biology and Ecology of the Porbeagle Shark, Lamna nasus. In: Camhi, M., E. Pikitch & E. Babcock, eds. *Sharks of the Open Ocean:Biology, Fisheries and Conservation*. Page(s) 105-113. Blackwell Publishing, United Kingdom.

Francis, M. P, Holdsworth, J. C & Block, B. A, 2015. Life in the open ocean: seasonal migration and diel diving behaviour of Southern Hemisphere porbeagle sharks (*Lamna nasus*). Marine Biology 162(11): 2305-2323.

Francis, M. P & Stevens, J. D, 2000. Reproduction, embryonic development, and growth of the porbeagle shark, *Lamna nasus*, in the southwest Pacific Ocean. *Fisheries Bulletin*. 98:41-63.

French, D. M. Reed, K. Jayko, S. Feng, H. Rines, S. Pavignano, T. Isaji, S. Puckett, A. Keller,F.W. French III, D. Gifford, J. McCue, G. Brown, E. MacDonald, J. Quirk, S. Natzke, R.Bishop, M. Welsh, M. Phillips and B.S. Ingram. 1996. Final Report, The CERCLA Type A NaturalResource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME),Technical Documentation, Vol. I - V. Submitted to the Office of Environmental Policy and Compliance, U.S. Department of the Interior, Washington, DC.

French, D.P. Schuttenberg, H.Z. and Isaji, T. 1999. Probabilities of oil exceeding thresholds of concern: examples from an evaluation for Florida power and light. In: Proceedings - AMOP 99 Technical Seminar, June 2-4, 1999, Calgary, Alberta, Canada, pp. 243-270.

French-McCay DP. 2002. Development and application of an oil toxicity and exposure model, OilToxEx. Environ Toxicol Chem 21: 2080–2094.

French-McCay, D.P. 2003. Development and application of damage assessment modelling: example assessment for the North Cape oil spill. Marine Pollution Bulletin 47(9), 9–12.

French-McCay, D.P. 2009. Oil spill impact modeling: Development and validation. Environmental Toxicology and Chemistry, 23: 2441-2456. https://doi.org/10.1897/03-382

French-McCay, D. Rowe, J.J. Whittier, N. Sankaranarayanan, S. and Etkin, D.S. 2004. Estimate of potential impacts and natural resource damages of oil. Journal of Hazardous Materials 107(1), 11–25.

Froese, R. & Pauly, D. (eds), 2023. FishBase. World Wide Web electronic publication. Available at: https://www.fishbase.org.au/v4.

Gagnon, M.M. and Rawson, C.A. 2010. Montara Well Release: Report on necropsies from a Timor Sea green sea turtle. Perth, Western Australia, Curtin University, vol. 15.

Gagnon M.M. Rawson C. 2011. Montara Well Release, Monitoring Study S4A – Assessment of Effects on Timor Sea Fish. Curtin University, Perth, Australia. 208 pages.Gambell, R. (1968). Seasonal Cycles and Reproduction in Sei Whales of the Southern Hemisphere. Discovery Reports. 35:31-134.

Gales, N.J. Shaughnessy, P.D. & Dennis, T.E. 1994. Distribution, abundance and breeding cycle of the Australian sea lion *Neophoca cinerea* (Mammalia: Pinnipedia). Journal of Zoology, London, 234: 353-370.

Gambell, R, 1968. Seasonal Cycles and Reproduction in Sei Whales of the Southern Hemisphere. *Discovery Reports*, vol. 35:31-134.

Gardner, M. J, Chaplin, J. A, a, Potter, I. C, Fairclough, D. V. 2015. Pelagic early life stages promote connectivity in the demersal labrid *Choerodon rubescens*. *Journal of Experimental Marine Biology and Ecology*, vol. 472, pp. 142 – 150.

Gaughan, D.J. and Santoro, K. (eds). 2018a. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2016/17: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Gaughan, D.J. Newman, S.J. and Wakefield, C.B. 2018b. Western Australian Marine Stewardship Council Report Series No. 11: Summary of the stock structure information used for determining spatial management of the index species for the scalefish resources of northern Western Australia. Department of Primary Industries and Regional Development, Western Australia. 32pp.

Gentilli, J 1971. Climates of Australia and New Zealand. *World Survey of Climatology*, vol. 13, ed. H. Landsberg, Elsevier, Amsterdam.

Gentilli, J 1972. Australian Climate Patterns. Nelson's Australasian Paperbacks.

Geraci, JR, St. Aubin, DJ. 1988. Synthesis of effects of oil on marine mammals. Department of Interior Minerals Management Service, Atlantic OCS Region. https://www.arlis.org/docs/vol1/18892759.pdf

Gibbons, M.J. and Hutchings, L. 1996. Zooplankton diversity and community structure around southern Africa, with special attention to the Benguela upwelling system. South African Journal of Science 92(2): 63–77.

Gibson, K. J, Streich, M. K. Topping, T. S, & Stunz, G. W, 2021. New Insights Into the Seasonal Movement Patterns of Shortfin Mako Sharks in the Gulf of Mexico. *Frontiers in Marine Science*, vol. 8, https://doi.org/10.3389/fmars.2021.623104

Gill, P. C. Ross, G. J. Dawbin, W. H. & Wapstra, H, 2000. Confirmed sightings of dusky dolphins (Lagenorhynchus obscurus) in southern Australian waters*. Marine mammal science*, vol.16(2), pp.452-459.

Gilmour, J, Speed, C. W & Babcock, R, 2016. Coral reproduction in Western Australia. *Peer J*. DOI 10.7717/peerj.2010.

Goldbogen, J.A. Calambokidis, J. Oleson, E. Potvin, J. Pyenson, N.D. Schorr, G. Shadwick, R.E. 2011a. Mechanics, hydrodynamics and energetics of blue whale lunge feeding: Efficiency dependence on krill density. Journal of Experimental Biology 214: 131-146. https://doi.org/10.1242/jeb.054726.

González J, Figueiras FG, Aranguren-Gassis M, Crespo BG, Fernández E, Morán XAG, Nieto-Cid M. 2009. Effect of a simulated oil spill on natural assemblages of marine phytoplankton enclosed in microcosms, Estuarine, Coastal and Shelf Science, vol. 83 (pg. 265-276).

Goodbody-Gringley, G. Wetzel, D.L. Gillon, D. Pulster, E. & Miller, A.l. 2013. Toxicity of Deepwater Horizon source oil and the chemical dispersant, Corexit® 9500, to coral larvae. PLOS One 8(1): e45574.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2003). A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal*, *37*(4), 16-34.

Green, B. S. and Gardner, C. 2009. Surviving a sea-change: survival of southern rock lobster (Jasus edwardsii) translocated to a site of fast growth. ICES Journal of Marine Science 66: 656–664.

Greene, C.D. Englehardt, F.R. Paterson, R.J. (eds.). 1985. Proceedings of the workshop on effects of explosives in the marine environment, 29-31 January 1985, Halifax. Can. Oil and Gas Lands Admin. Environ. Prot. Br. Ottawa, Ont. Tech. Rep. No. 5.

Guinea, M.L. 1995. The sea turtles and sea snakes of Ashmore Reef Reserve. Northern Territory University, Darwin.

Haddon. M. 2017. On the Potential Effects of a Seismic Survey on Commercial Fishery Catch Rates in the Great Australian Bight. In: Tuck, G.N. (ed.) 2018. Stock Assessment for the Southern and Eastern Scalefish and Shark Fishery 2016 and 2017. Part 2, 2017. Australian Fisheries Management Authority and CSIRO Oceans and Atmosphere, Hobart, pages 822-829.

Hancock, B. 2004. The biology and fishery of Roe's abalone Haliotis roei Gray in south-western Australia, with emphasis on the Perth fishery. PhD thesis, University of Western Australia. 184pp.

Harrington, J.J. McAllister, J. and Semmens, J.M. 2010. Assessing the short-term impact of seismic surveys on adult commercial scallops (Pecten fumatus) in Bass Strait. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.

Harris, R.E. Miller, G.W. & Richardson, W.J. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4): 795–812. doi: 10.1111/j.1748-7692.2001.tb01299.x

Harrison, P.L. 1999. Oil pollutants inhibit fertilisation and larval settlement in the scleractinian reef coral *Acropora tenuis* from the Great Barrier Reef, Australia in Sources, Fates and Consequences of Pollutants in the Great Barrier Reef and Torres Strait. Conference abstracts. Great Barrier Reef Marine Park Authority, Townsville, Queensland.

Hart, A.M., Leporati, S.C., Marriott, R.J., and Murphy, D. 2016. Innovative development of the *Octopus aff. tetricus* fishery in Western Australia. FRDC Project No 2010/200. Fisheries Research Report No. 270. Department of Fisheries, WA.

Hart, A. Strain, L. Hesp, A. Fisher, E. Webster, F. Brand-Gardner, S. and Walters, S. 2017. Marine Stewardship Council Full Assessment Report Western Australian Abalone Managed Fishery. Department of Fisheries, Government of Western Australia, Perth. 288pp.

Hart, A.M. Murphy, D.M. Harry, A.V. and Fisher, E.A. 2018. Western Australian Marine Stewardship Council Report Series No. 14: Resource Assessment Report Western Australian Octopus Resource. Department of Primary Industries and Regional Development. Government of Western Australia, Perth. Available from: https://www.fish.wa.gov.au/Documents/wamsc_reports/wamsc_report_no_14.pdf

Hassel, A. Knutsen, T. Dalen, J. Skaar, K. Løkkeborg, S. Misund, O.A. Østensen, Ø. Fonn, M. Haugland, E.K. 2004. Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). ICES Journal of Marine Science 61: 1165–1173.

Hastings, M.C. Popper, A.N. 2005. Effects of Sound on Fish. Technical report under Jones &and Stokes for the California Department of Transportation, Sacramento, CA.

Hatcher, A.I. and Larkum, A.W.D. 1982. The effects of short term exposure to Bass Strait Crude Oil and Corexit 8667 on benthic community metabolism in Posidonia australis Hook.f. dominated microcosms. Aquatic Botany, 12: 219-227

Hawkins, A.D. 2014. Responses of Free-Living Coastal Pelagic Fish to Impulsive Sounds. Proceedings of the 2nd International Conference on Environmental Interactions of Marine Renewable Energy Technologies (EIMR2014), 28 April – 02 May 2014, Stornoway, Isle of Lewis, Outer Hebrides, Scotland.

Hawkins, A.D. and Popper, A.N. 2012. Effects of noise on fish, fisheries, and invertebrates in the U.S. Atlantic and Arctic from energy industry sound-generating activities workshop report. Prepared by Normandeau Associates Inc. New Hampshire, USA for U.S. Department of the Interior, Bureau of Ocean Energy Management, Washington D.C.

Hawkins, A.D. Roberts, L. and Cheesman, S. 2014. Responses of free-living coastal pelagic fish to impulsive sounds. Journal of the Acoustical Society of America. 135(5): 3101-3116.

Hawkins, A.D. and Popper, A.N. 2017. A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. ICES Journal of Marine Science 74(3): 635-651.

Hayes, K. R. Lynne, V, Dambacher, J. M. Sharples, R & Smith, R, 2008. Ecological indicators for the exclusive economic zone waters of the South-west Marine Region. Final report (08/82) prepared by CSIRO, Hobart, for the Australian Government Department of the Environment and Heritage, Canberra.

Hayes, E. H. Fullagar, R. Field, J. H. et al. 2022. 65,000-years of continuous grinding stone use at Madjedbebe, Northern Australia. *Sci Rep*, vol. 12, 11747. Available at: https://doi.org/10.1038/s41598-022-15174-x

Hazel, J & Gyuris, E. 2006. Vessel-related mortality of sea turtles in Queensland, Australia. Wildlife Research - WILDLIFE RES. 33. 10.1071/WR04097.

Hazel, J, Lawler, I, Marsh, H, Robson, S. 2007. Vessel speed increases collision risk for the green turtle Chelonia mydas. Endangered Species Research. 3. 105-113. 10.3354/esr003105.

Hazel, J. Lawler, I.R. and Hanmann, M. 2009. Diving at the shallow end: Green turtle behaviour in near-shore foraging habitat, vol. 371, no. 1, pp. 84-92.

Hedley, S. L. Bannister, J. L. & Dunlop, R. A, 2011. Abundance estimates of Breeding Stock 'D' Humpback Whales from aerial and land-based surveys off Shark Bay, Western Australia, 2008. *Journal of Cetacean Research and Management*, Special Issue 3: 209-221.

Hegge, B, 1994. Low-energy sandy beaches of Southwestern Australia: two-dimensional morphology, sediments and dynamics. PhD Thesis, University of Western Australia.

Heitmeyer, R.M.; Wales, S.C. Pflug, L.A. 2003. Shipping Noise Predictions: Capabilities and Limitations. Marine Technology Society Journal, 37(4): 54-65.

Hesp, S. A, Potter, I. C, Hall, N. G. 2002. Age and size composition, growth rate, reproductive biology, and habitats of the West Australian dhufish (*Glaucosoma hebraicum*) and their relevance to the management of this species. *Fishery Bulletin*, vol. 100 (2), pp. 214 – 227.

Heyward, A.J. Farrell, P.D. & Seamark, R.F. 1994. The effect of petroleum based pollutants on coral gametes and fertilisation success. In: Proceedings of the Sixth Pacific Congress on Marine Science and Technology (p 119), Townsville, Queensland.

Heyward, A, Moore, C, Radford, B, Colquhoun, J. 2010. Monitoring program for the Montara Well Release Timor Sea: Final report on the nature of Barracouta and Vulcan Shoals. Report prepared by the Australian Institute of Marine Science for PTTEP Australasia (Ashmore Cartier) Pty. Ltd. in accordance with Contract No.: 000/2009/10-23. https://www.dcceew.gov.au/sites/default/files/env/pages/bcefac9b-ebc5-4013-9c88-a356280c202c/files/banks-shoals-report.pdf

Heyward, A. Colquhoun, J. Cripps, E. McCorry, D. Stowar, M. Radford, B. Miller, K. Miller, I. and Battershill, C. 2018. No evidence of damage to the soft tissue or skeletal integrity of mesophotic corals exposed to a 3D marine seismic survey. Marine Pollution Bulletin 129: 8-13.

Higgins, P.J. 2003. Handbook of Australian, New Zealand and Antarctic Birds Volume 6 Pardalotes to Strike Thrushes. Oxford University Press Australia.

Hillary, R.M. Bravington, M.V. Patterson, T.A. et al. 2018. Genetic relatedness reveals total population size of white sharks in eastern Australia and New Zealand. Sci Rep 8, 2661. https://doi.org/10.1038/s41598-018-20593-w

Holliday, D.V. Pieper, R.E. Clarke, M.E. and Greenlaw, C.F. 1987. The effects of airgun energy releases on the eggs, larvae and adults of the northern anchovy (*Engraulis mordax*). API Publication 4453. Report by Tracor Applied Sciences for American Petroleum Institute, Washington D.C, USA.

Holliday, D. Beckley, L.E. Weller, E. Sutton, A.L. 2011. Natural variability of macro-zooplankton and larval fishes off the Kimberley, north-western Australia: preliminary findings. Journal of the Royal Society of Western Australia 94: 181-195.

Holst, M. Richardson, W.J. Koski, W.R. Smultea, M.A. Haley, B. Fitzgerald, M.W. Rawson, M. 2006. Effects of Large and Small-Source Seismic Surveys on Marine Mammals and Sea Turtles. American Geophysical Union, Fall Meeting 2007, abstract id. OS42A-01.

Hook, S. Batley, G. Holloway, M. Irving, P. and Ross, A. 2016. Oil Spill Monitoring Handbook. CSIRO Publishing. Melbourne.

Horwood, J.W. 1987. The Sei Whale: Population Biology, Ecology and Management. Croom Helm Ltd, New York.

Houde, E.D. and Zastrow, C.E. 1993. Ecosystem- and taxon-specific dynamic and energetics properties of larval fish assemblages. Bulletin of Marine Science 53 (2): 290-335.

How, J.R, Webster, F.J, Travaille, K.L, Nardi, K. Harry, A.V, 2015. Western Australian Marine Stewardship Council Report Series No. 4: West Coast Deep Sea Crustacean Managed Fishery. Department Primary Industries and Regional Development. Government of Western Australia, Perth.

Howey-Jordan LA, Brooks EJ, Abercrombie DL, Jordan LKB, Brooks A, et al. 2013. Complex Movements, Philopatry and Expanded Depth Range of a Severely Threatened Pelagic Shark, the Oceanic Whitetip (*Carcharhinus longimanus*) in the Western North Atlantic. PLoS ONE 8(2): e56588. doi:10.1371/ journal.pone.0056588

Hubert, J. Campbell, J.A. and Slabbekoorn, H. 2020. Effects of seismic airgun playbacks on swimming patterns and behavioural states of Atlantic cod in a net pen. Marine Pollution Bulletin 160: 111680.

Hueter, R.E. Tyminski, J.P. Morris, J.J. Abierno, A.R. and Valdes, J.A. 2016. Horizontal and vertical movements of longfin mako (Isurus paucus) tracked with satellite-linked tags in the northwestern Atlantic Ocean. Fishery Bulletin 115(1): 101–116.

Irvine, L.M. Palacios, D.M. Lagerquist, B.A. Mate, B.R. 2019. Scales of Blue and Fin Whale Feeding Behavior off California, USA, With Implications for Prey Patchiness. Frontiers in Ecology and Evolution 7(338). https://doi.org/10.3389/fevo.2019.00338.

Jackson, J.B.C. Cubit, J.D. Keller, B.D. Batista, V. Burns, K. Caffey, H.M. Caldwell, R.L. Garrity, S.D. Getter, C.D. Gonzalez, C. Guzman, H.M. Kaufmann, K.W. Knap, A.H. Levings, S.C. Marshall, M.J. Steger, R. Thompson, R.C. & Weil, E. 1989. Ecological effects of a major oil spill on Panamanian coastal marine communities. Science, 243: 37–44.

Jenner, K. C. S. Jenner, M-N. M. & McCabe, K. A, 2001. Geographical and Temporal Movements of Humpback Whales in Western Australian Waters, *APPEA Journal*, vol. 441, no. 1, pp. 749-765.

Jenner, C. Jenner, M. Kent, C. S. Bouchet, P. Dunlop, R. and Burton, C. 2010. A comparison of southern hemisphere breeding stock 'D' humpback whale population estimates from two key locations along the Western Australian coast. Final Report for Australian Marine Mammal Centre. The Centre for Whale Research, Western Australia.

Jenner, C. and Jenner, M. 2011. Field Report: A description of humpback whale and other megafaun distribution and abundance in the Western Pilbara using aerial surveys 2009/2010. Available at: Humpback Whale Distribution and Abundance in the Near Shore SW Kimberley During Winter 2008 (seaturtle.org)

Jensen A.S. and Silber G.K. (2003) Large whale ship strike database. USDepartment of Commerce, NOAA Technical Memorandum. NMFS-OPR-, 37 pp.

Johnson, C.M. Beckley, L.E. Kobryn, H. Johnson, G.E. Kerr, I. and Payne, R. 2016. Crowdsourcing modern and historical data identifies sperm whale (Physeter macrocephalus) habitat offshore of South-Western Australia. Frontiers in Marine Science, 3, p.167.

Jones, I.T. Stanley, J.A. Mooney, T.A. 2020. Impulsive pile driving noise elicits alarm responses in squid (*Doryteuthis pealeii*), Marine Pollution Bulletin, 150: 110792.

Kaifu, K. Akamatsu, T. Segawa, S. 2008. Underwater sound detection by cephalopod statocyst. Fisheries Science, 74: 781–786.

Kangas, M, Chandrapavan, A, Wilkins, A, Fisher, E. A. & Evans, S, 2021. Resource Assessment Report Abrolhos Islands and Mid-West Trawl Managed Fishery Resource. Western Australian Marine Stewardship Council Report Series No. 20. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Kato, H, 2002. Bryde's Whales *Balaenopetra edeni* and *B. brydei,* in Perrin, W. F. Wrsig, B, and Thewissen, H. G. M. (eds.). *Encyclopaedia or Marine Mammals*, Academic Press, pp. 171-177.

Keller, K, Blake, S, and Cao, A, 2023. Western Deepwater Trawl Fishery. Fishery Status Reports 2023. Australian Bureau of Agricultural and Resource Economics and Sciences. Australian Government, Canberra.

Kemper, C. M. 2002. Distribution of the pygmy right whale, *Caperea marginata*, in the Australasian region. *Marine Mammal Science*, vol. 18(1), pp.99-111.

Kemper, C.M. Middleton, J.F. and van Ruth, P.D. 2013. Association between pygmy right whales (Caperea marginata) and areas of high marine productivity off Australia and New Zealand. New Zealand Journal of Zoology, 40(2), pp.102-128.

Kemper C. M, Steele-Collins E, Al-Humaidhi A, Segawa Fellowes T, Marsh O and Charlton C. 2022. Encounter Bay, South Australia, an Important Aggregation and Nursery Area for the Southern Right Whale, Eubalaena Australis (Balaenidae: Cetacea). *Transactions of the Royal Society of South Australia*, 1-21. DOI: https://doi.org/10.1080/03721426.2021.2018759.

Kennish, M.J. 1996. Practical handbook of Estuarine and Marine Pollution. Boca Raton, FL: CRC Press.

King, P. P. 1826. Narrative of a survey of the intertropical and western coasts of Australia: performed between the years 1818 and 1822. London, John Murray.

Kipple, B. Gabriel, C. 2004. Glacier Bay watercraft noise – Noise characterization for tour, charter, private, and government vessels, Technical report for Glacier Bay National Park and Reserve.

Knap, A.H. Sleeter, T.D. Dodge, R.E. Wyers, S.C. Frith, H.R. & Smith, S.R. 1985. The effects of chemically and physically dispersed oil on the brain coral *Diploria strigose* (Dana)—a summary review. pp. 547–551 in American Petroleum Institute, Proceedings 1985 Oil Spill Conference. API Publication Number 4385. Washington D.C. USA.

Koessler, M.W. and C.R. McPherson. 2023. Eureka 3D Marine Seismic Survey: Acoustic Modelling for Assessing Marine Fauna Sound Exposures. Document 03034, Version 1.0. Technical report by JASCO Applied Sciences for RPS Australia.

Koops, W, Jak, RG & van der Veen, DPC 2004. Use of dispersants in oil spill response to minimize environmental damage to birds and aquatic organisms, in Proceedings of Interspill 2004, Trondheim, Norway, paper no. 429.

Kordjazi, Z. Frusher, S. Buxton, C. D. and Gardner, C. 2015. Estimating survival of rock lobsters from long-term tagging programmes: how survey number and interval influence estimates. ICES Journal of Marine Science 72: 244–251.

Koshleva, V. 1992. The impacts of air guns used in marine seismic explorations on organisms living in the Barents Sea. Fisheries and Offshore Petroleum Exploitation, 2nd International Conference, Bergen, Norway, 6-8 April 1992.

Koslow, J.A. Greenwood, J. Lourey, M. Rosebrock, U. Wild-Allen, K. Margvelashvili, N. Pesant, S. Keesing, J. and Heine, J. 2006. Coastal and shelf biogeochemistry and modelling. Strategic research fund for the marine environment final report, 2, pp.123-185.

Kostyuchenko, L. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. Hydrobiological Journal 9: 45–48.

Ladich, F. Fay, R.R. 2013. Auditory evoked potential audiometry in fish. Reviews in Fish Biology and Fisheries 23(3): 317-364.

Laist, D.W. & Shaw, C. 2006. PRELIMINARY EVIDENCE THAT BOAT SPEED RESTRICTIONS REDUCE DEATHS OF FLORIDA MANATEES. Marine Mammal Science, 22, 472-479.

Laist, D. W. Knowlton, A. R. Mead, J. G. Collet, A. S. and Podesta, M. (2001). Collisions between ships and whales. Mar. Mamm. Sci. 17, 35–75. doi: 10.1111/j.1748-7692.2001.tb00980.x

Lalas, C. & McConnell, H. 2016. Effects of seismic surveys on New Zealand fur seals during daylight hours: Do fur seals respond to obstacles rather than airgun noise? Marine Mammal Science, 32(2): 643–663. doi: 10.1111/mms.12293

Last, P.R. and Stevens J.D. 2009. Sharks and Rays of Australia. CSIRO Publishing, Melbourne, pp. 550

Lemm, A, Hegge B and Masselink, G, 1999. Offshore wave climate, Perth (Western Australia), 1994–96. *Marine and Freshwater Research*, 50(2), 92–102.

Lenanton, R, StJohn, J, Keay, I, Wakefield, C, Jackson, G, Wise, B and Gaughan, D, 2009. Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 2: Stock structure and biology of two indicator species, West Australian dhufish (*Glaucosoma hebraicum*) and pink snapper (*Pagrus auratus*), in the

West Coast Bioregion. Final report to Fisheries Research and Development Corporation on Project No. 2003/052. Fisheries Research Report No. 174. Department of Fisheries, Government of Western Australia, Perth.

Leporati, S. C, & Hart, A. M. 2015. Stylet weight as a proxy for age in a merobenthic octopus population. *Fisheries Research*, vol. 161, pp. 235-243.

Lewis, P, Mitsopoulos, G and & Molony, B. 2012. Identification of critical habitats for juvenile dhufish (*Glaucosoma hebraicum*). NRM Project 09038 – Protecting Inshore and Demersal Finfish. Fisheries Research Report No. 238. Department of Fisheries, Government of Western Australia, Perth.

Lewis, P, 2020. Statewide Large Pelagic Resource in Western Australia. Resource Assessment Report No. 19. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Lewis M, Pryor R. 2013. Toxicities of oils, dispersants and dispersed oils to algae and aquatic plants: Review and database value to resource sustainability. Environmental Pollution 180:345–367

Liberman, M.C. 2015. Noise-induced hearing loss: permanent vs. temporary threshold shifts and the effects of hair-cell versus neuronal degeneration. pp. 1-7 in Popper, A.N. and Hawkins, A.D. (eds.) The effects of noise on aquatic life II. Springer, New York, USA.

Limpus, C.J. 2008a. A Biological Review of Australian Marine Turtle Species. 1. Loggerhead turtle, *Caretta* (Linneaus). The State of Queensland, Environmental Protection Agency, Australia.

Limpus, C.J. 2008b. A Biological Review of the Australian Marine Turtles 2. Green turtle *Chelonia mydas* (Linnaeus). The State of Queensland, Environmental Protection Agency, Australia.

Limpus, C.J (2009). A biological review of Australian marine turtle species. 6. Leatherback turtle, *Dermochelys coriacea* (Vandelli). Queensland: Environmental Protection Agency. Lindsey, T.R. 1986. The Seabirds of Australia. Angus and Robertson, Australia.

Lindsay, M. C. M. and Meathrel, C. E. 2008. Where, when and how? Limitations of the techniques used to examine dietary preference of Pacific gulls (*Larus pacificus*) using non-consumed parts of prey and regurgitated pellets of prey remains. Waterbirds 31, 611–619.

Long, T.M. Hanlon, R.T. Maat, A.T. Pinsker, H.M. 1989. Non-associative learning in the squid *Lolliguncula brevis* (Mollusca, Cephalopoda). Marine & Freshwater Behaviour & Physiology, 16(1), 1-9.

López, N.A. McAuley, R.B. and Meeuwig, J.J. 2022. Identification of the southernmost aggregation of scalloped hammerhead sharks (*Sphyrna lewini*) in Australia. Austral Ecology, 47: 717-722. https://doi.org/10.1111/aec.13149

Loya, Y. & Rinkevich, B. 1980. Effects of oil pollution on coral reef communities. Marine Ecology Progress Series, 3: 167–180.

MacArthur, L, Hyndes, G & Babcock, R, 2007. Western rock lobster in ecosystem processes of south-western Australia. Final report to Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

MacArthur, L. D., Hyndes, G. A., Babcock, R. C., & Vanderklift, M. A. 2008. Nocturnally active western rock lobsters Panulirus cygnus forage close to shallow coastal reefs. *Aquatic Biology*, *4*(2), 201-210.

Mackintosh, N. A, 1965. The stocks of whales. Fishing News (Books) Ltd, London.

Marchant, S. & Higgins, P.J. (eds) 1990. Handbook of Australia, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks. Oxford University Press, Melbourne, Victoria

Marshall, A. Kashiwagi, T. Bennett, M.B. Deakos, M. Stevens, G. McGregor, G. Clark, T. Ishiara, H. and Sato, K. 2018. *Mobila alfredi*–IUCN Red List of Threatened Species. Available at https://www.iucnredlist.org/species/195459/126665723. Accessed on 15 May 2019.

Martin, J. Keag, M. Newman, S. and Wakefield, C. 2014. Goldband Snapper *Pristipomoides multidens*. Accessed online on 27 February 2019 at https://www.fish.gov.au/2014-Reports/Goldband_Snapper.

Marquez, R. 1990. FAO species catalogue; Sea Turtles of the World. An annotated and illustrated catalogue of the sea turtle species known to date. *FAO Fisheries Synopsis*, vol. 11, no. 125, pp. 81. Rome: Food and Agriculture Organisation of United Nations.

Marriott, R. Jackson, G. Lenanton, R. Telfer, C. Lai, E. Stephenson, P. Bruce, C. Adams, D. Norriss, J. 2012. Biology and stock status of inshore demersal scalefish indicator species in the Gascoyne Coast Bioregion. Fisheries Research Report No. 228. Department of Fisheries, Western Australia. 216 pp.

Masselink, G & Pattiaratchi, C. B, 2001. Characteristics of the Sea Breeze System in Perth, Western Australia, and Its Effect on the Nearshore Wave Climate. *Journal of Coastal Research*,17(1), pp 173-187.

Matishov, G.G. 1992. The reaction of bottom-fish larvae to airgun pulses in the context of the vulnerable Barent Sea ecosystem. Fisheries and Offshore Petroleum Exploitation, 2nd International Conference. Bergen, Norway, 6-8 April 1992.

McClatchie, S, Middleton, J, Pattiaratchi, C, Currie, D, and Kendrick, G 2006. The South-west Marine Region: Ecosystems and Key Species Groups. Department of Environment and Water Resources. Australian Government, Canberra. Available at: https://parksaustralia.gov.au/marine/pub/scientific-publications/archive/sw-ecosystems-part1.pdf.

McCauley, R.D. 1994. Seismic surveys. In: Environmental Implications of Offshore Oil and Gas Development in Australia - The Findings of an Independent Scientific Review, Swan, J.M. Neff, J.M. and Young, P.C. (eds.). Australian Petroleum Exploration Association, Sydney, pp. 19–122.

McCauley R.D. Jenner, C. 2001. The underwater acoustic environment in the vicinity of Vincent and Enfield petroleum leases. North West Cape, Exmouth, WA. Report for Woodside Energy, by CMST, Curtin University, R2201-22, 42 pp.

McCauley, R.D. Fewtrell, J. Duncan, A.J. Jenner, C. Jenner, M.-N. Penrose, J.D. Prince, R.I.T. Adhitya, A. Murdoch, J. et al. 2000a. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on Humpback whales, sea turtles, fishes and squid. Report Number R99-15. Prepared for Australian Petroleum Production Exploration Association by Centre for Marine Science and Technology, Western Australia. 198 pp.

McCauley, R.D. Fewtrell, J. Duncan, A.J. Jenner, C. Jenner, M.-N. Penrose, J.D. Prince, R.I.T. Adhitya, A. Murdoch, J. et al. 2000b. Marine seismic surveys: A study of environmental implications. Australian Petroleum Production Exploration Association (APPEA) Journal 40(1): 692-708.

McCauley, R.D. Fewtrell, J. Duncan, A.J. Jenner, C. Jenner, M-N. Penrose, J.D. Prince, R.I.T. Adhitya, A. Murdoch, J. and McCabe, K. 2003. Marine seismic surveys: analysis and propagation of air-gun signals; and effects of exposure on Humpback whales, sea turtles, fishes and squid. In: Anon eds.), Environmental implications of offshore oil and gas development in Australia: further research, Australian Petroleum Production Exploration Association, Canberra.

McCauley, R.D. and Salgado Kent, C. 2007. Observations, catch and ear pathology of caged fish exposed to seismic survey passes. For Santos, Ltd. CMST Report R2007-19.

McCauley, R.D. Salgado Kent, C. and Archer, M. 2008. Impacts of seismic survey pass-bys on fish hearing and caged fish behaviour, Scott Reef Lagoon, Western Australia. Prepared for ERM and Woodside Energy, CMST Report No. 2008-52, Curtin University, Perth, Australia.

McCauley, R.D. Day, R.D. Swadling, K.M. Fitzgibbon, Q.P. Watson, R.A. and Semmens, J.M. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. Nature Ecology and Evolution 1: 1-8.

McCauley, R.D. and Duncan, A.J. 2011. Sea Noise Logger Deployment, Wheatstone and Onslow, April 2009 to November 2010: Great whales, fish and man-made noise sources. CMST tech. Report R2011-23, Curtin University of Technology, Perth, Western Australia.

McCauley R.D. and Jenner, C. 2010. Migratory patterns and estimated population size of Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) traversing the Western Australian coast based on passive acoustics. Paper SC/62/SH26 presented to the IWC Scientific Committee (unpublished).

McCauley, R. D. Gavrilov, A. N, Jolliffe, C. D, Ward, R, Gill, P. C, 2018. Pygmy blue and Antarctic blue whale presence, distribution and population parameters in southern Australia based on passive acoustics. Deep Sea Research Part II: *Topical Studies in Oceanography*, vol. 157-158, pp. 154-168.

McCay, DF, Rowe, JJ, Whittier, N, Sankaranarayanan, S, Etkin, DS. 2004. Estimation of potential impacts and natural resource damages of oil. Journal of Hazardous Materials, 107(1-2), pp 11-25.

McKinnon, A.D. Duggan, S. Carleton, J.H. Böttger-Schnack, R. 2008. Summer planktonic copepod communities of Australia's North West Cape (Indian Ocean) during the 1997-99 El Niño/La Niña. Journal of Plankton Research 30(7): 839-855.

McQueen, K. Meager, J.J. Nyqvist, D. Skjæraasen, J.E. Olsen, E.B. Karlsen, Ø. Kvadsheim, P.H. Handegard, N.O. Forland, T.N. Sivle, L.D. 2022 Spawning Atlantic cod (*Gadus morhua L.*) exposed to noise from seismic airguns do not abandon their spawning site, ICES Journal of Marine Science, 79(10): 2697–2708.

McQueen, K. Skjæraasen, J.E. Nyqvist, D. Olsen, E.B. Karlsen, Ø. Meager, J.J. Kvadsheim, P.H. Handegard, N.O. Forland, T.N. de Jong, K. Sivle, L.D. 2023. Behavioural responses of wild, spawning Atlantic cod (Gadus morhua L.) to seismic airgun exposure. ICES Journal of Marine Science, 80(4): 1052-1065.

Meekan, M, Wilson, SG, Halford, A, Retzel, A. 2001. A comparison of catches of fishes and invertebrates by two light trap designs, in tropical NW Australia. Marine Biology. 139. 373-381. 10.1007/s002270100577.

Meekan, M.G. Speed, C.W. McCauley, R.D. Fisher, R. Birt, M.J. Currey-Randall, L.M. Semmens, J.M. Newman, S.J. Cure, K. Stowar, M. Vaughan, B. Parsons, M.J.G. 2021. A large-scale experiment finds no evidence that a seismic survey impacts a demersal fish fauna. Proceedings of the National Academy of Sciences of the United States of America 118(30): e2100869118.

Melville-Smith, R. & Beale, N.E. 2009. Movement patterns of individual migrating western rock lobster, Panulirus cygnus, in Western Australia, New Zealand Journal of Marine and Freshwater Research, 43:5, 1095-1102.

Melville-Smith, R, Norton, S. M. G & Thomson, A. W, 2007. Biological and Fisheries Data for Managing Deep Sea Crabs in Western Australia. Final report to the FRDC on Project No. 2001/055. Fisheries Research Report No. 165. Department of Fisheries, Western Australia, 248 pp.

Milicich, M. J. Meekan, M. G. & Doherty, P. J. 1992. Larval supply: a good predictor of recruitment of three species of reef fish (Pomacentridae). Marine Ecology Progress Series, 86(2), 153–166. http://www.jstor.org/stable/24830497

Miller, I.R. and Cripps, E. 2013. Three-dimensional marine seismic survey has no measurable effect on species richness or abundance of a coral reef associated fish community. Marine Pollution Bulletin 7(1-2), 63-70. Möller, L.M. Attard, C.R.M. Bilgmann, K,. Andrews-Goff, V. Jonsen, I. Paton, D. Double M.C. 2020. Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. Scientific Reports 10(1): 21165. https://doi.org/10.1038/s41598-020-78143-2.

Miller, A., de Lestang, S., How, J., Gibbons, B., Lester, E., Navarro, M., Fitzhardinge, J., Brooker, M. and Langlois, T., 2023. Fine-scale variability in catch and growth rates of western rock lobsters (Panulirus cygnus) show heterogeneous life-history parameters. Marine and Freshwater Research, 74(4), pp.335-346.

MMOA Executive Committee, 2022. Marine Mammal Observer Association (MMOA): Position Statements. Key issues that should be addressed when developing mitigation plans, to minimise the effects of anthropogenic effects on marine fauna. Version 3. Consultation Document – February 2022, 32pp.

Moran, M, Burton, C and Jenke, 2003. Long-term movement patterns of continental shelf and inner gulf snapper (*Pagrus auratus*, Sparidae) from tagging in the Shark Bay region of Western Australia. *Marine and Freshwater Research*, vol. 54, pp. 913 – 922.

Morley, E.L. Jones, G. and Radford, A.N. 2014. The importance of invertebrates when considering the impacts of anthropogenic noise. Proceedings of the Royal Society B 281: 20132683.

Morris, C.J. Cote, D. Marin, B. Kehler D. 2018. Effects of 2D seismic on the snow crab fishery. Fisheries Research. 197, 67-77.

Morris, C.J. Cote, D. Martin, S.B. Mullowney, D. 2020. Effects of 3D seismic surveying on snow crab fishery. Fisheries Research, 232: 105719.

Moein, S.E. Musick, J.A. Keinath, J.A. Barnard, D.E. Lenhardt, M.L. and George, R. 1995. Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges, in Sea Turtle Research Program: Summary Report. In: Hales, L.Z. (ed.). Report from U.S. Army Engineer Division, South Atlantic, Atlanta GA, and U.S. Naval Submarine Base, Kings Bay GA. Technical Report CERC-95. 90 pp.

Moulton, V.D. Miller, G.W. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. In: K. Lee, H. Bain, & G.V. Hurley (eds.), Acoustic monitoring and marine mammal surveys in The Gully and outer Scotian Shelf before and during active seismic programs (pp. 29-40). Environmental Studies Research Funds Report No. 151. 154 pp.

Nedelec, S.L. Campbell, J. Radford, A.N. Simpson, S.D. and Merchant, N.D. 2016. Particle motion: the missing link in underwater acoustic ecology. Methods in Ecology and Evolution doi: 10.1111/2041-210X.12544.

Nedwell, J.R. Edwards, B. Turnpenny, A.W.H. Gordon, J. 2004. Fish and marine mammal audiograms: a summary of available information. Subacoustech Report ref: 534R0214.

Negri, A.P. & Heyward, A.J. 2000. Inhibition of fertilization and larval metamorphosis of the coral *Acropora millepora* (Ehrenberg, 1834) by petroleum products. Marine Pollution Bulletin, 41(7-12): 420-427.

Nelms, SE, Duncan, EM, Broderick, AC, Galloway, TS, et al. 2016. Plastic and marine turtles: a review and call for research. .ICES J Mar Sci, 73: 165−181

Newman, S.J. Young, G. C. Travers, M. J. Pember, M. B. Skepper, C. L. Williamson, P. C. and Potter, I. C. 2003. Characterisation of the inshore fish assemblages of the Pilbara and Kimberley coasts. Final Report to the Fisheries Research and Development Corporation for Project 2000/132. Fisheries Research and Development Corporation, Canberra, ACT.

Newman, S.J. Wise, B.S. Santoro, K.G. and Gaughan, D.J. (eds), 2021. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2020/21: The State of the Fisheries. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Newman, S.J., Santoro, K.G. and Gaughan, D.J. (eds). 2023. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2022/23: The State of the Fisheries. Department of Primary Industries and Regional Development, Western Australia.

Newman, S.J. Wise, B.S. Santoro, K.G. and Gaughan, D.J. (eds), 2023. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2021/22: The State of the Fisheries. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

New Zealand Birds Online, 2023. The digital encyclopedia of New Zealand birds. https://nzbirdsonline.org.nz/

Noriega, R, Davis, K, and Tuynman, H, 2023. Small Pelagic Fishery. Fishery Status Reports 2023. Australian Bureau of Agricultural and Resource Economics and Sciences. Australian Government, Canberra.

Nowacek, D.P. Johnson, M.P. Tyack, P.L. 2004. North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli Proceedings of the Royal Society B: Biological Sciences, 271: 227-231, doi.10.1098/rspb.2003.2570.

O'Brien, P. Y. & P. S. Dixon, 1976. The Effects of Oil and Oil Components on Algae: A review. British Phycological Journal 11:115-142.

Owen, K. Jenner, C.S. Jenner, M.-N.M. Andrews, R.D. 2016. A week in the life of a pygmy blue whale: Migratory dive depth overlaps with large vessel drafts. Animal Biotelemetry 4: 17. https://doi.org/10.1186/s40317-016-0109-4.

Pace, R. M. and G. K. Silber. 2005. Simple analysis of ship and large whale collisions: Does speed kill? Presentation at the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, CA, December 2005. Compendium of Abstracts.

Palmer, L., Gillespie, D., MacAulay, J. D., Sparling, C. E., Russell, D. J., & Hastie, G. D. (2021). Harbour porpoise (Phocoena phocoena) presence is reduced during tidal turbine operation. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(12), 3543-3553.

Parker, J.R.C. Saunders, B.J. Bennett, S. DiBattista, J.D. Shalders, T.C. & Harvey, E.S. 2019. Shifts in Labridae geographical distribution along a unique and dynamic coastline. Diversity and Distributions, 25(11): 1787-1799.

Parry, G.D. Heislers, S. Werner, G.F. Asplin, M.D. and Gason, A. 2002. Assessment of Environmental Effects of Seismic Testing on Scallop Fisheries in Bass Strait. Marine and Freshwater Resources Institute Report No. 50. Marine and Freshwater Resources Institute, Queenscliff, Victoria.

Parry, G.D. and Gason, A. 2006. The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. Fisheries Research 79:272-284.

Parsons, M.J.G. Barneche, D.R. Speed, C.W. McCauley, R.D. Day, R.D. Dang, C. Fisher, R. Gholipour-Kanani, H. Newman, S.J. Semmens, J.M. & Meekan, M.J. 2024. A large-scale experiment finds no consistent evidence of change in mortality or commercial productivity in silverlip pearl oysters (*Pinctada maxima*) exposed to a seismic source survey. Marine Pollution Bulletin, 115480, https://doi.org/10.1016/j.marpolbul.2023.115480.

Parsons, M.J. Longbottom, S. Lewis, P. McCauley, R.D. & Fairclough, D.V. 2013. Sound production by the West Australian dhufish (*Glaucosoma hebraicum*). Journal of the Acoustical Society of America, 134(4): 2701-2709. doi: 10.1121/1.4818775.

Parsons, M. Lewis, P. Longbottom, S. McCauley, R. & Fairclough, D. 2012. Dhu they or don't they? A study of sound production by three fish species of commercial and recreational importance in Western Australia. Conference paper, Acoustics 2012: Acoustics, Development and the Environment, Fremantle, Western Australia.

Parvin, S.J. 1998. The effects of low frequency underwater sound on divers. Proceedings of Undersea Defence Technology, Wembley, pp 227-232.

Parvin, S. 2005. Limits for underwater noise exposure of human divers and swimmers. Subacoustech. Presented at the National Physics Laboratory Seminar on Underwater Acoustics, Teddington, UK.

Parvin, S.J. Nedwell, J.R. Thomas, A.J. Needham, K. Thompson, R. 1994. Underwater sound perception by divers: The development of an underwater hearing thresholds curve and its use in assessing the hazard to divers from waterborne sounds. Defence Research Agency Report Number DRA/AWL/CR941004, June 1994.

Patterson, D.L. Woehler, E.J. Croxall, J.P. Cooper, J. Poncet, S. Hunter, S. and Fraser, W.R. 2008. Breeding distribution and population status of the Northern Giant Petrel Macronectes halli and Southern Giant Petrel M. giganteus. *Marine Ornithology*, 36, pp.115-124.

Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Timmiss, T, Woodhams, J and Curtotti, R, 2023a. Fishery Status Reports 2023. Australian Bureau of Agricultural and Resource Economics and Sciences. Australian Government, Canberra.

Patterson, H, Bromhead, D, and Dylewski, M, 2023b. Western Tuna and Billfish Fishery. Fishery Status Reports 2023. Australian Bureau of Agricultural and Resource Economics and Sciences. Australian Government, Canberra.

Patterson, H and Dylewski, M, 2023. Southern Bluefin Tuna Fishery. Fishery Status Reports 2023. Australian Bureau of Agricultural and Resource Economics and Sciences. Australian Government, Canberra.

Pattiaratchi, C, 2007. Understanding areas of high productivity within the South-west Marine Region. Report for the National Oceans Office, pp.1-53.

Pattiaratchi, C & Hetzel, Y, 2020. Sea Surface Temperature Variability Time Series Report. State and Trends of Australia's Ocean Report. Integrated Marine Observing System (IMOS).

Pattiaratchi, C & Woo, M, 2009. The mean state of the Leeuwin Current system between North West Cape and Cape Leeuwin. *Journal of the Royal Society of Western Australia*, 92: 221–241.

Pavey, C. R. 1992. The occurrence of the Pygmy Right Whale *Caperea marginata* (Cetacea: Neobalaenidae), along the Australian coast. *Australian Mammalogy*, vol. 15(1), pp.1-6.

Paxton, A.B. Taylor, J.C. Nowacek, D.P. Dale, J. Cole, E. Voss, C.M. and Peterson, C.H. 2017. Seismic survey noise disrupted fish use of a temperate reef. Marine Policy 78: 68-73.

Payne, J.F. 2004. Potential effect of seismic surveys on fish eggs, larvae and zooplankton. CSAS Research Document 2004/125. Canadian Science Advisory Secretariat, Department of Fisheries and Oceans, Canada.

Payne, J.F. Andrews, C.A. Fancey, L.L. Cook, A.L. Christian, J.R. 2007. Pilot study on the effects of seismic air gun noise on lobster (*Homarus americanus*). Canadian Technical Report of Fisheries and Aquatic Sciences No. 2712. V+46.

Payne, J.F. Andrews, C. Fancey, L. White, D. and Christian, J. 2008. Potential Effects of Seismic Energy on Fish and Shellfish: An Update since 2003. Report Number 2008/060. Canadian Science Advisory Secretariat. 22 pp.

Payne, J. F. Coady, J. and White, D. 2009. Potential effects of seismic air gun discharges on monkfish eggs (Lophius americanus) and larvae. National Energy Board, Canada.

Pearce, A. F 1991. Eastern boundary currents of the Southern Hemisphere. *Journal of the Royal Society of Western Australia*, vol. 74: 35–45.

Pearce, A. F, Rossbach, M, Tait, M and Brown, R 1999. Sea temperature variability off Western Australia 1990 to 1994. Fisheries WA Research Report No. 111. Fisheries Western Australia, Government of Western Australia, Perth.

Pearce, A. Helleren, S. Marinelli, M. 2000. Review of productivity levels of Western Australian coastal and estuarine waters for mariculture planning purposes, in Fisheries Research Report 123, 57 pp. Fisheries Western Australia Perth, Australia.

Pearce, A. F, Buchan, S, Chiffings, T, D'Adamo, N, Fandry, C. B, Fearns, P. R. C. S, Mills, D. J, Phillips, R. C and Simpson, C 2003. A review of the oceanography of the Dampier Archipelago, Western Australia. Museum of Western Australia, Perth, Western Australia.

Pearce, A. F & Feng, M 2013. The rise and fall of the "marine heat wave" off Western Australia during the summer of 2010/2011. *Journal of Marine Systems*, vol. 111, pp: 139-156.

Pearson, W.H. Skalski, J.R. and Malme, C.I. 1992. Effects of sounds from a geophysical survey device on behaviour of captive rockfish (Sebastes spp.). Canadian Journal of Aquatic Science 49(7): 1343–1356.

Pearson, W.H. Skalski, J.R. Sulkin, S.D. and Malme, C.I. 1994. Effects of seismic releases on the survival of development of zoeal larvae of Dungeness crab (Cancer magister). Marine Environmental Research 38: 93-113.

Peinado, P., Day R.D, Semmens J.M 2024. Transferability of knowledge between Southern Rock lobster (*Jasus edwardsii*) and Western rock lobster (*Panulirus cygnus*). Institute for Marine and Antarctic Studies, University of Tasmania.

Peña, H. Handegard, N.O. and Ona, E. 2013. Feeding herring schools do not react to seismic air gun surveys. ICES Journal of Marine Science 70: 1174–1180.

Pendoley, K.L. Schofield, G. Whittock, P.A. Ierodiaconou, D and Hays G.C. 2014. Protected species use of a coastal marine migratory corridor connecting marine protected areas, vol. 161, no. 6, pp. 1455-1466.

Pestorius, F.M. Cudahy, E. Fothergill. D.M. 2009. Evolution of navy diver exposure standards for deterministic underwater sound in the 100-500 Hz band. Meetings on Acoustics. Volume 8: 070002.

Peters, E.C. Meyers, P.A. Yevich, P.P. & Blake, N.J. 1981. Bioaccumulation and histopathological effects of oil on a stony coral. Marine Pollution Bulletin, 12(10): 333–339.

Phillips, J. C. & Huisman, J. M. 2009. Influence of the Leeuwin Current on the Marine Flora of the Houtman Abrolhos. *Journal of the Royal Society of Western Australia*, (92), pp: 139–146.

Pichegru, L. Nyengera, R. McInnes, A.M. Pistorius, P. 2017. Avoidance of seismic survey activities by penguins. Scientific Reports, 7:16305, doi:10.1038/s41598-017-16569-x.

Pickett, G.D. Eaton, D. Seaby, R. Arnold, G. 1994. Results of Bass Tagging in Poole Bay during 1992. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Laboratory Leaflet.

Pidcock, S. Burton, C. and Lunne, M. 2003. The potential sensitivity of marine mammals to mining and exploration in the Great Australian Bight Marine Park Marine Mammal Protection Zone. An independent review and risk assessment report to Environment Australia. Commonwealth of Australia. 114 pp.

Popper AN. 2018. Potential for Impact of Cumulative Sound Exposure on Fishes During a Seismic Survey. Produced for Santos Ltd. Bethany 3D Seismic Survey Environment Plan Summary.

Popper, A.N. and Clarke, N.L. 1976. The auditory system of the goldfish (Carassius auratus): effects of intense acoustic stimulation. Comparative Biochemistry Physiology Part A: Physiology 53:11–18.

Popper, A.N. Smith, M.E. Cott, P.A. Hanna, B.W. MacGillivray, A.O. Austin, M.E and Mann, D.A. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117: 3958.

Popper, A.N. Carlson, T.J. Hawkins, A.D. Southall, B.L. Gentry, R.L. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper.

Popper, A.N. Halvorsen, M.B. Kane, E. Miller, D.L. Smith, M.E. Song, J. Stein, P. and Wysocki, l.E. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122:623–635.

Popper, A.N. and Fay, R.R. 2011. Rethinking sound detection by fishes. Hearing Research 273, 25-36.

Popper, A. Hawkins, A. Fay, R. Mann, D. Bartol, S. Carlson, T. Coombs, S. Ellison, W. Gentry, R. Halvorsen, M. Løkkeborg, S. Rogers, P. Southall, B. Zeddies, D. and Tavolga, W. 2014, ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Part of the series SpringerBriefs in Oceanography pp 15-16.

Popper, A.N. Carlson, T.J. Gross, J.A. Hawkins, A.D. Zeddies, D.G. Powell, L. and Young, J. 2016. Effects of seismic air guns on pallid sturgeon and paddlefish. In: Popper, A.N. and Hawkins, A.D. (eds.). The Effects of Noise on Aquatic Life II. Volume 875. Springer, New York. pp 871-878.

Popper, A.N. and Hawkins, A.D. 2018. The importance of particle motion to fishes and invertebrates. Journal of the Acoustical Society of America 143 (1): 470-488.

Popper, A.N. and Hawkins, A.D. 2019. An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. Journal of Fish Biology 2019: 1-22.

Przeslawski, R. Hurt, L. Forrest, A. Carrol, A. and Geoscience Australia, 2016a. Potential short-term impacts of marine seismic surveys on scallops in the Gippsland Basin. Canberra. April. CC BY 3.0.

Przeslawski, R. Bruce, B. Carroll, A. Anderson, J. Bradford, R. Durrant, A. Edmunds, M. Foster, S. Huang, Z. Hurt, L. Lansdell, M. Lee, K. Lees, C. Nichols, P. and Williams, S. 2016b. Marine Seismic Survey Impacts on Fish and Invertebrates: Final Report for the Gippsland Marine Environmental Monitoring Project. Record 2016/35. Geoscience Australia, Canberra. 63 pp.

Przeslawski, R. Brooke, B. Carroll, A.G. Fellows, M. 2018. An integrated approach to assessing marine seismic impacts: Lessons learnt from the Gippsland Marine Environmental Monitoring project. Ocean & Coastal Management. Volume 160, 15 June 2018, pp 117 – 123.

PTTEP 2013. Montara Environmental Monitoring Program, Report of Search. PTTEP Australia, Western Australia. Available at http://www.au.pttep.com/wp-content/uploads/2013/10/2013-Report-of-Research-Book-vii.pdf. Accessed 16 May 2019.

Radford, C.A. Montgomery, J.C. Caiger, P. and Higgs, D.M. 2012 Pressure and particle motion detection thresholds in fish: a re-examination of salient auditory cues in teleosts. Journal of Experimental Biology 215: 3429–3435.

Reckendorf, A., Seidelin, L., & Wahlberg, M. (2023). Marine Mammal Acoustics. In: Brennecke, D., Knickmeier, K., Pawliczka, I., Siebert, U., Wahlberg, M. (eds) Marine Mammals. Springer, Cham. https://doi.org/10.1007/978-3-031-06836-2_2

Richardson, W.J. (ed.), 1999. Marine mammal and acoustical monitoring of Western Geophysical's openwater seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. From LGL Ltd. King City, Ont. and Greeneridge Sciences Inc. Santa Barbara, CA, for Western Geophysical, Houston, TX, and NMFS. Anchorage, AK, and Silver Spring, MD. 390 pp.

Richardson, W.J. Malme, C.I. 1993. Man-made noise and behavioral responses. In: The bowhead whale. Edited by J.J. Burns, J.J. Montague and C.J. Cowles. Society for Marine Mammalogy, Special Publication No. 2. Allen Press, Lawrence, Kansas. pp. 631–700.

Richardson, W.J. Greene, C.R. Malme, C.I. and Thomson, D.H. 1995. Marine Mammals and Noise. Academic Press, San Diego, 576 pp.

Richardson, L, Mathews, E, and Heap, A, 2005. Geomorphology and Sedimentology of the South Western Planning Area of Australia: Review and synthesis of relevant literature in support of Regional Marine Planning. *Geoscience Australia*, record 2005/17. Australian Government, Canberra.

Richardson, A.J. Matear, R.J. and Lenton, A. 2017. Potential impacts on zooplankton of seismic surveys. CSIRO, Australia. 34 pp.

Rigby, C.L. Barreto, R. Carlson, J. Fernando, D. Fordham, S. Francis, M.P. Jabado, R.W. Liu, K.M. Marshall, A. Pacoureau, N. Romanov, E. Sherley, R.B. and Winker, H. 2019a. *Isurus paucus*–The IUCN Red List of Threatened Species. Available at https://www.iucnredlist.org/species/60225/3095898. Accessed 11 April 2019.

Rigby, C.L. Barreto, R. Carlson, J. Fernando, D. Fordham, S. Francis, M.P. Herman, K. Jabado, R.W. Liu, K.M. Marshall, A. Pacoureau, N. Romanov, E. Sherley, R.B. & Winker, H. 2019b. Carcharhinus longimanus. The IUCN Red List of Threatened Species 2019: e.T39374A2911619. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T39374A2911619.en. Downloaded on 10 June 2021.

Ritz, D.A., 1972. Factors affecting the distribution of rock-lobster larvae (Panulirus longipes cygnus), with reference to variability of plankton-net catches. Marine Biology, 13, pp.309-317.

Roberts, L. Cheesman, S. Elliott, M. and Breithaupt, T. 2016. Sensitivity of *Pagurus bernhardus* (L.) to substrate-borne vibration and anthropogenic noise. Journal of Experimental Marine Biology and Ecology 474: 185–194.

Rodríguez, A. Dann, P. Chiaradia, A. 2017. Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters. *Journal for Nature Conservation, 39*, 68-72. https://doi.org/10.1016/j.jnc.2017.07.001.

Rogers, P. J. Huveneers, C, Page, B, & Goldsworthy, S. G. 2009. Movement patterns of pelagic sharks in the Southern and Indian Oceans: determining critical habitats and migration paths. SARDI Research Report Series No. 359.

Rolland, V. Barbraud, C. and Weimerskirch, H. 2009. Assessing the impact of fisheries, climate and disease on the dynamics of the Indian yellow-nosed albatross. Biological Conservation, 142(5), pp.1084-1095.

Ross, G. J. B. 2006. Review of the Conservation Status of Australia's Smaller Whales and Dolphins. Page(s) 124. Report to the Australian Department of the Environment and Heritage, Canberra. Available from: http://www.environment.gov.au/resource/review-conservation-status-australias-smaller-whales-and-dolphins.

Sætre, R. and Ona, E. 1996. Seismic investigations and harmful effects on fish eggs and larvae. An assessment of the possible effects on the level of recruitment. Fisken og Havet, Havforskningsinstituttet, Bergen (Norway), 1996, no. 8, 25 pp.

Salgado Kent, C.P. Gavrilov, A.N. Recalde-Salas, A. Burton, C.L.K. McCauley, R.D. Marley, S. 2012a. Passive acoustic monitoring of baleen whales in Geographe Bay, Western Australia, Proceedings of Acoustics, Nov 21-23, 2012. Acoustical Society of Australia, Freemantle, Western Australia.

Salgado Kent, C. Jenner. C. Jenner, M. Bouchet, P. and Rexstad, E. 2012b. Southern Hemisphere Breeding Stock D humpback whale population estimates from North West Cape, Western Australia. Journal of Cetacean Research Management 12(1): 29-38.

Salgado Kent, C. McCauley, R.D. Duncan, A. Erbe, C. Gavrilov, A. Lucke, K. and Parnum, I. 2016. Underwater Sound and Vibration from Offshore Petroleum Activities and their Potential Effects on Marine Fauna: An Australian Perspective. Centre for Marine Science and Technology (CMST), Curtin University. April 2016. Project CMST 1218; Report 2015-13. 184 pp.

Salgado Kent C.P, Burton C, Giroud M and Elsdon B. 2022. *A Photo-Identification Study of Southern Right Whales to Update Aggregation Area Classification in the Southwest of Australia*. Report to the National Environmental Science Program, Edith Cowan University. https://www.nespmarinecoastal.edu.au/project-1-22-final-report-2/.

Sanderson, P, G, Eliot, I, Hegge, B and Maxwell, S, 2000. Regional variation of coastal morphology in southwestern Australia: a synthesis. *Geomorphology*, 34(1-2), pp: 73-88.

Sandoval-Castillo, J, Robinson, N, Strain, L, Hart, A and Beheregaray, L. B 2015. Use of next generation DNA technologies for revealing the genetic impact of fisheries restocking and ranching. Australian Seafood CRC Report, No. 2012/714. Flinders University, Adelaide, 47pp.

Santulli, A. Modica, A. Messina, C. Ceffa, L. Curatolo, A. Rivas, G. Fabi, G. and D'Amelio, V. 1999. Biochemical responses of European Sea Bass (*Dicentrarchus labrax* L.) to the stress induced by off shore experimental seismic prospecting. Marine Pollution Bulletin 38: 1105–1114.

Scholik, A.R. and Yan, H.Y. 2001. Effects of underwater noise on auditory sensitivity of a cyprinid fish. Hearing Research 152:17–24.

Scott, K, 2013. Dwoort baal kaat / an old story retold by Kim Scott, Russell Nelly and the Wirlomin Noongar Language and Stories Project. University Press, Crawley. 36pp.

Shalders, T.C. Saunders, B.J. Bennett, S. Parker, J.R.C. & Harvey, E.S. 2018. Potential climate-mediated changes to the distribution and density of pomacentrid reef fishes in south-western Australia. Marine Ecology Progress Series, 604: 223-235 doi: https://doi.org/10.3354/meps12736.

Shaughnessy, P.D. 1999. The Action Plan for Australian Seals. Environment Australia. Canberra, ACT. 62 pp.

Shephard, J. M. Dunlop, J. N. and Bouten, W. 2018. Foraging movements of common noddies in the East Indian Ocean are dependent on breeding stage: implications for marine reserve design. *Pacific Conservation Biology*, 25(2), 164-173.

Shigenaka, G. 2001.Toxicity of Oil to Reef-Building Corals: A Spill Response Perspective. doi: https://10.13140/2.1.3728.0322.

Shigenaka, G. & Milton, S. (2003). Oil and sea turtles: biology, planning, and response. [Washington, D.C.]: National Oceanic and Atmospheric Administration, NOAA's National Ocean Service, Office of Response and Restoration.

Sierra-Flores, R. Atack, T. Migaud, H. Davie, A. 2015. Stress response to anthropogenic noise in Atlantic cod Gadus morhua L. Aquacultural Engineering, 67: 67-76.

Sims, J.R. Fothergill, D.M. Curley, M.D. 1999. Effects of a neoprene wetsuit hood on low-frequency underwater hearing thresholds. The Journal of the Acoustical Society of America, 105(2) Supplement: 1298.

Simmonds, J.E. and MacLennan, D. 2005. Fisheries acoustics: theory and practice. Second edition. Blackwell Science, Oxford, United Kingdom.

Simmonds, M. Dolman, S. and Weilgart, L. 2004. Oceans of Noise. A Whale and Dolphin Conservation Society Science Report. The Whale and Dolphin Conservation Society. Chippenham, Wiltshire, United Kingdom.

Slabbekoorn, H. Bouton, N. van Opzeeland, I. Coers, A. Ten Cate, C. and Popper, A.N. 2010. A noisy spring: the impact of globally rising underwater sound levels on fish. Trends in Ecology and Evolution 25: 419–427.

Slotte, A. Hansen, K. Dalen, J. and Ona, E. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67: 143-150.

Smale, D. A. Kendrick, G. A. Harvey, E. S. Langlois, T. J. Hovey, R. K. Van Niel, K. P. Waddington, K. I. Bellchambers, L. M. Pember, M. B. Babcock, R. C. & Vanderklift, M. A. 2012. Regional-scale benthic monitoring for ecosystem-based fisheries management (EBFM) using an autonomous underwater vehicle (AUV). *ICES Journal of Marine Science*, vol. 69(6), pp.1108-1118.

Smallwood, C. B, Hesp, S. A and Beckley, L. E. 2013. Biology, stock status and management summaries for selected fish species in south-western Australia. Fisheries Research Report No. 242. Department of Fisheries, Government of Western Australia, Perth.

Smith, M.E. Kane, A.S. Popper, A.N. 2004a. Noise-induced stress response and hearing loss in goldfish (Carassius auratus). Journal of Experimental Biology 207:427–435.

Smith, M.E. Kane, A.S. Popper, A.N. 2004b. Acoustical stress and hearing sensitivity in fishes: does the linear threshold shift hypothesis hold water? Journal of Experimental Biology 207:3591–3602.

Smith, K. D, Potter, I.C & Hall, N. G, 2004. Biological and fisheries data for managing the deep-sea crabs *Hypothalassia acerba* and *Chaceon bicolor* in Western Australia. Final Reports to the FRDC on Projects No. 1999/154 and 2001/055, 151 pp.

Smith, M.E. Coffin, A.B. Miller, D.L. Popper, A.N. 2006. Anatomical and functional recovery of the goldfish (Carassius auratus) ear following noise exposure. Journal of Experimental Biology 209:4193–4202.

Smith, M.E. Schuck, J.B. Gilley, R.R. Rogers, B.D. 2011. Structural and functional effects of acoustic exposure in goldfish: evidence for tonotopy in the teleost saccule. BMC Neuroscience 12:19.

Smith, J. N. Jones, D. Travouillon, K. Kelly, N. Doubles, M. and Bannister, J. L. 2021. Monitoring Population Dynamics of 'Western' Right Whales off Southern Australia 2018-2021: Final Report on activites for 2020. National Environmental Science Programme.

Smith, K. A. Bissell, A, & Bruce, C, 2022. Ecological Risk Assessment for the Marine Aquarium Fish Resource. Fisheries Research Report No. 323. Department of Primary Industries and Regional Development. Government of Western Australia, Perth.

Smith, J.N., Double, M. & Townsend, A. (2025). *Aerial survey of the Australian southern right whale (Eubalaena australis) 'western' population and development of AI for photo-identification*. Report to the National Environmental Science Program, Marine and Coastal Hub, Murdoch University.

Sobtzick, S. 2010. Dwarf minke whales in the northern Great Barrier Reef and implications for the sustainable management of the swim-with whales industry (Doctoral dissertation, James Cook University).

Solé, M. Sigray, P. Lenoir, M. van der Schaar, M. Lalander, E. André, M. 2017. Offshore exposure experiments on cuttlefish indicate received sound pressure and particle motion levels associated with acoustic trauma. Scientific Reports 7: 45899.

Southall, B.L. A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr. D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33(4): 411-521.

Southall, B.L. Finneran, J.J. Reichmuth, C. Nachtigall, P.E. Ketten, D.R. Bowles, A.E. Ellison, W.T. Nowacek, D.P. Tyack, P.L. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45(2): 125-232.

Southall, B.L. Nowacek, D.P. Bowles, A.E. Senigaglia, V. Bejder, L. Tyack, P.L. 2021. Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise. Aquatic Mammals 2021, 47(5), 421-464.

Sprogis, K. R. and Parra, G. J. 2022. Coastal dolphins and marine megafauna in Exmouth Gulf, Western Australia: informing conservation management actions in an area under increasing human pressure. *Wildlife Research*, 50(6), 435-450.

Stadler, J. Woodbury, D. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. Thirty-Eighth International Congress and Exposition on Noise Control Engineering 2009, INTER-NOISE 2009.

Stamation, K. Watson, M. Moloney, P. Charlton, C. and Bannister, J. 2020. Population estimate and rate of increase of southern right whales Eubalaena australis in southeastern Australia. *Endangered Species Research*, *41*, 373-383.Stevens, J.D. McAuley, R.B. Simpfendorfer, C.A. and Pillans, R.D. 2008. Spatial distribution and habitat utilisation of sawfish (Pristis spp) in relation to fishing in northern Australia, A report to the Department of the Environment, Water, Heritage and the Arts. CIRO and Western Australian Department of Fisheries.

Stone, C.J. 2003. Marine mammal observations during seismic surveys in 2000. JNCC Report 322. 66pp.

Stone, C.J. 2015. Implementation of and considerations for revisions to the JNCC guidelines for seismic surveys. JNCC Report 463b.

Stone, C.J. Tasker, M,L. 2006. The effects if seismic airguns on cetaceans in UK waters. J. Cetacean Res Manage. 8(3):255-263.

Strain, L. W. S, Brown, J. M & Hart, A. M, 2019. Recovering a collapsed abalone stock through translocation. Australian Seafood CRC Project No. 2011/762. Fisheries Research Report No. 292, Department of Primary Industries and Regional Development. Government of Western Australia.

Surman, C. A. 1998. Seabird breeding schedules at the Pelsaert Group of islands, Houtman Abrolhos, Western Australia between 1993 and 1998. Records Western Australian Museum, 19, 209-216.

Surman, C. A. Nicholson L. W. 2009. The good, the bad and the ugly: ENSO-driven oceanographic variability and its influence on seabird diet and reproductive performance at the Houtman Abrolhos, eastern Indian Ocean. *Marine Ornithology*, vol. 37:129−138.

Sutton, A. Beckley, L.E. 2017. Vertical structuring of epipelagic euphausiid assemblages across the thermohaline front in the south-east Indian Ocean. Journal of Plankton Research 39(3): 463-478.

Tang, K.W. Gladyshev, M.I. Dubovskaya, O.P. Kirillin, G. and Grossar, H-P. 2014. Zooplankton carcasses and non-predatory mortality in freshwater and inland sea environments. Journal of Plankton Research, 36: 597–612.

Thomson, R. Sporcic, M. Foster, S. Haddon, M. Potter, A. Carroll, A. Przeslawski, R. Knuckey, I. Koopman, M. Hartog, J. 2014. Examining Fisheries Catches and Catch Rates for Potential Effects of Bass Strait Seismic Surveys. CSIRO and Geosciences Australia.

Tomasko, D.A. and Lapointe, B.E. 1991. Productivity and biomass of Thalassia testudinum as related to water column nutrient availability and epiphyte levels: field observations and experimental studies. Marine Ecology Progress Series, 75: 9-17.

Thums, M, Ferreira, L, Jenner, C, Jenner, M, Harris, D, Davenport, A, Andrews-Goff, V, Double, M, Moller, L, Attard, C. R. M. Bilgmann, K, Thomson, P, & McCauley, R, 2022. Pygmy blue whale movement, distribution and important areas in the Eastern Indian Ocean. *Global Ecology and Conservation*, e02054. Available at: https://doi.org/10. 1016/j.gecco.2022.e02054

Triangle Energy Global, 2017. Cliff Head Field Offshore Operations Environment Plan Summary. Retrieved from: https://docs.nopsema.gov.au/A680655

Trotter, J. A. Pattiaratchi, C, Montagna, P, Taviani, M, Falter, J, Thresher, R, Hosie, A, Haig, D, Foglini, F, Hua, Q, & McCulloch, M. T. 2019. First ROV exploration of the Perth Canyon: Canyon setting, faunal observations, and anthropogenic impacts. *Frontiers in Marine Science*, vol. 6, p.173.

Turnpenny, A.W.H. and Nedwell, J.R. 1994. The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Report by Fawley Aquatic Research Laboratories Ltd, Hampshire, United Kingdom for United Kingdom Offshore Operators Association, London, United Kingdom.

Vanderlaan, A. S. M.and C. T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23: 144–156.

van der Knaap, I. Reubens, J. Thomas, L. Ainslie, M.A. Winter, H.V. Hubert, J. Martin, B. Slabbekoorn, H. 2021. Effects of a seismic survey on movement of free-ranging Atlantic cod, Current Biology, 31(7), 1555-1562.

van Herwerden, L, Aspden, W. J. Newman, S. J. Pegg, G. G. Briskey, L, & Sinclair, W, 2009. A comparison of the population genetics of *Lethrinus miniatus* and *Lutjanus sebae* from the east and west coasts of Australia: evidence for panmixia and isolation. *Fisheries Research*, vol. 100(2), pp. 148 – 155.

Varela, M. Bode, A. Lorenzo, J. ´Alvarez-Ossorio, M.T. Miranda, A. Patrocinio, T. Anad´on, R. Viesca, L. Rodríguez, N. Vald´es, L. Cabal, J. Urritia, A. García- Soto, C. Rodríguez, M. ´Alvarez-Salgado, X.A. Groom, S. 2006. The effect of the 'Prestige' oil spill on the plankton of the N–NW Spanish Coast. Mar. Pollut. Bull. 53, 272–286.

Vasconcelos, R.O. Amorim, M.C.P. Ladich, F. 2007. Effects of ship noise on the detectability of communication signals in Lusitanian toadfish. J. Exper. Biol. 210: 2104-2112.

Vereide, E.H. Mihaljevic, M. Browman, H.I. Fields, D.M. Agersted, M.D. Titelman, J. and de Jong, K. 2023. Effects of air gun discharges used in seismic surveys on development and mortality in nauplii of the copepod Acartia tonsa. Environmental Pollution 327 (2023) 121469.

Volkman, J.K. Miller, G.J. Revill, A.T. And Connell, D.W. 1994. 'Oil Spills'. In Swan, J.M. Neff, J.M. and Young, P.C. (Eds.), Environmental implications of offshore oil and gas development in Australia – the findings of an independent scientific review, pp 509-695; Australian Petroleum Exploration Association, Sydney.

Wadjemup Whadjuk Booja, n.d. Wadjemup Whadjuk Booja. Available at: https://www.alwayswadjemup.com/aboutus. Accessed 25/01/2024.

Wakefield, C. B. Newman, S. J. & Molony, B. W. 2010. Age-based demography and reproduction of hapuku, *Polyprion oxygeneios*, from the south coast of Western Australia: implications for management. *ICES Journal of Marine Science*, vol. 67 (6), pp. 1164–1174.

Wakefield, C. B. Newman, S. J. Marriott, R. J. Boddington, D. K. & Fairclough, D. V. 2013a. Contrasting life history characteristics of the eightbar grouper, *Hyporthodus octofasciatus* (Pisces: Epinephelidae), over a large latitudinal range reveals spawning omission at higher latitudes. *ICES Journal of Marine Science*, vol. 70, pp. 485 – 497.

Wakefield, C. B. Newman, S. J. Boddington, D. K. 2013b. Exceptional longevity, slow growth and late maturation infer high inherent vulnerability to exploitation for bass groper *Polyprion americanus* (Teleostei: Polyprionidae). *Aquatic Biology*, vol. 18: 161 – 174.

Wardle, C.S. Carter, T.J. Urquhart, G.G. Johnstone, A.D.F. Ziolkowski, A.M. Hampson, G. and Mackie, D. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21: 1005-1027.

Wartzok, D. Ketten, D.R. 1999. Marine Mammal Sensory Systems. In: Reynolds J and Rommel S (eds.). Biology of Marine Mammals. Smithsonian Institution Press, Washington, DC. pp 117-175.

Watson, M, Stamation, K, & Charlton, C, 2021. Calving rates, long-range movements and site fidelity of southern right whales (*Eubalaena australis*) in south-eastern Australia. *J*. *Cetacean Res*. *Manage*, vol. 22(1), pp.17-28.

Webster, F.J. Wise, B.S. Fletcher, W.J. and Kemps, H. 2018. Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia. Fisheries Research Report No. 288 Department of Primary Industries and Regional Development, Western Australia. 42 pp.

Weigmann, S. 2016. Annotated checklist of the living sharks, batoids and chimaeras (Chondrichthyes) of the world, with a focus on biogeographical diversity. Journal of Fish Biology 88(3): 837-1037.

Weilgart, L. S. (2007). A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology, 20(2).

Weir, C. 2006. Overt Responses of Humpback Whales (*Megaptera novaeangliae*), Sperm Whales (*Physeter macrocephalus*), and Atlantic Spotted Dolphins (*Stenella frontalis*) to Seismic Exploration off Angola. Aquatic Mammals 2008, 34(1): 71-83.

Wells, F.E and Keesing, J. K. 1989. Reproduction and feeding in the abalone *Haliotis roei* Gray. *Australian Journal of Marine and Freshwater Research* 40: 187-97.

Wells, F. E. & McDonald, J. I. 2010. Actions to implement and complement the National System for the Prevention and Management of Introduced Marine Pests in Western Australia. Fisheries Research Report No. 207. Department of Fisheries, Government of Western Australia, Perth.

White, W.T. Last, P.R. Stevens, J.D. and Yearsly, G.K. 2006. Economically important sharks and rays of Indonesia (No. 435-2016-33677).

Williams, A, Koslow, J. A, & Last, P. R. 2001. Diversity, density and community structure of the demersal fish fauna of the continental slope off western Australia (20 to 35° S). *Marine Ecology Progress Series*, vol. 212: 247-63.

Williams, A. J, Davies, C. R and Mapstone, B. D. 2006. Regional patterns in reproductive biology of *Lethrinus miniatus* on the Great Barrier Reef. *Marine and Freshwater Research*, vol. 57 (4), pp. 403 – 414.

Williams, A, Hamer, P, Haddon, M, Robertson, S, Althaus, F, Green, M & Kool, J, 2017. Determining Blue-eye Trevalla stock structure and improving methods for stock assessment. FRDC Project No. 2013/015.

Wise, B. S, St John, J and Lenanton, R. C. (eds), 2007. Spatial scales of exploitation among populations of demersal scalefish: implications for management. Part 1: Stock status of the key indicator species for the demersal scalefish fishery in the West Coast Bioregion. Final FRDC Report – Project No. 2003/052. Fisheries Research Report No. 163. Department of Fisheries, Government of Western Australia, Perth.

Woodside Energy Ltd. 2011. Impacts of seismic airgun noise on fish behaviour: a coral reef case study. Maxima 3D MSS Monitoring Program Information Sheet 1. Woodside Energy Ltd. Perth, Western Australia.

Young, C.N. Carlson, J.K. 2020. The biology and conservation status of the oceanic whitetip shark (*Carcharhinus longimanus*) and future directions for recovery. Rev Fish Biol Fisheries 30, 293–312 (2020).https://doi.org/10.1007/s11160-020-09601