wheatstone 4D marine seismic survey environment plan

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Document information

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1 environment plan summary

This *Wheatstone 4D Marine Seismic Survey Environment Plan Summary* (Table 1-1) has been prepared from material provided in this Environment Plan, and as required by Regulation 11(4) of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009.

Table 1-1: Environment Plan summary

Regulation	EP summary material requirement	Relevant section of the EP
11(4)(a)(i)	the location of the activity	Section 2.2, Section 3.1
11(4)(a)(ii)	a description of the receiving environment	Section 4, Ref. 1^
11(4)(a)(iii)	a description of the activity	Section 3
11(4)(a)(iv)	details of environmental impacts and risks	Section 6
11(4)(a)(v)	a summary of the control measures for the activity	Section 6
11(4)(a)(vi)	a summary of the arrangements for ongoing monitoring of the titleholder's environmental performance	Section 7
11(4)(a)(vii)	a summary of the response arrangements in the oil pollution emergency plan	Section 6.13, Ref. 2*
11(4)(a)(viii)	details of consultation already undertaken, and plans for ongoing consultation	Section 2.5.2.1
11(4)(a)(ix)	details of the titleholder's nominated liaison person for the activity	Section 2.4

^ *Available at appendix f*
* *Available publicly at: https://docs.nopsema.gov.au/A748691*

2 introduction

2.1 Overview

Chevron Australia Pty Ltd (CAPL) proposes to conduct a 4-dimensional (4D)[1] marine seismic survey (MSS) over the Wheatstone and Iago gas fields in Commonwealth waters. The 4D MSS aims to repeat the acquisition of the 3-dimensional (3D) MSS conducted over the same area in 2011–2012.

This Environment Plan (EP) documents the assessment and management of potential environmental impacts and risks associated with the 4D MSS in Commonwealth waters.

This EP has been prepared in accordance with the requirements of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E)R) as administered and for regulatory acceptance by the National Offshore Petroleum Safety and Environment Management Authority (NOPSEMA).

2.2 Location

The 4D MSS will be undertaken within Commonwealth waters north of Barrow Island, Western Australia (WA). The acquisition area includes the WA-46-L, WA-47-L, and WA-48-L production licences (Figure 2-1). There are no islands or other emergent features within or adjacent to the acquisition area.

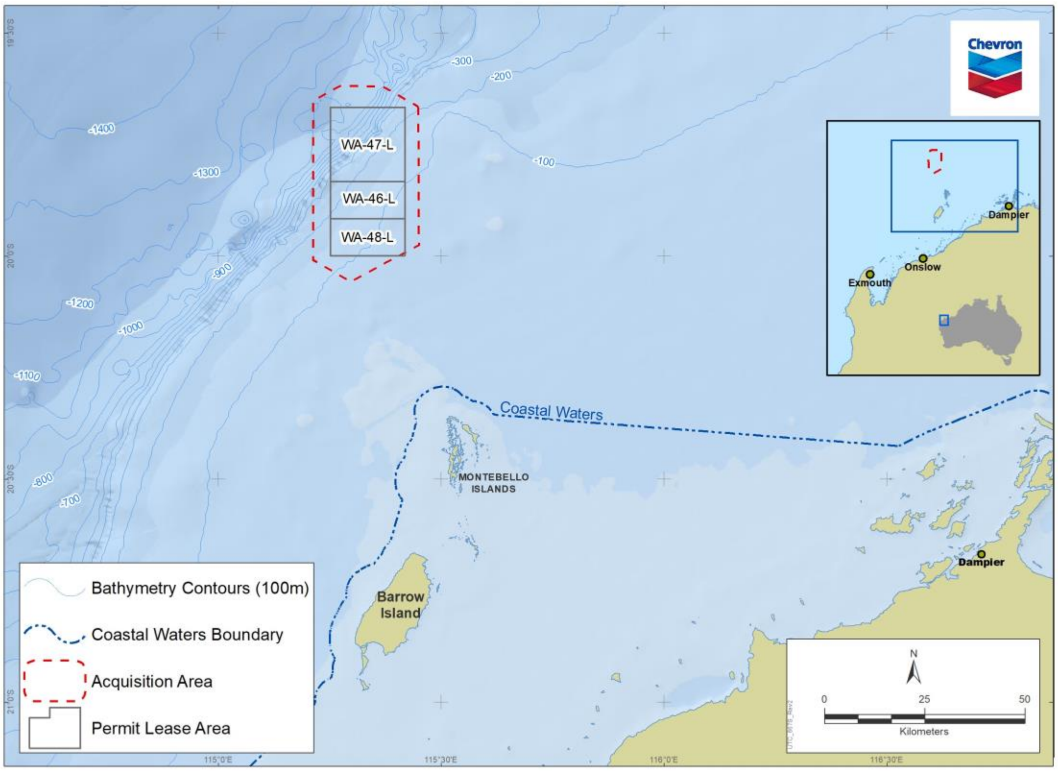


Figure 2-1: Wheatstone 4D MSS acquisition area

[1] Also known as a 'time-lapse' seismic survey.

2.3 Scope

This EP addresses the following activities in Commonwealth waters:

- seismic acquisition
- field support operations.

The following activities are excluded from the scope of this EP:

- vessels (including emergency response vessels) transiting to or from the Operational Area (OA); these vessels are deemed to be operating under the Commonwealth *Navigation Act 2012* and are not performing the petroleum activity.

2.4 Titleholder details

CAPL is the nominated titleholder of the production licences WA-46-L, WA-47-L, WA-48-L, on behalf of the titleholder companies listed in Table 2-1. The contact details for the nominated liaison person for this EP are listed in Table 2-2.

Regulation 15(3) of the OPGGS(E)R requires that CAPL notifies NOPSEMA of a change in the titleholder, a change to the titleholder's nominated liaison person, or a change in the contact details for either the titleholder or the nominated liaison person.

Regulation 286A of the OPGGS Act requires notification is provided to NOPSEMA and the National Offshore Petroleum Titles Administrator (NOPTA) if there is a change to a registered titleholder or contact details for the registered titleholder; this notification is to occur within 30 days of such a change.

Table 2-1: Titleholder details

Title	Detail	Titleholders	Nominated titleholder	Address
WA-46-L	Production Licence	Chevron Australia Pty Ltd Chevron (TAPL) Pty Ltd PE Wheatstone Pty Ltd Kyushu Electric Wheatstone Pty Ltd	Chevron Australia Pty Ltd (ACN: 086 197 757)	250 St Georges Terrace Perth, WA, 6000
WA-47-L	Production Licence			
WA-48-L	Production Licence	Chevron Australia Pty Ltd Kufpec Australia (Wheatstone Iago) Pty Ltd Chevron (TAPL) Pty Ltd PE Wheatstone Pty Ltd Kyushu Electric Wheatstone Pty Ltd		

Table 2-2: Nominated liaison person

Name	Birgit Cropp / Asten Roopra (public contact)
Company	Chevron Australia Pty Ltd
ACN	086 197 757
Position	Wheatstone Reservoir Development Team Lead / PGPA Operations Manager
Business Address	250 St Georges Terrace, Perth WA 6000
Telephone	+61 8 9216 4000
Email	ABUEnvPlanInfo@chevron.com

2.5 Environmental management framework

CAPL’s operations are managed in accordance with Chevron Corporation’s Operational Excellence Management System (OEMS), which is described in Section 7.

2.5.1 Environmental policy

CAPL’s commitment to environmental management in all aspects of operations is documented in Chevron Corporation’s Operational Excellence (OE) Policy 530 (appendix a).

2.5.2 Legislative framework

In accordance with Regulation 13(4) of the OPGGS(E)R, the legislative framework relevant to the petroleum activity is described in Table 2-3 and Table 2-4.

Table 2-3: Commonwealth legislative requirements

Legislation	Description	Requirements relevant to the risks associated with the petroleum activity	Demonstration of how requirements are met
Australian Maritime Safety Authority Act 1990	Aims to promote maritime safety, protect the marine environment from pollution from ships or other environmental damage caused by shipping, and provide for a national search and rescue service	Requirements include the involvement of the Australian Maritime Safety Authority (AMSA) in response to relevant spill events	Roles and responsibilities are described in the Oil Pollution Emergency Plan (OPEP) (Ref. 2).
Biosecurity Act 2015 Biosecurity Regulations 2016	Provides biosecurity protection in Australian waters beyond territorial limits	Pre-arrival information must be reported through the Maritime Arrivals Reporting System (MARS) before arrival in Australian waters	Section 6.7
		Australian Ballast Water Management Requirements (Ref. 4)	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) EPBC Regulations 2000	Provides for the protection and management of nationally and internationally important flora, fauna, ecological communities, and heritage places	The EP must describe matters protected under Part 3 of the EPBC Act and assess any impacts and risks to these protected matters	Section 4, and Section 6
		EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans	Section 6.2, and Section 6.6
		EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales (Ref. 5).	Section 6.5

Legislation	Description	Requirements relevant to the risks associated with the petroleum activity	Demonstration of how requirements are met
		Injury or fatality caused to EPBC-listed fauna shall be reported	Section 7.4.2
Navigation Act 2012	Provides for vessel and seafarer safety, and marine pollution prevention	Notice to Mariners	Section 6.1, and Section 6.12
Navigation Act 2012 *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* Various marine orders	Gives effect to the requirements under the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) in Australia	Marine order 30—Prevention of collisions	Section 6.12
		Marine order 91—Marine pollution prevention—oil	Section 6.8, Section 6.11, and Section 6.12
		Marine order 95—Marine pollution prevention—garbage	Section 6.9
		Marine order 96—Marine pollution prevention—sewage	Section 6.8
		Marine order 97—Marine pollution prevention—air pollution	Section 6.3
		Marine order 98—Marine pollution prevention—anti-fouling systems	Section 6.7
Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act) OPGGS Environment Regulations 2009 (OPGGS(E)R)	The OPGGS(E)R under the OPGGS Act requires a titleholder to have an accepted EP in place prior to commencement of a petroleum activity The regulations ensure petroleum activities are undertaken in an ecologically sustainable manner in accordance with an EP	An EP for a petroleum activity must be accepted by NOPSEMA before activities commence	This EP, including the OPEP (Ref. 2) and Operational and Scientific Monitoring Plan (OSMP) (Ref. 3)
Underwater Cultural Heritage Act 2018	Provides protection for shipwrecks, sunken aircraft and other cultural heritage sites in Australian waters	Identification of the presence of protected cultural heritage sites and assessment of any impacts and risks to these sites	Section 4, and Section 6

Table 2-4: Standards and guidelines

Standard / guideline	Description	Requirements relevant to the risks associated with the petroleum activity	Demonstration of how requirements are met
Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Ref. 6)	International Maritime Organization (IMO) guidelines for global management of biofouling	Requires a biofouling management plan and record book to be available and maintained	Section 6.7
National Light Pollution Guidelines for Wildlife, including Marine Turtles, Seabirds and Migratory Shorebirds (Ref. 7)	Outlines the process to be followed where there is the potential for artificial lighting to affect wildlife; applies to new projects, lighting upgrades and where there is evidence of wildlife being affected by existing artificial light	The EP must assess if artificial lighting is likely to affect wildlife and identify the management tools to minimise and mitigate impacts and risks	Section 6.4

2.5.2.1 Protected areas

Australian Marine Parks (AMPs) occur within Commonwealth waters and are proclaimed as Commonwealth reserves under the EPBC Act. In alignment with the EPBC Act, each reserve is assigned an IUCN category (or multiple categories); and each category has a set of Australian IUCN reserve management principles associated with it (as defined in Schedule 8 of the EPBC Regulations 2000). The IUCN categories and management principles associated with AMPs within the OA (refer to Section 4.5) for this petroleum activity are described in Table 2-5.

The *North-west Marine Parks Network Management Plan* (Ref. 8) enables activities to be conducted in zones consistent with the zone objectives while enabling the impacts to be effectively managed. The zones, objectives, and allowable activities associated within AMPs relevant to the petroleum activity are described in Table 2-6.

Table 2-5: IUCN categories and Australian IUCN reserve management principles

IUCN category	Australian IUCN reserve management principles
Managed resource protected area (category VI)	7.01 The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. 7.02 The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. 7.03 Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. 7.04 Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles

Table 2-6: AMP zones, objectives, and activities

Zone	Objective	Rules for activities	Requirements relevant to the risks associated with the petroleum activity	Demonstration of how requirements are met
Multiple use zone (VI)	The objective of the Multiple Use Zone (VI) is to provide for ecologically sustainable use and the conservation of ecosystems, habitats and native species	Mining operations (including exploration)^ is an allowable activity within this zone, subject to assessment and authorisation	The class approval for mining operations within a multiple use zone requires a NOPSEMA-accepted EP to be in place before activities commence	This EP, including the OPEP (Ref. 2) and Operational and Scientific Monitoring Plan (OSMP) (Ref. 3)

^ Mining operations are defined in Section 355(2) of the EPBC Act, and include offshore petroleum activities, transportation of minerals by pipeline, and oil spill response.

2.6 Stakeholder consultation

2.6.1 Methodology

CAPL followed the following process to undertake consultation for this petroleum activity:

- identify relevant stakeholders
- provide sufficient information to enable stakeholders to understand how this activity may affect their functions, interests, or activities
- assess the merit of any objections or claims raised by the stakeholders
- provide a response to the objection or claim, and ensure this is captured in the EP.

This methodology is guidance sourced from:

- NOPSEMA's *Environment plan decision making* guideline (Ref. 9)
- NOPSEMA's *Consultation with Commonwealth agencies with responsibilities in the marine area* guideline (Ref. 10)
- Australian Petroleum Production and Exploration Association's (APPEA's) draft *Stakeholder Consultation and Engagement Principles and Methodology for Environment Plans* (Ref. 11).

A process for ongoing consultation is described in Section 2.6.5.

2.6.2 Identification of relevant stakeholders

Establishing relevance under the OPGGS(E)R depends on the nature and scale of the petroleum activity and its associated impacts and risks. In accordance with Regulation 11A of the OPGGS(E)R, a 'relevant person' is defined as:

- each department or agency of the Commonwealth to which the activities to be carried out under the EP, or the revision of the EP, may be relevant
- each department or agency of a State or the Northern Territory to which the activities to be carried out under the EP, or the revision of the EP, may be relevant

- the department of the responsible State Minister, or the responsible Northern Territory Minister
- a person or organisation whose functions, interests, or activities may be affected by the activities to be carried out under the EP, or the revision of the EP
- any other person or organisation that the titleholder considers relevant.

With regards to Commonwealth agencies, advice provided in the NOPSEMA guideline (Ref. 10) has been taken into consideration in identifying relevance with respect to the activities provided for in this EP.

To facilitate successful stakeholder interaction appropriate to the nature and scale of the activities under the EP, CAPL have adopted the approach that there must be a direct connection between the activities that the EP provides for and the potential effect to a department, person, or organisation functions, interests, or activities. Based on the impact and risk assessments undertaken in this EP, CAPL understands that the impacts of the planned activities are limited to the vicinity of the OA, thus persons or organisations directly connected with functions, interests, or activities within the OA have been taken to be relevant.

CAPL acknowledges that the EP also includes a risk assessment for an emergency event (i.e., unplanned release from a vessel collision) that has the potential to effect areas extending beyond the OA. In the event of an emergency event occurring, additional stakeholder consultation would be undertaken in accordance with Section 2.6.5.1.

CAPL have previously engaged with relevant stakeholders prior to the 2011–2012 3D MSS. The list of stakeholders from the previous MSS was reviewed to ensure that any new 'relevant person' was also included in the stakeholder consultation process as part of this EP. For this EP, CAPL have elected to use the Western Australian Fishing Industry Council's (WAFIC) oil and gas consultation service to help determine relevant commercial fisheries and fishers as well as review and distribute fishery-specific consultation material. CAPL also reviewed the Parks Australia publicly available 'list of authorisations issued' to assist with the identification of relevant commercial tourism operators within Australian Marine Parks. The relevant stakeholders identified for consultation as part of this EP are listed in Table 2-7.

Table 2-7: Relevant stakeholders

Group	Stakeholder
Commonwealth departments or agencies	• Australian Fisheries Management Authority (AFMA) • Australian Hydrographic Office (AHO) • Australian Maritime Safety Authority (AMSA) • Department of Agriculture, Water and the Environment (DAWE) – Fisheries – Director of National Parks • Department of Defence / Border Force
State departments or agencies	• Department of Biodiversity, Conservation and Attractions (DBCA) • Department of Primary Industries and Regional Development (DPIRD) • Department of Transport (DoT) • Department of Mines, Industry Regulation and Safety (DMIRS)

Group	Stakeholder
Commonwealth fisheries (peak bodies)	• Australian Southern Bluefin Tuna Industry Association • Commonwealth Fisheries Association • Tuna Australia • Western Australian Fishing Industry Council (WAFIC) • Pearl Producers Association • Bilyara Holdings Mackerel Area 2 License Holder
Commercial fisheries	• West Coast Deep Sea Crustacean • Mackerel Managed Fishery (Area 2) • Onslow Prawn Managed Fishery • Pilbara Crab Managed Fishery • Pilbara Line Fishery • Pilbara Trap Managed Fishery • North West Slope Trawl Fishery • Western Tuna and Billfish Fishery
Recreational fisheries	• RecFishWest • Marine Tourism WA • Ashburton Anglers • Apache Charters • Blue Juice Charters • Blue Lightning Fishing Charters • Mahi Charters • Exmouth Deep Sea Fishing • Western Boat Charters • Go Diving • Surf Dive n Fish • Blue Sun 2 Boat Charters • Montebello Island Safaris • Pelican Charters • Point Samson Charters • Top Gun Charters • Exmouth Game Fishing Club • Nickol Bay Sport Fishing Club • Onslow Visitor Centre • Port Hedland Game Fishing Club • The Trustee for Wilderness Safari Unit Trust
Other petroleum operators	• Santos Ltd • Woodside Energy Ltd • PGS Australia Pty Ltd • TGS-NOPEC Geophysical Company Pty Ltd
Emergency response	• AECOM • Australian Marine Oil Spill Response Centre • Gorgon HSE / Emergency Management Specialists • DoT Oil Spill Response Coordination Unit • Oil Spill Response Limited • BMT • GHD

Group	Stakeholder
	• Cleanaway • Port Authorities
Aboriginal	• Buurabalayji Thalanyji Aboriginal Corporation (BTAC) • Robe River Kuruma Aboriginal Corporation • Wirrawandi Aboriginal Corporation RNTBC Native Title body for Yaburara and Coastal Mardudhunera Aboriginal Corporation (YACMAC) • Yamatji Marlpa Aboriginal Corporation
Local	• Shire of Ashburton • Onslow Chamber of Commerce and Industry • Onslow Community Reference Group • Onslow Salt
Industry bodies	• National Energy Resources Australia (NERA)

2.6.3 Provision of material

Under NOPSEMA's *Environment plan decision making* guideline (Ref. 9), stakeholders must be provided with sufficient information to enable them to understand how a petroleum activity may affect their functions, interests, or activities.

CAPL sent a detailed fact sheet to stakeholders on 8 June 2021, and again between 9–15 November 2021.This fact sheet summarised the activity, aspects, and the proposed control measures to manage impacts and risks. WAFIC was also used to convey a factsheet to the commercial fishing sector on 8 June 2021, and again on 9 November 2021. Given WAFIC is the peak industry body representing commercial fisheries in WA, their review and advice on the factsheet prior to release is therefore considered by CAPL as assurance that the factsheet provided sufficient information to the fishery stakeholders. A copy of the consultation materials is included in appendix b.

All records and responses from relevant persons were included in a sensitive information report provided separately to NOPSEMA to preserve the privacy of those persons or organisations consulted. Specifically, these records and responses were considered to contain personal information (as defined by the Commonwealth *Privacy Act 1988*) or information that at the request of the relevant persons are not to be published as per Regulation 11(A) of the OPGGS(E)R.

Section 2.6.5 describes the process for ongoing consultation, including the triggers for when additional consultation is required.

2.6.4 Assessment and response

Table 2-8 summarises the matters, objections, and claims made during consultation with relevant stakeholders, assesses their merits, and describes how CAPL will manage the objection or claim in this EP.

A record of all consultation undertaken specifically for this activity is included in the stakeholder engagement log, which has been provided in the sensitive information report sent separately to NOPSEMA.

Table 2-8: Summary of stakeholder objections/claims and titleholder reponse

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
Australian Fisheries Management Authority	16 June 2021	60	Response to Wheatstone 4D MSS factsheet	No objection or claim. AFMA provided a reminder to consult with fishers within the proposed area.	Not applicable	Acknowledged receipt of feedback, and CAPL confirmed that relevant fisheries within the OA have been identified and were included on relevant persons list for consultation.
AHO and AMSA	9 June 2021	64–65, 131, 153–154	Response to Wheatstone 4D MSS factsheet	No objection or claim. Requested that AMSA's Joint Rescue Coordination Centre (JRCC) be notified: • at least 24–48 hours before operations commence • when operations start and end Requested that the AHO be contacted no less than four working weeks before operations, with details relevant to the operations	AMSA have the authority to request such notifications given that their functions, interests, and activities have the potential to be affected by the activity. These requests are in line with standard industry practice.	Acknowledged receipt of feedback, and CAPL confirmed that notifications are included as control measures within this EP.
DBCA	16 June 2021	76–77	Response to Wheatstone 4D MSS factsheet	Request that CAPL undertake a risk assessment to determine the likelihood of potential impacts on marine fauna species within the project area commensurate with the scale and biological	DBCA is a State environmental regulator, thus the request is in line with their interests, functions, and activities.	Acknowledged receipt of feedback. CAPL confirmed that all concerns raised by DBCA would be addressed in the EP, including the following: • undertake third-party noise modelling to inform impact and risk

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				significance of the noise produced. DBCA note best practice methods should include: • underwater noise modelling • management zones • presence of Marine Fauna Observers DBCA refers CAPL to the EPBC Act Policy Statement 2.1. DBCA also notes that night operations require consideration of artificial light and vessel strike, and refers to the *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds*.		evaluation for all relevant receptors • apply management zones consistent with relevant regulatory guidance • commit to having MFOs on-vessel during the survey • address potential impacts and risks from vessel lighting
DMIRS	30 June 2021	71–72	Response to Wheatstone 4D MSS factsheet	DMIRS requested additional information on potential impacts of the activity on lands or waters under State jurisdiction, including • credible spill scenarios and response arrangements • commitment for incident reporting to	DMIRS is the State regulator for petroleum activities, thus the request is in line with their interests, functions, and activities.	Acknowledged receipt of feedback and confirmed that CAPL maintains response capability arrangements including interface and reporting to State departments and agencies in accordance with CAPL's Consolidated OPEP.

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				DMIRS for impacts relevant to WA.		
	28 July 2021	70–71	Response to Titleholder	DMIRS requested additional information • credible spill scenarios which may impact State lands or waters.		Acknowledged receipt of feedback. CAPL provided some additional information from spill modelling and confirmed that full description of the credible spill scenario and associated risk assessment would be available within the publicly available EP.
	27 April 2022	184 – 187	Response to Titleholder	DMIRS acknowledged the EP will be assessed by NOPSEMA and confirmed no further information is required at this stage. DMIRS requested the following: • pre-start notification confirming the start date of the proposed activity and a cessation notification to inform DMIRS upon completion of the activity • include information in the EP on notifying DMIRS of environmental incidents that could		Acknowledged receipt of feedback. CAPL confirmed DMIRS will be sent activity commencement and cessation notifications and would be notified in the event of an environmental incident that impacts State jurisdiction.

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				potentially impact on any land or water in State jurisdiction.		
DoT (Oil Spill Response Unit)	22 June 2021	66, 155	Response to Wheatstone 4D MSS factsheet	No objection or claim. Requested that if there is a risk of a spill impacting State Waters from the activity, that DoT be consulted.	DoT are the response agency for State Waters thus the request is in line with their interests, functions, and activities.	Acknowledged receipt of feedback, and CAPL confirmed that notification for DoT are included as within the CAPL Consolidated OPEP.
Director of National Parks (DNP)	12 July 2021	99–102	Response to Wheatstone 4D MSS factsheet	DNP requested additional information regarding: • proximity to the Montebello Marine Park and nearby marine parks are clearly identified • detailed consideration given to the impacts on marine fauna (specifically Flatback, Green, Loggerhead and Hawksbill turtles; seabirds foraging within Marin Park; Whale Shark, Humpback Whale and Pygmy Blue Whale • engagement with tourism and commercial fishing operators	DNP is responsible for the management of Australian Marine Parks, thus the request is in line with their interests, functions, and activities.	Acknowledged receipt of feedback, provided an updated map with AMPs displayed and provided information on CAPL's engagement with YMAC. CAPL confirmed that all questions raised by DNP relating to impacts to marine turtles, seabirds, whales and Whale Sharks would be addressed in the EP.

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				• engagement with the Yamatji Marlpa Corporation. Consideration should be given to the use of low power and shut down zones, timing of the activity, and detailed adaptive management approaches.		
	1 April 2022	172 – 183	Response to Wheatstone 4D MSS EP	DNP provided additional feedback via NOPSEMA and made the following claims: • the nationally recognised 60 km internesting buffer should be used and a precautionary approach be taken to schedule all seismic activity outside of peak Flatback turtle internesting periods from December to January • the EP should include further information to address any impacts on Wedge-tailed Shearwater breeding behaviours in the operational area.		Acknowledged receipt of feedback. CAPL provided additional information as outlined below: • detail on the reasoning for the timing of the survey and the requirement to undertake the Wheatstone 4D MSS during a similar time of year as the previous Wheatstone 3D MSS • CAPL reviewed all references cited in the *Recovery Plan for Marine Turtles in Australia* that relate to the 60 km internesting critical habitat buffer for Flatback Turtles and provided a summary of the review • further detail on CAPL's assessment of impacts and risks to

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				• requests that additional controls are used during peak migratory periods for Pygmy Blue Whales (December and April) • the list of 'Authorisations Issued' on the AMP website should be reviewed for identification of tourism operators within the region.		Wedge-tailed Shearwaters and revision of lighting controls • clarification on the costs associated with the use of PAM and CAPL's decision to adopt an additional adaptive management control (related to night or low visibility operations) to mitigate potential impacts and risks to Pygmy Blue Whales • confirmation that CAPL checked the AMP website and identified an additional marine tourism operator that was subsequently sent consultation material for the survey.
	20 May 2022	169 – 172	Response to Titleholder	Acknowledged receipt of CAPL's correspondence and confirmed DNP will defer to NOPSEMA for the assessment of impacts and risks to Flatback Turtles and Pygmy Blue Whales.		Acknowledged receipt of feedback and noted DNP will defer to NOPSEMA's EP assessment.

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
WAFIC	17 June 2021	17–27, 81–91, 122–130	Response to Wheatstone 4D MSS factsheet	Referred CAPL to the recent risk assessment undertaken by DPIRD on seismic activities and impacts to marine finfish and invertebrates. WAFIC also shared feedback from commercial fishers regarding a notable change in catch levels of Mackerel species following seismic survey activity, and the economic impacts of this on fishers. WAFIC raised an opportunity to research into the indirect impacts of seismic. WAFIC requested that these concerns are assessed and included in the EP.	WAFIC is the peak industry body for the WA commercial fishing, pearling and aquaculture sector; thus, the request is in line with their interests, functions, and activities.	Acknowledged receipt of feedback, and CAPL acknowledged the requirement to identify and assess all impacts and risks associated with the activity, and to apply control measures to reduce risks to ALARP and acceptable.
Fat Marine Pty Ltd	10 June 2021	86–88	Response to Wheatstone 4D MSS factsheet	Fat Marine Pty Ltd advised it had concerns about the proposed activity but had limited reception whilst at sea and would like to discuss its concerns at a more convenient time. In a brief email, Fat Marine Pty Ltd noted a recent encounter with another operator on their seismic	Not applicable	Acknowledged receipt of feedback. CAPL responded to Fat Marine Pty Ltd via email three times and via SMS on one occasion to arrange a time to listen to Fat Marine Pty Ltd's feedback and concerns, however CAPL received no response. WAFIC also attempted to contact Fat Marine Pty Ltd

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				activity and the disruption it caused.		and advised of CAPL's attempts to make contact and understand the concerns and WAFIC was also unsuccessful.
Haysito Holdings Pty Ltd	11 Nov 2021	149–152	Response to Wheatstone 4D MSS factsheet	Haysito Holdings indicates that seismic surveys during previous three years in mackerel fishing areas off Port Headland appear to have caused declines in catches from those areas. Raised concern that mackerel appears sensitive to seismic surveys and the same impact and catch decline may occur in the proposed survey area.	Management area for the Mackerel Managed Fishery intersects with the OA; thus, the request is in line with the commercial fishers interests, functions, and activities.	Acknowledged receipt of feedback. CAPL noted that a comprehensive impact and risk assessment will be included in the publicly available EP. CAPL noted that fishing effort data does not indicate any use of the acquisition area over the previous five years, and the proposed survey timing is outside main period of activity of the Mackerel Managed Fishery. CAPL also noted they will consider evidence-based adjustment protocols for commercial fishing should fishers be verifiable impacted to a commercial extent by the Wheatstone 4D MSS.
	18 Nov 2021	149–150	Response to Wheatstone 4D MSS factsheet	Haysito Holdings responded reiterating concerns about the declines in catch rates observed off Port Hedland. Also noted concern that mackerel species may leave and not return to an area		Acknowledged receipt of feedback. CAPL responded that shallow reef systems closest to the Montebello Islands are >30 km away and beyond the predicted area of noise exposure. CAPL reiterated that an

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				previously impacted by a seismic survey.		evidence-based adjustment protocol for commercial fishing would be considered.
Yamatji Marlpa Aboriginal Association	30 July 2021	92–93	Response to Wheatstone 4D MSS factsheet	No objection or claim. Confirmation that CAPL are consulting with the correct Aboriginal stakeholder groups, and advice to continue to engage directly with the relevant Prescribed Body Corporates (PBC).	Not applicable	Acknowledged receipt of feedback, and CAPL confirmed it will continue to engage relevant PBCs directly.
PGS Australia Pty Ltd	18 January 2022	165–166	Response to Wheatstone 4D MSS factsheet	No objection or claim. Confirmation that there are no plans to undertake the Rollo seismic survey during the acquisition timing proposed for the Wheatstone 4D MSS.	Not applicable	Acknowledged receipt of feedback.
TGS-NOPEC Geophysical Company Pty Ltd	18 January 2022	167–168	Response to Wheatstone 4D MSS factsheet	No objection or claim. Confirmation that there are no plans to undertake the NWS seismic survey during the acquisition timing proposed for the Wheatstone 4D MSS.	Not applicable	Acknowledged receipt of feedback.
NERA	28 April 2022	193 – 194	Response to Wheatstone 4D MSS EP	NERA provided information on the Collaborative Seismic EP (CSEP) and requested any updates	The CSEP OA intersects with the Wheatstone 4D MSS OA; thus, the request is in line with NERA's	Acknowledged feedback and confirmed updates on the timing of the Wheatstone 4D MSS will be sent to the CSEP

Stakeholder	Date	Sensitive information reference	Matter	Objection or claim	Assessment of merits	Titleholder response
				on the timing of the Wheatstone 4D MSS are sent to the CSEP feedback email. NERA noted the CSEP commits to a separation distance of 40 km between seismic sources.	interests, functions, and activities.	feedback email. CAPL also requested clarification on whether any surveys under the CSEP are currently planned within 40 km of the Wheatstone 4D MSS OA between December 2022 and April 2023.
	5 May 2022	192	Response to Titleholder	NERA confirmed there are currently no surveys planned under the CSEP and will provide CAPL 6-monthly updates.		Acknowledged receipt of feedback.

2.6.5 Ongoing consultation

The stakeholder notifications and ongoing consultation required for this petroleum activity is captured in Table 2-9.

Any objections or claims arising from ongoing consultation that have merit and have the potential to result in changes to the description of environment, impact or risk assessment, or control measures, will be subject to CAPL's Management of Change (MoC) process, in accordance with Section 7.3.2.2.

Table 2-9: Notifications and ongoing consultation

Stakeholder	Notification or ongoing consultation requirement	Timing	Frequency
Notifications			
AHO	Provide information to enable promulgation of Notice to Mariners Notify AHO via datacentre@hydro.gov.au	At least four weeks before commencing activities, or as otherwise agreed with AHO	Once, prior to activities commencing
AMSA	Provide information to enable promulgation of radionavigation warnings Notify AMSA's JRCC via rccaus@amsa.gov.au (phone: 1800 641 792 or +61 2 6230 6811)	At least 24 to 48 hours before commencing activities, or as otherwise agreed with AMSA	Once, prior to activities commencing
Interested other marine users including: • WAFIC • Commercial fisheries • RecFishWest • Marine Tourism WA • Woodside Energy Ltd • Santos Ltd • PGS Australia Pty Ltd • TGS-NOPEC Geophysical Company Pty Ltd • NERA	CAPL to provide notification to other marine users of commencement of activities for the Wheatstone 4D MSS	At least four weeks before commencing activities	Once, prior to activities commencing
DNP	Inform DNP once the EP has been accepted by NOPSEMA. Notify DNP via marineparks@awe.gov.au	Following NOPSEMA acceptance of the EP	Once, prior to activities commencing

Stakeholder	Notification or ongoing consultation requirement	Timing	Frequency
Ongoing consultation			
WAFIC	To inform of changes to activities or impacts/risks occurring that may affect fisheries Notify WAFIC via oilandgas@wafic.org.au	Prior to new or significant changes to activities or impacts/risks occurring	As required
Interested parties, potentially affected parties, government agencies including: • DNP • DMIRS	CAPL to advise of any new or significant changes to activities or impacts/risks within the scope of the EP, following an evaluation as per Section 7.3.2.2, that may potentially impact marine users	Prior to new or significant changes to activities or impacts/risks occurring	As required

2.6.5.1 Stakeholder consultation in the event of an emergency

In the event of an emergency spill event, CAPL will immediately conduct oil spill trajectory modelling using the actual inputs associated with the spill event to predict trajectory, as described in the OPEP (Ref. 2).

Once oil spill trajectory modelling is completed, CAPL will start engaging with potentially affected stakeholders (those considered relevant from Table 2-7 and any others identified from the oil spill trajectory modelling). The process for reaching out to these stakeholders includes direct contact (phone or email) or indirect contact via the CAPL website.

2.6.6 Public comment

In accordance with Regulation 11B of the OPGGS(E)R, the Wheatstone 4D MSS EP was published on the NOPSEMA website between 1–31 March 2022 with an invitation for any person to provide written comments on the content of the EP. To promote the public comment period, CAPL also published notices in The Australian, The West Australian, The Pilbara News, and on the homepage of the Chevron Australia website. Copies of the CAPL published notices are included in the sensitive information report.

No comments were received via the NOPSEMA website during the public comment period, and as such CAPL is not required to prepare and submit a written response statement. CAPL has also not received any further correspondence from any relevant stakeholders during the public comment period to those previously captured in Section 2.6.4.

3 description of the petroleum activity

3.1 Overview

This section provides a description of the petroleum activity as required under Regulation 13(1) of the OPGGS(E)R. The description of the petroleum activity is presented in the following sections:

- seismic acquisition (Section 3.2)
- field support operations (Section 3.3).

3.1.1 Purpose

The purpose of the Wheatstone 4D MSS is to acquire new seismic survey data over the production licences (WA-46-L, WA-47-L, WA-48-L) as part of a monitoring program.

3.1.2 Operational area

The general location of the Wheatstone 4D MSS is described in Section 2.2.

Three areas, based on the types of activity occurring, have been defined for the 4D MSS: acquisition area (or full fold area), full power zone (FPZ), and the operational area (OA) (Table 3-1). The coordinates of each of these areas and their location relative to each other is shown in Table 3-2 and Figure 3-1.

It is within the OA that the petroleum activity defined within Section 3 of this EP will be undertaken. The OA is situated ~30 km from the Montebello Islands, and ~119 km from the mainland (Figure 3-1).

Table 3-1: Wheatstone 4D MSS areas

Name	Activity	Approximate water depth	Area
Acquisition (full fold) area	The target area where the full seismic dataset is required.	80–1,090 m	1,074 km^2
Full power zone (FPZ)	The FPZ is defined as a 4 km buffer around the acquisition area. Within the FPZ the source is discharged at full power in order to achieve the required data capture (i.e., includes run-ins and run-outs).	60–1,130 m	1,644 km^2
Operational area (OA)	The OA for the petroleum activity is defined as a 15 km buffer around the acquisition area. All planned activities within scope of this EP will occur within the OA, including source ramp-up, bubble testing, line changes, equipment maintenance, and the seismic acquisition. Seismic acquisition will not be undertaken during vessel turns.	50–1,250 m	3,730 km^2

Table 3-2: Coordinates and water depths for the acquisition area, full power zone, and operational area for the Wheatstone 4D MSS

Point ID	Latitude^	Longitude^	Water depth (m)
Acquisition area			
1	-20.05696	115.2963	82
2	-20.00816	115.2127	151

Point ID	Latitude^	Longitude^	Water depth (m)
3	-19.65069	115.2123	1085
4	-19.61834	115.2729	1061
5	-19.61905	115.3686	946
6	-19.66441	115.4486	227
7	-19.97503	115.4499	79
Full power zone			
1	-20.09307	115.2976	75
2	-20.03834	115.1917	144
3	-20.01725	115.1757	165
4	-19.6456	115.1746	1123
5	-19.62181	115.1894	1129
6	-19.58402	115.261	1108
7	-19.58327	115.3739	898
8	-19.6334	115.4682	229
9	-19.65492	115.4854	214
10	-19.98007	115.4877	67
11	-20.00561	115.4702	61
Operational area			
1	-20.19243	115.2985	61
2	-20.18022	115.2368	77
3	-20.12161	115.1343	132
4	-20.07739	115.0894	186
5	-20.02273	115.0703	312
6	-19.62264	115.0726	1231
7	-19.58924	115.085	1235
8	-19.55729	115.1087	1245
9	-19.49739	115.2085	1238
10	-19.48324	115.2619	1208
11	-19.48443	115.3849	969
12	-19.50276	115.442	662
13	-19.55349	115.5307	358
14	-19.59276	115.57	219
15	-19.64808	115.5905	186
16	-19.99043	115.5923	80
17	-20.04325	115.5738	75
18	-20.08456	115.5343	67
19	-20.17893	115.3588	49

^ Coordinates provided in decimal degrees (GDA94)

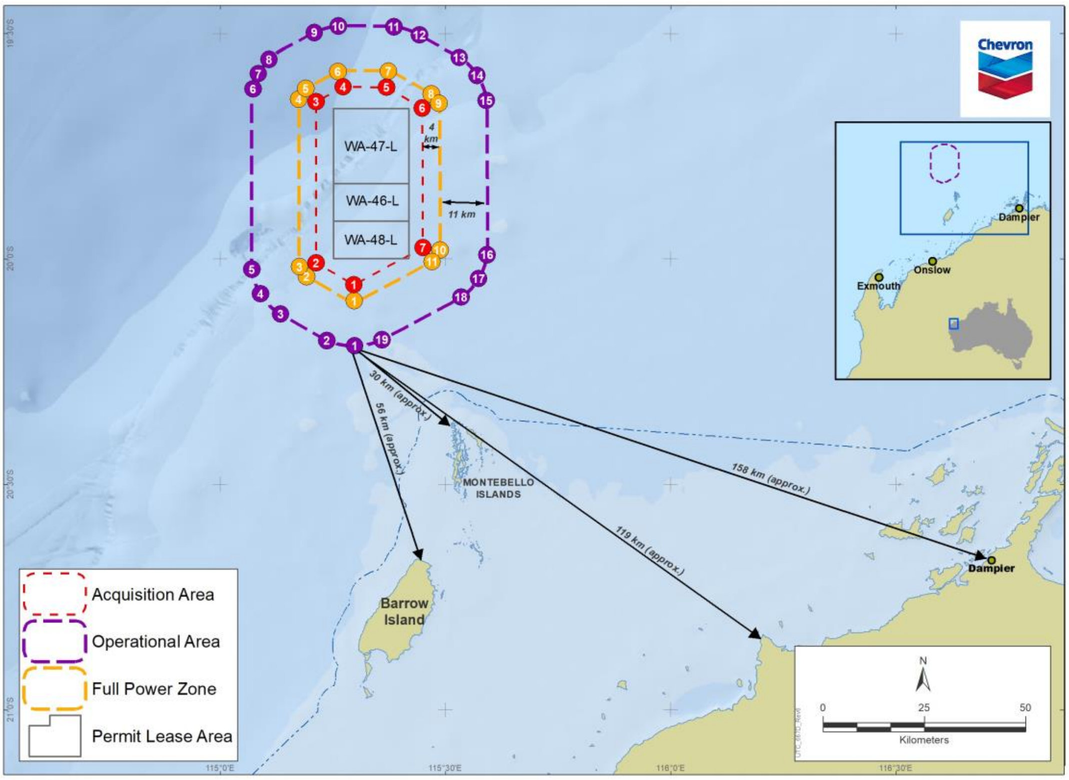


Figure 3-1: Acquisition area, full power zone, and operational area for the Wheatstone 4D MSS

3.1.3 Timing

The Wheatstone 4D MSS is scheduled to occur between mid-December 2022 and mid-April 2023, subject to vessel availability.

The MSS is estimated to take ~75 days to acquire the 120° azimuth survey lines and the optional 60° azimuth survey lines. This 75-day timeframe includes the deployment and retrieval of the equipment, testing, acquisition, and an allowance for typical standby and equipment downtime.

It is noted that should unforeseen circumstances eventuate during the survey (e.g., excessive downtime due to multiple cyclones, serious technical problems, etc.), the survey may take longer than this best estimate of ~75 days. The selection of a four-month window (mid-December 2022 to mid-April 2023) for acquisition is to allow for some contingency if required due to these unforeseen circumstances, and for the uncertainty of the seismic vessel's arrival in the survey area.

Seismic acquisition will be conducted 24 hours a day.

3.2 Seismic acquisition

The 4D MSS method is typical of seismic surveys conducted on the North West Shelf, and no unique equipment or acquisition methods are proposed.

This 4D MSS is aiming to repeat all 120° lines, and some of the 60° lines (specifically within the southern extent of the aqusition area to increase the data density around the Wheatstone Platform and Pluto Platform), from the previous 2011–2012 (Ref. 12) 3D MSS. A schematic of the proposed 120° and 60° azimuth acquisition lines is shown in Figure 3-2. The 4D MSS will most likely capture the

120° lines first, with the potential for subsequent capture of the 60° survey lines, depending on timing.

As shown in the schematic (Figure 3-2), the acquisition area extends beyond the boundaries of the Wheatstone and Iago gas fields. The survey has been designed this way to ensure that sufficient data is captured to develop an accurate and high-quality image of the reservoirs. In order to be able to detect the seismic signal for any given point at least a ~12 km diameter of surrounding recorded data is required, to allow that point to be fully imaged with fully processed (e.g., linear noise removal, demultiple, etc.) data.

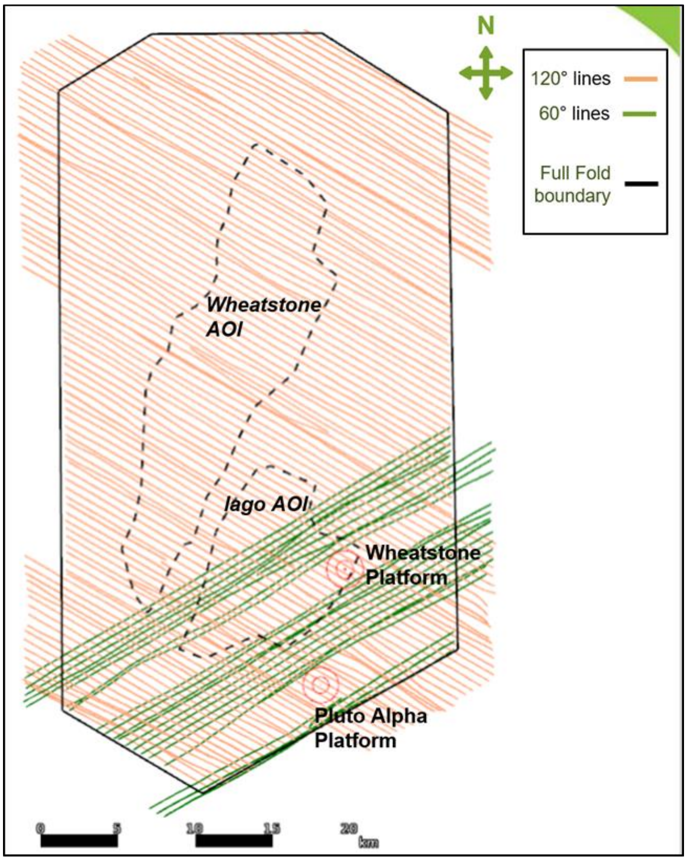


Figure 3-2: Schematic showing the proposed 120° and 60° azimuth acquisition lines for the 4D MSS

The 4D MSS acquisition parameters are provided in Table 3-3, and aim to replicate the acquisition parameters of the 3D MSS (Ref. 12) conducted over the same area in 2011–2012 in order to generate a comparable dataset. The data acquired will show the change in the Wheatstone and Iago gas reservoirs since the start of production in 2017. Figure 3-3 shows a schematic of the proposed acquisition configuration for the seismic survey. Seismic acquisition will be undertaken by a specialist geophysical contractor using a purpose-built seismic vessel (Section 3.3). The seismic vessel will tow seismic equipment along predetermined acquisition lines within the FPZ, to acquire the ~1,074 km^2 of seismic data from within the acquisition area (Figure 3-1). Seismic acquisition will not be undertaken during vessel turns.

For the 4D MSS to be successful, acquisition parameters and ambient environmental conditions need to be the same as the previous 3D MSS. The previous 3D MSS was acquired mid-November 2011 to mid-April 2012. The selected window for the 4D MSS acquisition is therefore similar (mid-December 2022 to mid-April 2023; Section 3.1.3). The reason for the Wheatstone 4D MSS starting in December rather than November is to limit the overlap with the predicted Pygmy Blue Whale migration timings (Section 4.3.1.1; Section 4.7).

It is intended that the seismic energy source will be the same as that used in the previous 2011–2012 3D MSS: a dual source with a source volume of ~4,130 cubic inches (cu.in) and mean operating pressure of ~2000 psi (Table 3-3). The use of a different or reduced source volume would affect the quality and useability of the 4D MSS data. For example, a reduced energy source will result in a weaker signal penetrating the subsurface resulting in an inferior signal to ambient noise ratio which diminishes the detectability of signals in the subsurface.

The acoustic source array will be towed astern of the vessel at a depth of ~5–8 m (+/-1 m). Acoustic signals will be produced at ~18.75 m intervals, achieved by alternating the powering of the dual sources. This corresponds to an acoustic signal being produced approximately every ~7–9 seconds.

Seismic reflections from subsurface layers will be detected by an array of up to 12 solid hydrophone streamers, which will extend up to 7 km behind the seismic vessel. The streamers will be towed at a depth of ~15–25 m below the sea surface and spaced ~100 m apart.

The streamers are equipped with steering devices which enables depth control and horizontal steering to reduce influence of wind and currents and maintain streamer separation. Streamer recovery devices (SRDs) are fitted to the streamers, whereby if the streamers go below a certain depth (generally 50 m), the SRDs automatically activate to raise the streamer to the surface for retrieval. Each streamer has a tail buoy and navigational light to delineate the end of the streamer.

Table 3-3: 4D MSS acquisition parameters

Parameter	Proposed specification
Source configuration	Dual source, ~50 m apart, flip flop arrangement
Maximum source volume	~4,130 cu.in.
Source operating pressure	~2,000 psi
Source tow depth	~5–8 m (+/-1 m)
Shot point interval	~18.75 m
No. of streamers	Up to 12
Streamer length	Up to 7 km
Streamer spacing	~100 m
Streamer array width	~1,100 m
Nominal streamer depth	~15–25 m
Line spacing	~500 m
Line direction	Two azimuths: 120°, 60°
Swath width	~7.5–8 km
Vessel speed during acquisition	~4–5 knots

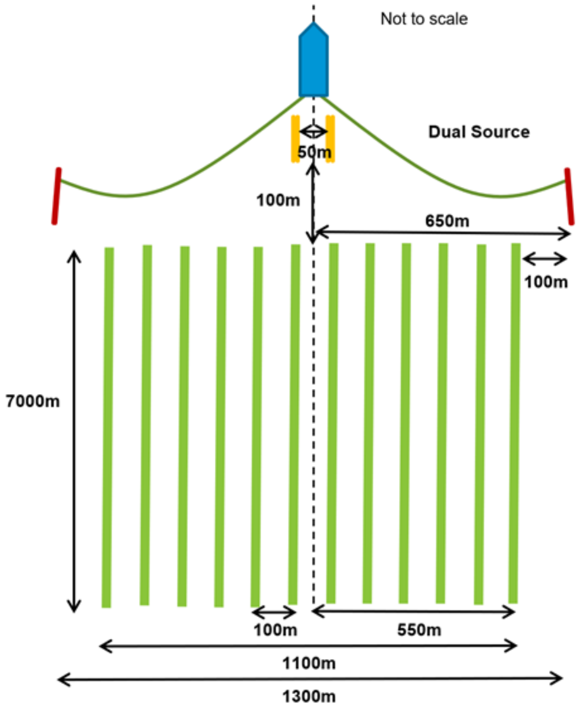


Figure 3-3: Schematic showing proposed acquisition configuration for the 4D MSS

3.3 Field support operations

Seismic acquisition will be undertaken using a purpose-built seismic vessel. Two dedicated support vessels will be used for logistical, safety and equipment management support during the 4D MSS, with at least one support vessel to always be with the seismic vessel. The seismic vessel will also have an onboard workboat, which may be launched to assist with equipment deployment, retrieval, or maintenance activities. There will be a 500 m radius Safe Navigation Area (SNA) requested around the seismic vessel and towed array for the duration of activities. This SNA will be maintained at all times except by those vessels providing supply to the seismic vessel like refuelling, resupply, etc.

The seismic and support vessels will operate from Dampier and/or Exmouth, and crew changes are planned to be conducted on a 2.5 or 5 weekly basis by helicopter (weather permitting for the seismic vessel), or port call.

Vessel anchoring within the OA shall not be permitted except during emergencies (if required).

Vessels will not use Heavy Fuel Oil (HFO) but will utilise a lighter marine fuel such as marine diesel oil (MDO) or Marine Gas Oil (MGO). If refuelling is required, the seismic vessel will be refuelled at sea by the support vessel. Both support vessels will return to port to bunker.

Vessels routinely discharge a variety of wastewater streams to the marine environment including sewage, greywater, food waste, cooling water, brine, and oily bilge water; vessels may also incinerate solid wastes.

In the event of unsafe environmental conditions (e.g., a cyclone passing over or close to survey area), equipment may be retrieved, and/or both the seismic and support vessels may transit away from the OA to a safer location. As per Section 2.3, once a vessel leaves the OA, it is no longer undertaking a petroleum activity.

4 description of the environment

4.1 Overview

This section provides a description of the environment as required under Regulation 13(2) of the OPGGS(E)R. For the purposes of this EP, CAPL have defined and described the following three areas:

- OA—as described in Section 3.1.1, this is the area in which the petroleum activities will be undertaken
- Environment that May Be Affected (EMBA)—defined as the area in which CAPL's activities may result in environmental impacts (thus for the purpose of this EP, defined as the area potentially impacted by hydrocarbons from a spill event above impact concentration thresholds [Table 6-11])
- Environmental Exposure Area (EEA)—defined as the outer area in which hydrocarbons from a spill event may be present in the environment (thus for the purpose of this EP, defined as the area potentially exposed to hydrocarbons from a spill event above exposure concentration thresholds [Table 6-10]).

These areas are shown in Figure 4-1.

CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1; appendix f) describes the environment within the total area in which all CAPL's activities may interact with the environment (i.e., includes activities and projects beyond the scope of this EP). The above three areas, the OA, EMBA and EEA, that are specifically relevant to activities within this EP, all occur within the spatial extent of Planning Area. Therefore, the descriptions as provided in the *Description of the Environment: CAPL Planning Area* (Ref. 1) are appropriate for providing supporting information for use in this EP. The identification of the specific values and sensitivities relevant to the areas for this EP are detailed in the following sections.

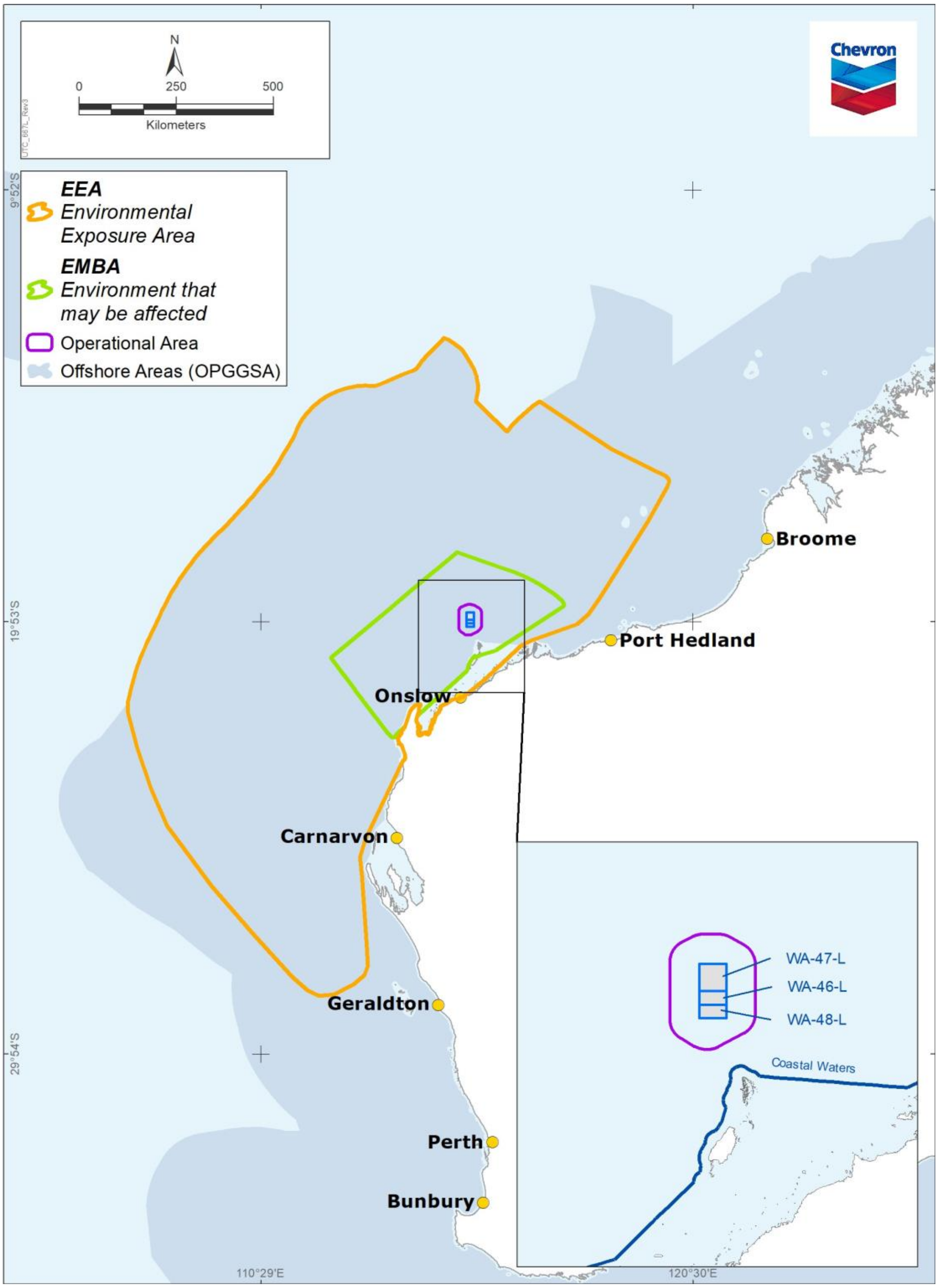


Figure 4-1: OA, EMBA, and EEA for the Wheatstone 4D MSS

4.2 Physical environment

CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1) identifies and summarises the physical environment within the Planning Area. No specific presence of physical values or sensitivities within the OA, EMBA, or EEA have been identified.

4.3 Biological environment

CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1) identifies and summarises the biological environment within the Planning Area. Key threats and relevant management actions from any Conservation Advices or Recovery Plans for threatened or migratory species have also been described (Ref. 1).

The specific presence of biological values and sensitivities within the OA, EMBA and EEA is detailed in the following subsections.

4.3.1 Marine mammals

Based on searches of the protected matters database (Ref. 13; appendix c), the threatened and/or migratory mammal species shown in Table 4-1 may be present within the OA, EMBA and EEA. Biologically important areas (BIAs) associated with marine mammal species are listed in Table 4-2. For the threatened and/or migratory species with BIAs within, or within close proximity to, the OA, additional information has been provided in the following subsections.

Table 4-1: Presence of threatened and/or migratory marine mammals

Common name	OA	EMBA	EEA
Cetaceans (whales)			
Antarctic Minke Whale, Dark-shoulder Minke Whale		✓	✓
Blue Whale	✓	✓	✓
Bryde's Whale	✓	✓	✓
Fin Whale	✓	✓	✓
Humpback Whale	✓	✓	✓
Sei Whale	✓	✓	✓
Southern Right Whale		✓	✓
Sperm Whale	✓	✓	✓
Cetaceans (dolphins)			
Indo-Pacific Humpback Dolphin	✓	✓	✓
Killer Whale, Orca	✓	✓	✓
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	✓	✓	✓
Sirenians			
Dugong		✓	✓

Table 4-2: Presence of BIAs for marine mammals

Common name	BIA behaviour	Seasonal presence	OA	EMBA	EEA
Humpback Whale	Migration (north and south)	Northern migration, late July to September		✓	✓
Pygmy Blue Whale	Distribution	(Not defined in database)	✓	✓	✓
	Foraging	(Not defined in database)		✓	✓
	Migration	Northern migration (enter Perth canyon January to May; pass Exmouth April to August; continue north to Indonesia); Southern migration (follow WA	✓	✓	✓

Common name	BIA behaviour	Seasonal presence	OA	EMBA	EEA
		coastline from October to late December)			
Dugong	Breeding	Year round		✓	✓
	Calving	Year round		✓	✓
	Foraging (high density seagrass beds)	Year round		✓	✓
	Nursing	Year round		✓	✓

4.3.1.1 Pygmy blue whales

A migration and distribution BIA for the Pygmy Blue Whale overlaps with the OA and FPZ.

Pygmy Blue Whales migrate along the west coast of Australia in the northern direction to their breeding grounds near the Indonesian Archipelago from mid-February to early June, and in the southern direction to the feeding grounds in the Southern Ocean from mid-November to early January (Ref. 14). Recent information collected from satellite tags showing that the Banda and Molucca seas in Indonesia are the likely destination for the northern migration of whales that feed off the Perth Canyon (Ref. 15; Ref. 16; Ref. 17).

Acoustic monitoring conducted by McCauley and Jenner (Ref. 18) in the Exmouth and northern Montebello Islands region identified a peak period in the northern migration of Pygmy Blue Whales from April to August, and from November through to late December during the southern migration. It was estimated by McCauley and Jenner (Ref. 18) that between seven and fifteen hundred Pygmy Blue Whales migrated southward past Exmouth in 2004.

CAPL noise loggers deployed for a full year period in 2019 detected Pygmy Blue Whales on their northern and southern migration. The noise loggers were located at various locations ~40–50 km west of the OA, and in ~ 1300 m water depth. The majority of Pygmy Blue Whales detected on their northern migration occurred from mid-April to the end July, then again on their southern migration in November through to early-December (Ref. 19). These peaks correspond with previously identified northern and southern migration periods of Pygmy Blue Whales.

It is known the Pygmy Blue Whales tend to follow the WA continental shelf edge between their feeding grounds of the Perth Canyon and the North West Cape. However, the migratory pathway of whales north of the North West Cape is less defined. The migration BIA for Pygmy Blue Whales has been historically described as occurring along the continental shelf edge between 500 m and 1,000 m water depths (Ref. 76; Ref. 68). However, more recent studies (e.g., Ref. 15; Ref. 14) suggest that Pygmy Blue Whales are likely to transit through deeper and further offshore waters north of the North West Cape. Satellite tracking data showed Pygmy Blue Whales on their northern migration travelled relatively near to the Australian coastline (100±1.7 km) in water depths of 1,369.5±47.4 m, until reaching the North West Cape, after which they travelled offshore (238±14 km) into progressively deeper water (2,617±143.5 m) (Ref. 15). Gavrilov et al. (Ref. 14) conducted a study using an array of ocean bottom seismographs to detect Pygmy Blue Whales traversing the area to the northwest of the North West Cape during their southern migration. This study found that Pygmy Blue Whales migrated southward much further from the WA coast compared to the northbound migration, at distances of up to 400 km from shore (Ref. 14).

McCauley and Jenner (Ref. 18) recorded 24-hour average counts of Pygmy Blue Whales along the WA coast during their migrations periods and found that the migratory habits are short and sharp pulses for the southbound Pygmy Blue Whales and a more protracted pulse of northbound Pygmy Blue Whales. This suggests that the southern migration Pygmy Blue Whales are swimming purposefully through the area to reach their southern feeding grounds, thus resulting in the data collected for Pygmy Blue Whales migrating through the area is not confounded by lingering Pygmy Blue Whales but they are swimming steadily past. This highlights that Pygmy Blue Whales may be present through the OA, however they are not expected to display any sedentary behaviours, as they are expected to travel through the area quickly.

The OA is located in water depths ranging from ~50–1,250 m. The defined BIA for Pygmy Blue Whales overlaps the northern part of the OA and FPZ; however, it is expected based on satellite tracking and acoustic detection studies that Pygmy Blue Whales are likely to travel predominantly to the northwest of the OA in deeper waters, particularly on their southern migration (November to December), but also during the northern migration (April to August).

4.3.1.2 Humpback whales

The migration (north and south) BIA for Humpback Whales is located ~5 km south of the OA, and ~16 km from the FPZ.

Humpback Whales migrate north annually (from June to October) between their feeding grounds in Antarctic waters and their calving grounds in Pilbara/Kimberley waters (Ref. 20). Northbound Humpback Whales tend to remain around the 200 m water depth contour, while southbound Humpback Whales tend to travel closer to Barrow Island and generally occur between 50 m and 200 m water depths (Ref. 20).

The Humpback Whale breeding and calving grounds in the southern Kimberley region extend from Broome to the northern end of Camden Sound, particularly between Lacepede Islands and Camden Sound (Ref. 69). Breeding and calving occurs in the region between mid-August and early-September (Ref. 69), followed by the start of the southern migration. Exmouth Gulf and Shark Bay are both important resting areas for migrating Humpback Whales, particularly for cow-calf pairs on the southern migration (Ref. 78). The southerly migration, from around the Lacepede Islands (north of Broome) extends parallel to the coast on approximately the 20–30 m depth contour (Ref. 20, Ref. 21). Southbound migration is more diffuse and irregular, lacking an obvious peak. An increase in southerly migrating individuals may be observed between the North West Cape and the Montebello Islands between August to early September (Ref. 20; Ref. 19). Females and calves are known to stop and rest in Exmouth Gulf and Shark Bay (Ref. 69).

4.3.2 Reptiles

Based on searches of the protected matters database (Ref. 13; appendix c), the threatened and/or migratory reptile species shown in Table 4-3 may be present within the OA, EMBA and EEA. Habitat critical to survival and BIAs associated with marine reptile species are listed in Table 4-4 and Table 4-5 respectively. For the threatened and/or migratory species with critical habitat or BIAs within, or within close proximity to, the OA, additional information has been provided in the following subsections.

Table 4-3: Presence of threatened and/or migratory reptiles

Common name	OA	EMBA	EEA
Turtles			
Flatback Turtle	✓	✓	✓
Green Turtle	✓	✓	✓
Hawksbill Turtle	✓	✓	✓
Leatherback Turtle	✓	✓	✓
Loggerhead Turtle	✓	✓	✓
Seasnakes			
Leaf-scaled Seasnake		✓	✓
Short-nosed Seasnake	✓	✓	✓

Table 4-4: Critical habitat to the survival of marine turtles

Common name	Nesting location	Internesting buffer	Seasonal presence	OA	EMBA	EEA
Flatback Turtle	Barrow Island, Montebello Islands, coastal islands from Cape Preston to Locker Island	60 km	October to March	✓	✓	✓
	Dampier Archipelago, including Delambre Island and Hauy Island	60 km	October to March		✓	✓
Green Turtle	Barrow Island, Montebello Islands, Serrurier Island, and Thevenard Island	20 km	November to March		✓	✓
	Exmouth Gulf and Ningaloo Coast	20 km	November to March		✓	✓
Hawksbill Turtle	Cape Preston to mouth of Exmouth Gulf including Montebello Islands and Lowendal Islands	20 km	October to February		✓	✓
Loggerhead Turtle	Exmouth Gulf and Ningaloo Coast	20 km	November to May		✓	✓

Table 4-5: Presence of BIAs for reptiles

Common name	BIA behaviour	Seasonal presence	OA	EMBA	EEA
Flatback Turtle	Aggregation			✓	✓
	Foraging	Summer		✓	✓
	Internesting			✓	✓
	Internesting buffer	Summer	✓	✓	✓
	Mating	Summer		✓	✓

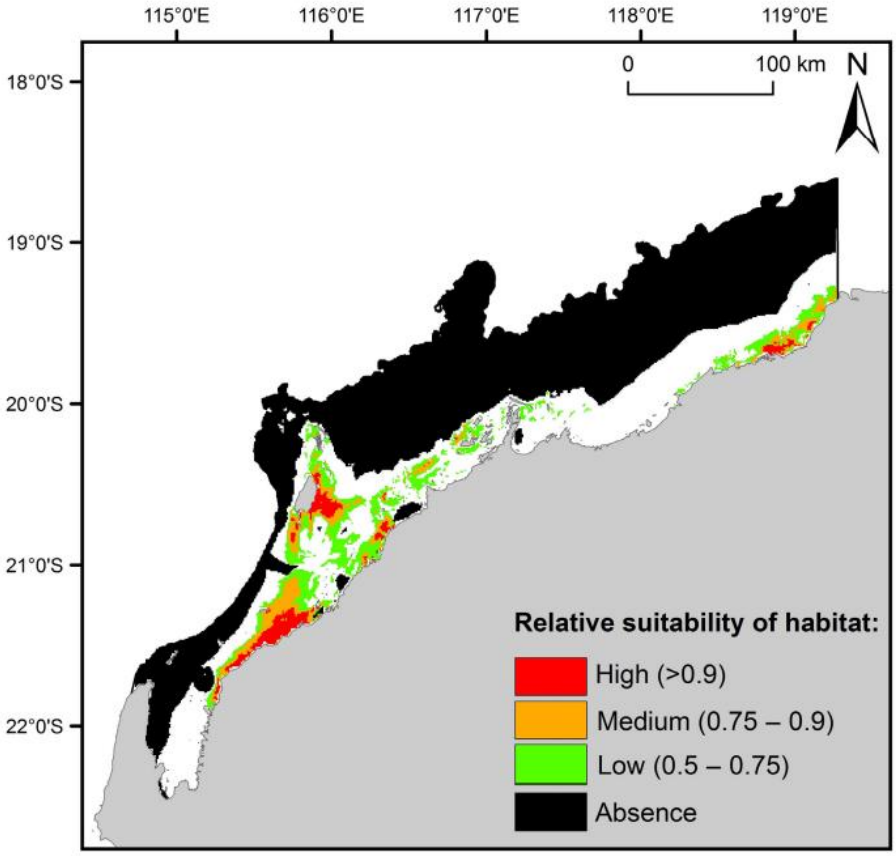
Common name	BIA behaviour	Seasonal presence	OA	EMBA	EEA
	Nesting	Summer		✓	✓
Green Turtle	Aggregation			✓	✓
	Basking	Summer		✓	✓
	Foraging	Summer, Year-round		✓	✓
	Internesting	Summer		✓	✓
	Internesting buffer	Summer		✓	✓
	Mating	Summer		✓	✓
	Nesting	Summer		✓	✓
Hawksbill Turtle	Foraging	Year-round, spring, early-summer		✓	✓
	Internesting	Spring and early-summer		✓	✓
	Internesting buffer	Year-round, spring, early-summer		✓	✓
	Mating	Year-round, spring, early-summer		✓	✓
	Nesting	Year-round, spring, early-summer		✓	✓
Loggerhead Turtle	Internesting buffer			✓	✓
	Nesting			✓	✓

4.3.2.1 Flatback turtles

The Montebello Islands supports Flatback Turtle nesting, occurring from October to March, with a peak in December to January. The Montebello Islands are identified as nesting habitat critical to the survival of the species, as is the 60 km internesting buffer around the Montebello Islands (Ref. 60). Both the internesting critical habitat and the internesting BIA overlap with the OA and FPZ.

During internesting, turtles remain close to the nesting beach or rookery (Ref. 60). The 60 km internesting buffer defined within the Recovery Plan is based primarily on the movements of tagged internesting Flatback Turtles in WA (Ref. 22). The study tracked 56 turtles from 4 different rookeries, which demonstrated varying internesting movements, with distances ranging from 3–62 km, with some turtles at all four rookeries remaining within 10 km of their nesting beaches. However, tracking data showed these movements were largely longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland, which represent the greater distances (Ref. 22). There is no evidence to suggest that Flatback Turtles move to deep offshore waters during internesting periods.

A habitat suitability modelling study for internesting Flatback Turtles in the NWS region of WA (Ref. 69) was conducted to identify areas of suitable Flatback Turtle internesting habitat and determine overlap with identified industrial hazards. The study used a turtle tracking dataset of 47 nesting female turtles from five important rookeries in the NWS study area, including Barrow Island, located ~55 km from the OA. The results showed internesting Flatback Turtles from all rookeries remained within water depths of <44 m, with a mean depth of <10 m (Ref. 69). Results also showed internesting turtles from all rookeries remained within <28 km of the nearest coast, with a mean distance from the coast of <6.1 km. The habitat suitability modelling study defined suitable Flatback Turtle internesting habitat as water depths of 0–16 m within 5–10 km of the coast. Unsuitable Flatback Turtle internesting habitat was defined as waters >25 m deep and >27 km from the coast (Ref. 69; Figure 4-2). The OA is located in waters classified as unsuitable for internesting Flatback Turtles.



Source: Ref. 69

Figure 4-2: Relative suitability of habitat for internesting Flatback Turtles

Consultation undertaken with the lead author of the aforementioned studies (Ref. 22; Ref. 69) and of papers outlined in the Woodside North-west Australia 4D Marine Seismic Survey Environment Plan (Ref. 23) has confirmed that the OA does not support suitable internesting habitat:

"…the location… [is] highly unlikely to host internesting Flatback Turtles from the Montebellos and do not represent important internesting habitat. Flatback turtles are known to spend their internesting time resting on the seabed, the areas you describe are simply too deep to support this behaviour (>73 m)." (Paul Whittock, Pendoley Environmental Pty Ltd, personal communication, October 2019).

Another recent study involving satellite tracking data for 11 Flatback Turtles following nesting on the Lacepede Islands (Ref. 24) found that Flatback Turtles remained at an average distance of 15.75±12.25 km from the nesting beach in water depths of <20 m.

Other previous studies (e.g., Ref. 273; Ref. 274; Ref. 275) have also presented findings that internesting behaviour was only observed in water depths of <40 m. One of these studies (Ref. 275) further indicates internesting Flatback Turtles have relatively shallow dives, with 85% of the time during spent in ≤20 m water depth, of which most was spent in 5–10 m (27±2.7%) and 10–15 m (22.3±3.5%) water depths.

Given the OA is located in water depths of greater than ~50 m, and is >25 km from the Montebello Islands, it is considered highly unlikely that internesting turtles will occur within the OA.

4.3.3 Fishes, including sharks and rays

Based on searches of the protected matters database (Ref. 13; appendix c), the threatened and/or migratory fish species shown in Table 4-6 may be present within the OA, EMBA and EEA. BIAs associated with fish species are listed in Table 4-7. For the threatened and/or migratory species with BIAs within, or within close proximity to, the OA, additional information has been provided in the following subsections.

Table 4-6: Presence of threatened and/or migratory fishes, including sharks and rays

Common name	OA	EMBA	EEA
Blind Cave Eel		✓	✓
Blind Gudgeon		✓	✓
Dwarf Sawfish, Queensland Sawfish	✓	✓	✓
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	✓	✓	✓
Green Sawfish, Dindagubba, Narrowsnout Sawfish	✓	✓	✓
Grey Nurse Shark (west coast population)	✓	✓	✓
Longfin Mako	✓	✓	✓
Narrow Sawfish, Knifetooth Sawfish	✓	✓	✓
Oceanic Whitetip Shark	✓	✓	✓
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred’s Ray, Resident Manta Ray	✓	✓	✓
Porbeagle, Mackerel Shark		✓	✓
Shortfin Mako, Mako Shark	✓	✓	✓
Whale Shark	✓	✓	✓
White Shark, Great White Shark	✓	✓	✓

Table 4-7: Presence of BIAs for fishes, including sharks and rays

Common name	BIA behaviour	Seasonal presence	OA	EMBA	EEA
Whale Shark	Foraging	Spring	✓	✓	✓
	Foraging (high density prey)	April–June, Autumn		✓	✓

4.3.3.1 Whale shark

The foraging BIA for Whale Sharks overlaps with both the OA and FPZ. The BIA is associated with foraging behaviours during northward migration from Ningaloo

Reef / North West Cape along the 200 m isobath during July to November (Ref. 65).

The Whale Shark is widely distributed in Australian waters (Ref. 25); but Ningaloo Reef is the main known seasonal aggregation area (Ref. 75). Whale sharks aggregate off Ningaloo Reef between March and July each year to feed (Ref. 25; Ref. 26). Their presence off Ningaloo Reef has been linked to coral mass spawning timing (Ref. 25). The Whale Shark is a suction filter feeder, with a diet consisting of planktonic and nektonic prey, and feeds at or close to the water's surface by swimming forward with mouth agape, sucking in prey (Ref. 25). While the species is generally encountered close to or at the surface, it will regularly dive and move through the water column. Following the aggregation period around Ningaloo Reef, their distribution is largely unknown, although three migration routes from Ningaloo reef have been identified through various surveys (Ref. 27):

- north-west, into Indian Ocean
- directly north, towards Sumatra and Java
- north-west, passing through the North West Shelf (NWS) region, travelling along the shelf break and continental slope.

Given that Whale Shark foraging within the BIA typically occurs between July and November, it is not expected that large numbers of Whale Sharks will be encountered within the OA during the 4D MSS.

4.3.3.2 Continental slope demersal fish communities

The OA overlaps with small areas of the Continental Slope Demersal Fish Communities key ecological feature (KEF) (Section 4.5). The KEF supports two distinct fish communities, one associated with the upper slope (225–500 m depth), and the other with the mid-slope (750–1,000 m depth) (Ref. 28). The continental slope between North West Cape and the Montebello Trough display a high degree of endemism, supporting more than 500 fish species, of which up to 76 are endemic (Ref. 28). The high number of species is believed to be associated with areas of enhanced biological productivity as a result of the interaction between seasonal currents and seabed topography (Ref. 28).

4.3.4 Seabirds and shorebirds

Based on searches of the protected matters database (Ref. 13; appendix c), the threatened and/or migratory seabird and shorebird species shown in Table 4-8 may be present within the OA, EMBA and EEA. BIAs associated with seabirds and shorebirds are listed in Table 4-9. For the threatened and/or migratory species with BIAs within, or within close proximity to, the OA, additional information has been provided in the following subsections.

Table 4-8: Presence of threatened and/or migratory seabirds and shorebirds

Common name	OA	EMBA	EEA
Abbott's Booby		✓	✓
Amsterdam Albatross		✓	✓
Asian Dowitcher		✓	✓
Australian Fairy Tern	✓	✓	✓
Australian Lesser Noddy			✓

Common name	OA	EMBA	EEA
Australian Painted Snipe		✓	✓
Bar-tailed Godwit		✓	✓
Barn Swallow		✓	
Black-browed Albatross			✓
Black-eared Cuckoo		✓	
Bridled Tern		✓	✓
Campbell Albatross, Campbell Black-browed Albatross		✓	✓
Caspian Tern		✓	✓
Cattle Egret		✓	
Christmas Island White-tailed Tropicbird, Golden Bosunbird	✓	✓	✓
Common Greenshank, Greenshank		✓	✓
Common Noddy	✓	✓	✓
Common Sandpiper	✓	✓	✓
Crested Tern		✓	
Curlew Sandpiper	✓	✓	✓
Eastern Curlew, Far Eastern Curlew	✓	✓	✓
Fairy Tern		✓	
Flesh-footed Shearwater		✓	✓
Fork-tailed Swift		✓	✓
Great Frigatebird, Greater Frigatebird	✓	✓	✓
Greater Crested Tern		✓	✓
Greater Sand Plover, Large Sand Plover			✓
Grey Falcon		✓	✓
Grey Wagtail		✓	✓
Indian Yellow-nosed Albatross			✓
Lesser Frigatebird, Least Frigatebird	✓	✓	✓
Little Tern			✓
Night Parrot		✓	✓
Northern Giant Petrel			✓
Northern Siberian Bar-tailed Godwit, Russkoye Bartailed Godwit		✓	✓
Oriental Plover, Oriental Dotterel		✓	✓
Oriental Pratincole		✓	✓
Osprey	✓	✓	✓
Pectoral Sandpiper	✓	✓	✓
Rainbow Bee-eater		✓	
Red Knot	✓	✓	✓
Red-tailed Tropicbird			✓
Roseate Tern		✓	✓

Common name	OA	EMBA	EEA
Sharp-tailed Sandpiper	✓	✓	✓
Shy Albatross			✓
Silver Gull		✓	
Soft-plumaged Petrel		✓	✓
Sooty Tern		✓	
Southern Giant Petrel	✓	✓	✓
Southern Royal Albatross			✓
Streaked Shearwater	✓	✓	✓
Wandering Albatross			✓
Wedge-tailed Shearwater		✓	✓
White-bellied Sea-Eagle		✓	
White-capped Albatross			✓
White-tailed Tropicbird			✓
White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren		✓	✓
Yellow Wagtail		✓	✓

Table 4-9: Presence of BIAs for seabirds and shorebirds

Common name	BIA Behaviour	Seasonal Presence	OA	EMBA	EEA
Bridled Tern	Foraging (in high numbers)	Late-September to early-May			✓
Fairy Tern	Breeding	July to late-September		✓	✓
Lesser Crested Tern	Breeding	March to June		✓	✓
Little Shearwater	Foraging	Early January to early December, mainly April to November			✓
Little Tern	Resting	June, July and October			✓
Roseate Tern	Breeding	Mid-March to July		✓	✓
Sooty Tern	Foraging	Late-August to early-May			✓
Wedge-tailed Shearwater	Breeding	Mid-August to April (Pilbara) or mid-May (Shark Bay)	✓	✓	✓
	Foraging (in high numbers)	Mid-August to May			✓
White-faced Storm petrel	Foraging (in high numbers)	(not defined in BIA database)			✓
White-tailed Tropicbird	Breeding	May and October			✓

4.3.4.1 Wedge-tailed shearwater

Behaviours used to define biologically important areas for seabirds in Commonwealth marine areas include breeding with a foraging buffer, and roosting (Ref. 276). The Wedge-tailed shearwater has a ‘breeding with a foraging buffer’ BIA that intersects with the OA (Table 4-9). The BIAs for this species are buffers around islands that this species is known to nest on. Bird species may forage in the waters surrounding the islands during nesting seasons. The Wedge-tailed Shearwater ‘foraging in high numbers BIA’ is much further south, near Carnarvon.

Wedge-tailed Shearwaters are a pelagic, migratory visitor to WA; estimates indicate more than one million shearwaters migrate to the Pilbara islands each year (Ref. 277); out of an estimated global population of five million (Ref. 278). The Wedge-tailed Shearwaters typically begin arriving at their WA colonies around August each year and will excavate burrows on vegetated islands for nesting; peak egg laying typically occurs during November; and they will typically leave nests in early April to early May and travel north to the Indian Ocean (Ref. 279; Ref. 280).

Known breeding locations in the North-west Marine Region include Forestier Island (Sable Island), Bedout Island, Dampier Archipelago, Passage Island, Lowendal Island, islands off Barrow Island (Mushroom, Double and Boodie islands), islands in the Onslow area (including Airlie, Bessieres, Serrurier, North and South Muiron and Locker islands), islands in Freycinet Estuary, and south Shark Bay (Slope, Friday, Lefebre, Charlie, Freycinet, Double and Baudin islands) (Ref. 278).

One of the closest colonies to the OA is Double Island (south of Barrow Island). Baseline monitoring (pre-construction of the Gorgon Gas Development) recorded ~20–50 Wedge-tailed Shearwater nesting burrows on North Double Island and ~300 on South Double Island (Ref. 281; Ref. 284). CAPL (Ref. 282; Ref. 284) provided an estimate of 500 burrows over a 2 ha portion of the north-eastern corner of South Double Island, supporting 5,000–10,000 pairs of Wedge-tailed Shearwaters.

This species forages relatively close to breeding islands and its diet consists of squid, fish, and crustaceans (Ref. 278). However, more recent studies have indicated bimodal foraging. A study on foraging behaviour of the Wedge-tailed Shearwaters during the 2018 nesting season on the Muiron Islands showed a bimodal foraging strategy that incorporated both short (<4 days) and long (>7 day) trips (Ref. 280). The foraging trips of the Wedge-tailed Shearwaters from the Muiron Islands were recorded over a large area, extending from the Cape Range Canyon to the Indonesian Archipelago; and a consistent pattern of foraging near seamounts was observed (Ref. 280). It is noted that this same area is part of the extent used by the Wedge-tailed Shearwaters from both Pelsaert and Houtman Abrolhos islands) (Ref. 283; Ref. 280). The use of a bimodal foraging strategy suggests that prey availability close to the colony (i.e., areas that would be utilised on short trips) are inadequate for the large numbers of breeding shearwaters (Ref. 280).

4.3.5 Marine habitat

Marine habitats considered to provide a specific value for matters of national environmental significance (MNES), as described in CAPL’s *Description of the Environment: CAPL Planning Area* (Ref. 1), that were identified within the OA, EMBA, and EEA are shown in Table 4-10.

Table 4-10: Marine habitat and key sensitivities

Matter of national environmental significance	Habitat type					Presence of key value or sensitivity		
	Seagrass	Mangroves	Coral	Saltmarsh	Macroalgae	OA	EMBA	EEA
Ningaloo Coast[1,2]		✓	✓				✓	✓
Ningaloo Marine Area – Commonwealth Waters[3]			✓				✓	✓
Mermaid Reef - Rowley Shoals[3]			✓					✓

1. *World Heritage Property*
2. *National Heritage Place*
3. *Commonwealth Heritage Place*

4.3.5.1 Operational area

CAPL has conducted extensive surveys within the WA-46-L, WA-47-L, and WA-48-L production licences, and within the vicinity of the Wheatstone platform, to understand the nature and composition of habitat and seabed sediments, and thus provide accurate bathymetry for geohazard assessment and engineering design. These surveys comprise high-resolution geophysical surveys, predominantly supported by seabed sampling campaigns. Data from these surveys were interpreted to characterise benthic substrate.

The benthic habitat within the production licences predominantly comprise soft substrate (Ref. 90). For example, imagery from these surveys indicate that the seabed around the Wheatstone LNG Project subsea infrastructure such as flowlines and drill centres, mostly comprises unvegetated, soft, and unconsolidated sediments with a low but varying degree of benthic invertebrate habitation (Figure 4-3, Figure 4-4) (Ref. 90).

The Wheatstone platform is on a ridgeline (~11 km long), in an area of hard substratum. Much of the seafloor at the Wheatstone platform and its immediate vicinity comprises hard rock with a thin veneer of sand (Ref. 91). The ridgeline is not an isolated area of hard substratum; with additional areas of hard substratum known to occur to the northeast and southeast of the Wheatstone platform. Hard substratum may support higher amounts of benthic fauna (such as sponges and soft corals), relative to soft substratum (Ref. 92).

Based on studies undertaken for the Wheatstone LNG Project, the categories of marine habitats and associated benthic fauna identified around the Wheatstone platform are described in more detail below.

Surveys for the Wheatstone LNG Project completed during 2010 indicated that benthic habitats were characterised by 2–10% cover of sessile benthic invertebrates (Ref. 90). The dominant sessile benthic invertebrates on the ridgeline were gorgonians and sponges (Ref. 90). A subsequent survey in 2016 found the dominant benthic organisms on the ridgeline included gorgonians, antipatharians (black coral) and hydrozoans (Ref. 94). Overall, the percentage cover and density of benthic organisms were low and spatially variable (Ref. 94) Findings reported in 2010 (Ref. 90) and 2016 (Ref. 94) are similar to those of other surveys conducted on the NWS, which found hard substratum to be characterised by epifauna assemblages dominated by gorgonians and sponges (Ref. 95).

The ridgeline will support fish communities that may differ to that found on the adjacent soft substratum, but are likely to be similar to other hard substratum on the NWS. According to Last et al (Ref. 97) there are 1,090 species of fishes in Australia's shelf demersal habitat defined as depths between 40 and 200 m. The exact number found in these depths on the NWS is unclear. Sainsbury et al. (Ref. 98) listed 732 species from shelf waters (30–150 m) between Exmouth and the Gulf of Carpentaria. Allen and Swainston (Ref. 99) listed 1062 species for shelf waters (mainland to outer NWS) of northern WA. Only a small sub-set of these species would be demersal that would largely be restricted to hard substratum. Such species would include groupers (*Epinephelus*) and some species of snapper belonging to the genus *Lutjanus* (Ref. 100).

Seagrasses and macroalgae, which are characteristic of sand habitats and reefs, are unlikely to occur within the Commonwealth waters of the OA (Ref. 101). This is most likely due to low benthic light levels characteristic of deep waters.

Based on available information, the level of diversity does not appear to be greater in the platform area than the remaining area of the ridgeline (Ref. 90). There are no identified ecologically isolated or regionally significant marine habitats found around the Wheatstone platform or in the wider OA (Ref. 90; Ref. 102).

Figure 4-3: Seabed survey image showing typical seabed habitat at IAG-1 drill centre for the Wheatstone Project

Figure 4-4: Seabed survey image showing typical seabed habitat at WST-3 drill centre for the Wheatstone Project

4.3.5.2 Other marine habitat

Rankin Bank is located ~1 km east of the OA and ~12 km east of the FPZ. While Rankin Bank is not protected and is not a KEF, it is the only large, complex bathymetrical feature on the outer western shelf of the West Pilbara region and represents habitats that are likely to play an important role in the productivity of the Pilbara region (Ref. 104). Rankin Bank consists of three submerged shoals delineated by the 50 m depth contour with water depths of ~18–30.5 m (Ref. 104). In 2013, AIMS and Woodside co-invested in a project to better understand the habitats and complexity of the submerged shoal ecosystems. Rankin Bank represents a diverse marine environment, predominantly composed of consolidated reef and algae habitat (~55% cover), followed by hard corals (~25% cover), unconsolidated sand/silt habitat (~16% cover), and benthic communities composed of macroalgae, soft corals, sponges and other invertebrates (~3% cover) (Ref. 104). Hard corals are a significant component of the benthic community of some parts of the bank, with abundance in the upper end of the range observed elsewhere on the submerged shoals and banks of north-west Australia (Ref. 105).

4.4 Commercial interests

4.4.1 Commercial fisheries

Natural and physical resources are described as substances occurring in nature that can be exploited for economic gain. The specific resources considered in this EP include commercial fisheries. CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1) identifies and summarises the commercial fisheries that have management areas present within the Planning Area, and seasonal catch data for the entire fishery. The occurrence of recent fishing effort within the areas (OA, EMBA, and EEA) specific to this EP are identified below.

The State-managed commercial fisheries with fishing effort recorded over a 20-year period (1999–2019) (Ref. 29) within areas that overlap the OA, EMBA, and EEA are listed in Table 4-11. Three fisheries were identified with activity within the vicinity of the OA; these are shown in Figure 4-5, Figure 4-6, and Figure 4-7. None of these fisheries operated more than three vessels within the OA in 2018. The Mackerel Managed Fishery utilises near-surface trolling or jig fishing methods, with vessels primarily active during May to November (Ref. 30), and with the bulk of the catch typically taken north of the OA within Kimberley waters (Ref. 31). The Pilbara Line and Pilbara Trap fisheries are part of the Pilbara Demersal Scalefish Fishery. The Pilbara Line Fishery (line fishing methods) operates on an exemption basis which restricts vessels to operating within a nominated 5-month block period each year. The Pilbara Trap Fishery (trap methods) is managed through area closures and effort allocations (Ref. 31). For the 2019 fishing year, the bulk of the catch within the Pilbara Demersal Scalefish Fishery was landed by the trawl sector (which does not occur within the OA); with a smaller contributions from the trap (23%) and line (5%) sectors (Ref. 30).

The Commonwealth-managed commercial fisheries with fishing effort recorded over a five-year period (2015–2020) (Ref. 31) within areas that overlap the OA, EMBA, and EEA are listed in Table 4-12. The only fishery with fishing effort recorded within the OA was the North West Slope Trawl Fishery (Table 4-12, Figure 4-8). Relative fishing intensity data is not available for this fishery due to low vessel numbers and confidentiality. The North West Slope Trawl Fishery use bottom (or demersal) trawl methods to target deep-water prawn and scampi that live on or near the seafloor.

The Southern Bluefin Tuna Fishery is active within waters in the Great Australian Bight and south-eastern Australia (i.e., not within the OA, EMBA, or EEA); however, the spawning grounds for Southern Bluefin Tuna are located in the north-east Indian Ocean (Ref. 31). This indicative spawning area extends into the OA, EMBA, and EEA.

Table 4-11: Presence of fishing effort recorded during 1999–2019 within State-managed commercial fisheries

Fishery	OA	EMBA	EEA
North Coast Bioregion			
Mackerel Managed Fishery	✓	✓	✓
Nickol Bay Prawn Managed Fishery		✓	✓
Onslow Prawn Managed Fishery		✓	✓
Pearl Oyster Managed Fishery			✓
Pilbara Crab Managed Fishery		✓	✓
Pilbara Fish Trawl (Interim) Managed Fishery		✓	✓
Pilbara Line Fishery	✓	✓	✓
Pilbara Trap Managed Fishery	✓	✓	✓
West Australian Sea Cucumber (Beche-De-Mer) Fishery		✓	✓
Gascoyne Bioregion			
Exmouth Gulf Prawn Managed Fishery		✓	✓
Gascoyne Demersal Scalefish Fishery			✓
Shark Bay Crab Fishery			✓

Fishery	OA	EMBA	EEA
Shark Bay Prawn Managed Fishery			✓
Shark Bay Scallop Managed Fishery			✓
West Coast Deep Sea Crustacean Fishery			✓
West Coast Bioregion			
West Coast Demersal Scalefish (Interim) Managed Fishery			✓
West Coast Rock Lobster Fishery			✓
Statewide			
Marine Aquarium Fish Managed Fishery		✓	✓
Specimen Shell Managed Fishery		✓	✓

Table 4-12: Presence of recent (2015-2020) fishing effort recorded within Commonwealth-managed commercial fisheries

Fishery	OA	EMBA	EEA
North-West Slope Trawl Fishery	✓	✓	✓
Western Deepwater Trawl		✓	✓
Western Tuna and Billfish Fishery			✓

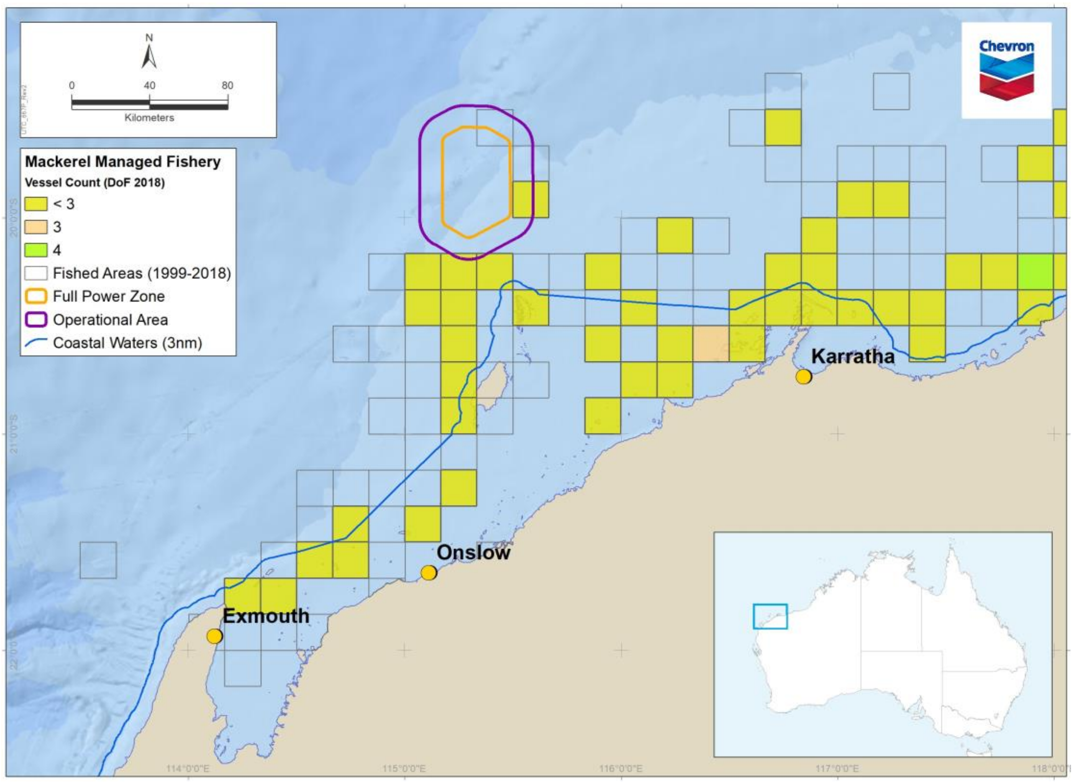


Figure 4-5: Recorded fishing effort (1999–2019), and active vessel counts for 2018, for the Mackerel Managed Fishery within the vicinity of the OA

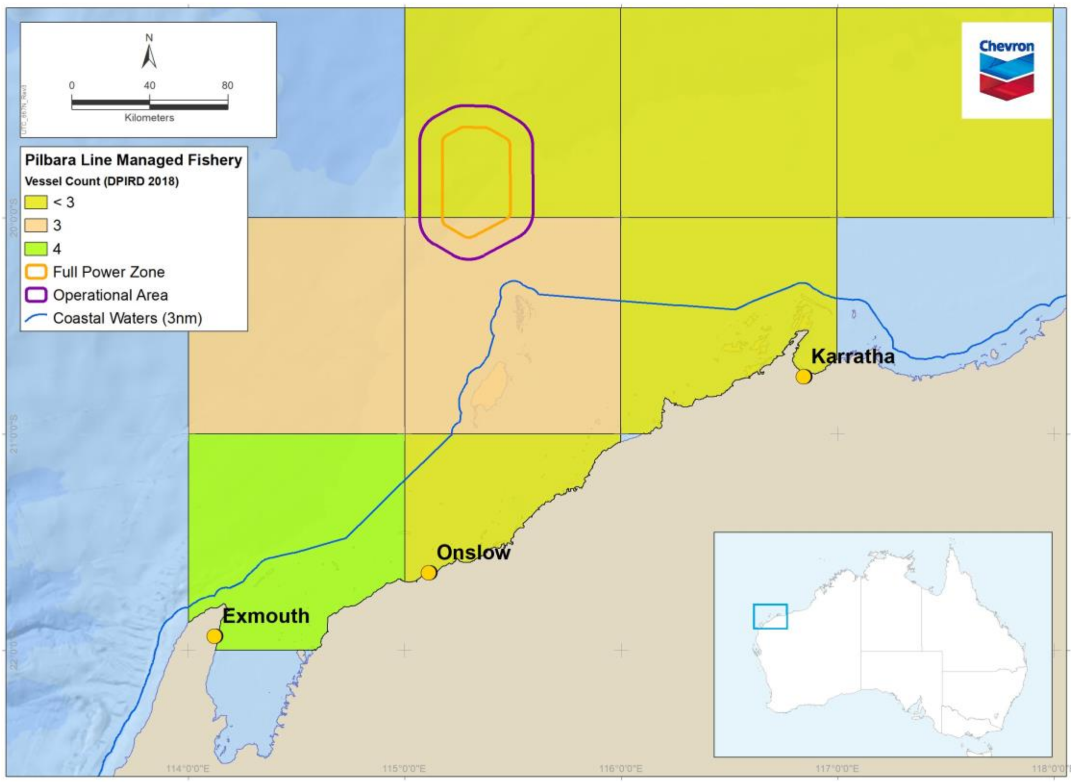


Figure 4-6: Recorded fishing effort (1999–2019), and active vessel counts for 2018, for the Pilbara Line Fishery within the vicinity of the OA

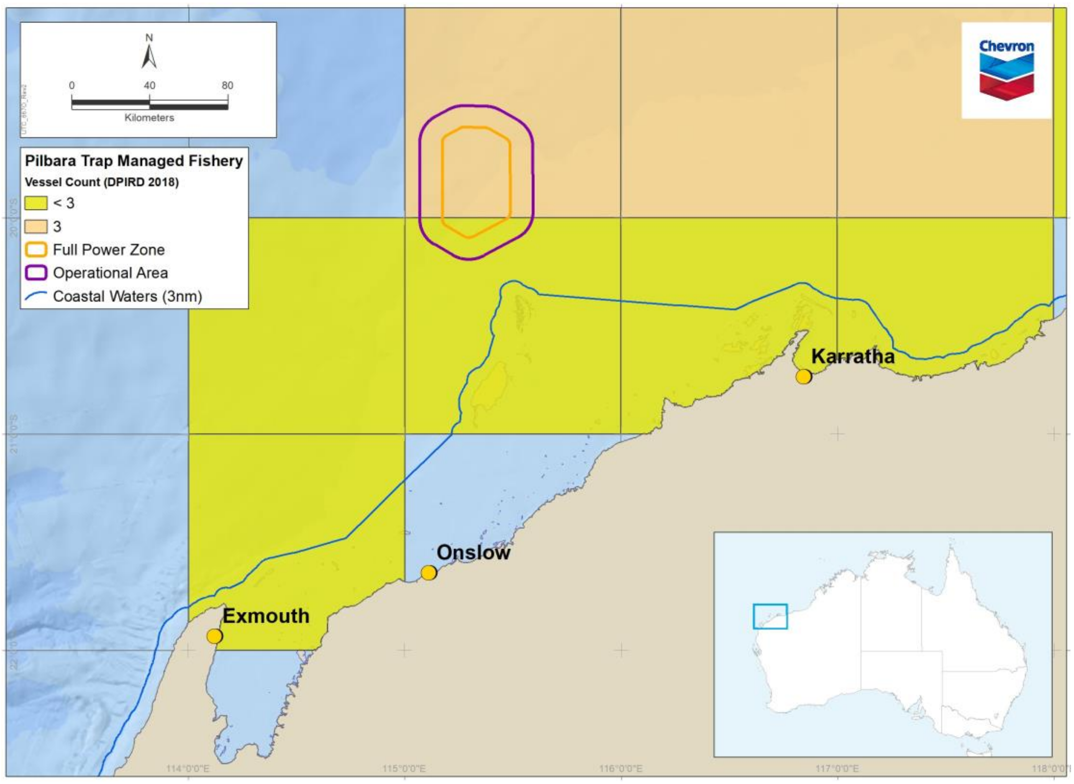
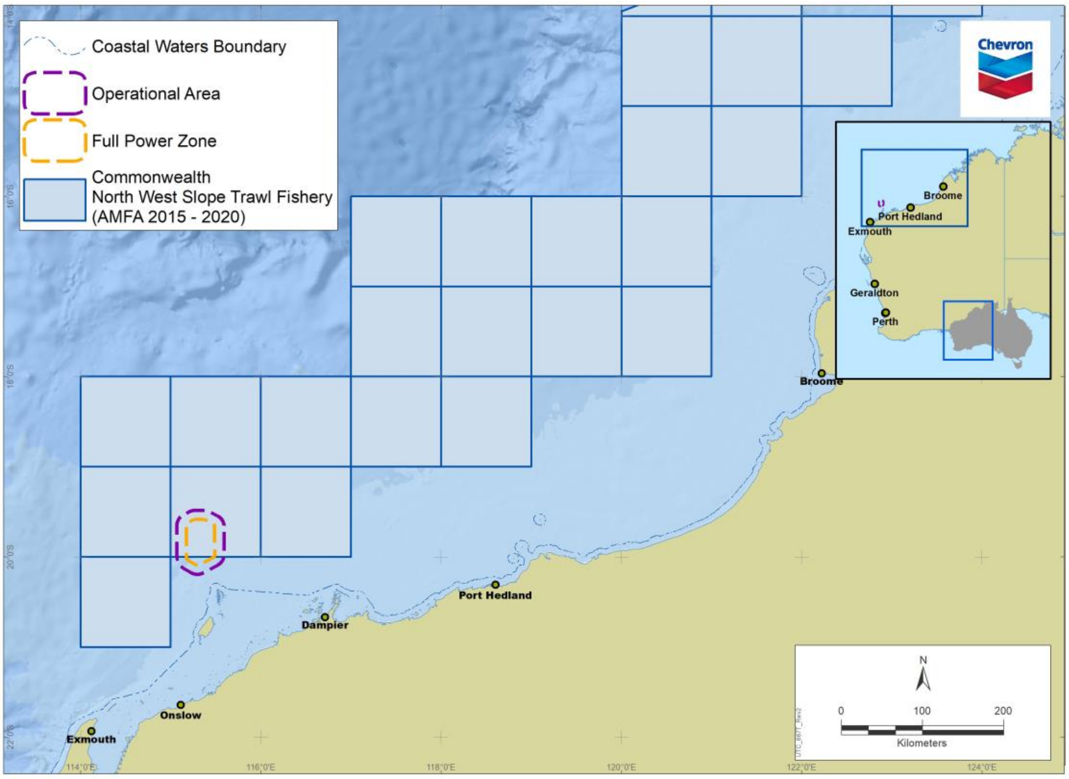


Figure 4-7: Recorded fishing effort (1999–2019), and active vessel counts for 2018, for the Pilbara Trap Managed Fishery within the vicinity of the OA



Source: Fisheries data were supplied by the ABARES from data collected by the AFMA. Where <5 vessels were operating data is available only in the form of a 'footprint' (i.e., total area of waters fished), and not as a relative fishing intensity.

Figure 4-8: Presence of fishing activity (2015-2020) for the North West Slope Trawl Fishery within the vicinity of the OA

4.4.1.1 Commercially targeted fish stocks

The North-west marine region provides fishing grounds for several commercial fisheries which target a variety of demersal and pelagic fish species. Indicator species can be established based on the spawning and distribution of fish species that are used to provide an indication of fish stocks targeted by fisheries and are relevant to the management of commercial fish stocks. The fish indicator species that are of relevance to the OA are Goldband Snapper, Rankin Cod, Red Emperor, Blue-spotted Emperor, Giant Ruby Snapper and Spanish Mackerel.

All of these indicator fish species are summarised in Table 4-13.

Table 4-13: Key indicator fish species relevant to the 4D MSS

Species	Distribution and habitat	Biological stock range	Reproduction and recruitment	Spawning season	References
Goldband Snapper	Goldband Snapper occur around offshore reefs, shoals, and areas of hard flat bottom with occasional benthos or vertical relief in depths of 50-200 m. Juveniles typically occur on uniform sedimentary habitat with no relief. Goldband Snapper are widely distributed throughout northern Australia, from the Gascoyne region of WA to SE Queensland.	Australian populations of Goldband Snapper are likely to form a single biological stock and there is gene flow among Goldband Snapper from the Northern Territory (Timor Sea and Arafura Sea) and between the Western Australian management units (Kimberley, Pilbara and Gascoyne).	Goldband Snapper are highly fecund, serial, broadcast spawners and they can produce several million eggs per season. Goldband Snapper can spawn approximately every three days / every week during the spawning period. Goldband Snapper spawn throughout their range rather than aggregate at specific locations. Juveniles remain in offshore waters with the adult spawning biomass but are found in association with different habitat. Fish are estimated to reach maturity after approximately 4.6 years Stock status: Sustainable	October – May (extended peak spawning period)	Ref. 205 Ref. 218 Ref. 208 Ref. 209 Ref. 203 Ref. 220
Rankin Cod	Rankin Cod are a demersal species distributed in continental shelf waters throughout tropical and sub-tropical northern Australia, from Shark Bay in WA to the NT in depths of 10-150 m. They are generally found in warm coastal waters in association with drop-offs and deep rocky reefs. Juveniles are generally found in inshore coral reefs.	There is low genetic variation and extensive connectivity among populations over large distances (at least 1,400 km). There is no evidence of discrete breeding populations of Rankin Cod in Western Australia, indicating that there is a single biological stock between Shark Bay and the Kimberley.	Rankin Cod are highly fecund, serial, broadcast spawners that release eggs over a protracted spawning period (8-10 months of the year) and appear to spawn across much of the continental shelf of the Pilbara region. Juveniles generally occur inshore from the adults in deeper waters, indicating there may be some movement of juveniles offshore with increasing age. Fish are	The species spawns for 8-10 months of the year in the Pilbara region. The main spawning season is June – December and in March (peaks August – October).	Ref. 205 Ref. 206 Ref. 217 Ref. 203 Ref. 220

Species	Distribution and habitat	Biological stock range	Reproduction and recruitment	Spawning season	References
			estimated to reach maturity after approximately 2 years. Stock status: Sustainable		
Red Emperor	Red Emperor occur from the central west coast of WA to southern Queensland. Red Emperor are widely distributed across the continental shelf and associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches in depths of 10-180 m.	The reproductive biology of Red Emperor results in a very broad distribution of eggs and larvae, which results in genetic connectivity over a wide geographic range. There is extensive connectivity and gene flow among populations across northern Australia (Queensland to Shark Bay in WA), indicating a single genetic stock. There is no evidence of discrete breeding populations between regions in WA.	Red Emperor are highly fecund, serial, broadcast spawners. Females release numerous batches of eggs over an extended spawning period. Juvenile fish are more common in nearshore waters and move offshore and recruit to the stock as they mature. Fish are estimated to reach maturity after approximately 4 – 6 years. Stock status: Sustainable	The species spawns for 10-12 months of the year on the north coast of WA. The main spawning season is September – June (with bimodal peaks September – November and January – March).	Ref. 207 Ref. 205 Ref. 218 Ref. 210 Ref. 203 Ref. 220
Blue-spotted Emperor	The Blue-spotted Emperor is distributed primarily from around Geraldton and the Abrolhos Islands in WA to Darwin in the NT. Greatest abundances are noted in the western Pilbara region. The species is often found in association with shallow reef, sand and mud areas at depths of 10-150 m.	There is extensive connectivity among populations of Blue-spotted Emperor over large distances, and there is considered to be a single biological stock in WA and potentially as far as the Northern Territory.	Blue-spotted Emperor are highly fecund, serial, broadcast spawners that release eggs over a protracted spawning period (11 months of the year). Fish are estimated to reach maturity after approximately 18 months. Stock status: Sustainable	The species spawns for 11 months of the year. The main spawning season is July – March (extended peak spawning period).	Ref. 218 Ref. 217 Ref. 205 Ref. 203 Ref. 220
Giant ruby Snapper	Ruby Snapper occurs across the Indo-West pacific region at depths of 150-480 m. In Australia, ruby snapper is recorded from Geraldton, WA to north-eastern Queensland.	The extent of the biological stock of Ruby Snapper is uncertain.	Like other snappers, Ruby Snapper are understood to be highly fecund, serial, broadcast spawners. Stock status: Sustainable	December-April (peak spawning period January-March).	Ref. 215 Ref.219 Ref. 205 Ref. 203

Species	Distribution and habitat	Biological stock range	Reproduction and recruitment	Spawning season	References
					Ref. 220
Spanish Mackerel	Spanish Mackerel are a pelagic species that are widely distributed throughout Indo-West Pacific waters. In Australia, Spanish Mackerel are found from approximately Geraldton in WA to Northern NSW. Adult movements in Australian waters occur over ranges of 100 – 300 km at depths from 1 m to at least 50 m.	Spanish Mackerel in northern Australia form three distinct genetic stocks: an east coast stock, a Torres Strait stock, and a single stock across the north and west coasts of Australia (Northern Territory and WA). Consequently, the whole of the WA Mackerel Managed Fishery (spanning the Kimberley, Pilbara and Gascoyne regions) is defined as a single stock.	Spanish Mackerel spawning occurs in coastal waters. They are serial spawners and alongshore dispersal of eggs maintains genetic homogeneity. Females are capable of producing a batch of hundreds of thousands of eggs every 1-3 days during the spawning season, though a spawning frequency of 1.9 to 5.9 days has also been reported. Larvae are commonly associated with reef lagoonal areas, before juveniles move to estuary and foreshore nursery and feeding grounds where they tend to remain for the first year of life. Fish are estimated to reach maturity after approximately 2 years. Stock status: Sustainable	September – December (peak spawning).	Ref. 211 Ref. 204 Ref. 212 Ref. 213 Ref. 214 Ref. 220

4.4.2 Shipping

AMSA collects vessel traffic data from a variety of sources, including satellite shipborne automated identification system (AIS) data, across Australia's Search and Rescue region. This data has been used to develop Figure 4-9, which shows recent vessel traffic within the vicinity of the OA.

The OA is located to the south-east and west of the nearest NWS shipping fairways (Figure 4-9). Commercial vessels transiting the NWS are expected to remain within the fairways and therefore will not typically coincide with the OA. Vessel traffic within and around the OA is most likely to comprises offshore support vessels for petroleum activities.

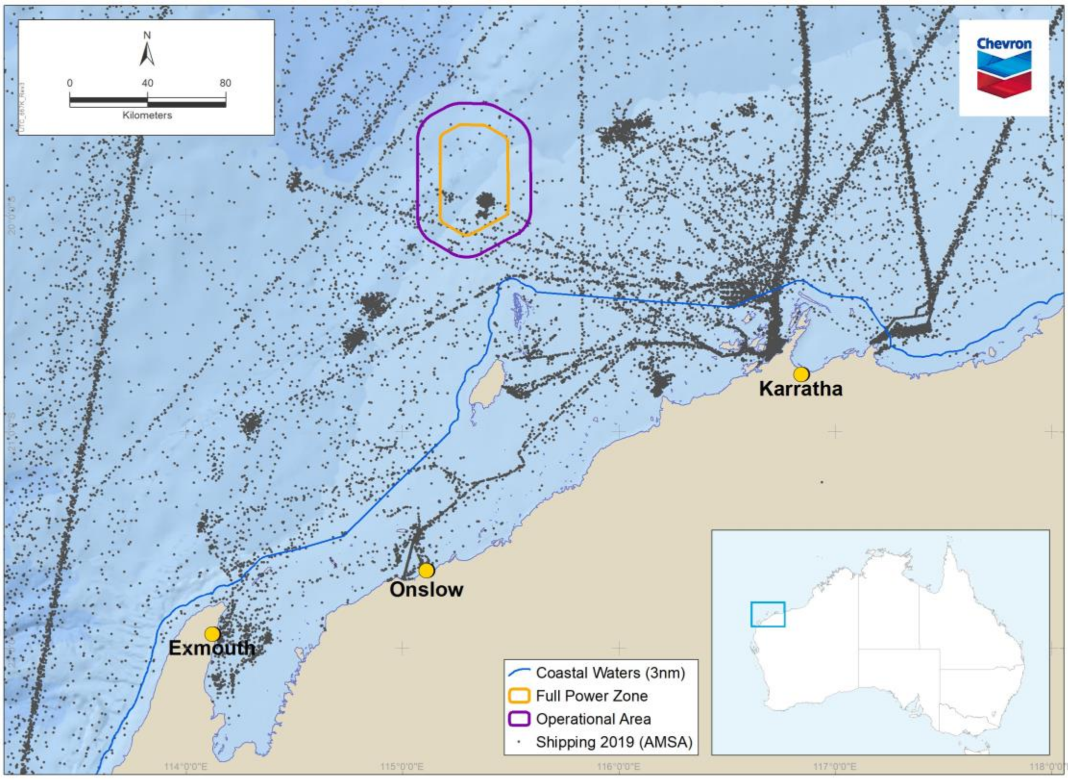


Figure 4-9: Vessel traffic within the vicinity of the OA

4.4.3 Other petroleum activities

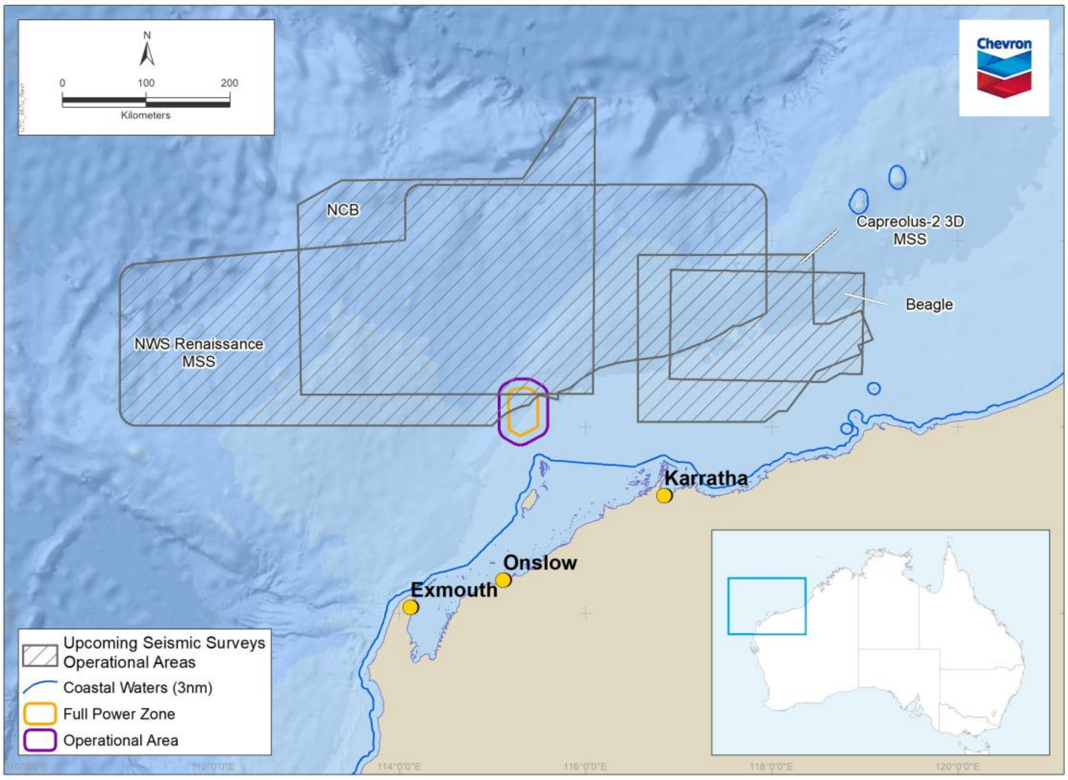
The CAPL Wheatstone Platform and Woodside Energy Pluto-A Platform are located within the OA (Figure 3-2). Both platforms have gazetted petroleum safety zones (PSZs) of 500 m in place under the OPGGS Act.

There are other operational platforms located outside the OA, the closest being:

- Santos operated John Brooks platform (~32 km from OA, and ~43 km from FPZ)
- Santos operated Wonnich platform (~36 km from OA, and ~47 km from FPZ)
- Woodside Energy operated Goodwyn Alpha platform (~32 km from OA, and ~43 km from FPZ).

In order to identify the potential for concurrent seismic surveys, surveys currently being assessed by NOPSEMA or approved (but not yet conducted) were identified from the NOPSEMA website (Ref. 187). Those surveys that may occur concurrently within a ~100 km of the OA are described in Table 4-14, and approximate OAs shown in Figure 4-10.

Consultation with seismic operators for the surveys described in Table 4-14 during January 2022 indicate that no concurrent activities for the two surveys (Rollo Multiclient MSS or the NWS Renaissance North Multi Client MSS) with overlapping OAs with the Wheatstone 4D MSS are currently scheduled. The third survey (Capreolus-2 3D MSS) may occur at a similar time; however, this survey is located ~100 km east from the 4D MSS.



'NWS Renaissance MSS' refers to the North West Shelf Renaissance North Multi Client Marine Seismic Surveys described in Table 4-14. 'Beagle' and 'NCB' (Northern Carnarvon Basin) are part of the Rollo Multiclient Marine Seismic Surveys described in Table 4-14

Figure 4-10: Proposed seismic surveys within the vicinity of the OA

Table 4-14: Proposed seismic surveys within the vicinity of the OA

Activity	Organisation	Status	Description	Interaction with Wheatstone 4D MSS
Capreolus-2 3D Marine Seismic Survey 2020 – 2024	TGS-NOPEC Geophysical Company Pty Ltd	• Approval: EP accepted by NOPSEMA on 10 November 2020. • Activity: Not commenced • Approval expiry: November 2025	• Up to 190 days to acquire 10,000 km^2 • No activity within southern OA during October to June • No activity within northern OA during April to August, and October to December	• Area: ~100 km west of the OA • Timing: Potential to occur at same time
Rollo Multiclient Marine Seismic Surveys	PGS Australia Pty Ltd	• Approval: EP accepted by NOPSEMA on 4 October 2018. • Activity: Commenced • Approval expiry: October 2023	• Two OAs: Northern Carnarvon Basin, Beagle • 3D seismic surveys over specific petroleum titles and adjacent vacant acreage over a period of five years, • Within the OAs a maximum of two surveys may be undertaken at the same time greater than 40 km apart.	• Area: survey OAs overlap • Timing: Potential to occur at same time
North West Shelf Renaissance North Multi Client Marine Seismic Surveys	TGS-NOPEC Geophysical Company Pty Ltd	• Approval: EP accepted by NOPSEMA on 13 June 2018. • Activity: Not commenced • Approval expiry: June 2023	• Proposed acquisition of up to 25,000 km^2 of 3D seismic data over a period of two years.	• Area: survey OAs overlap • Timing: Potential to occur at same time

4.4.4 Tourism and recreation

Tourism and recreation activities are unlikely to occur within the OA, due to the distance offshore and the water depths (ranging from ~50–1,250 m). Recreational fishing in the Northwest Shelf Province is mainly concentrated around the coastal waters and islands (including Dampier Archipelago, Ningaloo Marine Park, North West Cape area, Montebello Islands and other islands and reefs in the region). Occasional recreational fishing occurs at Rankin Bank (located ~1 km east of the OA and ~12 km east of the FPZ). Rankin Bank has been shown to support a diverse fish assemblage that attracts recreational fishing to the area.

The Montebello Islands Marine Park (overlaps with the OA) is the next closest location for tourism to the OA, with some charter boat operators taking visitors to remote islands for diving and recreational fishing.

Recreational diving is typically restricted to shallow water depths (e.g., up to 30 m, based on the advanced open water diving certification prescribed depth limit). Thus, recreational diving is unlikely within the OA due to the water depths being greater than ~50 m. A review of charter boat websites did not identify diving activity at Rankin Bank.

4.5 Qualities and characteristics of locations, places, and areas

CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1) identifies and describes the qualities and characteristics of the locations, places, and areas, present within the Planning Area, that CAPL considers to comprise these receptor groups:

- Ramsar wetlands
- threatened ecological communities (TECs)
- Australian Marine Parks (AMPs)
- key ecological features (KEFs).

Specific to activities within this EP, there were no Ramsar wetlands or TECs identified within the OA, EMBA, or EEA. The specific presence of AMPs and KEFs within the OA, EMBA, and EEA is detailed in Table 4-15 and Table 4-16 respectively. For AMPs or KEFs that occur within, or within close proximity to, the OA, additional information has been provided in the following subsections.

Table 4-15: Presence of AMPs

Australian Marine Park	OA	EMBA	EEA
Abrolhos			✓
Argo-Rowley Terrace			✓
Carnarvon Canyon			✓
Gascoyne		✓	✓
Mermaid Reef			✓
Montebello	✓	✓	✓
Ningaloo		✓	✓
Shark Bay			✓

Table 4-16: Presence of KEFs

Key ecological feature	OA	EMBA	EEA
Ancient coastline at 125 m depth contour	✓	✓	✓
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula		✓	✓
Commonwealth waters adjacent to Ningaloo Reef		✓	✓
Continental slope demersal fish communities	✓	✓	✓
Exmouth Plateau		✓	✓
Glomar Shoals		✓	✓
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals			✓
Perth Canyon and adjacent shelf break, and other Western demersal slope and associated fish communities			✓
Wallaby Saddle			✓
Demersal slope and associated fish communities of the Central Western Province			✓

4.5.1 Australian Marine Parks

The following types of values have been identified for the Montebello Marine Park within the North-west Marine Parks Network Management Plan (Ref. 8), and are summarised in Table 4-17:

- natural values—habitats, species and ecological communities, and the processes that support their connectivity, productivity and function
- cultural values—living and cultural heritage recognising Indigenous beliefs, practices and obligations for country, places of cultural significance and cultural heritage sites
- heritage values—non-Indigenous heritage that has aesthetic, historic, scientific or social significance
- socioeconomic values—the benefits for people, businesses and/or the economy.

The intersect between the OA and FPZ for the Wheatstone 4D MSS (as defined Table 3-1) and the Montebello Marine Park are shown in Figure 4-11. The OA overlaps ~15.8%, and the FPZ overlaps ~4.4% of the Montebello Marine Park.

The Montebello Marine Park is zoned as a Multiple Use Zone (IUCN VI), which is a zone "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" (Ref. 8).

Table 4-17: Significance and values of the Montebello Marine Park

Type	Description
Statement of significance	The Montebello Marine Park is significant because it contains habitats, species, and ecological communities associated with the Northwest Shelf Province. It includes one KEF: the ancient coastline at the 125 m depth contour (valued as a unique seafloor feature with ecological properties of regional significance).

Type	Description
	The Marine Park provides connectivity between deeper waters of the shelf and slope, and the adjacent Barrow Island and Montebello Islands Marine Parks. A prominent seafloor feature in the Marine Park is Trial Rocks consisting of two close coral reefs. The reefs are emergent at low tide.
Natural values	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important seafloor feature and migratory pathway for humpback whales. A KEF of the Marine Park is the ancient coastline at the 125m depth contour where rocky escarpments are thought to provide biologically important habitat in areas otherwise dominated by soft sediments. The Marine Park supports a range of species including species listed as threatened, migratory, marine or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds, internesting, foraging, mating, and nesting habitat for marine turtles, a migratory pathway for humpback whales and foraging habitat for whale sharks.
Cultural values	Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. At the commencement of this plan, there is limited information about the cultural significance of this Marine Park. The Yamatji Marlpa Aboriginal Corporation is the Native Title Representative Body for the Pilbara region.
Heritage values	No international, Commonwealth or national listings apply to the Marine Park at commencement of this plan, however the Marine Park is adjacent to the Western Australia Barrow Island and the Montebello–Barrow Island Marine Conservation Reserves which have been nominated for national heritage listing. The Marine Park contains two known shipwrecks listed under the Historic Shipwrecks Act 1976: *Trial* (wrecked in 1622), the earliest known shipwreck in Australian waters and *Tanami* (unknown date).
Social and economic values	Tourism, commercial fishing, mining and recreation are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation.

(Source: Ref. 8)

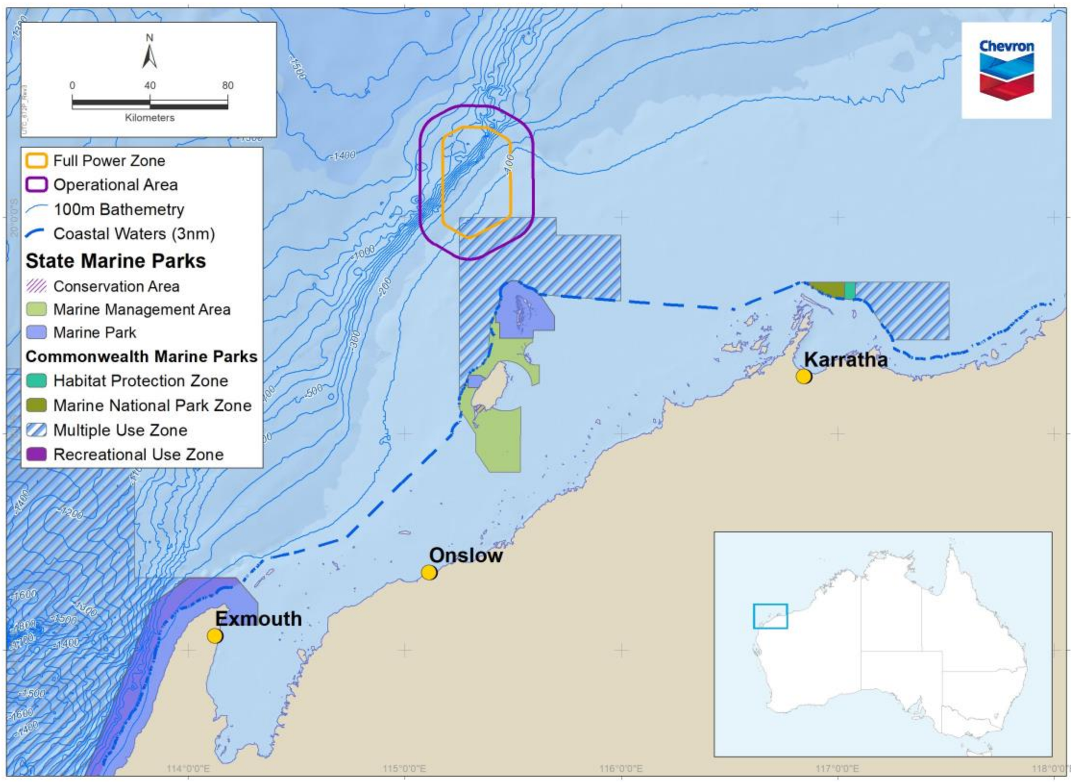


Figure 4-11: Location of Montebello Marine Park in relation to the OA and FPZ for the Wheatstone 4D MSS

4.5.2 Key ecological features

KEFs are elements of the Commonwealth marine environment that are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity. KEFs are not MNES and have no legal status in their own right; however, they may be considered as components of the Commonwealth marine area.

The importance and values have been identified for each KEF within the SPRAT database (Ref. 28), and are summarised in Table 4-18. The OA overlaps ~1.0% of the ancient coastline at 125 m depth contour KEF, and ~1.5% of the continental slope demersal fish communities KEF.

Table 4-18: Importance and values of key ecological features within the OA

KEF	Description
Ancient coastline at 125 m depth contour	The ancient coastline at 125 m depth contour is defined as a KEF as it is a unique seafloor feature with ecological properties of regional significance. The ancient submerged coastline provides areas of hard substrate and therefore may provide sites for higher diversity and enhanced species richness relative to surrounding areas of predominantly soft sediment. Little is known about fauna associated with the hard substrate of the escarpment, but it is likely to include sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates, representative of hard substrate fauna in the North West Shelf bioregion. The escarpment may also facilitate increased availability of nutrients off the Pilbara by interacting with internal waves and enhancing vertical mixing of water layers. Enhanced productivity associated with the sessile communities and increased nutrient availability may attract larger marine life such as whale sharks and large pelagic fish.

KEF	Description
	Humpback whales appear to migrate along the ancient coastline.
Continental slope demersal fish communities	This species assemblage is recognised as a KEF because of its biodiversity values, including high levels of endemism. The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the Australian continental slope. The continental slope between North West Cape and the Montebello Trough has more than 500 fish species, 76 of which are endemic, which makes it the most diverse slope bioregion in Australia. The slope of the Timor Province and the Northwest Transition also contains more than 500 species of demersal fish of which 64 are considered endemic (Last et al. 2005). The Timor Province and Northwest Transition bioregions are the second-richest areas for demersal fish across the entire continental slope. The demersal fish species occupy two distinct demersal community types (biomes) associated with the upper slope (water depth of 225–500 m) and the mid-slope (750–1,000 m). Although poorly known, it is suggested that the demersal-slope communities rely on bacteria and detritus-based systems comprised of infauna and epifauna, which in turn become prey for a range of teleost fish, molluscs, and crustaceans. Higher-order consumers may include carnivorous fish, deepwater sharks, large squid, and toothed whales. Pelagic production is phytoplankton based, with hot spots around oceanic reefs and islands. Although the reasons for the high levels of endemism are not fully understood, the presence of such a diversity of fish and high numbers of endemic species in these bioregions suggests there are important interactions occurring between the physical processes and trophic structures. The data to support high endemism is scarce and the assumption of high endemism could reflect the small sample size. Bacteria and fauna present on the continental slope are the basis of the food web for demersal fish and higher-order consumers in this system. Loss of benthic habitat along the continental slope at depths known to support demersal fish communities may lead to a decline in species richness, diversity and endemism associated with this feature.

(Source: Ref. 28)

4.6 Heritage value of places

CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1) identifies and describes heritage values present within the Planning Area.

The World Heritage properties, National Heritage places, and Commonwealth Heritage places within the OA, EMBA and EEA are listed in Table 4-19, Table 4-20, and Table 4-21 respectively.

Historic shipwrecks and sunken aircrafts (>75 years old) and other underwater heritage artefacts and sites are protected under the Commonwealth *Underwater Cultural Heritage Act 2018*. The Australasian Underwater Cultural Heritage Database (Ref. 33) identified that four historic shipwrecks may be within the OA, and several occur within the spatial extent of the EMBA and EEA; and no historic sunken aircrafts were identified within the OA, EMBA, or EEA. The historic shipwrecks that may be within the OA are *Curlew* (1911), *Marietta* (1905), *Wild Wave (China)* (1873), and *Vianen* (1628). As shown on Figure 4-12, the wreck coordinates recorded within the database are likely to be indicative only (as the same coordinates are provided for all four shipwrecks) while the wreck location description varies.

Table 4-19: World Heritage properties

World Heritage Properties	OA	EMBA	EEA
The Ningaloo Coast		✓	✓

Table 4-20: National Heritage places

National Heritage Properties	OA	EMBA	EEA
HMAS Sydney II and *HSK Kormoran* shipwreck sites			✓
The Ningaloo Coast		✓	✓

Table 4-21: Commonwealth Heritage places

Commonwealth Heritage Properties	OA	EMBA	EEA
HMAS Sydney II and *HSK Kormoran* shipwreck sites			✓
Learmonth Air Weapons Range Facility			✓
Mermaid Reef - Rowley Shoals			✓
Ningaloo Marine Area – Commonwealth Waters		✓	✓

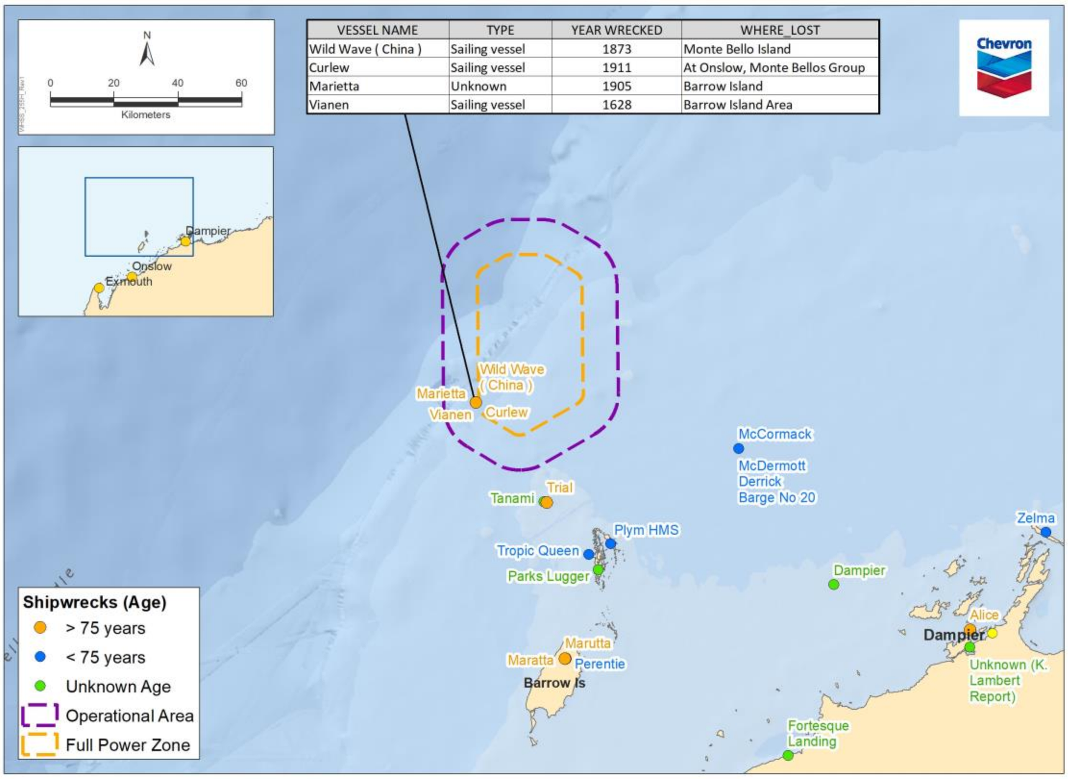


Figure 4-12: Indicative locations of shipwrecks in relation to the OA and FPZ for the Wheatstone 4D MSS

4.7 Summary of seasonal sensitivities

Periods of the year coinciding with key environmental sensitivities, including EPBC Act listed Threatened and/or Migratory species, potentially occurring within the OA are presented in Table 4-22.

Table 4-22: Seasonal presence of environmental sensitivities within the vicinity of the OA

Species	January	February	March	April	May	June	July	August	September	October	November	December
Seismic acquisition	Grey	Grey	Grey	Grey								Grey
Pygmy Blue Whale- northern migration (Montebello region)				Green	Red	Red	Green	Green				
Pygmy Blue Whale- southern migration (Montebello region)											Green	Green
Humpback Whale migration						Green	Green	Green	Green	Green		
Flatback Turtle Internesting (nesting at Montebello Islands)	Red	Green	Green							Green	Green	Red
Whale Shark-foraging/aggregation near Ningaloo			Green	Red	Red	Green	Green					
Whale Shark - foraging BIA							Green	Green	Green	Green	Green	
Wedge-tailed Shearwater (foraging)	Green	Green	Green	Green				Green	Green	Green	Green	Green
Wedge-tailed Shearwater (migrating)				Green	Green			Green				
Australian Fairy Tern (foraging)	Green	Green								Green	Green	Green
Goldband Snapper spawning (extended peak spawning)	Green	Green	Green	Green	Green					Green	Green	Green
Rankin Cod spawning			Green			Green	Green	Red	Red	Red	Green	Green
Red Emperor spawning	Red	Red	Red	Green	Green	Green			Red	Red	Red	Green
Blue-spotted Emperor (extended peak spawning)	Green	Green	Green				Green	Green	Green	Green	Green	Green
Giant Ruby Snapper spawning	Red	Red	Red	Green								Green
Spanish Mackerel spawning									Red	Red	Red	Red

Grey	Planned survey acquisition
Green	Species may be present/display biologically important behaviour in the region
Red	Peak period. Presence of animals reliable and predictable each year.

5 environmental impact and risk assessment methodology

This section provides a description of the methods used to identify and evaluate the environmental impacts and risks associated with the petroleum activities (as described in Section 3) and any potential emergency conditions associated with these activities. These methods support the environmental impact and risk assessment as required under Regulation 13(5) of the OPGGS(E)R.

The impact and risk assessment for this EP was undertaken in accordance with the CAPL's *ABU OE Risk Management Process* (Ref. 34) and using Chevron Corporation's Integrated Risk Prioritization Matrix (Table 5-1). This approach generally aligns with the processes outlined in ISO 31000:2018 *Risk management – Principles and guidelines* (Ref. 35) and the HB 203:2012 *Managing environment-related risk* (Ref. 36).

The impact and risk assessment process and evaluation involved consulting with environmental, health, safety, commissioning, start-up, operations, maintenance, engineering, and emergency response personnel. The impacts and risks considered and covered in this EP were identified and informed by:

- experience gained during the previous Wheatstone 3D MAZ seismic survey
- expertise and experience of CAPL personnel involved in operations
- stakeholder engagement (Section 2.5.2.1).

5.1 Identification and description of the petroleum activity

All components of the petroleum activity and potential emergency conditions relevant to the scope of this EP are described and evaluated during the impact and risk assessment. The petroleum activity is described in detail in Section 3.

5.2 Identification of particular values and sensitivities

The presence of environmental values and sensitivities within the OA, EMBA, and wider EEA is documented in Section 4, with these values and sensitivities further described in CAPL's *Description of the Environment: CAPL Planning Area* (Ref. 1; appendix f). In accordance with Regulation 13(3) of the OPGGS(E)R, the particular values and sensitivities were identified as:

- the world heritage values of a declared World Heritage property within the meaning of the EPBC Act
- the national heritage values of a National Heritage place within the meaning of the EPBC Act
- the ecological character of a declared Ramsar wetland within the meaning of the EPBC Act
- the presence of a listed threatened species or listed threatened ecological community within the meaning of the EPBC Act
- the presence of a listed migratory species within the meaning of the EPBC Act
- any values and sensitivities that exist in, or in relation to, part or all of:
  - a Commonwealth marine area within the meaning of the EPBC Act
  - Commonwealth land within the meaning of the EPBC Act.

Because many protected, rare, or endangered fauna have the potential to transit through the OA, EMBA, and wider EEA, the habitat and/or temporal area that supports protected and endangered fauna (including areas defined as BIAs for these species) is considered the particular value or sensitivity.

5.3 Identification of relevant aspects

CAPL defines an aspect as an element of CAPL's activities, products, or services related to an operation that has the potential to interact with the environment at present or later (e.g., physical presence, planned discharges).

After describing the petroleum activity, an assessment was carried out to identify potential interactions between the petroleum activity and the receiving environment. The outcomes of stakeholder consultation also contributed to this scoping process.

Note: Potential interactions with safety, health, and assets is outside the scope of this EP.

Environmental aspects categorised for use in the impact and risk assessment of this petroleum activity include:

- physical presence
- air emissions
- light emissions
- underwater sound
- invasive marine pests
- planned discharges
- unplanned releases.

5.4 Identification or impacts and risks

Potential impacts and risks arising from the aspects were then identified during a scoping exercise and then evaluated in detail.

5.5 Evaluation of impacts and risks

5.5.1 Consequence

After identifying the aspects, and associated potential impacts and risks, the potential consequences were evaluated using the Integrated Risk Prioritization Matrix (Table 5-1). The consequence level is determined by considering:

- the spatial scale or extent of potential interactions within the receiving environment
- the nature of the receiving environment (within the spatial extent), including proximity to sensitive receptors, relative importance, and sensitivity or resilience to change
- the impact mechanisms (cause and effect) of the aspect within the receiving environment (e.g., persistence, toxicity, mobility, bioaccumulation potential)
- the duration and frequency of potential effects and time for recovery

- the potential degree of change relative to the existing environment or to acceptability criteria.

For aspects that have the potential to cause both impacts and risks, the highest level consequence was carried through the remainder of the assessment to ensure the most conservative analysis is presented.

Table 5-1: Chevron Corporation's Integrated Risk Prioritization Matrix

Likelihood Descriptions	Expected to occur	Likely	1	6	5	4	3	2	1
	Conditions may allow to occur	Occasional	2	7	6	5	4	3	2
	Exceptional conditions may allow to occur	Seldom	3	8	7	6	5	4	3
	Reasonable to expect will not occur	Unlikely	4	9	8	7	6	5	4
	Has occurred once or twice in the industry	Remote	5	10	9	8	7	6	5
	Rare or unheard of	Rare	6	10	10	9	8	7	6
Consequence Descriptions				6	5	4	3	2	1
				Incidental	Minor	Moderate	Major	Severe	Catastrophic
				Limited environmental impact	Localised, short-term environmental impact	Localised, long-term environmental impact	Short-term, widespread environmental impact	Long-term widespread environmental impact	Persistent landscape-scale environmental impact

5.5.2 Control Measures and ALARP

The process for identifying control measures depends on the ‘as low as reasonably practicable’ (ALARP) decision context set for that particular aspect. Regardless of the process, control measures are assigned in accordance with the defined environmental performance outcomes, with the objective to eliminate, prevent, reduce, or mitigate consequences associated with each identified environmental impact and risk.

5.5.2.1 ALARP decision context

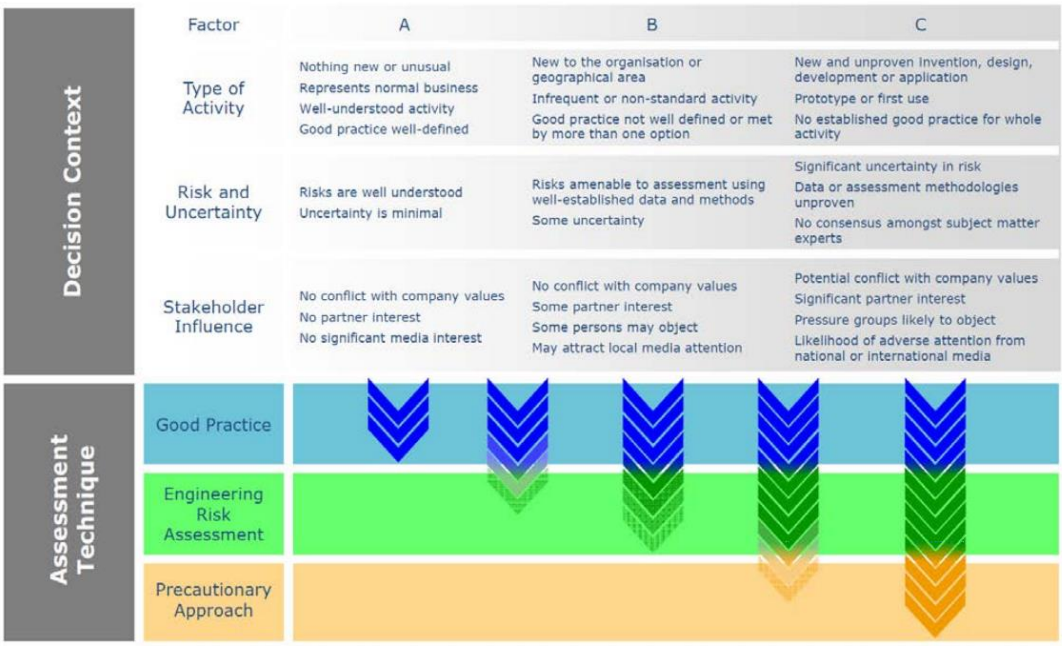
In alignment with NOPSEMA’s ALARP guidance note (Ref. 37), CAPL has adapted the approach developed by Oil and Gas UK (OGUK) (Ref. 38) for use in an environmental context to determine the assessment technique required to demonstrate that impacts and risks are ALARP. Specifically, the framework considers the magnitude of impacts and risks along with these guiding factors:

- activity type
- risk and uncertainty
- stakeholder influence.

A Type A decision (Figure 5-1) is made for lower-order impacts and risks (Table 5-3) where they are relatively well understood, activities are well-practised, and there is no significant stakeholder interest. However, if good practice is not sufficiently well defined, additional assessment may be required. In addition, where an aspect associated with the activity is listed as either a key threat to a protected matter under a document made or implemented under the EPBC Act (such as recovery plans, conservation management plans, or a conservation advice), or identified as an aspect of concern to a listed conservation value under an EPBC Act marine bioregional plan, and can result in a credible impact or risk to these sensitivities, additional control consideration will be undertaken.

A Type B decision (Figure 5-1) is made for higher-order impacts and risks (Table 5-3) if there is greater uncertainty or complexity around the activity, and there are relevant concerns from stakeholders. In this instance, established good practice is not considered sufficient and further assessment is required to support the decision and ensure the risk is ALARP.

A Type C decision (Figure 5-1) typically involves sufficient complexity, higher-order impact and risks (Table 5-3), uncertainty, or stakeholder interest to require a precautionary approach. In this case, relevant good practice still has to be met, additional assessment is required, and the precautionary approach must be considered for those controls that only have a marginal cost benefit.



(Source: Ref. 37)

Figure 5-1: ALARP decision support framework

In accordance with the regulatory requirement to demonstrate that environmental impacts and risks are ALARP, CAPL has considered the above decision context in determining the level of assessment required. This is applied to each aspect described in Section 6. The assessment techniques considered include:

- good practice
- engineering risk assessment
- precautionary approach.

5.5.2.2 Good practice

OGUK (Ref. 38) defines 'good practice' as:

> *The recognised risk management practices and measures that are used by competent organisations to manage well-understood hazards arising from their activities.*

Good practice can also be used as the generic term for those measures that are recognised as satisfying the law. For this EP, sources of good practice include:

- requirements from Australian legislation and regulations
- relevant Commonwealth government policies
- relevant Commonwealth government guidance
- relevant industry standards
- relevant international conventions.

If the ALARP technique is determined to be good practice, further assessment (an engineering risk assessment) is not required to identify additional controls. However, additional controls that provide a suitable environmental benefit for an insignificant cost have been identified.

5.5.2.3 Engineering risk assessment

All impacts and risks that require further assessment are subject to an engineering risk assessment. Based on the various approaches recommended by OGUK (Ref. 38), CAPL believes the methodology most suited to this activity is a comparative assessment of risks, costs, and environmental benefit. A cost–benefit analysis should show the balance between the risk benefit (or environmental benefit) and the cost of implementing the identified measure, with differentiation required such that the benefit of the risk-reduction measure can be seen and the reason for the benefit understood.

5.5.2.4 Precautionary approach

After considering all available engineering and scientific evidence, OGUK (Ref. 38) state that if the assessment is insufficient, inconclusive, or uncertain, then a precautionary approach to hazard management is needed. A precautionary approach will mean that uncertain analysis is replaced by conservative assumptions that will result in control measures being more likely to be implemented.

That is, environmental considerations are expected to take precedence over economic considerations, meaning that a control measure that may reduce environmental impact is more likely to be implemented. In this decision context, the decision could have significant economic consequences to an organisation.

5.5.3 Likelihood

For environmental impacts (where there is a planned emission or discharge resulting in a known change to the environment) likelihood is not considered.

For risks where the aspect or event may lead to environmental impacts under certain circumstances, the likelihood (probability) of the defined consequence occurring is determined. The likelihood is considered on the assumption that all control measures are in place. The likelihood of a consequence occurring was identified using one of the six likelihood categories shown in Table 5-1.

5.5.4 Quantification of the level of risk

The Integrated Risk Prioritization Matrix (Table 5-1) was applied during an environmental risk assessment workshop. This matrix uses consequence and likelihood rankings of 1 to 6, which when combined, result in a risk level between 1 (highest risk) and 10 (lowest risk). Risk assessment outcomes are based solely on assessment of risk to the environment (as defined under the OPGGS(E)R).

5.6 Impact and risk acceptability criteria

NOPSEMA provides guidance on demonstrating that impacts and risks will be of an ‘acceptable level’ (Ref. 9). This guidance indicates that an acceptable level is the level of impact or risk to the environment that may be considered broadly acceptable with regard to all relevant considerations, including:

- principles of ecologically sustainable development (ESD)
- legislative and other requirements (including laws, policies, standards, conventions)
- matters protected under Part 3 of the EPBC Act, consistent with relevant policies, guidelines, threatened species recovery plans, management plans, management principles etc.

- internal context (titleholder policy, culture, processes, standards and systems)
- external context (existing environment, stakeholder expectations).

5.6.1 Principles of ESD and precautionary principle

The principles of ESD are considered in Table 5-2 in relation to acceptability evaluations.

Under the EPBC Act, the Minister must also take into account the precautionary principle in determining whether or not to approve the taking of an action. The precautionary principle (Section 391(2) of the EPBC Act) is that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there may be threats of serious or irreversible environmental damage.

Table 5-2: Principles of ESD in relation to petroleum activity acceptability evaluations

Principles of ESD	How they have been applied
(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social, and equitable considerations	CAPL's impact and risk assessment process integrates long-term and short-term economic, environmental, social, and equitable considerations. This is demonstrated through the Integrated Risk Prioritization Matrix (Table 5-1), which includes provision for understanding the long-term and short-term impacts associated with its activities, and the ALARP process, which balances the economic cost against environmental benefit. As this principle is inherently met by applying the EP assessment process, it is not considered separately for each evaluation.
(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	Consider if there is serious or irreversible environmental damage (i.e., consequence level between Major [3] and Catastrophic [1]). If so, assess whether there is significant uncertainty associated with the aspect.
(c) the principle of inter-generational equity – that the present generation should ensure that the health, diversity, and productivity of the environment is maintained or enhanced for the benefit of future generations	The risk assessment methodology ensures that impacts and risks are reduced to levels that are considered ALARP. If the impacts and risk are determined to be serious or irreversible, the precautionary principle is implemented to ensure that risks are managed to ensure that the environment is maintained for the benefit of future generations.
(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Evaluate if there is the potential to affect biological diversity and ecological integrity.
(e) improved valuation, pricing, and incentive mechanisms should be promoted	Not considered relevant for petroleum activity acceptability demonstrations.

5.6.2 Defining an acceptable level of impact and risk

In alignment with NOPSEMA's ALARP guidance note (Ref. 37), CAPL has applied the approach that lower-order environmental impacts or risks (Table 5-3) assessed as Decision Context A are 'broadly acceptable', while higher-order environmental impacts or risks determined to be Decision Context B or C require further evaluation against a defined acceptable level because they are not inherently 'broadly acceptable'. However, in alignment with NOPSEMA's decision making guidance (Ref. 9) even where the impact or risk is evaluated as being a lower-order impact or risk, but the aspect associated with the activity is listed as a threat to a protected matter under a document made or implemented under the EPBC Act, or identified as an aspect of concern to a listed conservation value under an EPBC Act Marine Bioregional Plans, and can result in a credible impact or risk, CAPL will define an acceptable level of impact and risk in accordance with a document made or implemented under the EPBC Act.

Table 5-3: CAPL definition of lower-order and higher-order impacts and risks

Magnitude	Impacts	Risk	Decision context
Lower-order	Consequence Level: 4–6	Risk Level: 7–10	A
Higher-order	Consequence Level: 1–3	Risk Level: 1–6	B or C

CAPL will consider these types of documents when defining the acceptable level of impact or risk:

- bioregional plans
- AMP plans
- conservation advice
- recovery plans
- government guidelines.

The objectives of the documents are identified and, having regard for the described activity, CAPL will set an acceptable level of impact that aligns with these objectives. Where the impact arising from the activity is inconsistent with the defined level (or objectives of the relevant documents), it is unacceptable.

5.6.3 Summary of acceptance criteria

Table 5-4 outlines the criteria that CAPL used to demonstrate that impacts and risks from each identified aspect are acceptable.

Table 5-4: Acceptability criteria

Criteria	Test
Principles of ESD	Is there the potential to affect biological diversity and ecological integrity? Do activities have the potential to result in permanent/irreversible, medium-large scale, and/or moderate-high intensity environmental damage?
	If yes: Is there significant scientific uncertainty associated with the aspect?
	If yes: Are there additional measures to prevent degradation of the environment from this aspect?
Relevant environmental legislation and other requirements	Confirm that impact and risk management is consistent with relevant Australian environmental management laws and other regulatory / statutory requirements.

Criteria	Test
Internal context	Confirm that all good practice control measures were identified for this aspect through CAPL's management systems and that impact and risk management is consistent with company policy, culture, and standards.
External context	What objections and claims regarding this aspect were made, and how were they considered / addressed?
Defined acceptable level	Is the impact and risk broadly acceptable (i.e. Decision Context A)?
	If no: For higher-order environmental impacts and risks (Decision Context B or C), what is the defined level of impact, and does the activity meet this level?

5.7 Environmental performance outcomes, standards, and measurement criteria

Environmental performance outcomes, performance standards, and measurement criteria were defined to address the environmental impacts and risks identified during the risk assessment.

CAPL is committed to conducting activities associated with the petroleum activity in an environmentally responsible manner and aims to implement best practice environmental management as part of a program of continual improvement to reduce impacts and risks to ALARP. CAPL defines environmental performance outcomes, standards, and measurement criteria that relate to the management of the identified environmental risks as:

- **Environmental performance outcomes**—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 standards**—a statement of the performance required of a control measure

– These statements will consider the effectiveness of the control measures, and, in accordance with NOPSEMA's decision making guidance (Ref. 9), effectiveness will be considered with regards to the controls' functionality, availability, reliability, survivability, independence, and compatibility with other control measures

- **Measurement criteria**—compliance and assurance statement or records that detail how CAPL enacts the outlined performance standard; these are used to determine whether the environmental performance outcomes and standards were met and whether the implementation strategy was complied with. If no practicable quantitative target exists, a qualitative criterion is set.

6 environmental impact and risk assessment and management strategy

This section provides an evaluation of the impacts and risks associated with the petroleum activity appropriate to the nature and scale of each impact and risk, details the control measures that are used to reduce the risks to ALARP and to an acceptable level, and identifies the associated environmental performance outcomes, performance standards, and measurement criteria, as required under Regulations 13(5), 13(6) and 13(7) of the OPGGS(E)R.

Table 6-1 summarises the impacts and risks that were identified and evaluated for this activity.

Table 6-1: Summary of impact and risk evaluation

Section	Aspect	Impact	Risk			Decision context	ALARP	Acceptable
		C^	C^	L	R			
6.1	Physical presence—other marine users	–	6	4	9	A	Yes	Yes
6.2	Physical presence—marine fauna	–	6	4	9	A	Yes	Yes
6.3	Air emissions	6	–	–	–	A	Yes	Yes
6.4	Light emissions	6	5	5	9	A	Yes	Yes
6.5	Underwater sound—seismic acquisition	5	5	3	7	B	Yes	Yes
6.6	Underwater sound—field support operations	5	5	6	10	A	Yes	Yes
6.7	Invasive marine pests	–	2	6	7	A	Yes	Yes
6.8	Planned discharges—vessel operations	6	6	6	10	A	Yes	Yes
6.9	Unplanned release—waste	–	6	5	10	A	Yes	Yes
6.10	Unplanned release—loss of equipment	–	6	4	9	A	Yes	Yes
6.11	Unplanned release—loss of containment	–	5	5	9	A	Yes	Yes
6.12	Unplanned release—vessel collision event	–	5	5	9	A	Yes	Yes
6.13.4.1	Ground disturbance – shoreline spill response	–	5	5	9	A	Yes	Yes
6.13.4.2	Physical presence—oiled wildlife response	–	5	5	9	A	Yes	Yes

C = consequence, L = likelihood, R = risk

^ Where an aspect is identified as having both potential impacts and risks, the highest-level consequence was evaluated in detail to ensure that justification is provided to support the highest consequence level for that aspect.

6.1 Physical presence—other marine users

Source			
Activities identified as having the potential to result in an interaction with other marine users are: • presence of vessels within the OA during the seismic survey • presence of towed equipment from the seismic vessel.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	–	Unplanned interactions with other marine uses may result in: • disruption to commercial shipping and fishing vessels • disruption to other petroleum facilities or activities	 6 6
Consequence evaluation			

Disruption to commercial shipping and fishing vessels

The seismic vessel and at least one of the support vessels will be present within the OA for the duration of the survey (~75 days during mid-December to mid-April; Section 3.1.3). The second support vessel will either be present within the OA or transiting to/from port during the survey period. There will be a 500 m SNA around the seismic vessel and towed array, which will be maintained at all times except by those vessels providing supply to the seismic vessel (e.g., refueling, resupply, etc.). The OA consists of an area of ~3,730 km^2.

The use of vessels during the seismic survey (particularly the seismic vessel due its limited maneuverability) has the potential to result in a disruption to other marine users, including commercial shipping or fishing vessels.

As identified in Section 4.4.1, there are four commercial fisheries (three State, one Commonwealth) that have recent fishing effort that overlaps with the OA.

The State-managed Mackerel Managed Fishery has a management area that overlaps with the OA (specifically with Area 2 of the fishery). The extent to which the OA overlaps Area 2 of the fishery management area is <1%. Limited fishing effort was recorded within the 10 nm graticular blocks that overlap the OA (Ref. 31; Figure 4-5). Specifically, during 2018, fishing effort was recorded in blocks outside the FPZ with <3 fishing vessels present (Figure 4-5). The Mackerel Managed Fishery vessels are primarily active during May to November (Ref. 30), which is outside of the proposed timing of the seismic survey (Section 3.1.3).

The State-managed Pilbara Line Fishery has a management area that overlaps with the OA. The extent to which the OA overlaps the fishery management area is <1%. The Pilbara Line Fishery operates on an exemption basis which restricts vessels to operating within a nominated 5-month block period each year. Recorded fishing effort during 2018 indicated that up to 3 vessels may have been operating within the OA (Figure 4-6).

The State-managed Pilbara Trap Fishery has a management area that overlaps with the OA (specifically with the Schedule 1 [open waters] area of the fishery). The extent to which the OA overlaps Schedule 1 of the fishery management area is <1%. Recorded fishing effort during 2018 indicated that up to 3 vessels may have been operating within the OA (Figure 4-7).

The Commonwealth-managed North West Slope Trawl Fishery has a management area that overlaps with the OA. The extent to which the OA overlaps this trawl fishery management area is <1%. Fishing activity within the Commonwealth trawl fisheries is restricted to waters >200 m water depth. Fishing effort was recorded within the 60 nm graticular block that overlaps the OA each year during the 2015–2020 period (Ref. 31; Figure 4-8). While fishing intensity data is not available for this fishery, vessel activity is expected to be relatively low given that the entire fishery has a small number of active permits and vessels (e.g., seven permits with four vessels were active during the 2018-2019 season [Ref. 1])

The OA is located outside the North West Shelf shipping fairways and commercial vessel traffic density within and around most of the OA is low, with the exception of around existing petroleum infrastructure (risk evaluated separately below) (Figure 4-9).

Therefore, the presence of vessels within the OA during the seismic survey are not expected to significantly affect commercial shipping operators. Any deviation required by these vessels is not

expected to impact on the functions, interests, or activities of other marine users (as confirmed by stakeholder consultation records). In summary, the physical presence of vessels is not expected to cause significant impacts to other commercial shipping or fishing vessels, and the risks are considered limited with potential consequences. Therefore, CAPL has ranked the potential consequence to other marine users from physical presence as Incidental (6).
Disruption to other petroleum facilities or activities There are two existing oil and gas production facilities within the OA: the CAPL-operated Wheatstone Platform and the Woodside-operated Pluto Platform; both of which have a 500 m radius Petroleum Safety Zone (PSZ) in place. The acquisition lines for the seismic survey have been designed such that the seismic vessel and towed array should avoid both platform PSZs. Vessels will adhere to entry prohibitions into designated PSZs, unless an application for entry and presence has been approved. The potential for concurrent seismic activities within the vicinity of the OA is possible based on three existing approved seismic surveys (Section 4.4.3). Two of these approved survey scopes overlap the OA, while the third is ~100 km east (Figure 4-10). Consultation with seismic operators for the surveys described in Table 4-14 indicate that no concurrent activities for the two surveys (Rollo Multiclient MSS or the NWS Renaissance North Multi Client MSS) with overlapping OAs with the Wheatstone 4D MSS are currently scheduled. The third survey (Capreolus-2 3D MSS) described in Table 4-14 may occur at a similar time, however this survey is located ~100 km east from the 4D MSS. Should concurrent seismic surveys be scheduled within proximity to each other, these are typically managed via simultaneous operations plans (SIMOPS) and time-sharing arrangements. The physical presence of vessels within the OA is not expected to cause significant impacts to other petroleum facilities or activities, and the risks are considered limited with potential consequences. Therefore, CAPL has ranked the potential consequence to other marine users from physical presence as Incidental (6).
ALARP decision context justification
Offshore commercial vessel operations are commonplace and well-practised nationally and internationally. The control measures to manage the risks associated with unplanned interactions with other marine users are well defined and understood by the industry. During stakeholder consultation, no objections or claims were raised regarding disturbance/disruption to other marine users arising from the petroleum activity. The risks arising from the physical presence of vessels to other marine users are considered lower-order risks in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.

Good practice control measures and source

Control measure	Source
Stakeholder engagement	Communicating the activity details, location, requested SNA, and presence of vessels to other marine users ensures they are informed and aware, thereby reducing the risk of unplanned interactions. In addition to consultation undertaken during the preparation of this EP (Section 2.5.2.1), relevant stakeholders will also be notified at least four weeks prior to the commencement of activities (Table 2-9).
Maritime safety information	Maritime safety information, such as AUSCOAST radio-navigation warnings, are issued by the Joint Rescue Coordination Centre (JRCC) Australia, part of AMSA. Under the *Navigation Act 2012*, the AHO is also responsible for maintaining and disseminating navigational charts and publications, including providing safety-critical information to mariners (including any change to prohibited/restricted areas, obstructions to surface navigation, etc.) via the Notice to Mariners system. Notice to Mariners can be permanent or temporary notifications. As per Table 2-9, maritime safety information (radio-navigation warnings and/or Notice to Mariners will be issued; thus enabling other marine users to also safely plan their activities.

Marine Safety Reliability and Efficiency (MSRE) process	CAPL's *ABU MSRE Corporate OE Process* (Ref. 43) ensures that various legislative requirements are met. These include: • crew meet the minimum standards for safely operating a vessel, including watchkeeping requirements • navigation, radar equipment, and lighting meets industry standards. These requirements will ensure that direct vessel radio contact is available to other marine users operating in this area to enable ease of communication in highlighting risks and SNAs.	
Managing Safe Work (MSW) process	CAPL's *Managing Safe Work OE Process* (Ref.) ensures that workplace safety and health hazards are assessed and managed. The permit to work (PTW) system is part of this process and includes simultaneous operations (SIMOPS) and hazard analysis. Where required under the MSW process, a SIMOPS Plan will be developed to identify and manage hazards arising from the 4D MSS activities and other planned petroleum activities when occurring within the same area.	
Petroleum safety zones	PSZs are specified areas surrounding petroleum wells, structures, or equipment which vessels or classes of vessel are prohibited from entering or being present in. In compliance with the OPGGS Act, vessel(s) will adhere to vessel entry prohibitions into designated PSZs, unless an application for entry and presence has been approved.	
Adjustment protocol	CAPL will consider an evidence-based adjustment protocol for the commercial fishing sector should fishers be verifiably impacted to a commercially material extent by the 4D MSS (Section 7.3.4.1). CAPL will assess claims from commercial fishing license holders for temporary loss of catch, displacement, or equipment loss/damage, occurring within the OA and during the 4D MSS.	
Additional control measures and cost-benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	Due to the nature and scale of vessel activities within the scope of this EP, the slow-moving nature of vessels within the OA, and the limited area of operation, the likelihood of interaction with other marine users is considered low. As such, CAPL consider that the likelihood of the consequence occurring is Unlikely (4).	
Risk level	Very low (9)	
Determination of acceptability		
Principles of ESD	The risks associated with this aspect are associated with unplanned interactions causing incidental disruption to other marine users, which is not considered as having the potential to affect biological diversity and ecological integrity. The consequence associated with this aspect is Incidental (6). Therefore, no further evaluation against the Principles of ESD is required	
Relevant environmental legislation and other requirements	Legislation and other requirements considered relevant for this aspect include: • Commonwealth *Navigation Act 2012.*	
Internal context	These CAPL environmental performance standards or procedures were deemed relevant for this aspect: • MSRE process (Ref. 43) • MSW process (Ref. 42).	

External context	During stakeholder consultation, no objections or claims were raised regarding interaction with other marine users arising from the activity.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
No impacts to other marine users outside of the OA from petroleum activities	**Stakeholder engagement** Relevant stakeholders will be advised of the commencement and expected completion dates of the activity and any relevant SNA information prior to commencing offshore activities	Stakeholder consultation records
	Maritime safety information Notify relevant agency of activities, vessel movements, and requested SNA, to enable them to generate radio-navigation warnings and/or Notice to Mariners prior to commencing offshore activities	Record of lodgment of notification to relevant agency
	MSRE process Vessels will meet the crew competency, navigation equipment, and radar requirements of the MSRE process	Records indicate that vessels meet the crew competency, navigation equipment, and radar requirements of the MSRE process
	MSW process Where required, CAPL will develop and implement SIMOPS Plan(s) to manage 4D MSS and other planned petroleum activities	Records indicate that where identified as relevant, a SIMOPS Plan has been developed and implemented
	Petroleum safety zones Vessels will adhere to entry prohibitions into designated PSZs, unless an application for entry and presence has been approved	Records demonstrate that vessel activity did not occur within designated petroleum safety zones, without an approved application for entry and presence, within the OA
Reduce the impact to commercial fishery licence holders within the OA from petroleum activities	**Adjustment protocol** CAPL will assess any evidence-based claims from commercial fishery licence holders for compensation in line with the adjustment protocol (Section 7.3.4.1)	Records show that any evidence-based claim from commercial fishery licence holders was assessed and decision finalised

6.2 Physical presence—marine fauna

Source			
Activities identified as having the potential to result in an interaction with marine fauna are: • presence of vessels within the OA during the seismic survey • presence of towed equipment from the seismic vessel.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	–	Unplanned interactions with marine fauna may result in: • injury or death of marine fauna	6
Consequence evaluation			

Surface-dwelling fauna are the species most at risk from this aspect and thus are the focus of this evaluation. As identified in Section 4.3, several marine species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. Several BIAs and/or critical habitat also overlap with the OA, including:

- Pygmy Blue Whale (migration and distribution BIAs)
- Flatback Turtle (internesting BIA, internesting critical habitat)
- Whale Shark (foraging BIA).

As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna.

The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) identifies vessel disturbance as a key threat; however, it also notes that this is particularly an issue in shallow coastal foraging habitats, internesting areas with high numbers of recreational and commercial craft, or areas of marine development. The Recovery Plan defines the critical habitat for internesting as a distance seaward from nesting critical habitat of 60 km for Flatback Turtles (Ref. 63). However, recent studies (Ref. 69) have indicated that the internesting behaviour of Flatback Turtles on the North West Shelf appears more spatially restricted than that suggested by the Recovery Plan (Ref. 63). Whittock et. al. (Ref. 69) reported that Flatback Turtles preference habitats within proximity of the coast and at relatively shallow depths during the internesting periods. Specifically, during the study, a maximum distance from the nearest coast and maximum water depth of 27.8 km and <44 m respectively was recorded, with the mean maximum distance away from the nearest coast and mean water depth being less than 6.1 km and <10 m respectively (Ref. 69). This suggests that although the OA does overlap with some internesting critical habitat and internesting buffer BIA, due to the OA being located offshore (>25 km from the Montebello Islands) and with increasing water depths (up to ~1,250 m) it would be very unlikely that turtles would be aggregating within the OA during their internesting period. Consequently, only a small number of transient marine turtles are expected to be present. The OA within this EP occurs in Commonwealth waters only, does not include shallow coastal habitats, and is not expected be highly utilised during internesting periods. Therefore, vessel disturbance to turtles is not evaluated further, and the focus of this evaluation is on cetaceans and sharks, as they provide a representative case to enable an indicative consequence evaluation to be undertaken.

A review of the documents made or implemented under the EPBC Act for all shark and cetacean species likely to be present within the OA (i.e., Whale Sharks [Ref. 65], Fin Whale [Ref. 66], Sei Whale [Ref. 67], and Blue Whale [Ref. 68]) indicates that either vessel disturbance or interaction (such as collisions) as a key threat to the recovery of the species.

For all cetacean species likely to be present within the OA, these documents indicate that management actions are limited to reporting of incidents via the national database (included within reporting requirements in Section 7.4.2) and ensuring that the risk of vessel strike is assessed (see the following text below).

Cetaceans are naturally inquisitive marine mammals that are often attracted to offshore vessels and facilities. The reaction of whales to the approach of a vessel is quite variable. Some species remain motionless when near a vessel, while others are curious and often approach vessels that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster-moving vessels (Ref. 70). There have been recorded instances of cetacean deaths in Australian waters (e.g., a Bryde's Whale in Bass Strait in 1992) (Ref. 72), although the data indicates deaths are more likely to be associated with container ships and fast ferries. Mackay et al. (Ref. 73) report that four fatal and three non-fatal collisions with Southern Right Whales were recorded in Australian waters between 1950 and 2006, with one fatal and one non-fatal collision reported between 2007 and 2014.

The *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68 indicates that although all forms of vessels can collide with whales, severe or lethal injuries are more likely to occur by larger or faster vessels. Laist et al. (Ref. 71) found that larger vessels with reduced maneuverability moving >10 knots may cause fatal or severe injuries to cetaceans, with the most severe injuries caused by vessels travelling >14 knots. Given that vessels will be slow moving whilst undertaking the activities within the scope of this EP (Section 3.2), any interaction with marine fauna would not be expected to cause severe injuries.

As described in Section 4.3.1.1, migrating Pygmy Blue Whales are likely to occur in the Exmouth to Montebello Islands region from April to August (northern migration) and from November to December (southern migration). As the 4D MSS is scheduled to occur between mid-December to mid-April there is the possibility that the seismic survey could overlap with the end of the southern migration period (December) and the start of the northern migration period (April). However, as discussed in Section 4.3.1.1, although the defined BIA for Pygmy Blue Whales overlaps the northern part of the OA and FPZ, it is expected based on recent satellite tracking and acoustic detection that Pygmy Blue Whales are likely to travel predominantly to the northwest of the OA in deeper waters, particularly on their southern migration.

The migration BIA for Humpback Whales is located ~5 km south of the OA, and Humpback Whales are typically present from June to October (Section 4.3.1.2). As such, the presence of Humpback Whales within the OA during the acquisition of the 4D MSS is not expected.

A review of the documents made or implemented under the EPBC Act for Whale Sharks indicate that management actions should consider minimising offshore developments and transit time of large vessels in areas close to marine features likely to correlate with Whale Shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea). On the basis that vessels activities are minimised to the smallest practicable extent (as also driven by economic considerations), the high-density foraging BIA is not located within the OA and given that the nature and scale of vessel operations over the course of this EP are limited the activity is considered to be consistent with all relevant management actions.

Whale Sharks are known to spend considerable time close to the surface increasing their vulnerability to vessel strike. Whale sharks tagged off Western Australia (Ref. 74, Ref. 75) spent ~25% of their time <2 m from the surface and >40% of their time in the upper 15 m of the water column. Spending such considerable time within 15 m of the surface leaves them vulnerable to collision with smaller vessels as well as larger commercial vessels that have drafts greater than 20 m below the surface. A search of the National Database did not identify any previous incidences of vessel strikes with Whale Sharks, indicating that although the risk is possible, previous events are limited in frequency. Although the OA overlaps the Whale Shark foraging BIA, vessels will be stationary or slow-moving whilst implementing the activities within the scope of this EP.

The seismic survey is scheduled to occur between mid-December to mid-April (Section 3.1.3), which is outside of when Whale Sharks are likely to be foraging with in the BIA (July to November) (Ref. 76). As such, significant numbers of Whale Sharks are not expected to occur within the OA.

Consequently, incidences of fauna strike are not expected considering the slow vessel speed, the low number of vessels within the OA at any one time and the very low (cetaceans) and no (whale sharks) reports of fauna strikes. If a fauna strike did occur and resulted in death, it is not expected to have a detrimental effect on the overall population; this event would result in a limited environmental impact (individual impacts). Given the limited impacts expected to marine fauna from vessel strikes, it is therefore expected that there would also be limited environmental impacts to the values of the Montebello Marine Park.

Historically turtles have been recorded as becoming trapped in the streamer tail buoys. Tail buoys are now either of a design that does not represent an entrapment risk to turtles, or turtle guards are used as standard equipment (if the tail buoy is not of the newer design). Thus, there is no cause effect pathway for entrapment of turtles in streamer buoys, and this risk is not evaluated further.

In summary, the physical presence of vessels or towed equipment is not expected to cause significant impacts to marine fauna, and the risks are considered limited with potential consequences. Therefore, CAPL has ranked the potential consequence to marine fauna from physical presence as Incidental (6).

ALARP decision context justification		
Offshore commercial vessel operations are commonplace and well-practised nationally and internationally. The control measures to manage the risks associated with unplanned interactions with marine fauna are well defined via legislative requirements that are considered standard industry practice. These are well understood and implemented by the petroleum industry and CAPL. During stakeholder consultation, no objections or claims were raised regarding interaction with marine fauna arising from the activity. The risks arising from the physical presence of vessels are considered lower-order risks in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.		
Good practice control measures and source		
Control measure	**Source**	
EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans	The requirements to manage interactions between vessels and cetaceans are detailed in the EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans. These regulations describe strategies to ensure cetaceans are not harmed during offshore interactions with people.	
Turtle entanglement prevention	A tail buoy will be fitted to the end of each streamer. Tail buoys are brightly coloured and contain a radar reflector and navigation light to be visible to other marine users. If the tail buoys are of a design that represents an entrapment risk to turtles, they will be fitted with guards to prevent accidental entrapment of turtles.	
Acquisition timing	Seismic acquisition surveys will be scheduled to avoid regional peak migration periods for cetaceans and shark species to reduce the likelihood of high numbers of individuals transiting through the OA.	
Additional control measures and cost-benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	Due to the nature and scale of vessel activities within the scope of this EP, the slow-moving nature of vessels within the OA, and the limited area of operation, the likelihood of a vessel collision or buoy entanglement with marine fauna is considered low. Based upon previous experience in the OA, CAPL consider that the likelihood of the consequence occurring is Unlikely (4).	
Risk level	Very low (9)	
Determination of acceptability		
Principles of ESD	The risks associated with this aspect are associated with unplanned interactions causing individual fauna injury or mortality, which is not considered as having the potential to affect biological diversity and ecological integrity. The consequence associated with this aspect is Incidental (6). Therefore, no further evaluation against the Principles of ESD is required.	
Relevant environmental legislation and other requirements	Legislation and other requirements considered relevant for this aspect include: • EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans • *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) • *Conservation Advice Balaenoptera borealis Sei Whale* (Ref. 67) • *Conservation Advice Balaenoptera physalus Fin Whale* (Ref. 66)	

	• *Conservation Advice Rhincodon typus Whale Shark* (Ref. 65) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle)* (Ref. 64) • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).	
Internal context	No CAPL environmental performance standards or procedures were deemed relevant for this aspect.	
External context	During stakeholder consultation, no objections or claims were raised regarding interaction with marine fauna arising from the activity.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan. However, given that vessel strike is listed as a threat to protected matters under documents made or implemented under the EPBC Act, CAPL has defined an acceptable level of impact such that it is not inconsistent with these documents. The Conservation Advices for Blue Whales, Sei Whales, and Fin Whales (Ref. 68; Ref. 67; Ref. 66) all specify the following action: • ensure all vessel strike incidents are reported in the National Ship Strike Database. This action is incorporated into reporting requirements under this EP (Section 7.4.2).	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
No injury or mortality to marine fauna within the OA from petroleum activities	**EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans** Seismic and support vessels will implement caution and no approach zones, where practicable: • caution zone (300 m either side of whales; 150 m either side of dolphins)– vessels must operate at ≤6 knots within in this zone, maximum of three vessels within zone, and vessels should not enter if a calf is present • no approach zone (300 m to the front and rear of whales and 100 m either side; 300 m for whale calves; 150 m to the front and rear of dolphins and 50 m either side)–vessels should not enter this zone, and should not wait in front of the direction of travel of an animal ***Exception****: does not apply to seismic vessel towing equipment and operating under constrained manoeuvrability; or to any vessel in the event of an emergency.*	Induction materials include relevant marine fauna caution and no approach zone requirements Training records confirm personnel involved in offshore vessel activities have completed the induction Vessel records show if marine fauna interaction occurred within caution or approach zones, and what mitigation (e.g., divert or slow vessel) measure was implemented

	Turtle entanglement prevention If the tail buoys are of a design that represents an entrapment risk to turtles, they will be fitted with turtle guards prior to deployment	Inspection records verify turtle guards are installed on tail buoys where required (or buoys have been designed to not represent an entanglement risk to turtles)
	Acquisition timing Seismic acquisition scheduled to avoid regional peak migration periods for cetaceans and shark species	Records confirm that the seismic survey has been acquired during a period mid-December to mid-April

6.3 Air emissions

Source			
Activities identified as having the potential to result in air emissions are: • combustion of marine fuel from vessels within the OA during seismic survey • combustion of aviation fuel from helicopters within the OA during seismic survey.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
Air emissions may result in: • localised and temporary reduction in air quality • contribution to the reduction of the global atmospheric carbon budget	 6 6	N/A	–
Consequence evaluation			
Localised and temporary reduction in air quality Modelling was undertaken for nitrogen dioxide (NO_2) emissions from a mobile offshore drilling unit MODU power generation for another offshore project (Ref. 77). NO_2 is the focus of the modelling because it is considered the main (non-greenhouse) atmospheric pollutant of concern, with larger predicted emission volumes compared to other pollutants, and has potential to impact on human health (as a proxy for environmental receptors). Results of this modelling indicate that on an hourly average, there is the potential for an increase in ambient NO_2 concentrations of 0.0005 ppm within 10 km of the emission source and an increase of <0.1 µg/m^3 (0.00005 ppm) in ambient NO_2 concentrations >40 km away. The *National Environmental Protection (Ambient Air Quality) Measure* (NEPM) recommends that hourly exposure to NO_2 is <0.12 ppm with annual average exposure <0.03 ppm. Given that referencing this modelling is considered overly conservative as the volume of fuel required for power generation is expected to be significantly less for the seismic and support vessels when compared to MODU operations, and as the highest hourly averages (0.00039 ppm or 0.74 µg/m^3) were restricted to a distance of ~5 km from the MODU (Ref. 77), exposures from vessel activities covered under this EP would be well below NEPM standards and thus any impacts were considered to be Incidental (6).			
Contribution to the reduction of the atmospheric carbon budget Direct GHG emissions from activities within this EP are estimated to be ~0.002 Mtpa CO_2-e[2]. These direct emissions represent ~0.0004% of national Australian emissions (when compared to 2021 inventory) (Ref. 78). According to the IPCC, Assessment Sixth Report for Working Group 1, “the total anthropogenic effective radiative forcing in 2019, relative to 1750, was 2.72 [1.96 to 3.48] Wm^{-2} (*medium confidence*) and has likely been growing at an increasing rate since the 1970s, [and] . . . Over 1750–2019, CO_2 increased by 131.6 ± 2.9 ppm (47.3%).”[3] The IPCC defines the term “carbon budget” as “refer[ing] to the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level with a given probability, taking into account the effect of other anthropogenic climate forcers. This is referred to as the total carbon budget when expressed starting from the pre-industrial period, and as the remaining carbon budget when expressed from a recent specified date. Historical cumulative CO_2 emissions determine to a large degree warming to date, while future emissions cause future additional warming. The remaining carbon budget indicates how much CO_2 could still be emitted while keeping warming below a specific temperature level.”[4] The remaining carbon budget for a 50% likelihood to limit global warming to 1.5°C, 1.7°C, and 2°C is respectively, 500 Gt CO_2, 850 Gt CO_2, and 1350 Gt CO_2.[5]			

[2] Emissions calculation is based on 75 days of vessel activity, and 1 day of helicopter activity, using NGER energy content and emissions factors (Ref. 272).

[3] IPCC, AR6, WG1, at TS-35 (Ref. 79).

[4] IPCC, AR6, WG1, at SPM-48 footnote 43 (Ref. 80).

[5] IPCC, AR6, WG1, at SPM-29 Table SPM.2 (Ref. 80).

If the total direct GHG emissions from activities associated with this EP are ~0.002 Mtpa CO_2-e, then the activities under this EP may contribute ~1.5–4.0 x 10^{-7} percent to the reduction in the total remaining global carbon budget, which is a *de minimis* decrease.

Due to the overall *de minimis* contribution to the reduction of the global carbon budget from the activities under this EP, the impact of contribution to the global carbon budget has been evaluated as having the potential to result in an Incidental (6) consequence.

ALARP decision context justification

Offshore commercial vessel operations and subsequent air emissions arising from these activities are commonplace in offshore environments, both nationally and internationally. The control measures to manage the risk associated with atmospheric emissions are well defined via legislative requirements that are considered standard industry practice. These are well understood and implemented by the petroleum industry and CAPL.

During stakeholder consultation, no objections or claims were raised regarding air emissions arising from the activity.

The impacts arising from atmospheric emissions constitute lower-order impacts (Table 5-3). As such, CAPL applied ALARP Decision Context A for this aspect.

Good practice control measures and source

Control measure	Source
Reduced sulfur content fuel	Sulfur content of diesel/fuel oil complies with Marine Order 97 and Regulation 14 of MARPOL 73/78 Annex VI. Only low-sulfur (0.50 mass % concentration [m/m]) fuel oil will be used to minimise sulfur oxides (SO_x) emissions when available
Marine Order 97: Marine Pollution Prevention – Air Pollution	Prior to commencement of activities, the MSRE process (Ref. 43) is used to verify that all vessels comply with Marine Order 97: Marine Pollution Prevention – Air Pollution (appropriate to vessel class) for emissions from combusting fuel, including: • Vessels will hold a valid International Air Pollution Prevention (IAPP) certificate and a valid international energy efficiency (IEE) certificate • All vessels (as appropriate to vessel class) will have a Ship Energy Efficiency Management Plan (SEEMP) as per MARPOL 73/78 Annex VI • Vessel engine nitrous oxides (NO_x) emission levels will comply with Regulation 13 of MARPOL 73/78 Annex VI.

Additional control measures and cost benefit analysis

Control measure	Benefit	Cost
N/A	N/A	N/A

Likelihood and risk level summary

Likelihood	N/A
Risk level	N/A

Determination of acceptability

Principles of ESD	The potential impact associated with this aspect is limited to a direct reduction in air quality for a localised area for a short time, which is not considered to have the potential to affect biological diversity and ecological integrity. The impact associated with this aspect is a *de minimis* contribution to the reduction of the global carbon budget, which is not considered to have the potential to affect intergenerational equity. The control measures identified above are considered to reduce this impact to ALARP. The consequence associated with this aspect is Incidental (6). Therefore, no further evaluation against the Principles of ESD is required.
Relevant environmental	Legislation and other requirements considered relevant to this aspect include:

legislation and other requirements	• Marine Order 97 • MARPOL 73/78.	
Internal context	These CAPL environmental performance standards or procedures were deemed relevant for this aspect: • MSRE process (Ref. 43).	
External context	During stakeholder consultation, no objections or claims were raised regarding atmospheric emissions arising from the activity.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
No impacts to air quality outside of the OA from petroleum activities	**Reduced sulfur content fuel** Only low-sulfur (0.50 mass % concentration [m/m]) fuel oil will be used to minimise SO_x emissions when available	Bunker receipts verify the use of low-sulfur fuel oil
	Marine Order 97: Marine Pollution Prevention – Air Pollution Prior to commencement of activities, the following will be verified, as per the MSRE process: • vessels will hold a valid International Air Pollution Prevention (IAPP) certificate and a valid international energy efficiency (IEE) certificate • all vessels (as appropriate to vessel class) will have a Ship Energy Efficiency Management Plan (SEEMP) as per MARPOL 73/78 Annex VI • Vessel engine nitrous oxides (NOx) emission levels will comply with Regulation 13 of MARPOL 73/78 Annex VI.	OVIS report / ABU Marine OE Inspection Checklist confirms vessels hold IAPP and IEE certificates, and a SEEMP is in place (as appropriate to class), and NO_x emission levels comply with regulations

6.4 Light emissions

<table>
<tr><th colspan="4">Source</th></tr>
<tr><td colspan="4">Activities identified as having the potential to result in light emissions are:
• navigation and operational lighting from vessels within the OA during seismic survey.</td></tr>
<tr><th colspan="4">Potential impacts and risks</th></tr>
<tr><th>Impacts</th><th>C</th><th>Risks</th><th>C</th></tr>
<tr><td>Light emissions may result in:
• localised and temporary change in ambient light.</td><td>6</td><td>A change in ambient light may result in:
• attractant for light-sensitive species and in turn affect predator-prey dynamics</td><td>5</td></tr>
<tr><th colspan="4">Consequence evaluation</th></tr>
<tr><td colspan="4">Localised and temporary change in ambient light
As the seismic survey will be undertaken 24 hours a day, lighting is required at night for navigation and to ensure safe operations when working on the seismic vessel.
Monitoring undertaken by Woodside (Ref. 81) indicates that light density from navigational lighting on a MODU attenuated to below 1.0 lux and 0.03 lux at distances of ~300 m and ~1.4 km, respectively. Light densities of 1.0 lux and 0.03 lux are comparable to natural light densities experienced during deep twilight and during a quarter moon.
Based on Woodside (Ref. 81), CAPL expects that its vessel activities will result in temporary changes to ambient light emissions no larger than a radius of ~1.4 km from the seismic or support vessels. Navigational lighting is expected to be the less on vessels in comparison to a MODU, therefore referencing this modelling is considered an overly conservative approach for this consequence evaluation.
Given the limited extent of the change arising from navigational lighting, the impacts associated with a direct change in ambient light levels was determined to be Incidental (6).</td></tr>
<tr><td colspan="4">Acting as an attractant to light-sensitive species and in turn affecting predator–prey dynamics
There is no evidence to suggest that artificial light sources adversely affect the migratory, feeding, or breeding behaviours of cetaceans. Cetaceans predominantly use acoustic senses rather than visual sources to monitor their environment (Ref. 82), so light is not considered to be a significant factor in cetacean behaviour or survival.
Light-sensitive fauna (including reptiles, birds and fish) are the species most at risk from this aspect and thus are the focus of this evaluation. As identified in Section 4.3, several marine species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. Several BIAs and/or critical habitat also overlap with the OA, including:
• Flatback Turtle (internesting buffer BIA, internesting critical habitat)
• Whale Shark (foraging BIA)
• Wedge-tailed Shearwater (breeding BIA).
As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna.
The National Light Pollution Guidelines (Ref. 7) indicate that a 20 km buffer or exposure area can provide a general precautionary light impact limit based on observed effects of sky glow on marine turtle hatchlings demonstrated to occur at 15–18 km (Ref. 83; Ref. 84) and fledgling seabirds grounded in response to artificial light 15 km away (Ref. 85).
Studies conducted between 1992 and 2002 in the North Sea confirmed that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Ref. 86) and that lighting can attract birds from large catchment areas (Ref. 87). These studies indicate that migratory birds are attracted to lights from offshore platforms when travelling within a radius of 5 km from the light source, but their migratory paths are unaffected outside this zone (Ref. 88). At its closest, the OA is located ~25 km from the coast (Montebello Islands). As light emissions from vessels are expected to result in a change to ambient conditions up to a maximum of ~1.4 km from the vessel, no coastal areas (and therefore fledgling seabirds) are expected to be exposed.</td></tr>
</table>

Anthropogenic disturbance and artificial lighting is identified as a threat within the *Wildlife Conservation Plan for Migratory Shorebirds* (Ref. 89). It is possible that nocturnally active seabirds and/or migratory shorebirds may be affected by light-spill and make alterations to their normal behaviours. Procellariforms (shearwaters, petrels and albatross) species forage at night on bioluminescent prey, and therefore are attracted to light of any kind (Ref. 285; Ref. 87). The presence of the Wedge-tailed Shearwater is seasonal, typically occurring between mid-August to April in the Pilbara; and they are known to forage either relatively close to breeding islands or over a large area, depending on prey availability (Section 4.3.4.1). If the 4D MSS extends into April, there is the potential for up to two week overlap of with the period when Wedge-tailed Shearwaters are starting to depart on their migration north to the Indian Ocean. The mechanism of birds being attracted to light is not proven, but it is proposed that the artificial lighting may override the internal magnetic compass of migratory shorebirds or nocturnal seabirds (Ref. 287). However, Marquenie (Ref. 286) estimated that a change in migratory behaviour of birds was limited to <5 km from the source. Therefore, this type of impact is expected to be spatially restricted to the immediate vicinity of the vessel/s and affect only individuals (rather than populations). The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) identifies light emissions as a key threat because it can disrupt critical behaviours, such as nesting, hatchling orientation, sea finding, and dispersal behaviour. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) defines the critical habitat for nesting for each species at a stock level. The closest nesting critical habitats to the OA for Flatback Turtles include Barrow and Montebello islands (Ref. 63). At its closest, the OA is located ~25 km from the coast (Montebello Islands). As light emissions from vessels are expected to result in a change to ambient conditions up to a maximum of ~1.4 km from the vessel, no coastal areas (and therefore no adult nesting turtles, or turtle hatchlings) are expected to be exposed. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) defines the critical habitat for internesting as a distance seaward from nesting critical habitat of 60 km for Flatback Turtles. However, recent studies (Ref. 69) have indicated that the internesting behaviour of Flatback Turtles on the North West Shelf appears more spatially restricted than that suggested by the Recovery Plan (Ref. 63). Whittock et. al. (Ref. 69) reported that Flatback Turtles preference habitats within proximity of the coast and at relatively shallow depths during the internesting periods. Specifically, during the study, a maximum distance from the nearest coast and maximum water depth of 27.8 km and <44 m respectively was recorded, with the mean maximum distance away from the nearest coast and mean water depth being less than 6.1 km and <10 m respectively (Ref. 69). This suggests that although the OA does overlap with some internesting critical habitat, due to the OA being located offshore (>25 km from the Montebello Islands) and with increasing water depths (up to ~1,250 m) it would be very unlikely that turtles would be aggregating within the OA during their internesting period. Consequently, as the presence of Flatback Turtles within the OA during the 4D MSS is likely to be limited, and any disruption to their behaviour is expected to be minimal given the spatially limited (up to ~1.4 km) change in ambient light levels due to vessel presence. Vessels, and their associated light fields, are also not stationary during the survey; thus further reducing the risk of introducing a consistent and extended exposure to artificial light within critical habitat. Given the limited spatial and temporal exposures to marine fauna from moving vessel/s artificial light, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park. Consequently, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Minor (5).
ALARP decision context justification
Offshore commercial vessel operations and subsequent light emissions arising from these activities are commonplace in offshore environments nationally and internationally. During stakeholder consultation, no objections or claims were raised regarding light emissions arising from the activity. The impacts and risks associated with light emissions are well understood, and considered lower-order impacts and risks in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.
Good practice control measures and source

Control measure	Source
MSRE process	CAPL's *ABU MSRE Corporate OE Process* (Ref. 43) ensures that various legislative requirements are met. This includes ensuring that lighting

	sufficient for navigational, safety and emergency requirements are met, as appropriate to vessel class.	
Light management	The scheduled 4D MSS (~75 days between mid-December to mid-April) overlaps with the turtle nesting season (September to March). Recent studies of habitat suitability for internesting Flatback Turtles (Ref. 69) indicate that due to the water depths and distance from nesting beaches, the OA is unlikely to be used by Flatback Turtles during their internesting period. If the 4D MSS extends into April, there is the potential for up to a two week overlap of with the period when Wedge-tailed Shearwaters are starting to depart on their migration north to the Indian Ocean. As a conservative management measure, seismic and support vessels working at night within during the 4D MSS will be required to reduce lighting to the minimum required for safe operations.	
Additional control measures and cost-benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	Due to the nature and scale of this petroleum activity, vessel activities are likely to be focused within offshore waters away from the coast. As such the likelihood of exposing sensitive receptors resulting in the identified consequence was considered Remote (5).	
Risk level	Very low (9)	
Determination of acceptability		
Principles of ESD	The risk associated with this aspect is disruption to light-sensitive species behaviour, which given the location, is not considered as having the potential to affect biological diversity and ecological integrity. The impact associated with this aspect is Incidental (6). Therefore, no further evaluation against the Principles of ESD is required.	
Relevant environmental legislation and other requirements	Legislation and other requirements considered for this aspect include: • Commonwealth *Navigation Act 2012* • *National Light Pollution Guidelines* (Ref. 7) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • *Wildlife Conservation Plan for Migratory Shorebirds* (Ref. 89) • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).	
Internal context	No CAPL environmental performance standards or procedures were deemed relevant for this aspect.	
External context	During stakeholder consultation, no objections or claims were raised regarding light emissions arising from the activity.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan. However, given that light pollution is listed as a threat to protected matters under documents made or implemented under the EPBC Act, CAPL has defined an acceptable level of impact such that it is not inconsistent with these documents. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) specifies the following relevant 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.	

<table>
<tr><td></td><td colspan="2">No other specific relevant actions were identified within other documents implemented under the EPBC Act.

The OA does intersect with critical habitat as identified within the Recovery Plan for Flatback Turtles (Table 4-4). However, recent studies indicate that the preferred internesting habitat for Flatback Turtles is closer to coasts (<27.8 km) and in shallow water depths (<44 m). These studies indicate that the presence of Flatback Turtles within the OA during the 4D MSS is likely to be limited; and further that the presence of Flatback Turtles within the outer extents of the defined critical habitat internesting buffer is unlikely.

CAPL has defined an acceptable level of impact as no displacement of marine fauna from critical habitat.</td></tr>
<tr><th>Environmental performance outcome</th><th>Performance standard / Control measure</th><th>Measurement criteria</th></tr>
<tr><td rowspan="2">Avoid displacement of marine fauna from critical habitat during nesting seasons from petroleum activities</td><td>MSRE process
Vessels will meet the lighting requirements of the MSRE process</td><td>Records indicate that vessels meet lighting requirements of the MSRE process</td></tr>
<tr><td>Light management
Seismic and support vessels working at night will be required to reduce lighting to the minimum required for safe operations</td><td>Inspection records during night operations confirm only minimum lighting for safe operations is used</td></tr>
</table>

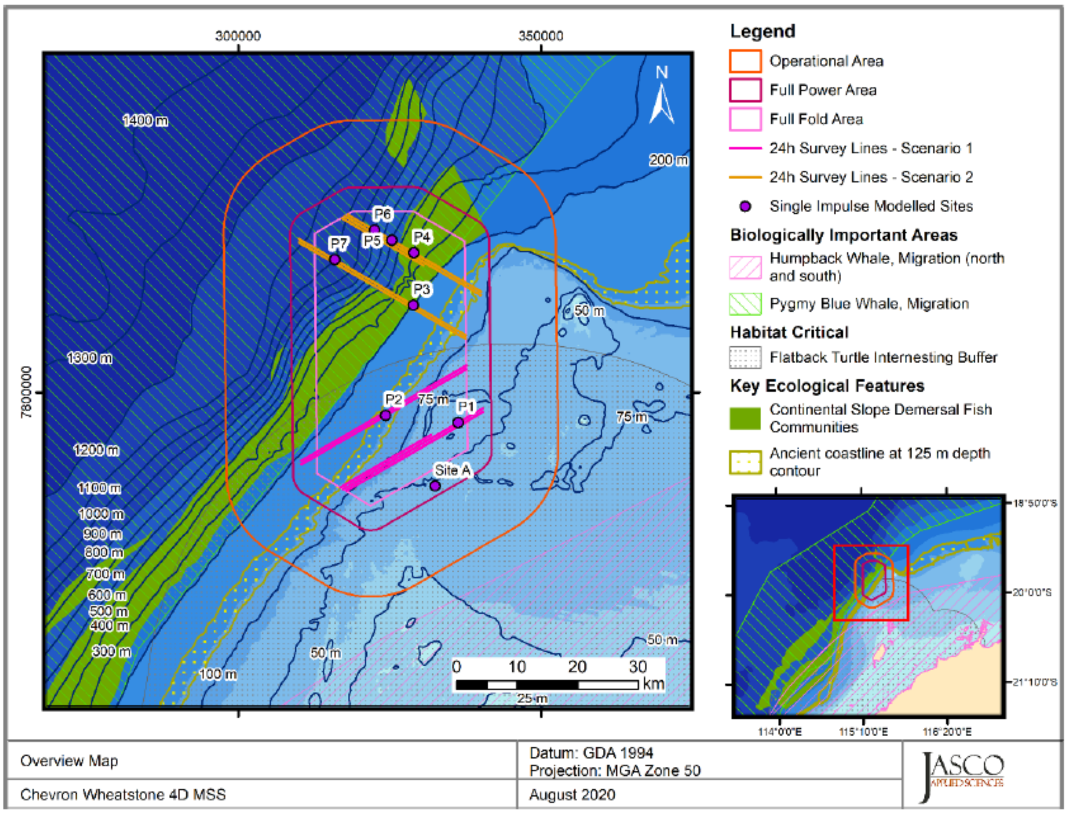
6.5 Underwater sound—seismic acquisition

6.5.1 Acoustic modelling

CAPL commissioned JASCO Applied Sciences to conduct acoustic modelling to inform the risk assessment associated with underwater sound exposure from seismic acquisition (Ref. 188; appendix d). The modelling was undertaken to assist in understanding the potential acoustic impact on receptors including marine mammals, fish, turtles, benthic invertebrates, plankton, sponges, corals, and divers (Ref. 188).

JASCO's specialised airgun array source model (AASM) was used to predict acoustic signatures and spectra for a 4,130 cu.in airgun array (Ref. 188). AASM accounts for individual airgun volumes, airgun bubble interactions, and array geometry to yield accurate source predictions (Ref. 188). Complementary underwater acoustic propagation models were used in conjunction with the array signature to estimate sound levels (Ref. 188). Estimated underwater acoustic levels are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL_{24h}) as appropriate for different noise effect criteria (Ref. 188).

JASCO designed the modelling study to take into consideration the location of key environmental and social receptors, and the range of water depths across the FPZ. Eight standalone single impulse sites and two scenarios for survey operations over 24 hours to assess accumulated SEL (SEL_{24h}) were modelled (Figure 6-1; Table 6-2).



Source: Ref. 188

Figure 6-1: Locations for acoustic modelling

Table 6-2: Acoustic modelling sites, water depths, and associated receptors

24 hr Scenario	Site	Tow direction	Approximate water depth	Relevant receptors
1	1	60°	82 m	Marine mammals (Humpback Whales), turtles, fish, fish egg and larvae, Wheatstone ridgeline
	2		126 m	Ancient Coastline at 125 m Depth Contour KEF, fish, invertebrates, sponges and corals, fish egg and larvae
	3		200 m	Continental Slope Demersal Fish Communities KEF, marine mammals (Blue Whales), fish, fish egg and larvae
2	4	120°	400 m	Continental Slope Demersal Fish Communities KEF, marine mammals (Blue Whales), fish, fish egg and larvae
	5		600 m	Marine mammals (Blue Whales), invertebrates, fish egg and larvae
	6		800 m	Marine mammals (Blue Whales), fish, fish egg and larvae
	7		1000 m	Marine mammals (Blue Whales), fish, fish egg and larvae
N/A	A	120°	64 m	Divers, turtles, Humpback Whales, fish, invertebrates, sponges and corals, fish egg and larvae

6.5.1.1 Exposure criteria

Different species groups perceive and respond to sound differently, and so a variety of exposure criteria for the different types of impacts and species groups are considered. JASCO (Ref. 188) have selected the following noise effect thresholds, based on current best available science, for use in the impact and risk assessment:

- peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL_{24h}) from the US National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (Ref. 179) for the onset of permanent threshold shift (PTS)[6] and temporary threshold shift (TTS)[7] in marine mammals (Table 6-3)
- marine mammal behavioural threshold based on the current NOAA (Ref. 190) criterion for marine mammals of 160 dB re 1 µPa (SPL) for impulsive sound sources (Table 6-3)
- peak pressure levels (PK) and frequency-weighted accumulated sound exposure levels (SEL_{24h}) from Finneran et al. (Ref. 181) for the onset of PTS and TTS in marine turtles (Table 6-3)
- marine turtle behavioural response threshold of 166 dB re 1 µPa (SPL) (Ref. 191), as applied by the US NMFS, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL) (Ref. 178; Ref. 194) (Table 6-3)

[6] PTS is a physical injury to an animals hearing organs.

[7] TTS is a temporary reduction in an animals hearing sensitivity due to receptor hair cells in the cochlea becoming fatigued.

- sound exposure guidelines for fish, fish eggs and larvae (including plankton) (Ref.182) (Table 6-3)
- peak-peak pressure levels (PK-PK) at the seafloor to help assess effects of noise on crustaceans [no effect sound level of 202 dB re 1 µPa, and maximum sound level of 209–213 dB re 1 µPa] and bivalves [maximum sound level of 212–213 dB re 1 µPa] through comparing to results in Day et al. (Ref. 193), Day et al. (Ref. 195), Day et al. (Ref. 194), Day et al. (Ref. 196) and Payne et al. (Ref.197)
- for comparison to current literature, a no effect sound level for sponges and corals of 226 dB re 1 µPa (PK), is reported for comparing to Heyward et al. (Ref. 198).
- an SPL human health assessment threshold of 145 dB re 1 µPa (SPL) for sound exposure to people swimming and diving derived from Parvin (Ref.199) and considering Ainslie (Ref. 200).

Recent Commonwealth guidance has defined “injury to Blue Whales” as both PTS and TTS hearing impairment, as well as any other form of physical harm arising from anthropogenic sources of underwater noise (Ref. 202).

Table 6-3: Noise effect criteria for impulsive sound for different types of impacts and species groups

Receptor	Mortal or potential mortal injury	Recoverable injury	Permanent threshold shift	Temporary threshold shift	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 183 dB re 1 µPa²s PK: 219 dB re 1 µPa	SEL_{24h}: 168 dB re 1 µPa²s PK: 213 dB re 1 µPa	N/A	SPL: 160 dB re 1 µPa
Mid-frequency cetaceans	N/A	N/A	SEL_{24h}: 185 dB re 1 µPa²s PK: 230 dB re 1 µPa	SEL_{24h}: 170 dB re 1 µPa²s PK: 224 dB re 1 µPa	N/A	SPL: 160 dB re 1 µPa
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 155 dB re 1 µPa²s PK: 202 dB re 1 µPa	SEL_{24h}: 140 dB re 1 µPa²s PK: 196 dB re 1 µPa	N/A	SPL: 160 dB re 1 µPa
Marine turtles	N/A	N/A	SEL_{24h}: 204 dB re 1 µPa²s PK: 232 dB re 1 µPa	SEL_{24h}: 189 dB re 1 µPa²s PK: 226 dB re 1 µPa	N/A	SPL: 166 dB re 1 µPa SPL: 175 dB re 1 µPa
Fish (no swim bladder) (relevant to sharks)	SEL_{24h}: >219 dB PK: >213 dB	SEL_{24h}: >216 dB PK: >213 dB	N/A	SEL_{24h}: >>186 dB	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish (swim bladder not involved in hearing)	SEL_{24h}: 210 dB PK: >207 dB	SEL_{24h}: 203 dB PK: >207 dB	N/A	SEL_{24h}: >>186 dB	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish (swim bladder involved in hearing)	SEL_{24h}: 207 dB PK: >207 dB	SEL_{24h}: 203 dB PK: >207 dB	N/A	SEL_{24h}: 186 dB	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae (relevant to plankton)	SEL_{24h}: >210 dB PK: >207 dB	(N) Moderate (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Relative risk (high, moderate, low) is given for fauna at three distances from the source (near [N], intermediate [I] and far [F]). Source: Ref. 188

6.5.1.2 Modelling outputs

The modelled sound contours were not symmetrical around the sound source (Ref. 188). The distances to the behavioural response criteria for both marine mammals and turtles were typically greater at the shallower sites, and those closer to the continental shelf (Ref. 188). The orientation of the sound source was also found to influence the directivity pattern, with greater distances to sound levels in the broadside (perpendicular to the tow) direction as compared to the endfire (along the tow) direction (Ref. 188).

Horizontal maximum distances (R_{max}) from the sound source to the relevant noise effect criteria for marine mammals, turtles, fish, and plankton are shown in Table 6-4 (Ref. 188). Distances to noise effect criteria varied between the individually modelled sites and scenarios, the largest of these has been reported in Table 6-4. The largest R_{max} value was applied to from the edge of the FPZ to determine ensonified areas for use in the risk assessment (Section 6.5.3). Given the variability in R_{max} distances the individually modelled sites and scenarios, this is considered a conservative approach for risk assessment purposes.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that a receptor is consistently exposed to such noise levels at a fixed position (Ref. 188). Where the modelled SEL_{24h} exposure is larger than those for PK pressure criteria, they often represent an unlikely worst-case scenario (Ref. 188). Realistically, marine fauna are unlikely to remain stationary in the same location for a 24 hour period. Therefore, a modelled exposure area for the SEL_{24h} criteria does not mean that marine fauna travelling within this area will be impaired, but rather that they could be exposed to the sound level associated with impairment (either PTS or TTS) if they remained in that location for 24 hours.

At distances offshore from the continental shelf, the single impulse sound fields demonstrate that there is significantly less sound energy above 400 m as compared to greater depths. This distribution of sound over the water column means that it is likely that the maximum-over-depth SEL_{24h} results for TTS in low-frequency cetaceans at greater distances from continental shelf do not accurately represent the actual exposures that whales migrating at predominantly shallow depths will receive (Ref. 188).

The maximum horizonal distance for exposure to the PK-PK no effect sound level at the seafloor was for crustaceans was 0.431–0.913 km (Figure 6-6; Figure 6-7) depending on the modelled site (Ref. 188). The maximum distance for exposure to the PK-PK maximum sound level at the seafloor for crustaceans was 0.101–0.366 km depending on the modelled site (Ref. 188). The maximum distance for exposure to the PK-PK maximum sound level at the seafloor for bivalves was 0.159–0.241 km depending on the modelled site (Ref. 188).

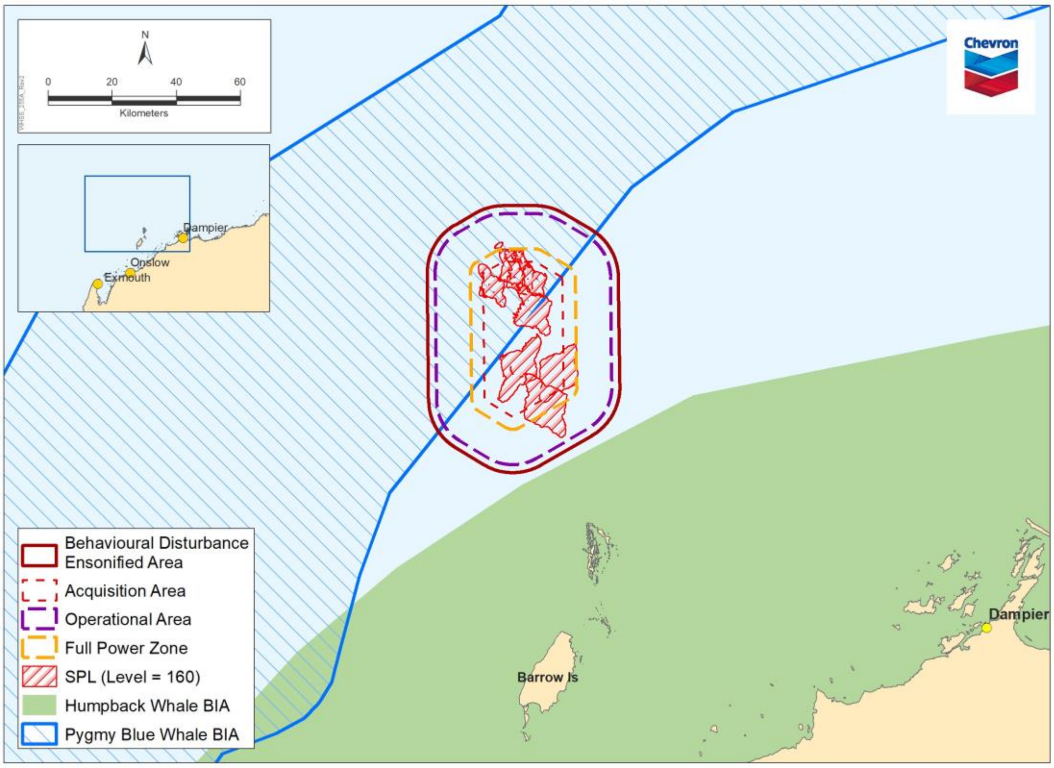
The PK noise effect criteria at the seafloor for sponges and corals was not reached (Ref. 188).

For human health, the maximum distance for exposure to the SPL noise effect criteria at Site A (~64 m water depth) was 51.07 km. The SPL human health assessment will not be exceeded in water depths (<25 m) relevant to recreational diving around the Montebello Islands (Ref. 188).

Table 6-4: Modelled maximum horizontal distances (R_{max}) from modelled sites or scenarios to reach noise effect criteria for impulsive sound

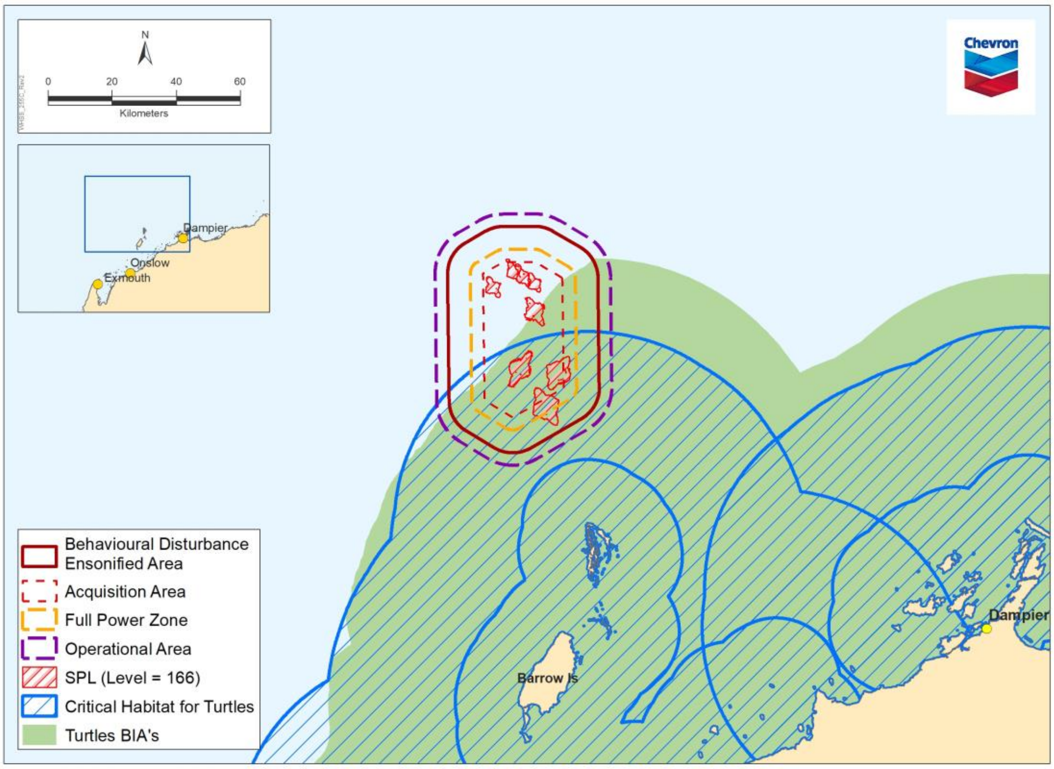
Receptor	Mortal or potential mortal injury	Recoverable injury	Permanent threshold shift	Temporary threshold shift	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 6.61 km PK: 0.04 km	SEL_{24h}: 95.4 km PK: 0.07 km	N/A	SPL: 13.45 km (Figure 6-2)
Mid-frequency cetaceans	N/A	N/A	SEL_{24h}: – PK: –	SEL_{24h}: – PK: 0.02 km	N/A	SPL: 13.45 km (Figure 6-2)
High-frequency cetaceans	N/A	N/A	SEL_{24h}: <0.02 km PK: 0.45 km	SEL_{24h}: 1.63 km PK: 1.00 km	N/A	SPL: 13.45 km (Figure 6-2)
Marine turtles	N/A	N/A	SEL_{24h}: <0.02 km PK: –	SEL_{24h}: 3.84 km (Figure 6-4) PK: 0.02 km	N/A	SPL: 7.11 km (Figure 6-3)
Fish (no swim bladder) (relevant to sharks)	SEL_{24h}: <0.02 km PK: 0.096 km	SEL_{24h}: <0.02 km PK: 0.096 km	N/A	SEL_{24h}: 8.63 km (Figure 6-5)	N/A	N/A
Fish (swim bladder not involved in hearing)	SEL_{24h}: <0.02 km PK: 0.27 km	SEL_{24h}: <0.02 km PK: 0.27 km	N/A	SEL_{24h}: 8.63 km (Figure 6-5)	N/A	N/A
Fish (swim bladder involved in hearing)	SEL_{24h}: <0.02 km PK: 0.27 km	SEL_{24h}: <0.02 km PK: 0.27 km	N/A	SEL_{24h}: 8.63 km (Figure 6-5)	N/A	N/A
Fish eggs and fish larvae (relevant to plankton)	SEL_{24h}: <0.02 km PK: 0.27 km	N/A	N/A	N/A	N/A	N/A

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m). Source: Ref. 188.



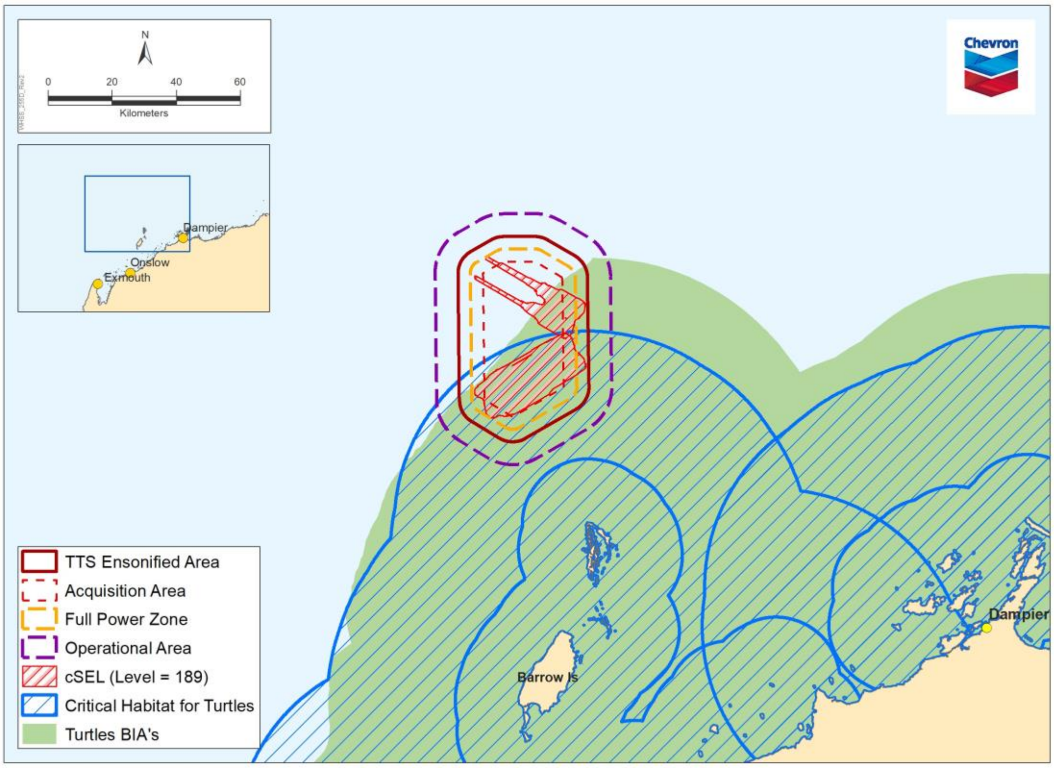
Behavioural Disturbance Ensonified Area is the maximum Rmax from all modelled sites (Table 6-4) applied as a buffer around the FPZ. SPL levels are shown for each of the modelling sites (as per Table 6-2).

Figure 6-2: Precited behavioural disturbance areas for marine mammals



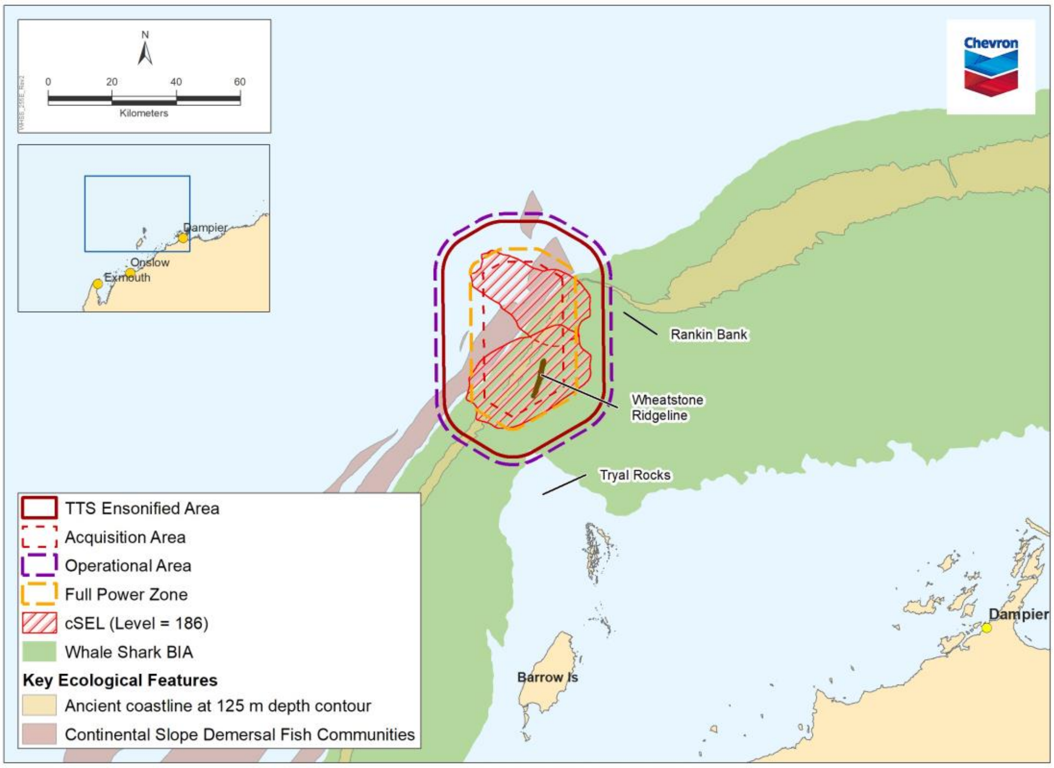
Behavioural Disturbance Ensonified Area is the maximum R_{max} from all modelled sites (Table 6-4) applied as a buffer around the FPZ. SPL levels are shown for each of the modelling sites (as per Table 6-2).

Figure 6-3: Precited behavioural disturbance areas for marine turtles



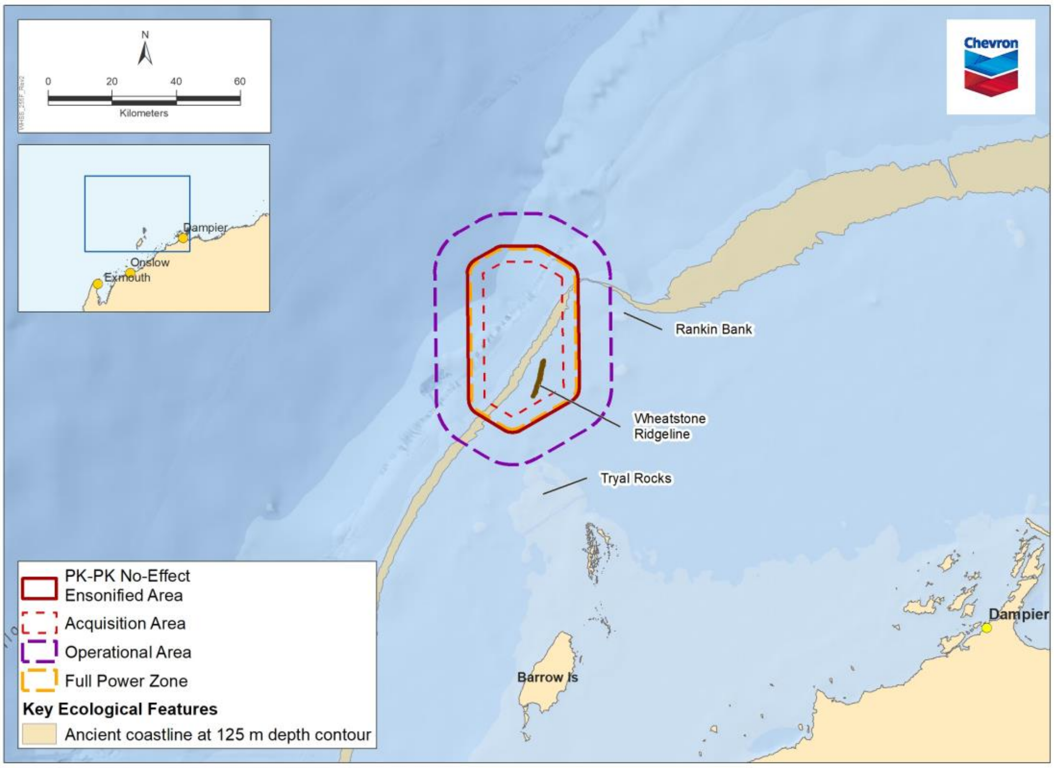
TTS Ensonified Area is the maximum R_{max} from all modelled sites (Table 6-4) applied as a buffer around the FPZ. SEL levels are shown for each of the two modelling scenarios (as per Table 6-2).

Figure 6-4: Precited auditory impairment (TTS) areas for marine turtles



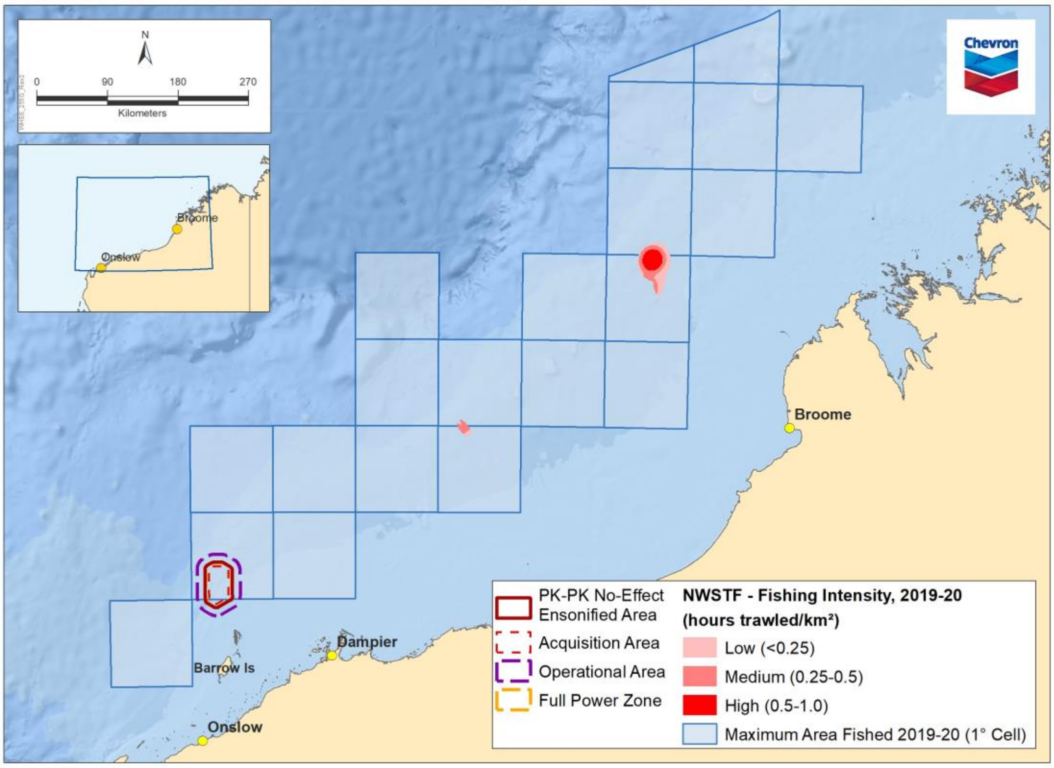
TTS Ensonified Area is the maximum R_{max} from all modelled sites (Table 6-4) applied as a buffer around the FPZ. SEL levels are shown for each of the two modelling scenarios (as per Table 6-2).

Figure 6-5: Precited auditory impairment (TTS) areas for fish



PK-PK No Effect Ensonified Area is the maximum modelled R_{max} (Section 6.5.1.2) applied as a buffer around the FPZ.

Figure 6-6: Predicted no effect areas for crustaceans (in relation to marine habitats)



PK-PK No Effect Ensonified Area is the maximum modelled R_{max} (Section 6.5.1.2) applied as a buffer around the FPZ.

Figure 6-7: Predicted no effect areas for crustaceans (in relation to the NWSTF)

6.5.2 Pygmy Blue Whale exposure modelling

In addition to the acoustic modelling study, JASCO undertook an acoustic exposure analysis for migrating Pygmy Blue Whales (Ref. 189; appendix e), which describes the modelled predictions of sound levels that individual Pygmy Blue Whales may receive during the 4D MSS.

Sound exposure distribution estimates are determined by moving large numbers of simulated animals ('animats') through a modelled time-evolving sound field, computed using specialised sound source and sound propagation models (Ref. 189). This approach provides the most realistic prediction of the maximum expected root-mean-square sound pressure level (SPL), peak pressure level (PK), and the temporal accumulation of sound exposure level (SEL_{24h}) that are now considered the most relevant sound metrics for the assessment of effects (Ref. 189). The resulting sound fields from the acoustic modelling study (Section 6.5.1; Ref. 188) were used to predict animat sound exposures.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to model the movement of Pygmy Blue Whales through the predicted sound field. Biologically meaningful movement rules were applied to each animat in the model to represent Pygmy Blue Whale behaviours. This included swim speeds, direction, diving and ascent rates, dive depths (for both migratory dives near the surface and deeper exploratory or feeding dives), and time spent at or near the surface before diving again. The animats, were set to simulate the real-world movements of migrating Pygmy Blue Whales within the migratory BIA.

The same noise effect criteria as defined for low-frequency cetaceans in Section 6.5.1.1 were used in this Pygmy Blue Whale exposure modelling.

The modelled 95th percentile exposure ranges ($ER_{95\%}$) from the sound source to the relevant noise effect criteria for Pygmy Blue Whales are shown in Table 6-5 (Ref. 189). The largest $ER_{95\%}$ value was applied to from the edge of the FPZ to determine ensonified areas for use in the risk assessment (Section 6.5.3). For comparison, the horizontal maximum distances (R_{max}) for low-frequency cetaceans from the acoustic modelling in Section 6.5.1 are repeated in Table 6-5.

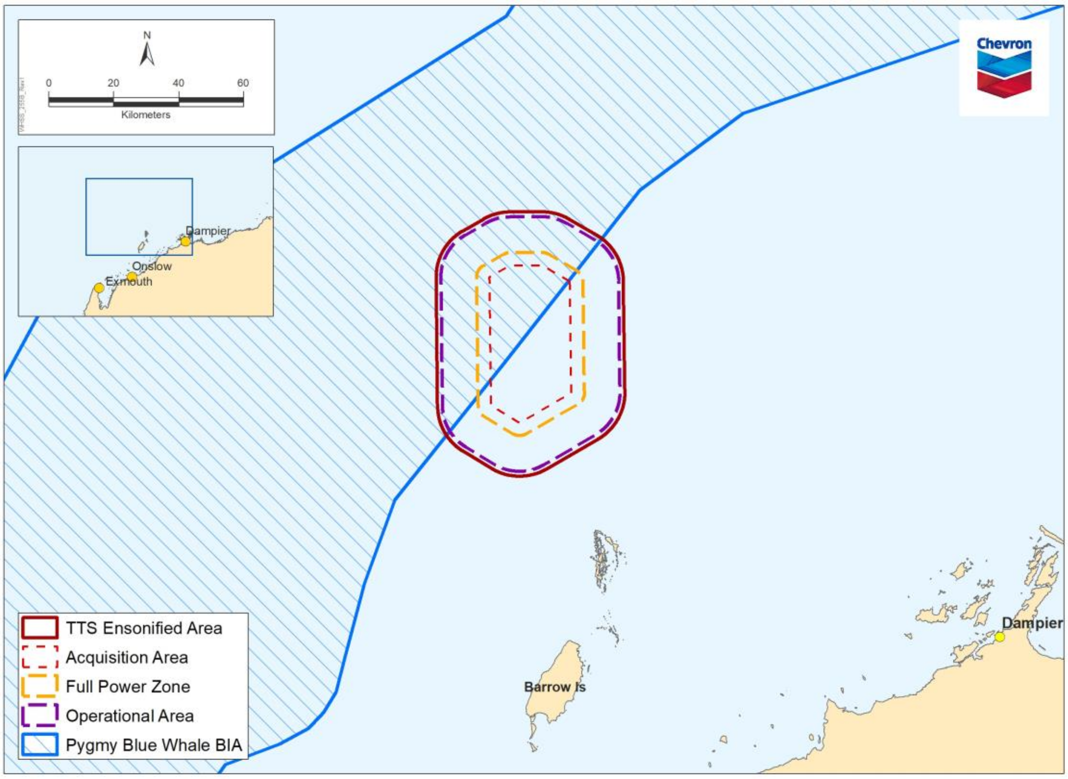
The $ER_{95\%}$ to both the PTS and TTS SEL_{24h} noise effect criteria thresholds are substantially lower than distances predicted by acoustic modelling (Table 6-5; Ref. 189). Acoustic modelling is inherently more conservative as it does not incorporate the complex interactions of both a moving sound field and moving receivers (Ref. 189).

The $ER_{95\%}$ to the PTS and TTS PK thresholds, and to the behavioral response thresholds, was similar between the two modelling studies. This is as expected given these noise effect criteria are based off single loudest exposures by each of the animats during the model simulation (Ref. 189).

The probability of exposure within $ER_{95\%}$ range in all cases varied between 65–88%, indicating that most, but not all, animats within the $ER_{95\%}$ range were exposed above threshold (Ref. 189). This is due to the animats constantly changing their position in three-dimensions as they exhibit their modelled behaviour, and also changing their position in relation to the sound fields, thus potentially limiting the length of time they are within the exposure radius (Ref. 189).

Table 6-5: Modelled 95th percentile exposure ranges ($ER_{95\%}$) and probability of exposure, compared to modelled maximum horizontal distances (R_{max}) for Pygmy Blue Whales

Modelling	Parameter	Permanent threshold shift	Temporary threshold shift	Behavioural
Acoustic modelling	R_{max}	SEL_{24h}: 6.61 km PK: 0.04 km	SEL_{24h}: 95.4 km PK: 0.07 km	SPL: 13.45 km
Exposure modelling	$ER_{95\%}$	SEL_{24h}: 0.06 km PK: 0.03 km	SEL_{24h}: 12.5 km (Figure 6-8) PK: 0.06 km	SPL: 12.43 km
	Probability of exposure	SEL_{24h}: 70% PK: 78%	SEL_{24h}: 65% PK: 88%	SPL: 68%



TTS Ensonified Area is the maximum modelled ER95% (Table 6-5) applied as a buffer around the FPZ.

Figure 6-8: Precited auditory injury (TTS) areas for Pygmy Blue Whales

6.5.3 Risk assessment

Source			
Activities identified as having the potential to result in underwater sound are: • seismic acquisition within the OA. These activities result in the emission of the impulsive sound.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
Underwater sound emissions may result in:		A change in ambient underwater sound may result in:	

• localised and temporary change in ambient underwater sound.	5	• behavioural disturbance	5
		• auditory impairment, temporary threshold shift (TTS), permanent threshold shift (PTS), recoverable or non-recoverable injury to marine fauna	5
		• injury or auditory impairment to humans	6

Consequence evaluation

Localised and temporary change in ambient underwater sound

Anthropogenic underwater sound emitted during the 4D MSS activities will result in a change in ambient noise levels.

Underwater broadband ambient sound spectrum levels range from 45–60 dB re 1 µPa in quiet regions (light shipping and calm seas) to 80–100 dB re 1 µPa for more typical conditions, and >120 dB re 1 µPa during periods of high winds, rain or 'biological choruses' (many individuals of the same species vocalise near simultaneously in reasonably close proximity to each other) (Ref. 222). Low-frequency ambient sound levels (20–500 Hz) are frequently dominated by distant shipping plus some great whale species. Light weather-related sounds will be in the 300–400 Hz range, with wave conditions and rainfall dominating the 500–50,000 Hz range (Ref. 222).

The rate of sound attenuation from the seismic source is dependent on local sound propagation characteristics, including seawater temperature and salinity profiles, water depth, bathymetry and the geoacoustic properties of the seabed (Ref. 201). A seismic sound source is typically a short, discrete, non-continuous, low-frequency pulse.

While the individual impulses are short and discrete, the 4D seismic survey is estimated to take ~75 days to complete, noting that the sound source is not stationary during this duration. Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz (Ref. 188). The modelled 4,130 cu.in array had a pronounced broadside directivity for 1/3-octave-bands between ~125–316 Hz, which caused a noticeable axial bulge in the modelled acoustic footprints (Ref. 188). The overall broadband (10–25,000 Hz) unweighted per-pulse SEL source level of the 4,130 cu.in seismic source operating at 5 m depth was 229.6 dB 1 μPa^2m^2s in the broadside direction and 229.2 dB 1 μPa^2m^2s in the endfire direction. The peak SPL in the same directions was 250.1 dB re 1 µPa m and 248.2 dB re 1 µPa m, respectively (Ref. 188).

Given the details above, the consequence of seismic acquisition causing a change in ambient underwater sound has been assessed as Minor (5) as it will result in a localized and short-term environmental impact.

Marine mammals

Behavioural disturbance

Acoustic modelling indicated that the R_{max} from the source to SPL behavioural noise effect criteria for all cetaceans was 13.45 km (Table 6-3, Table 6-4, Figure 6-2).

As identified in Section 4.3.1, several marine mammal species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. In addition, a migration and distribution BIA for the Pygmy Blue Whale also overlaps with the OA and FPZ (Section 4.3.1.1). As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna.

The Humpback Whale migration BIA is located ~5 km from the OA and ~16 km from the FPZ (Section 4.3.1.2), with migration occurring between June and October. Given there is no temporal overlap in the use of this migration BIA for Humpback Whales and the 4D MSS, no behavioural disturbance is predicted.

As the OA and FPZ overlaps a migration BIA for the Pygmy Blue Whale, there is the potential for Pygmy Blue Whales to be present during migration periods. However, given the acquisition timing (mid-December to mid-April) for the 4D MSS is predominantly outside the migration periods (April to August, and November to late-December), the OA is within an open-water environment (i.e., not a confined migratory pathway), and there will be a single seismic vessel operating, it is not expected that the 4D MSS would result in a significant change to migration behaviours or displace species outside of the BIA. In addition, it is expected that whales in the vicinity of a seismic source will avoid the immediate area due to an aversive response to the sound (Ref. 5). It is considered that any such temporary displacement during a seismic survey is unlikely to result in any real biological cost unless the interaction occurs during critical behaviours (e.g., breeding, feeding, and resting), or in important areas such as narrow migratory corridors (Ref. 5). The OA is not within a confined migratory corridor, and other critical behaviours are not expected.

Given the limited spatial and temporal exposures to marine mammals from underwater impulsive sound above the noise effect criteria for behavioural disturbance from the moving seismic vessel, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

Consequently, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Minor (5).

TTS and PTS

Acoustic modelling indicated that the R_{max} from the source to TTS and PTS single pulse PK noise effect criteria for low-frequency cetaceans was 0.07 km and 0.04 km respectively; and for high-frequency cetaceans was 1.00 km and 0.45 km respectively (Table 6-3, Table 6-4).

Acoustic modelling also indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria for low-frequency cetaceans was 95.4 km and 6.61 km respectively; and for high-frequency cetaceans was 1.63 km and <0.02 km respectively (Table 6-3, Table 6-4). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

While relatively high R_{max} values were estimated for the cumulative 24-hour exposures (SEL_{24h}) for low-frequency cetaceans, the additional exposure modelling for Pygmy Blue Whales, which takes into consideration both a moving sound source and a moving cetacean, substantially reduced these estimated exposure areas to 12.5 km for TTS (compared to 95.4 km) and 0.06 km for PTS (compared to 6.61 km) (Table 6-5; Figure 6-8). While this exposure modelling (Ref. 189) was undertaken specifically for Pygmy Blue Whales, it is considered an analogue for other low-frequency cetaceans in that the modelled R_{max} distances from the acoustic modelling (Ref. 188) for 24-hour exposure are likely substantially over conservative.

The SEL_{24h} threshold for mid-frequency cetaceans was not reached within the limits of the modelling resolution (20 m) (Table 6-3, Table 6-4). The PK threshold for mid-frequency cetaceans was 0.02 km for TTS and was not reached for PTS (Table 6-3, Table 6-4). Dolphins typically have peak sensitivities in the higher frequency ranges and are less likely to be affected by lower frequency seismic sounds and as such, less vulnerable to acoustic trauma (Ref. 5). As such, no further evaluation of mid-frequency cetaceans (e.g., dolphins, Sperm Whale) has been undertaken.

High-frequency cetaceans are toothed whales specialised at hearing at high frequencies, such as the Pygmy Sperm Whale and Dwarf Sperm Whale. These species are not listed as threatened under the EPBC Act, but may occur within the OA (appendix c). All cetacean species are expected to be transiting through the area; no areas of known aggregation within or around the OA have been identified.

Low-frequency cetaceans are baleen whales specialised at hearing at low frequencies. Within the OA, low-frequency cetaceans include the following threatened species: Blue, Bryde's, Fin, and Sei Whales (Section 4.3.1). A migration and distribution BIA for the Pygmy Blue Whale also overlaps a small proportion of the OA and FPZ (Section 4.3.1.1). The Humpback Whale migration BIA is located ~5 km from the OA and ~16 km from the FPZ (Section 4.3.1.2), with migration occurring between June and October. Given there is no temporal overlap in the use of this migration BIA for Humpback Whales and the 4D MSS, no TTS or PTS impacts are predicted. A such the following consequence evaluation for low-frequency cetaceans focusses on Pygmy Blue Whales.

<u>Pygmy Blue Whales</u>

As detailed in Section 4.3.1.1, migrating Pygmy Blue Whales are likely to occur in the Exmouth – Montebello region from November through to late-December (southern migration) and from April through to August (with a peak in May and June) (northern migration). As the 4D MSS is planned between mid-December to mid-April there is the potential for some overlap with the end of the southern migration period (December) and the start of the northern migration period (April). However, as discussed in Section 4.3.1.1, although the defined BIA for Pygmy Blue Whales passes through the northern part of the OA, it is expected based on recent satellite tracking and acoustic detection studies that the Pygmy Blue Whales are more likely to travel predominantly to the northwest of the OA in deeper waters, particularly during their southern migration (November to December).

Based on the exposure modelling (Ref. 189) a Pygmy Blue Whale would need to be within 30 m of the seismic source to be exposed to noise level above the noise effect criteria a for single pulse PTS, and within 60 m of the seismic source to be exposed to noise level above the noise effect criteria for single pulse TTS or cumulative SEL_{24h} PTS (Table 6-5). Based on the implementation of industry standard controls such as soft starts, and the expected behavioural avoidance if exposed to noise, it would be highly unlikely for a Pygmy Blue Whale to be as close as 60 m to the seismic vessel, thus TTS and PTS from either single pulse and PTS sound exposure over 24 hr is not predicted, and no further evaluation has been undertaken for these types of effects.

The exposure modelling (Ref. 189) indicated that a Pygmy Blue Whale would need to be within 12.5 km of the seismic source over a 24-hour period to be exposed to noise level above the noise effect criteria for TTS SEL_{24h} (Table 6-5; Figure 6-8). However, it is noted that the exposure modelling (Ref. 189) conservatively assumes Pygmy Blue Whales do not exhibit avoidance behaviour from the seismic source; however, in reality, avoidance behaviour is expected to occur (Ref. 5). This expected avoidance behaviour is supported by other studies. For example, Moulten and Holst (Ref. 223) documented that Blue Whales were seen farther (~677 m) from the seismic vessel during periods when the source was active (1,904 m) vs. silent (1,227 m), based on analysing 9,180 hours of seismic survey observations in eastern Canada from 2003 to 2008. Additionally, Stone et al. (Ref. 224) undertook a comprehensive study of 181,000 hours of marine mammal observations during 1,196 seismic surveys from 1994-2010 in the UK and concluded as a combined group, on average, baleen whales were shown to stay 500 m further away from the seismic source when active compared to when off, suggesting the group exhibit natural avoidance. Given the distance to the behavioural response noise effect criteria is 12.43 km (Table 6-4) it would be highly unlikely Pygmy Blue Whales would be consistently exposed to sound levels over 24 hrs that would result in TTS. It is more likely that migrating Pygmy Blue Whales would exhibit natural avoidance.

The Conservation Management Plan for the Blue Whale (Ref. 68) includes a specific action that "Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area". The OA does not intersect with a foraging BIA for the Pygmy Blue Whale (Table 4-2). The nearest foraging BIA occurs ~225 km southwest of the OA, offshore from North West Cape; and as such is not exposed to underwater sound emissions resulting from activities under this EP. Double et al. (Ref. 225) acknowledged that: "While anthropogenic noise may alter blue whale behaviour, it is unlikely to pose a conservation risk unless it causes population level consequences such as changes in growth, reproduction and survival of individuals. Elevated ambient noise has been responsible for abandonment or avoidance of critical habitat by a number of cetacean species including gray whale, bowhead whales and killer whales. Critical habitat includes habitat used to meet essential lifecycle requirements such as foraging and breeding, both of which are activities likely to be impacted by elevated ambient noise for the Pygmy Blue Whales." It is expected that the natural avoidance behaviour exhibited by baleen whales will result in Blue Whales moving away, and therefore not being consistently exposed to sound levels above the TTS effect criteria within ~12.5 km from the seismic vessel for a 24-hour period. In the unlikely event that this did occur, it would be at the individual scale, and not population level.

Based on the relatively small (e.g., up to two weeks) potential of temporal overlap with either the Pygmy Blue Whale southbound or northbound migration, the small spatial overlap (i.e., the FPZ overlaps ~720 km^2 (~0.23%) of the Pygmy Blue Whale migration BIA), the absence of critical behaviours (e.g., breeding, feeding, and resting), or important areas such as narrow migratory corridors, the predicted sound levels from seismic acquisition may affect individuals but are not considered likely to cause ecologically significant impacts at a population level for Pygmy Blue Whales.

In summary, the behavioral disturbance to individual Pygmy Blue Whales is expected to the temporary and short term and has been evaluated as Minor (5); and the potential for TTS injury to Pygmy Blue Whales is expected to be limited and has been evaluated as Incidental (6).

Turtles

Behavioural disturbance

Acoustic modelling indicated that the R_{max} from the source to SPL behavioural noise effect criteria for turtles was 7.11 km (Table 6-3, Table 6-4, Figure 6-3).

McCauley et al. (Ref. 192) found that turtles showed behavioural responses (i.e., increased swimming behaviour) to an approaching seismic source at received sound levels of approximately 166 dB SPL, and a stronger avoidance response at around 175 dB SPL. Similarly, Moein et al. (Ref. 227) monitored the behaviour of penned Loggerhead Turtles to seismic sources operating at 175–179 dB SPL. Avoidance of the seismic source was observed at first exposure, but the turtles

habituated to the sound over time. Finneran et al. (Ref. 181) identified 175 dB SPL as the level at which marine turtles are expected to actively avoid seismic sound exposure. As identified in Section 4.3.2, several marine reptile species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. In addition, an internesting BIA and critical habitat for Flatback Turtles also overlaps with the OA and FPZ (Section 4.3.1.1). As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, or marine under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) details that Flatback Turtles nest at the Montebello Islands from October to March, with the peak between November and January, which overlaps the seismic survey timing. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) identifies an action for addressing key threats to the Pilbara Flatback Turtle stock of "manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival". However, as discussed in Section 4.3.2.1, although the defined internesting BIA and critical habitat for Flatback Turtles overlaps the southern part of the OA, it is expected based on recent studies that Flatback Turtles are unlikely to occur within the OA during their internesting period due to the habitat suitable for internesting being in shallower and nearshore waters. There is no evidence to date to indicate Flatback Turtles swim out into deep offshore waters during the internesting period. Given that the ensonified area for behavioural disturbance is not predicted to overlap with the habitat suitable for internesting, and that if marine turtles did occur further offshore within the OA, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Incidental (6). Given the limited spatial and temporal exposures expected to internesting marine turtles from underwater impulsive sound above the noise effect criteria for behavioural disturbance from the moving seismic vessel, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park. *TTS and PTS* Acoustic modelling indicated that the R_{max} from the source to TTS single pulse PK noise effect criteria for turtles was 0.02 km; the threshold for PTS was not reached (Table 6-3, Table 6-4). Based on the expected behavioural avoidance if exposed to noise, it would be highly unlikely for a marine turtle to be as close as 20 m to the seismic source thus TTS is not predicted, and no further evaluation has been undertaken for this type of effect. Acoustic modelling also indicated that the R_{max} from the source to TTS and PTS SEL_{24h} noise effect criteria for turtles was 3.84 km and <0.02 km respectively (Table 6-3, Table 6-4, Figure 6-4). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario. As described above, it is expected that marine turtles would exhibit avoidance behaviour from the seismic source. Given the distance to the behavioural response noise effect criteria is 7.11 km (Table 6-4) it would be highly unlikely that Flatback Turtles would be consistently exposed to sound levels over 24 hrs that would result in TTS (which requires them to remain within 3.84 km of the source). In addition, ensonification for TTS SEL_{24h} noise effect criteria is not expected to extend into the areas defined as suitable habitat for internesting Flatback Turtles in accordance with recent studies (Section 4.3.2.1). Given that the ensonified area for SEL_{24h} TTS and PTS is not predicted to overlap with the habitat suitable for internesting, and that if marine turtles did occur further offshore within the OA, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Incidental (6). Given the limited spatial and temporal exposures expected to internesting marine turtles from underwater impulsive sound above the noise effect criteria for auditory impairment or injury from the moving seismic vessel, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.
Fish (with no swim bladder) Cartilaginous fish, such as sharks and rays, or pelagic fish such as mackerel, do not have swim bladders. As identified in Section 4.3, several fish species (including shark and ray species) listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. A foraging BIA for the Whale Shark also overlaps with the OA.

Based on the values and sensitivities within the OA, the following fish have been identified as relevant for this evaluation:

- Whale Sharks
- pelagic fish species including commercial fish species such as mackerel.

As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, or marine under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. Social and economic values of this AMP include commercial fishing. *Behavioural disturbance*

Impulsive sound sources have been identified as a high, moderate, and low risk of causing behavioural changes within the near (tens of metres), intermediate (hundreds of metres), and far (thousands of metres) distances from a sound source respectively; and a low risk of causing masking changes at all distances (Table 6-3).

Potential behavioural impacts to finfish from seismic sounds include temporary stunning, changes in position in the water, displacement from area and effects on breeding behaviours (Ref. 226). However, the transient nature of the seismic source and the highly mobile nature of pelagic fish species means that behavioural avoidance responses and effects on distribution will be incidental, localised and of short duration.

Mortal, potential mortal, and recoverable injury

Acoustic modelling indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury single pulse PK noise effect criteria for fish (with no swim bladder) was <0.02 km (Table 6-3, Table 6-4).

Acoustic modelling also indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury SEL_{24h} noise effect criteria for fish (with no swim bladder) was 0.096 km (Table 6-3, Table 6-4). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

These modelling results indicate that a fish (with no swim bladder) would have to be in very close proximity to the seismic vessel to be at risk of injury, for both a single pule or cumulative 24-hour exposure.

TTS

Acoustic modelling indicated that the R_{max} from the source to TTS SEL_{24h} noise effect criteria for fish (with no swim bladder) was 8.63 km (Table 6-3, Table 6-4, Figure 6-5). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

<u>Whale Sharks</u>

Whale Shark migration along the WA coast occurs mainly between July and November (Section 4.3.3.1). Based on the 4D MSS timing of mid-December to mid-April, there is no temporal overlap with the Whale Shark migration period.

Whale Sharks' auditory sensitivity or susceptibility to sound-induced effects have not been tested. Like all elasmobranchs, they are lacking a swim bladder and have no air-filled chambers or accessory morphological structures to their hearing system that could serve as hearing specialisations. Like other shark species, they can be considered to have relatively insensitive hearing and less likely to be negatively affected by intense underwater sound.

It is expected that the potential effects to Whale Sharks associated with underwater sound 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. (Ref.182) guidelines, which detail that there is the potential for high risk of behavioural impacts in fish species near the seismic source (tens of metres) with the level of risk declining to low at thousands of metres from the seismic source.

Given that there is no exposure to migrating Whale Sharks from underwater impulsive sound from the moving seismic vessel (due to timing of the 4D MSS), it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

As the timing of the 4D MSS does not overlap the period when Whale Sharks are likely to be in the area, potential impacts to Whale Sharks are assessed as a consequence level of Incidental (6) as impacts are unlikely to occur.

<u>Pelagic fish species including commercial fish species such as mackerel</u>

Key pelagic fish species that may occur in the OA include Spanish Mackerel and various other mackerels (e.g., Grey Mackerel), as well as various species of tuna and billfish. These species

either do not possess a swim bladder or it is poorly developed and not directly connected to hearing (Ref.182), indicating that they are sensitive only to the particle motion component of sound at close range to a sound source. Pelagic fishes such as mackerel travel distances of 100–300 km or more, while tunas and billfish may travel in the order of thousands of kilometres. Therefore, pelagic fishes can reasonably be expected to exhibit an avoidance response and swim away from the approaching seismic source before sound levels approach levels that may result in mortality, injury or TTS. As detailed in Table 6-6 the principal depth range for Spanish Mackerel, which is targeted by the Mackerel Managed Fishery, is up to 50 m. As the OA is in water depths 50 m and deeper, the FPZ is in water depths >60 m and there has been no catch effort for the fishery within the FPZ in the last five years, significant impacts to this species and hence the fishery is not predicted. In addition, a risk assessment facilitated by DPIRD was undertaken (Ref. 226), and this assessment determined that the risk of any impact type (i.e., including behaviour, hearing impairment, and injury) to pelagic finfish (e.g., Spanish Mackerel, Silver Trevally) from a >4,000 cu.in seismic array in waters >250 m depth was negligible. The potential impacts to pelagic fish species, including commercial fish species, from underwater sound emissions from the seismic source are assessed as a consequence level of Incidental (6) as impacts are expected to be limited. Given the limited spatial and temporal exposures expected to commercial fish species from underwater impulsive sound from the moving seismic vessel, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.
Fish (with swim bladder) Fish with swim bladders include: • demersal fish species such as tropical snappers and emperors (swim bladders not used for hearing) • some reef fish and site-attached fish species (swim bladders used for hearing). Most, if not all, demersal fish species expected to occur in the OA have relatively poor hearing compared to fishes with hearing specialisations and swim bladders directly involved in hearing. Based on the values and sensitivities within the OA, the following fish have been identified as relevant for this evaluation: • demersal fish species including commercial fish species such as tropical snappers and emperors • demersal fish species associated with the Continental Slope Demersal Fish KEF • site-attached fish species associated with the Ancient Coastline at 125 m Depth Contour KEF • site-attached fish species associated with the Wheatstone ridgeline. As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include the ancient coastline at 125 m depth contour KEF. Social and economic values of this AMP include commercial fishing. Fish communities at Rankin Bank have been excluded as it is located ~12 km from the FPZ and the furthest predicted distance to a fish sound exposure criterion is 8.63 km (Ref. 188), therefore impacts are not predicted. *Behavioural disturbance* Impulsive sound sources have been identified as a moderate/high risk of causing behavioural changes within the near (tens of metres) or intermediate distances (hundreds of metres) from a sound source respectively; and a low risk of causing masking changes (Table 6-3). Potential behavioural impacts to finfish from seismic sounds include temporary stunning, changes in position in the water, displacement from area and effects on breeding behaviours (Ref. 226). However, the transient nature of the seismic source and the relatively deep waters of most of the OA and FPZ, suggests that behavioural responses on demersal or site-attached fish will be incidental, localised and of short duration. *Mortal, potential mortal, and recoverable injury* Acoustic modelling indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury single pulse PK noise effect criteria for fish (with swim bladders) was <0.27 km (Table 6-3, Table 6-4). Acoustic modelling also indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury SEL_{24h} noise effect criteria for fish (with swim bladders) was <0.02 km (Table 6-3, Table 6-4). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both

a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

These modelling results indicate that a fish (with swim bladders) would have to be in very close proximity to the seismic vessel to be at risk of injury, for both a single pule or cumulative 24-hour exposure.

No studies to date have demonstrated direct mortality of adult fish in response to seismic acoustic emissions, even within 1–7 m of the source (Ref. 228; Ref. 229; Ref.182; Ref. 230). 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, as cited in NSW DPI (Ref. 231)).

TTS

Acoustic modelling indicated that the R_{max} from the source to TTS SEL_{24h} noise effect criteria for fish (with swim bladders) was 8.63 km (Table 6-3, Table 6-4, Figure 6-5). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

Fish that showed TTS recovered to normal hearing levels within 18–24 hours. For the acoustic modelling TTS was modelled over the cumulative period of 24 hr based on Popper (Ref. 182) who states: *"The time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fish receives the maximum exposure. Thus, 24 hours is likely far too long a period for calculating the accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours."* Popper (Ref. 182) in his review of TTS for the Santos Bethany 3D MSS, which considered similar fish species as likely to be present in the OA, noted:

- it is highly unlikely that there would be physical damage to fishes as a result of the seismic survey, unless the animals are very close to the source (perhaps within a few metres)
- most fishes in the Bethany region (and given the similarity in fish species, this also applies for the NWS region), being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey
- 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 fishes 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 fishes 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.

<u>Demersal fish species (including commercial species)</u>

Demersal fish species likely to be within the FPZ are various species of snapper, emperors, rock cods and groupers and typically have a swim bladder not used for hearing.

The majority of studies relevant to behavioural responses in demersal fish species (Ref. 236; Ref. 237; Ref. 192; Ref. 238; Ref. 239; Ref. 240; Ref. 241; Ref. 242), indicate that exposure to a mobile seismic source resulting in behavioural response such as startle, changes in swimming speed or direction and avoidance are likely to be limited to durations of minutes or hours and occur within hundreds of metres of the seismic source as it passes.

The modelled distances to the mortality and injury sound exposure guidelines range from <20 m to 270 m (Table 6-4). As discussed previously, the sound exposure guidelines for mortality and injury are considered highly conservative. While mortality or injury to fishes in the immediate proximity of the seismic source is theoretically possible, free swimming fishes such as the demersal species that are likely to be present within the FPZ are expected to be able to avoid the seismic source as it approaches. The demersal fish species likely to be present in the FPZ (predominantly snappers, emperors and rock cods), despite exhibiting particular habitat preferences and some fidelity to an area, can be found across a variety of habitats and are typically mobile with home ranges in the order of kilometres or tens of kilometres (Ref. 232; Ref. 231; Ref. 233; Ref. 234; Ref. 235). Therefore, demersal fishes can reasonably be expected to exhibit an avoidance response and swim away from the approaching seismic source before sound levels approach levels that may result in mortality, injury or TTS.

The modelled distance to the TTS SEL_{24h} cumulative sound exposure guideline is 8.63 km (Table 6-4). There is the potential for some fishes to experience TTS if they stayed within the exposure range for a period of 24 hours. However, as detailed by Popper (Ref. 182), recovery would start as soon as the most intense sounds ended with recovery within 24 hours or less and therefore the likelihood of TTS having a significant impact on fish fitness (in terms of communication, detection of predators or prey, etc.) is low.

A recent field study by Meekan et al. (Ref. 270) found no short-term (days) or long-term (months) effects of exposure on the composition, abundance, size structure, behaviour or movement of demersal fish species targeted by commercial fisheries on the NWS of WA.

The FPZ overlaps the ~1.6% of the area of catch effort of Pilbara Trap Fishery (2014–2019 data) and ~1% of the area of catch effort of Pilbara Line Fishery (2014–2019 data). The main species landed by these fisheries in the Pilbara subregion are Blue Spotted Emperor, Red Emperor and Rankin Cod (Ref. 243). Table 6-6 details that the FPZ overlaps 0.9% of the Blue Spotted Emperor stock range, 0.3% of Red Emperor stock range and 0.9% of the Rankin Cod stock range.

Potential impacts to demersal fish species, including commercial fish species, from underwater sound emissions from the seismic source are assessed as a consequence level of Minor (5) as impacts will be localised and short term based on the following:

- there are no documented cases of mortality (both immediate and delayed) in free-swimming fish upon exposure to seismic source sound in experimental or field studies (Ref. 244)
- recent studies show no short-term (days) or long-term (months) effects of exposure on the composition, abundance, size structure, behaviour or movement of demersal fish species targeted by commercial fisheries (Ref. 270)
- the potential for fish to receive TTS is assessed as being acceptable based on hearing loss and any subsequent decrease in fitness would be temporary and recovery occurring in a relatively short timeframe (<24 hrs)
- any behavioural impacts are likely to be short-lived (minutes or hours) and occur within hundreds of metres of the seismic source as it passes
- the stock assessment for all key indicator commercial fish species (Table 6-6) indicates adequate stock status, breeding stock and fishery catch levels (Ref. 243)
- as recovery from TTS or behavioural effects is expected in hours to days, no population level effects are predicted to commercial fish species, thus lasting effects on their catchability, and consequently to commercial catch rates, are not predicted
- there are no predicted impacts to the ecosystems or habitats of the North Coast Fishing Bioregion, where the seismic survey is located within, therefore the seismic survey does not threaten the sustainability of the fisheries that cover smaller areas than the overall distribution of commercial fish species in the North Coast Fishing Bioregion
- commercial fish catches within the Pilbara Demersal Scalefish Fisheries (trawl, trap and line) have been within or exceeded the acceptable catch ranges since 2016, despite a history of seismic surveys across the fisheries.

Given the limited spatial and temporal exposures expected to commercial fish species from underwater impulsive sound from the moving seismic vessel, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

<u>Demersal fish species associated with the Continental Slope Demersal Fish KEF</u>

The demersal fish species associated with the KEF occupy two distinct demersal community types (biomes) associated with the upper slope, in water depths of 225–500 m and the mid-slope, in water depths of 750-1,000 m (Ref. 28).

As detailed in Table 6-2, Site 3, Site 4 and Scenario 2 best represent sound modelling for the KEF. The modelled distances to the mortality and injury sound exposure guidelines range from <20 to 150 m (Ref. 188). The modelled distance to the TTS 24-hr cumulative sound exposure guideline is 7.56 km (Ref. 188). Thus, there is the potential for some fishes to experience TTS; but as detailed by Popper (Ref. 182) recovery would start as soon as the most intense sounds ended with recovery within 24 hours or less and therefore the likelihood of TTS having a significant impact on fish fitness (in terms of communication, detection of predators or prey, etc.) is low.

Thus, potential impacts to fish species associated with the KEF are not likely to be ecologically significant based on:

- the area of potential overlap with the FPZ is <1% of the total area of the KEF.
- there are no documented cases of mortality (both immediate and delayed) in free-swimming fish upon exposure to seismic source sound in experimental or field studies (Ref. 244)
- the potential for fish to receive TTS is assessed as being acceptable based on hearing loss and any subsequent decrease in fitness would be temporary and recovery occurring in a relatively short timeframe (<24 hrs)

- demersal fish species associated with the KEF are expected to be able to avoid the seismic source as it approaches
- The *Marine Bioregional Plan for the North-west Marine Region* (Ref. 76) rates the impact of underwater sound pollution to the KEF as "*not of concern"* which is based on the impacts are minimal or that the pressure is managed effectively through routine management measures.

The potential impacts to fish species associated with the Continental Slope Demersal Fish KEF from underwater sound emissions from the seismic source are assessed as a consequence level of Minor (5) as impacts will be localised and short term.

<u>Fish species associated with the Ancient Coastline at 125 m Depth Contour KEF</u>

There is little information in relation to fish species associated with the Ancient Coastline at 125 m Depth Contour KEF. DEWHA (Ref. 246) details enhanced productivity associated with the sessile communities and increased nutrient availability may attract larger marine life such as Whale Sharks and large pelagic fish. Preliminary data from the AIMS North West Shoals to Shore research program identified that the KEF is dominated by sandy habitats with some areas of hard substrate with filter feeder communities typical of the North West Shelf (Ref. 247). Thus, substantial benthic communities that would support site-attached fish species are not likely to be present. AIMS (Ref. 248) detailed that fish communities were characteristic of the region and were dominated by various shark species including hammerhead and tiger sharks.

Santos commissioned RPS to undertake a study to describe the fishes associated with the Ancient Coastline at the 125 m Depth Contour KEF. Nine sites at three separate geographic locations were surveyed in the KEF. Key findings from the study in relation to the Ancient Coastline at the 125 m Depth Contour KEF were:

- a total of 643 fish from 39 species and 17 families were recorded with Goldband Snapper (*Pristipomoides multidens*) and Yellow Spotted Rock Cod (*Epinephelus areolatus*) being the only commercially important species observed at these locations on the KEF
- no escarpment, complex relief, emergent bedrock or complex epibiota assemblages were recorded on video or observed on the vessel sounder at the KEF survey sites
- limited variation in fish assemblages of the KEF were observed between the three KEF study locations
- although within-site variability was high, abundances of fish species were low in the area, comprising relatively mobile demersal fish species
- the four most ubiquitous species were Lunartail Pufferfish (72% deployments), Threadfin Bream (67% deployments), Longnose Trevally (59% deployments) and Giant Trevally (47% deployments).

As detailed in Table 6-2, Site 2 and Scenario 1 best represent sound modelling for the KEF. The modelled distances to the mortality and injury sound exposure guidelines range from <20 m to 192 m (Ref. 188). As discussed previously, the sound exposure guidelines for mortality and injury are considered highly conservative. While mortality or injury to fishes in the immediate proximity of the seismic source is theoretically possible, mobile demersal and pelagic fish species that are likely to be present within the KEF are expected to be able to avoid the seismic source as it approaches.

The modelled distance to the TTS SEL_{24h} cumulative sound exposure guideline is 8.63 km (Ref. 188). Thus, there is the potential for some fishes to experience TTS, but as detailed by Popper (Ref. 182) recovery would start as soon as the most intense sounds ended with recovery within 24 hours or less and therefore the likelihood of TTS having a significant impact on fish fitness (in terms of communication, detection of predators or prey, etc.) is low.

Thus, potential impacts to fish species associated with the KEF are not likely to be ecologically significant based on:

- the area of potential overlap with the FPZ is <1% of the total area of the KEF.
- there are no documented cases of mortality (both immediate and delayed) in free-swimming fish upon exposure to seismic source sound in experimental or field studies (Ref. 244)
- the potential for fish to receive TTS is assessed as being acceptable based on hearing loss and any subsequent decrease in fitness would be temporary and recovery occurring in a relatively short timeframe (<24 hrs)
- studies to date have identified predominately mobile demersal and pelagic fish species associated with the KEF and these species are expected to be able to avoid the seismic source as it approaches
- The *Marine Bioregional Plan for the North-west Marine Region* (Ref. 76) rates the impact of underwater sound pollution to the KEF as *"of less concern"* which is based on the impacts are

unlikely to be substantial or that current management measures in place are effective in minimising or mitigating the impact.

Given that the potential impacts to fish species associated with the KEF are not expected to be ecologically significant, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

The potential impacts to fish species associated with the Ancient Coastline at 125 m Depth Contour KEF from underwater sound emissions from the seismic source are assessed as a consequence level of Minor (5) as impacts will be localised and short term.

Fish species associated with the Wheatstone ridgeline

There is no information in relation to fish species associated with the Wheatstone ridgeline so it is assumed that fish species would be similar to those associated with the hard substrate of the Ancient Coastline at the 125 m Depth Contour KEF. Thus, it is likely that fish species would consist of demersal and pelagic species characteristic of the region.

As detailed in Table 6-2, Site 1 and Scenario 1 best represent sound modelling for the Wheatstone ridgeline. The modelled distances to the mortality and injury sound exposure guidelines range from <20 to 270 m (Ref. 188). As discussed previously, the sound exposure guidelines for mortality and injury are considered highly conservative. While mortality or injury to fishes in the immediate proximity of the seismic source is theoretically possible, mobile demersal and pelagic fish species that are likely to be present within the Wheatstone ridgeline are expected to be able to avoid the seismic source as it approaches.

The modelled distance to the TTS SEL_{24h} cumulative sound exposure guideline is 8.63 km (Ref. 188). Thus, there is the potential for some fishes to experience TTS, but as detailed by Popper (Ref. 182) recovery would start as soon as the most intense sounds ended with recovery within 24 hours or less and therefore the likelihood of TTS having a significant impact on fish fitness (in terms of communication, detection of predators or prey, etc.) is low.

Thus, potential impacts to fish species at the Wheatstone ridgeline is not likely to be ecologically significant based on:

- there are no documented cases of mortality (both immediate and delayed) in free-swimming fish upon exposure to seismic source sound in experimental or field studies (Ref. 244)
- the potential for fish to receive TTS is assessed as being acceptable based on hearing loss and any subsequent decrease in fitness would be temporary and recovery occurring in a relatively short timeframe (<24 hrs)
- mobile demersal and pelagic fish species likely to be associated with the Wheatstone ridgeline are expected to be able to avoid the seismic source as it approaches.

The potential impacts to fish species associated with the Wheatstone ridgeline are assessed as a consequence level of Minor (5) as impacts will be localised and short term.

Plankton

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. The noise effect criteria for fish eggs and fish larvae has been identified as relevant for plankton (Ref. 188; Section 6.5.1.1), and as such has been used for the following consequence evaluation.

Behavioural disturbance

Impulsive sound sources have been identified as moderate risk of causing behavioural changes to plankton in close proximity to the sound source; and there is low risk of causing behavioural change beyond this close proximity, and low risk of masking at all distances from the sound source (Table 6-3).

Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Plankton also have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (Ref. 76). Sound emissions on sparse plankton populations are unlikely to cause a significant change in behaviour at a measurable level. Therefore, the potential behavioural impacts from sound emissions on plankton are not evaluated further.

Mortal or potential mortal injury

Acoustic modelling indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury single pulse PK noise effect criteria for fish eggs and fish larvae was <0.27 km (Table 6-3, Table 6-4).

Acoustic modelling also indicated that the R_{max} from the source to mortal, potential mortal, or recoverable injury SEL_{24h} noise effect criteria for fish eggs and fish larvae was <0.02 km

(Table 6-3, Table 6-4). Note that the SEL_{24h} is a cumulative metric that assumes a receptor is consistently exposed to the relevant noise effect criteria for a 24-hour period. In reality, given both a moving sound source (i.e., the seismic vessel) and moving marine fauna, these modelled outputs are likely to be an overly conservative and unlikely worst-case scenario.

Any potential mortality or mortal injury effects to plankton have to be assessed in the context of natural mortality rates. Mortality or mortal injury impacts to plankton (including fish eggs and larvae) resulting from seismic acoustic emissions are likely to be inconsequential compared to natural mortality rates. These have been reported to be very high, exceeding 50% per day in some species and commonly exceeding 10% per day (Ref. 249). In a review of mortality estimates (Ref. 250) the mean mortality rate for marine fish larvae was 0.24, a rate equivalent to a loss of 21.3% per day. In the experiment undertaken by McCauley et al. (Ref. 251) zooplankton mortality rate background levels were 19%, thus predicted impacts to zooplankton from the seismic survey are likely to be within natural mortality rates. Sætre and Ona (Ref. 252) calculated that under the 'worst-case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population, and they concluded that mortality rates caused by exposure to underwater sound are so low compared to natural mortality that the impact from seismic surveys must be regarded as insignificant.

Richardson et al. (Ref. 253) modelled the results from McCauley et al. (Ref. 254) in the context of ocean ecosystem dynamic and zooplankton population dynamic. They determined that zooplankton abundance would not be adversely affected during the extensive movement of water masses carrying plankton through areas targeted by seismic acquisition, and the rapid reproductive cycle and high reproductive potential characteristics of planktonic organisms. The study showed that it would take approximately three days after the end of a typical 4,000 cu.in seismic survey for the zooplankton to recover to original levels. In addition, zooplankton communities may begin to recover during the seismic survey such that a continuous decline in zooplankton throughout the duration of the seismic survey is not anticipated and parts of the seismic survey area would be replenished as the seismic survey progressed (Ref. 253).

As identified in Section 4, the following values and sensitivities have been identified as relevant to this consequence evaluation:

- foraging BIA for Whale Sharks
- fish eggs and larvae for commercial fisheries.

Foraging BIA for Whale Sharks

As described in Section 4.3.3.1, the Whale Shark is a suction filter feeder, with a diet consisting of planktonic and nektonic prey. The foraging BIA for Whale Sharks overlaps with both the OA and FPZ, and is associated with the northward migration of Whale Sharks from the Ningaloo Reef area during July to November (Section 4.3.3.1). The acquisition timing (mid-December to mid-April) for the 4D MSS is outside of the migration period (July to November) and therefore use of the foraging BIA for Whale Sharks. Given that there is no temporal overlap between the use of the foraging BIA by Whale Sharks and the 4D MSS, and the naturally high plankton recovery rates as described above, no further evaluation of this sensitivity has been undertaken.

Fish eggs and larvae for commercial fisheries

DPIRD (Ref. 254) has defined the depth ranges and spawning periods for a range of key indicator species for the North Coast commercial fish species. For those key commercial fish species that have spawning periods overlapping the timing of the 4D MSS (Goldband Snapper, Rankin Cod, Red Emperor, Blue-spotted Emperor and Ruby Snapper), they spawn throughout their ranges rather than aggregating at a specific area (Ref. 254). Spanish Mackerel is the exception as they form spawning schools around inshore reefs (Ref. 254).

To evaluate the consequence to commercial fish spawning the assessment considers:

- spatial-temporal analysis to provide context on the proportion of the spawning biomass that may be exposed during the 4D MSS
- natural variability in fish distribution, spawning biomass and recruitment
- sustainability status of the fish stocks and fisheries.

Newman et al. (Ref. 255) note that the mixed or multispecies fisheries in WA are managed using an indicator species approach where one or more species in the suite are used to monitor the status of the fishery.

A spatial-temporal analysis was undertaken as detailed in Table 6-6 to determine the overlap between the 4D MSS and the principal spawning ranges and timings 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 underwater sound from the 4D MSS.

Spawning for Spanish Mackerel, the key indicator species for the Mackerel Managed Fishery, is not predicted to be impacted as the principal depth range for the species, and hence spawning, is <50 m (Ref. 254) and the depth of the OA and FPZ is >50 m and >60 m respectively.

The spatial-temporal analysis is not intended to provide an exact estimate of how much each species' spawning success rate will be impacted. Instead, it demonstrates that the proportion of eggs and larvae that may be affected is relatively small compared to the larger overall spawning biomass, spawning area and spawning periods of each stock, which is important context for this consequence evaluation. The analysis identified that the spatial overlap ranges from ~0.3% (Red Emperor) to ~3.8% (Ruby Snapper) and the temporal overlap ranges from ~25% (Red Emperor) to ~49% (Ruby Snapper) (Table 6-6).

Based on the spatial-temporal analysis the overlap of spawning timing and area with the OA and timing is small and conservative based on:

- The key commercial fish species have multiple, broadcast spawning behaviours which offset potentially high natural embryo and larval mortality as a result of predation or other environmental factors that may occur at a regional scale, and thereby spreads the risk or potential opportunity for larval settlement over large areas and long timeframes.
- Fish spawning will not be evenly distributed through their range or within the OA.
- Only a small area within the OA will be impacted at a time as the seismic vessel moves through the OA over the 75-day period.
- The sound source will not be operating for the entire 75-day period which includes down time, equipment set-up and maintenance and line turns.

Impacts to fish spawning are not predicted to lead to a reduction in spawning stock as impacts to fish eggs and larvae are likely to be inconsequential compared to natural mortality rates (Ref. 249, Ref. 250, Ref. 251, Ref. 252).

In addition, the spawning biomass and breeding stock for the key indicator species for assessment and stock status have been assessed as sustainable - adequate (Ref. 243) for the past 5 years, in which time there has been both ongoing commercial fishing and seismic surveys undertaken.

The potential impacts to fish eggs and larvae from underwater sound emissions from the seismic source is assessed as a consequence level of Minor (5) as impacts will be localised and short term.

Table 6-6: Commercial fish species spawning spatial and temporal overlap

Key indicator fish stock*	FPZ spatial overlap with stock range^	FPZ temporal overlap with spawning period^
Goldband Snapper		
Principal depth range: 50 – 200 m	1.3% (1,644/124,441)	31% (75/243)
Stock range (area within depth range): 124,441 km² A single genetic stock is considered from Lynher Bank north of Broome to Shark Bay. For this assessment a smaller stock range extending to the North West Cape, which is the westerly limit of the Pilbara fisheries, has been used.		
Spawning period: 243 days (Oct-May)		
Red Emperor*		
Principal depth range: 10 – 180 m	0.3% (1,644/124,441)	25% (75/303)
Stock range (area within depth range): 494,173 km² A single genetic stock between Queensland and Shark Bay in WA. For this assessment a smaller stock range to the WA-NT border has been used.		
Spawning period: 303 days (Sept-Jun)		
Rankin Cod*		
Principal depth range: 10 – 150 m	0.9% (1,644/177,449)	31% (75/245)
Stock range (area within depth range): 177,449 km² A single biological stock from the Lacepede Islands to Abrolhos Islands.		
Spawning period: 245 days (Jun-Dec, Mar)		

Blue-spotted Emperor*		
Principal depth range: 5 – 110 m	0.9% (1,644/177,449)	27% (75/274)
Stock range (area within depth range): 177,449 km^2 A single biological stock from the Lacepede Islands to Abrolhos Islands.		
Spawning period: 274 days (Jul-Mar)		
Ruby Snapper		
Principal depth range: 150 – 480 m	3.8% (1,644/43,572)	49% (75/152)
Stock range (area within depth range): 43,572 km^2 The genetic stock is uncertain. For this assessment the Pilbara management unit has been used.		
Spawning period: 152 days (Dec-Apr)		
Spanish Mackerel*		
Principal depth range: 0 – 50 m	No overlap (OA in >50 m water depth; FPZ in >60 m water depth)	N/A
Stock range (area within depth range): 186,753 km^2 The north and west coasts of Australia (NT and WA). For this assessment a smaller stock from the NT border to Shark Bay has been used.		
Spawning period: 91 days (Sept-Dec)		

** indicator species monitored for the sustainability of the fishery*

^ spatial and temporal overlaps calculated on assumption that entire FPZ area and entire duration of the seismic acquisition occur within stock range and spawning period.

Benthic invertebrates

Acoustic modelling indicated that the maximum horizontal distance from the source to the PK-PK no effect sound level at the seafloor for crustaceans was 0.913 km (Figure 6-6, Figure 6-7); and to the maximum sound level at the seafloor was 0.366 km (Section 6.5.1.2). Acoustic modelling indicated that the maximum distance from the source to the PK-PK maximum sound level for bivalves was 0.241 km (Section 6.5.1.2).

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 (Ref. 256; Ref. 257) or "hear" sound in the way that mammals and fish can. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves (Ref. 188).

There have been several recent reviews of seismic underwater sound impacts to invertebrates — Carroll et al. (Ref. 230), Edmonds et al. (Ref. 258), Ref. 259 and Webster et al. (Ref. 226). Several studies have been undertaken on decapods (crabs, lobsters, prawns) with a range of effects to no effects identified, though none have found any evidence of increased mortality due to acoustic impacts from seismic exposure. A range of physiological responses have been identified in some studies at sound levels typically received within a few hundred metres from the seismic source or from repeated exposure at the same sound levels. This repeated exposure is not realistic in an actual seismic survey as the vessel is transiting along sail lines with a swath width approximately 7.5–8 km apart, therefore a single receptor will not be exposed to repeated exposure at the same sound level.

From 2013 to 2015, a long-term study evaluated the acoustic impacts from seismic exposure on southern rock lobsters (*Jasus edwardsii*) (Ref. 260). The study found that sub-lethal effects, relating to impairment of reflexes, damage to the statocysts and reduction in numbers of haemocytes (possibly indicative of decreased immune response function), were observed after exposure to measured received sound levels of 209 to 212 dB PK-PK. Payne et al. (Ref. 261) in a study on seismic impacts to the American lobster (*Homarus americanus*) found no effects in righting time or haemolymph biochemistry but a possible reduction in calcium after exposure to received sound levels of 202 dB PK-PK.

At received sound levels of 209 dB PK-PK (Ref. 260) impacts to spiny lobster embryonic development were not observed with hatched larvae found to be unaffected in terms of egg development, the number of hatched larvae, larval dry mass and energy content and larval competency (i.e., survival in adverse conditions); thus, recruitment should be unaffected.

Recent Australian studies (Ref. 262; Ref. 263; Ref. 264; Ref. 265) have focussed on commercial scallops (*Pecten fumatus*). Przeslawski et al. (Ref. 262; Ref. 263) examined the short-term impacts on scallops and other marine invertebrates from a 2,530 cu.in seismic source and found no evidence of mortality or change in condition following exposure to a seismic survey. Day et al. (Ref. 264; Ref. 265) exposed scallops to maximum received sound exposures of up to 213 dB PK-PK with exposure not resulting in any immediate mass mortality; however, repeated exposure was considered to possibly increase the risk of mortality. Though Day et al. (Ref. 264) recorded increased mortality with repeated exposure to a seismic source, it has not been established as to whether this was due to the seismic source exposure or other mechanism related to the study design (Ref. 262). Using a precautionary approach, if the increased mortality was due to the seismic source then the increased mortality identified translates to an annual increase of between 9.4% and 20%. These fall towards the low end of what might be expected when compared with natural mortality rates in wild scallop populations, which range from 11-51% with a six year mean of 38% (Ref. 264).

As identified in Section 4, the following values and sensitivities have been identified as relevant to this consequence evaluation:

- scampi (crustaceans) associated with the North West Slope Trawl Fishery
- invertebrate communities associated with the ancient coastline at 125 m depth contour KEF
- invertebrate communities associated with the Wheatstone ridgeline.

<u>Scampi (crustaceans) associated with the North West Slope Trawl Fishery</u>

As identified in Section 4.4, the North West Slope Trawl Fishery (NWSTF) has recorded fishing effort within the OA, with low vessel numbers, during the 2015-2020 period. The key target species of the NWSTF is Australian scampi (*Metanephrops australiensis*) with smaller quantities of velvet scampi (*M. velutinus*) and Boschma's scampi (*M. boschmai*) (Ref. 266). Scampi are a benthic species that inhabits the continental shelf, typically occurring at depths of 420-500 m, and preferring a comparatively firmer substrate (Ref. 267). In the event that scampi are present within the OA, some may 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 reduce fitness of some individual scampi but impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population.

<u>Invertebrate communities associated with the ancient coastline at 125 m depth contour KEF</u>

The FPZ overlaps ~0.75% of the ancient coastline at 125 m depth contour KEF (122/16,242 km^2). Preliminary data from the AIMS North West Shoals to Shore research program, which includes multibeam and towed video surveys of an area of the KEF that the OA and FPZ overlaps, identified that the KEF is dominated by sandy habitats with some areas of hard substrate with filter feeder communities typical of the North West Shelf (Ref. 248). Thus, substantial benthic invertebrate communities are not likely to be present. Some invertebrates within the KEF may 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 reduce fitness of some individuals within the small (<0.75%) area of overlap with the KEF but impacts at a population level would be unlikely as there would be sufficient unaffected individuals to maintain the population. The ecosystem functioning and integrity of the ancient coastline at 125 m depth Contour KEF are not predicted to be altered. It is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

<u>Invertebrate communities associated with the Wheatstone ridgeline</u>

As detailed in Section 4.3.4.1, the Wheatstone ridgeline comprises hard rock with a sand veneer (Ref. 91). Benthic surveys identified that for sessile benthic organisms, gorgonians and sponges were dominant (Ref. 90); however, as per the consequence evaluation for marine habitats below, no effect to these is predicted to occur. The dominant infauna species were polychaetes and crustaceans. Some invertebrates within the ridgeline may experience sound levels that could result in low-level, sub-lethal effects (e.g., impairment of reflexes, damage to statocysts and reduction in numbers of haemocytes). These sub-lethal effects could reduce fitness of some individuals within the area of overlap but impacts at a population level would be unlikely as there would be sufficient unaffected individuals to maintain the population. The ecosystem functioning and integrity of the ridgeline are not predicted to be altered.

The potential impacts to benthic invertebrates within the OA from underwater sound emissions from the seismic source are assessed as a consequence level of Minor (5) as impacts will be localised and short term.

Marine habitat (corals, sponges)

Acoustic modelling indicated that the PK no effect sound level at the seafloor for sponges and corals was not reached (Section 6.5.1.2). As such, no further evaluation of coral and sponge habitats has been undertaken.

Humans (divers, swimmers)

Acoustic modelling indicated that the SPL human health assessment threshold at Site A (~64 m water depth) was 51.07 km.

Guidance note DMAC 12 issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" recommends that where diving and seismic activities are scheduled to occur within a distance of 45 km of each other, it would be good practice for all parties to be made aware of the planned activity where practicable. Within 45 km of the OA the following were identified:

- Recreational diving and snorkeling at the Montebello Islands
- Commercial diving at the Pluto, Wheatstone, Goodwyn Alpha, John Brookes, or Wonnich oil and gas facilities
- Commercial diving at pearl leases within the Montebello Islands Marine Park Special Purpose Zone (Pearling).

From the acoustic modelling study (Ref. 188), the shallow waters (<25 m) around the Montebello Islands are not predicted to be ensonified above 140 dB SPL considering the closest potential location where the seismic source could be active (Site A). Therefore, the isopleth corresponding to the human health assessment threshold of 145 dB SPL will not be exceeded in water depths relevant to recreational diving at the Montebello Islands or commercial diving at pearl leases within the Montebello Islands Marine Park Special Purpose Zone (Pearling). The influence of the bathymetry on the sound fields and the orientation of the source are the reason the shallow waters around the Montebello Islands are not predicted to be ensonified above the human health assessment threshold (Ref. 188).

There is the potential for commercial diving to occur at the Wheatstone and Pluto oil and gas facilities within the OA and the John Brookes, Goodwyn Alpha and Wonnich facilities, which are located within 45 km of the OA. If diving activities are required to be undertaken at the time of the seismic survey, consultation and management of activities will be undertaken as per the Guidance DMAC 12: Safe Diving Distance from Seismic Surveying Operations (Ref. 268).

The potential impacts to recreational and commercial divers from underwater sound emissions from the seismic source is assessed as a consequence level of Incidental (6) as impacts are unlikely to occur.

Concurrent operations

Cumulative impacts from seismic surveys can potentially occur when the activities take place concurrently in close proximity to each other, or when the timing between surveys is less than the recovery rate of any potential impacts.

Concurrent Surveys

For seismic surveys that occur at the same time, the Bureau of Ocean Energy Management (Ref. 269) recommends a 40 km geographic separation distance (based on worst-case scenarios) between the sources of concurrent seismic surveys to minimise the impacts to marine life, by providing a 'corridor' between vessels. As detailed in Section 4.4.3, the following seismic surveys have OAs that overlap (and therefore occur within 40 km) of the Wheatstone 4D MSS:

- Rollo Multiclient MSS
- NWS Renaissance North Multi Client MSS.

Consultation with seismic operators for the surveys described in Table 4-14 during January 2022 indicate that no concurrent activities for the two surveys (Rollo Multiclient MSS or the NWS Renaissance North Multi Client MSS) with overlapping OAs with the Wheatstone 4D MSS are currently scheduled. The third survey (Capreolus-2 3D MSS) described in Table 4-14 may occur at a similar time, however this survey is located ~100 km east from the 4D MSS. As such, no further evaluation on the risks from concurrent seismic surveys has been undertaken.

Previous Surveys

A review of previous seismic surveys over or adjacent to the OA identified:

- Woodside Pluto and Harmony 4D seismic surveys undertaken from December 2019 through to February 2020.

Based on the acoustic modelling study and sound impact assessment conducted for the seismic survey the recovery periods for any impacts to receptors are predicted to be: • Immediately after completing seismic acquisition for migratory or transient species that may avoid the area such as whales, Whale Sharks, turtles and pelagic fishes. • Days or weeks after completing seismic acquisition for demersal fish species, including key indicator commercial fish species that may show avoidance or behavioural reactions. • Days to months after completing seismic acquisition for plankton, based on the CSIRO modelling study (Ref. 253). • Weeks to months after completing seismic acquisition for site-attached fish species and benthic invertebrates as only sub-lethal effects were identified that would not reduce reproductive potential or inhibit spawning. Based on the fishing effort reported in the annual State of the Fisheries reports (2013 to 2019) for key indicator commercial fish species, there has been no decline in the total annual catch, despite seismic surveys having been conducted within this period and overlapping the area of catch and effort for these fisheries. As the most recent survey to overlap the OA was conducted December 2019 to February 2020, there will be a gap of 34 months prior to the commencement of the Wheatstone 4D MSS, and thus cumulative impacts to receptors are not predicted. As such, no further evaluation on the risks from repeated seismic surveys has been undertaken.
ALARP decision context justification
Marine seismic surveys are commonplace and well-practised nationally and internationally. Impacts from sound emissions are relatively well understood though there is the potential for uncertainty in relation to the level of impact. The application of control measures to manage impacts and risks arising from this aspect are well defined and understood by the industry and are considered standard industry practice. During stakeholder consultation objections and claims were raised regarding underwater sound emissions impacts on commercial fish species which have been addressed. As such, CAPL applied ALARP Decision Context B for this aspect, and consideration of additional controls was undertaken to ensure the potential impacts and risks associated with underwater sound are managed to ALARP.

Good practice control measures and source	
Control measure	**Source**
EPBC Act Policy Statement 2.1 – Standard Management Procedures	The requirements to manage interactions between offshore seismic vessels and whales are detailed in the *EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales*. This policy describes a framework to minimise the risk of biological consequences from seismic acoustic sources to whales within biologically important areas or during critical behaviours. The policy also provides practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic acquisition activities. The management procedures described in the policy should be applied whenever whales are, or might be, encountered (where “whales” includes baleen whales and larger toothed whales). By implementing these control measures and managing interactions with cetaceans near the seismic vessel, the potential risks from underwater sound are reduced. The Standard Management Procedures defined within Policy 2.1 should be followed by all vessels conducting seismic surveys in Australian waters, irrespective of location and time of year. Precaution zones As per the requirements of EPBC Act Policy Statement 2.1 and the results of acoustic modelling (Ref. 188), the following precaution zones will apply during the 4D MSS: • Observation zone: 3+ km horizontal radius from the acoustic source • Low power zone: 2 km horizontal radius from the acoustic source

	• Shut-down zone: 500 m horizontal radius from the acoustic source. Part A – Standard management procedures • A.1 Pre-survey planning: • A.2 Trained crew: • A.3 During surveys: • A.4 Compliance and sighting reports EPBC Policy 2.1 considers that the likelihood of encountering whales increases from low to moderate-high where a survey is spatially and/or temporally proximate to aggregation areas, migratory pathways and/or areas considered to provide biologically important habitat. As the 4D MSS is scheduled to occur between mid-December and mid-April, and therefore overlaps with Pygmy Blue Whale migration (southbound during December, and northbound during April), EPBC Policy 2.1 also requires consideration of Part B management procedures is required under the policy – refer to assessment under 'additional control measures' below.
DMAC Guidance	Guidance note DMAC 12 issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" (Ref. 268) recommends that where diving and seismic activities are scheduled to occur within a distance of 45 km of each other, it would be good practice for all parties to be made aware of the planned activity where practicable. If diving activities are required to be undertaken at the time of the seismic survey, consultation and management of activities will be undertaken as per the Guidance DMAC 12: Safe Diving Distance from Seismic Surveying Operations (Ref. 268).
BOEM Guidance	For seismic surveys that occur at the same time, the Bureau of Ocean Energy Management (BOEM) (Ref. 269) recommends a 40 km geographic separation distance between the sources of concurrent seismic surveys to minimise the impacts to marine life, by providing a 'corridor' between vessels.
Adjustment protocol	CAPL will consider an evidence-based adjustment protocol for the commercial fishing sector should fishers be verifiably impacted to a commercially material extent by the 4D MSS (Section 7.3.4.1). CAPL will assess claims from commercial fishing license holders for temporary loss of catch, displacement, or equipment loss/damage, occurring within the OA and during the 4D MSS.

Additional control measures and cost-benefit analysis

Control measure	Benefit	Cost
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.1 Marine Mammal Observers	The use of marine fauna observers (MFOs) can increase the visual detection of cetaceans present within proximity to the seismic vessel. Being able to better locate cetaceans and implement the precaution zones, will assist in reducing the risk of behavioural or hearing impairment impacts to cetaceans.	Costs for engaging a MFO are expected to be in the order of ~$800-1,000/day. The use of MFOs and detection of cetaceans may lead to increased survey duration and overall costs due to power downs and shut-downs of the activity. However, the cost of MFOs and the benefit of reducing impacts to cetaceans is considered to outweigh the financial costs from not implementing this control. Therefore, control

		measure has been adopted for use.
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.2 Night-time/Poor-visibility	Limiting seismic operations during night-time or poor-visibility conditions would reduce the probability of a cetacean occurring the low power or shut down zones and not being detected.	Reducing operational timing to daylight hours only would significantly increase the duration and operational cost of the MSS. This increase in duration would require the survey to either be split over multiple years or extend beyond the mid-December to mid-April acquisition window; both of which would also introduce additional environmental risks. Given the small temporal overlap of the migratory period for Pygmy Blue Whales (southbound during December, and northbound during April) and the 4D MSS (mid-December to mid-April), the additional cost of limiting seismic operations during night-time or poor-visibility conditions is grossly disproportionate to the environmental benefit. Therefore, control measure has not been adopted for use.
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.3 Spotter Vessel(s) and Aircraft	Use of spotter vessels or aircraft may be used to assist in detecting the presence of individuals or groups of cetaceans, during daylight operations only. The policy recommends considering this management procedure when the likelihood of encountering whales is 'high'. This is not considered to be the case for the 4D MSS as it is occurring outside the period of Humpback Whale migration, and outside the peak Pygmy Blue Whale migration with a small temporal overlap with the end of the southbound migration period during December or the beginning of the northbound migration during April.	Cost of specialist aircraft with good downward visibility (or a spotter vessel) with additional MFOs required on board aircraft/vessel are estimated at approximately $10–20,000 per day. Use of these spotter aircraft/vessels would also introduce additional environmental and safety risks. Given the small temporal overlap of the migratory period for Pygmy Blue Whales (southbound during December, and northbound during April) and the 4D MSS (mid-December to mid-April), the additional cost and risks of the use of spotter aircraft/vessels is grossly disproportionate to the environmental benefit. Therefore, control

		measure has not been adopted for use.
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.4 Increased Precaution zones and Buffer zones	The policy recommends considering this management procedure when surveys are in or near important habitats, such as feeding, breeding or resting areas increased precaution zones or buffer zones. As the seismic survey is not within and does not impact on feeding, breeding or resting areas increased precaution or buffer zones are not required.	N/A
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.5 Passive Acoustic Monitoring (during entire survey period)	Potential to detect vocalizing cetaceans which might not otherwise be visible at the sea surface. Although PAM can be used to supplement visual observations made by the MFO, the method is dependent upon animals vocalising. Therefore, the method is only effective at detecting vocalizing cetaceans and is also dependent on environmental conditions. The approach is most effective for detecting odontocetes (toothed cetaceans, e.g., orcas, dolphins, Sperm Whales) that produce clicks and whistles that can be more readily differentiated from low frequency seismic impulses and vessel noise than low frequency calls by baleen whales (e.g., Humpback, Pygmy Blue, Fin, Sei, Bryde's Whales). Verfuss et al. (Ref. 271) who undertook a review of low visibility monitoring techniques, concluded that PAM works best in low background sound fields as high levels of sound can mask the vocalisations produced by the target species when overlapping in frequency and time. PAM detections of baleen whales during active seismic surveys are extremely low or entirely absent, but the method can work well with many odontocete species. As such PAM is not considered to be appropriate for use in detecting baleen whales such as Pygmy Blue Whales.	Sophisticated PAM systems are required to effectively filter low frequency cetacean calls and such systems are not readily available on all seismic vessels. Costs for engaging a trained PAM operator are expected to be in the order of ~$1,000/day (~$75,000 for the survey). However, there are also additional costs (e.g., provision of equipment, operator support, mobilisation costs, etc.). Therefore, it is estimated the total cost for PAM operations during the 4D MSS would be in the order of ~$105,000. The significant additional cost of having a trained PAM operator on board for the duration of the survey when there may be few or no detections of the targeted low-frequency whale species (i.e., Pygmy Blue Whale) is considered grossly disproportionate to any limited additional benefit that PAM might provide. Therefore, control measure has not been adopted for use.
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.5 Passive Acoustic Monitoring (during peak migration periods only)	Potential to detect vocalising cetaceans which might not otherwise be visible at the sea surface. However, as per above discussion, PAM detections of baleen whales during active seismic surveys are extremely low or entirely absent, but the method can work well with many odontocete species. As such PAM is not considered to be appropriate for use in detecting baleen whales such as Pygmy Blue Whales.	Costs for engaging a trained PAM operator are expected to be in the order of ~$1,000/day (i.e., up to ~$28,000 allowing for both two-week peak migration periods). However, there are also additional costs associated with the provision of equipment, operator support, mobilisation costs and

		other logistical considerations (e.g., the PAM operator may be unable to leave the vessel immediately after the peak migration period). Therefore, it is estimated the total cost for PAM operations during both the December and April peak migratory period would be in the order of ~$60,000. The significant additional cost of having a trained PAM operator on board for the duration of peak migration periods during the survey when there may be few or no detections of the targeted low-frequency whale species (i.e., Pygmy Blue Whale) is considered grossly disproportionate to any limited additional benefit that PAM might provide. Therefore, control measure has not been adopted for use.
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.6 Adaptive Management	The policy recommends considering this management procedure when the survey is in an area that is spatially or temporally on the edge of areas considered to provide biologically important habitat. The 4D MSS may overlap either the end of the Pygmy Blue Whale southbound migration period during December or the beginning of the Pygmy Blue Whale northbound migration period during April (i.e., there is potential for up to an approximate two-week overlap period during either the start or end of the survey). In recognition of this temporal and spatial overlap with the ends of predicted migration periods, adaptive management for night and/or low visibility conditions may assist in managing the potential increased likelihood of encountering whales during peak migration periods. The following will be implemented during December and April: • if the survey is required to shut-down or power-down three or more times per day for three consecutive days as a result of the presence of Pygmy Blue Whales, then the seismic operations must not be undertaken at night or during low visibility conditions.	Potentially reducing operational timing to daylight hours only when consistently observed within low-power or shut-down zones during peak migration periods for Pygmy Blue Whale would increase the duration and operational cost of the MSS. However, given the small temporal overlap of the migratory period for Pygmy Blue Whales (southbound during December, and northbound during April) and the 4D MSS (mid-December to mid-April), the additional cost of limiting seismic operations during night-time or poor-visibility conditions is not considered grossly disproportionate to the environmental benefit. Therefore, control measure has been adopted for use.

	• seismic operations cannot resume at night or during low visibility conditions, until there has been a 24-hour period, which included seismic operations during good visibility conditions, during which no shut-downs or power-downs have occurred for Pygmy Blue Whales.	
EPBC Act Policy Statement 2.1 – Additional Management Procedures – B.6 Adaptive Management	The policy recommends considering this management procedure when the survey is in an area that is spatially or temporally on the edge of areas considered to provide biologically important habitat. The 4D MSS may overlap either the end of the Pygmy Blue Whale southbound migration period during December or the beginning of the Pygmy Blue Whale northbound migration period during April (i.e., there is potential for up to an approximate two-week overlap period during either the start or end of the survey). In recognition of this temporal and spatial overlap with the ends of predicted migration periods, and acknowledging that the predicted SEL_{24h} TSS extends up to 12.5 km from a sound source, the use of an extended observation zone during December and April pre start-up procedures is proposed. Supplementary marine fauna observations from the bridge-watch crew on the support vessel/s (noting at least one will always be within the OA with the seismic vessel) will be used to during the pre start-up 30 minute visual observation period to extend the observation zone beyond the required 3 km from the seismic vessel (as per the Standard Management Procedures under Policy 2.1). These supplementary observations are not intended as a dedicated MFO role, as bridge-watch crew will also be required to fulfil their primary responsibilities onboard the support vessel. However, any supplementary observations from a support vessel will increase the visual observation distance from the seismic vessel; and will therefore assist in reducing the risk of hearing impairment impacts to cetaceans.	No additional personnel costs. However, the detection of cetaceans in an extended observation zone may lead to increased survey duration and overall costs due to power downs and shut-downs of the activity. However, the benefit of reducing impacts to cetaceans is considered to outweigh the financial costs from not implementing this control. Therefore, control measure has been adopted for use.
Survey timed to avoid nesting season for Flatback Turtles	The Montebello Islands supports Flatback Turtle nesting, occurring from October to March, with a peak in December to January (Section 4.3.2.1). The Recovery Plan (Ref. 63) lists the Montebello Islands as a critical nesting location and applies a 60 km internesting buffer. This internesting critical habitat, as well as an internesting	If all nesting season for Flatback Turtles were avoided, the 4D MSS could not be acquired. Altering the proposed acquisition period would also introduce risks for other sensitive species Therefore, control

	BIA for Flatback Turtles overlap with the OA and FPZ (Section 4.3.1.1). However, as discussed in Section 4.3.2.1, although the defined internesting BIA and critical habitat for Flatback Turtles overlaps the southern part of the OA, it is expected based on recent studies that Flatback Turtles are unlikely to occur within the OA during their internesting period due to the habitat suitable for internesting being in shallower and nearshore waters. Timing the 4D MSS to avoid the nesting season for Flatback Turtles would result in the seismic survey coinciding with peak migration periods of cetaceans known to migrate through the OA. These cetacean species are considered more susceptible to the potential impacts associated with the seismic survey, and therefore the seismic survey timeframes have been set to avoid those peak migration periods and rather than the nesting season for turtles. It is not possible to time the 4D MSS to avoid both periods of turtle nesting and cetacean migration, as this would not allow for a sufficient window of time to acquire the seismic survey.	measure has not been adopted for use.
Application of observation and shutdown procedures for marine turtles	Extending fauna observations to include marine turtles will minimise the potential for acoustic impacts to internesting turtles should there be a presence within the OA. The use of a 100 m shutdown zone is considered to be a practicable measure to implement. A 100 m shutdown zone is considered to be conservative given that PK TTS effects were predicted to be limited to <20 m from (and PK PTS was not predicted to be reached). The seismic source will be shut down, or start-up will be delayed for 15 minutes, if a turtle is observed within the shut-down zone. Operation of the seismic source using soft-start shall only resume when 15 minutes have lapsed since the turtle sighting or the turtle has been observed to move outside the shutdown zone.	There is the potential for increased operational costs due to additional and/or prolonged shutdowns due to marine turtle sightings. However, the cost of MFOs and the benefit of reducing impacts to cetaceans is considered to outweigh the financial costs from not implementing this control. Therefore, control measure has been adopted for use.
Survey timed to avoid spawning times for commercially targeted key indicator species	Combined spawning periods for the key indicator species cover all 12 months of the year. The spatial area of overlap is very small (up to 3.8% for species that have very large stock ranges covering significant proportions of the NW of Australia). Timing the seismic survey to avoid spawning times for commercially targeted key species would result in the seismic survey coinciding with peak migration periods of cetaceans known to migrate through the OA. These	If all spawning periods for commercially targeted key indicator species were avoided, the 4D MSS could not be acquired. Altering the proposed acquisition period would also introduce risks for other sensitive species Therefore, control measure has not been adopted for use.

	cetacean species are considered more susceptible to the potential impacts associated with the seismic survey, and therefore the seismic survey timeframes have been set to avoid those peak migration periods and rather than spawning periods for fish species which have been shown to be less sensitive. It is not possible to time the seismic survey to avoid both periods of fish spawning and cetacean migration, as this would not allow for a sufficient window of time to acquire the seismic survey.	

Likelihood and risk level summary	
Likelihood	With the identified controls implemented it is unlikely (4) that impacts such as mortality, mortal injury, injury, PTS or TTS will occur to receptors. It is more likely that receptors would exhibit short term behavioural avoidance to the seismic source as it moves through the seismic survey area. Although localised and temporary behavioural disturbance may occur, it is unlikely that this would result in any impact to a sensitive life stage of the fauna identified. It is reasonable to expect that impacts such as these will not occur during this project with the identified controls in place. Therefore, the likelihood is considered Seldom (3).
Risk level	Low (7)
Determination of acceptability	
Principles of ESD	The impacts and risks associated with this aspect are assessed as localised and short-term. There is no threat of serious or irreversible environmental damage or significant impact to biological diversity or ecological integrity associated with underwater sound emissions from the seismic source during the seismic survey. The aspect and potential interactions are well understood and managed in accordance with applicable industry standards and industry good practice. The consequence associated with this aspect is Minor (5). Therefore, no further evaluation against the Principles of ESD is required.
Relevant environmental legislation and other requirements	Legislation and other requirements considered applicable for this aspect include: • EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans • *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) • *Conservation Advice Balaenoptera borealis Sei Whale* (Ref. 67) • *Conservation Advice Balaenoptera physalus Fin Whale* (Ref. 66) • *Conservation Advice Rhincodon typus Whale Shark* (Ref. 65) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle)* (Ref. 64) • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).
Internal context	No CAPL environmental performance standards / procedures were deemed relevant for this aspect.
External context	During stakeholder consultation concerns were raised by WAFIC and individual stakeholders (Section 2.6.4). All stakeholder concerns have been assessed, responded to and controls adopted for objections and claims which hold merit. Proposed

	controls have been developed based on the advice of WAFIC and individual licence holders.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan. However, given that underwater sound is listed as a threat to protected matters under documents made or implemented under the EPBC Act, CAPL has defined an acceptable level of impact such that it is not inconsistent with these documents. The *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) specifies the following relevant action: • anthropogenic noise in BIAs will be managed such that any Blue Whale continues to utilise the area without injury, and is not displaced from a foraging area. No other specific relevant actions were identified within other documents implemented under the EPBC Act. The OA does not intersect with a foraging BIA for the Pygmy Blue Whale (Table 4-2). The nearest foraging BIA occurs ~225 km southwest of the OA, offshore from North West Cape; and as such is not exposed to underwater sound emissions resulting from activities under this EP. Therefore, CAPL has defined an acceptable level of impact as no injury to marine fauna.	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
No injury to marine fauna from underwater sound emissions from petroleum activities	**EPBC Act Policy Statement 2.1 – Standard Management Procedures** The following precaution zones for whales will be implemented during the 4D MSS: • Observation zone: 3+ km horizontal radius from the acoustic source • Low power zone: 2 km horizontal radius from the acoustic source • Shut-down zone: 500 m horizontal radius from the acoustic source.	Records demonstrate that all personnel are aware of the required precaution zones as required under EPBC Policy 2.1
	EPBC Act Policy Statement 2.1 – Standard Management Procedures The following standard procedures will be implemented during the 4D MSS: • Pre start-up visual observation • Sort start • Start-up delay • Operations • Stop work • Night-time and low visibility.	Records demonstrate that seismic operations were undertaken in accordance with the standard management procedures defined under EPBC Policy 2.1
	EPBC Act Policy Statement 2.1 – Additional Management Procedures A minimum of one dedicated marine fauna observer (MFO) will be on-duty on the seismic vessel during all active operations during daylight hours for the 4D MSS. The on-duty MFO will be responsible for undertaking fauna observations.	Daily MFO observation reports from seismic vessel

	EPBC Act Policy Statement 2.1 – Additional Management Procedures Two trained MFOs will be available on the seismic vessel during the 4D MSS acquisition to allow for a second MFO to be brought on-duty if required under the EPBC Policy 2.1 standard management procedures (e.g., start-up delay procedures)	Records show that two trained MFOs were always onboard the seismic vessel during the 4D MSS acquisition
	EPBC Act Policy Statement 2.1 – Additional Management Procedures Supplementary whale observations from the support vessel/s will be implemented during December and April: • at least one support vessel will be within the OA at all times • where practicable (given primary crew duties), the bridge-watch from the support vessel/s will record observations for whales during the pre start-up visual observation period	Induction records show support vessels bridge-watch crew were provided with whale observations and reporting guidelines Whale observation reports from support vessels during December and April
	EPBC Act Policy Statement 2.1 – Additional Management Procedures The following night and low visibility procedures will be implemented during December and April: • if the survey is required to shut-down or power-down three or more times per day for three consecutive days as a result of Pygmy Blue Whales, then the seismic operations must not be undertaken at night or during low visibility conditions • seismic operations cannot resume at night or during low visibility conditions, until there has been a 24-hour period, which included seismic operations during good visibility conditions, during which no shut-downs or power-downs have occurred for Pygmy Blue Whales.	Daily MFO observation reports from seismic vessel
	Observation shutdown procedures for marine turtles Marine fauna observations from the seismic vessel will include marine turtles during the 4D MSS, during the pre start-up visual observation period.	Daily MFO observation reports from seismic vessel
	Observation shutdown procedures for marine turtles A shut-down zone of 100 m horizontal radius from the acoustic source, for marine turtles, will be implemented for the 4D MSS. • The seismic source will be shut down, or start-up will be delayed for 15 minutes, if a turtle is observed within the shut-down zone. • Operation of the seismic source using soft-start shall only resume when 15 minutes have lapsed since the turtle	Records demonstrate that seismic operations were undertaken in accordance with the additional turtle shutdown procedures

	sighting or the turtle has been observed to move outside the shutdown zone.	
No injury to divers from underwater sound emissions from petroleum activities	**DMAC Guidance** If diving activities are scheduled to occur at the time of the 4D MSS, consultation and management of activities will be undertaken as per the Guidance DMAC 12: Safe Diving Distance from Seismic Surveying Operations	If required, records demonstrate that DMAC guidance was implemented for concurrent seismic and diving operations
No cumulative underwater sound emissions from petroleum activities	**BOEM Guidance** For concurrent seismic surveys, a separation distance of 40 km between seismic sources will be maintained	If required, records demonstrate that a 40 km separation distance was maintained for concurrent seismic operations
Reduce the impact to commercial fishery licence holders within the OA from petroleum activities	**Adjustment protocol** CAPL will assess any evidence-based claims from commercial fishery licence holders for compensation in line with the adjustment protocol (Section 7.3.4.1)	Records show that any evidence-based claim from commercial fishery licence holders was assessed and decision finalised

6.6 Underwater sound—field support operations

6.6.1 Acoustic modelling

Acoustic modelling undertaken by Woodside for pipelay and support vessels (Ref. 183) is considered suitable to inform potential sound exposures from this activity as the vessels are expected to be similar (or smaller) in size to those modelled thus source sound levels are expected to be similar (or smaller), and the physical environment of the operational area is comparable. The modelling (Ref. 183) also provides an indication of cumulative sound exposures by considering sound emissions from multiple vessel sources at a single location. On the basis that multiple vessels (i.e., a seismic vessel and a support vessel) will be within the OA during the 4D MSS, CAPL considers the use of this analogue modelling appropriate to inform this risk assessment.

The outcomes of this modelling (Ref. 183) are summarised throughout the subsequent risk and impact assessment (Section 6.6.2).

In the absence of modelling, the estimates of SPL from helicopter operations (149–162 dB re 1 µPa) (Ref. 176; Ref. 177) has been used for the purposes of behavioural thresholds for this consequence evaluation. Given the nature of helicopter operations (i.e., crew transfers) covered under this EP, exposure to sound from this source for an extended period (e.g., 12 or 24 hours) is not credible, and as such, comparison against the cumulative sound exposure level criterions is not relevant.

6.6.1.1 Exposure criteria

Different species groups perceive and respond to sound differently, and so a variety of exposure criteria for the different types of impacts and species groups are considered. The following noise effect thresholds, based on current best available science, have been used in the impact and risk assessment:

- frequency-weighted accumulated sound exposure levels (SEL_{24h}) from the NOAA Technical Guidance (Ref. 179) for the onset of PTS and TTS[8] in marine mammals (Table 6-7)
- un-weighted SPL for behavioural threshold for marine mammals based on NOAA (Ref. 180) (Table 6-7)
- frequency-weighted accumulated sound exposure levels (SEL_{24h}) from Finneran et al. (Ref. 181) for the onset of PTS and TTS in marine turtles (Table 6-7)
- sound exposure guidelines for fish, fish eggs and larvae (including plankton) (Ref.182) (Table 6-7).

Recent Commonwealth guidance has defined “injury to Blue Whales” as both PTS and TTS hearing impairment, as well as any other form of physical harm arising from anthropogenic sources of underwater noise (Ref. 202).

[8] TTS is a temporary reduction in an animals hearing sensitivity due to receptor hair cells in the cochlea becoming fatigued.

Table 6-7: Noise effect criteria for continuous sound for different types of impacts and species groups

Receptor	Mortal or potential mortal injury	Recoverable injury	Permanent threshold shift	Temporary threshold shift	Masking	Behavioural
Low-frequency cetaceans	N/A	N/A	SEL_{24h}: 199 dB re 1 µPa²s	SEL_{24h}: 179 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
Mid-frequency cetaceans	N/A	N/A	SEL_{24h}: 198 dB re 1 µPa²s	SEL_{24h}: 178 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
High-frequency cetaceans	N/A	N/A	SEL_{24h}: 173 dB re 1 µPa²s	SEL_{24h}: 153 dB re 1 µPa²s	N/A	SPL: 120 dB re 1 µPa
Marine turtles	N/A	N/A	SEL_{24h}: 220 dB re 1 µPa²s	SEL_{24h}: 200 dB re 1 µPa²s	N/A	N/A
Fish (no swim bladder) (relevant to sharks)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish (swim bladder not involved in hearing)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish (swim bladder involved in hearing)	(N) Low (I) Low (F) Low	SEL_{48h}: 170 dB	N/A	SEL_{12h}: 158 dB	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae (relevant to plankton)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	N/A	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) Moderate (F) Low

Relative risk (high, moderate, low) is given for fauna at three distances from the source (near [N], intermediate [I] and far [F]).

6.6.2 Risk assessment

Source			
Activities identified as having the potential to result in underwater sound are: • vessels or helicopter operations within the OA. These activities result in the emission of continuous sound.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
Underwater sound emissions may result in:		A change in ambient underwater sound may result in:	
• localised and temporary change in ambient underwater sound.	5	• behavioural disturbance	5
		• auditory impairment, temporary threshold shift (TTS), permanent threshold shift (PTS), recoverable or non-recoverable injury to marine fauna	–

Consequence evaluation

Localised and temporary change in ambient underwater sound

Anthropogenic underwater sound emitted during the 4D MSS activities will result in a change in ambient noise levels.

Underwater broadband ambient sound spectrum levels range from 45–60 dB re 1 µPa in quiet regions (light shipping and calm seas) to 80–100 dB re 1 µPa for more typical conditions, and >120 dB re 1 µPa during periods of high winds, rain or 'biological choruses' (many individuals of the same species vocalise near simultaneously in reasonably close proximity to each other) (Ref. 222). Low-frequency ambient sound levels (20–500 Hz) are frequently dominated by distant shipping plus some great whale species. Light weather-related sounds will be in the 300–400 Hz range, with wave conditions and rainfall dominating the 500–50,000 Hz range (Ref. 222).

Studies of underwater sound generated from propellers of offshore vessels when holding position indicate highest measured SPL up to 137 dB re 1 µPa and 120 dB re 1mPa at 405 m and ~3-4 km from the sound source (Ref. 174). When underway at ~12 knots vessel sound of 120 dB re 1 µPa was recorded at 0.5–1 km (Ref. 174). Generally, during active seismic operations, the seismic vessel will be only going a speed of ~4–5 knots within the OA (similarly, the support vessel will transit at a similar speed during active seismic operations within the OA), producing lower underwater sound emissions than what were recorded by the study.

Sound emitted from helicopter operations is typically below 500 Hz (Ref. 175). The peak-received level diminishes with increasing helicopter altitude, but the duration of audibility often increases with increasing altitude. Estimates of SPL for helicopters range 149–162 dB re 1 µPa (Ref. 176; Ref. 177). Richardson et al. (Ref. 176) report that helicopter sound was audible in air for four minutes before it passed over underwater hydrophones, but detectable under water for only 38 seconds at 3 m depth, and 11 seconds at 18 m depth.

Given the details above, the consequence of vessel or helicopter operations causing a change in ambient underwater sound has been assessed as Minor (5) as it will result in a localised and short-term environmental impact.

Marine Mammals

Behavioural disturbance

Acoustic modelling for support vessels indicate that the maximum radial distance in any direction from the source to 120 dB re 1 µPa was 4.9 km (Ref. 183).

As identified in Section 4.3.1, several marine mammal species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. In addition, a migration and distribution BIA for the Pygmy Blue Whale also overlaps with the OA and FPZ (Section 4.3.1.1). As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna.

The Humpback Whale migration BIA is located ~5 km from the OA (Section 4.3.1.2), with migration occurring between June and October. Given there is no temporal or spatial overlap in the use of this migration BIA for Humpback Whales and the 4D MSS, no behavioural disturbance is predicted. As the OA overlaps a migration BIA for the Pygmy Blue Whale, there is the potential for a larger number of cetaceans to be present during migration periods. However, given the activity timing (mid-December to mid-April) for the 4D MSS is predominantly outside the peak migration periods (April to August, and November to late-December), is within an open-water environment (i.e., not a confined migratory pathway), the close proximity (<5 km) to a vessel before behavioural response is likely to occur, it is not expected that the 4D MSS would result in a significant change to migration behaviours or displace species outside of the BIA. Estimates of SPL for helicopters range 149–162 dB re 1 µPa (Ref. 176; Ref. 177), which is above the noise exposure criterion for behavioural disturbance. However, the spatial and temporal extent of the potential exposure to underwater sound from helicopters is limited (e.g., 38 seconds at 3 m depth, and 11 seconds at 18 m depth; Ref. 176). The helicopter operations covered under this EP (i.e., crew transfers for seismic vessel) are also expected to be infrequent. Therefore, given the limited nature of the exposure, potential impacts from helicopters on cetacean behaviour are not evaluated further. Given the limited spatial and temporal exposures to marine mammals from underwater continuous sound above the noise effect criteria for behavioural disturbance from the moving seismic and support vessels, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park. Consequently, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Minor (5). *TTS and PTS* Acoustic modelling for support vessels indicate that the maximum radial distance in any direction from the source to a SEL_{48h} threshold of 170 dB re µPa^2.s was <0.010 km, and to a SEL_{12h} threshold of 158 dB re µPa^2.s was <0.097 km (Ref. 183). Given that the noise exposure criteria for marine mammals for TTS and PTS is based on a SEL_{24h} at similar or higher thresholds (Table 6-7), these distances (<10–100 m) are considered a conservative estimate. Consequently, TTS and PTS for marine mammals from continuous sound sources is not expected to occur given that, exceedance of noise exposure criteria requires the mammals to remain in vicinity (<10–100 m) of the vessel over a 24-hour period.
<u>Turtles</u> *TTS and PTS* Acoustic modelling for support vessels indicate that the maximum radial distance in any direction from the source to a SEL_{48h} threshold of 170 dB re µPa^2.s was <0.010 km, and to a SEL_{12h} threshold of 158 dB re µPa^2.s was <0.097 km (Ref. 183). Given that the noise exposure criteria for marine turtles for TTS and PTS is based on a SEL_{24h} at higher thresholds (Table 6-7), these distances (<10–100 m) are considered a conservative estimate. Consequently, TTS and PTS for marine turtles from continuous sound sources is not expected to occur given that, exceedance of noise exposure criteria requires turtles to remain in vicinity (<10–100 m) of the vessel over a 24-hour period.
<u>Fish including sharks and rays</u> *Behavioural disturbance* Continuous sound sources have been identified as a moderate risk of causing behavioural changes, a high risk of causing masking changes, within the near and intermediate vicinity of a sound source for all fish groups (Table 6-7). Continuous sound of any level that is detectable by fishes can mask signal detection, and thus may have a pervasive effect on fish behaviour. However, the consequences of this masking and any attendant behavioural changes for the survival of fishes are unknown (Ref. 182). It is expected that most fish (including sharks and rays) will exhibit avoidance behaviour from a sound source if it reaches levels that may cause behavioural or physiological effects. As identified in Section 4.3, several fish species listed as threatened and/or migratory under the EPBC Act have the potential to occur within the OA. A foraging BIA for the Whale Shark also overlaps with the OA. As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, or marine under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. Whale Shark migration along the WA coast occurs mainly between July and November (Section 4.3.3.1). Based on the 4D MSS timing of mid-December to mid-April, there is no

temporal overlap with the Whale Shark migration period. It is expected that the potential effects to Whale Sharks associated with underwater sound will be the same as for other pelagic fish species.

Pelagic fish species are likely to be transient through the OA. If the fish are within the immediate vicinity of the sound source, behavioural responses are expected to be limited to an initial startle reaction before either returning to normal, or resulting in the fish moving away from the area (Ref. 184). Demersal fish species may reside around existing subsea infrastructure (i.e., if it is providing suitable artificial habitat) within the OA. However, given the water depths within most of the OA, the sound levels at the seabed are expected to be below impact thresholds.

Given that there is no exposure to migrating Whale Sharks from underwater continuous sound from the moving seismic and support vessels (due to timing of the 4D MSS), it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

Consequently, only localised short-term behavioural impacts to transient individuals have the potential to arise from these activities and have therefore been evaluated as Minor (5).

TTS and Recoverable injury

Continuous sound sources have been identified as low risk of causing injury or mortality to fish with no swim bladders, or those with bladders not involved in hearing (Table 6-7).

For fish species with a swim bladder involved in hearing, acoustic modelling for support vessels indicate that the maximum radial distance from the source to the recoverable injury criterion was <0.01 km, and to the TSS criterion was 0.097 km (Ref. 183).

Pelagic fish species are likely to be transient through the OA. Given their transient nature, these fish are not expected to remain within close proximity (~10–100 m) of a sound source for extended periods (12–48 hours) such that an injury due to continued sound exposure would occur.

Demersal fish species may reside around existing subsea infrastructure (i.e., if it is providing a suitable artificial habitat) within the OA. However, given the water depths within most of the OA, the sound levels at the seabed are expected to be below impact thresholds and thus exposure to demersal species is not expected.

On this basis, neither TTS nor recoverable injury to fish are considered credible, and have therefore not been considered further.

Plankton

Behavioural disturbance

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.

Continuous sound sources have been identified as high risk of causing masking or behavioural changes to plankton in close proximity to the sound source; this risk decreases with increasing distance from the source (Table 6-7).

Any effects to plankton have to be assessed in the context of natural mortality rates, which are generally considered high and variable. Plankton also have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (Ref. 76). Sound emissions on sparse plankton populations are unlikely to cause a significant change in behaviour at a measurable level. Therefore, the potential behavioural impacts from sound emissions on plankton are not evaluated further.

TTS and Recoverable injury

Continuous sound sources have been identified as low risk of causing injury or mortality to plankton (Table 6-7), and as such are not discussed further.

ALARP decision context justification

Offshore commercial vessel operations are commonplace and well-practised nationally and internationally. The application of control measures to manage impacts and risks arising from this aspect are well defined, understood by the industry, and are considered standard industry practice.

During stakeholder consultation, no objections or claims were raised regarding underwater sound emissions arising from the activity.

Although some species that are known to be sensitive to underwater sound have the potential to be exposed to underwater noise above exposure criteria during these activities, the impacts and

risks arising from underwater sound emissions are considered lower-order impacts and risks in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.		
Good practice control measures and source		
Control measure	**Source**	
EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	The requirements to manage interactions between vessels and cetaceans are detailed in the EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans. These regulations describe strategies to ensure whales are not harmed during offshore interactions with people. By implementing these control measures and managing interactions with cetaceans near the vessels, the potential impacts from underwater sound are limited.	
Additional control measures and cost-benefit analysis		
Control Measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	Baleen whales may exhibit behavioural avoidance when sound levels are at or above 160 dB re 1 µPa (Ref. 180). Baleen whales display a gradation of behavioural responses to pulsed sound, suggesting that acoustic discharges are audible to whales at considerable distances from the source, but that they are not disrupted from normal activities such as vessel operations (Ref. 185), particularly during migration. As described above, other species such as turtles and fish are expected to initially practice avoidance behaviours in response to sound emissions, and thus the likelihood of underwater sound from these activities resulting in longer-term impact is very unlikely (Ref. 184; Ref. 186). Although localised and temporary behavioural disturbance may occur, it is unlikely that this would result in any impact to a sensitive life stage of the fauna identified. Consequently, CAPL consider the likelihood of the consequence occurring as being Rare (6).	
Risk level	Very low (10)	
Determination of acceptability		
Principles of ESD	The impacts and risks associated with this aspect are limited to localised, short-term behavioural changes. On the assumption that this potential impact occurs during a sensitive life stage (such as migration), CAPL would not expect these activities to affect migration, internesting, or foraging behaviours, nor impact on individuals or the wider population. As such, this aspect is not considered as having the potential to affect biological diversity and ecological integrity. The consequence associated with this aspect is Minor (5). Therefore, no further evaluation against the Principles of ESD is required.	
Relevant environmental legislation and other requirements	Legislation and other requirements considered applicable for this aspect include: • EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans • *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) • *Conservation Advice Balaenoptera borealis Sei Whale* (Ref. 67) • *Conservation Advice Balaenoptera physalus Fin Whale* (Ref. 66) • *Conservation Advice Rhincodon typus Whale Shark* (Ref. 65) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • *Approved Conservation Advice for Dermochelys coriacea (Leatherback Turtle)* (Ref. 64) • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).	

Internal context	No CAPL environmental performance standards / procedures were deemed relevant for this aspect.
External context	During stakeholder consultation, no objections or claims were raised regarding underwater sound emissions arising from the activity.
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan. However, given that underwater sound is listed as a threat to protected matters under documents made or implemented under the EPBC Act, CAPL has defined an acceptable level of impact such that it is not inconsistent with these documents. The *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) specifies the following relevant action: • anthropogenic noise in BIAs will be managed such that any Blue Whale continues to utilise the area without injury, and is not displaced from a foraging area. No other specific relevant actions were identified within other documents implemented under the EPBC Act. The OA does not intersect with a foraging BIA for the Pygmy Blue Whale (Table 4-2). The nearest foraging BIA occurs ~225 km southwest of the OA, offshore from North West Cape; and as such is not exposed to underwater sound emissions resulting from activities under this EP. Therefore, CAPL has defined an acceptable level of impact as no injury to marine fauna.

Environmental performance outcome	Performance standard / Control measure	Measurement Criteria
No injury to marine fauna from underwater sound emissions from petroleum activities	**EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans** Seismic and support vessels will implement caution and no approach zones, where practicable: • caution Zone (300 m either side of whales and 150 m either side of dolphins)– vessels must operate at ≤6 knots within this zone, maximum of three vessels within zone, and vessels should not enter if a calf is present • no approach zone (300 m to the front and rear of whales and 100 m either side; 300 m for whale calves; 150 m to front and rear of dolphins and 50 m either side;)–vessels should not enter this zone, and should not wait in front of the direction of travel or an animal or pod, or follow directly behind. ***Exception****: does not apply to seismic vessel towing equipment - operating under constrained manoeuvrability, or in an emergency.*	Induction materials include relevant marine fauna caution and no approach zone requirements
		Training records confirm personnel involved in offshore vessel activities have completed the induction
		Vessel records show if marine fauna interaction occurred within caution or approach zones, and what mitigation (e.g., divert or slow vessel) measure was implemented

6.7 Invasive marine pests

Source			
Activities identified as having the potential to result in the introduction of an invasive marine pest (IMP) are: • planned discharged of ballast water or the presence of biofouling on vessels undertaking seismic survey activities within the OA.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	–	An introduction of an IMP may result in: • displacement of, or compete with, native species.	2

Consequence evaluation

IMPs are likely to have little or no natural competition or predators, thus potentially outcompeting native species for food or space, preying on native species, or changing the nature of the environment. It is estimated that Australia has >250 introduced marine pests, and that approximately one in six introduced marine species becomes a pest (Ref. 106).

IMPs primarily occur in shallow waters with high levels of slow-moving or stationary shipping traffic (such as ports). The probability of successful IMP settlement and recruitment decreases in well-mixed, deep ocean waters away from coastal habitats. IMP colonisation also requires a suitable habitat in which to establish itself, such as rocky and hard substrates or subsea infrastructure. The Australian Government Bureau of Resource Sciences (BRS) established that the relative risk of an IMP becoming established around Australia decreases with distance from the coast. Modelling conducted by BRS (Ref. 221) estimates: 33% chance of colonisation at 3 nm, 8% chance at 12 nm, and 2% chance at 24 nm

The OA for the 4D MSS is in deeper waters ranging ~50–1,250 m, and as such low light levels are expected at the seabed. The OA is also located >25 km offshore from the closest island (Montebello Islands), and >100 km (>54 nm) from the mainland coast and large ports.

The particular values and sensitivities within the OA with the potential to be impacted by the introduction of an IMP within the OA include:

- continental slope demersal fish communities (KEF)
- ancient coastline at 125 m depth contour (KEF)
- ridgeline habitat and associated communities.

As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include the ancient coastline at 125 m depth contour KEF.

The benthic habitat within the OA predominantly comprises soft substrates (Section 4.3.5.1). Although the KEFs and ridgeline habitat may have a mixture of soft and hard substrates, these habitats are located in deep, well-mixed offshore waters, which is unlikely to facilitate the introduction and establishment of IMPs.

Once established, some IMPs can be difficult to eradicate (Ref. 107) and therefore there is the potential for a long-term change in habitat structure. Highly disturbed shallow water and coastal marine environments (such as marinas) have been found to be more susceptible to colonisation than open-water environments, where the number of dilutions and the degree of dispersal is high (Ref. 108; Ref. 109; Ref. 110; Ref. 111). Although invasive species are identified as being of concern to marine reptile species under the *North-west Marine Bioregional Plan* (Ref. 76), the risk is associated with terrestrial based species, and thus is not relevant to the activities covered under this EP.

If an IMP was introduced, and if it did colonise an area, there is the potential for that colony to spread outside the OA resulting in a widespread long-term impact, therefore resulting in a Severe (2) consequence.

ALARP decision context justification

Offshore commercial vessel operations, and subsequent planned discharges, are commonplace and well-practiced locally, nationally, and internationally.

The causes resulting in an introduction of an IMP from a planned release of ballast water or hull biofouling are well understood by the industry and CAPL. The control measures to manage the risk associated with the introduction of an IMP are well defined via legislative requirements that are considered standard industry practice. These control measures are well understood and implemented by the petroleum industry and CAPL. Specifically, CAPL has worked in the region for over 10 years, thus has a demonstrated understanding of industry requirements and their operational implementation in these areas.

The risk of introducing an IMP is considered a lower-order risk in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.

Good practice control measures and source

Control measure	Source
Quarantine procedure	CAPL's *Quarantine Procedure Marine Vessels* (Ref. 48) provides information about quarantine compliance to CAPL, contractors, and others associated with marine vessels. The procedure also ensures that the requirements of various legislative or relevant guidelines are met, including: • undertaking biofouling risk assessments in line with the with the *National Biofouling Management Guidance for the Petroleum Production and Exploration Industry* (Ref. 112) and Vessel Check system • requirements for biofouling management plans and/or biofouling record books, in accordance with the *Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines)* MPEC.207(62) 2011 (Ref. 6) The quarantine procedure requires that all relevant biofouling information is provided to enable suitable risk assessments to be completed.
Ballast water management	The *Australian Ballast Water Management Requirements* (Ref. 4) describes the management requirements for ballast water exchange, including: • non-discharge of 'high-risk' ballast water in Australian ports or waters • full ballast exchange outside Australian territorial seas • documentation of all ballast exchange activities.
Anti-fouling certificate	The Commonwealth *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* enacts Marine Order 98 (Marine pollution – anti-fouling systems). This marine order describes the conditions for when an antifouling certificate is required.
Maritime Arrivals Reporting System (MARS)	Under the Commonwealth *Biosecurity Act 2015*, pre-arrival information must be reported through MARS before a vessel arrives in Australian waters.

Additional control measures and cost-benefit analysis

Control Measure	Benefit	Cost
N/A	N/A	N/A

Likelihood and risk level summary

Likelihood	As vessel activities are occurring in deeper Commonwealth waters (not within shallow coastal areas), and with the well-known and implemented IMP control measures in place, it is considered Rare (6) that an IMP would be introduced resulting in impacts to the ecological functions of benthic habitats within or in close proximity to the OA.
Risk level	Low (7)

Determination of acceptability

Principles of ESD	The potential risks associated with this aspect is a widespread long-term impact to benthic communities. The introduction of an IMP to these communities has the potential to affect biological diversity and ecological integrity. The consequence associated with this aspect is Severe (2). Therefore, further evaluation against the remaining Principles of ESD is required.

<table>
<tr><td></td><td colspan="2">There is little uncertainty associated with this aspect as the activities and cause pathways are well known and the activities are well regulated and managed. The habitat within the OA is known from baseline studies, thus the understanding of benthic habitat at these locations is well understood. As such, there is limited scientific uncertainty associated with this aspect; consequently the precautionary principle has not been applied.</td></tr>
<tr><td>Relevant environmental legislation and other requirements</td><td colspan="2">Legislation and other requirements considered relevant for this aspect include:
• Commonwealth Biosecurity Act 2015
• Commonwealth Protection of the Sea (Harmful Anti-fouling Systems) Act 2006 (enacted by Marine Order 98 [Marine pollution – anti-fouling systems])
• Australian Ballast Water Management Requirements (Ref. 4)
• Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) MPEC.207(62)) 2011 (Ref. 6)
• National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Ref. 112)
• North-west Marine Parks Network Management Plan 2018 (Ref. 8).</td></tr>
<tr><td>Internal context</td><td colspan="2">This CAPL environmental performance standard / procedure was deemed relevant for this aspect:
• Quarantine Procedure Marine Vessels (Ref. 48)</td></tr>
<tr><td>External context</td><td colspan="2">During stakeholder consultation, no objections or claims were raised regarding IMPs arising from the activity.</td></tr>
<tr><td>Defined acceptable level</td><td colspan="2">These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.</td></tr>
<tr><th>Environmental performance outcome</th><th>Performance standard / Control measure</th><th>Measurement criteria</th></tr>
<tr><td rowspan="2">No introduction and establishment of invasive marine pests within the OA due to petroleum activities</td><td>Quarantine procedure
All marine vessels undertaking activities in the OA must meet the relevant requirements of the Quarantine Procedure Marine Vessels, including that where required:
• biofouling risk assessments are completed
• biofouling management plans and/or biofouling record books are available.</td><td>Records confirm that relevant vessels meet requirements of the Quarantine Procedure Marine Vessels</td></tr>
<tr><td>Ballast water management
International marine vessels will be required to comply with the key Australian Ballast Water Management Requirements, which are:
• non-discharge of 'high-risk' ballast water in Australian ports or waters
• full ballast exchange outside Australian territorial seas</td><td>For international marine vessels, records show compliance with the Australian Ballast Water Management Requirements</td></tr>
</table>

	• documentation of all ballast exchange activities.	
	Anti-fouling certificate Marine vessels greater than 400 GT with an anti-foul coating are to maintain up-to-date international antifouling coating certification in accordance with *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* and/or the International Convention on the Control of Harmful Anti-fouling Systems on Ships	Inspection reports confirm that international antifouling coating certifications are up-to-date
	Maritime arrivals reporting system Vessels entering into the Australian territorial sea from outside Australian territory will complete pre-arrival reporting (unless Excepted under Biosecurity Determination 2016), in accordance with the *Biosecurity Act 2015*	Records confirm that international vessels completed pre-arrival reporting (or can demonstrate meeting conditions for an exception)

6.8 Planned discharges—vessel operations

Source			
Activities identified as having the potential to result in planned discharges are: • vessels operations (during the seismic survey) within the OA. The types of planned vessel discharges include deck wash-water, fire-fighting foam, sewage, greywater, food wastes, cooling water, and oily bilge water.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
Planned discharges from vessels may result in: • localised and temporary reduction in water quality.	6	A change in ambient water quality may result in: • changes to predator-prey dynamics.	6

Consequence evaluation

Localised and temporary reduction to water quality

The routine vessel discharges will be of low volume during the seismic survey and of an intermittent and transient nature as the vessels move through the OA.

Open marine waters are typically influenced by regional wind and large-scale ocean current patterns resulting in the rapid mixing of surface and near-surface waters—where vessel discharges would occur (Ref. 113). Vessel discharges would occur in these surface and near-surface waters. Therefore, nutrients from sewage, or other similar, discharges will not accumulate or lead to eutrophication due to the highly dispersive environment (Ref. 113). This outcome was verified by sewage discharge monitoring for another offshore project (Ref. 114), which determined that a 10 m^3 sewage discharge reduced to ~1% of its original concentration within 50 m of the discharge location. In addition, monitoring at distances 50 m, 100 m, and 200 m downstream, 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. This modelling was based on volumes that far exceed volumes expected during vessel operations for the 4D MSS. Therefore, the extent of impacts are expected to be localised to the discharge location.

Monitoring of desalination brine of continuous wastewater discharges (including cooling water) undertaken by Woodside for its Torosa South-1 drilling program in the Scott Reef complex found that discharge water temperature decreases quickly as it mixes with the receiving waters, with the discharge water temperature being <1 °C above ambient within 100 m (horizontally) of the discharge point, and 10 m vertically (Ref. 114).

A vessel's bilge system is designed to safely collect, contain and dispose of oily water so that discharge of hydrocarbons to the marine environment is minimised or avoided. Bilge water is processed via an oil-water separator before being discharged to sea. Discharge is intermittent and occurs at or near surface waters. As such, oily bilge discharges are expected to readily dilute and disperse under the action of waves and currents in surface waters. In addition, once exposed to air, any volatile components of the oil will readily evaporate.

Testing of fire-fighting deluge systems onboard vessels often leads to a release of fire-fighting foams offshore. Toxicological effects from these types of foams is typically only associated with prolonged or frequent exposures, such as on land and in watercourses near firefighting training areas (Ref. 115; Ref. 116). These conditions are not consistent with the use under this EP where use of the systems may arise once or twice over the duration of this EP. In their diluted form (as applied in the event of a fire or test), fire-fighting foams are generally considered to have a relatively low toxicity to aquatic species (Ref. 117; Ref. 118) and further dilution of the foam mixtures in dispersive aquatic environments may then occur before there is any substantial demand for dissolved oxygen (Ref. 119).

Consequently, CAPL believes that the change in water quality from these standard discharges is limited to a localised area and returns to ambient following completion of the discharge; therefore, any impacts are Incidental (6).

Changes to predator / prey dynamics

The overboard discharge of sewage and macerated food waste creates a localised and temporary food source for scavenging marine fauna or seabirds, whose numbers may temporarily increase as a result, thus increasing the food source for predatory species.

However, the rapid consumption of this food waste by scavenging fauna, and physical and microbial breakdown, ensures that the impacts of food waste discharges are insignificant and temporary and that all receptors that may potentially be in the water column are not impacted. The values and sensitivities within the OA with the potential to be affected by changes in predator–prey dynamics include: • Whale Shark (foraging BIA) • Fish communities (associated with the various KEFs). As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna; and also the ancient coastline at 125 m depth contour KEF. Effects on environmental receptors along the food chain—fish, reptiles, birds, and cetaceans—are not expected beyond the immediate vicinity of the discharge in open waters (Ref. 113). Studies into the effects of nutrient enrichment from offshore sewage discharges indicate that the influence of nutrients in open marine areas is much less significant than that experienced in enclosed areas (Ref. 120) and suggest that zooplankton composition and distribution in areas associated with sewage dumping grounds are not affected. However, if any changes in phytoplankton or zooplankton abundance and composition occur, they are expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (Ref. 121; Ref. 122; Ref. 123). As described above, plankton communities are not affected by sewage discharges, but if they are, such effects would be highly localised (expected to return to background conditions within tens to a few hundred metres of the discharge location). Consequently, subsequent indirect impacts to other marine fauna are not expected, and thus are not considered further. Although fish are likely to be attracted to these discharges, any attraction and consequent change to predator–prey dynamics is expected to be limited to close to the release and thus is expected to result in localised impacts to species. Any increased predation is not expected to result in more than a limited environmental impact; therefore, the consequence is Incidental (6). Given the limited impacts expected to predatory-prey dynamics from planned vessel discharges, it is therefore expected that there would also be limited environmental impacts to the values of the Montebello Marine Park.	
ALARP decision context justification	
Offshore commercial vessel operations, and subsequent planned discharges, are commonplace and well-practiced locally, nationally, and internationally. The control measures to manage the risk associated with these planned discharges are well defined via legislative requirements that are considered standard industry practice. These are well understood and implemented by the petroleum industry and CAPL. During stakeholder consultation, no objections or claims were raised regarding vessel discharges arising from the activity. The impacts associated with these discharges are lower-order impacts in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.	
Good practice control measures and source	
Control measure	**Source**
MARPOL 73/78 sewage discharge	Marine Order 96 (Sewage) gives effect to MARPOL 73/78 Annex IV. MARPOL is the International Convention for the Prevention of Pollution from Ships is aimed at preventing both accidental pollution and pollution from routine operations.
MARPOL 73/78 food waste discharge	Marine Order 95 (Marine pollution prevention – garbage) gives effect to MARPOL 73/78 Annex V, which details the conditions in which macerated and unmacerated food waste can be discharged to the environment.
MARPOL 73/78 oily bilge discharge	Marine Order 91 (Marine pollution prevention – oil) gives effect to MARPOL 73/78 Annex I, which details the conditions by which oily bilge is authorized to be discharged to the environment.

<table>
<tr><th colspan="3">Additional control measures and cost benefit analysis</th></tr>
<tr><th>Control measure</th><th>Cost</th><th>Benefit</th></tr>
<tr><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><th colspan="3">Likelihood and risk level summary</th></tr>
<tr><td>Likelihood</td><td colspan="2">Given the nature and scale of this activity with standard control measures in place, it is considered Rare (6) that these discharges would result in any impact to the ecological function of the particular values and sensitivities present within the OA.</td></tr>
<tr><td>Risk level</td><td colspan="2">Very low (10)</td></tr>
<tr><th colspan="3">Determination of acceptability</th></tr>
<tr><td>Principles of ESD</td><td colspan="2">The potential impacts and risks associated with this aspect is limited to a short-term direct reduction in water quality in a localised area, which is not considered as having the potential to affect biological diversity and ecological integrity.
Accordingly, the consequence associated with this aspect is Incidental (6).
Therefore, no further evaluation against the Principles of ESD is required.</td></tr>
<tr><td>Relevant environmental legislation and other requirements</td><td colspan="2">Legislation and other requirements considered relevant to this aspect include:
• Marine Order 91
• Marine Order 95
• Marine Order 96
• MARPOL 73/78 Annex I, IV and V
• North-west Marine Parks Network Management Plan 2018 (Ref. 8).</td></tr>
<tr><td>Internal context</td><td colspan="2">These CAPL environmental performance standards or procedures were deemed relevant for this aspect:
• MSRE process (Ref. 43).</td></tr>
<tr><td>External context</td><td colspan="2">During stakeholder consultation, no objections or claims were raised regarding planned discharges from vessel operations arising from the activity.</td></tr>
<tr><td>Defined acceptable level</td><td colspan="2">These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.</td></tr>
<tr><th>Environmental performance 0utcomes</th><th>Performance standard / Control measure</th><th>Measurement criteria</th></tr>
<tr><td>No impacts to marine habitats, or marine fauna outside of the OA from vessel discharges during petroleum activities</td><td>MARPOL 73/78 sewage discharge
Offshore discharge of sewage from vessels will be in accordance with these MARPOL 73/78 Annex IV requirements:
• An IMO approved comminution and disinfection system to discharge (greater than 3 nm from the nearest land); or
• An IMO approved Sewage Treatment Plant at any location; or</td><td>Records show sewage is discharged in accordance with MARPOL 73/78 Annex IV, including current International Sewage Pollution Prevention (ISPP) Certificate (for marine vessels >400 T or certified to carry more than 15 persons)</td></tr>
</table>

	• Untreated sewage discharged ≥12 nm from the nearest land while the vessel is proceeding at no less than 4 knots.	
	MARPOL 73/78 food waste discharge Offshore discharge of food waste from vessels will be in accordance with these MARPOL 73/78 Annex V requirements: • macerated to no greater than 25 mm and when the marine vessel is at least 3 nm from the nearest land; or • unmacerated when the marine vessel is at least 12 nm from the nearest land.	Records show food waste is discharged in accordance with MARPOL 73/78 Annex V
	MARPOL 73/78 oily bilge water discharge Oily bilge water will be discharged to marine environment only when the concentration is <15 ppm in accordance with MARPOL 73/78, Annex I: • through an IMO approved on board oil-water separator; and • when the marine vessel is en route.	Records show oily bilge water is discharged in accordance with MARPOL 73/78 Annex I, including current International Oil Pollution Prevention (IOPP) Certificate

6.9 Unplanned release—waste

Source			
Activities identified as having the potential to result in the unplanned release of waste are: • vessel operations during seismic survey within the OA. Because waste is generated on board vessels, inappropriate management and storage has the potential to result in a release to the environment.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	–	Unplanned release of waste to the environment may result in: • marine pollution resulting in entanglement or injury of marine fauna	6
Consequence evaluation			
If hazardous or non-hazardous waste is lost overboard, the extent of exposure to the environment is limited. Marine fauna most at risk from marine pollution include marine reptiles and seabirds, through ingestion or entanglement (Ref. 63; Ref. 65). Ingestion or entanglement has the potential to limit feeding or foraging behaviours and thus can result in marine fauna injury or death. In 2003, "[i]njury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris" was listed as a key threatening process under the EPBC Act (Ref. 124). However, the national Threat Abatement Plan (Ref. 124) identifies that harmful marine debris includes "land-sourced garbage, fishing gear from recreational and commercial fishing abandoned or lost to the sea, and vessel-sourced, solid, non-biodegradable floating materials disposed of or lost at sea". This type of waste is not associated with the activities described under this EP and given the restricted exposures and the limited quantity of waste with the potential to cause marine pollution that is expected to be generated from petroleum activities, it is expected that any impacts from marine pollution would result in limited impacts to individuals. Thus, CAPL ranked this consequence as Incidental (6).			
ALARP decision context justification			
Offshore commercial vessel operations, and the subsequent management of waste, are commonplace and well-practiced activities within the industry. The control measures to manage the risk associated with an accidental release of waste are well defined via legislative requirements that are considered standard industry practice. There is a good understanding of the release pathways, and the control measures required to manage these events are well understood and implemented by the petroleum industry and CAPL. During stakeholder consultation, no objections or claims were raised regarding waste management arising from the activity. An unplanned release of waste is a lower-order risk in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.			

Good practice control measures and source	
Control measure	**Source**
Marine Order 95 (Marine pollution prevention – garbage)	MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations. Specifically, MARPOL 73/78 Annex V requires that a garbage management plan and garbage record book is in place and implemented, and describes various requirements that are to be applied when managing waste offshore. Marine Order 95 (Marine pollution prevention – garbage) gives effect to MARPOL 73/78 Annex V.

Additional control measures and cost-benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A

Likelihood and risk level summary	
Likelihood	Marine pollution arising from mismanaged waste offshore has occurred previously in the industry but is not expected to occur during these activities, given the control measures in place. As such, the likelihood of incidental consequences to values and sensitivities from an unplanned release of waste is considered Remote (5).
Risk level	Very low (10)
Determination of acceptability	
Principles of ESD	The potential risk associated with this aspect is limited to individuals and consequently is not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Incidental (6). Therefore, no additional evaluation against the Principles of ESD is required.
Relevant environmental legislation and other requirements	Legislation and other requirements considered relevant to this aspect include: • Marine Order 95 • MARPOL 73/78 • *Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (2018)* (Ref. 124) • *Conservation Advice Rhincodon typus Whale Shark* (Ref. 65) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) • *National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011–2016* (Ref. 125) • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).
Internal context	No CAPL environmental performance standards / procedures were deemed relevant for this aspect.
External context	During stakeholder consultation, no objections or claims were raised regarding waste management arising from the activity.
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.

Environmental performance outcome	Performance standard / Control measure	Measurement criteria
No uncontrolled release of waste to the environment during petroleum activities	**Marine Order 95 (Marine pollution prevention – garbage)** Marine vessels >100 T (or certified to carry >15 persons) will have a Garbage Management Plan on board, in accordance with MARPOL 73/78 Annex V	OVIS report / ABU Marine OE Inspection Checklist verifies that a Garbage Management Plan is on board marine vessels >100 T or certified to carry >15 persons
	Marine Order 95 (Marine pollution prevention – garbage) Marine vessels >400 T (or certified to carry >15 persons) will have a Garbage Record Book on board, in	Current and completed Garbage Record Book (for marine vessels >400 T or certified to carry >15 persons)

	accordance with MARPOL 73/78 Annex V	
	Marine Order 95 (Marine pollution prevention – garbage) For waste that is incinerated on board a marine vessel, the incinerator is to be IMO-approved and the waste incinerated is to be recorded in accordance with MARPOL 73/78 Annex V	Current International Air Pollution Prevention (IAPP) Certificate (for marine vessels >400 T or certified to carry >15 persons)
		Current and completed Garbage Record Book (for marine vessels >400 T or certified to carry >15 persons).

6.10 Unplanned release—loss of equipment

Source

Activities identified as having the potential to result in the unplanned loss of equipment are:

- use and handling of seismic equipment during deployment and/or retrieval
- mechanical failure/damage to equipment.

Potential impacts and risks

Impacts	C	Risks	C
N/A	–	Unplanned release of hazardous material to the environment may result in:	
		• disruption to other marine users from temporary navigation hazards	6
		• alternation of marine habitats arising from seabed disturbance	6

Consequence Evaluation

Disruption to other marine users from temporary navigation hazards

The loss of seismic equipment (seismic source and/or streamers) may pose a navigation hazard to other users that may be present within the OA at the time of equipment loss. Other vessels would be required to avoid the area until equipment can be recovered (if possible). If the equipment is not recovered, with time it may sink to the seabed. This disruption to other users is considered to be short term and localised to the immediate vicinity of the lost equipment, therefore is expected to involve individual vessel interactions. Thus, CAPL ranked this consequence as Incidental (6).

Alternation of marine habitats arising from seabed disturbance

In the event of damage or loss of seismic streamers, tail buoy, and/or acoustic source equipment, potential environmental impacts would be limited to physical disturbance to benthic communities in the OA arising from the associated equipment potentially sinking and settling on the seabed. As such, any impact to the seabed as a result of a loss of seismic equipment are likely to be a highly localised disturbance.

The particular values and sensitivities within the OA with the potential to be impacted by unplanned seabed disturbance within the OA include:

- continental slope demersal fish communities (KEF)
- ancient coastline at 125 m depth contour (KEF)
- ridgeline habitat and associated communities.

As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include the ancient coastline at 125 m depth contour KEF.

The KEFs and ridgeline habitat may have a mixture of soft and hard substrates, with hard substratum considered likely to support higher amounts of benthic fauna. However, studies of the ridgeline habitat have shown that the coverage of marine habitat is low (e.g., 2–10%) (Section 4.3.5.1).

The potential impacts to benthic habitats as a result of loss of seismic equipment are considered unlikely, limited to individual occurrences and highly localised (i.e., area of impact limited to the size of equipment) thus will not have an impact on the values of the sensitive benthic habitats within the OA. Thus, CAPL ranked this consequence as Incidental (6). Given that the potential impacts to marine habitats associated with the ancient coastline KEF are not expected to be ecologically significant, it is therefore expected that there would also be no long-term or significant impacts to the values of the Montebello Marine Park.

ALARP decision context justification

Offshore seismic and vessel operations are commonplace and well-practiced industry activities.

The control measures to manage the risk associated with loss of equipment scenarios from these activities are well defined via good practice measures that are considered standard industry practice in seismic data acquisition operations. These control measures are well understood and implemented by the petroleum industry and CAPL

During stakeholder consultation, no objections or claims were raised regarding waste management arising from the activity.

An unplanned release of waste is a lower-order risk in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.

Good practice control measures and source

Control measure	Source
Operating procedures	Operating procedures for seismic equipment will be implemented to ensure: • streamers are fitted with appropriate equipment to allow for safe deployment, operation and recovery (if required), including: – steerable fins – streamer recovery devices (SRDs) – surface marker buoys – real-time monitoring equipment – tail buoys • equipment is routinely checked and maintained to ensure integrity • streamer deployment will not occur in water closer than 12 nm to shore, or in waters <50 m deep • seismic equipment will only be deployed in suitable sea state in accordance with seismic operators matrix of permitted operations.
Stakeholder engagement	In the event of a loss of equipment that results in a navigational hazard, other marine users within the vicinity will be notified via VHF.
Marine incident report	Reporting marine incidents is an important part of ensuring the safety of people and vessels. In the event of a loss of equipment meeting the requirements of a marine incident, an incident alert report must be issued to AMSA within 4 hours of the incident.

Additional control measures and cost benefit analysis

Control measure	Benefit	Cost
N/A	N/A	N/A

Likelihood and risk level summary

Likelihood	Loss of equipment has occurred previously in the industry but is not considered likely to occur during these activities, given the control measures in place. As such, the likelihood of incidental consequences to values and sensitivities from an unplanned loss of equipment is considered Unlikely (4).
Risk level	Very low (9)

Determination of acceptability

Principles of ESD	The potential risk associated with this aspect is highly localised and limited to individual occurrences and is therefore not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Incidental (6). Therefore, no additional evaluation against the Principles of ESD is required.
Relevant environmental legislation and other requirements	Legislation and other requirements considered relevant to this aspect include: • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).
Internal context	No CAPL environmental performance standards or procedures were deemed relevant for this aspect.
External context	During stakeholder consultation, no objections or claims were raised regarding loss of equipment arising from the activity.

<table>
<tr><td>Defined acceptable level</td><td colspan="2">These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan</td></tr>
<tr><th>Environmental performance outcome</th><th>Performance standard / Control measure</th><th>Measurement criteria</th></tr>
<tr><td rowspan="7">No loss of seismic equipment within the OA during petroleum activities</td><td>Operating procedures
Streamers are fitted with SRDs prior to deployment to bring the equipment to the surface in the event of loss.</td><td>Records confirm that all streamers have been fitted with SRD.</td></tr>
<tr><td>Operating procedures
Equipment is routinely checked and maintained to ensure integrity</td><td>Records show that all equipment is routinely checked</td></tr>
<tr><td rowspan="3">Operating procedures
Deployment, operation, and retrieval of streamers as per operational procedures, including:
• streamer deployment will not occur in water <12 nm to shore, or in waters <50 m deep
• streamers will only be deployed in suitable sea state in accordance with matrix of permitted operations (MOPO).</td><td>Records show that seismic vessel holds procedures for streamer deployment, operations, and retrieval</td></tr>
<tr><td>Records show that streamers were not deployed <12 nm from shore and water depths <50m</td></tr>
<tr><td>Daily reports demonstrate that streamers were deployed in accordance with seismic vessel's MOPO</td></tr>
<tr><td>Stakeholder engagement
In the event of a loss of equipment that results in a navigational hazard, other marine users within the vicinity will be notified via VHF</td><td>Vessel records confirms notification to other marine users</td></tr>
<tr><td>Marine incident report
In the event of a loss of equipment meeting the requirements of a marine incident, an incident alert report must be issued to AMSA within 4 hours of the incident</td><td>Records confirm incident alert issued to AMSA within 4 hours of a marine incident occurring</td></tr>
</table>

6.11 Unplanned release—loss of containment

Source

The operation of vessels includes handling, using, and transferring hazardous materials, and has the potential to result in a loss of containment (LOC) event. Based on the activities described in this EP, the following potential LOC scenarios were identified:

- using, handling, and transferring hazardous materials and chemicals on board (<1 m^3)[1]
- transferring hazardous materials between vessels (50 m^3)[2].

[1] A range of hydrocarbons and other hazardous chemicals / materials are likely to be present onboard vessels; however, the maximum credible volume associated with a single-point failure was estimated to be ~1 m^3 based on the loss of an entire intermediate bulk container due to rupture while handling.

[2] AMSA (Ref. 126) suggests the maximum credible spill volume from a refuelling incident with continuous supervision is approximately the transfer rate × 15 minutes. Assuming failure of dry-break couplings and an assumed 200 m^3/h transfer rate (based on previous operations), this equates to an instantaneous spill volume of ~50 m^3.

Potential impacts and risks

Impacts	C	Risks	C
N/A	–	Unplanned release of hazardous material to the environment may result in: • indirect impacts to fauna arising from chemical toxicity	5

Consequence Evaluation

Indirect impacts to fauna arising from chemical toxicity

Upon release, a loss of 50 m^3 of a hazardous material (such as MDO) would be expected to result in a localised and short-term change to water quality in surface waters. Given the surface release, and the known weathering and fate behaviour of MDO (Section 6.12.2.1), the small 50 m^3 volume is expected to form a film on the surface and rapidly evaporate and disperse following release. The environmental impacts associated with a surface release of 50 m^3 of MDO are much less than those associated with a loss of MDO from a vessel collision (Section 6.12), and thus are not evaluated in detail here.

The values and sensitivities within the OA with the potential to be exposed to decreased water quality within surface waters from an unplanned LOC include:

- Pygmy Blue Whale (migration and distribution BIAs)
- Flatback Turtle (internesting buffer BIA, internesting critical habitat)
- Whale Shark (foraging BIA).
- continental slope demersal fish communities (KEF)
- commercial fisheries.

As identified in Section 4.5.1, the OA overlaps with the Montebello Marine Park. Natural values of this AMP include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna; and also, the ancient coastline at 125 m depth contour KEF. Social and economic values of this AMP include commercial fishing.

Based on the nature of these unplanned releases, which are non-continuous and expected to occur in a location where no specific sedentary behaviours for values and sensitivities have been identified, the extent and severity of any potential impact is expected to be limited.

Given the nature of unplanned releases covered under this EP and the transient nature of identified values and sensitivities, fauna would need to pass directly through the plume almost immediately upon release to be impacted.

Any potential impact from such an event is expected to be short term and limited to a small number of individuals, thus the consequence level was determined as Minor (5). Given the limited spatial and temporal exposures to marine fauna from a minor LOC event, it is therefore expected that there would also be limited environmental impacts to the values of the Montebello Marine Park.

ALARP decision context justification		
Offshore commercial vessel operations are commonplace and well-practiced industry activities. The control measures to manage the risk associated with LOC scenarios from these activities are well defined via legislative requirements that are considered standard industry practice. There is a good understanding of potential spill sources, and the control measures required to managed these are well understood and implemented by the petroleum industry and CAPL. Modelling was undertaken for several scenarios associated with this aspect to support the environmental risk evaluation. Modelling has removed some of the uncertainty associated with this aspect and supports the evaluation that due to the distance offshore and distance to sensitive receptors, these risks are lower-order risks in accordance with Table 5-3. As such, CAPL applied ALARP Decision Context A for this aspect.		
Good practice control measures and source		
Control measure	**Source**	
MSRE process	The MSRE process (Ref. 43) ensures that various legislative requirements and CAPL standards are met. Specifically, pre-mobilisation inspections may include: • visual checks of accessible equipment and hydraulic hoses for defects • confirmation that dry-break couplings or similar automated stop devices are available for use on marine vessels that are refuelled at sea • secondary containment is available for hydrocarbons and chemicals stored on the deck of marine vessels • bunkering procedures are available.	
Ship Oil Pollution Emergency Plan (SOPEP)/ Shipboard Marine Pollution Emergency Plan	MARPOL 73/78 Annex I and Marine Order 91 (Marine pollution prevention – oil) requires that each vessel has an approved SOPEP in place. To prepare for a spill event, the SOPEP details: • response equipment available to control a spill event • review cycle to ensure that the SOPEP is kept up to date • testing requirements, including the frequency and nature of these tests. In the event of a spill, the SOPEP details: • reporting requirements and a list of authorities to be contacted • activities to be undertaken to control the discharge of oil • procedures for coordinating with local officials.	
Additional control measures and cost benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	The likelihood that a LOC event results in a Minor (5) consequence was determined to be Remote (5). With the control measures in place, it was considered very unlikely that a large LOC event associated with this activity would occur, and even more unlikely that such an event would impact any of the identified values and sensitivities, which are known to be transient and unlikely to be present at the exact location of the LOC.	
Risk level	Very low (9)	
Determination of acceptability		
Principles of ESD	The potential risk associated with this aspect would be short term, apply to some individuals, and consequently is not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Minor (5). Therefore, no additional evaluation against the Principles of ESD is required.	

Relevant environmental legislation and other requirements	Legislation and other requirements considered relevant for this aspect include: • Marine Order 91, Marine pollution prevention – oil • MARPOL 73/78 • *North-west Marine Parks Network Management Plan 2018* (Ref. 8).	
Internal context	These CAPL environmental performance standards or procedures were deemed relevant for this aspect: • MSRE process (Ref. 43).	
External context	During stakeholder consultation, no objections or claims were raised regarding LOC management arising from the activity.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
No leak or spill of hydrocarbons / hazardous materials to the environment during petroleum activities	**MSRE process** Prior to commencement of activities, the following will be undertaken during a pre-mobilisation vessel inspection, as per the MSRE process: • visual checks of accessible equipment and hydraulic hoses for defects • confirmation that dry-break couplings or similar automated stop devices are available for use on marine vessels that are refuelled at sea • confirmation that secondary containment is available for hydrocarbons and chemicals stored on the deck of marine vessels.	OVIS report / ABU Marine OE Inspection Checklist confirms that equipment and hydraulic hoses are visually free of defects, dry-break couplings or similar are available for use, and, and secondary containment is available on the deck of the marine vessel
	MSRE process Refuelling is undertaken in accordance with CAPL-approved refuelling / bunkering procedures, which include the appropriate weather / sea / visibility conditions, as determined by the Vessel Master.	Records confirm that refuelling is undertaken in accordance with CAPL-approved refuelling / bunkering procedure
Reduce the risk of impacts to the environment from the unplanned release of hydrocarbons / hazardous materials during petroleum activities	**SOPEP** Marine vessels >400 T will carry on board a Shipboard Oil Pollution Emergency Plan (SOPEP) in accordance with MARPOL 73/78 Annex I – Prevention of Oil Pollution	OVIS report / ABU Marine OE Inspection Checklist confirms an approved SOPEP is on board marine vessels >400 T
		Inspection records (or similar) show drills conducted in accordance with SOPEP
		Inspection records (or similar) show spill kits available in accordance with SOPEP

	SOPEP In the event of a vessel-based spill event, emergency response activities will be implemented in accordance with the vessel SOPEP (or equivalent)	Records confirm that emergency response activities were implemented in accordance with the vessel SOPEP in the event of a vessel-based spill.

6.12 Unplanned release—vessel collision event

6.12.1 Credible scenario

A vessel collision event within the OA is considered a credible (but unlikely) unplanned event. A major marine spill because of vessel collision is only likely to occur under exceptional circumstances (e.g., loss of DP, navigational error, inclement weather conditions). Given the location, water depths, and lack of submerged features within the OA, grounding is not considered credible, and is not considered further.

Based upon the types of vessels typically used for seismic surveys, size of largest fuel tanks and fuel type to be utilised for the activities in this EP, CAPL was able to identify the typical credible worst-case scenario (as per AMSA guidelines; Ref. 126) as being a surface release of ~1,000 m^3 of MDO.

6.12.1.1 Spill Modelling

6.12.2 Spill modelling

CAPL commissioned RPS to conduct spill modelling to inform the risk assessment associated with a vessel collision event (Ref. 127). While a vessel collision event has the potential to occur anywhere within the OA, the spill modelling was completed for a release location that represented the point closest to the nearest shoreline at the Montebello Islands (Table 6-8).

A three-dimensional oil spill model (SIMAP) was used to simulate the drift, spread, weathering and fate of the spilled oil (Ref. 127). Modelling was conducted using a stochastic approach, where multiple simulations (using the same spill parameters) were conducted, but under varying meteorological and oceanographic conditions.

Table 6-8 summarises the model settings; Table 6-9 summarises the hydrocarbon properties for MDO; and Table 6-10 and Table 6-11 describe the modelled environmental exposure and impact thresholds respectively.

Table 6-8: Vessel collision spill scenario model settings

Parameter	Details
Release location	Southern boundary of the OA, at closest point to the Montebello Islands (and within the Commonwealth Montebello Marine Park)
Latitude	20°09'22" S
Longitude	115°24'11" E
Water depth	~50–60 m
Oil type	MDO
Simulation spill type	Surface
Simulation spill volume	1,063 m^3 (based on the largest single tank)
Simulation spill duration	24 hours
Total simulation duration	50 days
Number of randomly selected spill simulation start times	100 per season (300 total)
Seasons modelled	Summer (December to February) Transitional (March, October, November) Winter (April to September)

Table 6-9: Physical properties and boiling point ranges for MDO

Characteristic	Value			
Density	829.1 kg/m3 (at 25 °C)			
Dynamic viscosity	4 cP			
Pour point	-14 °C			
API gravity	37.6 API			
Classification	Group II, light persistent oil			
Boiling point	Volatile <180 °C	Semi-volatile 180–265 °C	Low volatility 265–380 °C	Residual >380 °C
	6.0%	34.6%	54.4%	5.0%

Table 6-10: Hydrocarbon environmental exposure thresholds

Environmental exposure threshold^	Justification
Surface ≥1 g/m² (low)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the surface exposure threshold at ≥1 g/m². This threshold is used to establish a planning area for scientific monitoring (Ref. 128).
In-water (dissolved) ≥10 ppb (low)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the in-water (dissolved) exposure threshold at ≥10 ppb. This threshold is used to establish a planning area for scientific monitoring (specifically, for water quality) (Ref. 128).
In-water (entrained) ≥10 ppb (low)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the in-water (entrained) exposure threshold at ≥10 ppb. This threshold is used to establish a planning area for scientific monitoring (specifically, for water quality) (Ref. 128).
Shoreline ≥10 g/m² (low)	CAPL has set the shoreline exposure threshold at ≥10 g/m². This threshold is consistent with the low exposure value for shoreline oil within NOPSEMA's oil spill modelling bulletin (Ref. 128).

^ Environmental exposure thresholds have been used to define the EEA, and the presence of environmental values and sensitivities within this area have been identified in Section 4. These exposure thresholds and the spatial extent of the EEA is not used as part of the environmental impact and risk assessment presented below.

Table 6-11: Hydrocarbon environmental impact thresholds

Environmental impact threshold	Justification
Surface ≥1 g/m² (low)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the surface impact threshold for socio-economic effects at ≥1 g/m². This threshold is equivalent to ~1,000 L/km² or a layer thickness of ~1 µm. At this concentration, oil on the water surface is expected to be visible. The Bonn Agreement Oil Appearance Code (Ref. 129) describes a 0.3–5.0 µm thick oil layer as having a rainbow-coloured appearance. Due to this visibility, there is the potential to impact nature-based activities (such as tourism) via a reduction in aesthetics.
Surface ≥10 g/m² (moderate)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the surface impact threshold for ecological effects at ≥10 g/m². This threshold is equivalent to ~10,000 L/km² or a layer thickness of ~10 µm. The Bonn Agreement Oil Appearance Code (Ref. 129) describes a 5–50 µm thick oil layer as having a metallic appearance. This threshold is considered by NOPSEMA to approximate the lower limit of harmful effects to birds and marine mammals (Ref. 128). This

Environmental impact threshold	Justification
	threshold is consistent with observations ranging from physical oiling to toxicity effects for marine fauna within literature, including French et al. (Ref. 130), French-McCay (Ref. 131), Engelhardt (Ref. 132), Clark (Ref. 133), Geraci and St. Aubin (Ref. 134) and Jenssen (Ref. 135).
In-water (dissolved) ≥50 ppb (moderate)	Laboratory studies have shown that dissolved oil exert most of the toxic effects of oil on aquatic biota (e.g., Carls et al. [Ref. 136], Nordtug et al. [Ref. 137], Redman [Ref. 138]). Being soluble, the dissolved oil can be taken up by organisms directly from the water column by absorption through external surfaces and gills, as well as through the digestive tract. In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the in-water (dissolved) impact threshold for sublethal ecological effects at ≥50 ppb. This threshold is considered by NOPSEMA to approximate potential toxic effects, particularly sublethal effects to sensitive species (Ref. 128). This threshold is based on an instantaneous concentration, and therefore only requires the dissolved oil to be at this concentration for one-hour (based on minimum model time-step) to trigger this threshold.
In-water (dissolved) ≥4,800 ppb.hrs (moderate)	Toxicity is the relative ability of a substance to cause adverse effects; and this relative ability is dependent on factors including both dose and duration. As such, CAPL has set the in-water (dissolved) impact threshold for lethal ecological effects at ≥4,800 ppb.hrs. This threshold is based on the instantaneous concentration (50 ppb) recommended by NOPSEMA but also applies a duration component of 96 hours. Therefore, dissolved oil needs to be at this concentration consistently for 96 hours to trigger this threshold. French-McCay (Ref. 139) reviewed toxicity data for marine biota exposed to dissolved oil and found that 95% of species and life stages exhibited 50% population mortality (LC50) for total PAH concentrations between 6–400 ppb (with an average of 50 ppb) after 96 hours exposure.
In-water (entrained) ≥100 ppb (high)	Entrained oil are insoluble droplets suspended in the water column, and as such exposure pathways are direct contact with external tissue or direct oil consumption. In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the in-water (entrained) impact threshold for sublethal ecological effects at ≥100 ppb. This threshold is considered by NOPSEMA as appropriate for informing risk evaluation (Ref. 128). This threshold is based on an instantaneous concentration, and therefore only requires the entrained oil to be at this concentration for one-hour (based on minimum model time-step) to trigger this threshold. French-McCay (Ref. 140) identified that if total hydrocarbons in entrained oil droplets was to be evaluated as a risk, 100 ppb would be an extremely conservative sublethal threshold.
In-water (entrained) ≥9,600 ppb.hrs (high)	CAPL has set the in-water (entrained) impact threshold for lethal ecological effects at ≥9,600 ppb.hrs. This threshold is based on the instantaneous concentration (100 ppb) recommended by NOPSEMA but also applies a duration component of 96 hours. Therefore, entrained oil needs to be at this concentration consistently for 96 hours to trigger this threshold. It is however noted that entrained oil, especially when in weathered state, is typically not considered toxic.
Shoreline ≥10 g/m^2 (low)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the shoreline impact threshold for socio-economic effects at ≥10 g/m^2. This threshold is equivalent to ~10 mL/m^2 or ~2 teaspoons/m^2.

Environmental impact threshold	Justification
	At this concentration, oil on the shoreline is expected to be visible. Due to this visibility, there is the potential to impact nature-based activities (such as tourism or recreational use) via a reduction in aesthetics.
Shoreline ≥100 g/m^2 (moderate)	In accordance with NOPSEMA's oil spill modelling bulletin (Ref. 128), CAPL has set the shoreline impact threshold for ecological effects at ≥100 g/m^2. This threshold is equivalent to ~100 mL/m^2 or 20 teaspoons/m^2. French et al. (Ref. 130) and French-McCay (Ref. 131) define shoreline oil accumulation at ≥100 g/m^2 as potentially harmful to wildlife (including invertebrates, birds, furbearing aquatic mammals and marine reptiles), based on studies for sub-lethal and lethal impacts. Impacts on vegetated habitats (such as saltmarsh and mangroves) have been observed at higher concentrations of shoreline oil. Observations by Lin and Mendelssohn (Ref. 141) demonstrated that loadings of >1,000 g/m^2 of oil during the growing season would be required to impact marsh plants significantly. Similar thresholds have been found in studies assessing oil impacts on mangroves (e.g., Grant et al. [Ref. 142], Suprayogi and Murray [Ref. 143]).

^ Environmental impact thresholds have been used to define the EMBA, and the presence of environmental values and sensitivities within this area have been identified in Section 4. These impact thresholds and the spatial extent of the EMBA is used as part of the environmental impact and risk assessment presented below.

6.12.2.1 Weathering and fate

MDO is a light-persistent fuel oil used in the maritime industry. It has a density of 829.1 kg/m^3, an API of 37.6, and a low pour point (−14 °C) (Table 6-9). The low viscosity (4 cP) indicates that this oil will spread quickly when released and will form a thin film on the sea surface, increasing the evaporation rate.

Generally, about 6.0% of the MDO mass should evaporate within the first 12 hours (boiling point <180 °C); a further 34.6% should evaporate within the first 24 hours (boiling point 180°C–265 °C); and an additional 54.4% should evaporate over several days (boiling point 265°C–380 °C). Approximately 5% (by mass) of MDO will not evaporate at atmospheric temperatures. These compounds will persist in the environment.

While MDO will typically remain on the water surface (where it is subject to evaporation), it is noted that some of the heavy components have a strong tendency to physically entrain into the upper water column in the presence of moderate winds (i.e. >12 knots) and breaking waves but can re-float to the surface if these energies abate (Ref. 127).

6.12.2.2 Modelling outputs

Stochastic modelling outputs from RPS (Ref. 127) are summarised in Table 6-12 having regard to the particular values and sensitivities identified in Section 4.

For the 1,063 m^3 MDO release at the southern boundary of the OA, at the closest point to Montebello Islands:

- The maximum distance from the release location to the ≥1 g/m^2 visible impact threshold was ~64 km south-southwest (transitional), and ~38 km south-southwest (summer) for the ≥10 g/m^2 impact threshold.
- The probability of contact to any shoreline at ≥10 g/m^2 was 7% in summer, 1% in winter, and no contact predicted in transitional months. The minimum time before shoreline contact was ~3 days and the maximum volume of oil ashore

was 24.4 m^3. The maximum length of shoreline exposed at ≥10 g/m^2 was ~27 km, and at ≥100 g/m^2 was ~10 km.

- No dissolved oil at ≥50 ppb impact thresholds was predicted to occur during any season.
- Entrained oil at ≥100 ppb impact thresholds was predicted to occur. However, entrained oil was predicted to remain in the surface layers, with no exposure at depths >10 m below the surface predicted to occur during any season.

Table 6-12: Vessel collision spill modelling EMBA receptor exposure summary

Sensitivity	Name	Surface^		In-water (dissolved)^	In-water (entrained)^	Shoreline^	
		≥1 g/m²	≥10 g/m²	≥50 ppb	≥100 ppb	≥10 g/m²	≥100 g/m²
		(probability of exposure, minimum time to exposure)		(probability of exposure)	(probability of exposure)	(probability of exposure, minimum time to exposure, mean length of shoreline)	
AMP	Gascoyne	—	—	—	1–4%	—	—
	Montebello	100%, ~1 hour	100%, ~1 hour	—	89–97%	—	—
	Ningaloo	—	—	—	0–1%	—	—
KEF	Ancient coastline at 125 m depth contour	0–6%, ~0.75 days	—	—	19–30%	—	—
	Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	—	—	—	1–4%	—	—
	Commonwealth waters adjacent to Ningaloo Reef	—	—	—	0–1%	—	—
	Continental slope demersal fish communities	0–1%, ~2.7 days	—	—	9–27%	—	—
	Exmouth Plateau	—	—	—	0–2%	—	—
	Glomar Shoals	—	—	—	0–2%	—	—
World Heritage Properties / National Heritage Places	The Ningaloo Coast *(inferred from Cape Range IBRA, and Exmouth shoreline)*	—	—	—	0–2%	0–2%, ~14.4 days, ~3 km	—
Commonwealth Heritage Properties	Ningaloo Marine Area – Commonwealth Waters *(inferred from Ningaloo IMCRA)*	—	—	—	1–2%	—	—

^ Ranges in values shown are due to the different results between seasons.

6.12.3 Risk assessment

Source			
Activities identified as having the potential to result in a vessel collision event are: • vessels operations within the OA. A vessel collision event may occur as a result of a loss of DP, navigational error or floundering due to weather.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	–	The potential environmental impacts associated with hydrocarbon exposures from a vessel collision event are:	
		• marine pollution resulting in sublethal or lethal effects to marine fauna	5
		• smothering of subtidal and intertidal habitats	5
		• indirect impacts to commercial fisheries	5
		• reduction in amenity resulting in impacts to tourism and recreation.	5
		• changes to values and sensitivities of Australian Marine Parks	5

Consequence evaluation

Marine pollution resulting in sublethal or lethal effects to marine fauna

Marine mammals

Marine mammals may be exposed to hydrocarbons from an oil spill at the water surface or within the water column. Marine mammals can be exposed to oil externally (e.g., swimming through surface slick) or internally (e.g., swallowing the oil, consuming oil-affected prey, or inhaling of volatile oil related compounds) (Ref. 144; Ref. 145).

Direct contact with hydrocarbons may result in skin and eye irritation, burns to mucous membranes of eyes and mouth, and increased susceptibility to infection (Ref. 146). However, direct contact with surface oil is considered to have little deleterious effect on whales, possibly due to the skin's effectiveness as a barrier. Furthermore, effect of oil on cetacean skin is probably minor and temporary (Ref. 146). French-McCay (Ref. 147) identifies that a ≥10 g/m^2 oil thickness threshold has the potential to impart a lethal dose to the 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.

The physical impacts from ingested hydrocarbons with subsequent lethal or sublethal impacts are applicable; however, the susceptibility of cetaceans varies with feeding habits. Baleen whales are not particularly susceptible to ingestion of oil in the water column as they feed by skimming the surface (i.e., they are more susceptible to surface slicks). Toothed whales and dolphins may be susceptible to ingestion of dissolved and entrained oil as they gulp feed at depth. As highly mobile species, in general it is very unlikely that these animals will be constantly exposed to concentrations of hydrocarbons in the water column for continuous durations (e.g., >48–96 hours) that would lead to chronic effects.

Studies have shown little impact on Bottlenose Dolphins after hydraulic and mineral oil immersion and ingestion, although there was evidence of temporary skin damage in dolphins and a Sperm Whale from contact with various oil products including crude oil (Ref. 146; Ref. 148).

Marine mammals are vulnerable if they inhale volatiles when they surface within a hydrocarbon slick. For the short period that they persist, vapours from the spill are a significant risk to mammal health, with the potential to damage mucous membranes of the airways and the eyes, which will reduce the health and potential survivability of an animal. Inhaled volatile hydrocarbons are transferred rapidly to the bloodstream and may also accumulate in tissues (Ref. 146).

Stochastic modelling was used to identify BIAs for marine mammals that may be exposed to hydrocarbon concentrations greater than impact thresholds within the EMBA. These were:

- Humpback Whale (migration, resting)
- Pygmy Blue Whale (distribution, migration, foraging)
- Dugongs (breeding, calving, foraging, nursing).

As these species are considered most sensitive to surface exposures, deterministic analyses were utilised to understand the potential extent and duration of exposure.

The deterministic model for the worst-case trajectory for the Montebello Islands indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <5 days following the spill event, with a maximum area of coverage of ~99 km^2 occurring 36 hours after the spill commenced. This deterministic scenario is considered most relevant for offshore waters, and subsequent impacts to offshore BIA's in those regions. Using the Pygmy Blue Whale migration BIA as an example, modelling indicates that the extent of surface exposures was predicted to be limited to <1% of the entire BIA.

The deterministic model for the worst-case trajectory for Ningaloo World Heritage area indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <2 days following the spill event, with a maximum area of coverage of ~32 km^2 occurring 18 hours after the spill commenced. This deterministic scenario is considered most relevant for nearshore waters around Ningaloo and Exmouth Gulf, and subsequent impacts to nearshore BIA's in those regions. Using the Dugong breeding BIA as an example, modelling indicates that the extent of surface exposures was predicted to be limited to <1% of the entire BIA. As the extent and duration of exposure to nearshore environments is expected to be limited the potential for environmental impacts would also be limited. However, it is acknowledged that behaviours in nearshore waters are likely to result in increased sensitivity to hydrocarbon exposures as species are less likely to be transient.

Based on an assessment of the predicted magnitude and duration of surface oil, and entrained oil, it is expected that only a small proportion of any marine mammal population would be exposed above the defined impact exposure thresholds. Therefore, the potential impacts of oil to cause sublethal or lethal effects was ranked as Incidental (6) and Minor (5), respectively.

Reptiles

Marine reptiles may be exposed to hydrocarbons from an oil spill at the water surface or on the shoreline. Marine reptiles can be exposed to oil externally (e.g., swimming through surface slick) or internally (e.g., swallowing the oil, consuming oil-affected prey, or inhaling of volatile oil related compounds) (Ref. 149).

Marine turtles are vulnerable to the effects of oil at all life stages: eggs, hatchlings, juveniles, and adults. Several aspects of turtle biology and behaviour place them at risk, including a lack of avoidance behaviour, indiscriminate feeding in convergence zones, and large pre-dive inhalations (Ref. 150). Oil effects on turtles can include impacts to the skin, blood, digestive, and immune systems, and increased mortality due to oiling.

Shoreline hydrocarbons can impact turtles coming ashore at nesting beaches. Eggs may also be exposed during incubation, potentially resulting in increased egg mortality and detrimental effects on hatchlings. Hatchlings may be particularly vulnerable to toxicity and smothering as they emerge from the nests and make their way over the intertidal area to the water (Ref. 149).

BIAs for the Flatback Turtle, Loggerhead Turtle, Green Turtle, and Hawksbill Turtle may be exposed to hydrocarbon concentrations greater than the impact thresholds. The behaviours associated with these BIAs include aggregation, basking, foraging, internesting, mating, and nesting.

The Montebello Islands was the only area predicted to be exposed to shoreline hydrocarbons accumulation of ≥100 g/m^2. These islands are identified as habitat critical to the survival of Flatback, Green and Hawksbill turtles (Table 4-4). As such nesting adult turtles and hatchlings may be exposed as they traverse the intertidal area, resulting in potential smothering and acute impacts to some hatchlings during that nesting season.

The deterministic model for the worst-case trajectory for the Montebello Islands indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <5 days following the spill event, with a maximum area of coverage of ~99 km^2 occurring 36 hours after the spill commenced. This deterministic run also predicted the largest volume of oil ashore as ~24 m^3, and the maximum length of shoreline exposed to ≥100 g/m^2 was ~10 km occurring ~4 days after the spill commenced. Using the Flatback Turtle internesting and nesting BIAs around Montebello Islands as an example, modelling indicates that the extent of surface and shoreline exposures was predicted to be limited to <1% of the entire BIA, or <1% of the coastline.

This information indicates that if a vessel spill event occurred during the nesting season, it is unlikely to impact entire local nesting populations.

Based on an assessment of the predicted magnitude and duration of surface and shoreline oil, it is expected that only a small proportion of any marine reptile population would be exposed above the defined impact thresholds. Therefore, the potential impacts of oil to cause sublethal or lethal effects was ranked as Incidental (6) and Minor (5), respectively.

Fishes, including sharks and rays

Fish, including sharks and rays, may be exposed to hydrocarbons from an oil spill within the water column. Most fish do not break the sea surface, and therefore the risk from surface oil is not relevant; however, some shark species (including Whale Sharks) feed in surface waters, so there is also the potential for surface hydrocarbons to be ingested.

Potential effects include damage to the liver and lining of the stomach and intestine, and toxic effects on embryos (Ref. 151). Fish are most vulnerable to oil during embryonic, larval and juvenile life stages. However, very few studies have demonstrated increased mortality of fish as a result of oil spills (Ref. 152; Ref. 153; Ref. 154).

Demersal fish are not expected to be impacted given the presence of entrained oil ≥100 ppb is predicted in the surface layers (<10 m water depth) only.

Pelagic free-swimming fish and sharks are unlikely to suffer long-term damage from oil spill exposure because dissolved/entrained hydrocarbons are typically insufficient to cause harm (Ref. 155). Pelagic species are also generally highly mobile and as such are not likely to suffer extended exposure (e.g., >48–96 hours) at concentrations that would lead to chronic effects due to their patterns of movement. Near the sea surface, fish can detect and avoid contact with surface slicks meaning fish mortalities rarely occur in the event of a hydrocarbon spill in open waters (Ref. 156). Fish that have been exposed to dissolved hydrocarbons can eliminate the toxicants once placed in clean water; hence, individuals exposed to a spill are likely to recover (Ref. 157). Marine fauna with gill-based respiratory systems, including Whale Sharks, are expected to have higher sensitivity to exposures of entrained oil.

BIAs for fishes including sharks and rays that may be exposed to hydrocarbon concentrations greater than impact thresholds include:

- Whale Shark (foraging).

As these species are considered most sensitive to surface exposures, deterministic analyses were utilised to understand the potential extent and duration of exposure.

The deterministic model for the worst-case trajectory for Montebello Islands indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <5 days following the spill event, with a maximum area of coverage of ~99 km^2 occurring 36 hours after the spill commenced. This deterministic scenario is considered most relevant for offshore waters, and subsequent impacts to offshore BIA's in those regions. Using the Whale Shark foraging BIA, modelling indicates that the extent of surface exposures was predicted to be limited to <1% of the entire BIA.

Based on an assessment of the predicted magnitude and duration of surface oil, and both instantaneous and time-integrated entrained oil, it is expected that only a small proportion of any fish population would be exposed above the defined impact thresholds. Therefore, the potential impacts of oil to cause sublethal or lethal effects was ranked as Incidental (6) and Minor (5), respectively.

Seabirds and shorebirds

Birds that rest at the water's surface (e.g., shearwaters) or surface-plunging birds (e.g., terns, boobies) are particularly vulnerable to surface hydrocarbons (Ref. 158; Ref. 150). Damage to external tissues, including skin and eyes, can occur, along with internal tissue irritation in lungs and stomachs (Ref. 159). Acute and chronic toxic effects may result where the product is ingested as the bird attempts to preen its feathers (Ref. 159).

Breeding BIAs for the Fairy Tern, Lesser Crested Tern, Roseate Tern, and Wedge-tailed Shearwater may be exposed to hydrocarbon concentrations greater than impact thresholds.

The Montebello Islands was the only area predicted to be exposed to shoreline hydrocarbons accumulation of ≥100 g/m^2.

The deterministic model for the worst-case trajectory for the Montebello Islands indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <5 days following the spill event, with a maximum area of coverage of ~99 km^2 occurring 36 hours after the spill commenced. This deterministic run also predicted the largest volume of oil ashore as ~24 m^3, and the maximum length of shoreline exposed to ≥100 g/m^2 was ~10 km occurring ~4 days after the spill commenced. Using the Wedge-tailed Shearwater breeding BIA around the Montebello Islands as an example, modelling indicates that the extent of surface and shoreline exposures was predicted to be limited to <1% of the entire BIA, or <1% of the coastline. This information indicates that if a vessel spill event occurred during breeding season, it is unlikely to impact entire local nesting populations.

Based on an assessment of the predicted magnitude and duration of surface and shoreline oil, it is expected that only a small proportion of any seabird population would be exposed above the defined impact thresholds. Therefore, the potential impacts of oil to cause sublethal or lethal effects was ranked as Incidental (6) and Minor (5), respectively.

Smothering of subtidal and intertidal habitats

Coral, seagrass and macroalgae

The effects of physical contact on subtidal habitats are similar, and studies have shown that it can cause sublethal stress and reduced growth rates in seagrass (Ref. 160; Ref. 161), act as a barrier to diffusion of CO_2 across cell walls in macroalgae (Ref. 162), and a decline in metabolic rate and partial mortality in corals (Ref. 163; Ref. 164) and impair respiration and photosynthesis by symbiotic zooxanthellae (Ref. 165; Ref. 166). The recovery of benthic habitats can be slow, with studies following the Deepwater Horizon incident showing long-term non-acute effects of the spill on coral colonies seven years after the event (Ref. 167).

Stochastic modelling predicted coral reefs associated with the following key values or sensitivities within the EMBA (Table 4-10) have the potential to be exposed to hydrocarbon concentrations above impact thresholds:

- Ningaloo Coast (World Heritage Property, National Heritage Place).

Coral, seagrass, and macroalgae habitats are also known to occur around the Barrow and Montebello islands, and to a smaller extent around some of the other Pilbara inshore islands.

Stochastic modelling showed that in-water (entrained) hydrocarbons were predicted to remain within the surface layers only. Therefore, exposure to coral reefs in deeper waters are not predicted to occur. However, smothering of benthic habitat communities may occur if a surface slick occurs in the intertidal area.

The deterministic model for the worst-case trajectory for the Montebello Islands indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <5 days following the spill event, with a maximum area of coverage of ~99 km^2 occurring 36 hours after the spill commenced. This deterministic run also predicted the largest volume of oil ashore as ~24 m^3, and the maximum length of shoreline exposed to ≥100 g/m^2 was ~10 km occurring ~4 days after the spill commenced.

The deterministic model for the worst-case trajectory for the Ningaloo World Heritage area indicates that surface hydrocarbons concentrations ≥1 g/m^2 (i.e., visible threshold) are present for <2 days following the spill event, with a maximum area of coverage of ~32 km^2 occurring 18 hours after the spill commenced.

These deterministic scenarios are considered most relevant for nearshore waters and subsequent impacts to nearshore corals. Therefore, as the extent and duration of exposure to nearshore environments is expected to be limited the potential for environmental impacts would also be limited.

Based on an assessment of the predicted magnitude and duration of surface oil, and both instantaneous and time-integrated entrained oil, it is expected that only a small proportion of any coral habitat would be exposed above the defined impact thresholds. Therefore, the potential impacts of oil to cause smothering was ranked as Minor (5).

Mangroves and intertidal mudflats

Shoreline hydrocarbons can have smothering and toxic effects on mangroves and intertidal mudflats. Acute and chronic impacts to the health of mangrove communities can occur via pneumatophore smothering and exposure to the toxic volatile fraction of the hydrocarbons (Ref. 168). Intertidal mudflats, which are typically sheltered and have a large surface area for oil absorption, can trap oil, potentially causing toxicity impacts to infauna. Intertidal mudflats are very sensitive to oil pollution because the oil enters lower layers of the mudflats where a lack of oxygen prevents the oil from decomposing (Ref. 168).

Stochastic modelling predicted shoreline accumulation above the ≥100 g/m^2 impact threshold may occur at the Montebello Islands during summer; but no accumulation ≥1,000 g/m^2 was predicted to occur. This higher threshold is typically associated with impacts to coastal vegetation communities (Table 6-11), and therefore, shoreline exposure to mangroves and intertidal mudflats is not discussed further.

Indirect impacts to commercial fisheries As identified in Section 4.4.1, several commercial fisheries have management areas and recent fishing effort recorded within the EMBA. Direct impacts commercially targeted fish species are expected to occur from in-water exposures. Stochastic modelling showed that there no dissolved oil above impact thresholds (≥50 ppb) was predicted to occur during any season. Entrained oil above impact thresholds (≥100 ppb) was predicted to occur; however, was predicted to remain in the surface layers, with no exposure at depths >10 m below the surface predicted to occur during any season. Although exposures above impact thresholds have the potential to affect the recruitment of targeted commercial and recreational fish species, any acute impacts are expected to be limited, given this event is singular, non-continuous, and will result in a limited volume of hydrocarbon being released over a short time. On this basis recruitment of targeted species is not expected to be impacted significantly given the extent of exposure to concentrations above impact thresholds are expected to be limited due to rapid dilution and dispersion upon release. Spill events also have the potential to impact commercial fisheries through indirect impacts associated with tainting. Tainting is a change in the characteristic smell or flavour, and renders the catch unfit for human consumption or sale due to public perception. Tainting may not be a permanent condition but will persist if the organisms are continuously exposed; but when exposure is terminated, depuration will quickly occur (Ref. 169). Regardless of the small potential for tainting, customer perception that tainting has occurred may cause a larger impact then the direct impact itself. However, as this event is singular, non-continuous, and will result in a limited volume of hydrocarbon being released over a short time period, and the low persistence of the hydrocarbon in the environment, customer perceptions are not expected to be altered for a prolonged period. Modelling predicts that inshore exposure would be limited, whilst offshore exposures are expected to dilute and disperse over a longer period of time. In both instances, it is expected that any impacts from this type of event would likely be short term in duration. Therefore, CAPL assesses the consequence to commercial fisheries as localised and short term and it is ranked as Minor (5).
Reduction in amenity resulting in impacts to tourism and recreation Modelling predicts shoreline exposure ≥10 g/m^2 (visible impact threshold) from a vessel spill event during summer has the potential to occur predominantly along the Montebello and Barrow Islands, with smaller/patchier occurrences along some of the other Pilbara inshore islands and North West Cape coast, depending on the environmental conditions at the time of the event. Only a small area of the Montebello Islands was predicted to be exposed during winter, and no shoreline contact was predicted to occur during transitional) seasons. The deterministic model for the worst-case trajectory for the Montebello Islands indicates that the maximum length of shoreline oil above the visible impact threshold (≥10 g/m^2) at any given time was ~23 km, and the maximum volume of oil ashore was ~24 m^3. Shoreline loading can impact the visual amenity of coastal areas and limit beach access for users, impacting tourism and recreation activities. However, given the short-term and localized disturbance to marine tourism and recreation activities, CAPL has ranked the consequence as Minor (5).
Changes to values and sensitivities of Australian Marine Parks Modelling predicts surface exposure ≥10 g/m^2 and entrained exposure ≥100 ppb from a vessel spill event as having a high probability (89–100%) of occurrence within the Montebello Marine Park (Table 6-12). Modelling predicted a low probability (<5%) of entrained oil exposure within the Gascoyne and Ningaloo Marine Parks (Table 6-12). No interaction with seabed was predicted to occur. Given the much higher probability of exposure, the following evaluation is focused on the Montebello Marine Park. As identified in Section 4.5.1, the natural values of the Montebello Marine Park include species listed as threatened, migratory, marine, or cetacean under the EPBC Act, as well as any identified BIAs for regionally significant marine fauna. Social and economic values of the Montebello Marine Park include commercial fishing. The consequence evaluations to marine fauna and commercial fisheries are provided above. Given the expected behaviour and weathering of the oil, limited spatial and temporal exposure to marine fauna or commercial fish species above impact exposure thresholds, the potential impacts of a vessel spill event to the values and sensitivities of the Montebello Marine Park has been ranked as Minor (5).

ALARP decision context justification	
Seismic and support vessels commonly operate near each other during offshore surveys, and these activities are well-practised nationally and internationally. The control measures to manage the risk associated with vessel collisions are well defined via legislative requirements that are considered standard industry practice. These are well understood and implemented by the petroleum industry and CAPL. Specifically, CAPL has worked in the region for over 10 years, and has a demonstrated understanding of industry requirements and their operational implementation in these areas. During stakeholder consultation, no objections or claims were raised regarding vessel collision scenarios arising from the activity. The risks associated with a vessel collision are considered lower-order risks in accordance with Table 5-3. As such, CAPL would apply ALARP Decision Context A for this aspect.	
Good practice control measures and source	
Control measure	**Source**
Marine Safety Reliability and Efficiency (MSRE) process	CAPL's *ABU MSRE Corporate OE Process* (Ref. 43) ensures that various legislative requirements are met. These include: • crew meet the minimum standards for safely operating a vessel, including watchkeeping requirements • navigation, radar equipment, and lighting meets industry standards. These requirements will ensure that direct vessel radio contact is available to other marine users operating in this area to enable ease of communication in highlighting risks and nearby SNAs.
Maritime safety information	Maritime safety information, such as AUSCOAST navigational warnings, are issued by the Joint Rescue Coordination Centre (JRCC) Australia, part of AMSA. Under the *Navigation Act 2012*, the AHO is also responsible for maintaining and disseminating navigational charts and publications, including providing safety-critical information to mariners (including any change to prohibited/restricted areas, obstructions to surface navigation, etc.) via the Notice to Mariners system. Notice to Mariners can be permanent or temporary notifications. Where required, AUSCOAST and/or Notice to Mariners will be issued; thus enabling other marine users to also safely plan their activities.
Managing Safe Work (MSW) process	CAPL's *Managing Safe Work OE Process* (Ref. 42) ensures that workplace safety and health hazards are assessed and managed. The permit to work (PTW) system is part of this process and includes simultaneous operations (SIMOPS) and hazard analysis. Where required under the MSW process, a SIMOPS Plan will be developed to identify and manage hazards arising from the 4D MSS activities and other planned petroleum activities when occurring within the same area.
SOPEP / Shipboard Marine Pollution Emergency Plan	MARPOL 73/78 Annex I and Marine Order 91 (Marine pollution prevention – oil) requires that each vessel has an approved SOPEP in place. To prepare for a spill event, the SOPEP details: • response equipment available to control a spill event • review cycle to ensure that the SOPEP is kept up to date • testing requirements, including the frequency and nature of these tests. In the event of a spill, the SOPEP details: • reporting requirements and a list of authorities to be contacted • activities to be undertaken to control the discharge of oil procedures for coordinating with local officials.

Oil Pollution Emergency Plan (OPEP)	Under the OPGGS(E)R, NOPSEMA require that the petroleum activity have an accepted OPEP in place before commencing the activity. If a vessel collision occurs, the OPEP will be implemented. CAPL has developed a NOPSEMA-accepted OPEP (Ref. 2) to support all spill response activities across all its assets.	
Operational and Scientific Monitoring Plan (OSMP)	The OSMP details the arrangements and capability in place for operational and scientific monitoring. Operational monitoring collects information about the oil spill to aid planning and decision making for executing spill response or clean-up operations. Scientific monitoring focuses on the environmental impact attributable to the spill or the associated response activities and informs requirements for remediation (if required). CAPL has developed a NOPSEMA-accepted OSMP (Ref. 3) to support all spill monitoring activities across all its assets.	
Additional control measures and cost benefit analysis		
Control measure	**Benefit**	**Cost**
N/A	N/A	N/A
Likelihood and risk level summary		
Likelihood	Based on industry data, vessel collisions are considered rare, with only 3% of all marine incidents that occurred in Australian waters between 2005 and 2012 associated with a vessel collision event. As most vessel collisions involve the LOC of a forward tank, which are generally double-lined and smaller than other tanks, the loss of the maximum credible volumes used in this scenario is unlikely. Considering the inherent low likelihood of a collision occurring, the safeguards in place, and enactment of the OPEP, the potential likelihood of causing the consequences described in this section is Remote (5)	
Risk level	Very Low (9)	
Acceptability summary		
Principles of ESD	The potential impact associated with this aspect would be short term, apply to some individuals, and consequently is not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Minor (5). Therefore, no additional evaluation against the Principles of ESD is required.	
Relevant environmental legislation and other requirements	Legislation and other requirements relevant for this aspect include: • Commonwealth *Navigation Act 2012* • Marine Order 91, Marine Pollution Prevention – oil • Marine Order 30, Prevention of collisions • *Conservation Management Plan for the Blue Whale 2015–2025* (Ref. 68) • *Conservation Advice Balaenoptera borealis Sei Whale* (Ref. 67) • *Conservation Advice Balaenoptera physalus Fin Whale* (Ref. 66) • *Conservation Advice Rhincodon typus Whale Shark* (Ref. 65) • *Recovery Plan for Marine Turtles in Australia* (Ref. 63) • North-west Marine Parks Network Management Plan (Ref. 8).	
Internal context	These CAPL environmental performance standards or procedures were deemed relevant for this aspect: • MSRE process (Ref. 43) • MSW process (Ref. 42) • OPEP (Ref. 2)	

	• OSMP (Ref. 3).
External context	During stakeholder consultation, no objections or claims were raised regarding a vessel collision event arising from the activity.
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan. However, given that chemical discharge and/or pollution (of which an oil spill is a component) is listed as a threat to protected matters under documents made or implemented under the EPBC Act, CAPL has defined an acceptable level of impact such that it is not inconsistent with these documents. The *Recovery Plan for Marine Turtles in Australia* (Ref. 63) specifies the following relevant action areas and action: • minimise chemical and terrestrial discharge • ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs. No other specific relevant actions were identified within other documents implemented under the EPBC Act. CAPL addresses spill response and monitoring within their OPEP (Ref. 2) and OSMP (Ref. 3). Therefore, CAPL has defined an acceptable level of impact as minimising the risk of impacts to the environment from spills from vessel operations.

Environmental performance outcome	Performance standard / Control measure	Measurement criteria
No leak or spill of hydrocarbons / hazardous materials to the environment during petroleum activities	**MSRE process** Vessels will meet the crew competency, navigation equipment, and radar requirements of the MSRE process	Records indicate that vessels meet the crew competency, navigation equipment, and radar requirements of the MSRE process
	Maritime safety information Notify relevant agency of activities, vessel movements, and requested SNA, to enable them to generate radio-navigation warnings and/or Notice to Mariners prior to commencing offshore activities	Record of lodgment of notification to relevant agency
	MSW process Where required, CAPL will develop and implement SIMOPS Plan(s) to manage the 4D MSS and other planned petroleum activities	Records indicate that MSW process has been applied, and where identified as relevant, a SIMOPS Plan has been developed and implemented
Reduce the risk of impacts to the environment from the unplanned release of hydrocarbons / hazardous materials during petroleum activities	**SOPEP** Marine vessels >400 T will carry on board a Shipboard Oil Pollution Emergency Plan (SOPEP) in accordance with MARPOL 73/78 Annex I – Prevention of Oil Pollution	OVIS report / ABU Marine OE Inspection Checklist confirms an approved SOPEP is on board marine vessels >400 T
		Inspection records (or similar) show drills conducted in accordance with SOPEP
	SOPEP In the event of a vessel-based spill event, emergency response	Records confirm that emergency response activities were implemented in accordance with the

	activities will be implemented in accordance with the vessel SOPEP (or equivalent).	vessel SOPEP in the event of a vessel-based spill.
	OPEP In the event of a spill occurring, the OPEP will be implemented	Records confirm the OPEP has been implemented
	OSMP In the event of a spill occurring, the OSMP will be implemented	Records confirm the OSMP has been implemented

6.13 Spill response

6.13.1 Response option selection

6.13.1.1 Strategic NEBA

CAPL has developed a series of Strategic Net Environmental Benefit Analysis (NEBAs) (Ref. 170) using generalised scenarios that reflect the spill risks associated with all CAPL offshore WA operations. Hydrocarbons associated with spill events from all CAPL operations were grouped into oil types as defined by the International Tanker Owners Pollution Federation Ltd (ITOPF) classification system:

- Group 1 – including Iago, Wheatstone, and Jansz condensate; Wheatstone trunkline fluids; and Wheatstone flowline fluids
- Group 2 – including MDO, Gorgon condensate, Barrow Island crude, and Gorgon/Jansz mixed trunkline fluids
- Group 3 / 4 – including HFO and intermediate fuel oil (IFO) (depending on blend).

These NEBAs were developed as a pre-spill planning tool for all CAPL EPs, to facilitate response option selection and support the development of the overall response strategies by identifying and comparing the potential effectiveness and impacts of oil spill response options (Ref. 171). After considering the benefits and drawbacks of each response option on the ecological, social, and economic receptors within the EMBA, the response options that were determined to minimise the impacts to the environment and people were pre-selected.

6.13.1.2 Protection prioritisation process

CAPL has developed a Protection Prioritisation Process (PPP) (Ref. 172) to support decision making in the event of a significant spill event. The information within the PPP document is used to identify priorities for protection within the activity specific spill scenario(s) EMBA, such as that described in Section 4. The identification of priorities for protection assists in the identification of resources to be assessed within the strategic and operational NEBAs, as described above. The NEBA considers the protection priority values, the EMBA, and the various control measures, including their feasibility, likely success, environmental benefits, level of effectiveness and performance of response tactics. The output of the NEBA and the protection priorities identified will then guide the strategic direction of the response through informing decisions made around tactical planning and response option selection.

The PPP (Ref. 172) ranks receptors (natural or anthropogenic value or resource that is potentially sensitivity to marine oil pollution) using a 5 level scale (from Very Low (1) to Very High (5)) based on a number of factors, including their sensitivity and vulnerability to oil, their conservation status and the biological and socioeconomic importance of the receptor. The CAPL PPP (Ref. 172) aligns with WA Department of Transport (DoT) PPP (Ref. 173) and utilises the same shoreline cells to illustrate broad scale identification of sensitive areas.

Areas with high value receptors and at greatest risk of contact with oil (as indicated by stochastic modelling) are assigned a high protection priority and designated as priority planning areas. The process for identifying these areas (described in the PPP document [Ref. 172]) considers all High (4) and Very High (5) ranked shoreline cells where contact above the moderate exposure threshold (from stochastic modelling across all seasons) is predicted within 4 days (96 hours). As described in the PPP (Ref. 172), the 4-day contact timeframe is based on the expected time it would take CAPL to develop and implement a Tactical Response Guide (TRG) for an area predicted to be impacted. For contact outside this timeframe, it expected that CAPL will have reasonable time to develop and implement a TRG prior to oil contacting the resource.

High and Very High value areas (DoT shoreline cells) identified for contact within this timeframe have been identified in Table 6-13 for the vessel collision event. These priority planning areas, and the specific receptors identified within them, are considered to ensure that tactical planning and response option selection are appropriate.

Table 6-13: Priority planning areas for vessel collision event spill scenario

Potential area of impact	Distance from source of spill	Shoreline values	Planned response tactics
DoT Shoreline Cell # 318 (Montebello Islands)	30 km	Turtles – BIAs including nesting Seabirds – BIAs including breeding Mangroves Coral and reef communities Marine Park	Monitor, Evaluation and Surveillance Shoreline Clean-up Oiled Wildlife Response

6.13.2 Activity-specific response option selection

To select the appropriate response options for this EP, hydrocarbons applicable to the worst credible scenarios specific to this activity are:

- Group 2 – MDO.

The outcomes of the Strategic NEBA are outlined in Table 6-1 of the OPEP (Ref. 2). Taking into account the priority planning areas identified in Table 6-13, the outcomes of the Strategic NEBA determined that the recommended response options proposed to be used for the spill scenarios associated with this EP include:

- Monitoring, Evaluation, and Surveillance (MES)
- Shoreline Protection and Deflection (SPD)
- Shoreline Clean-up (SHC).

These response options are carried out alongside Oiled Wildlife and Waste Management response tactics. CAPL does not consider Oiled Wildlife and Waste Management as separate response options as they are implemented as support tactics for all spill events in a manner that is commensurate to the level of impact and risk of that event.

6.13.3 CAPL existing spill response capability assessment

Based on the spill response arrangements that CAPL has in place across the business, the capability of these arrangements was determined. This process involved:

- identifying CAPL's existing response arrangements and the equipment and personnel available to CAPL under these arrangements

- defining the response package for each response option, and identifying the critical components for each response package (i.e., equipment or personnel that are limited in number and cannot be purchased or accessed readily)
- determining the number of critical components available to CAPL under existing arrangements
- identify the number of response packages available to CAPL under existing arrangements
- defining the volume of hydrocarbons that could be recovered or treated per response package.

The outcome of this evaluation is included as Appendix C of the OPEP (Ref. 2).

6.13.3.1 CAPL project-specific capability requirement assessment

To understand the spill response capability required for this activity, CAPL assessed the worst-case credible spill event and used modelling to understand the number of packages per response technique that may be required to respond to that event. The steps involved in this assessment were:

1. Review the Strategic NEBA (Ref. 170) and priority planning areas to understand the planned response to an event.
2. Predict the average surface hydrocarbon volume per day; and average volume of hydrocarbon accumulated onshore per shoreline per day (if relevant) to calculate the number of response packages required per response strategy.
3. Review the number of response packages available to determine if the capability exists.

6.13.3.2 CAPL planned response vessel collision

In accordance with the Strategic NEBA (Ref. 170), the response strategies proposed to be used for this spill scenario and response package calculations are described below. Offshore containment and recovery (CAR) would not be effective because of the hydrocarbon properties (Group 2).

Implement MES response

A MES response will commence for a vessel collision as soon as the spill is identified. This may range from very simplistic visual observation only, through to more involved monitoring and evaluating tactics. Appendix C of the OPEP (Ref. 2) has documented the arrangements that CAPL have in place to implement all the required MES tactics; therefore, this technique is not discussed further.

Implement SPD response

Deterministic analysis for the largest volume of oil ashore indicates that ~24.4 m^3 may wash ashore within ~3 days after release. The volume of oil ashore was used to support the planned response requirements—the volume of hydrocarbons that would need to be treated by an SPD response is directly correlated to the volume of oil that may wash ashore.

Based on Appendix C of the OPEP (Ref. 2), each protection team is expected to recover 15.6 m^3 of hydrocarbon per day. On the assumption that 24.4 m^3 washes ashore on the third day, CAPL would need up to two SPD packages available on day two to implement the SPD response. Confirmation that CAPL has the arrangements in place to implement the required number of packages is provided in Table 6-14.

Implement SHC response

For a spill event such as this (a non-continuous release), deterministic analysis indicates shoreline accumulation (if it occurs) occurs rapidly. CAPL will implement strategies to protect prioritised values and sensitivities; however, the focus may be on SHC operations if time restricts the ability to conduct SPD activities.

Deterministic analysis for the largest volume of oil ashore indicates that 24.4 m^3 may wash ashore within ~3 days after release; and the maximum length of actionable shoreline oil was predicted to be ~10 km within ~4 days This scenario predicted exposure to the western coastlines of the Montebello Islands.

The Montebello Islands consists of a series of relatively flat limestone islands and sandy beaches and lagoons, easily accessed by boat (dependent on weather and sea conditions). On this basis, response planning indicates it would be feasible to conduct SHC activities.

Based on Appendix C of the OPEP (Ref. 2), each SHC team is expected to recover 1.6 m^3 of hydrocarbon per day. If 5 clean-up teams are mobilised on day 3 and used each day, all hydrocarbons can be recovered 5 days from the start of the spill (3 days of SHC response). If required, these efforts could be ramped up as directed and informed by MES activities.

Table 6-14: Vessel collision response package deployment timeline

Response technique	Days following event							Weeks following event				
	1	2	3	4	5	6	7	2	3	4	5	6
No. packages – planned MES	1	1	1	1	1	1	1	1	0	0	0	0
Does CAPL have the required capability?	Y	Y	Y	Y	Y	Y	Y	Y				
No. packages – planned SPD	0	2	2	0	0	0	0	0	0	0	0	0
Does CAPL have the required capability?		Y	Y									
No. packages – planned SHC	0	0	5	5	5	0	0	0	0	0	0	0
Does CAPL have the required capability?			Y	Y	Y							

6.13.4 Spill response environmental risk assessment

6.13.4.1 Ground disturbance – shoreline spill response

Conducting SPD or SHC involves moving personnel and equipment, which triggers the environmental aspect of ground disturbance.

SPD aims to decrease the overall effect of oil on shorelines before they are impacted and uses booms and sorbents placed adjacent to sensitive shoreline habitats to deflect or capture surface oil.

The objective of SHC is to apply techniques that are appropriate to the shoreline type to remove as much oil as possible. Various techniques may be used alone or in combination to clean oiled shorelines, including shoreline assessment, natural recovery, sorbents, sediment reworking, manual and mechanical removal, and washing, flooding, and flushing.

Source			
In the event of a worst-case spill event (vessel collision event releasing MDO), implementing SPD and SHC techniques involves people and equipment, which may disturb shoreline habitat.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	-	Conducting SPD and SHC, including moving personnel and equipment, has the potential to damage terrestrial habitats (including nests), with subsequent impacts to fauna such as turtles and birds.	5
Consequence evaluation			
Potential impacts of SPD and SHC vary, depending on the method used and the shoreline habitat. General impacts include physical disturbance from using personnel, vehicles, and equipment. Particular values and sensitivities in the area that may be affected by the spill include sensitive shoreline habitats (such as mangroves) and nesting / foraging habitat for fauna species such as turtles and birds. The impacts associated with undertaking SHC may be more than if the hydrocarbon product was left in place and remediated through natural processes. Leaving the product in place is a common response option if continual human and vessel/vehicle traffic has the potential to generate greater impacts than the product itself. This technique has been implemented internationally, including for the Montara spill (where persistent components of the product were left to naturally break down in dense coastal mangroves) and the Macondo spill (where marshes and wetlands that had been impacted by weathered product were allowed to recover naturally). If a smaller extent of shoreline is impacted, the impacts from an SHC response activity may be lessened and more localised. Potential impacts associated with using vehicles, personnel, and equipment during SHC (and/or SPD) can include disturbing wildlife feeding or breeding (including damage to nests) and damaging dune structures, vegetation, or intertidal habitats. These shoreline activities have the potential to result in short-term and localised damage to or alteration of habitats and ecological communities and therefore the consequence is ranked as Minor (5).			
ALARP decision context justification			
The risks associated with shoreline oil spill response techniques are well understood, with the techniques having been applied successfully for a number of large spill events. Although there is a good understanding of these response techniques, there is uncertainty regarding the specific location at which this may be undertaken, and the level of response that may be required in these areas. Spill modelling was used to inform the extent of such a spill, and thus provide a sound basis for response planning (including shoreline response) to such an incident. Control measures to manage the risks associated with shoreline spill response techniques are well defined with most being linked to detailed monitoring plans that feed into tactical planning requirements and NEBAs. During stakeholder consultation, no objections or claims were raised regarding spill response activities. The risks arising from implementing shoreline response techniques in the event of a spill are extremely low, and CAPL consider these to be lower-order risks in accordance with Table 5-3. As such, CAPL considers ALARP Decision Context A should be applied for this aspect.			

Good practice control measures and source	
Control measure	**Source**
OSMP	The OSMP details the arrangements and capability in place for operational and scientific monitoring. Operational monitoring collects information about the oil spill to aid planning and decision making for executing spill response or clean-up operations. Scientific monitoring focuses on the environmental impact attributable to the spill or the associated response activities and informs requirements for remediation (if required). CAPL has developed an NOPSEMA-accepted OSMP (Ref. 3) to support all spill monitoring activities across all its assets. Specifically, Operational Study 6 – Rapid Seabird and Shorebird Assessment and Operational Study 7 – Rapid Marine Megafauna Assessment provide information on the presence of wildlife with regards to predicted trajectory to understand the level of oiled wildlife response (OWR) required.
Likelihood and risk level summary	
Likelihood	Depending on the clean-up technique and habitat, potential consequences of shoreline cleaning are remote (Note: Mechanical methods are generally expected to have greater consequences than manual cleaning). With the control measures in place, CAPL assessed the likelihood of the consequence described above as Remote (5).
Risk level	Very low (9)
Acceptability summary	
Principles of ESD	The potential impact associated with this aspect is considered to have the potential to result in minor, localised, incidental damage to, or alteration of, habitats and ecological communities; however, this is not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Minor (5). Therefore, no additional evaluation against the Principles of ESD is required.
Relevant environmental legislation and other requirements	No legislation and other requirements relevant to this aspect were identified.
Internal context	This CAPL environmental performance standard / procedure was considered relevant for this aspect: • OSMP (Ref. 3).
External context	During stakeholder consultation, no objections or claims were raised regarding spill response activities.
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.

Environmental performance outcome	Performance standard / Control measure	Measurement criteria
Reduce the risk of impacts to the environment during event response	**OSMP** In the event of a spill occurring, the OSMP will be implemented	Records confirm the OSMP has been implemented

6.13.4.2 Physical presence—oiled wildlife response

Oiled wildlife response (OWR) activities are aimed at treating fauna that have encountered, or are likely to encounter, spilt hydrocarbons. OWR generates the environmental aspect of physical presence/interaction with fauna, through handling, treating, rehabilitating, and releasing fauna.

Source			
In the event of a worst-case spill event (vessel collision event releasing MDO), the handling and treating marine fauna (through an OWR) will result in personnel interacting with marine fauna.			
Potential impacts and risks			
Impacts	**C**	**Risks**	**C**
N/A	-	Conducting OWR has the potential to cause further harm to oiled fauna due to hazing, barriers, deterrents, and cleaning activities, and has the potential to cause injury/death.	5
Consequence evaluation			
Particular environmental values that may be affected by OWR activities include marine fauna such as turtles and birds. Due to the intensive nature of OWR activities and the fragile nature of many shore and wading birds, OWR activities can have high bird mortality rates. Physical exclusion and hazing operations can result in entanglement and stress-related impacts to marine birds. Cleaning of oiled wildlife may result in skin irritations, impacts to the hydrophobic properties of bird plumage, and stress-induced physiological effects. Spill modelling indicates that areas along the coast frequented by fauna, such as the Montebello Islands, are areas where OWR is most likely to be undertaken. If a spill coincided with turtle nesting/hatchling or bird nesting periods, a large number of animals may be treated using OWR. Impacts from hazing and deterrents are anticipated to be localised to the area of potential spill impact and limited to the spill period. Even if OWR was undertaken during nesting periods, only a small proportion of the nesting population would be involved as the species potentially involved nest widely elsewhere. The potential consequences associated with an OWR are localised and short term and are ranked as Minor (5).			
ALARP decision context justification			
The risks associated with OWR are well understood, with the technique having been applied successfully for a number of large spill events. Although there is a good understanding of the response technique, there is uncertainty regarding the specific location at which this may be undertaken, the number of animals that may be impacted, and thus the level of response that may be required. Spill modelling was used to inform the extent of such a spill, and thus provide a sound basis for response planning to such an incident. Control measures to manage the risks associated with OWR are well defined with most being linked to detailed monitoring plans that feed into tactical planning requirements and NEBAs. During stakeholder consultation, no objections or claims were raised regarding OWR activities. The risks arising from implementing OWR in the event of a spill are extremely low, and CAPL consider these to be lower-order risks in accordance with Table 5-3. As such, CAPL considers ALARP Decision Context A should be applied for this aspect.			

Good practice control measures and source	
Control measure	**Source**
OSMP	The OSMP details the arrangements and capability in place for operational and scientific monitoring. Operational monitoring collects information about the oil spill to aid planning and decision making for executing spill response or clean-up operations. Scientific monitoring focuses on the environmental impact

	attributable to the spill or the associated response activities and informs requirements for remediation (if required). CAPL has developed a NOPSEMA-accepted OSMP (Ref. 3) to support all spill monitoring activities across all its assets. Specifically, Operational Study 6 – Rapid Seabird and Shorebird Assessment and Operational Study 7 – Rapid Marine Megafauna Assessment provide information on the presence of wildlife with regards to predicted trajectory to understand the level of OWR required.	
Likelihood and risk level summary		
Likelihood	Where there is the possibility for surface oil to impact wildlife, the risks associated with OWR are lower than those associated with inaction. With the control measures in place, the likelihood of the described consequences occurring from OWR activities was determined to be Remote (5).	
Risk level	Very low (9)	
Acceptability summary		
Principles of ESD	The potential impact associated with this aspect is considered as having the potential to result in a localised incidental impact and thus is not expected to affect biological diversity and ecological integrity. The consequence associated with this aspect is Minor (5). Therefore, no additional evaluation against the Principles of ESD is required.	
Relevant environmental legislation and other requirements	No legislation and other requirements considered relevant to this aspect were identified.	
Internal context	The CAPL environmental performance standard / procedure considered relevant for this aspect is: • OSMP (Ref. 3).	
External context	During stakeholder consultation, no objections or claims were raised regarding spill response activities.	
Defined acceptable level	These impacts and risks are inherently acceptable as they are considered lower-order impacts in accordance with Table 5-3. In addition, the potential impacts and risks evaluated for this aspect are not inconsistent with any relevant recovery or conservation management plan, conservation advice, or bioregional plan.	
Environmental performance outcome	**Performance standard / Control measure**	**Measurement criteria**
Reduce the risk of impacts to the environment during event response	**OSMP** In the event of a spill occurring, the OSMP will be implemented	Records confirm the OSMP has been implemented

7 implementation strategy

This section provides a description of the implementation strategy as required under Regulation 14 of the OPGGS(E)R. The implementation strategy identifies the systems, practices, and procedures used to ensure the environmental impacts and risks of the petroleum activities are continuously reduced to ALARP and the environmental performance outcomes and standards detailed in Section 6 are achieved.

7.1 Operational Excellence Management System

CAPL's operations are managed in accordance with Chevron Corporation's OEMS, which is a comprehensive management framework that supports the corporate commitment to protect the safety and health of people and the environment. The OEMS aligns with ISO 14001:2015 *Environmental management systems - Requirements with guidance for use* (Ref. 41) and meets the requirements of the OPGGS(E)R.

OE systematically manages workforce safety and health, process safety, reliability, and integrity, environment, efficiency, security, and stakeholders to meet the OE objectives and ensure safe operations of CAPL facilities and projects. The OEMS comprises the following key components (Figure 7-1):

- **leadership and OE culture**—through the OEMS, CAPL leaders engage employees and contractors to build and sustain the OE culture and deliver OE performance
- **management system cycle** (MSC)—by applying the MSC, CAPL leaders make risk-based and data-driven decisions, prioritise activities, and direct improvements
- **focus areas and OE expectations** (including common expectations)—focus areas are categories of OE risks and include workforce safety and health, process safety reliability and integrity, environment, efficiency, security, and stakeholder engagement; OE expectations guide the design, management, and assurance of the presence and effectiveness of safeguards.

The OEMS outlines the process for identifying, establishing, and maintaining safeguards and to provide assurance that they are in place, functioning as intended, and are in accordance with legal and OE requirements. The risk management process (Figure 7-1) assesses and identifies safeguards, which are the hardware and human actions designed to directly prevent or mitigate an incident or impact associated with the project, personnel, and the environment. The assurance process (Figure 7-1) provides the verification and validation that the safeguards are in place and functioning as intended.

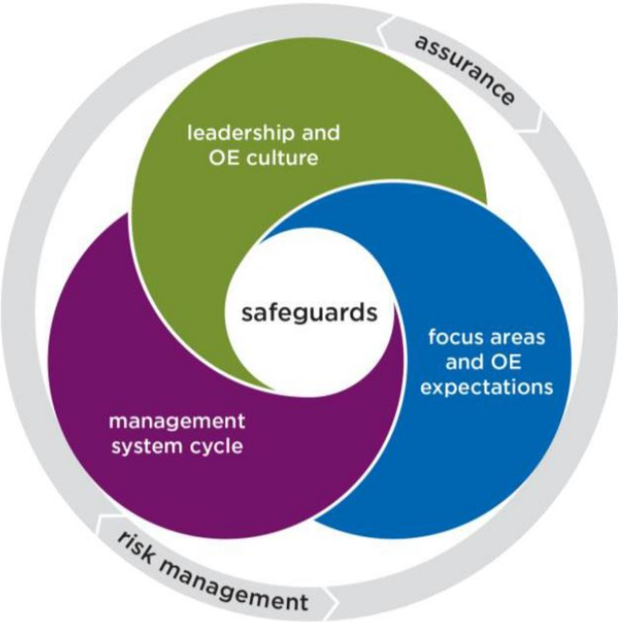


Figure 7-1: Overview of Chevron Corporation's OEMS

7.2 Leadership and OE culture

CAPL leaders demonstrate and are accountable for the consistent and rigorous application of the OEMS to drive performance and manage risks. The actions and visibility of leaders reinforce CAPL's commitment to place the highest priority on the safety and health of its workforce, and on the protection of communities, the environment, and its assets.

7.2.1 Roles and accountability

CAPL leaders have the overall accountability for the implementation of the OEMS.

7.2.1.1 Chain of command (petroleum activity)

As required under Regulation 14(4) of the OPGGS(E)R, a clear chain of command for implementing the petroleum activity is outlined in Figure 7-2.

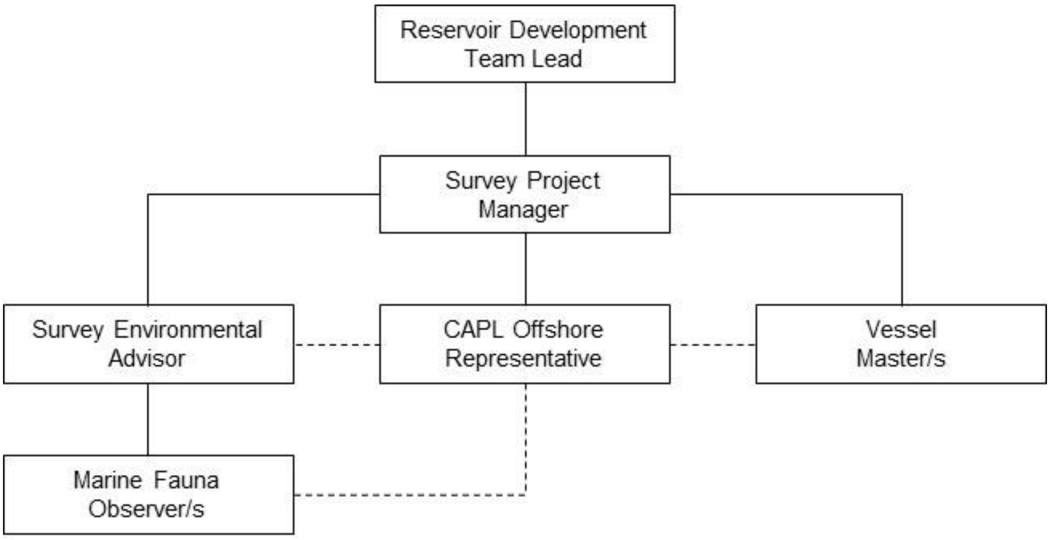


Figure 7-2: Chain of command—petroleum activities

7.2.1.2 Roles and responsibilities (petroleum activity)

The roles and responsibilities of key CAPL and contractor personnel for implementing task-specific control measures are detailed in Section 6, and are summarised in Table 7-1.

Table 7-1: Key roles and responsibilities—petroleum activities

Role	Responsibilities
Survey Project Manager	• Overall responsibility for implementing, managing, and reviewing this EP Ensure that: • all third-party vessels or contractors are aware of any requirements within this EP • ongoing consultation is conducted in accordance with Section 2.6.5
CAPL Offshore Representative	Ensure that: • all personnel are made aware of their requirements under this EP • impacts and risks are continually reduced to ALARP by implementing this EP in accordance with Section 6 • all incidents are reported to Survey Project Manager
Survey Environmental Advisor	Ensure that: • all personnel are made aware of their requirements under this EP • impacts and risks are continually reduced to ALARP by implementing this EP in accordance with Section 6 • all changes to this EP are subject to a Management of Change assessment as described in Section 7.3.2.2 • compliance with this EP is verified in accordance with Section 7.3.6 • this EP is reviewed in accordance with Section 7.5.
Vessel Master/s	Ensure that: • impacts and risks are continually reduced to ALARP by implementing this EP in accordance with Section 6 • all necessary vessel-related documentation (e.g., SOPEPs, certificates, etc.) is available in accordance with Section 6 • all marine safety information notifications are issued in accordance with Table 2-9 and Section 6 • all incidents are reported to CAPL Offshore Representative • all emissions and discharges are monitored and recorded in accordance with Section 6.
Marine Fauna Observer/s	• Undertake visual observations for marine fauna in accordance with Section 6 • Record and report all sightings of marine fauna to the Survey Environmental Advisor • Provide advice to the CAPL Offshore Representative and Vessel Master (or delegate) regarding delay or shut down seismic source, if required, in accordance with Section 6.5 of this EP • Assist Survey Environmental Advisor with compliance verification as required.

7.2.1.3 Training and competency (petroleum activity)

In accordance with Regulation 14(5) of the OPGGS(E)R, each employee responsible for implementing task-specific control measures during operational activities must be aware of their specific responsibilities as detailed in this EP.

People who hold responsibilities relating to implementing this EP are hired by CAPL on the basis of their particular qualifications, experience, and competency.

All external contractor personnel involved with activities within scope of this EP will hold qualifications or training certification relevant to their role, which will be confirmed through the contractor selection process, audits and review processes.

Personnel with specific responsibilities under this EP (refer to Section 7.2.1.2) will be made aware of their role-specific responsibilities under this EP.

All personnel (including contractors) are required to attend inductions that are relevant to their role (Table 7-2).

Table 7-2: Inductions—petroleum activities

Induction	Required personnel	Scope
Induction	All relevant personnel	Before commencing activities, all personnel, including subcontractors, must attend an induction that includes an overview of the requirements of this EP. This induction fosters environmental stewardship amongst all personnel and ensures that they are aware of the control measures implemented to minimise the potential impact on the environment. The induction includes: • awareness of Chevron Corporation's Operational Excellence Policy 530 (appendix a) • an overview of environmental sensitivities, and key impacts and risks from the petroleum activity • cetacean interaction requirements under Part 8 of the EPBC Regulations 2000 • whale interaction requirements under EPBC Act Policy 2.1 • good waste management and hazardous materials housekeeping requirements • incident reporting requirements • incident response arrangements.

7.3 Focus areas and OE expectations

The OE expectations are organised into six focus areas (Figure 7-3). The OE expectations provide guidance to design, operate, maintain, improve, and assure the presence and effectiveness of safeguards. Common expectations also apply and support the OE expectations and focus areas Figure 7-3.

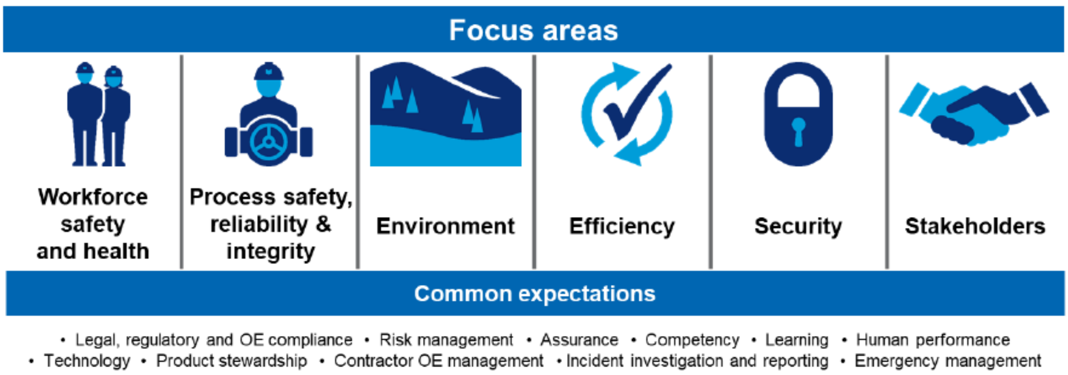


Figure 7-3: Focus areas and common expectations

The focus areas and common expectations relevant to this EP, and their key processes that demonstrate how CAPL is effective in reducing environmental impacts and risks to ALARP and an acceptable level, are listed in Table 7-3. Each of these focus areas and common expectations are described in further detail in the following subsections.

Table 7-3: Relevant focus areas and common expectations

Focus area or common expectation	Key processes
Focus area	
Workplace safety and health	• *Managing Safe Work (MSW): ABU Standardised OE Process* (Ref. 42) • *Marine Safety Reliability and Efficiency: ABU Standardised OE Process* (Ref. 43) • *ABU Hazardous Materials Management Procedure: ABU Standardised OE Procedure* (Ref. 44)
Process safety, reliability and integrity	• OE Information Management: ABU Standardised OE Process (Ref. 45) • *Management of Change for Facilities and Operations: ABU Standardised OE Process* (Ref. 46)
Environment	• *Environmental Stewardship: ABU Standardised OE Process (Ref. 47)* • *Quarantine Procedure Marine Vessels. ABU Standardised OE Process (Ref. 48)*
Stakeholders	• *Stakeholder Engagement and Issues Management: ABU Standardised OE Process* (Ref. 49)
Common expectation	
Risk management	• *ABU OE Risk Management Process* (Ref. 34)
Assurance	• *OE Assurance Corporate Process* (Ref. 50) • *OE Corporate Standard Incident Investigation* (Ref. 53) • *OE Data Reporting Standard (Ref. 54)*
Incident investigation and reporting	• *Incident Investigation and Reporting (II&R) Execution Manual* (Ref. 55)
Emergency management	• *Emergency Management OE Process* (Ref. 56) • OPEP (Ref. 2) • *Operational and Scientific Monitoring Plan* (OSMP) (Ref. 3)

7.3.1 Workforce safety and health

7.3.1.1 Managing safe work

The MSW expectation is to assess workplace safety and health hazards and manage the risks associated with the execution and control of work performed by CAPL employees, their delegates, contractors, and subcontractors. The MSW system (Ref. 42) is implemented to ensure safe work practices are made available to the workforce. Standards and procedures relating to MSW relevant to this EP include the permit to work (PTW) system. The PTW system, which includes simultaneous operations (SIMOPS) and hazard analysis, is a way to identify, communicate, mitigate, and control hazards associated with work that have the potential to adversely affect HSE. As the potential consequence associated with each task increases, so does the level of controls and approval that are required.

7.3.1.2 Marine

The Marine Safety Reliability and Efficiency (MSRE) process (Ref. 43) identifies the requirements and activities necessary to deliver safe, reliable, and efficient third-party marine operations. This process describes key roles and responsibilities for managing marine safety and establishes measurement and verification activities designed to promote a process of continual improvement.

The MSRE process applies to all marine vessels, emergency response, and all other (non-bulk petroleum) vessels chartered, owned, or operated by CAPL. The process also applies to vessels contracted by an affiliate or contractor that provide marine support or marine services to CAPL.

Vessels are assured and endorsed for their intended work scope by the MSRE Process Authority (or delegate). Contractors and subcontractors are required to meet all requirements in the Corporate Marine Standard (Ref. 57), including the MSRE Marine Contractor HES (MarCHES) qualification and performance monitoring. Contractors and subcontractors are also required to meet any in-force global MSRE marine notices, which must be complied with until they are revoked or added to the CAPL Marine Standard.

The key elements of the MSRE process that apply to the activities outlined in this EP are:

- vessel inspections—vessels used by CAPL or its affiliates must undergo a vessel audit/inspection process before deployment to ensure that the vessels and the staffing levels meet safety requirements and are fit-for-purpose; inspections also ensure emergency procedures (such as SOPEP/SMPEP) are available and that the required standards are met for navigation equipment, lighting, waste systems, and other marine safety protocols including Marine Order 30 (Prevention of Collisions)
- competency management—vessels used by CAPL must be operated by competent personnel who meet applicable international and local regulations
- cargo handling—cargo transport and handling operations on marine vessels must comply with handling procedures and align to standard marine industry practices
- complicated and/or heavy lifts—all lifting and installing of heavy equipment near offshore infrastructure must meet the detailed requirements
- hose management—operations involving the transfer of bulk liquids using loading hoses must align to standard industry practice and safety of the environment
- vessel communication—vessels must have in place communications procedures for operations close to installations, or other mobile units to ensure that safe positioning and communications are maintained at all times.

Vessels provide an activity-specific operational guideline (ASOG), based on their use and specification, which must be accepted by CAPL.

7.3.1.3 Hazardous materials

CAPL's *Hazardous Materials Management Procedure* (Ref. 44) outlines the process for HSE assessment and approval of hazardous materials. Hazardous materials include those classified as 'hazardous substances or 'dangerous goods'.

The *Hazardous Materials Management Procedure* is designed to:

- assess hazardous materials requested for procurement for their HSE risks
- ensure that appropriate controls are identified for using procured hazardous materials and that these controls are communicated to the requestors of the materials and end users at locations within CAPL's operations
- ensure no product includes CAPL-prohibited ingredients
- ensure substitutes were considered if a product contains CAPL-restricted ingredients.

As part of the hazardous materials selection process, hazardous materials that will be discharged to the environment will undergo a detailed environmental assessment. This environmental assessment is guided by the methodology and classification system used by the Offshore Chemical Notification Scheme (OCNS) and Chemical Hazard Assessment and Risk Management (CHARM). Hazardous materials not listed on OCNS or CHARM, are still subject to the environmental assessment described below.

The environmental assessment includes an evaluation of the potential environmental risks that could be associated with the chemical, and considers the relevant dosage, quantity and frequency of the chemical discharge, the location and nature of the receiving environment, and the assessment criteria described in Table 7-4.

The chemical selection process ensures impacts and risks associated with chemical discharge are reduced to levels that are ALARP and acceptable, while meeting operational performance requirements.

Table 7-4: Chemical risk assessment criteria

Assessment criteria	Selection rationale
Potential for acute and/or chronic toxicity to aquatic life	The toxicity of a chemical is the fundamental consideration within this assessment. This reflects the UK OCNS system which ranks chemicals based on their toxicity, and then adjusts rankings depending on biodegradation and bioaccumulation properties. The scale for toxicity is based on the toxicity rating classification system used by DMIRS, from Hinwood et al. (Ref. 58).
Persistence or biodegradability	Biodegradation rate provides an indication of the potential persistence of the chemical within the environment, and therefore the potential duration of exposure for environmental sensitivities. The scale for biodegradation is based on adjustment criteria used by Centre for Environment, Fisheries and Aquaculture Science (CEFAS) to finalise chemical hazard assessment scores under the OCNS system.
Bioaccumulation or bio-concentration	Indicates the potential for the chemical (or components of the chemical) to accumulate within biological matrices and food chains. Chemicals which may not be toxic and are introduced to the environment in low concentrations can concentrate within biological matrices to the point where they become toxic and may have either acute or chronic effects.

Assessment criteria	Selection rationale
	The scale for bioaccumulation is based on adjustment criteria used by CEFAS to finalise chemical hazard assessment scores under the OCNS system.

7.3.2 Process safety, reliability and integrity

7.3.2.1 OE information management

Under the OEMS, records (including compliance records to demonstrate environmental performance and compliance with commitments in this EP) will be retained in accordance with Regulation 27 of the OPGGS(E)R.

The OE information management process (Ref. 45) explains how critical information related to HSE, reliability, efficiency, and process safety is to be identified, developed, assessed, and maintained so that the workforce has access to, and is using, the most current information. This document describes key roles, responsibilities, and competencies associated with the process, and includes measurement and verification activities.

Vessel contractors will maintain records as above and are required to make these available upon request.

7.3.2.2 Management of change

Management of Change (MoC) expectations are to manage proposed changes to design, equipment, operations and products before they are implemented. In conjunction with the *ABU OE Risk Management Process* (Section 7.3.5), the *Management of Change for Facilities and Operations* process (Ref. 46) is followed to document and assess the impact of changes to activities described in this EP. These changes will be addressed to determine if there is potential for any new or increased environmental impact or risk not already provided for in this EP. If these changes do not trigger relevant petroleum regulations, as detailed below, this EP will be revised, and changes recorded in the EP without resubmission.

In accordance with Regulation 17 of the OPGGS(E)R this EP must be resubmitted to NOPSEMA under the relevant jurisdiction in the following circumstances:

- before commencing a new activity, or any significantly modification or new stage of the activity, not provided for in this EP
- if a change in the titleholder results in a change in the manner in which the impacts and risks of the activity are managed
- as soon as practicable after the occurrence of any significant new environmental impact or risk, or significant increase in an existing environmental impact or risk, that is not provided for in this EP
- as soon as practicable after the occurrence of a series of new environmental impacts or risks, or a series of increases in existing environmental impacts or risks, occur which, taken together, amount to the occurrence of a significant new environmental impact or risk, or a significant increase in an existing environmental impact or risk, not provided for in this EP.

7.3.3 Environment

The Environment Focus Area provides CAPL's framework for the protection of the environment and community health using a risk-based approach that addresses potential environmental impacts.

7.3.3.1 Environmental stewardship

The Environmental Stewardship process (Ref. 47) is designed to identify, assess, and manage potentially significant environmental impacts in a consistent manner and continually improve environmental performance. The objectives of the process are to:

- provide a consistent approach to Environmental Stewardship
- reduce the potential for environmental impacts
- support continual improvement in environmental performance throughout the lifecycle of Chevron's assets.

7.3.3.2 Quarantine

The *Quarantine Procedure Marine Vessels* (Ref. 48) provides information about quarantine compliance to CAPL, contractors, and others associated with marine vessels.

The purpose of this procedure in relation to the offshore title areas is to prevent offshore facilities and activities associated with CAPL title areas becoming staging areas for the introduction of marine pests into Australian waters and ports.

This procedure also outlines the requirements for vessels operating in title areas and details the premobilisation requirements and ongoing management of vessels operating in title areas.

7.3.4 Stakeholders

Stakeholder engagement expectations are to manage social, political, and reputational risks to CAPL (and Chevron), address potential business impacts, and generate business value by:

- identifying, assessing, and prioritising issues
- building and maintaining relationships with external stakeholders, including governments and the communities where CAPL operates
- developing and executing issue management and stakeholder engagement plans, tracking engagements and issues, and validating the effectiveness of plans.

The *Stakeholder Engagement and Issues Management Process* (Ref. 49) details an integrated approach for engaging stakeholders and managing external stakeholder issues. This process describes key roles and responsibilities for stakeholder engagement, establishes measurement and verification activities designed to monitor the effectiveness of the stakeholder engagement process and to promote continual improvement.

In accordance with Regulation 14(9) of the OPGGS(E)R, Section 2.5.2.1 describes the process undertaken for appropriate consultation with relevant authorities and relevant interested persons or organisations. CAPL will continue to engage with relevant stakeholders as described in Section 2.6.5.

7.3.4.1 Adjustment Protocol

CAPL is committed to reducing impacts to commercial fisheries within its area of operations to ALARP. CAPL will consider an evidence-based adjustment protocol for the commercial fishing sector should fishers be verifiably impacted to a commercially material extent by the 4D MSS (Table 7-5). CAPL will provide reasonable monetary adjustment to a commercial fishing licence holder for temporary loss of catch, displacement, or equipment loss/damage, occurring within the OA and during the 4D MSS. The onus will be on the commercial fishing license holder to provide evidence to CAPL where impacts are identified with verifiable catch-data to support the claim.

All evidence-based claims made by commercial fishery licence holders will be assessed for merit by CAPL. CAPL will not accept claims under this EP if the claim covers the same time, area, fishing activity, or equipment made in another claim for a different seismic survey. If a claim cannot be resolved between CAPL and the fisher, an independent expert will be engaged to assess the claim.

Table 7-5: Commercial fisheries adjustment protocol

Claim type	Considerations
Temporary loss of catch	• Loss of catch by the commercial fishing licence holder is based on an assessment of what the commercial fishing licence holder would have caught during that month within the OA "but for" the 4D MSS • A loss of catch will be concluded if there is a reduction in the catch per unit of effort for each species calculated over a month, compared to the average historical catch per unit of effort for the same species and corresponding month • If a loss of catch is substantiated, payments will be calculated based on the reduced kilograms per species caught, multiplied by the market price per kilogram at the time the catch would have been sold • Loss of catch claims will be assessed for the months during the 4D MSS and for up to 3 months from the completion date • Where a commercial fishing licence holder wants to receive a loss of catch payment, they will need to provide CAPL with monthly catch disposal records and multiple years (preferably 10 years, but will be decided on a case by case basis) of historical data to allow average monthly catch rates per species to be determined • The commercial fishing licence holder must provide evidence that their vessel(s) continued to fish over the claim period • Where a commercial fishing licence holder intends to make a temporary loss of catch claim, they will need to notify CAPL as soon as practicable, and they will need to have submitted the claim and supporting evidence within 6 months of the completion of the 4D MSS.
Displacement	• Where a commercial fishing licence holder is displaced from the OA such that it is required to relocate their operations to another area during the 4D MSS, CAPL will consider a once-off payment to reimburse operational expenses which are in addition to those the commercial fishing licence holder would have borne "but for" the 4D MSS • Where a commercial fishing licence holder intends to make an operational expense claim for relocation, they will need to notify CAPL as soon as practicable and prior to relocating, and state why the seismic survey has caused them to relocate • Where a commercial fishing licence holder wants to be reimbursed for any relocation operational expenses, they will need to provide CAPL with evidence of the operating costs of bait, fuel, wages and any other

Claim type	Considerations
	costs that are additional to the costs that would have been incurred to catch the fish "but for" the relocation • Where a commercial fishing licence holder intends to make a displacement expenses claim, they will need to notify CAPL within 14 days of the displacement occurring, and have submitted the claim and supporting evidence within 1 month of the completion of the 4D MSS.
Equipment loss or damage	• Where a commercial fishing licence holder intends to make an equipment damage or loss expenses claim, they will need to evidence that CAPL was made aware of the specific equipment location and deployment dates • Where a commercial fishing licence holder intends to make an equipment damage or loss expenses claim, they will need to notify CAPL within 14 days of the loss/damage occurring, and have submitted the claim and supporting evidence within 1 month of the completion of the 4D MSS.

7.3.5 Risk management

The risk management process (Ref. 34) assesses and identifies safeguards, which are the hardware and human actions designed to directly prevent or mitigate an incident or event and is designed to be consistent with the environmental risk management requirements of ISO 14001 *Environmental Management System* (Ref. 40) and ISO 31000:2018 *Risk management – Principles and guidelines* (Ref. 39).

This risk management process is summarised in Section 5 of this EP. Additional risk assessments must be undertaken if the MoC process (Section 7.3.2.2) is triggered. Risk assessments are undertaken in accordance with this process.

The *ABU OE Risk Management Process* (Ref. 34) and the *Management of Change for Facilities and Operations* process (Ref. 46) are the key systems CAPL use to ensure, that in accordance with Regulation 14(3)(a) of the OPGGS(E)R, the impacts and risks of the petroleum activity continue to be identified and reduced to ALARP.

7.3.6 Assurance

Within the OEMS, assurance is a common expectation that supports the OE objective of each focus area. The *ABU OE Assurance Process* (Ref. 50) enables CAPL to deliver assurance that safeguards are established and functioning; it details:

- a framework for managing safeguards and verification activities that assure that CAPL complies with applicable legal and OEMS requirements
- a process to identify and resolve potential noncompliance

the minimum qualifications and organisational capability to execute this process. The *ABU OE Assurance Plan* (Ref. 51) is a multi-year plan that documents the CAPL ABU integrated assurance system and associated assurance activities (Figure 7-4). The *ABU OE Assurance Plan* is reviewed and approved annually and includes:

- a list of OE assurance priorities based on risk
- a schedule of assurance activities to evaluate safeguards and verifications (e.g., safeguard assurance workshops, audits, and assurance programs)

- reference to asset assurance plans that outline asset specific assurance activities and risk-based frequency (i.e., field inspection programs, audits, compliance reviews, performance reviews).

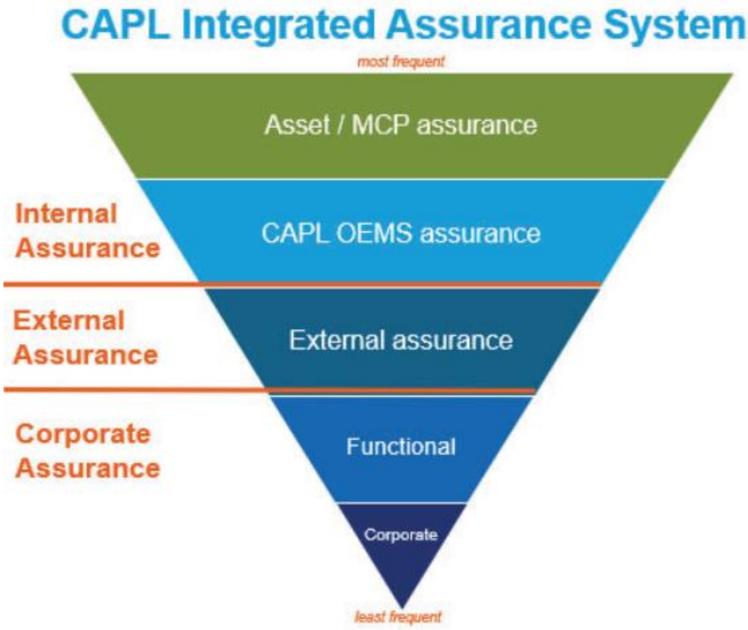


Figure 7-4: ABU integrated assurance system

To support the implementation of the *ABU OE Assurance Process*, CAPL have developed an ABU integrated assurance system (Figure 7-4), which integrates and leverages assurance activities across the various levels of CAPL business through to the corporate level—to provide confidence that safeguards are in place and functioning as intended. This integrated assurance system includes:

- asset / facility / function assurance: ongoing, routine, planned verifications of safeguards specific for the asset / facility (e.g., HSE inspections, audits, asset integrity inspections, preventive maintenance, emergency drills and exercises, compliance reviews, performance reviews)
- ABU OEMS assurance: implemented through the established system-based assurances within the OEMS and ABU OE processes (e.g., assessments, reviews, audits, inspections, workshops, engagements) that support the CAPL assets and major capital project assurance plans and identify and respond to the systemic deterioration of safeguards and progress areas for improvement
- external assurance: assurance activities undertaken by third-party entities (e.g., regulatory inspections, joint venture partner reviews)
- corporate and functional assurance: assurance activities of CAPL functional groups (e.g., drilling and completions, HSE, FE) and OEMS focus areas to address OEMS requirements, safeguards and areas for improvement.

Assurance activities are scheduled on a risk-based approach and conducted to verify the effectiveness of safeguards and verifications and the extent to which requirements are met by CAPL.

Assurance activities focus on in-field activities and administrative processes, depending on the activities being undertaken and assurance priorities (these priorities are based on risk) and provide sufficient demonstration that environmental performance outcomes and environmental performance standards have been met and the activity implemented in accordance with this implementation strategy. A record of all assurance activities undertaken, and the outcomes, are maintained and actions are tracked until closure.

Environmental performance standards in the EP will undergo a compliance review and evidence will be gathered for each environmental performance standard to support the end of activity environmental report. Assurance related to the Wheatstone 4D MSS activities described in this EP will be summarised in the end of activity report submitted to NOPSEMA (Section 7.4.3).

7.3.6.1 Managing Instances of Potential Nonconformance

The reporting, investigation, and tracking of non-conformances are managed via Chevron's *OE Corporate Standard Incident Investigation* (Ref. 53) and *OE Data Reporting Standard* (Ref. 54). These processes apply to instances where the requirements of this EP have not been met. These processes are used if audit findings identify that activities in the scope of this EP are not being implemented in accordance with the risk and impact control measures identified in Section 6.

Audit findings and corrective actions are recorded and tracked in a CAPL compliance assurance database for timely closure of actions. Audit findings that identify a breach of an environmental performance outcome or environmental performance standard will be reported in accordance with Section 7.4.2.

Any suggested changes to activities or control measures arising from audit findings or instances of potential noncompliance will be subject to a MoC process in accordance with Section 7.3.2.2.

7.3.7 Incident investigation and reporting

Incident investigation and reporting (IIR) expectations are to identify, report, record and investigate incidents, analyse trends, correct deficiencies, and share and adopt relevant lessons learned.

The *Incident Investigation and Reporting (II&R) Execution Manual* (Ref. 55) defines the requirements to report, classify, record, and investigate incidents and near misses, including but not limited to injury, occupational illness, environmental impact, reliability, business disruption, and community concern.

The IIR process includes these requirements:

- training for employees and contractors to recognise and report events
- internal and external notification of events
- investigating incidents at the probable level of consequence, with the rigor of investigation based upon learning opportunity and incident severity
- allocating an incident management sponsor for selected investigations
- sharing alerts, lessons learned, and bulletins
- tracking recommended actions to closure
- analysing event trends.

Events that meet the required criteria are recorded in the CAPL incident management system (IMS). The system holds records of the associated investigation results. The lessons learned from selected investigations are shared to reduce the likelihood of future comparable events.

Specific incident reporting requirements for this EP are detailed in Section 7.4.2.

7.3.8 Emergency management

CAPL's emergency management implementation strategy is described in the following sub-sections.

In addition to CAPL's overarching emergency management strategies, and with specific reference to vessel-based activities, an approved SOPEP will also be in place (in accordance with vessel class requirements) as required by MARPOL 73/78 Annex I and Marine Order 91 (Marine pollution prevention – oil). In the event of a vessel-based spill event the SOPEP will be implemented by the Vessel Master. Control measures and environmental performance standards relating to SOPEPs are described in Sections 6.11 and 6.12, and requirement have not been duplicated here.

7.3.8.1 Emergency management arrangements

The emergency management arrangements outline a systematic approach for preventing, preparing for, responding to, and recovering from emergency events and are intended to provide a standardised corporate management and response structure that details emergency management documentation, Emergency Response Organisation (ERO), facilities and equipment, and training and exercises.

The ERO provides a standardised management and response structure for any emergency. Personnel filling roles within this structure may include full-time professionals, but most will be part-time volunteers drawn from across the workforce.

The system used to organise CAPL's emergency management teams (EMTs) is based on the Incident Command System and provides a standardised approach to the coordination of an emergency response across all hazards, including oil spill response. This program is compatible with the Australasian Inter-service Incident Management System (AIIMS), and the *National Plan for Maritime Environmental Emergencies* (National Plan; Ref. 59) and is consistent with the core aspects presented in the International Maritime Organisation (IMO) equivalent courses.

The ERO comprises the groups listed in Table 7-6; this table also describes the major functions of teams during an emergency.

Figure 7-5 to Figure 7-7 outline the organisational chart of the On-site Response Teams (ORTs) and EMTs. The Crisis Management Teams (CMTs), which focus on the business implications of incidents and events, are further described in the *ABU Crisis Management Plan* (Ref. 60).

As the incident escalates and the workload of each function increases, it may be necessary to delegate specific roles to additional people within each section. These roles may lead a team of people to fulfil the tasks under their control.

To establish emergency response arrangements that can be scaled up or down depending on the nature of the incident by integrating with other local, regional, national, and industry plans and resources, CAPL has adopted a tiered approach in its response system. This tiered-response model scales the number of resources mobilised for a response, and the emergency team activated, according to the severity of the incident. This approach is consistent with the *International Convention on Oil Pollution Preparedness, Response and Cooperation 1990*. The response tiers and resources that may be mobilised for an oil spill incident within CAPL are further described within the OPEP (Ref. 2).

Table 7-6: CAPL emergency management teams

Team	Description
Tier 1 (CAPL)	
On-site Response Teams (ORTs)	Responsible for on-scene tactical response operations during an incident. ORTs are led by an On-scene Commander (OC) who has incident control during smaller Level 1A incidents, which do not require further escalation to an incident management team. If the IEMT is activated, the OC will come under the direction of the Operations Section Chief (OSC).
Installation Emergency Management Team (IEMT)	The IEMT is led by an Incident Commander (IC) and operates out of an on-site emergency command centre. The IEMT may be activated to take control of Level 1B incidents and coordinate local resources and ORTs.
Perth Emergency Management Team (PEMT)	The PEMT is led by an IC and operates out of a Perth-based emergency command centre. The PEMT may be activated in a support role to assist IEMTs with the emergency response to major incidents that require coordination of further resources, personnel, and support. If required, incident control may also be transferred from the installation to the PEMT to manage the ongoing response (proactive phase) for long-duration, complex incidents such as a major oil spill. The PEMT stands up at the direction of the PEMT IC for Level 2 and 3 incidents.
CAPL Crisis Management Team (CMT)	Comprises senior CAPL executives and ensures emergency response and crisis management operations are carried out consistent with The Chevron Way, Chevron Corporation policies, and the tenets of OE. The CMT stands up at the direction of the CAPL Crisis Manager for Level 3 incidents.
Tier 2 (Regional Response)	
Chevron Corporation's Asia–Pacific Regional Response Team	An enterprise-level team able to support CAPL during the initial response (reactive phase) to a significant incident and help manage the transition to the ongoing response (proactive phase).
Tier 3 (Global Response)	
Chevron Corporation's Functional Response Teams	Enterprise-level teams with specific technical expertise in selected command staff positions and unit positions in the Planning, Logistics, and Finance sections. Team members are trained to support the management of global- and regional-level (Tier 2 and 3) incidents but are available to support any response.
Chevron Corporation's Worldwide Emergency Response Team	An enterprise-level team of Chevron Corporation's most highly trained and experienced personnel capable of filling IMS command and general staff roles of a response organisation, including Deputy IC. Team members are trained to support the management of global-level (Tier 3) incidents but are available to support any response.
Chevron Corporation's Advisory and Resource Team	An enterprise-level initial assessment and support team available to advise during the initial stages of a significant event, assess incident potential, and help the local response team marshal additional resources.

7.3.8.2 Emergency management process

The *Emergency Management OE Process* (Ref. 56) is CAPL's system for emergency management. The process ensures CAPL is prepared to respond immediately and effectively to all emergencies involving contractor- or CAPL-owned or -operated assets as defined in their scope of work.

The emergency management process (Ref. 56) nine key elements.

- emergency scenarios, including worst case, have been identified; these scenarios are based on the findings from risk assessments of significant safety, health and environmental hazards and other sources (e.g., historical incidents)
- emergency response plans are developed and maintained to address emergency scenarios
- a reliability program is in place for inspection, testing and preventative maintenance of critical emergency response equipment and systems supporting emergency response plans
- an incident management system (IMS) is in place capable of immediately and effectively managing all emergencies
- a training and exercise program, including minimum training and exercise requirements, has been developed to establish and maintain emergency response capability
- crisis management plans have been developed to address a potential crisis or significant event
- business continuity plans have been developed in conformance with the Business Continuity Planning Corporate OE Process (Ref. 61).

The OPEP (Ref. 2) acts as an operational document to ensure an appropriate response to the emergency events described in this EP. Smaller spills will be monitored, evaluated, and cleaned up as part of routine duties, where relevant and appropriate to the nature and scale of the spill, and will not require activation of the ORT or OPEP. Several emergency management subprocesses are outlined below that are integral to emergency preparedness and management.

7.3.8.3 Chain of command (emergency response)

A well-delineated EMT chain of command has been established for emergency response (Figure 7-5 to Figure 7-7). As incidents grow in size or complexity, command may transfer several times. Within the response structure, command may transfer between On-scene Commanders (OC) at the tactical level. For a major incident, incident command may transfer to a designated Control Agency or to the Perth EMT, if required.

Although the identity of those filling command positions may change over the course of the incident, the continuity of responsibility and accountability will be maintained. Typically, specialists for particular response options will fulfil Task Leader positions in the ORT where they will be expected to oversee a team or particular response operations.

Throughout an incident, a formal handover will be conducted whenever any command or control position is transferred from one person to another.

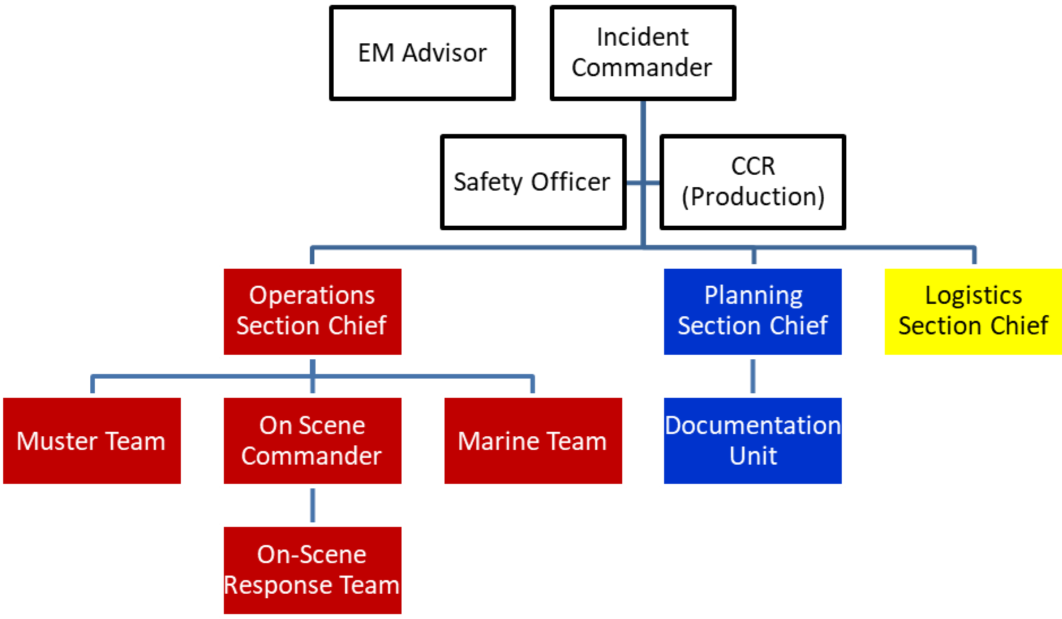


Figure 7-5: Basic installation EMT organisation chart

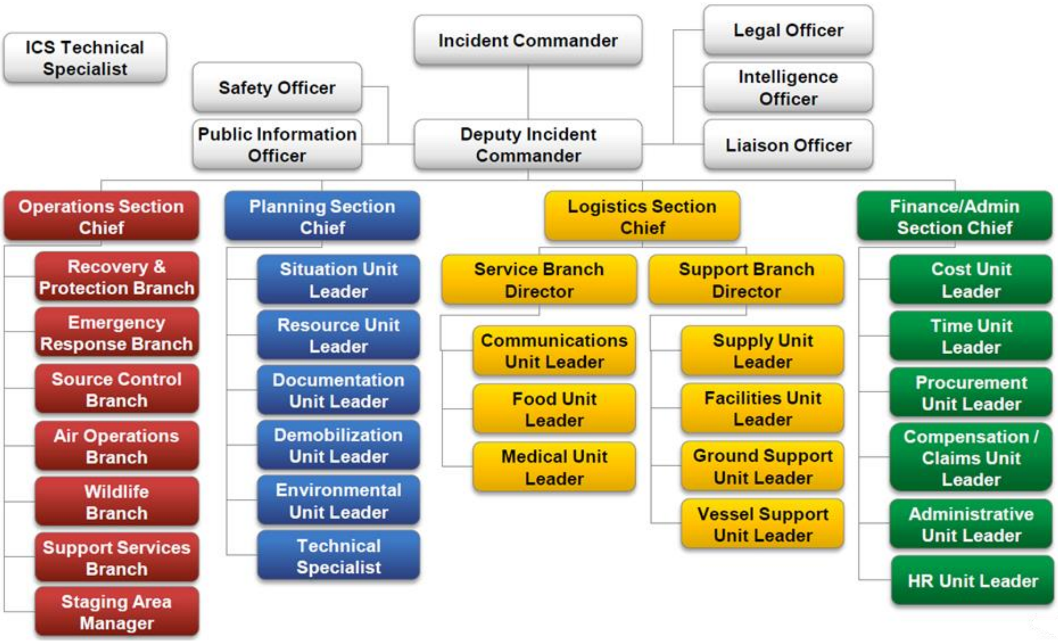


Figure 7-6: Expanded EMT organisation chart

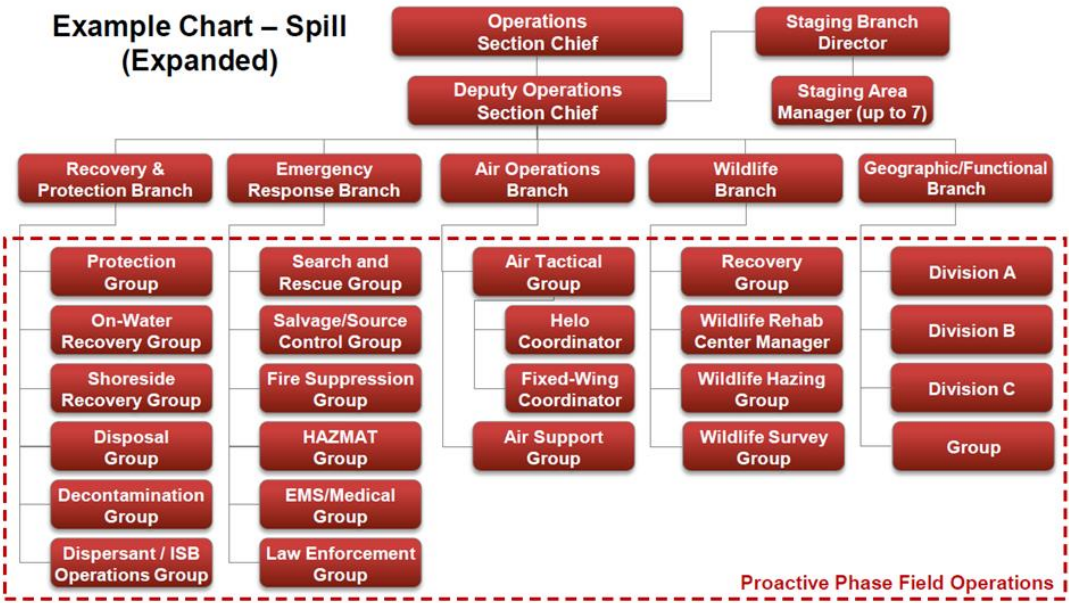


Figure 7-7: Example expanded operations section organisation chart

7.3.8.4 Roles and responsibilities (emergency response)

Table 7-7 provides additional information about the structure of these teams and the key individual roles and responsibilities during emergency response.

Table 7-7: Key roles and responsibilities—emergency response

Role	Responsibilities
On-Site Response Team	
On-Scene Commander (OC) *(Vessel Master)*	• Safely and effectively organises and manages the ORT response operations • Keeps the EMT informed regarding the nature and status of the incident and on-site tactical response operations
Site Safety Officer	• Ensures that appropriate actions are taken to protect the safety and health of ORT response personnel
Task Leader	• Safely carries out their assignment consistent with directions received from the OC, branch director, division, or group supervisor
Emergency Management Team	
Incident Commander (IC)	• Manages the overall emergency response operations and ensures that they are carried out safely, effectively, and efficiently • Establishes direct line of communications with the OC • Mobilises the EMT and assigns additional support from other response teams (as appropriate to the incident) for Level 2 and 3 incidents that require support beyond the ORT
Operations Section Chief (OSC)	• Provides strategic direction and support to the OC and muster and/or shelter area managers • Receives information regarding the nature and status of the ORT and provides support for mustering and/or shelter-in-place operations • Disseminates information to the IC and other members of the EMT
Planning Section Chief	• Focuses on the incident's potential using the compilation and display of information regarding the nature and status of an incident and emergency response operations

Role	Responsibilities
	• Assists the IC in defining strategic objectives • Assists the IC in providing information to the Level 3 EMT • Compiles and retains documentation
Logistics Section Chief	• Obtains personnel, equipment, materials, and supplies needed to mount and sustain emergency response operations • Provides services necessary to ensure that emergency response operations are carried out safely and efficiently

7.3.8.5 Training and competency (emergency response)

Competencies and training requirements for the EMT, ORT, and other personnel during implementation of the OPEP (Ref. 2) are outlined in Table 7-8. Competency and training records for personnel, including contractors and subcontractors, are maintained.

Table 7-8: Competency and training requirements—emergency response

Role	Summary	Training Standard
Note: Personnel with no specialist emergency response duties should undergo training in line with their responsibilities as indicated below for 'All personnel'.		
All personnel	• Provide basic first response to an incident, including, but not limited to: conducting a quick assessment; making safe; notifying anyone else in danger; and raising the alarm • Complete basic procedures in response to an alarm and evacuate to a muster point (as necessary) • Frequency: every 3 years if not involved in response or drills/exercises	
In addition to the above, personnel responsible for roles with specialist oil spill response duties should undergo further training and practice in line with the responsibilities set out below. Training is provided to maintain the capability to respond to all hazards in line with the Incident Command System implemented by CAPL.		
Emergency Management Teams (EMTs)		
PEMT Incident Commander	• Selected Perth based personnel, would typically with a manager or senior manager role within CAPL • Competencies: overall management of emergency response operations and ensure operations are performed safely, effectively, and efficiently. Commands the EMT • Frequency: once a year (maintenance of competencies may be through response or training/drills/exercises)	• ICS-100 Introduction to the Incident Command System • ICS-200 Basic Incident Command System training • ICS-220 Initial Response Team • ICS-300 Intermediate Incident Command System Training (PEMT members only) • Oil Spill Awareness Training
PEMT Command and General Staff	• Selected Perth based personnel, typically a manager, or personnel with skills and knowledge appropriate to the function • Competencies: provides strategic direction, internal	• ICS-100 Introduction to the Incident Command System • ICS-200 Basic Incident Command System training • ICS-220 Initial Response Team

Role	Summary	Training Standard
	planning, logistics, and operational support. Operates from the emergency command centre and supports the IC who is responsible for the overall control of the incident • Frequency: once a year (maintenance of competencies may be through response or training/drills/exercises)	• ICS-300 Intermediate Incident Command System Training (PEMT members only) • Oil Spill Awareness Training

7.3.8.6 Oil spill exercise schedule

The CAPL *Oil Spill Response Multi-Year Exercise and Drill Schedule* (Ref. 62) describes the schedule of training and exercise required for all emergency events. The training and exercise program incorporates CAPL's oil spill exercise schedule for oil spill training, drills, and exercises. As CAPL's response arrangements are common among its assets, and resource capabilities are shared, the testing and exercise schedule has been developed to test the various response options. The focus changes for each exercise to ensure any unique aspects of that location (e.g., resources at risk, first-strike equipment) are tested.

The objective is to test and maintain the capability to respond to emergency events. The exercises aim to test:

- notification, activation, and mobilisation of the ORT and EMT
- efficiency and effectiveness of equipment deployment
- efficiency and effectiveness of communication systems.

The testing schedule is a live document that is subject to change. The multi-year exercise schedule (Ref. 62) outlines the proposed testing arrangements to be completed, including the exercise types (Table 7-9) and proposed level of response to be tested (Table 7-10) that may be used to meet the defined objectives. A minimum of one test for each level will be conducted each year.

Table 7-9: Exercise types

Type	Details
Notification exercise	• Tests the procedures to notify and activate the EMTs, support organisations, and regulators
Tabletop exercise	• Normally involves interactive discussions of a simulated scenario amongst members of an EMT; personnel or equipment are not mobilised
Drill	• Conducts field activities such as equipment deployment, shoreline assessment, monitoring etc.
Functional exercise	• Activates at least one EMT to establish command, control, and coordination of a serious emergency event • Often more complex as it simulates several different aspects of an oil spill incident and may involve third parties.

Table 7-10: Exercise levels

Level	Details
Level 1 – ORT	• May be held in conjunction with a Level 2 EMT exercise • Designed to evaluate the ability of ORTs to implement the Gorgon Emergency Management System as it applies to ORTs • ORTs are encouraged to conduct as many exercises as they want each year that do not include the ERO or a Level 2 EMT
Level 2 – EMT	• Exercises may include the participation of an ORT and may be held in conjunction with a Level 3 EMT exercise • Usual duration – one to two hours • Designed to evaluate a Level 2 EMT's ability to notify and activate team members, set up a Level 2 EMT emergency command centre, and implement the Gorgon Emergency Management System as it applies to Level 2 EMTs
Level 3 – EMT	• Each exercise may include the participation of a Level 2 EMT and/or ORT • Usual duration – three to six hours • Designed to evaluate the EMT's ability to notify and activate team members, transfer command to a Level 3 EMT Emergency Command Centre and implement the Gorgon Emergency Management System as it applies to incident escalation

The training and exercise program outlines the process for evaluating training, drills, and exercises against defined objectives, and incorporating lessons learned. An after-action report is generated for all Level 2 (and above) exercises, which is used during spill exercises to assess the effectiveness of the exercise against its objectives and to record recommendations. Relevant actions are then assigned to the responsible party where they are tracked to completion using internal processes. Exercise planners will be required to refer to previous recommendations for continual review and improvement.

Response arrangements as detailed in the OPEP (Ref. 2) must be tested:

- when they are introduced
- when they are significantly amended
- not later than 12 months after the most recent test
- if a new location for the activity is added to this EP after the response arrangements have been tested, and before the next test is conducted: test the response arrangements in relation to the new location as soon as practicable after it is added to this EP

7.4 Environmental monitoring and reporting

7.4.1 Environmental monitoring

Regulation 14(7) of OPGGS(E)R requires that the implementation strategy provides for sufficient monitoring of, and maintaining a quantitative record of, emissions and discharges such that this record can be used to assess whether the environmental performance outcomes and standards in the EP are being met.

CAPL and vessel contractors will monitor and record emissions and discharges as detailed in Section 6 to ensure that that this record can be used to assess whether the environmental performance outcomes and standards in this EP are being met.

If an emergency condition resulting in a Level 2 or 3 spill event occurs, CAPL will implement the OSMP (Ref. 3), which is identified as a control measure in Section 6.12 and Section 6.13.4. The OSMP describes a program of monitoring, and is the principal tool for determining the extent, severity, and persistence of environmental impacts from an emergency condition and the emergency response activities to be undertaken by CAPL.

7.4.2 Incident reporting

Environmental incidents will be reported by CAPL in accordance with Table 7-11.

Table 7-11: Incident reporting

<table>
<tr><th colspan="2">Recordable Incident reporting – Regulation 26B</th></tr>
<tr><td colspan="2">Legislative definition of 'recordable incident':
'Recordable incident, for an activity, means a breach of an environmental performance objective or environmental performance standard, in the environment plan that applies to the activity, that is not a reportable incident'
Recordable incidents are breaches of the environmental performance outcomes and standards described in Section 5.7.</td></tr>
<tr><td>Reporting requirements</td><td>Report to / Timing</td></tr>
<tr><td>Written notification to NOPSEMA by the 15th of each month
As a minimum, the written incident report must describe:
• the incidents and all material facts and circumstances concerning the incidents
• any actions taken to avoid or mitigate any adverse environmental impacts
• any corrective actions already taken, or that may be taken, to prevent a repeat of similar incidents.
If no recordable incidents occur during the reporting month, a 'nil report' will be submitted.</td><td>Submit written report to NOPSEMA by the 15th of each month</td></tr>
<tr><th colspan="2">Reportable Incident reporting – Regulations 26, 26A, and 26AA</th></tr>
<tr><td colspan="2">Legislative definition of 'reportable incident':
'Reportable incident, for an activity means an incident relating to an activity that has caused, or has the potential to cause an adverse environmental impact; and under the environmental risk assessment process the environmental impact is categorised as moderate or more serious than moderate.'
Therefore, reportable incidents under this EP are those events (not planned activities) that have a moderate or greater consequence (or risk) level. In accordance with this definition, the reportable incidents identified under this EP are:
• introduction of an IMP (Section 6.7).</td></tr>
<tr><td>Reporting requirements</td><td>Report to</td></tr>
<tr><td>Verbal or written notification must be undertaken within two hours of the incident or as soon as practicable. This information is required:
• the incident and all material facts and circumstances known at the time
• any actions taken to avoid or mitigate any adverse environmental impacts.</td><td>Report verbally to NOPSEMA within two hours or as soon as practicable and provide written record of notification by email.
Phone: (08) 6461 7090
Email: submissions@nopsema.gov.au</td></tr>
</table>

Verbal notifications must be followed by a written report as soon as practicable, and not later than three days following the incident. At a minimum, the written incident report will include: • the incident and all material facts and circumstances • actions taken to avoid or mitigate any adverse environmental impacts • any corrective actions already taken, or that may be taken, to prevent a recurrence. If the initial notification of the reportable incident was verbal, this information must be included in the written report.	Written report to be provided to: • NOPSEMA: submissions@nopsema.gov.au • National Offshore Petroleum Titles Authority: info@nopta.gov.au
Additional Reporting Requirements	
Reporting requirements	**Report to**
An oil/gas pollution incident that occurs within a marine park or is likely to impact on a marine park. The notification should include: • titleholder details • time and location of the incident (including name of marine park likely to be affected) • proposed response arrangements as per the OPEP (e.g., dispersant, containment, etc.) • confirmation of providing access to relevant monitoring and evaluation reports when available • contact details for the response coordinator.	Report verbally to the DNP (24-hour) Marine Duty Officer as soon as practicable, and also provide a follow-up email. Phone: 0419 293 465 Email: marine.compliance@environment.gov.au
Death or injury to individual(s) from an EPBC Act Listed Species as a result of the petroleum activities	Report injury to or mortality of EPBC Act Listed Threatened or Migratory species within seven business days of observation to DAWE or equivalent: • Phone: +61 2 6274 1111 • Email: EPBC.Permits@environment.gov.au
Vessel collision with marine mammals (whales)	Reported as soon as practicable. https://data.marinemammals.gov.au/report/shipstrike
Presence of any suspected IMP or disease within 24 hours	DPIRD: • Email: biosecurity@fish.wa.gov.au • Phone: FishWatch 24-hour hotline: 1800 815 507
Unplanned release that is likely to impact land or water within Western Australian State jurisdiction	Reported as soon as practicable. petroleum.environment@dmirs.wa.gov.au

7.4.3 Routine environmental reporting

Regulation 26C of the OPGGS(E)R requires environmental performance reporting for the activity described in this EP, as summarised in Table 7-12. Routine notifications required by Regulations 29 and 30 of the OPGGS(E)R and also included in Table 7-12.

Table 7-12: Routine external reporting requirements

Reporting requirement	Description	Reporting to	Timing
Environmental performance reporting	A report detailing environmental performance of the activity detailed in this EP	NOPSEMA submissions@nopsema.gov.au Phone: +61 8 6461 7090	Within three months of completion of activities
Notification of start of activity	CAPL must complete Form FM1405 and submit to NOPSEMA at least 10 days before activity commencement	NOPSEMA submissions@nopsema.gov.au or: https://securefile.nopsema.gov.au/filedrop/submissions	Once prior to activity commencement
Notification of start of activity	CAPL must notify DNP at least 10 days before commencement of the activity within an AMP. The notification should include: • titleholder details • contact details for a titleholder representative • details of the OA and overlap with an AMP • name and IMO vessel number of vessel/s entering an AMP • type and duration of activity • link to activity summary on NOPSEMA website.	DNP: marineparks@environment.gov.au	Once prior to activity commencement within an AMP
Notification of start of activity	CAPL will provide DMIRS a pre-start notification confirming the start date of the proposed activity	DMIRS: Petroleum.environment@dmirs.wa.gov.au	Once prior to activity commencement
End of EP notification	CAPL must complete Form FM1405 and submit to NOPSEMA within 10 days of activity completion	NOPSEMA submissions@nopsema.gov.au or: https://securefile.nopsema.gov.au/filedrop/submissions	Once post activity completion
Notification of conclusion of activity	CAPL must notify DNP following completion of the activity within an AMP.	DNP: marineparks@environment.gov.au	Once post to activity completion within an AMP

Reporting requirement	Description	Reporting to	Timing
Notification of conclusion of activity	CAPL must notify DMIRS following completion of the activity	DMIRS: Petroleum.environment@dmirs.wa.gov.au	Once post activity completion

7.5 Environment Plan review

If required, any revisions and/or resubmission of this EP to NOPSEMA, in accordance with Regulation 17 of the OPGGS(E), will be undertaken in accordance with the OEMS, and particularly the MoC process (Section 7.3.2.2).

8 abbreviations and definitions

Table 8-1 defines the acronyms and abbreviations used in this document.

Table 8-1: Abbreviations and Definitions

Acronym/ Abbreviation	Definition
AASM	Airgun array source model
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABU	Australian Business Unit
ACN	Australian Company Number
AFMA	Australian Fisheries Management Authority
AHO	Australian Hydrographic Office
AIIMS	Australasian Inter-service Incident Management System
AIMS	Australian Institute of Marine Science
AIS	Automated identification system
ALARP	As low as reasonably practicable
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
API	American petroleum index
APPEA	Australian Petroleum Production and Exploration Association
ASOG	Activity-specific operational guideline
AUSCOAST	A type of navigational warning
BIA	Biologically important areas
BTAC	Buurabalayji Thalanyji Aboriginal Corporation
CAPL	Chevron Australia Pty Ltd
CAR	Containment and recovery
CEFAS	(United Kingdom) Centre for Environment, Fisheries and Aquaculture Science
CHARM	Chemical Hazard Assessment and Risk Management
CMT	Crisis Management Team
DAWE	(Commonwealth) Department of Agriculture, Water and the Environment
DBCA	(Western Australia) Department of Biodiversity, Conservation and Attractions
DEWHA	(Commonwealth) Department of the Environment, Water, Heritage and the Arts
DMIRS	(Western Australia) Department of Mines, Industry Regulation and Safety
DNP	(Commonwealth) Director of National Parks
DoT	(Western Australia) Department of Transport
DP	Dynamic positioning
DPIRD	(Western Australia) Department of Primary Industries and Regional Development
EEA	Environmental exposure area

Acronym/ Abbreviation	Definition
EIS	Environmental impact statement
EMBA	Environment that may be affected
EMT	Emergency Management Team
EP	Environment Plan
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ERO	Emergency Response Organisation
ESD	Ecologically sustainable development
FE	Facilities engineering
FPZ	Full power zone
GDA	Geocentric datum of Australia
GHG	Greenhouse gas
HB	Handbook
HFO	Heavy fuel oil
HIRA	Hazard Identification and Risk Assessment
HSE	Health, safety, and environment
IAPP	International Air Pollution Prevention
IBRA	Interim Biogeographic Regionalisation for Australia
IC	Incident Commander
IEE	International energy efficiency
IEMT	Installation Emergency Management Team
IFO	Intermediate fuel oil
IIR	Incident investigation and reporting
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organisation
IMP	Invasive marine pest
IMS	Incident management system
IOPP	International Oil Pollution Prevention
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardisation
ISPP	International Sewage Pollution Prevention
ITOPF	International Tanker Owners Pollution Federation Limited
JASMINE	JASCO Animal Simulation Model Including Noise Exposure model
JRCC	Joint Resource Coordination Centre
KEF	Key ecological feature
km	Kilometre
LC_{50}	Lethal concentration with the potential to result in a 50% mortality of a sample population

Acronym/ Abbreviation	Definition
LNG	Liquefied natural gas
LOC	Loss of containment
m	Metre
MarCHES	Marine Contractor HES
MARPOL	The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978; also known as MARPOL 73/78.
MARS	Maritime Arrivals Reporting System
MAZ	Multi-azimuth
MBES	Multibeam echo sounder
MDO	Marine diesel oil
MES	Monitoring, evaluation, and surveillance
MFO	Marine fauna observer
MGO	Marine gas oil
MoC	Management of change
MODU	Mobile offshore drilling unit
MOPO	Matrix of permitted operations
MSC	Management system cycle
MSRE	Marine safety reliability and efficiency
MSS	Marine seismic survey
MSW	Managing safe work
N/A	Not applicable
NEBA	Net environmental benefit analysis
NEPA	National Environmental Protection Measure
NERA	National Energy Resources Australia
NMFS	National Marine Fisheries Service
NOAA	(United States) National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environment Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NSW	New South Wales
NT	Northern Territory
NWS	North West Shelf (of Western Australia)
NWSTF	North West Slope Trawl Fishery
OA	Operational area
OC	On-scene Commander
OCNS	Offshore Chemical Notification Scheme
OE	Operational Excellence
OEMS	Operational Excellence Management System

Acronym/ Abbreviation	Definition
OGUK	Oil and Gas UK
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS(E)R	Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
ORT	On-site Response Team
OSC	Operations Section Chief
OSMP	Operational and Scientific Monitoring Plan
OVIS	Offshore Vessel Information System
OWR	Oiled wildlife response
PAH	Polycyclic aromatic hydrocarbon
PAM	Passive acoustic monitoring
PCB	Prescribed Body Corporate
PEMT	Perth Emergency Management Team
PGPA	Policy, Government, and Public Affairs
PMST	Protected matters search tool
PPP	Protection Prioritisation Process
PSZ	Petroleum safety zone
PTS	Permanent threshold shift
PTW	Permit to Work
ROV	Remotely operated underwater vehicle
SEEMP	Ship Energy Efficiency Management Plan
SEL	Sound exposure level
SHC	Shoreline clean-up
SIMAP	Spill Impact Mapping and Analysis Program
SIMOPS	Simultaneous operations
SMPEP	Shipboard Marine Pollution Emergency Plan
SNA	Safe navigation area
SOPEP	Ship Oil Pollution Emergency Plan
SPD	Shoreline protection and deflection
SPL	Sound pressure level
SRD	Streamer recovery device
TEC	Threatened ecological community
TTS	Temporary threshold shift
UK	United Kingdom
VHF	Very high frequency radio
WA	Western Australia

Acronym/ Abbreviation	Definition
WAFIC	Western Australian Fisheries Industry Council
YACMAC	Yaburara and Coastal Mardudhunera Aboriginal Corporation

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appendix a operational excellence—policy 530

policy 530

operational excellence: achieving world-class performance

It is the policy of Chevron Corporation to protect the safety and health of people and the environment, and to conduct our operations reliably and efficiently. The Operational Excellence Management System (OEMS) is the way Chevron systematically manages workforce safety and health, process safety, reliability and integrity, environment, efficiency, security, and stakeholder engagement and issues. OEMS puts into action our Chevron Way value of Protecting People and the Environment, which places the highest priority on the safety and health of our workforce and the protection of communities, the environment and our assets. Compliance with the law is a foundation for the OEMS.

Our OEMS is a risk-based system used to understand and mitigate risks and maintain and assure safeguards. OEMS consists of three parts:

leadership and OE culture

Leadership is the largest single factor for success in OE. Leaders are accountable not only for achieving results, but achieving them in the right way. Leaders must demonstrate consistent and rigorous application of OE to drive performance and meet OE objectives.

focus areas and OE expectations

Chevron manages risks to our employees, contractors, the communities where we operate, the environment and our assets through focus areas and OE expectations that guide the design, management and assurance of safeguards.

management system cycle

Chevron takes a systematic approach to set and align objectives; identify, prioritize and close gaps; strengthen safeguards and improve OE results.

We will assess and take steps to manage OE risks within the following framework of focus areas and OE expectations:

Workforce Safety and Health: We provide a safe and healthy workplace for our employees and contractors. Our highest priorities are to eliminate fatalities and prevent serious injuries and illnesses.

Process Safety, Reliability and Integrity: We manage the integrity of operating systems through design principles and engineering and operating practices to prevent and mitigate process safety incidents. We execute reliability programs so that equipment, components and systems perform their required functions across the full asset lifecycle.

Environment: We protect the environment through responsible design, development, operations and asset retirement.

Efficiency: We use energy and resources efficiently to continually improve and drive value.

Security: We protect personnel, facilities, information, systems, business operations and our reputation. We proactively identify security risks, develop personnel and sustainable programs to mitigate those risks, and continually evaluate the effectiveness of these efforts.

Stakeholders: We engage stakeholders to foster trust, build relationships, and promote two-way dialogue to manage potential impacts and create business opportunities. We work with our stakeholders in a socially responsible and ethical manner, consistent with our respect for human rights, to create a safer, more inclusive business environment. We also work with our partners to responsibly manage Chevron's non-operated joint venture partnerships and third-party aviation and marine activities.

There are specific OE expectations which need to be met under each focus area. Additional expectations apply to all focus areas and address legal, regulatory and OE compliance; risk management; assurance; competency; learning; human performance; technology; product stewardship; contractor OE management; incident investigation and reporting; and emergency management.

Through disciplined application of the OEMS, we integrate OE processes, standards, procedures and behaviours into our daily operations. While leaders are responsible for managing the OEMS and enabling OE performance, every individual in Chevron's workforce is accountable for complying with the principles of 'Do it safely or not at all' and 'There is always time to do it right'.

Line management has the primary responsibility for complying with this policy and applicable legal requirements within their respective functions and authority limits. Line management will communicate this policy to their respective employees and will establish policies, processes, programs and standards consistent with expectations of the OEMS.

Employees are responsible for understanding the risks that they manage and the safeguards that need to be in place to mitigate those risks. Employees are responsible for taking action consistent with all Company policies, and laws applicable to their assigned duties and responsibilities. Accordingly, employees who are unsure of the legal or regulatory implications of their actions are responsible for seeking management or supervisory guidance.

M Hatfield

Mark Hatfield
Managing Director, Australasia Business Unit

the human energy company™

appendix b stakeholder engagement—fact sheet

wheatstone 4D seismic program

environment plan commercial fishing consultation

June 2021

overview

Chevron Australia is planning to conduct a 4D seismic survey over the Wheatstone and Iago gas fields as part of its standard reservoir management practice.

The proposed survey will be conducted using conventional seismic survey equipment and methodology. It will serve as a "timelapse" measurement and will be compared to data acquired in 2011/2012 to assist Chevron understand how the Wheatstone reservoir is performing.

location and water depths

The survey will be conducted within WA-46-L, WA-47-L, WA-48-L and surrounding permits located approximately 150 kilometers north-west of Dampier with water depths ranging from 80 to 1,140m depths.

At its closest point the full power zone will also be about 36km from the Montebello Islands.

See location map on page 5.

schedule and duration

Expected start is late 2022 or early 2023, subject to approvals and vessel availability. The project will run approximately 60-80 days depending on weather conditions.

activity summary

The proposed survey will be conducted by a purpose-built seismic vessel that will traverse a series of "sail lines" within the operational area at a speed of around 7-9kph. The vessel will follow as closely as possible the sail lines from the 2011/2012 survey.

The vessel will use compressed air to create "bubbles" that collapse and send directionally focused low-frequency sound waves towards the sea floor. A series of hydrophones (located in a series of streamers trailed behind the vessel) then capture the returning sound waves and record the data that is later interpreted by geoscientists.

The seismic vessel contracted for the Wheatstone 4D survey will tow the following equipment:

- Up to 14 streamers at a length of up to 7 kms and a depth of up to 25m.
- Two source arrays of approximately 4,130 cu.in. volume at a depth of 5-8m.

For best 4D seismic data results, the 2022/23 source size must match that of the 2011/12 survey.

A small number of support and chase vessels (likely two) will be used to assist with re-supply, re-fueling and other standby functions.

seismic surveys (3D and 4D)

Seismic surveys produce detailed images of the geology beneath the earth's surface. This information can assist identify location and size of oil and gas reservoirs and how, over time, a reservoir is performing.

A 4D seismic survey is simply a time-lapse version of 3D and allows for comparison with previous surveys to provide a better understanding of what is occurring in reservoirs over time.

survey area

The Wheatstone 4D full power zone is about 1,644 km^2 while the operational area associated with the survey will be about 3,700km^2. See location map for more details.

approvals process

Petroleum activities in Commonwealth waters, which includes seismic surveys, are regulated by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

Before a seismic survey can take place, Chevron Australia must develop a plan for managing the environment (the Environment Plan or EP) which will be assessed by NOPSEMA in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009)*.

The EP will describe the environment in which the survey will take place, an assessment of the impacts and risks arising from the survey, and the identification of control measures to manage the potential impacts and risks to levels that are acceptable and as low as reasonably practicable (ALARP).

The EP is also required to outline how relevant stakeholders whose interests, functions and activities may be affected by the survey have been identified, engaged and consulted. The EP must include how feedback has been assessed and responded to.

Seismic survey environment plans must be submitted to NOPSEMA and published on its website for a 30-day public comment period.

Chevron Australia is currently aiming for the EP associated with this activity to be made available for broader public comment in late Q3 or early Q4 2021.

Chevron Australia is seeking comments on the proposed activities from relevant and interested stakeholders during the development of the EP and ahead of the formal public consultation period.

commercial fishing

Chevron Australia recognises the commercial fishing sector is an important and relevant stakeholder group whose members may have interests, functions, and activities that could be affected by the activities associated with this program. Chevron Australia is committed to engaging early and working proactively with the commercial fishing sector and specific information tailored for the sector will be developed and distributed to relevant stakeholders using advice from the Western Australia Fishing Industry Council (WAFIC). On-the-water communications and cooperation is a Chevron Australia priority.

diving

It is highly unlikely seismic noise would be detectable to the human ear but as the survey will be conducted about 36km from the Montebello Islands relevant commercial charters, tour operators and the WA Charter Boat Owners and Operators Association will be informed and consulted.

broader stakeholders

As well as consulting commercial fishing and other relevant stakeholders, Chevron Australia will keep informed any stakeholders who identify an interest in our planned activities.

environmental impact

Seismic surveying is an established science with strict requirements and operational procedures in place to minimise potential impact to the marine environment.

As part of the environmental approval process associated with an Environment Plan, we will outline the general marine environment and control measures to manage the potential impacts and risks. Proposed control measures are outlined on page 4 and any additional control measures identified during stakeholder engagement and the public comment period will be considered for inclusion in the Environment Plan. All relevant and available scientific information relating to potential environment impacts and risks, including to target fish species, will be considered in developing the Environment Plan.

communications with mariners

Seismic vessels will operate within the Operational Area and marine notices will be issued prior to the start of work to alert other mariners that access to these areas may be limited. This will include a temporary 500m 'safe navigation area' around the primary vessel and streamers during seismic operations.

Updates will be provided on vessel movements and activities to meet relevant stakeholder needs. Chevron Australia will ensure open radio access between other ocean users and the primary seismic vessel to enhance on-the-water communications. Radio information will be communicated to relevant potentially affected parties as part of the start-up notification process prior to survey commencement.

implications for stakeholders

Chevron is assessing potential impacts and risks to the marine environment and relevant stakeholders from the planned seismic activities and is considering timing, duration, location and potential impacts. These, and proposed control measures are summarised on page 4.

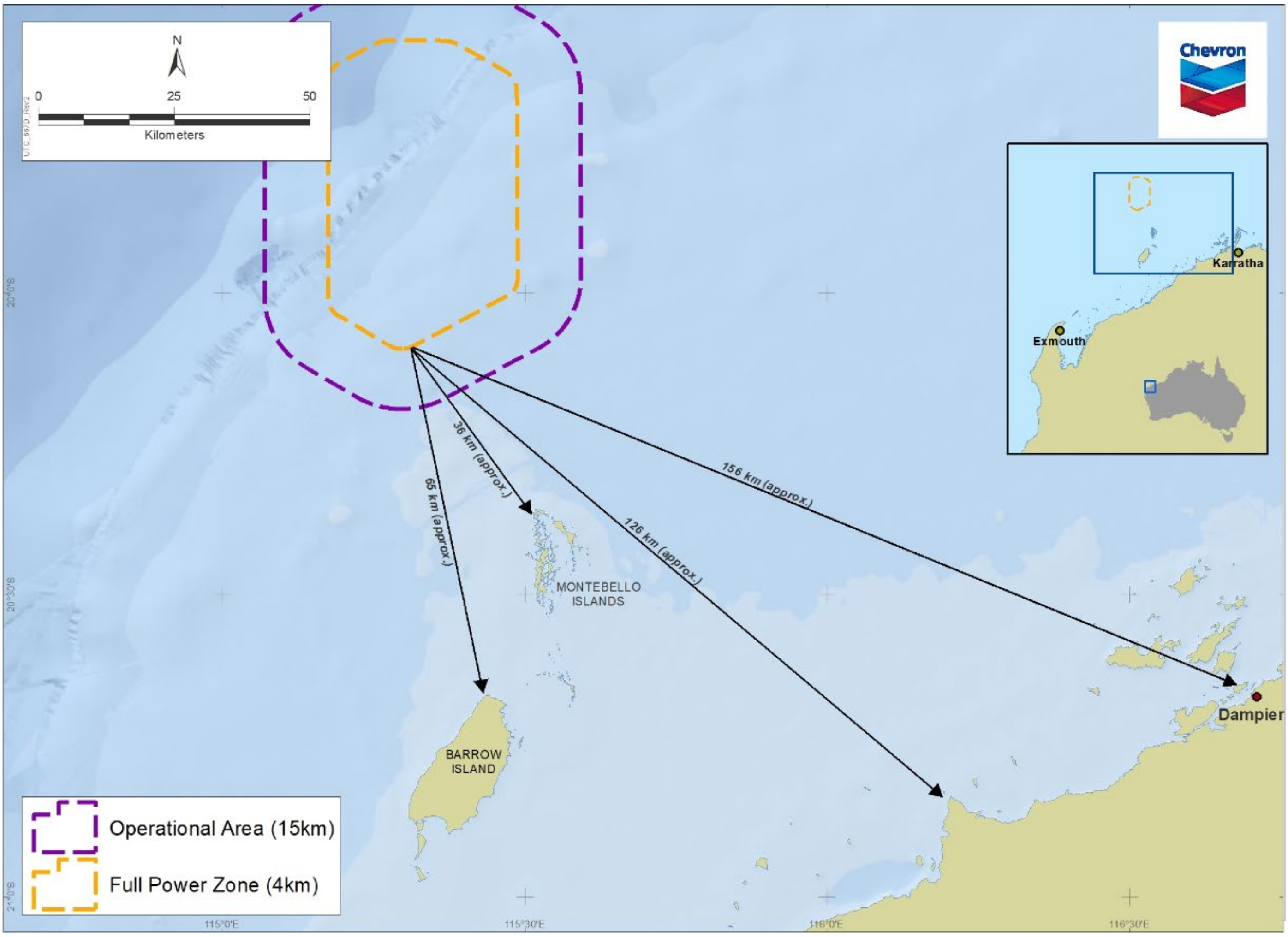
Further details will be provided in the Environment Plan and will incorporate feedback generated during the consultation process.

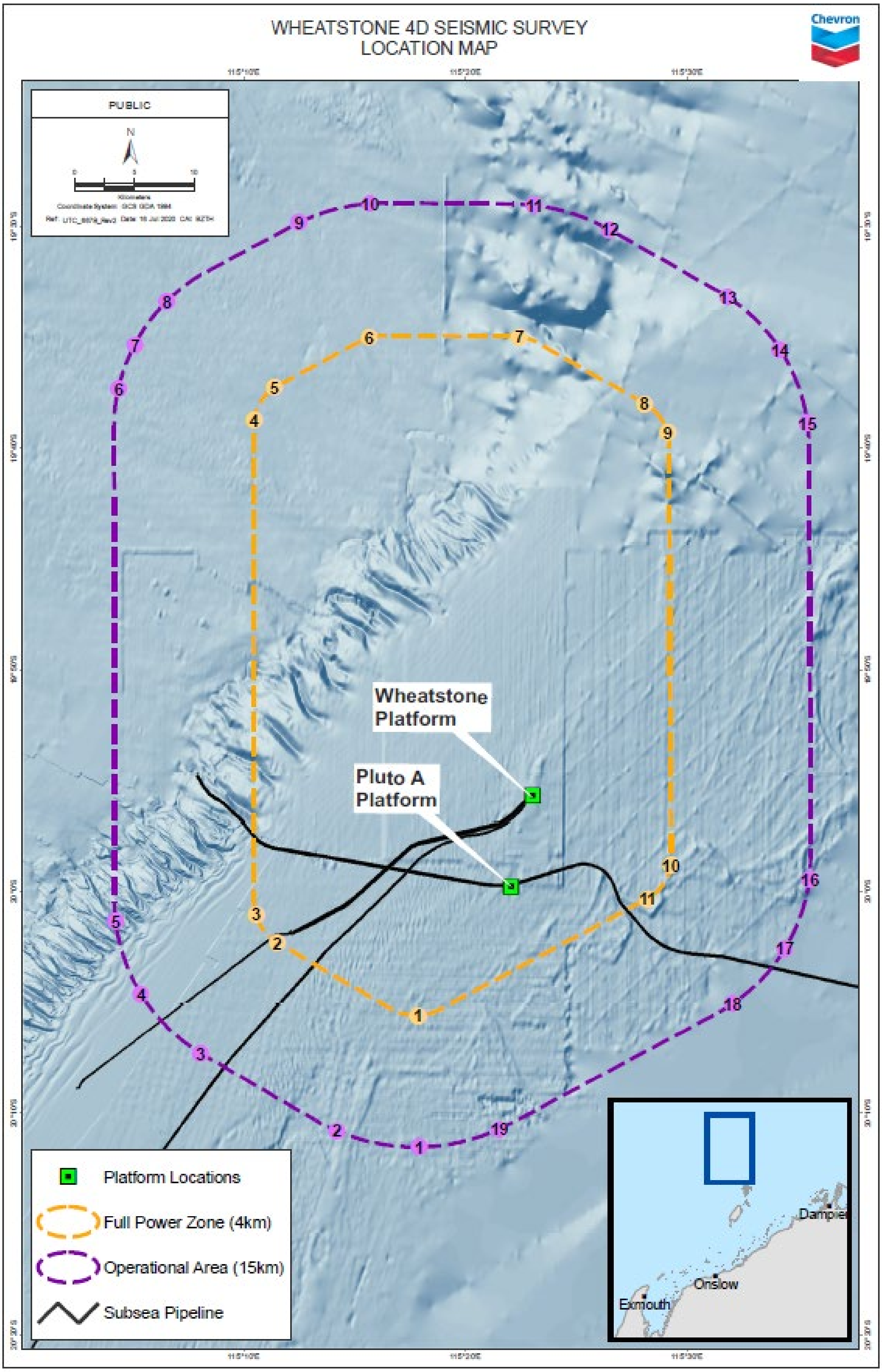
Summary of key impacts/risks and proposed controls

Potential Impact or Risk	Proposed Control
Planned Activities	
Interests of relevant stakeholders: • Defence activities • Petroleum operations and exploration • Shipping • Diving	• Consultation with petroleum titleholders, commercial fishers and their representative organisations and government departments to inform decision-making for the activity and development of the EP. • Notification to relevant stakeholders a minimum of four weeks prior to the commencement of activities. • Ongoing consultation via updates on vessel movements during the survey at a frequency to meet relevant stakeholder needs.
Commercial fishing	• Working with Department of Primary Industries and Regional Development (Fisheries) to have a comprehensive understanding of peak fish spawning activities of the key indicator commercial species and, where reasonable, to avoid peak spawning periods. • Consultation with commercial fishers and their representative organisations, and government departments (i.e. DPIRD, Australian Fisheries Management Authority) to inform decision making for the activity and development of the EP. • Notification to relevant stakeholders a minimum of four weeks prior to the commencement of activities. • Ongoing consultation by way of updates on vessel movements during the survey at a frequency to meet relevant stakeholder needs, encouraging ease of radio access between the seismic vessel and commercial fishing operators. • Chevron will consider an evidence-based adjustment protocol for the commercial fishing sector should fisher(s) be verifiably impacted to a commercially material extent by the seismic program. This will be explored with WAFIC during the development of the EP.
Marine fauna interactions	• Two dedicated marine fauna observers on survey vessel throughout the survey. • Marine fauna sightings recorded and reported to Commonwealth Department of Agriculture, Water and the Environment.
Underwater noise	• Implementation of Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Policy Statement 2.1. • Noise modelling to inform potential impacts and input to mitigation and management measures.
Marine discharges	• Marine discharges managed as per legislative requirements.
Vessel interaction	• Relevant marine users and Government maritime safety agencies notified of survey start and end dates, vessel details and any exclusion zones prior to commencement of the survey. • A 500 m radius safe navigation area will be in place around the seismic vessel and streamers during the survey. • Seismic vessel will display appropriate day shapes and lights to indicate the vessel is towing and is therefore restricted in its ability to manoeuvre. • Streamers fitted with surface tail buoys with radar reflectors. • Visual and radar watch always maintained on vessels. • Vessels will have automatic identification system. • Support vessel on standby to direct marine users away from the seismic vessel and its towed equipment.

Waste	• Waste managed in accordance with legislative requirements and vessel Waste Management Plan. • Wastes managed and disposed of in a manner that prevents accidental loss to the environment. • Wastes transported onshore to recycling or disposal facilities by a licensed waste contractor.
Unplanned Activities	
Hydrocarbon release	• Spill response plans, equipment and materials available and maintained. • Refuelling procedures and equipment used to prevent spills to the marine environment.
Introduction of marine pests	• Vessels assessed and managed as appropriate to prevent the introduction of marine pests. • Compliance with Australian ballast water and biosecurity requirements and guidance.
Other	• Recreational fishing is not permitted on the seismic vessel or supporting vessels.

location maps





NOTE: See next page for coordinates and depths of locations indicated in map above

ID	Area	Lat_GDA94	Long_GDA94	Depth (metres)
1	Full Power	115° 17' 51.534" E	20° 5' 35.039" S	75
2	Full Power	115° 11' 30.116" E	20° 2' 18.035" S	144
3	Full Power	115° 10' 32.601" E	20° 1' 2.108" S	165
4	Full Power	115° 10' 28.451" E	19° 38' 44.169" S	1123
5	Full Power	115° 11' 21.863" E	19° 37' 18.533" S	1129
6	Full Power	115° 15' 39.447" E	19° 35' 2.490" S	1108
7	Full Power	115° 22' 26.020" E	19° 34' 59.779" S	898
8	Full Power	115° 28' 5.379" E	19° 38' 0.235" S	229
9	Full Power	115° 29' 7.427" E	19° 39' 17.727" S	214
10	Full Power	115° 29' 15.824" E	19° 58' 48.241" S	67
11	Full Power	115° 28' 12.890" E	20° 0' 20.190" S	61
1	Operational Area	115° 17' 54.778" E	20° 11' 32.765" S	61
2	Operational Area	115° 14' 12.388" E	20° 10' 48.802" S	77
3	Operational Area	115° 8' 3.562" E	20° 7' 17.795" S	132
4	Operational Area	115° 5' 22.014" E	20° 4' 38.606" S	186
5	Operational Area	115° 4' 13.147" E	20° 1' 21.844" S	312
6	Operational Area	115° 4' 21.336" E	19° 37' 21.517" S	1231
7	Operational Area	115° 5' 5.828" E	19° 35' 21.247" S	1235
8	Operational Area	115° 6' 31.508" E	19° 33' 26.240" S	1245
9	Operational Area	115° 12' 30.495" E	19° 29' 50.591" S	1238
10	Operational Area	115° 15' 42.839" E	19° 28' 59.662" S	1208
11	Operational Area	115° 23' 5.654" E	19° 29' 3.955" S	969
12	Operational Area	115° 26' 31.029" E	19° 30' 9.944" S	662
13	Operational Area	115° 31' 50.574" E	19° 33' 12.565" S	358
14	Operational Area	115° 34' 12.080" E	19° 35' 33.923" S	219
15	Operational Area	115° 35' 25.662" E	19° 38' 53.083" S	186
16	Operational Area	115° 35' 32.245" E	19° 59' 25.552" S	80
17	Operational Area	115° 34' 25.504" E	20° 2' 35.692" S	75
18	Operational Area	115° 32' 3.472" E	20° 5' 4.420" S	67
19	Operational Area	115° 21' 31.685" E	20° 10' 44.133" S	49

providing feedback

Feedback from the commercial fishing sector and other interested and relevant stakeholders on potential or perceived impacts associated with Chevron Australia's proposed Wheatstone seismic survey will be carefully considered and assessed.

Please note that stakeholder feedback and Chevron Australia's response will be included in the EP.

NOTE: If feedback is identified as sensitive by a stakeholder, Chevron Australia will make this known to NOPSEMA in order for the information to remain confidential.

Feedback can be directed to:

Micha Stoker
Partnerships Advisor
abuenvplaninfo@chevron.com
(08) 9216 4000

appendix c protected matters search reports

Australian Government
Department of Agriculture, Water and the Environment

OPERATIONAL AREA

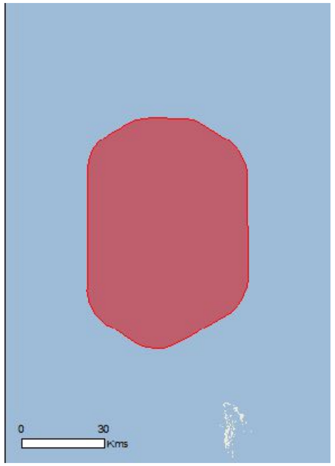
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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

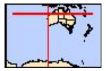
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 10/11/21 11:16:57



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

Coordinates
Buffer: 0.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	21
Listed Migratory Species:	36

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	68
Whales and Other Cetaceans:	27
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	2

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

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

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish,		Species or species

Name	Threatened	Type of Presence
Network Pipefish [66200]		habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted		Species or species

Name	Status	Type of Presence
Bottlenose Dolphin [68418]		habitat may occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Montebello	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Continental Slope Demersal Fish Communities	North-west

Caveat

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

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

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

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-20.093585 115.52071,-20.166083 115.384178,-20.1797 115.357313,-20.187796 115.338177,-20.192212 115.316096,-20.192948 115.290336,-20.190004 115.265311,-20.185588 115.249302,-20.178964 115.232926,-20.123409 115.137319,-20.122889 115.136436,-20.118242 115.128227,-20.111986 115.119763,-20.100761 115.107618,-20.088065 115.096394,-20.077577 115.08885,-20.067272 115.083513,-20.056968 115.078913,-20.048688 115.075785,-20.040223 115.073393,-20.031943 115.071369,-20.024215 115.070449,-20.016855 115.069161,-20.008234 115.069382,-19.63762 115.069529,-19.614067 115.073945,-19.593458 115.082041,-19.574322 115.093818,-19.557393 115.10633,-19.529425 115.144603,-19.496304 115.209373,-19.488207 115.229246,-19.483791 115.251326,-19.482319 115.276351,-19.483791 115.385282,-19.489679 115.416195,-19.510288 115.457412,-19.554449 115.534327,-19.582418 115.564504,-19.605971 115.579224,-19.627315 115.58732,-19.650132 115.592472,-19.981342 115.593944,-19.99827 115.592104,-20.014463 115.58732,-20.030287 115.581064,-20.04464 115.573336,-20.058256 115.564504,-20.0704 115.552727,-20.083649 115.537639,-20.093585 115.52071

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Australian Government
Department of Agriculture, Water and the Environment

EMBA

EPBC Act Protected Matters Report

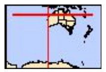
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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

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

Report created: 10/11/21 11:13:27

Coordinates
Buffer: 0.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	41
Listed Migratory Species:	56

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	1
Listed Marine Species:	98
Whales and Other Cetaceans:	29
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	3

Extra Information

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

State and Territory Reserves:	9
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	6

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The Ningaloo Coast	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

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

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Fish		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro	Vulnerable	Species or species

Name	Status	Type of Presence
[89262]		habitat likely to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

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

Name
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur

Name	Threatened	Type of Presence
		within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

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

Name	Status	Type of Presence
		habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Gascoyne	Multiple Use Zone (IUCN VI)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	Recreational Use Zone (IUCN IV)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Barrow Island	WA
Bundegi Coastal Park	WA
Cape Range	WA
Jurabi Coastal Park	WA
Lowendal Islands	WA
Montebello Islands	WA
Muiron Islands	WA
Unnamed WA40828	WA
Unnamed WA41080	WA

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Cape Range Subterranean Waterways	WA

Key Ecological Features (Marine)

[Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west

Caveat

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

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

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

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-22.05834 114.109,-21.95807 114.138,-21.86586 114.149,-21.81345 114.191,-21.7851 114.164,-21.81553 114.08,-21.87437 113.996,-21.9751 113.933,-22.31392 113.818,-22.32869 113.807,-22.47903 113.638,-22.58207 113.55,-22.54086 113.491,-20.7182 112.104,-19.5849 113.464,-19.17163 113.954,-18.87707 114.303,-18.72201 114.481,-18.26542 115.029,-18.63755 116.07,-18.63864 116.074,-18.63972 116.077,-18.64081 116.081,-18.64191 116.085,-18.75403 116.432,-18.89829 116.745,-19.11615 117.119,-19.27807 117.347,-19.42528 117.506,-19.51654 117.524,-20.5352 115.949,-20.57568 115.858,-20.62058 115.687,-20.65443 115.571,-20.70595 115.489,-20.67063 115.447,-20.73466 115.381,-20.77661 115.354,-20.8826 115.292,-21.0298 115.269,-22.05834 114.109

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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

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

Report created: 09/11/21 16:43:42

Coordinates
Buffer: 0.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	2
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	54
Listed Migratory Species:	68

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	4
Commonwealth Heritage Places:	4
Listed Marine Species:	126
Whales and Other Cetaceans:	33
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	15

Extra Information

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

State and Territory Reserves:	28
Regional Forest Agreements:	None
Invasive Species:	15
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	10

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The Ningaloo Coast	WA	Listed place
Historic		
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

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

Name
North-west
South-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Fish		

Name	Status	Type of Presence
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Pseudomys fieldi Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding likely to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Congregation or aggregation known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

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

Name
Commonwealth Land -
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - LEARMONTH - RAAF BASE

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Learmonth Air Weapons Range Facility	WA	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Historic		
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Species or species habitat may occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding likely to occur within area
Phaethon lepturus fulvus Christmas Island White-tailed Tropicbird, Golden Bosunbird [26021]	Endangered	Species or species habitat may occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Congregation or aggregation known to occur within area

Name	Threatened	Type of Presence
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur

Name	Threatened	Type of Presence
		within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

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

Name	Status	Type of Presence
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Carnarvon Canyon	Habitat Protection Zone (IUCN IV)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Shark Bay	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Airlie Island	WA
Barrow Island	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Bundegi Coastal Park	WA
Burnside And Simpson Island	WA
Cape Range	WA
Giralia	WA
Gnandaroo Island	WA
Jurabi Coastal Park	WA
Little Rocky Island	WA
Locker Island	WA
Lowendal Islands	WA
Montebello Islands	WA
Muiron Islands	WA
North Sandy Island	WA
Round Island	WA
Serrurier Island	WA
Tent Island	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA41080	WA
Unnamed WA44665	WA

Name	State
Unnamed WA44667	WA
Victor Island	WA
Whalebone Island	WA
Whitmore,Roberts,Doole Islands And Sandalwood Landing	WA
Y Island	WA

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Cape Range Subterranean Waterways	WA
Exmouth Gulf East	WA
Mermaid Reef	EXT

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Wallaby Saddle	North-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west

Caveat

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

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

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

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-15.87446 118.60978,-16.56963 120.0194,-17.5519 119.45585,-19.85389 118.03874,-20.30256 116.78609,-20.3787 116.61001,-20.45009 116.50056,-21.23055 115.66299,-21.57687 115.2415,-21.64177 115.14517,-21.63357 115.10544,-21.68647 115.05622,-21.67427 114.99233,-21.67066 114.97343,-21.68898 114.91726,-21.79193 114.77567,-21.79942 114.72089,-21.8447 114.64925,-21.91429 114.64578,-21.94562 114.61666,-21.9797 114.61503,-22.00252 114.57006,-22.01615 114.57598,-22.02687 114.55349,-22.06017 114.54796,-22.06056 114.5479,-22.06318 114.54746,-22.06678 114.51665,-22.08448 114.52987,-22.12217 114.52237,-22.12932 114.50096,-22.17014 114.50577,-22.1555 114.48102,-22.15982 114.45558,-22.21188 114.49445,-22.20879 114.45256,-22.23402 114.45147,-22.24165 114.45951,-22.23818 114.45093,-22.24668 114.45979,-22.24266 114.44299,-22.27166 114.45811,-22.27403 114.42944,-22.29313 114.45592,-22.30043 114.42372,-22.33137 114.40801,-22.34659 114.4245,-22.34299 114.44366,-22.35177 114.43058,-22.35718 114.4402,-22.35122 114.40625,-22.38411 114.39655,-22.39354 114.41577,-22.39044 114.39317,-22.42691 114.39738,-22.4328 114.38471,-22.43937 114.3946,-22.44233 114.37979,-22.45932 114.39165,-22.50103 114.35519,-22.47935 114.32471,-22.4873 114.31928,-22.43499 114.30884,-22.45731 114.22561,-22.49733 114.21866,-22.52391 114.1808,-22.52494 114.15509,-22.47412 114.12167,-22.41337 114.12234,-22.40995 114.14035,-22.3976 114.14643,-22.39777 114.13111,-22.35666 114.17696,-22.30571 114.17797,-22.30175 114.15007,-22.32967 114.11493,-22.26223 114.13282,-22.19249 114.08476,-22.15499 114.08029,-21.95807 114.13799,-21.86586 114.14882,-21.81345 114.19122,-21.7851 114.16417,-21.81553 114.07988,-21.87437 113.99633,-21.9751 113.933,-22.31392 113.81775,-22.40755 113.75021,-22.47147 113.7384,-22.49686 113.72333,-22.49683 113.70772,-22.51774 113.71379,-22.55041 113.66462,-22.57886 113.65392,-22.59565 113.67325,-22.62802 113.6681,-22.66471 113.68632,-22.71745 113.6706,-22.71559 113.71037,-22.75523 113.7549,-22.95355 113.82615,-23.03511 113.82923,-23.08268 113.81319,-23.1214 113.76101,-24.20266 113.25559,-24.91566 112.90847,-25.34722 112.78651,-25.76939 112.82404,-27.43931 112.946,-27.86148 112.96476,-28.07725 112.88971,-28.28365 112.64579,-28.51819 112.18609,-28.55571 111.83897,-28.43375 111.56691,-28.12416 111.21979,-27.12972 110.30977,-25.90701 109.26727,-24.61545 108.3115,-23.77111 107.94562,-22.82357 107.62664,-22.00738 107.41087,-21.76466 107.40326,-20.27831 107.80199,-18.5604 108.79231,-17.26691 109.95443,-16.37763 110.75276,-15.5591 111.22771,-14.89214 111.62182,-14.4475 112.30899,-14.36666 113.13763,-14.00287 114.0269,-13.23486 114.75449,-13.4976 115.12839,-13.73521 115.25729,-13.88082 115.34105,-13.98641 115.40101,-14.33634 115.56292,-14.75066 115.49219,-15.3154 116.03357,-15.46448 116.19047,-15.44268 116.20835,-14.93316 116.72436,-14.8651 116.81156,-14.7706 116.94288,-15.87446 118.60978

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-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
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-Other groups and individuals

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Please feel free to provide feedback via the Contact Us page.

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appendix d acoustic modelling

Wheatstone 4D MSS Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Document ID:	**ABU201200423**
Revision ID:	**0**
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Information Sensitivity:	**Company Confidential**

Wheatstone 4D MSS

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Document Information

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Document Owner	Birgit Cropp	Department	Asset Development

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Rev No.	Description	Date	Prepared By	Checked by	Approved By
A	Final Draft	19 August 2020	Jasco	PDJB	NA

Approvals

	Name	Signature	Date
Author:	Jasco Applied Sciences		
Checked:	Paul de Lestang		
Approved:	Birgit Cropp		

Wheatstone 4D Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Paul de Lestang
Chevron Australia Pty Ltd
Contract: C1791146

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned Wheatstone 4D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic effect on receptors including marine mammals, fish, sea turtles, benthic invertebrates, plankton, sponges and corals, and divers. Modelling considered a 4130 in^3 seismic source in a dual source configuration (18.75 m inter pulse interval), towed at 5 m depth behind a single vessel.

A specialised airgun array source model was used to predict the acoustic signature of the seismic source, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at eight sites within the survey area. The water depths at the modelled sites ranged between 64 and 1000 m. Accumulated sound exposure fields were predicted for two representative scenarios for likely operations within the survey area over 24 hours.

The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey was defined and applied to all modelling.

The sound footprints are highly directional, and while the maximum distances to criteria are presented in the summary, this distance may not be relevant to receptors or areas of interest in a specific direction. For example, the distances to SPL criteria for behavioural response in marine mammals, and behavioural response and disturbance in turtles are typically greater for the shallower sites, and those close to the continental shelf. However, the orientation of the source is also key, as the array has a pronounced directivity pattern, with greater distances to sound levels in the broadside direction as compared to the endfire direction. The influence of the bathymetry on the sound fields and the orientation of the source are the reason the humpback whale migratory BIA is not predicted to be ensonified above the marine mammal behavioural disturbance threshold or the shallow waters around the Montebello Islands are not predicted to be ensonified above the human health assessment threshold of 145 dB re 1 µPa.

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. Where the corresponding SEL_{24h} radii are larger than those for peak pressure criteria, they often represent an unlikely worst-case scenario. More realistically, marine mammals, fish and sea turtles 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. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna 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 permanent threshold shift (PTS) or temporary threshold shift (TTS)) if it remained in that location for 24 hours.

The analysis considered the distances from the seismic source at which several effects criteria or relevant sound levels were reached. The results are summarised below for the representative single-impulse sites and accumulated SEL scenarios. The noise effect criteria for impairment of marine mammals, fish and sea turtles use dual metrics (PK and SEL_{24h}), and the longest distance associated with either metric is required to be applied, and thus is presented in this summary.

At long ranges off the continental shelf, the single impulse sound fields demonstrate that there is significantly less sound energy above 400 m as compared to greater depths. This distribution of sound over the water column means that it is likely that the maximum-over-depth SEL_{24h} results for TTS in low-frequency cetaceans at long range off the continental shelf do not accurately represent the actual exposures whales migrating at predominantly shallow depths will receive.

Marine mammals

Table 1. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and PTS and TTS thresholds for marine mammals.

Hearing group	Modelled distance to effect threshold (R_{max})		
	Behavioural response[1]	Impairment: TTS[2]	Impairment: PTS[2]
LF cetaceans		95.4	6.61
MF cetaceans	13.45	-	-
HF cetaceans		1.63	0.450

[1] Noise exposure criteria: NOAA (2019)
[2] Noise exposure criteria: NMFS (2018)

Sea turtles

Table 2. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and PTS and TTS thresholds for sea turtles.

Hearing group	Modelled distance to effect threshold (R_{max})			
	Behavioural response[1]	Behavioural disturbance[2]	Impairment: TTS[3]	Impairment: PTS[3]
Turtles	7.11	2.83	3.84	<0.02

[1] Noise exposure criteria: NSF (2011)
[2] Noise exposure criteria: McCauley et al. (2000b)
[3] Noise exposure criteria: Finneran et al. (2017)

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics associated with mortality and potential mortal injury as well as impairment in the following groups:
    - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
    - Fish with a swim bladder not used for hearing
    - Fish that use their swim bladders for hearing
    - Fish eggs and fish larvae

Table 3. Summary of maximum fish, fish eggs and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios

Relevant hearing group	**Effect criteria**	**Scenario 1**		**Scenario 2**	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.096 (seafloor)	PK	0.07
	TTS	SEL_{24h}	8.63	SEL_{24h}	7.56
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.27	PK	0.15
	TTS	SEL_{24h}	8.63	SEL_{24h}	7.56
Fish eggs and larvae	Injury	PK	0.27	PK	0.15

Invertebrates, Sponges, Coral and Plankton

To assist with assessing the potential effects on these receptors, the following were determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered for seafloor sound levels; the sound level was reached at ranges between 0.431 and 0.913 km depending on the modelled site.
- Sponges and coral: the PK sound level at the seafloor directly underneath the seismic source was estimated at three modelled sites and compared to the no effect sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was not reached.
- Plankton: The maximum distance to potential injury in plankton, applying the threshold from Popper et al. (2014), is 0.27 km within the water column.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned Wheatstone 4D Marine Seismic Survey (MSS) to assist in understanding the potential acoustic impact on receptors including marine mammals, fish, sea turtles, benthic invertebrates, plankton, sponges and corals, and divers.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict acoustic signatures and spectra for a 4130 in^3 airgun array. AASM accounts for individual airgun volumes, airgun bubble interactions, and array geometry to yield accurate source predictions.

Complementary underwater acoustic propagation models were used in conjunction with the selected array signature to estimate sound levels considering environmental effects. Single-impulse sound fields were predicted at eight defined locations within the potential survey area, and an accumulated sound exposure field was predicted for two representative scenarios for survey operations over 24 h (Section 2). A conservative sound speed profile that would be most supportive of sound propagation conditions for the potential survey period was defined and applied throughout.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

Section 3 explains the metrics used to represent underwater acoustic fields and the effect criteria considered. Section 4 details the methodology for predicting the source levels and modelling the sound propagation, including the specifications of the seismic source and all environmental parameters the propagation models require. Section 5 presents the results, which are then discussed and summarised in Section 6.

2. Modelling Scenarios

Eight standalone single impulse sites and two scenarios for survey operations over 24 hours to assess accumulated SEL were modelled. The locations of all modelled sites are provided in Table 4, with all sites and the acquisition lines shown in Figure 1 along with the survey boundaries. The modelling assumed that a survey vessel sailed along survey lines at ~4.5 knots, with an impulse interval of 18.75 m.

The proposed survey plan includes lines orientated either 60/240° (represented by Scenario 1) or 120/300° (represented by Scenario 2). The two sets of survey lines modelled represent 24 h of survey; this period is based on the various effect criteria that are evaluated in this study. The line scenarios were selected to incorporate both potential acquisition line orientations (referred to as either 60 or 120°), and the offshore and inshore sections of the Full Power Area, to aid in the assessment of sound levels within the Biologically Important Areas (BIAs) and Key Ecological Features (KEFs) within the region. The different line orientations are essential considering the potential sound propagation characteristics that may arise during survey acquisition. The 60/240° (Scenario 1) lines considered were in the southern part of the Full Power Area, close to coastal receptors, with the broadside aspect of the source orientated towards both the humpback whale and pygmy blue whale migration BIAs. The 120/300° (Scenario 2) lines considered were in the northern part of the Full Power Area, and included the most offshore full-length survey lines, which extend into the pygmy blue whale migration BIA. The Scenario 2 lines also will represent the potential sound fields parallel to the continental shelf.

Both accumulated SEL scenarios consisted of four full lines and a fifth partial line during a 24-hour period and included 8,233 seismic impulses. During line turns, the seismic source was not operating. It is computationally prohibitive to perform sound propagation modelling for every seismic impulse. Therefore, a subset of seismic impulse locations was selected based on the variation in environmental properties within the entire survey area. For this study, seven locations were considered sufficient to represent the variation in sound propagation along the modelled survey lines; their selection was mainly based on the variation in water depth within the survey area. The modelled sound fields at these seven single impulse sites were transposed along the survey lines to model the scenarios' SEL_{24h} sound fields (see Appendix C.3). An eighth location was chosen to represent the shallowest point within the Full Power Area. This location was used to calculate single impulse metrics, including evaluating the distance to the human health assessment threshold of 145 dB re 1 µPa (SPL), in relation to the Montebello Islands, south of the survey area.

Table 4. Location details for the single impulse modelled sites and associated SEL_{24h} scenario.

Relevant SEL_{24} Scenario	Site	Latitude (S)	Longitude (E)	UTM Zone 50		Water depth (m)	Tow direction (°)
				X (m)	Y (m)		
1	1	19° 56' 03.3456" S	115° 26' 08.5946" E	336285	7795031	82	60
	2	19° 55' 21.1646" S	115° 19' 17.9753" E	324332	7796213	126	
	3	19° 45' 32.2431" S	115° 22' 01.9962" E	328926	7814368	200	
2	2	19° 55' 21.1646" S	115° 19' 17.9753" E	324332	7796213	126	120
	3	19° 45' 32.2431" S	115° 22' 01.9962" E	328926	7814368	200	
	4	19° 40' 51.5469" S	115° 22' 06.4766" E	328974	7823000	400	
	5	19° 39' 42.2812" S	115° 20' 02.9133" E	325354	7825095	600	
	6	19° 38' 47.8390" S	115° 18' 25.4959" E	322500	7826741	800	
	7	19° 41' 24.5095" S	115° 14' 39.2009" E	315957	7821857	1000	
N/A	A†	20° 01' 42.5825" S	115° 23' 54.7001" E	332491	7784563	64	120

†Shallowest location within Full Power Area.

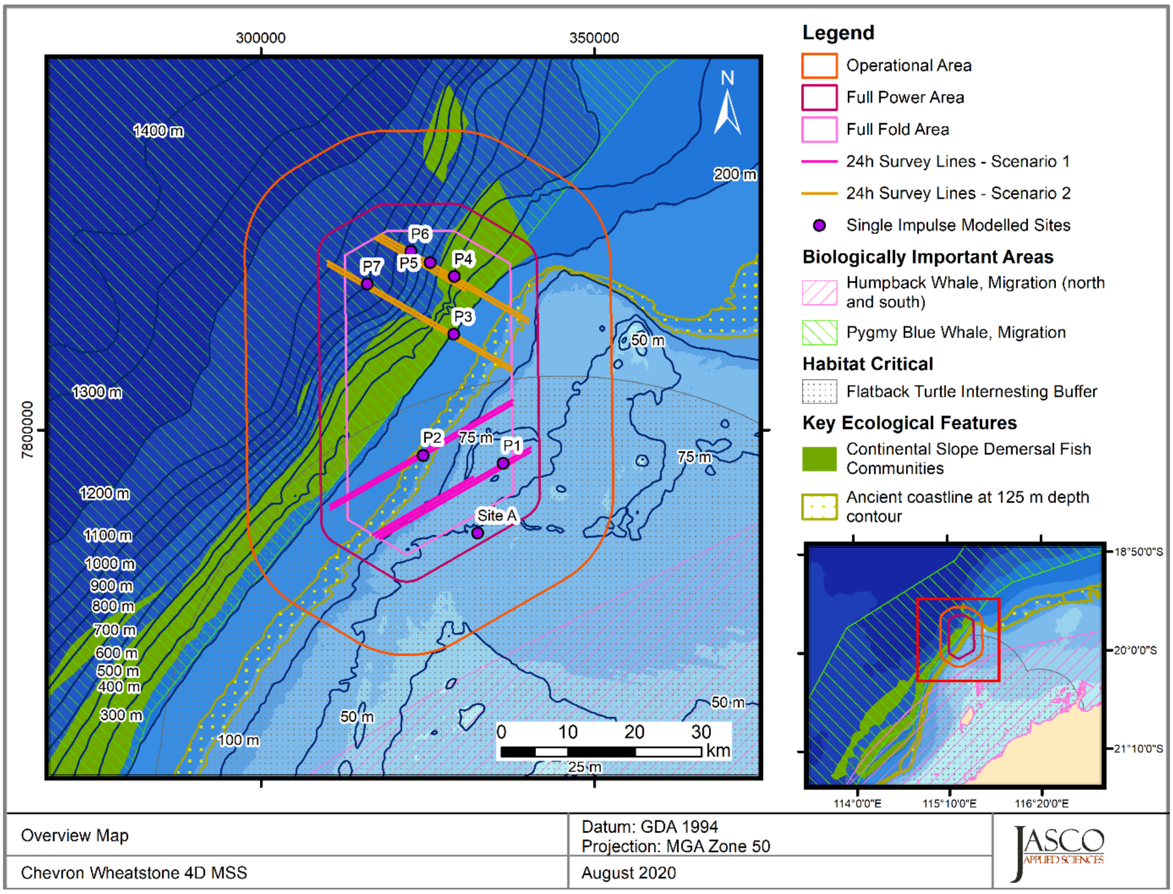

Figure 1. Overview of the modelled sites, acquisition lines, and features for the Wheatstone 4D MSS.

3. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a "per pulse" assessment or over 24 h, and appropriate notations indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

Whether acoustic exposure levels might injure, impair or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury and impairment, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that have investigated the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

The following thresholds, guidelines and sound levels for this study were chosen because they represent the best available science, and sound levels presented in literature for fauna with no defined thresholds:

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals.
2. Marine mammal behavioural threshold based on the current NOAA (2019) criterion for marine mammals of 160 dB re 1 µPa (SPL; L_p) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs and larvae (including plankton) (Popper et al. 2014).
4. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of PTS and TTS in turtles.
5. Turtle behavioural response threshold of 166 dB re 1 µPa (SPL; L_p) (NSF 2011), as applied by the US NMFS, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL; L_p) (McCauley et al. 2000a, 2000b).
6. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) at the seafloor to help assess effects of noise on crustaceans through comparing to results in Day et al. (2016a), Day et al. (2019b) , Day et al. (2016b), Day et al. (2017) and Payne et al. (2008).
7. For comparison to current literature, a no effect sound level for sponges and corals of 226 dB re 1 µPa (PK; L_{pk}), is reported for comparing to Heyward et al. (2018).
8. An SPL human health assessment threshold of 145 dB re 1 µPa (SPL; L_p) for sound exposure to people swimming and diving derived from Parvin (2005), and considering Ainslie (2008).

Additionally, to assess the size of the low-power zone required under the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA 2008), the distance to an unweighted per-pulse SEL of 160 dB re 1 µPa^2·s (SEL; L_E) is reported.

The following sections (Sections 3.1–3.4.2 and Appendix A.3 and A.5) expands on the thresholds and sound levels for marine mammals, fish, fish eggs, fish larvae, sea turtles, benthic invertebrates and humans.

3.1. Marine Mammals

There are two categories of auditory threshold shifts or hearing loss: PTS, a physical injury to an animal's hearing organs; and TTS, a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea becoming fatigued.

To help assess the potential for the possible injury and hearing sensitivity changes in marine mammals, this report applies the criteria recommended by NMFS (2018), considering both PTS and TTS, which are numerically identical to Southall et al. (2019). These criteria, along with the applied behavioural criteria (NOAA 2019), are summarised in Table 5, with descriptions included in Appendix A.3.1 (auditory impairment) and Appendix A.3.2 (behavioural response), with frequency weighting explained in Appendix A.4.

Table 5. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals.

Hearing group	NOAA (2019)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	**PK** (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196

* 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–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

3.2. Fish, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure guidelines for fish and turtles, work begun by a panel convened by NOAA two years earlier. The resulting guidelines included noise exposure guidelines for different groups of species for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative levels for three types of immediate effects:

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

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound levels. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report and are included in Table 6 for completeness only. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to effect from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different guidelines were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately. Table 6 lists relevant effect guidelines from Popper et al. (2014).

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. Popper et al. (2014) recommend applying a standard period, where this is either defined as a justified fixed period or the duration of the activity; however, Popper et al. (2014) also included caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 hours has been applied in this study for SEL, which is similar to that applied for marine mammals in NMFS (2016, 2018).

Additional information is provided in Appended A.5.

Table 6. Criteria for seismic noise exposure for fish, fish eggs, and fish larvae adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae (relevant to plankton)	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

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), intermediate (I), and far (F).

3.3. Sea Turtles

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. Popper et al. (2014) suggested thresholds for onset of mortal injury and mortality for sea turtles and, in absence of taxon-specific information, adopted the levels for fish that do not hear well (suggesting that this likely would be conservative for sea turtles).

Finneran et al. (2017) presented revised thresholds for sea turtle injury and hearing impairment (TTS and PTS). Their rationale is that sea turtles have best sensitivity at low frequencies and are known to have poor auditory sensitivity (Bartol and Ketten 2006, Dow Piniak et al. 2012). Accordingly, TTS and PTS thresholds for turtles are likely more similar to those of fishes than to marine mammals (Popper et al. 2014).

McCauley et al. (2000a) observed the behavioural response of caged sea turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the sea turtles increased their swimming activity and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural disturbance response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011). In addition the 175 dB re 1 µPa level from McCauley et al. (2000a) is recommended as a criterion for behavioural disturbance. In addition, the Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy et al. 2017) acknowledges the 166 dB re1 µPa SPL reported by McCauley et al. (2000a) as the level that may result in a behavioural response to marine turtles. These thresholds are shown in Table 7.

Table 7. Criteria for acoustic effects of impulsive noise on sea turtles: Unweighted SPL, SEL_{24h}, and PK thresholds

Effect type	Criterion	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Behavioural response	NSF (2011)	166	NA	
Behavioural disturbance	McCauley et al. (2000b)	175		
PTS onset thresholds* (received level)	Finneran et al. (2017)	NA	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 h period and has a reference value of 1 µPa²s.

3.4. Invertebrates

3.4.1. Benthic Invertebrates (Crustaceans and Bivalves)

Research is ongoing into the relationship between sound and its effects on crustaceans and bivalves, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves.

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

The pressure and acceleration examples provided in Day et al. (2016a)(Figures 11 and 12) indicate that the acceleration and pressure signals occurred simultaneously, which was interpreted as an indication that the waterborne sounds were responsible for the accelerations measured by the geophones. For clarity, it is important to distinguish that the acceleration from waterborne sound energy is *not* ground roll, which Day et al. (2016a) correctly define as the sound that propagates along the interface at a speed lower than the shear wave speed of the sediment. However, the report subsequently uses ground roll for all further discussions of particle acceleration. While Day et al. (2016a) discuss that they chose the simplest measure of ground roll, it should have been referring to as ‘the acceleration from waterborne sound energy’, or ‘waterborne acceleration’ for short.

For crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and it is therefore applied in this assessment. Additionally for context, the maximum PK-PK sound levels measured during the passes of the 150 in³ airgun and reported in Day et al. (2016a), Day et al. (2016b), and Day et al. (2019) 209–213 dB re 1 µPa are also included.

For bivalves, PK-PK sound levels of 212 and 213 dB re 1 µPa are presented to allow comparison to the maximum sound levels measured in Day et al. (2016a) (also reported in Day et al. (2017)) during the passes of the 150 in^3 airgun (reported in Table 7 of Day et al. (2016a)).

3.4.2. Plankton

To assess impacts to plankton, there are only a few studies to base nominal thresholds for effect assessment on. Popper et al. (2014) cites many of the references and studies on potential impacts of noise emissions on fish eggs and larvae prior to 2014. Results presented in Day et al. (2016b) for embryonic lobsters and Fields et al. (2019) for copepods align with those presented in Popper et al. (2014), which is that mortality and sub-lethal injury are limited to within tens of metres of seismic sources. Additionally, the Popper et al. (2014) guidelines (Table 6), are extrapolated from simulated pile driving signals which have a more rapid rise time and greater potential for trauma than pulses from a seismic source.

Other research, such as McCauley et al. (2017), has indicated the potential for effects at longer range, however Fields et al. (2019) noted that it was difficult to reconcile the high mortality reported by McCauley et al. (2017) with the low mortalities reported in the greater previous body of earlier research and their experiment. They recommended further research into whether it is the sound pulse itself (i.e. the energy, peak pressures, or particle acceleration), the (turbulent) fluid flow occurring more slowly (i.e. not related to the sound pulse), or other effects such as the bubble cloud that which might cause higher mortality near the seismic source.

3.5. Human health assessment threshold

Underwater, the human ear is about 20 dB less sensitive than it is in air at low frequencies (20 Hz), increasing to 40 dB at mid-frequencies (less than 1 kHz), and increasing to 70–80 dB less sensitive at higher frequencies (Parvin 1998). Divers who wear neoprene hoods have even higher hearing thresholds (lower sensitivity) above 500 Hz because the hood material absorbs high-frequency sounds (Sims et al. 1999). Exposure studies related to divers have typically focused on military sonar exposure, with little information on seismic survey operations, and as such care is required when considering thresholds for recreational divers and swimmers, particularly for impulsive sounds such as seismic surveys (Ainslie 2008).

The auditory threshold of hearing under water was lowest at 1 kHz (70 dB re 1 µPa SPL) and increased for lower and higher frequencies to around 120 dB re 1 µPa at 20 Hz and at 20 kHz (Parvin 1998). Fothergill et al. (2000) and Fothergill et al. (2001) conducted controlled acoustic exposure experiments on military divers under fully controlled conditions at a US Ocean Simulation Facility and an US Open water test facility; in all tests, the diver were covered with soft or hard shell dive suits and their position and distance relative to sound source, signal characteristics and received levels were controlled and documented (Pestorius et al. 2009). A total of 89 male Navy divers were exposed to pure tone signals and sweeps between 160-320 Hz at SPLs up to 160 dB re 1 µPa. The divers were exposed to these sounds over 100 seconds at depths from 10 to 40 metres. The divers rated the sounds on a severity scale. For frequencies between 100 and 500 Hz, at a received SPL of 130 dB re 1 µPa, divers and swimmers detected body vibration. None of the divers tested rated levels of 140 dB re 1 µPa as “very severe”; however, at 157 dB re 1 µPa, sound was rated as “very severe” 19 per cent of the time. No physiological damage was observed at the highest levels tested: 160 dB re 1 µPa (Fothergill et al. 2001). In a subsequent study, recreational divers were exposed to tonal signals or 30 Hz-sweeps at frequencies between 100 and 500 Hz at received levels of 130-157 dB re 1 µPa (Pestorius et al. 2009). Each exposure lasted for seven seconds. Nine female and 17 male scuba divers were tested, all wearing full body neoprene wetsuits. Diver aversion and perception of body vibration were used as test parameters. The results showed no sex-specific differences. The results differed as a function of frequency – while test results showed a strong overall variation between subjects, signals at 100 Hz elicited the strongest aversion in all tests and even at 148 dB a few diver ratings indicated extreme aversion. Due to this and the strong variation between test subjects, the following exposure limit for both military and recreational divers was suggested as a conservative measure: For frequencies between 100 and 500 Hz, the maximum SPL should be 145 dB re 1 µPa over a maximum continuous exposure of 100 seconds or with a maximum duty cycle of 20 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).

Considering only frequencies between 100 and 500 Hz, Parvin (2005) suggested 145 dB re 1 µPa as a safety criterion for recreational divers and swimmers. Seismic impulses are broadband sources, and therefore, to be precautionary, the 145 dB re 1 µPa SPL suggested by Fothergill et al. (2001) and Parvin (2005) has been applied in this study as a broadband SPL and as a human health assessment threshold for recreational divers and swimmers. This does not imply that this level is associated with the onset of injury.

4. Methods

4.1. Parameters Overview

Sound propagation was modelled up to 100 km from each single impulse modelled site (listed in Table 4). The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendix C. A single sound speed profile for May was considered in this modelling study; this was identified as the period that would provide the farthest propagation over the potential operational window (November to the end of May; see Appendix C.4.2).

The acoustic properties of the seabed in the survey acquisition area vary depending on the water depth and the area on the continental shelf. Three geoacoustic profiles were developed and used for various modelled sites (see Appendix C.4.3).

For sites with water depths <100 m the seabed profile consisted of acoustic properties to represent fine calcareous sand layer, approximately 45 m overlying an acoustic basement. For sites with water depths between 100 and 300 m the seabed profile consisted of a thick fine calcareous sand layer, approximately 400 m thick, overlying an acoustic basement. Finally, for sites with water depths greater than 300 m, a thick calcareous silt layer, approximately 400 m thick, overlying an acoustic basement was considered for the seabed acoustic properties. Further detail is provided in Appendix C.4.3.

4.2. Acoustic Source Model

The pressure signature of the individual airguns and the composite decidecade-band point-source equivalent directional levels (i.e., source levels) of the seismic sources were modelled with JASCO's Airgun Array Source Model (AASM). Although AASM accounts for notional pressure signatures of each seismic source with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

All seismic sources considered were modelled over AASM's full frequency range, up to 25 kHz. Appendix B.1details this model.

4.3. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and Gaussian beam acoustic ray-trace model (MONM-BELLHOP, 5 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 5 Hz to 2048 Hz).
- Wavenumber integration model (VSTACK, 5 Hz to 1024 Hz).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK. Appendix B.2 details each model. MONM-BELLHOP was used to calculate SEL of a 360° area around each source location. The model calculated propagation losses up to distances of 100 km from the source in each cardinal direction, with a horizontal separation of

10 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta = 2.5°$ for a total of $N = 144$ radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 1750 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using Bellhop for frequencies from 5 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency-range of interest.

FWRAM was used to model synthetic seismic pulses and to generate a generalised range-dependent SEL to SPL conversion function for the considered modelled sites (Appendix C.2). FWRAM was run to 100 km at five of the eight single impulse modelling sites, along four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency. Along each radial, the computation was done with a regular depth step of 1 m over the entire water column, and a horizontal range step of 10 m. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM-BELLHOP to estimate SPL values. FWRAM was also used to calculate water column PK levels.

VSTACK was used to calculate close range PK and PK-PK levels along transects at the seafloor from the loudest direction of the seismic source at the shallowest modelled site within the survey area (Site A). The maximum modelled range for VSTACK was 1000 m and a variable receiver range increment that increased away from the source was used, which increased from 10 to 25 m. Received levels were computed for receivers at the seafloor.

During a seismic survey, new sound energy is introduced into the environment with each pulse from the seismic source. The vessel towing the airgun was modelled travelling at 4.5 knots, with each of the two airgun arrays operational every 37.5 m, or an overall inter-pulse-interval of 18.75 m. Both modelling scenarios included 8233 seismic impulses and a racetrack turn distance of 7.5 km. While some effect criteria are based on the per-pulse energy released, others, such as the marine mammal, turtle and fish SEL criteria used in this report (Sections 3) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic pulse impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses. Appendix C.3 provides additional details on the methods used to calculate the accumulated sound energy for the considered scenarios.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section 4.2) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the seismic source, with results provided in Appendix C.5.1 along with the horizontal directivity plots.

Table 8 shows the PK and per-pulse SEL source levels in the horizontal-plane broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions. The vertical source level that accounts for the “surface ghost” (the out of phase reflected pulse from the water surface) is also presented to make it easier to compare the output of other seismic source models.

Figure C-10 shows the broadside, endfire, and vertical overpressure signature and corresponding power spectrum levels for the source. The signature consists of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy was produced at frequencies below 500 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the source and correspond with the volumes and relative locations of the airguns to each other.

Table 8. Far-field source level specifications for the 4130 in^3 seismic source, for a 5 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa²m²s)		
		5–2000 Hz	2000–25000 Hz	5–25000 Hz
Broadside	250.1	229.6	188.3	229.6
Endfire	248.2	229.2	190.3	229.2
Vertical	258.9	235.8	200.8	235.8
Vertical (surface affected source level)	258.9	238.8	205.2	238.8

5.2. Per-Pulse sound fields

This section presents the per-pulse sound fields in terms of maximum-over-depth SPL, SEL, PK, and seafloor PK and PK-PK.

The different metrics are presented for the following reasons:

- SPL sound fields were used to determine the distances to marine mammal and turtle behavioural thresholds (see Sections 3.1 and 3.3) and the human health assessment threshold (Section 3.4.2).
- Per-pulse SEL sound fields are used as inputs into the 24 h SEL scenarios and context for the range to 160 dB re 1 µPa²·s, relevant for the EPBC Act Policy Statement 2.1 (DEWHA 2008).
- PK metrics within the water column are relevant to thresholds and guidelines for marine mammals, sea turtles, fish, fish eggs and larvae (as well as plankton) (Sections 3.1–3.3).
- PK metrics at the seafloor are relevant to guidelines for fish, fish eggs and larvae (Section 3.3) and the sound level for no effect on corals and sponges
- PKPK metrics at the seafloor are relevant to sound levels used in the assessment of impacts to benthic invertebrates (Section 3.4.1).

SPL sound fields were used to determine the distances to marine mammal and turtle behavioural thresholds (see Sections 3.1 and 3.3). The maximum and 95% distances (calculated as detailed in Appendix C.1) for per-pulse SEL and SPL metrics are presented in Tables 9–13. The SPL sound fields, and distances to relevant isopleths can be visualised on the contour maps presented in Figures 2 to 9, whilst the per-pulse SEL sound field maps are presented in Appendix D.

The SPL sound fields are also presented as vertical slices along the endfire and broadside directions out to 50 km, with the airgun array in the centre (Figures 11 to 18). These figures help illustrate how sound propagates in various water depth regimes (e.g. from shallow versus deep sites, and toward deep-water versus over the continental shelf). The figures are arranged with the slice orientated towards deep-water always shown on top, and the slice parallel to the continental shelf on the bottom. Long-range slices (out to 100 km) in the broadside direction are shown for Site 2, offshore (Figure 19) and Site 7, parallel to the continental shelf (Figure 20).

The humpback whale migratory BIA is not predicted to be ensonified to the sound level used to assess marine mammal behavioural disturbance (160 dB re 1 µPa, NOAA (2019)) from the closest modelling site, Site A, or the closest modelling site with the broadband lobe orientated towards the BIA, Site 1.

The shallow waters (< 25m) around the Montebello Islands are not predicted to be ensonified above 140 dB re 1 µPa (Figure 10) considering the closest potential location where the source could be active (Site A) with a tow azimuth of 120°. Therefore, the isopleth corresponding to the human health assessment threshold of 145 dB re 1 µPa will not be exceeded in water depths (< 25m) relevant to recreational diving.

Maximum distances to PK thresholds were calculated over the entire water column (maximum-over-depth) at five sites (Sites 1, 3, 4, 6 and 7; Table 13), and at the seafloor at three sites (Sites 2, 5 and A; Table 14). The maximum-over-depth PK sound fields were used to determine distances to marine mammal, turtle, fish, fish egg and larvae injury thresholds. The seafloor PK sound fields were used to determine distances to sponges and corals, fish, fish eggs and larvae injury thresholds.

The PK-PK at the seafloor were modelled at Sites 2, 5, and A. These sound fields were used to calculate maximum distances to thresholds for benthic invertebrates (Section 3.4.1).

5.2.1. Tabulated results

Table 9. *Scenario 1, tow azimuth 60°*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 4130 in^3 source to modelled maximum-over-depth SPL isopleths from the modelled single impulse sites, with water depth indicated.

SPL (L_p; dB re 1 µPa)	Site 1 (Depth: 82 m)		Site 2 (Depth: 126 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05
190	0.28	0.26	0.34	0.31
180	1.55	1.27	1.14	1.00
175#	2.83	2.33	2.4	1.97
170	4.36	3.56	4.06	3.4
166†	6.25	5.08	6.25	4.96
160‡	9.98	8.06	13.45	10.36
150	26.57	19.7	64.46	39.65
145	50.18	32.56	>100.0	/
140	>100.0	/	>100.0	/

Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000a).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 10. *Scenario 2, tow azimuth 120º*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 4130 in^3 source to modelled maximum-over-depth SPL isopleths from the modelled single impulse sites, with water depth indicated.

SPL (L_p; dB re 1 µPa)	**Site 3 (Depth: 200 m)**		**Site 4 (Depth: 400 m)**		**Site 5 (Depth: 600 m)**		**Site 6 (Depth: 800 m)**		**Site 7 (Depth: 1000 m)**		**Site A (Depth: 64 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
190	0.16	0.14	0.16	0.14	0.16	0.14	0.16	0.13	0.16	0.14	0.34	0.29
180	0.95	0.81	0.57	0.49	0.52	0.44	0.51	0.44	0.51	0.44	1.89	1.62
175#	2.1	1.74	1.43	1.26	1.12	0.95	1.00	0.82	0.92	0.78	2.81	2.39
170	3.83	3.14	2.58	2.24	2.4	2.04	2.67	2.31	2.74	2.34	4.87	3.95
166†	5.75	4.99	5.04	3.44	4.38	3.73	4.41	3.75	3.71	3.2	7.11	5.64
160‡	11.15	9.66	12.28	8.46	10.19	7.79	9.95	7.45	8.37	6.44	12.26	9.82
150	45.09	26.03	39.28	31.44	35.27	27.27	31.64	23.11	28.59	21.22	32.63	25.62
145	>100.0	/	67.75	56.08	65.43	52.10	54.49	47.8	55.9	44.18	51.07	36.89
140	>100.0	/	>100.0	/	>100.0	/	>100.0	/	>100.0	/	81.92	58.83

Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000a).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NOAA 2019).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 11. *Scenario 1, tow azimuth 60º*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 4130 in^3 source to modelled maximum-over-depth per-pulse SEL isopleths from the modelled single impulse sites, with water depth indicated.

Per-pulse SEL (L_p; dB re 1 µPa^2·s)	**Site 1 (Depth: 82 m)**		**Site 2 (Depth: 126 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	<0.02	<0.02	<0.02	<0.02
190	0.05	0.04	0.05	0.04
180	0.39	0.29	0.36	0.33
170	2.26	1.57	1.5	1.23
160#	6.07	5.0	5.74	4.8
150	15.1	11.0	16.3	12.8
140	35.8	24.4	73.4	56.8
130	>100.0	/	>100.0	/

Low power zone assessment criteria DEWHA (2008).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 12. *Scenario 2, tow azimuth 120º*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 4130 in³ source to modelled maximum-over-depth per-pulse SEL isopleths from the modelled single impulse sites, with water depth indicated..

Per-pulse SEL (L_p; dB re 1 µPa²·s)	**Site 3 (Depth: 200 m)**		**Site 4 (Depth: 400 m)**		**Site 5 (Depth: 600 m)**		**Site 6 (Depth: 800 m)**		**Site 7 (Depth: 1000 m)**		**Site A (Depth: 64 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
190	0.05	0.04	0.05	0.05	0.06	0.04	0.05	0.04	0.05	0.05	0.05	0.05
180	0.18	0.16	0.19	0.16	0.18	0.16	0.18	0.15	0.18	0.15	0.35	0.33
170	1.03	0.88	0.7	0.59	0.59	0.5	0.58	0.5	0.58	0.49	2.37	1.91
160#	5.57	4.69	2.8	2.43	3.26	2.34	2.94	2.52	3.11	2.72	7.01	5.51
150	19.4	14.7	13.5	11.0	14.1	11.4	13.2	9.75	9.82	8.04	17.3	13.4
140	57.1	44.5	45.1	37.4	47.7	38.1	42.6	34.4	40.9	31.4	38.9	31.2
130	>100.0	/	>100.0	/	>100.0	/	>100.0	/	>100.0	/	>100.0	/

Low power zone assessment criteria DEWHA (2008).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 13. Maximum (R_{max}) horizontal distances (km) from the 4130 in³ array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles, at five modelling sites (Table 4) , with water depth and tow azimuth indicated.

Hearing group	**PK threshold** (L_{pk}; dB re 1 µPa)	**Distance R_{max} (km)**				
		Tow 60º	Tow 120º			
		Site 1 (Depth: 82 m)	Site 3 (Depth: 200 m)	Site 4 (Depth: 400 m)	Site 6 (Depth: 800 m)	Site 7 (Depth: 1000 m)
Low-frequency cetaceans (PTS)	219	0.04	0.04	0.04	0.04	0.04
Low-frequency cetaceans (TTS)	213	0.07	0.07	0.07	0.07	0.07
Mid-frequency cetaceans (PTS)	230	—	—	—	—	—
Mid-frequency cetaceans (TTS)	224	0.02	0.02	0.02	0.02	0.02
High-frequency cetaceans (PTS)	202	0.45	0.26	0.26	0.26	0.26
High-frequency cetaceans (TTS)	196	1.00	0.84	0.52	0.52	0.52
Turtles (PTS)	232	—	—	—	—	—
Turtles (TTS)	226	0.02	0.02	0.02	0.02	0.02
Fish: No swim bladder (also applied to sharks)	213	0.07	0.07	0.07	0.07	0.07
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.27	0.15	0.15	0.15	0.15

A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Table 14. Maximum (R_{max}) horizontal distances (in m) from the 4130 in^3 array to modelled seafloor peak pressure levels (PK) from three single-impulse modelled sites (Table 4), with water depth indicated.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)		
		Site 2 (Depth: 126 m)	Site 5 (Depth: 600 m)	Site A (Depth: 64 m)
Sponges and corals†	226	*	*	*
Fish: No swim bladder (also applied to sharks)	213	0.069	*	0.096
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.192	*	0.237

† Heyward et al. (2018)
An asterisk indicates that the sound level was not reached.

Table 15. Maximum (R_{max}) horizontal distances (in m) from the 4130 in^3 seismic source to modelled seafloor peak-peak pressure levels (PK-PK) from three single-impulse modelled sites (Table 4), with water depth indicated. Results included in relation to benthic invertebrates (Section 3.4.1).

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (km)		
	Site 2 (Depth: 126 m)	Site 5 (Depth: 600 m)	Site A (Depth: 64 m)
213[a,b,c]	0.159	*	0.230
212[b,c]	0.197	*	0.241
210[a,b]	0.354	0.101	0.274
209[a,b]	0.366	0.141	0.290
202[d]	0.842	0.431	0.913

[a] Day et al. (2019a), lobster experiments, maximum single impulse exposure measured.
[b] Day et al. (2016a), lobster and scallop experiments, maximum single impulse exposure measured.
[c] Day et al. (2017), scallop experiments, maximum single impulse exposure measured.
[d] Payne et al. (2008), lobster, no mortality or damage to mechano-sensory systems, recoverable injury

5.2.2. Sound field maps and graphs

5.2.2.1. Sound Level Contour Maps

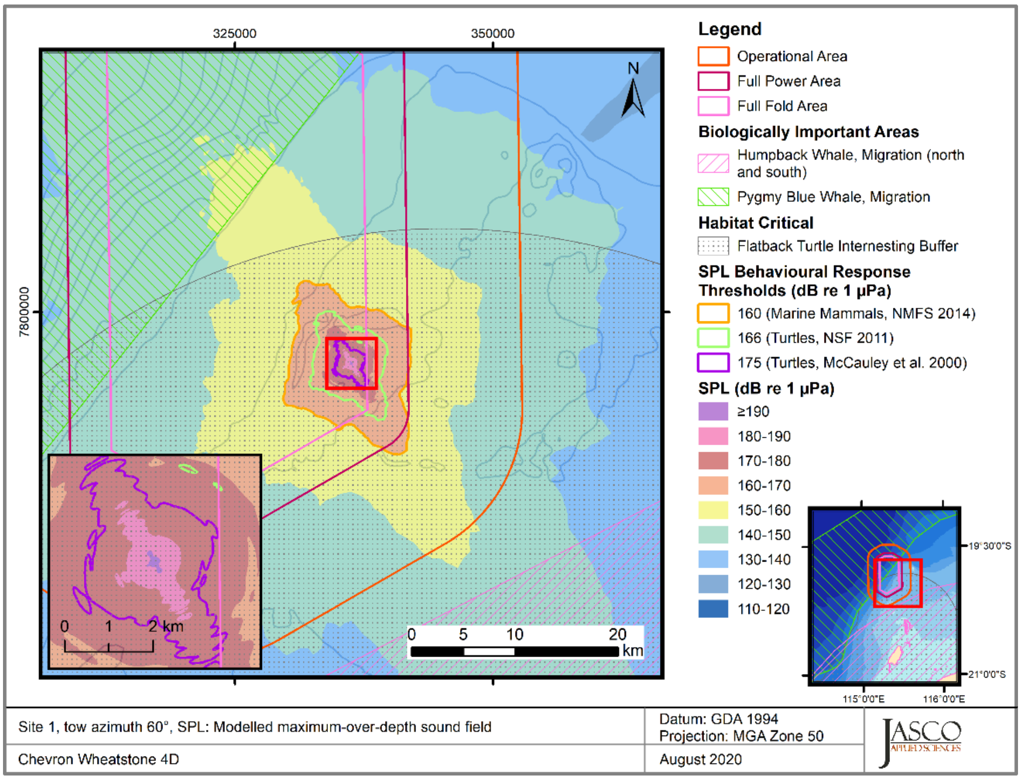

Figure 2. *Site 1, tow azimuth 60º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

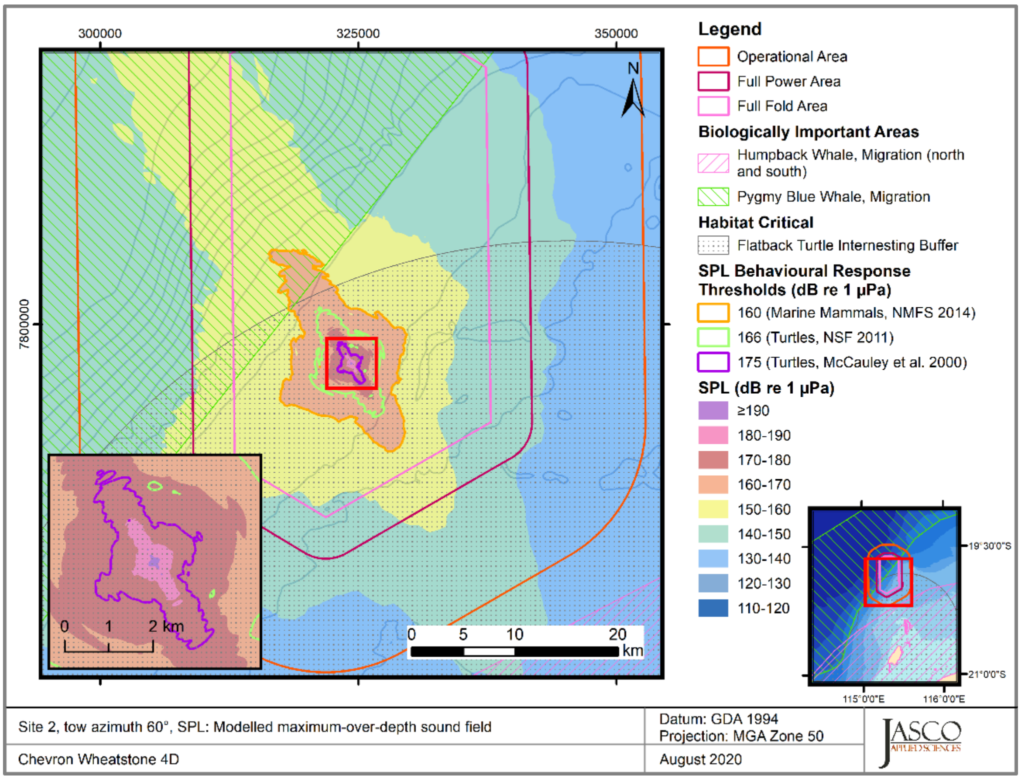

Figure 3. *Site 2, tow azimuth 60º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

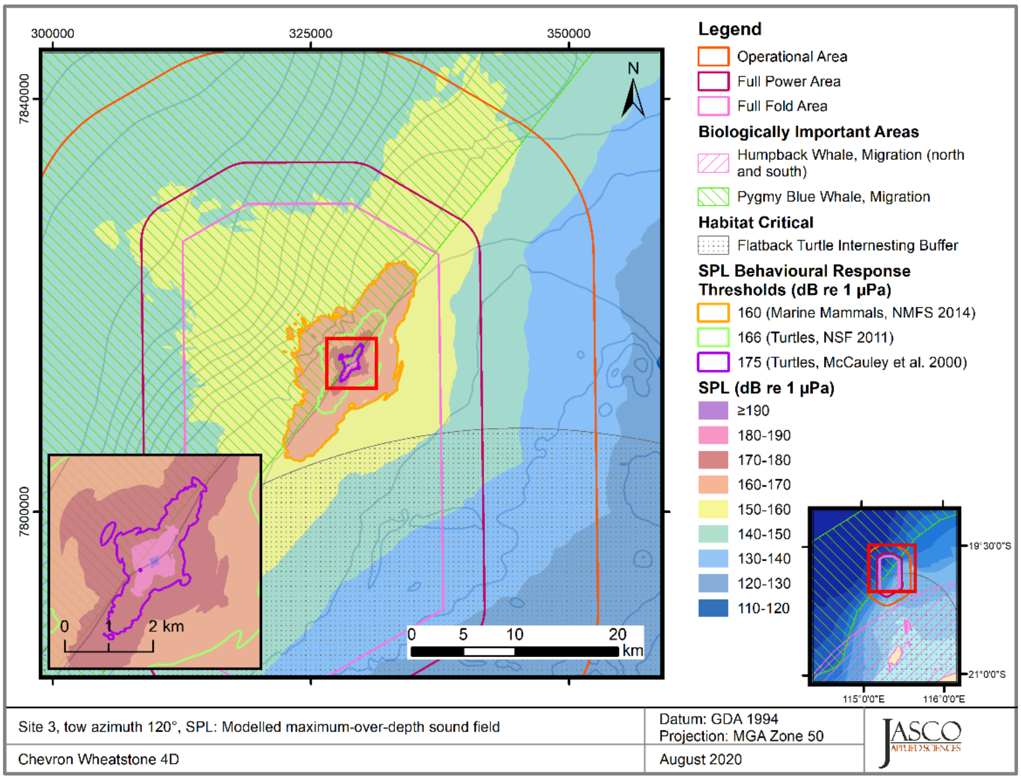

Figure 4. *Site 3, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

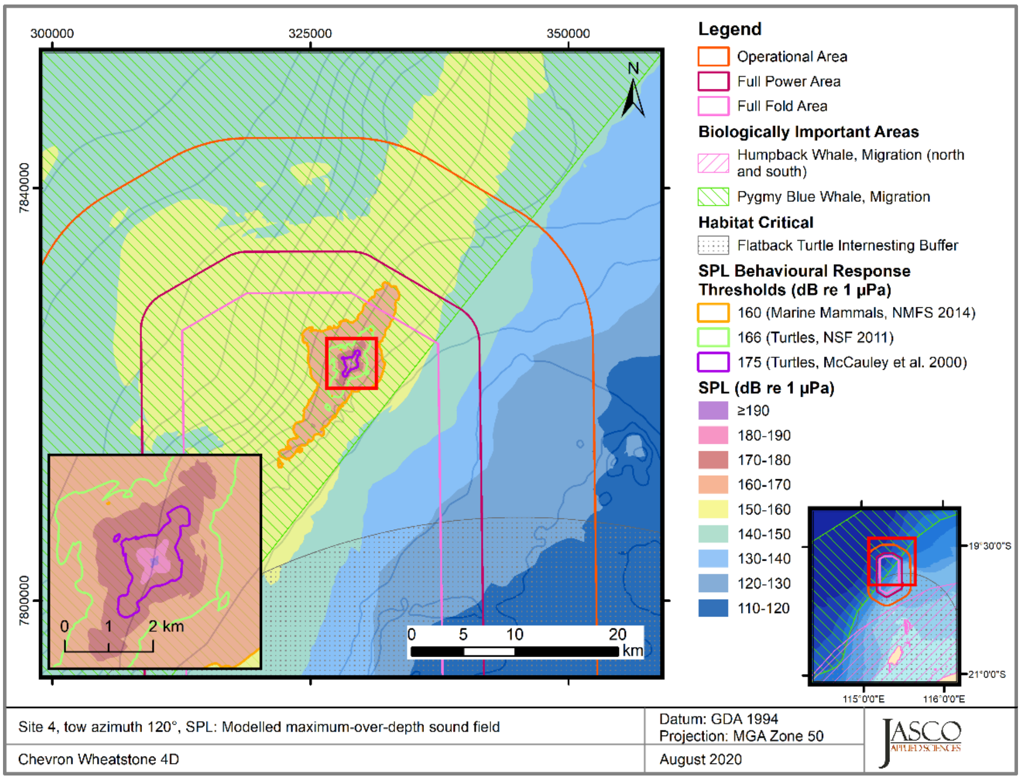

Figure 5. *Site 4, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

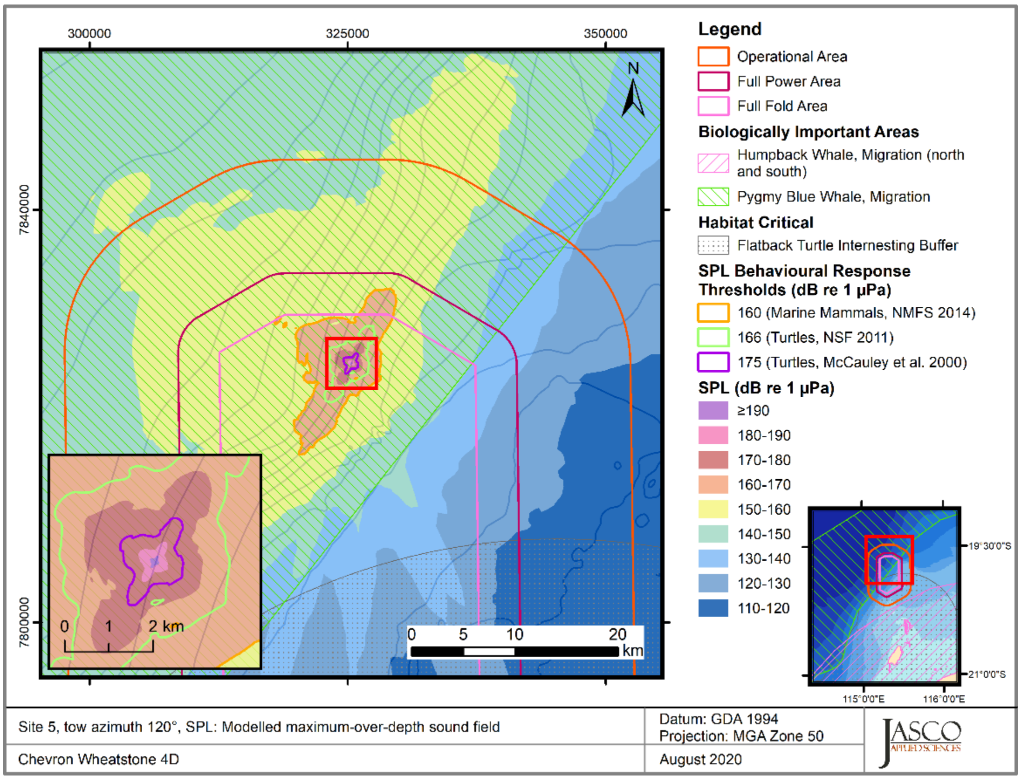

Figure 6. *Site 5, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

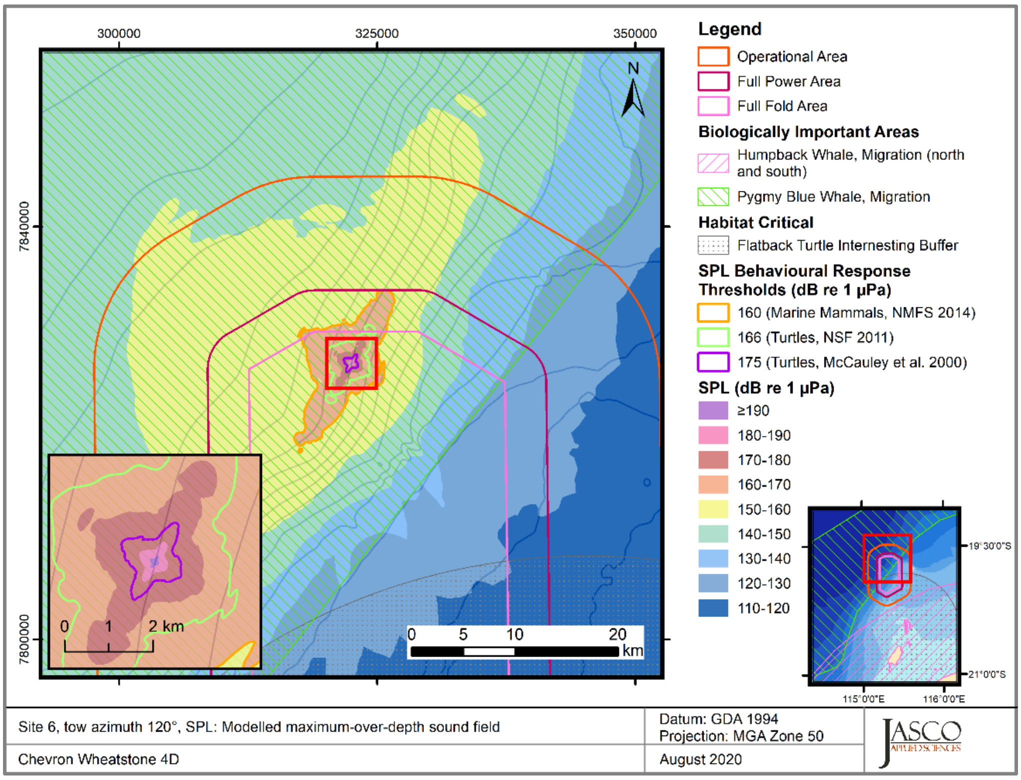

Figure 7. *Site 6, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

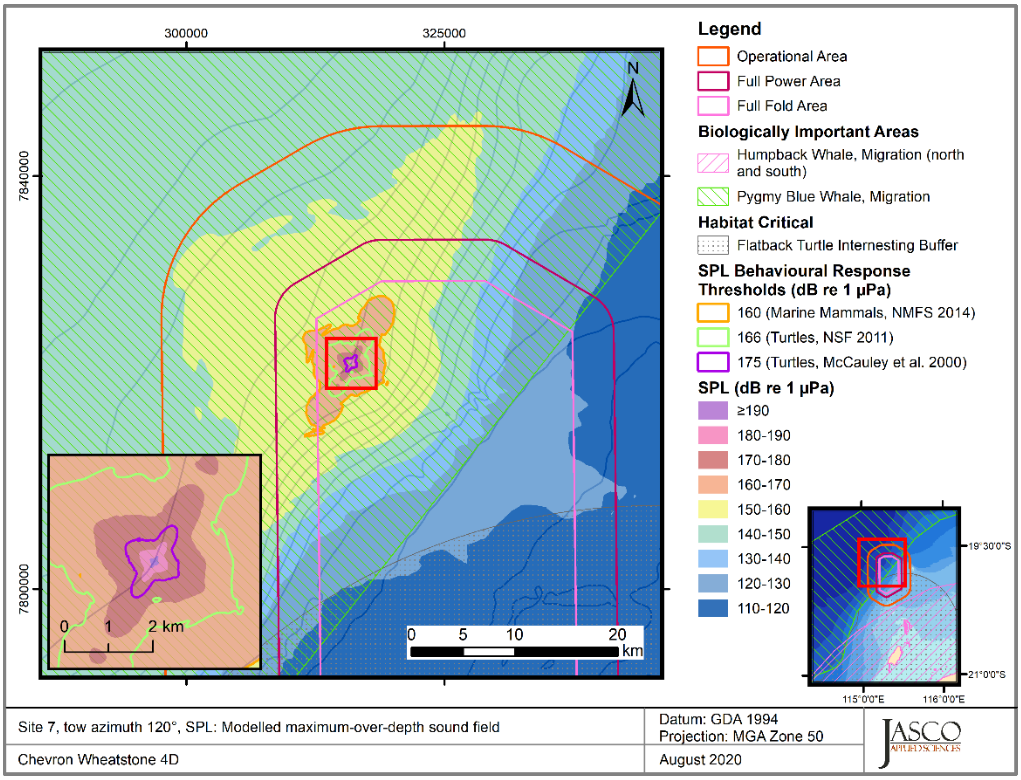

Figure 8. *Site 7, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

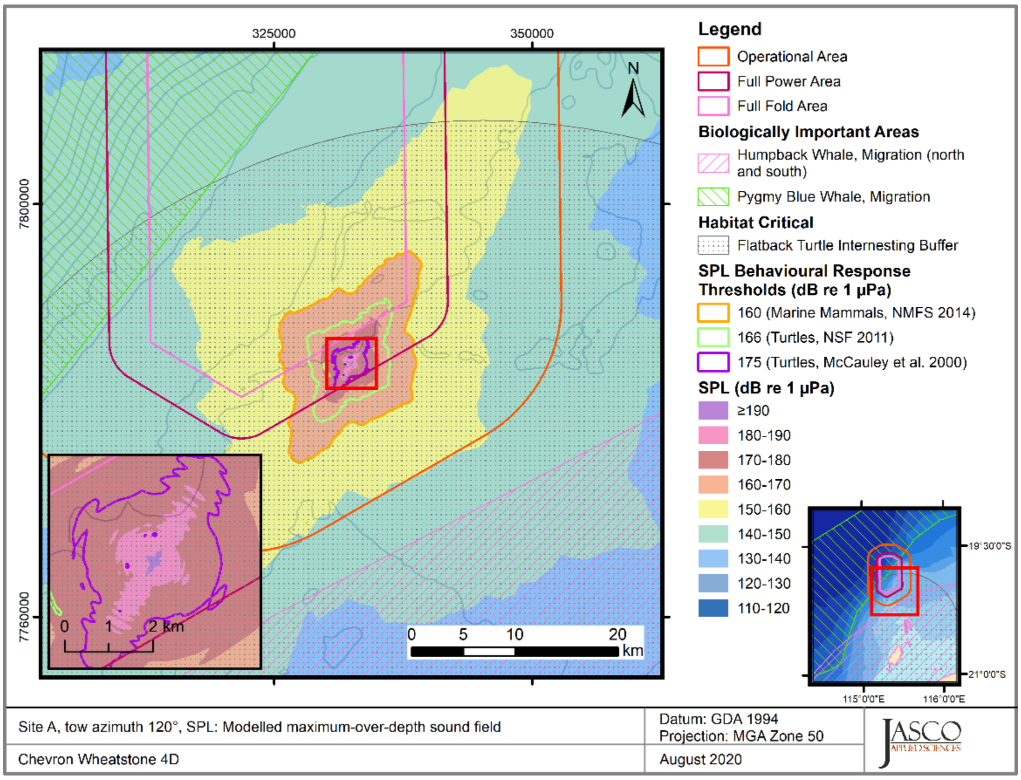

Figure 9. *Site A, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth of behavioural response thresholds for marine mammals and turtles.

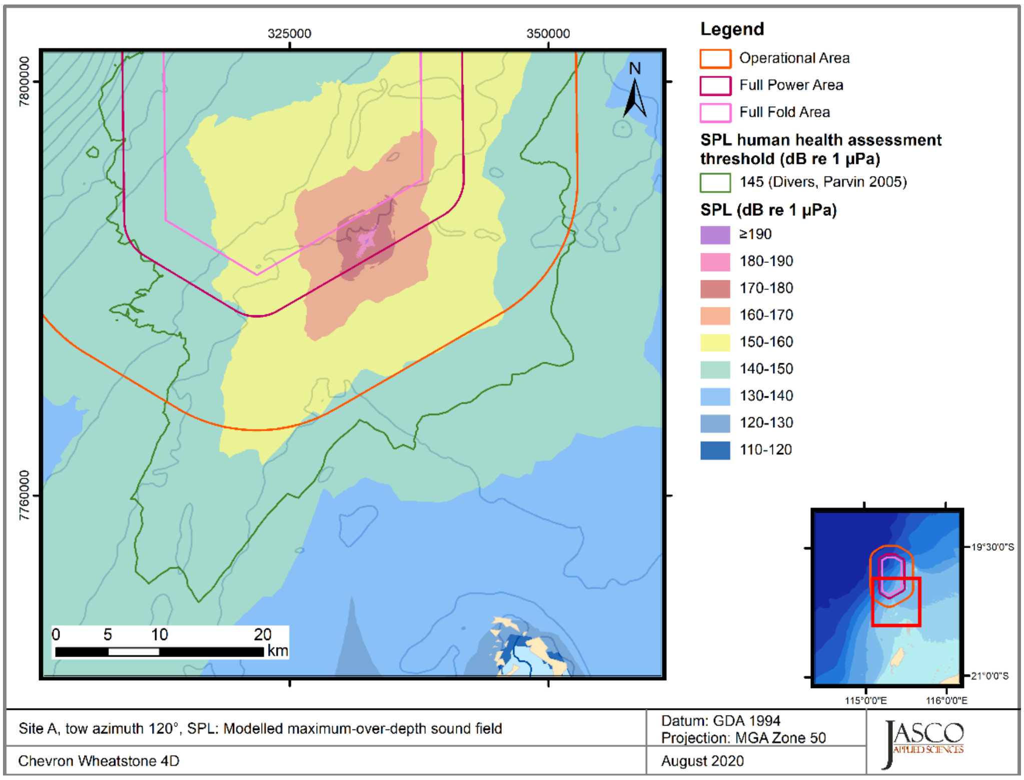

Figure 10. *Site A, tow azimuth 120º, SPL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth for the human divers health assessment threshold.

5.2.2.2. Vertical Slices of Modelled Sound Fields

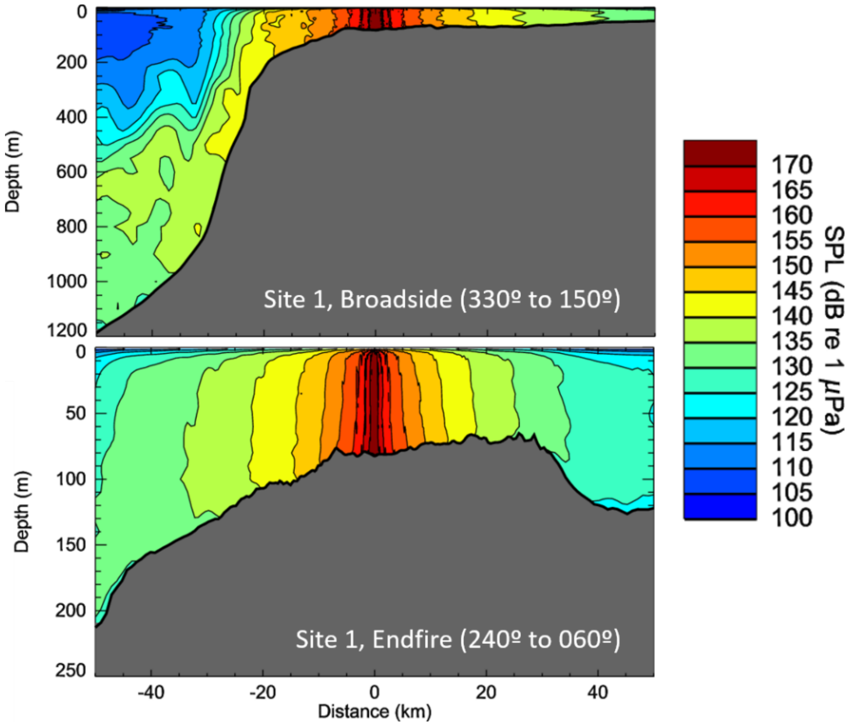

Figure 11. Site 1, *tow azimuth 60º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

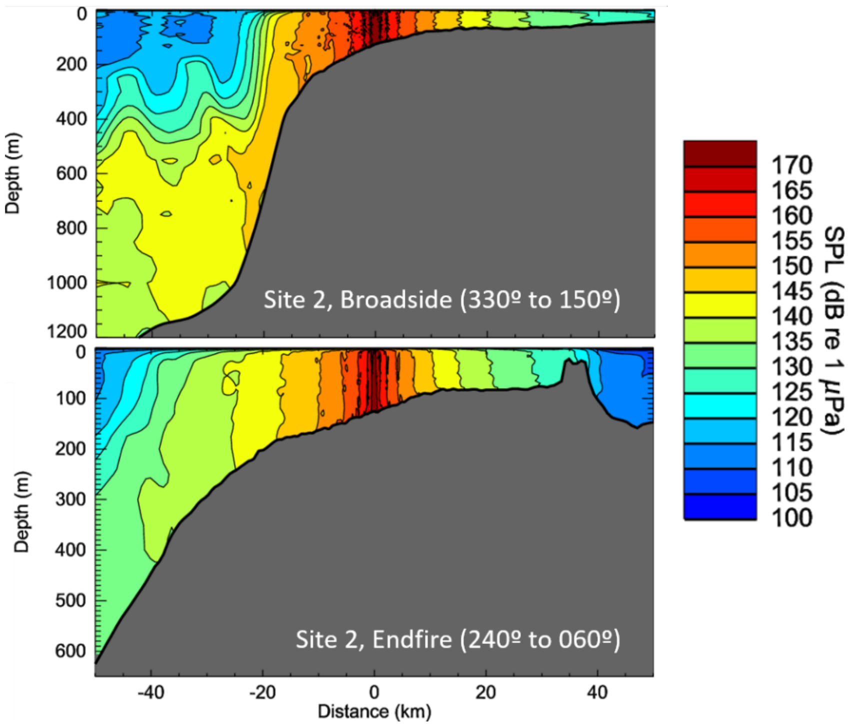

Figure 12. Site 2, *tow azimuth 60º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

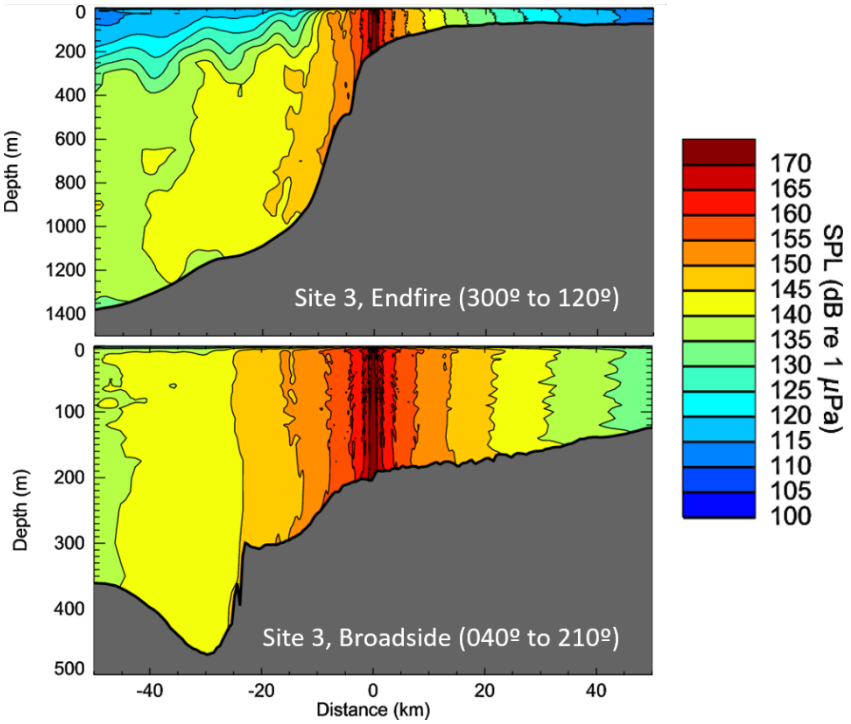

Figure 13. Site 3, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

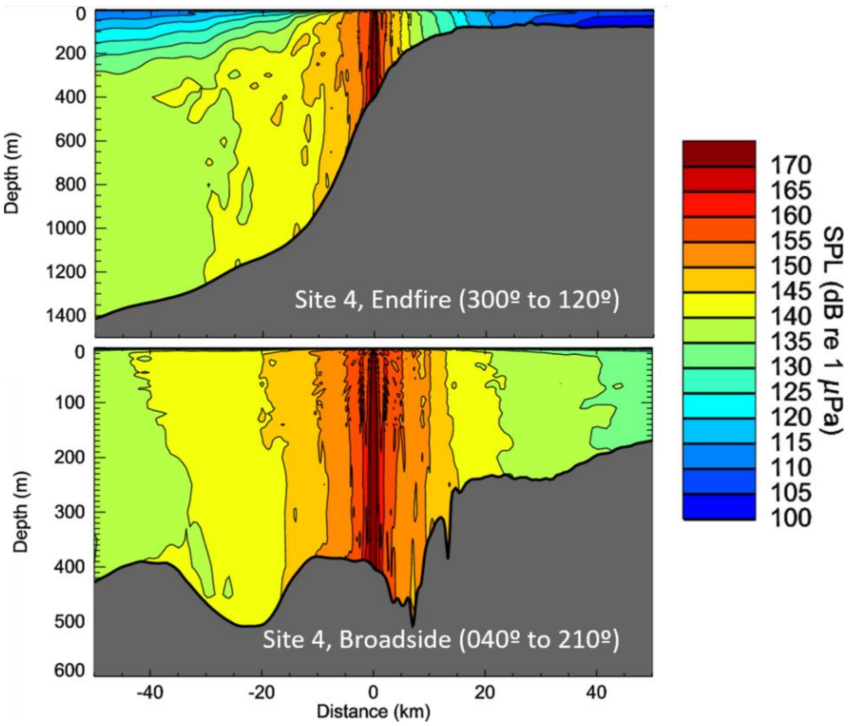

Figure 14. Site 4, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

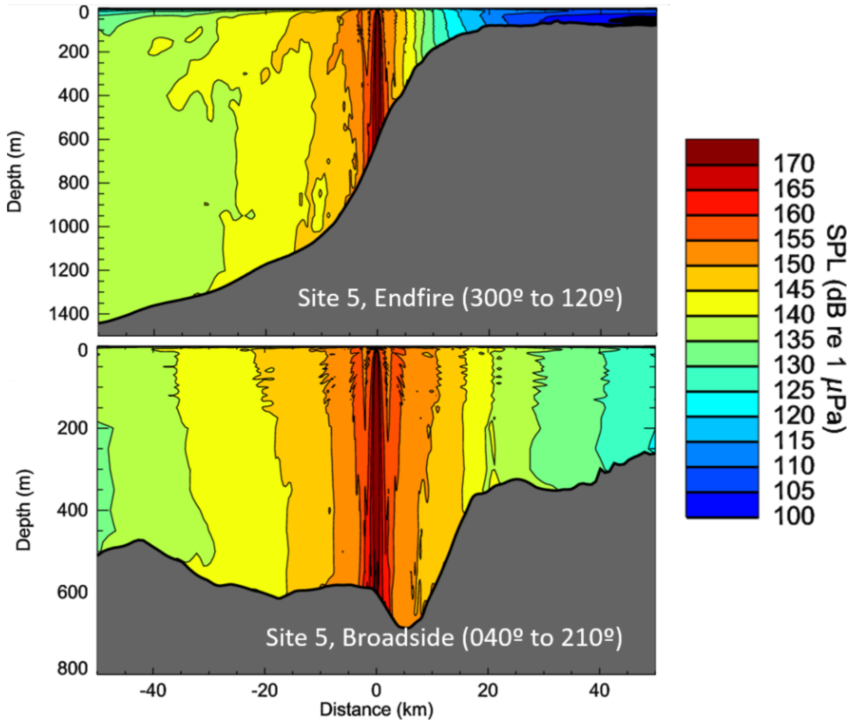

Figure 15. Site 5, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

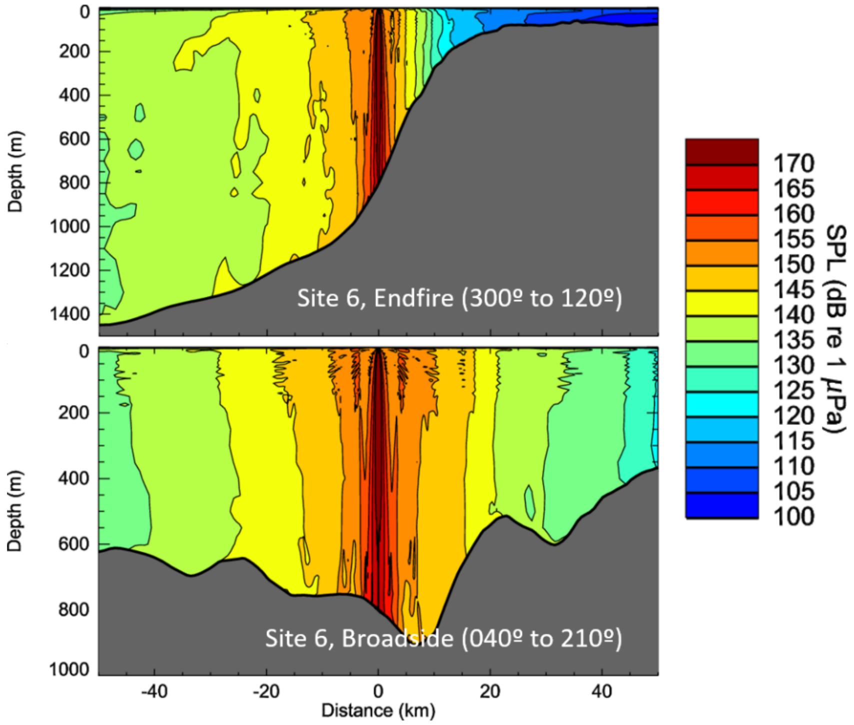

Figure 16. Site 6, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

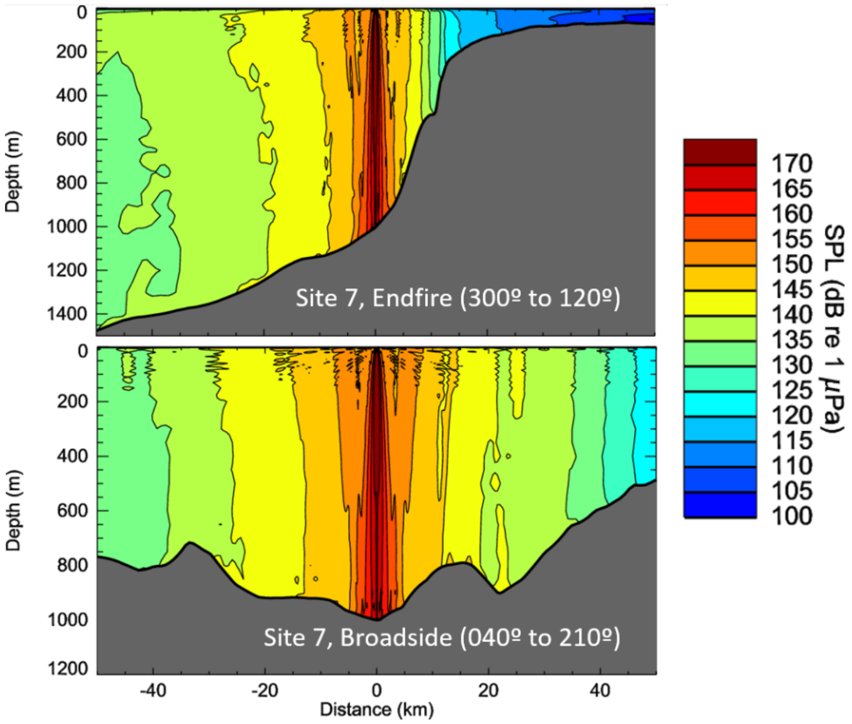

Figure 17. Site 7, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

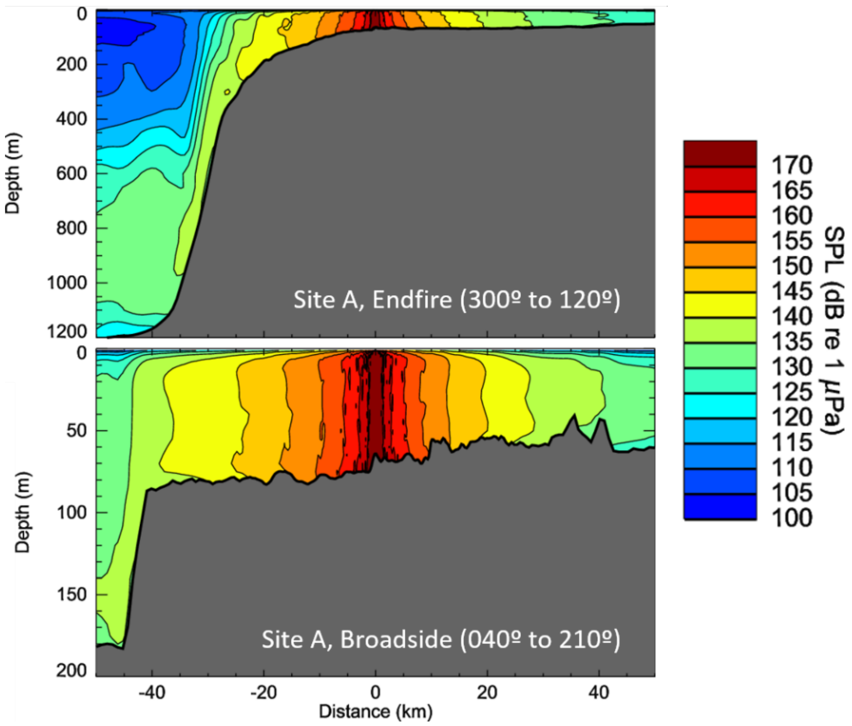

Figure 18. Site A, *tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, along (endfire) and perpendicular to the tow direction (broadside). The direction of each slice is also indicated in degrees from UTM north.

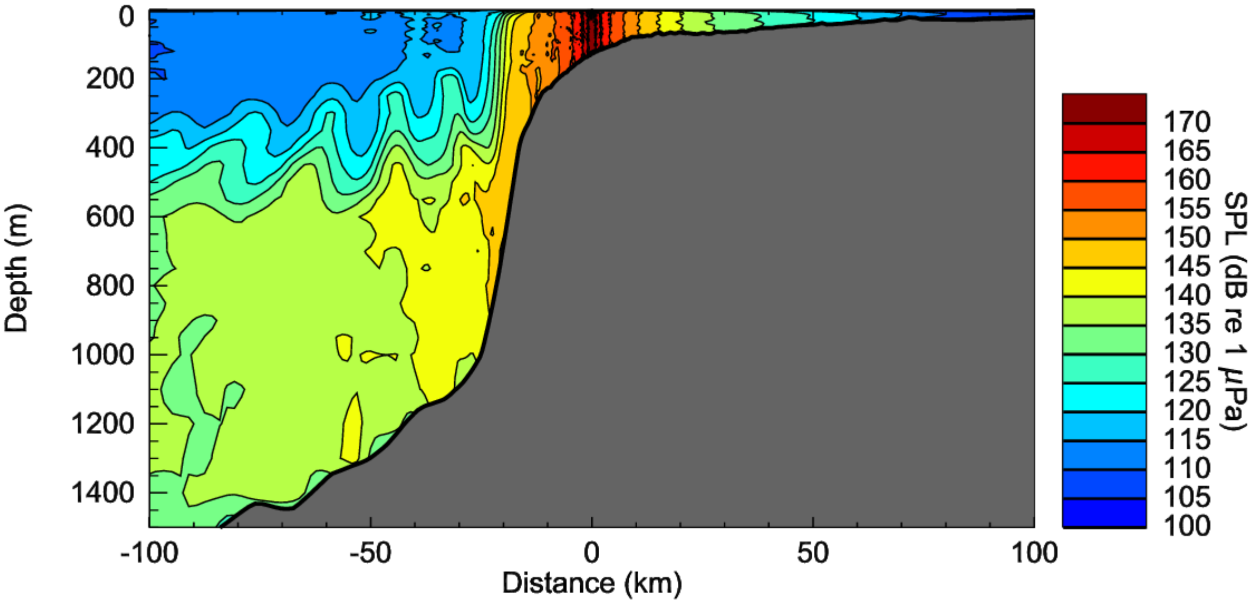

Figure 19. *Site 2, tow azimuth 60º, SPL*: Sound level contours on vertical slice of the sound field, perpendicular to the tow direction (broadside) along Broadside, (330 º to 150º).

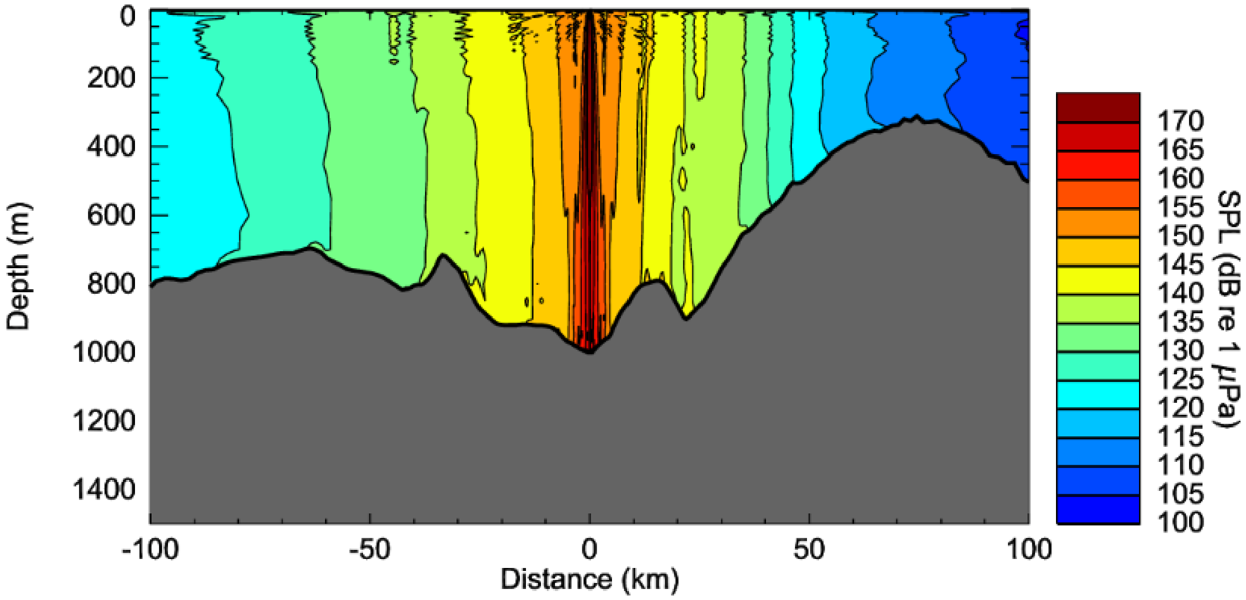

Figure 20. *Site 7, tow azimuth 120º, SPL*: Sound level contours on vertical slice of the sound field, perpendicular to the tow direction (broadside) along Broadside, (300 º to 120º).

5.3. Multiple Pulses Sound Fields

This section presents the sound fields in terms of SEL accumulated over 24 h of survey, for the modelled two survey scenarios: in the southern part of the survey area, along a tow azimuth 60º, and in the northern section of the survey area, along a tow azimuth of 120º. Frequency-weighted SEL_{24h} sound fields were used to estimate the maximum and 95% distances (R_{max} and $R_{95\%}$; calculated as detailed in Appendix C.1) to marine mammals and turtle PTS and TTS thresholds (listed in Table 16), and to estimate maximum distance and the area to injury and TTS guidelines for fish (Table 17). The distances to TTS for fish are presented as maximum-over-depth only, distances at the seafloor will be approximately similar given the distribution of sound within the water column at the sites within the scenarios, as evident in the vertical slice plots (Section 5.2.2.2).

The SEL_{24h} sound fields are presented as contour maps in Figures 21 and 22. These figures present the unweighted SEL_{24h} in 10 dB steps, as well as the isopleths corresponding to thresholds or guidelines for which R_{max} is greater than 20 m.

For each modelling scenario, the distance from the centre point of each outside acquisition line, either the northern-most (most offshore) or southern-most (most nearshore) line to the furthest point on the TTS isopleth was calculated. For Scenario 1, the 60º tow azimuth lines, the extent from north-most line centre point to the edge of the offshore TTS isopleth lobe was 95.4 km, whilst the extent from south-most line centre point to the edge of the inshore TTS isopleth lobe was 35.1 km. For Scenario 2, the 120º tow azimuth lines, the extent from north-most line centre point to the edge of the offshore TTS isopleth lobe was 54.8 km, whilst the extent from the south-most line centre point to the edge of the inshore TTS isopleth lobe was 14.8 km.

5.3.1. Tabulated Results

Table 16. *Marine Mammal and sea turtle criteria*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the survey lines to permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds considering 24 h of survey activity.

Hearing group	Weighted SEL thresholds ($L_{E,24h}$; dB re 1 µPa²·s)	Scenario 1 (tow azimuth 60º)		Scenario 2 (tow azimuth 120º)	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
PTS					
Low-frequency cetaceans	183	6.61	5.28	5.91	4.35
Mid-frequency cetaceans	185	-	-	-	-
High-frequency cetaceans	155	<0.02	/	<0.02	/
Sea Turtles	204	<0.02	/	<0.02	/
TTS					
Low-frequency cetaceans	168	95.4	81.6	64.7	51.8
Mid-frequency cetaceans	170	-	-	-	-
High-frequency cetaceans	140	1.63	0.99	0.97	0.57
Sea Turtles	189	3.84	3.09	3.53	2.78

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is smaller than the modelling resolution (20 m).

Table 17. *Fish guideline*: Maximum horizontal distances (R_{max}, in km) from the survey lines and area (km^2) to injury and temporary threshold shift (TTS) thresholds considering 24 h of survey activity.

Marine fauna group	Guidline for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Maximum-over-depth			
		Scenario 1		Scenario 2	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
Mortality and potential mortal injury					
I	219	<0.02	/	<0.02	/
II, fish eggs and fish larvae	210	<0.02	/	<0.02	/
III	207	<0.02	/	<0.02	/
Fish recoverable injury					
I	216	<0.02	/	<0.02	/
II, III	203	<0.02	/	<0.02	/
Fish TTS					
I, II, III	186	8.63	832.2	7.56	657.9

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A slash indicates that the area is not reported when the R_{max} is smaller than the modelling resolution (20 m).

5.3.2. Sound Level Contour Maps

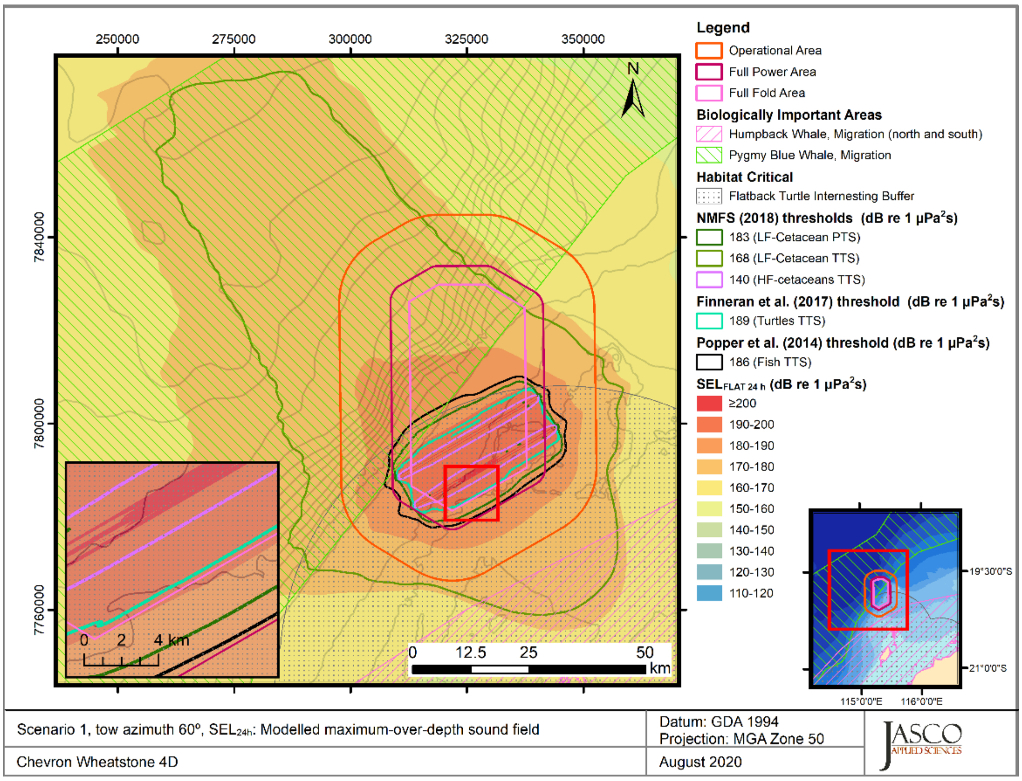

Figure 21. *Scenario 1, tow azimuth 60º*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for cetaceans, turtles and fish.Isopleths omitted here were not reached or large enough to display graphically at the mapped scale.

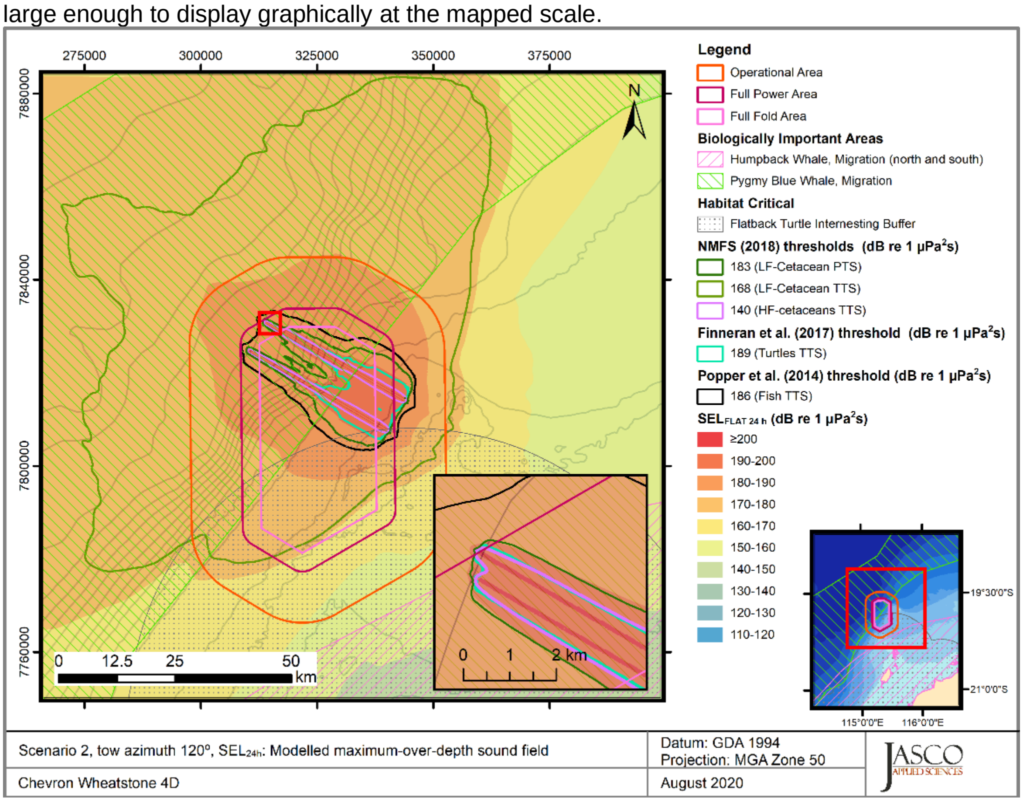

Figure 22. *Scenario 2, tow azimuth 120º*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for cetaceans, turtles and fish.Isopleths omitted here were not reached or large enough to display graphically at the mapped scale.

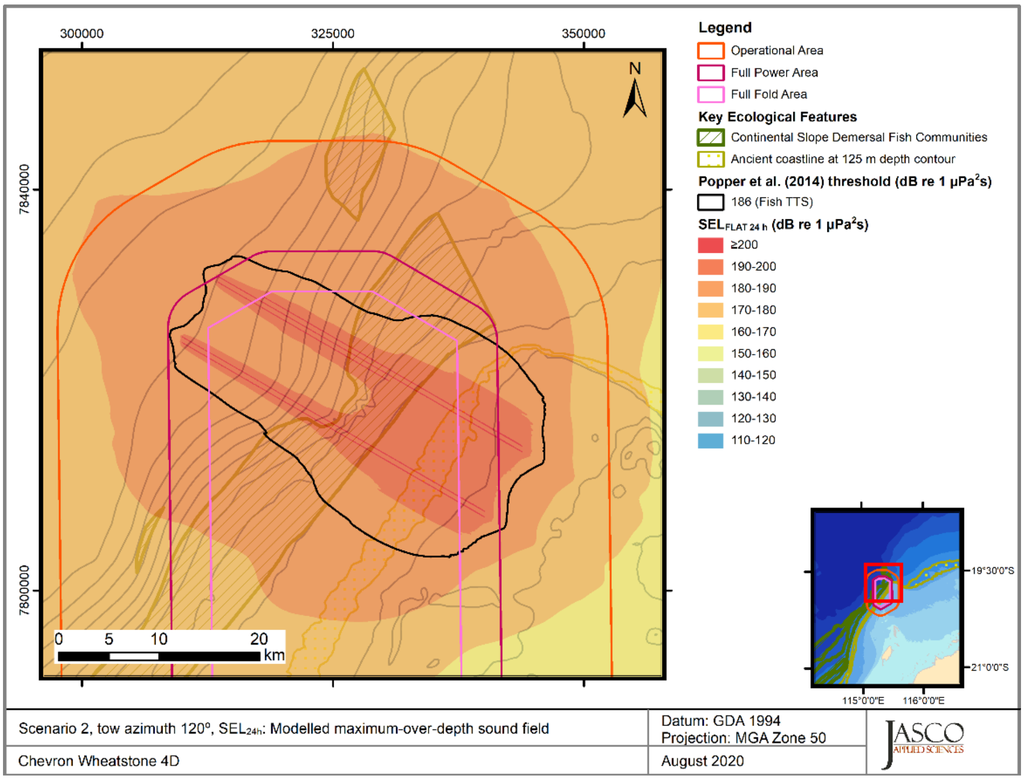

Figure 23. *Scenario 2, tow azimuth 120º*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for fish TTS in relation to the Continental Slope Demersal Fish Communities KEF.

6. Discussion and Conclusion

This modelling study predicted underwater sound levels associated with the planned Wheatstone 4D MSS. The underwater sound field was modelled for a 4130 in^3 seismic source (Appendix C.5).

An analysis of seasonal sound speed profiles for the initial potential survey time period (November to May), the results of which are presented in Appendix C.4.2, determined that the profile from May was expected to be most favourable to longer-range sound propagation, and thus precautionary estimates of distances to received sound level thresholds within the water column, due to the a slight upward refracting profile in the upper 50 m. Modelling also accounted for site-specific bathymetric variations (Appendix C.4.1) and local geoacoustic properties (Appendix C.4.3).

Most acoustic energy from a seismic source is output at lower frequencies, in the tens to hundreds of hertz. The modelled 4130 in^3 array had a pronounced broadside directivity for 1/3-octave-bands between ~125 to 316 Hz (Appendix C.5.1), which caused a noticeable axial bulge in the modelled acoustic footprints.

The overall broadband (10–25000 Hz) unweighted per-pulse SEL source level of the 4130 in^3 seismic source operating at 5 m depth was 229.6 dB 1 $\mu Pa^2 m^2 s$ in the broadside direction and 229.2 dB 1 $\mu Pa^2 m^2 s$ in the endfire direction. The peak source pressure level in the same directions was 250.1 and 248.2 dB re 1 µPa m, respectively (Table 8).

6.1. Per-Pulse Sound Levels

The per-pulse modelling sites encompassed water depths from 64 to 1000 m across three different geological areas with a single representative water column profile. At all single impulse sites the distances to identified isopleths were greater in the broadside direction than in the endfire direction, a difference apparent in all footprint maps in Section 5.2.2.1. The array directionality and frequency content coupled with the bathymetry had a considerable effect on propagation at longer distances, with generally larger lobes of sound energy extending into the deeper waters or along the continental shelf. The vertical slice plots (Section 5.2.2.2) assist in demonstrating the influence of the bathymetry, source location and sound speed profile on the sound field. Furthermore, sources located in deeper water have a lower "cut-off frequency (f_c)" than sources in shallower water. The cut-off frequency is a single number that describes how much acoustic energy can propagate with minimal loss between then sea-surface and seafloor interfaces. For a given acoustic signal, frequencies below f_c are subject to higher loss compared to frequencies above the f_c (Jensen et al. 2011). For sources in waters greater than 150 m deep (Sites 3–7), the cut off frequency was less than 10 Hz, and for these sites a large amount of low-frequency energy can propagate in the water column compared to sources in shallow water below 150 m (Sites 1, 2 and A).

The sound speed profile (Figure C-8) was primarily downwards refracting apart from a moderate surface duct and the profile had a minimum sound speed at approximately 1000 m that forms the sound channel axis, which is indicative of deep ocean profiles. For source locations above the continental shelf break and continental slope significant amounts energy reflected from the seabed can be trapped in the deep sound channel and propagate for large distances within the ocean interior. This is particularly obvious in the slice plots showing 100 km either side of the source in the broadside direction (Figures 19 and 20). This phenomenon resulted in large ranges to all isopleths in the offshore directions, furthermore the largest ranges occur when the broadside azimuth of the array points in the offshore direction. The shallow surface duct (≤50 m deep) in the profiles shown in Figure C-8 is not deep enough to trap energy below approximately 550 Hz (Equation 1.36 in Jensen et al. (2011)). The surface duct therefore can only trap the higher frequencies of the array that contribute less to the broadband source level than lower frequencies (Figure C-10). However, when trapped, high frequencies can propagate with little loss and can produce higher levels near the sea-surface than scenarios where no surface duct is present.

At longer ranges, particularly in the offshore direction, there is significantly less sound energy above 400 m as compared to greater depths (Figure 19). The implications of the distribution of the sound field within the water column for marine mammals is that migratory mysticetes, such as pygmy blue whales within the BIA, who mainly use the shallower depths (Owen et al. 2016), will not be exposed to higher sound levels at longer ranges. For instance, the mean maximum depth of exploratory dives was 107 ± 81 m, ranging between 23–320 m, while the majority of migration (94% of observed time) was spent at water depths of less than 24 m (Owen et al. 2016).

Three geoacoustic profiles have been considered for the modelling sites, which vary depending on the water depth and the area on the continental shelf. The three profiles are comparable, and the differences had a less pronounced influence on the sound field than the directionality of the airgun array and interaction with the bathymetry and sound speed profile.

The distances to SPL thresholds for behavioural response in marine mammals, and behavioural response and disturbance in turtles typically decrease as water depth increases (Tables 9 and 10). However, the orientation of the source is also key, as the array has a pronounced directivity pattern, with greater distances to sound levels in the broadside direction as compared to the endfire direction. The influence of the bathymetry on the sound fields and the orientation of the source are the reason the humpback whale migratory BIA is not predicted to be ensonified above the marine mammal behavioural disturbance threshold or the shallow waters around the Montebello Islands are not predicted to be ensonified above the human health assessment threshold of 145 dB re 1 µPa.

The distances to seafloor effect criteria (Sections 3.2 and 3.4) for fish and benthic invertebrates at the seafloor decrease with increasing depth.

6.2. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic source operation was modelled considering two representative scenarios with a realistic acquisition pattern for the Wheatstone 4D MSS. The modelling predicted the accumulation of sound energy, considering the change in location and the azimuth of the source at each pulse point, which were used to assess possible impacts to marine mammals and the SEL_{24h} based fish and marine mammal criteria. The results were presented as maps of the accumulated exposure levels and tabulated values of ranges to threshold levels and exposure areas for the given effects criteria (Section 5.3).

The footprints and range maxima for all SEL_{24h} criteria are substantially influenced by the locations of the source near the shelf break and slope. For an acquisition line which transitions from shallow to deep water, more low frequency energy is transmitted into the water column, where it can be trapped in the deep-water sound channel and propagate with minimal loss. This effect is manifested in the large extent for isopleths and R_{max} distances to thresholds in the offshore direction shown Figures 21–23. Furthermore, the rate of attenuation decreases as range from the acquisition lines increases, and propagation of this nature can further reduce the attenuation rate and allow lower levels to persist to longer ranges.

The pygmy blue whale migratory BIA is ensonified above the low-frequency cetacean TTS threshold for both scenarios. The 60º tow azimuth acquisition lines within Scenario 1 orientate the broadside lobe towards the humpback whale migratory BIA, thus leading to its ensonification above the TTS threshold. Similar distances to the TTS threshold in a southern direction are expected from other acquisition lines with a tow azimuth of 60° which may be closer to the humpback whale migratory BIA. Therefore the measured distance of 14.8 km, the extent from the south-most line centre point to the edge of the inshore TTS isopleth lobe, (Section 5.3) can likely be used as a buffer distance to calculate the potential overlap of the TTS isopleth with the BIA.

Given the distribution of the single impulse sound fields over the water column, particularly in deeper water, as discussed in Section 6.1, it is likely that the maximum-over-depth SEL_{24h} results for TTS in low-frequency cetaceans at long range off the continental shelf do not accurately represent the actual exposures whales migrating at predominantly shallow depths will receive.

6.3. Summary

This section presents a summary of the distances to the noise effect criteria applied in this study (Section 3) as relevant to the impact assessment. The effect criteria for impairment of marine mammals, fish and sea turtles use dual metrics (PK and SEL_{24h}), and the longest distance associated with either metric is required to be applied, and thus is presented in this summary.

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. Where the corresponding SEL_{24h} radii are larger than those for peak pressure criteria, they often represent an unlikely worst-case scenario. More realistically, marine mammals, fish and sea turtles 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. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna 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.

Marine mammals

- Table 18 summarises the distances to effect thresholds for marine mammals.

Table 18. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and PTS and TTS thresholds for marine mammals (PK values from Table 13 and SEL_{24h} values from Table 16).

Hearing group	Modelled distance to effect thresholds (R_{max})		
	Behavioural response[1]	Impairment: TTS[2]	Impairment: PTS[2]
LF cetaceans		95.4	6.61
MF cetaceans	13.45	-	-
HF cetaceans		1.63	0.450

[1] Noise exposure criteria: NOAA (2019)
[2] Noise exposure criteria: NMFS (2018)

Sea turtles

- Table 19 summarises the distances to effect thresholds for sea turtles.

Table 19. Maximum (R_{max}) horizontal distances (in km) from modelled sites or scenarios to behavioural response thresholds and PTS and TTS thresholds for sea turtles (PK values from Table 13 and SEL_{24h} values from Table 16).

Hearing group	Modelled distance to effect thresholds (R_{max})			
	Behavioural response[1]	Behavioural disturbance[2]	Impairment: TTS[3]	Impairment: PTS[3]
Turtles	7.11	2.83	3.84	<0.02

[1] Noise exposure criteria: NSF (2011)
[2] Noise exposure criteria: McCauley et al. (2000b)
[3] Noise exposure criteria: Finneran et al. (2017)

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative guidelines based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics associated with mortality and potential mortal injury as well as impairment in the following groups:
  - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
  - Fish with a swim bladder that do not use it for hearing
  - Fish that use their swim bladders for hearing
  - Fish eggs and fish larvae
- Table 20 summarises the distances to injury guidelines for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 20. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios (PK values from Tables 13 and 14 and SEL_{24h} values from Table 17).

Relevant hearing group	**Effect criteria**	**Scenario 1**		**Scenario 2**	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Injury	PK	0.096 (Site A, seafloor)	PK	0.07
	TTS	SEL_{24h}	8.63	SEL_{24h}	7.56
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	PK	0.27	PK	0.15
	TTS	SEL_{24h}	8.63	SEL_{24h}	7.56
Fish eggs, and larvae	Injury	PK	0.27	PK	0.15

Invertebrates, Sponges, Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following were determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered for seafloor sound levels; the sound level was reached at ranges between 0.431 and 0.913 km depending on the modelled site (Table 15).
- Sponges and coral: the PK sound level at the seafloor directly underneath the seismic source was estimated at all modelled sites and compared to the no effect sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was not reached at any of the modelled sites (Table 14).
- Plankton: The maximum distance to potential injury in plankton, applying the threshold from Popper et al. (2014), is 0.27 km (Table 13) within the water column.

Glossary

1/3-octave
One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017).

1/3-octave-band
Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

A-weighting
Frequency-selective weighting for human hearing in air that is derived from the inverse of the idealized 40-phon equal loudness hearing function across frequencies.

absorption
The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

Auditory frequency weighting (auditory weighting function, frequency-weighting function)
The process of band-pass filtering sounds to reduce the importance of inaudible or less-audible frequencies for individual species or groups of species of aquatic mammals (ISO 2017). One example is M-weighting introduced by Southall et al. (2007) to describe "Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds".

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

bar
Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^5 Pa or 10^{11} µPa.

boxcar averaging
A signal smoothing technique that returns the averages of consecutive segments of a specified width.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

continuous sound
A sound whose sound pressure level remains above ambient sound during the observation period (ANSI/ASA S1.13-2005 R2010). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decade
Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 2006).

decidecade
One tenth of a decade (ISO 2017). Note: An alternative name for decidecade (symbol ddec) is "one-tenth decade". A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a "one-third octave".

decidecade band
Frequency band whose bandwidth is one decidecade. Note: The bandwidth of a decidecade band increases with increasing centre frequency.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. See also broadside direction.

ensonified
Exposed to sound.

far-field
The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

fast-average sound pressure level
The time-averaged sound pressure levels calculated over the duration of a pulse (e.g., 90%-energy time window), using the leaky time integrator from Plomp and Bouman (1959) and a time constant of 125 ms. Typically used only for pulsed sounds.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

hearing group
Groups of marine mammal species with similar hearing ranges. Commonly defined functional hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seabed.

hearing threshold
The sound pressure level for any frequency of the hearing group that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for hearing high frequencies.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic airguns and impact pile driving.

low-frequency (LF) cetacean
The functional cetacean hearing group that represents mysticetes (baleen whales) specialized for hearing low frequencies.

mean-square sound pressure spectral density
Distribution as a function of frequency of the mean-square sound pressure per unit bandwidth (usually 1 Hz) of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2/Hz$.

median
The 50th percentile of a statistical distribution.

mid-frequency (MF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for mid-frequency hearing.

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but they use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI/ASA S3.20-1995 R2008). For example, marine vessels, aircraft, machinery, construction, and vibratory pile driving (NIOSH 1998, NOAA 2015).

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The skulls of toothed whales are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid
A common term used to describe members of the Otariidae, eared seals, commonly called sea lions and fur seals. Otariids are adapted to a semi-aquatic life; they use their large fore flippers for propulsion. Their ears distinguish them from phocids. Otariids are one of the three main groups in the superfamily Pinnipedia; the other two groups are phocids and walrus.

otariid pinnipeds in water (OPW)
The functional pinniped hearing group that represents eared seals under water.

parabolic equation method
A computationally efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

particle acceleration
The rate of change of particle velocity. Unit: metre per second squared (m/s^2). Symbol: *a*.

particle velocity
The physical speed of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: *v*.

peak pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

peak-to-peak pressure level (PK-PK)
The difference between the maximum and minimum instantaneous pressure levels. Unit: decibel (dB).

percentile level, exceedance
The sound level exceeded *n*% of the time during a measurement.

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

phocid
A common term used to describe all members of the family Phocidae. These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves. Phocids are one of the three main groups in the superfamily Pinnipedia; the other two groups are otariids and walrus.

phocid pinnipeds in water (PPW)
The functional pinniped hearing group that represents true/earless seals under water.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

power spectrum density
Generic term, formally defined as power in W/Hz, but sometimes loosely used to refer to the spectral density of other parameters such as square pressure or time-integrated square pressure.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pressure, hydrostatic
The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

rms
root-mean-square.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for airguns], single-strike SEL [for pile drivers], 24-hour SEL).

sound exposure spectral density
Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2 \cdot s/Hz$.

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound intensity
Sound energy flowing through a unit area perpendicular to the direction of propagation per unit time.

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 μPa^2:

$$L_p = 10\log_{10}(p^2/p_0^2) = 20\log_{10}(p/p_0)$$

Unless otherwise stated, SPL refers to the root-mean-square (rms) pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 metre from the acoustic centre of the source. Unit: dB re 1 µPa·m (pressure level) or dB re 1 $\mu Pa^2 \cdot s \cdot m$ (exposure level).

spectrum
An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also referred to as propagation loss.

wavelength
Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow the American National Standard Institute and International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI R2013), but these standards are not always consistent.

The zero-to-peak sound pressure, or peak sound pressure (PK or $L_{p,pk}$; dB re 1 µPa), is the decibel level of the maximum instantaneous acoustic pressure in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,\mathrm{pk}} = 10\log_{10}\left(\frac{\max|p^2(t)|}{p_0^2}\right) = 20\log_{10}\left(\frac{\max|p(t)|}{p_0}\right) \tag{A-1}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of an acoustic event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure (PK-PK or $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure, possibly filtered in a stated frequency band, attained by an impulsive sound, $p(t)$:

$$L_{p,\mathrm{pk\text{-}pk}} = 10\log_{10}\left(\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2}\right) \tag{A-2}$$

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt \Big/ p_0^2\right) \tag{A-3}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,fast}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,boxcar\ 125ms}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90% SPL ($L_{p,90\%}$). In this report, SPL refers to $L_{p,boxcar\ 125ms}$.

The sound exposure level (SEL or L_E; dB re 1 µPa²·s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right) \quad \text{(A-4)}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}} \quad \text{(A-5)}$$

Because the SPL and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \quad \text{(A-6)}$$

When applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., *LE,LF,24h*; see Appendix 0).

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. They are approximately one third of an octave (base 2) wide and are therefore often referred to as 1/3-octave-bands. Each octave represents a doubling in sound frequency. The centre frequency of the ith band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{\frac{i}{10}}\,\text{kHz} \quad \text{(A-7)}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{lo,i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{hi,i} = 10^{\frac{1}{20}} f_c(i) \quad \text{(A-8)}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band 7 (f_c (7) = 5 Hz) to band 44 ($f_c(44)$ = 25 kHz).

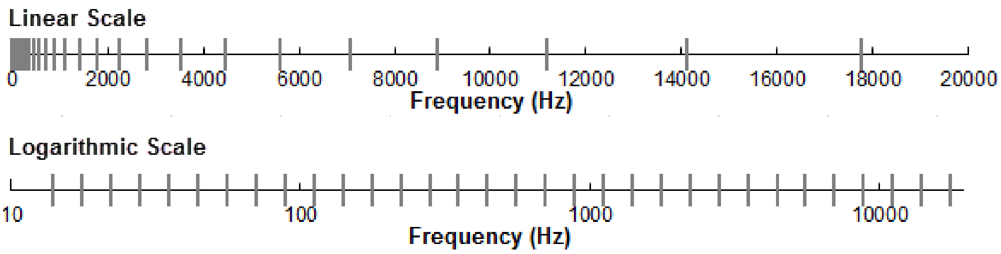

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\text{lo},i}$ and $f_{\text{hi},i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{\text{lo},i}}^{f_{\text{hi},i}} S(f)\, df \tag{A-9}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}} \tag{A-10}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient noise signal. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

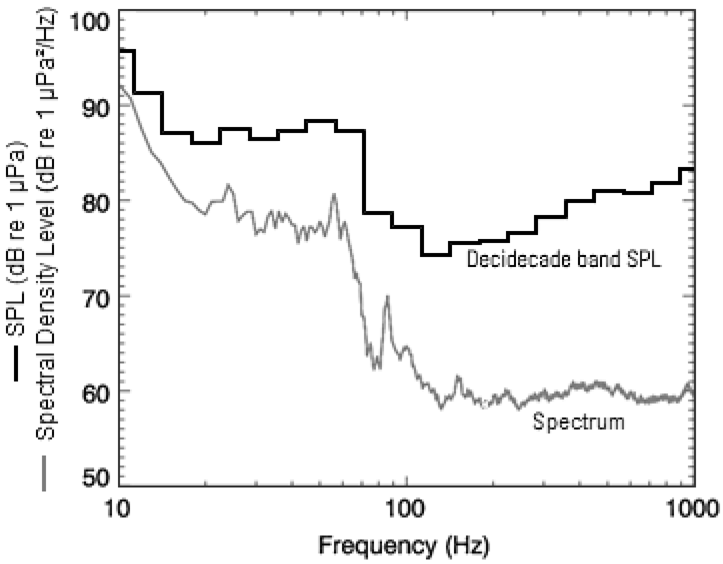

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

A.3. Marine Mammal Effect Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources–primarily airguns used in seismic surveys–could cause auditory impairment. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both impairment and disturbance. The following sections summarise the recent development of thresholds; however, this field remains an active research topic.

A.3.1. Auditory Impairment

There are two categories of auditory threshold shifts (also termed Noise Induced Threshold Shift, NITS): Permanent Threshold Shift (PTS), a physical injury to an animal's hearing system; and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of physiological and mechanical processes in the inner ear. While PTS undoubtedly constitutes an injury, TTS (as a temporary effect) was not considered in the same way. However, recent research clearly indicates that already moderate levels (<12 dB) of TTS produced an accelerated hearing loss (PTS) resulting from progressive neural degeneration with age (Kujawa and Liberman 2006, 2009, Maison et al. 2013, Kujawa and Liberman 2015).

The criteria for assessing possible effects of impulsive sounds (such as pile driving or seismic impulses) noise on marine mammals, NMFS (2018), was applied in this study.

A.3.2. Behavioural response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

For impulsive noise, NMFS currently uses step function thresholds of 160 dB re 1 µPa SPL (unweighted) to assess and regulate noise-induced behavioural impacts for marine mammals (NOAA 2018, NOAA 2019). The threshold for impulsive sound is derived from the High-Energy Seismic Survey (HESS) panel (HESS 1999) report that, in turn, is based on the responses of migrating mysticete whales to airgun sounds (Malme et al. 1984). The HESS team recognised that behavioural responses to sound may occur at lower levels, but significant responses were only likely to occur above a SPL of 140 dB re 1 µPa. Southall et al. (2007) found varying responses for most marine mammals between a SPL of 140 and 180 dB re 1 µPa, consistent with the HESS (1999) report, but lack of convergence in the data prevented them from suggesting explicit step functions.

A.4. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.4.1. Marine mammal frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-11)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

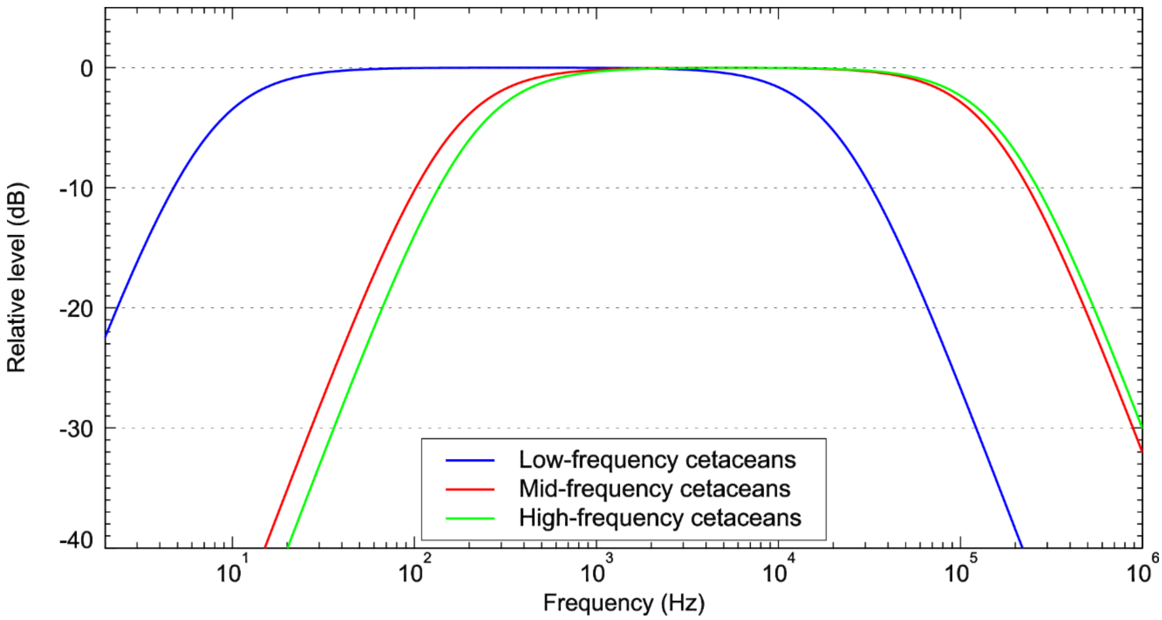

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

A.5. Fish, Fish Eggs, and Fish Larvae Effect Criteria

In general, any adverse effects of seismic sound on fish behaviour depends on the species, the state of the individuals exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a single-impulse of a maximum received level of either 231 dB re 1 µPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

In the discussion of the criteria, Popper et al. (2014) discuss the complications in determining a relevant period of mobile seismic surveys, as the received levels at the fish change between impulses because the source is moving, and that in reality a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach (CPA) are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be in close proximity to a sound source (i.e., overlap in space and time between the source and receiver). For example, accumulation time for fast moving (relative to the receiver) mobile sources is driven primarily by the characteristics of the source (i.e., speed, duty cycle; NMFS 2016, 2018).

As discussed in Popper (2018), many fish species move around, some over large distances. The author suggests that it is reasonable to think that if the sound of a seismic source becomes too loud, the fish will move away from the source because they are able to determine the direction of a sound source. If the fish moves away, the amount of energy to which it is exposed is likely to be one or a few seismic pulses, and these would not likely be loud enough to result in any effect because the fish would move away at a much lower level signal than could cause harm. Data on TTS for fish are very limited, with the only study that examined recovery from seismic impulses being Popper et al. (2005). Popper (2018) states that if this study had been conducted on wild, free-swimming fish instead of caged ones, there would have been no effect whatsoever because they were likely to have moved away from the source as it approached them, as would happen with normally free-moving demersal and pelagic fish species associated with a 3-D seismic survey in northern Australian waters, extrapolating from the Bethany 3-D assessed in Popper (2018).

Therefore, the time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fish receives the maximum exposure, and 24 h is likely too long a period for calculating the accumulation of energy in determining potential harm (e.g., damage or TTS) (Popper 2018). 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 h (or less) is very likely. If TTS does occur, the duration of exposure to the most intense sounds that could result in TTS will be over just a few hours. Thus, energy accumulating over longer periods than a few hours is probably inappropriate (Popper 2018).

Appendix B. Models

B.1. Acoustic Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landrø (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

While airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (800−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into decidecade frequency bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered a directional point source in the far field.

A seismic array consists of many sources and the point source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Sound Propagation Models

B.2.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 5 Hz to 2 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies > 2 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ number of planes (Figure B-1).

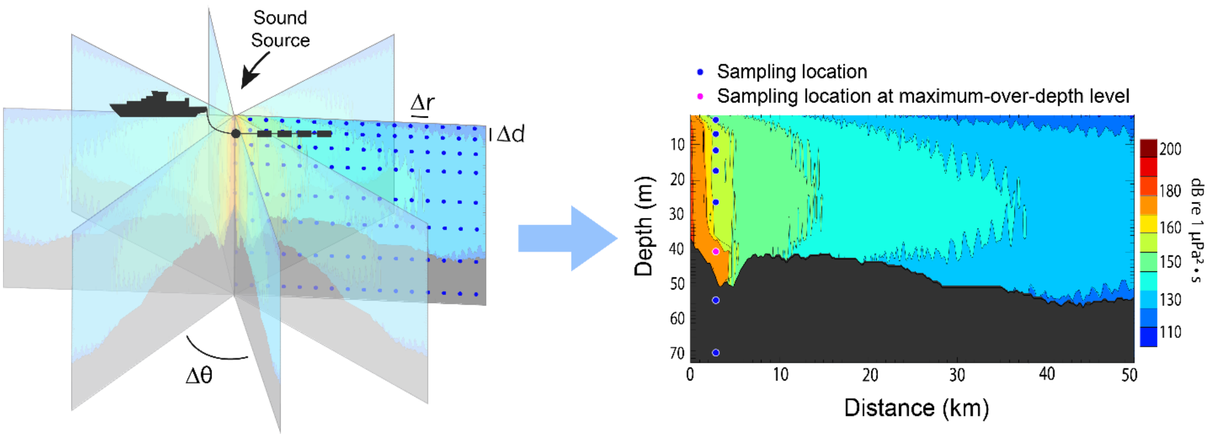

Figure B-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many frequency bands, starting at 5 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The decidecade-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received decidecade-band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure B-2). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure B-2) upward so that the trend line encompasses 90% of all the data (dashed line, Figure B-2).

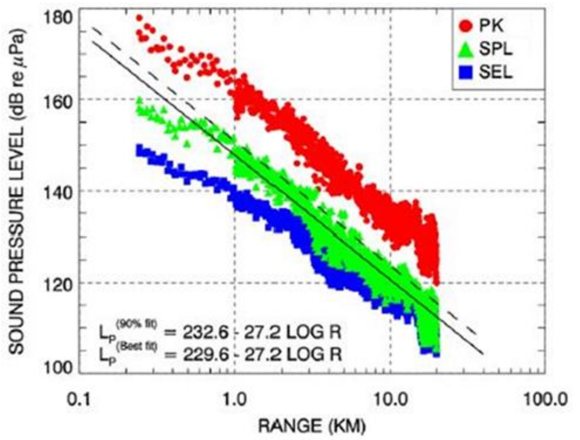

Figure B-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

B.2.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

B.2.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

B.3. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix C. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

C.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure C-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure C-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure C-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

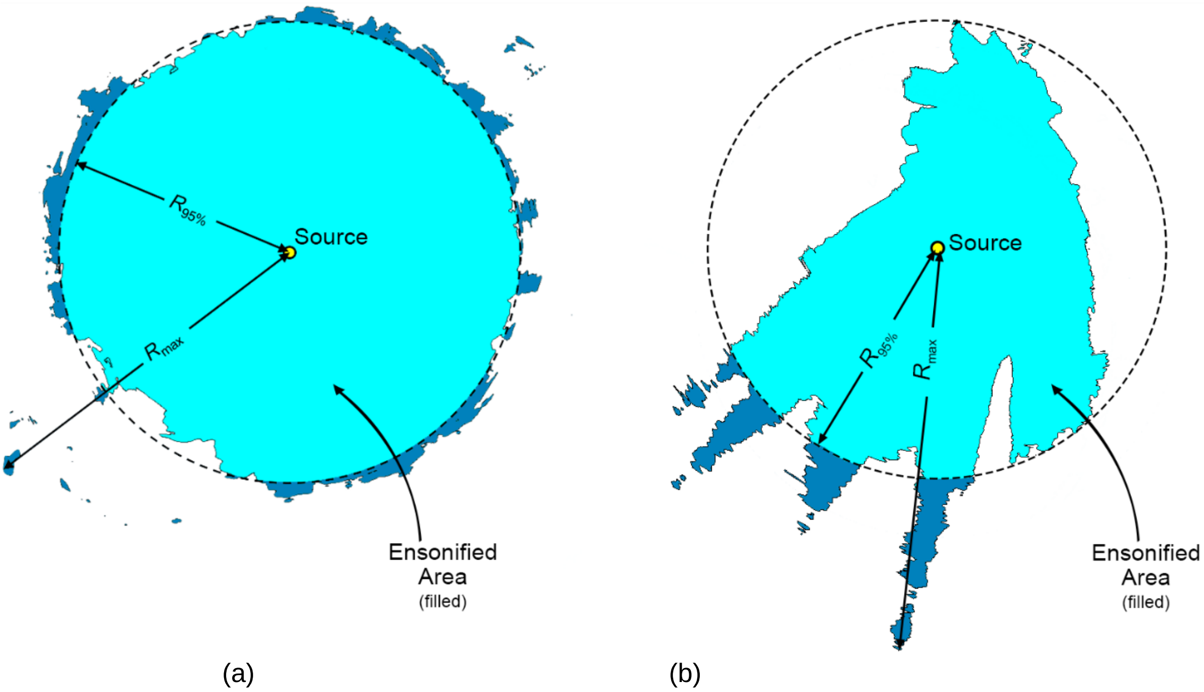

Figure C-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

C.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017b). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix B.2.2) was used to model synthetic seismic pulses over the frequency range 5–2048 Hz. This was performed along all broadside and endfire radials at three sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL -to-SPL offsets were averaged in 0.02 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range- dependent conversion function was averaged between the two sites and applied to predicted per-pulse SEL results from MONM to model SPL values. Figures D-2–D-4 show the conversion offsets for Sites 1, 3, 4, 6 and 7; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source.

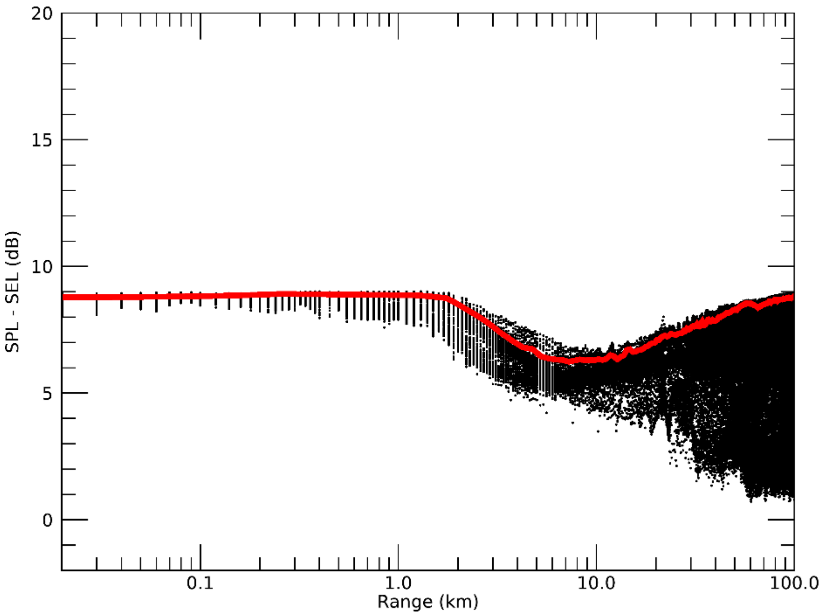

Figure C-2. *Site 1*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 4130 in^3 seismic source. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

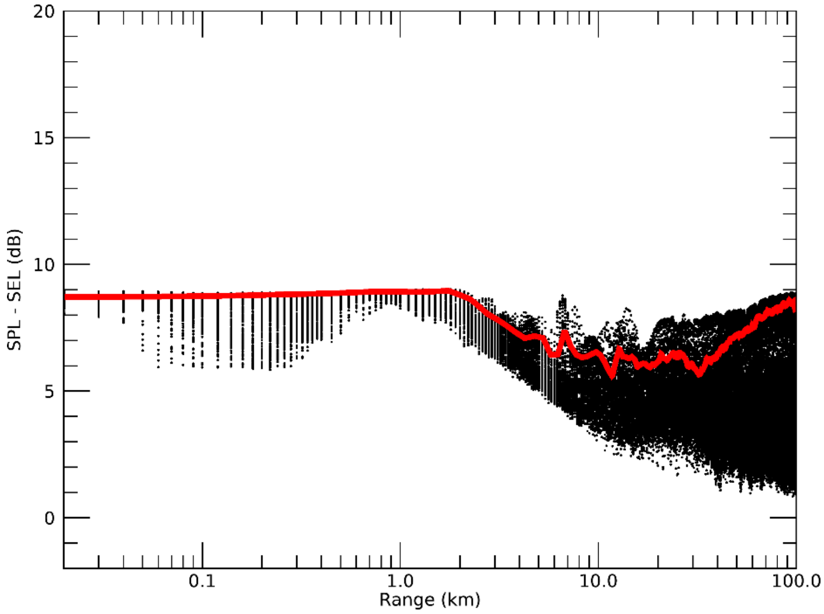

Figure C-3. *Site 3*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 4130 in^3 seismic source. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

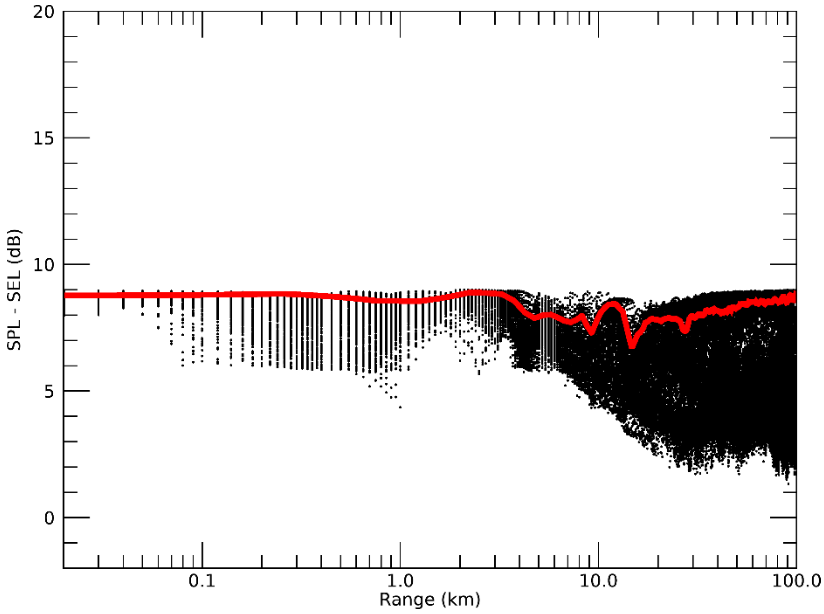

Figure C-4. *Site 4*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 4130 in^3 seismic source. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

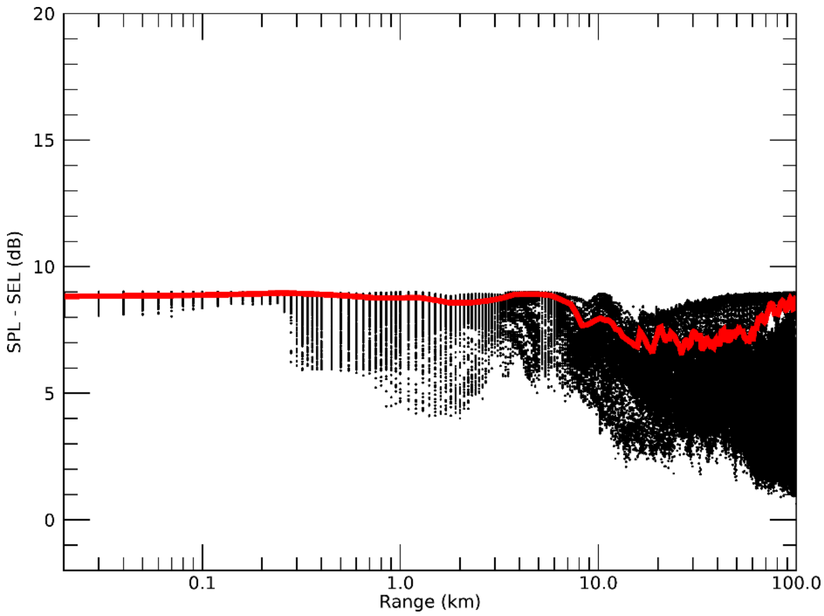

Figure C-5. *Site 6*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 4130 in^3 seismic source. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

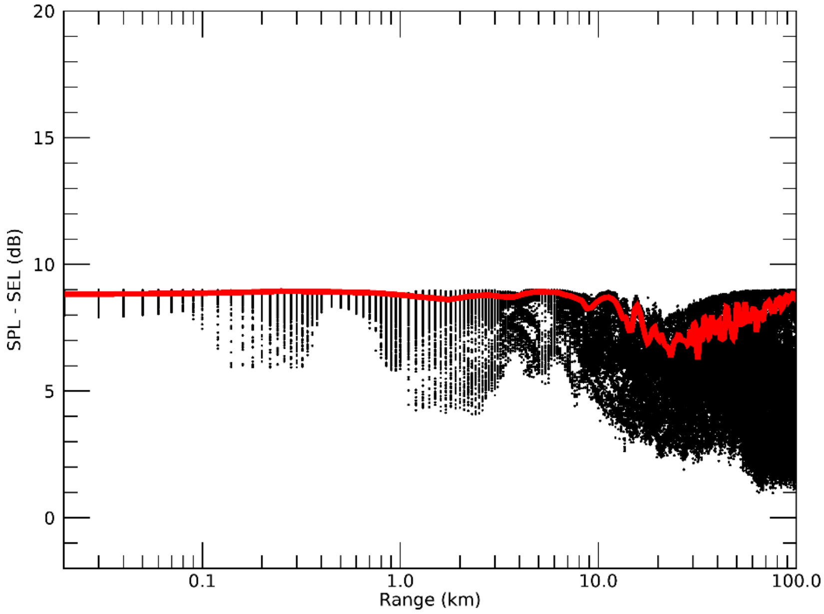

Figure C-6. *Site 7*: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 4130 in^3 seismic source. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

C.3. Accumulated SEL Calculation

When there are many seismic pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields. The single-impulse SEL fields were computed over model grids approximately 200 × 200 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

The unweighted (fish and turtles) and frequency-weighted (mammals) SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

C.4. Environmental Parameters

C.4.1. Bathymetry

Water depths throughout the modelled area were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009) for the region shown in Figure 1. Bathymetry data were extracted and re-gridded onto a Universal Transverse Mercator (UTM) coordinate projection (Zone 50) with a regular grid spacing of 100 × 100 m to generate the bathymetry in Figure C-7.

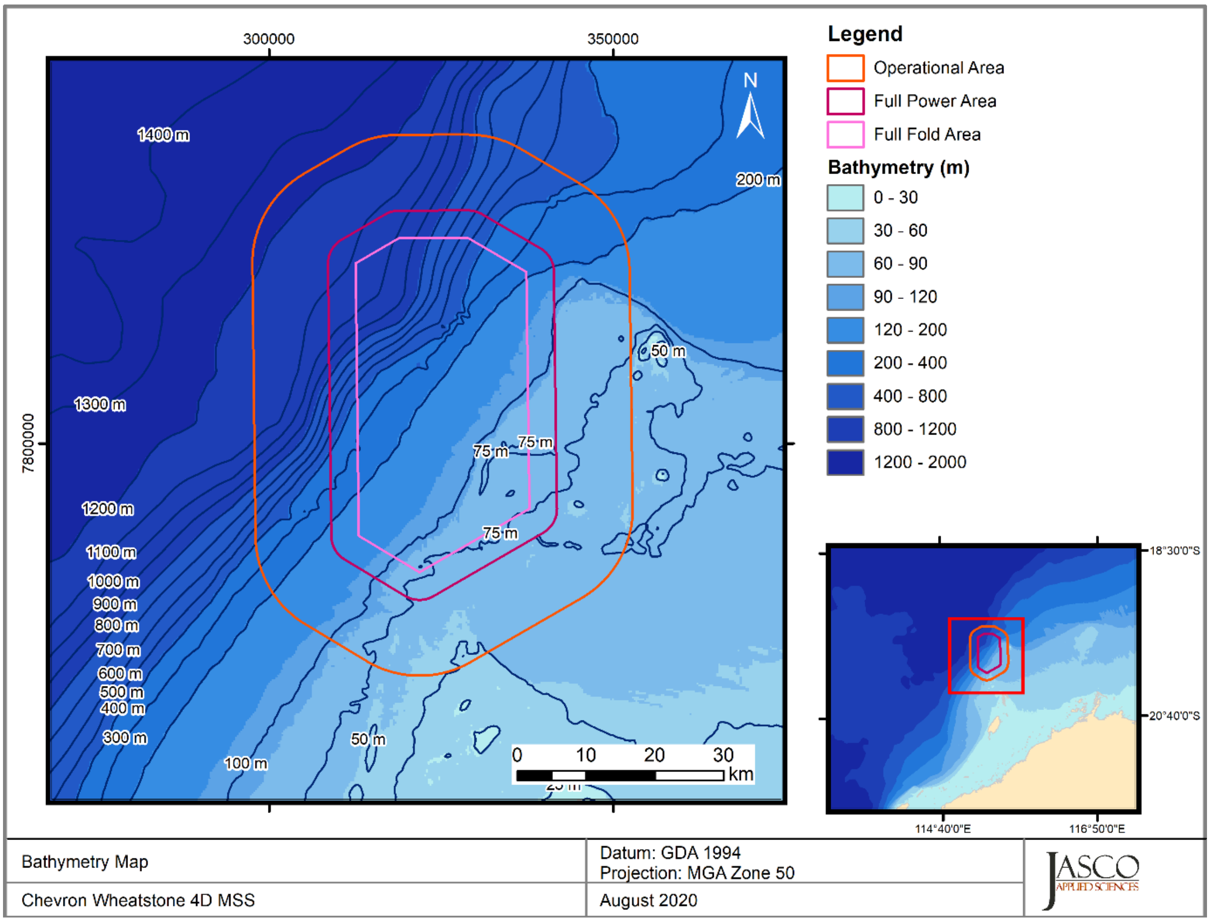

Figure C-7. Map of the modelling area presenting the variation in water depth.

C.4.2. Sound speed profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's Generalized Digital Environmental Model V 3.0 (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean sound speed profiles for November to May (operational time) were derived from the GDEM profiles within a 100 km box radius encompassing all modelling sites. The sound speed profile in May is expected to be most favourable to longer-range sound propagation during the proposed survey time frame due to a slight upward refracting profile in the upper 50 m. As such, May was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Figure C-8 shows the resulting profile used as input to the sound propagation modelling.

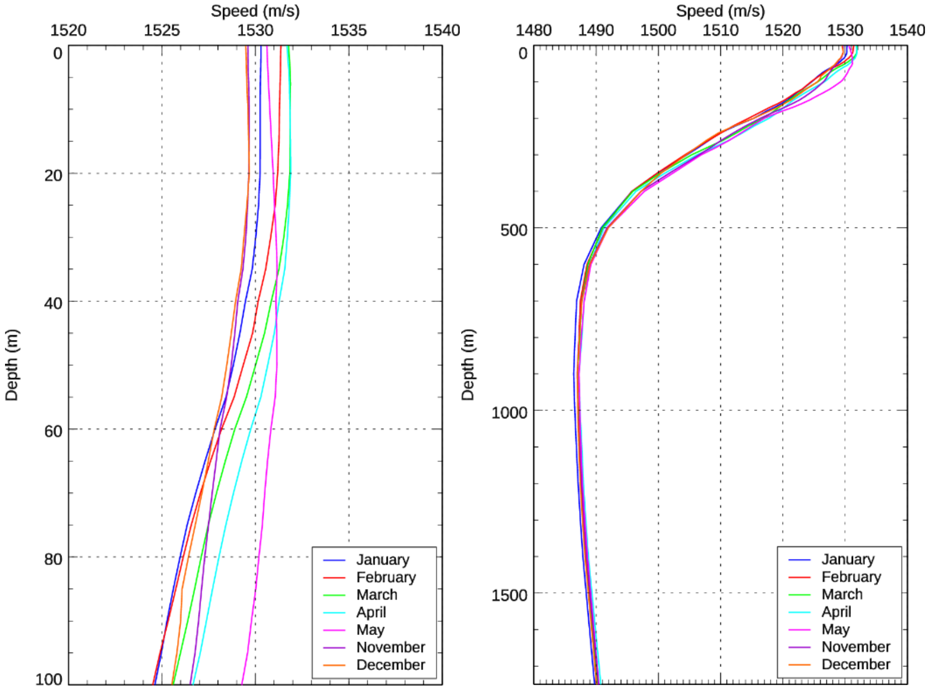

Figure C-8. Monthly averaged sound speed profiles for representative months over the year. The plot on the left shows the top 100 m of water; the plot on the right shows the profiles over the entire water column The profile for May was used in modelling all sound fields. All profiles were calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

C.4.3. Geoacoustics

Geoacoustic parameters used for modelled sites at are located within the North West Transition Province (NWT) of the North West Marine Region of Australia (Baker et al. 2008), which is dominated by fine calcareous sand, fine muddy sand and sandy mud. Representative median grain sizes were estimated and used in the grain-shearing model proposed by Buckingham (2005) to predict the geoacoustic parameters for un-lithified (unconsolidated) sediments. Grainsizes were estimated at the seafloor from sedimentary grain size data obtained from the Australian Government's Marine Sediments (MARS) database (Heap 2009), data were queried within the vicinity of the operational area. The grain-shearing model proposed by Buckingham (2005) was used to calculate changes in geoacoustic properties with depth from the seafloor for the un-lithified sedimentary package.

Core information from IODP Cruise 356 (Gallagher et al. 2017) was used to determine the deeper stratigraphy and to estimate the thickness of un-lithified sediment. The geoacoustic parameters from Duncan et al. (2009) were used for the cemented sediments at the bottom of the un-lithified stack. Tables C-1 to C-3 list the parameters used for modelling.

Table C-1. Geoacoustic profile for the Site 1 and Site A. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	Predicted lithology	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed(m/s)	Attenuation (dB/λ)
0–10	Muddy carbonate sand (unconsolidated)	2.03	1627-1788	0.07-0.69	293.7	3.65
10–20	Increasingly consolidated muddy carbonate sand	2.03	1788-1842	0.69-0.89		
20–45		2.03	1842-1927	0.89-1.10		
>45	Calcarenite (Cemented)	2.4	2800	0.1		

Table C-2. Geoacoustic profile for the Sites 2-3. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	Predicted lithology	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed(m/s)	Attenuation (dB/λ)
0–10	Muddy carbonate sand (unconsolidated)	2.03	1617-1780	0.07-0.70	293.7	3.65
10–20	Increasingly consolidated muddy carbonate sand	2.03	1780-1833	0.70-0.87		
20–50		2.03	1833-1932	0.87-1.14		
40-400		2.03	1935-2362	1.14-1.97		
>400	Calcarenite (Cemented)	2.4	2800	0.1		

Table C-3. Geoacoustic profile for the Sites 4-7. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	Predicted lithology	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed(m/s)	Attenuation (dB/λ)
0–10	Carbonate silt (unconsolidated)	1.92	1545-1655	0.05-0.52	195.7	3.65
10–20	Increasingly consolidated carbonate silt	1.92	1655-1690	0.52-0.64		
20–50		1.92	1690-1753	0.64-0.86		
40-400		1.92	1753-2023	0.86-1.55		
>400	Calcarenite (Cemented)	2.4	2800	0.1		

C.5. Seismic Source

The layout of the 4130 in³ seismic source used for modelling in this study is provided in Figures B.3-9. Details of the airgun parameters are provided in Tables B.3-4.

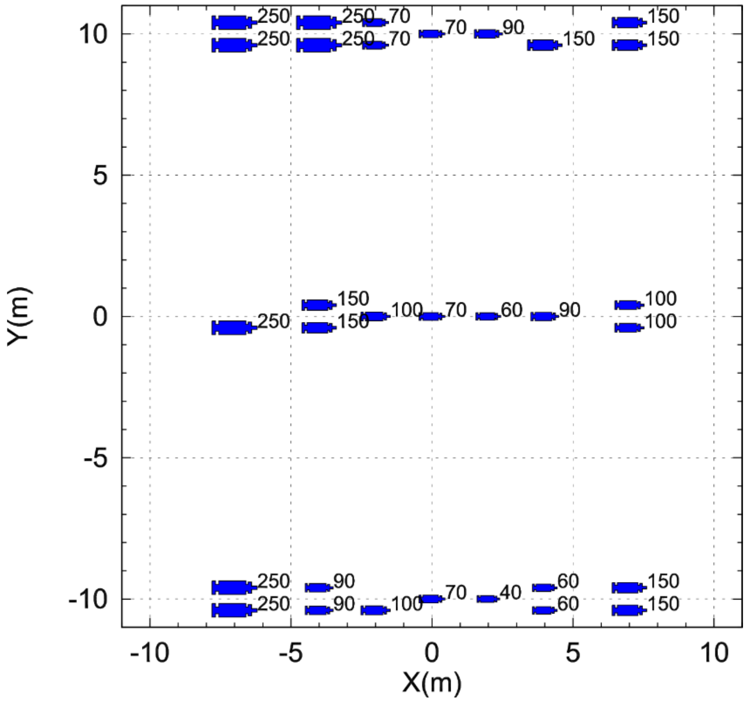

Figure C-9. Layout of the modelled 4130 in³ array. Tow depth is 5 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table C-4.

Table C-4. Layout of the modelled 4130 in³ array. Tow depth is 5 m. Firing pressure for all guns is 2000 psi. Also see Figure C-9.

String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in³)	String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in³)	String	Gun	*x* (m)	*y* (m)	*z* (m)	Vol (in³)
	1	7	-10.4	5	150		1	7	-0.4	5	100		1	7	9.6	5	150
	2	7	-9.6	5	150		2	7	0.4	5	100		2	7	10.4	5	150
	3	4	-10.4	5	60		3	4	0	5	90		3	4	9.6	5	150
	4	4	-9.6	5	60		4	2	0	5	60		4	4	10.4	5	spare
	5	2	-10	5	40		5	0	0	5	70		5	2	10	5	90
1	6	0	-10	5	70	2	6	-2	0	5	100	3	6	0	10	5	70
	7	-2	-10.4	5	100		7	-4	-0.4	5	150		7	-2	9.6	5	70
	8	-2	-9.6	5	spare		8	-4	0.4	5	150		8	-2	10.4	5	70
	9	-4	-10.4	5	90		9	-7	-0.4	5	250		9	-4	9.6	5	250
	10	-4	-9.6	5	90		10	-7	0.4	5	spare		10	-4	10.4	5	250
	11	-7	-10.4	5	250								11	-7	9.6	5	250
	12	-7	-9.6	5	250								12	-7	10.4	5	250

C.5.1. Array Source Levels and Directivity

Figure C-10 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction) and vertical overpressure signature and corresponding power spectrum levels for the 4130 in^3 array (Appendix C.5). Horizontal decidecade-band source levels are shown as a function of band centre frequency and azimuth (Figure C-11).

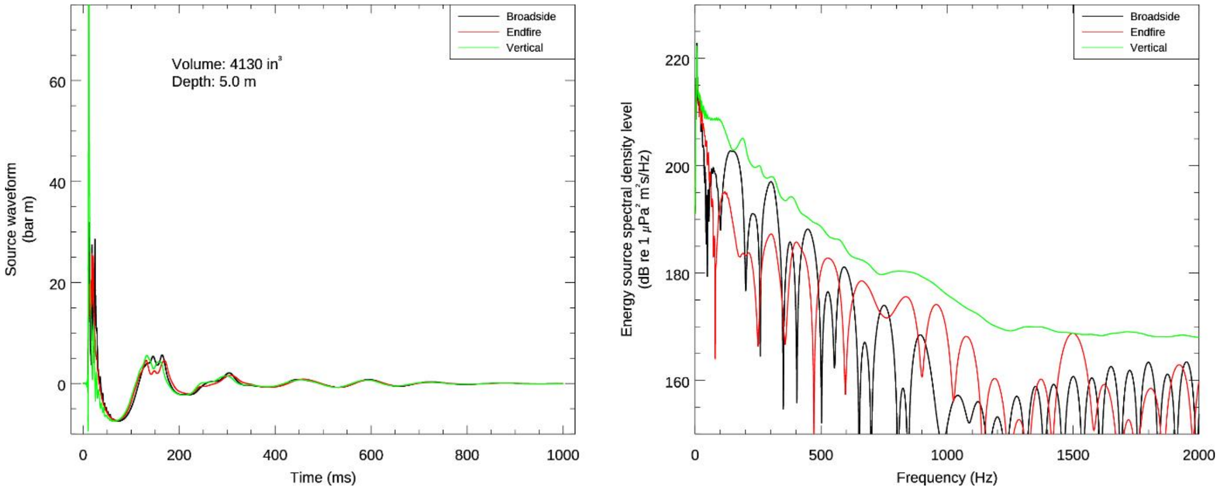

Figure C-10. Predicted source level details for the 4130 in^3 array at 5 m towed depth.(Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions (no surface ghost).

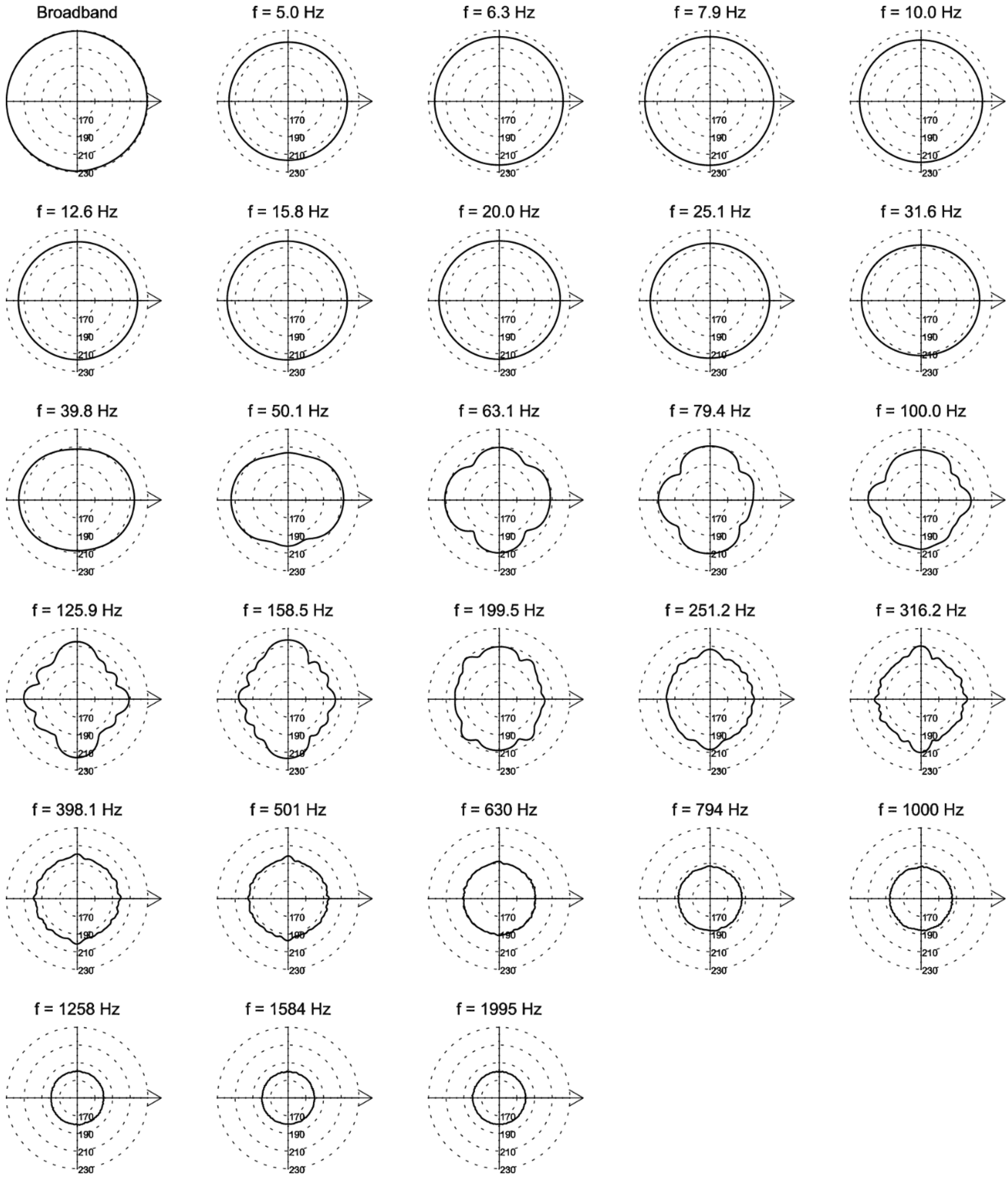

Figure C-11. Directionality of the predicted horizontal source levels for the 4130 in^3 seismic source, 5 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the decidecade bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 6 m (see Figure C-10).

Appendix D. Per-Pulse SEL Sound Field Maps

Per-pulse SEL maps for all modelled sites are provided in Figures D-1 through D-8.

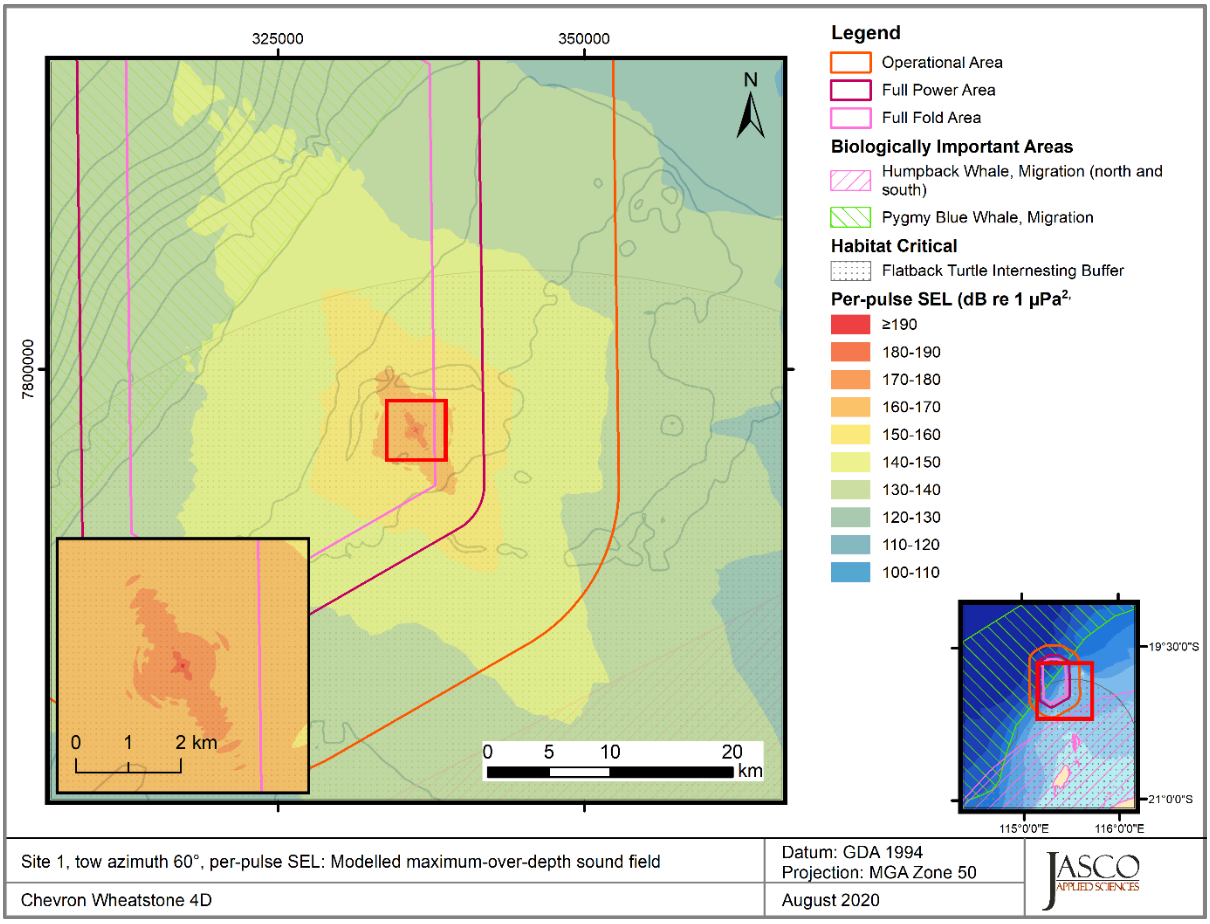

Figure D-1. *Site 1, tow azimuth 60º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

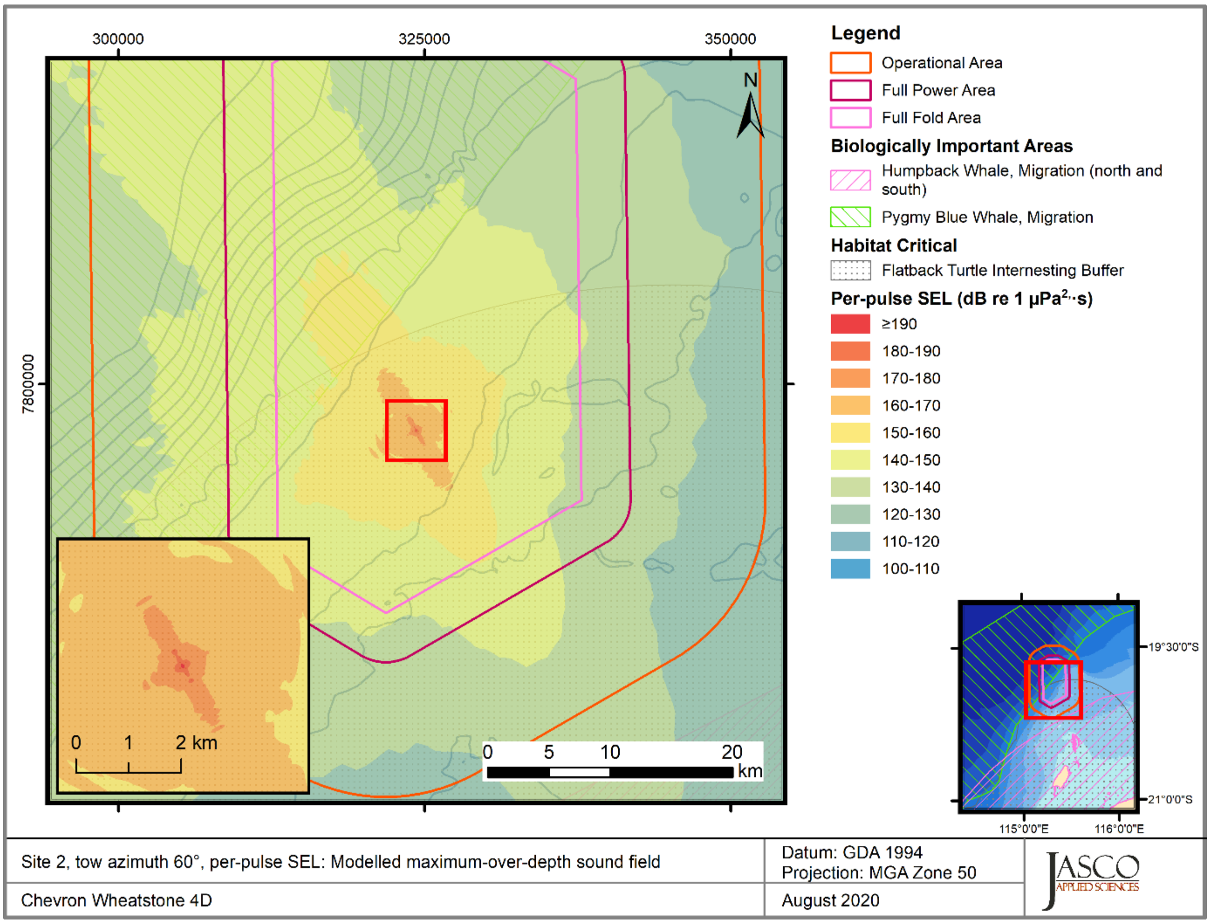

Figure D-2. *Site 2, tow azimuth 60º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

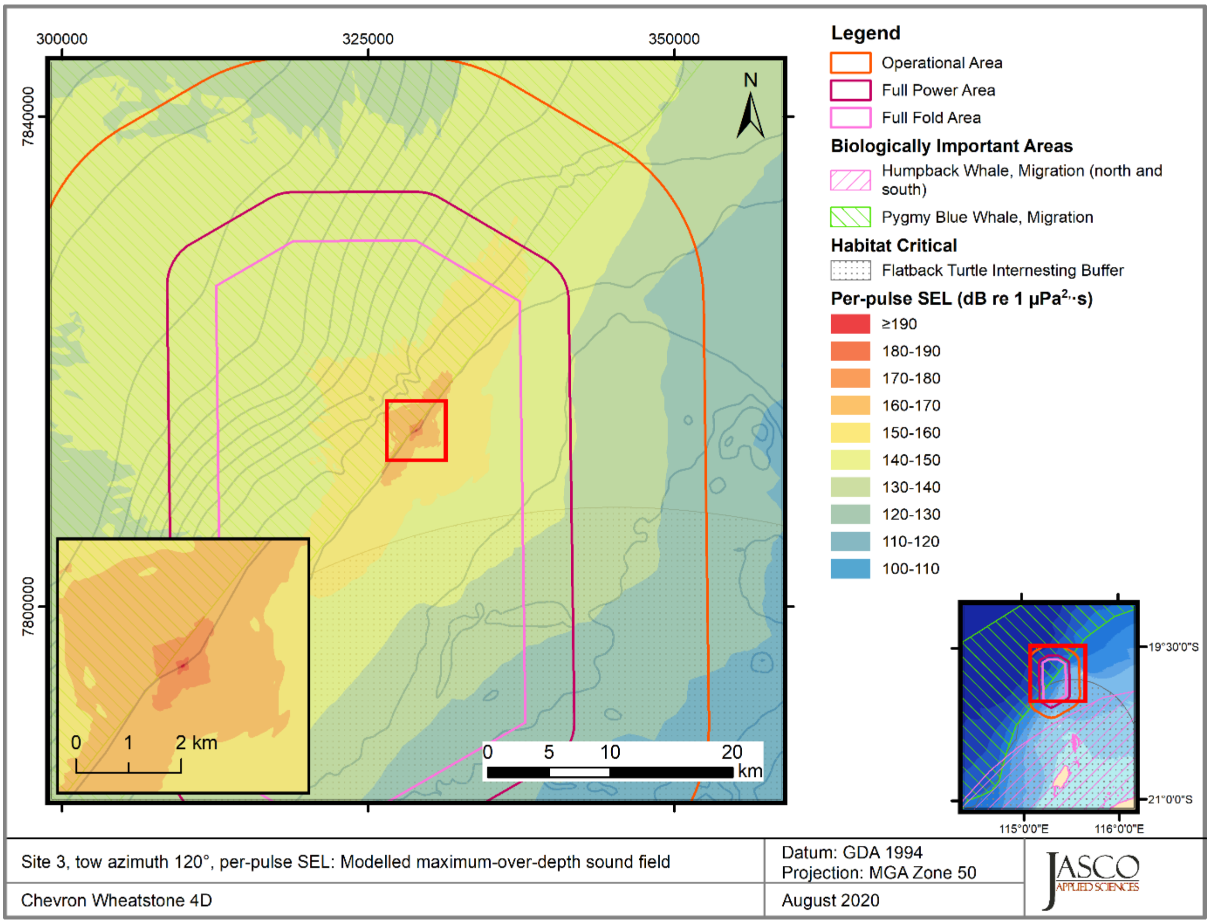

Figure D-3. *Site 3, tow azimuth 120º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

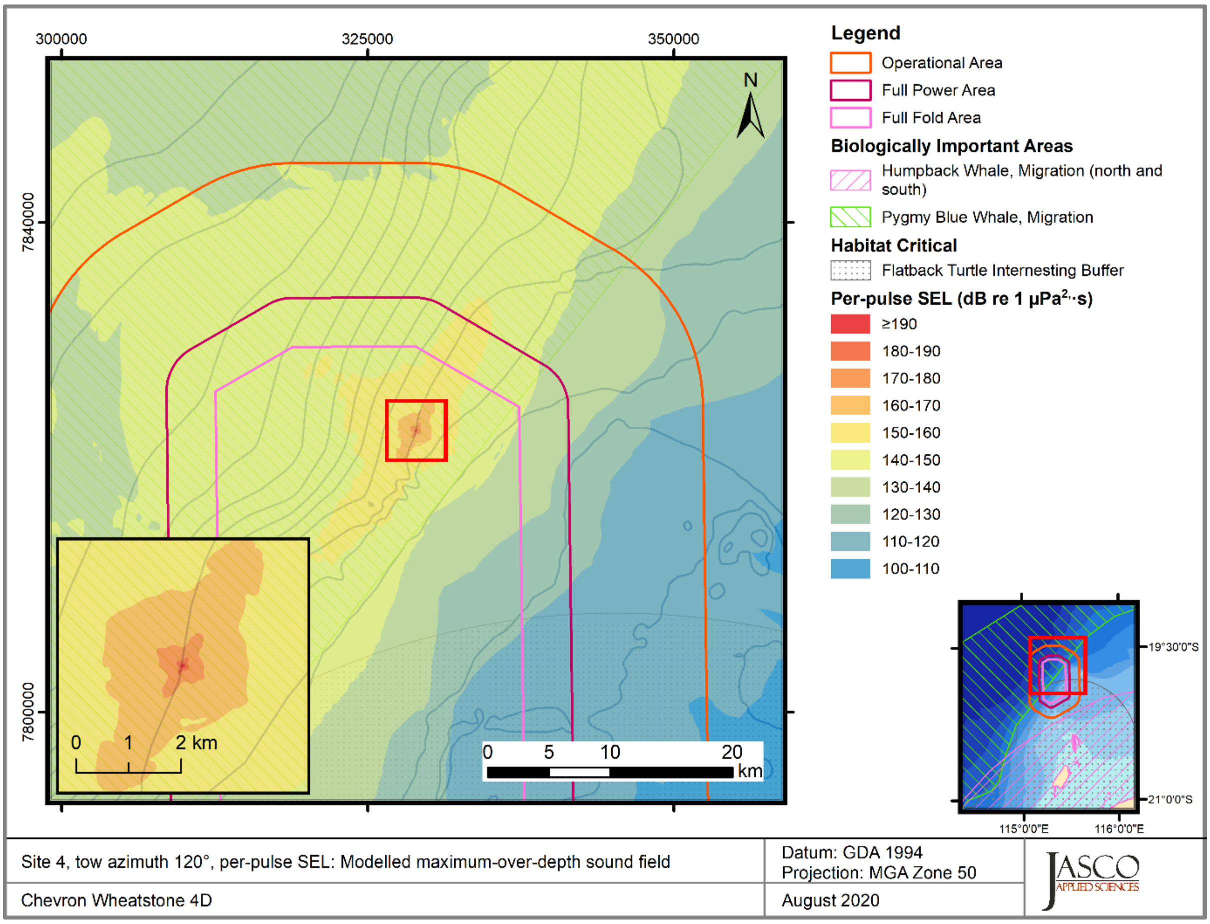

Figure D-4. *Site 4, tow azimuth 120º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

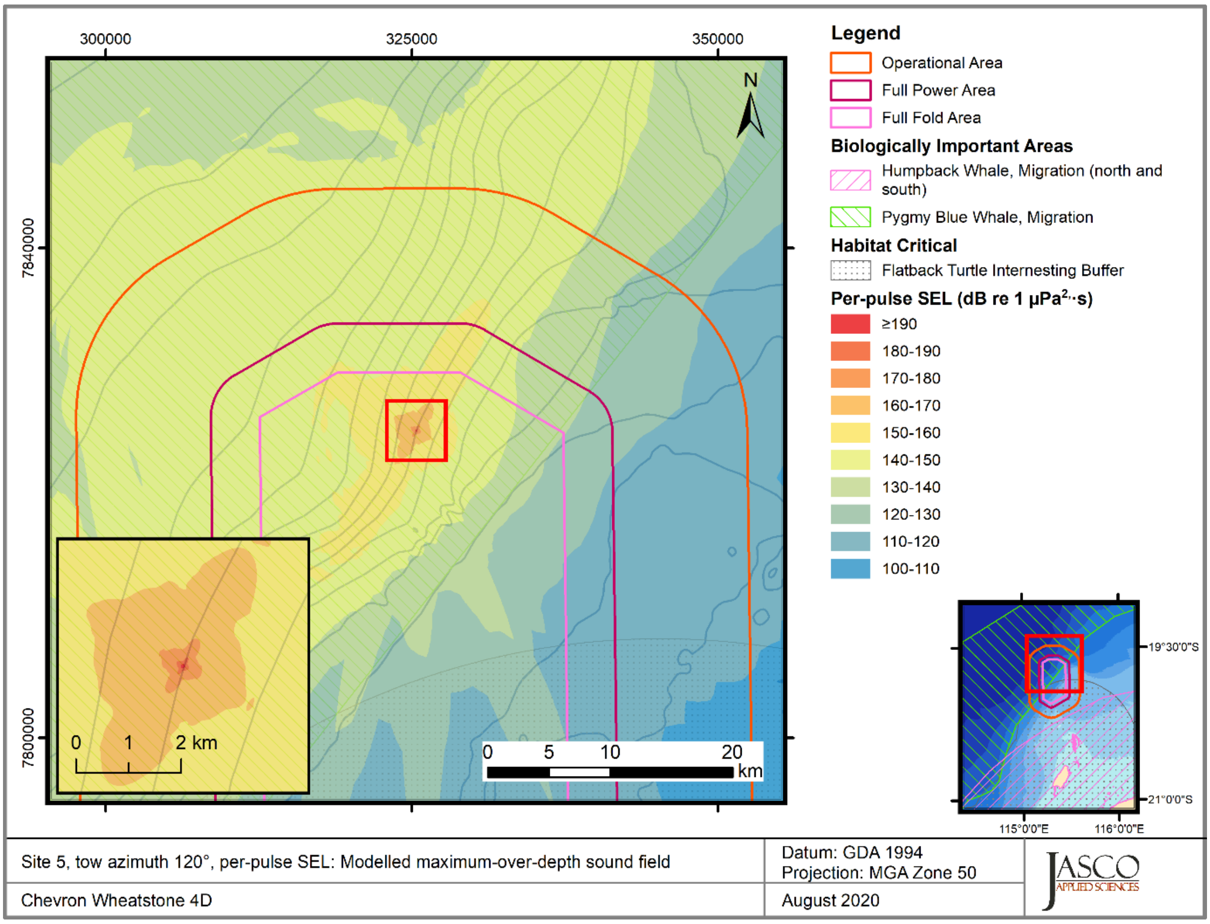

Figure D-5. *Site 5, tow azimuth 120º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

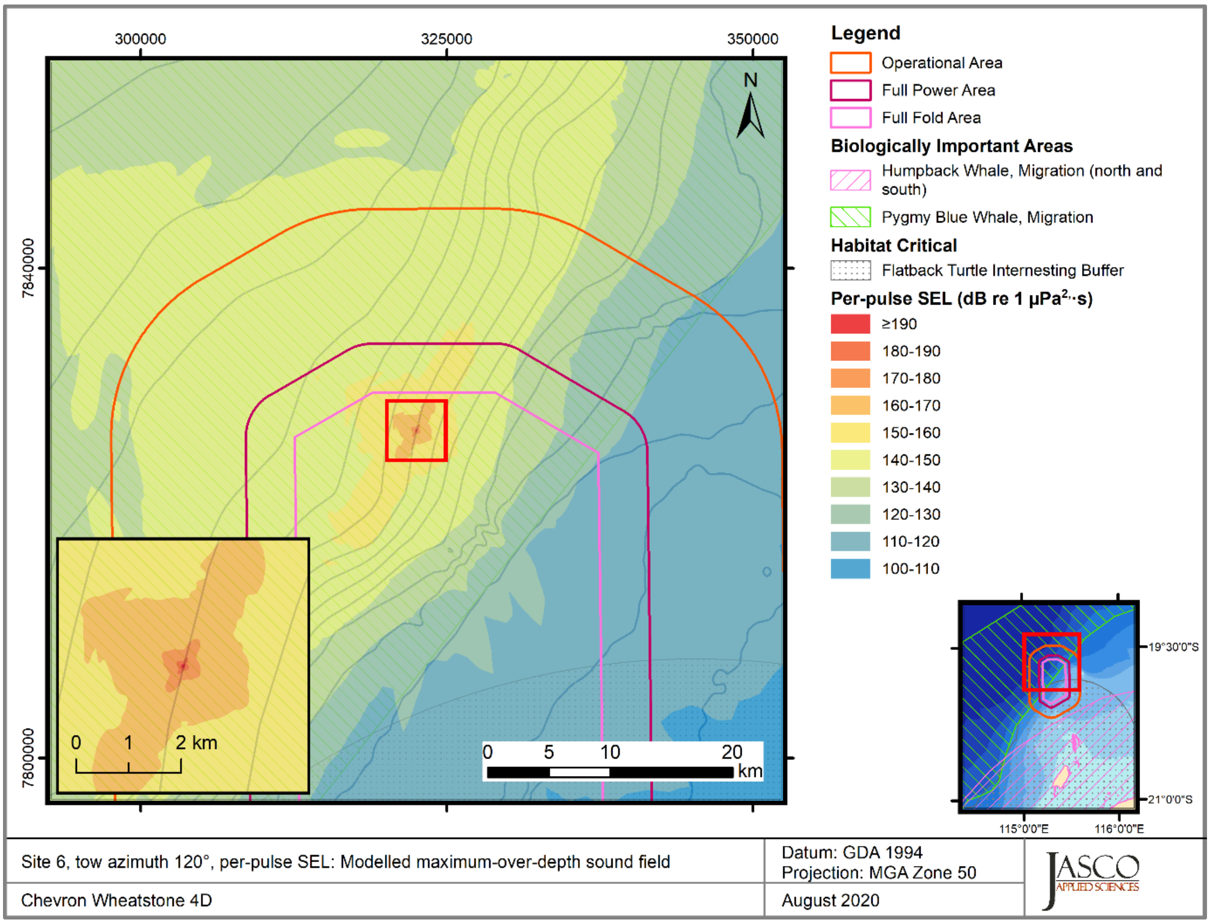

Figure D-6. Site 6, tow azimuth 120º, per-pulse SEL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

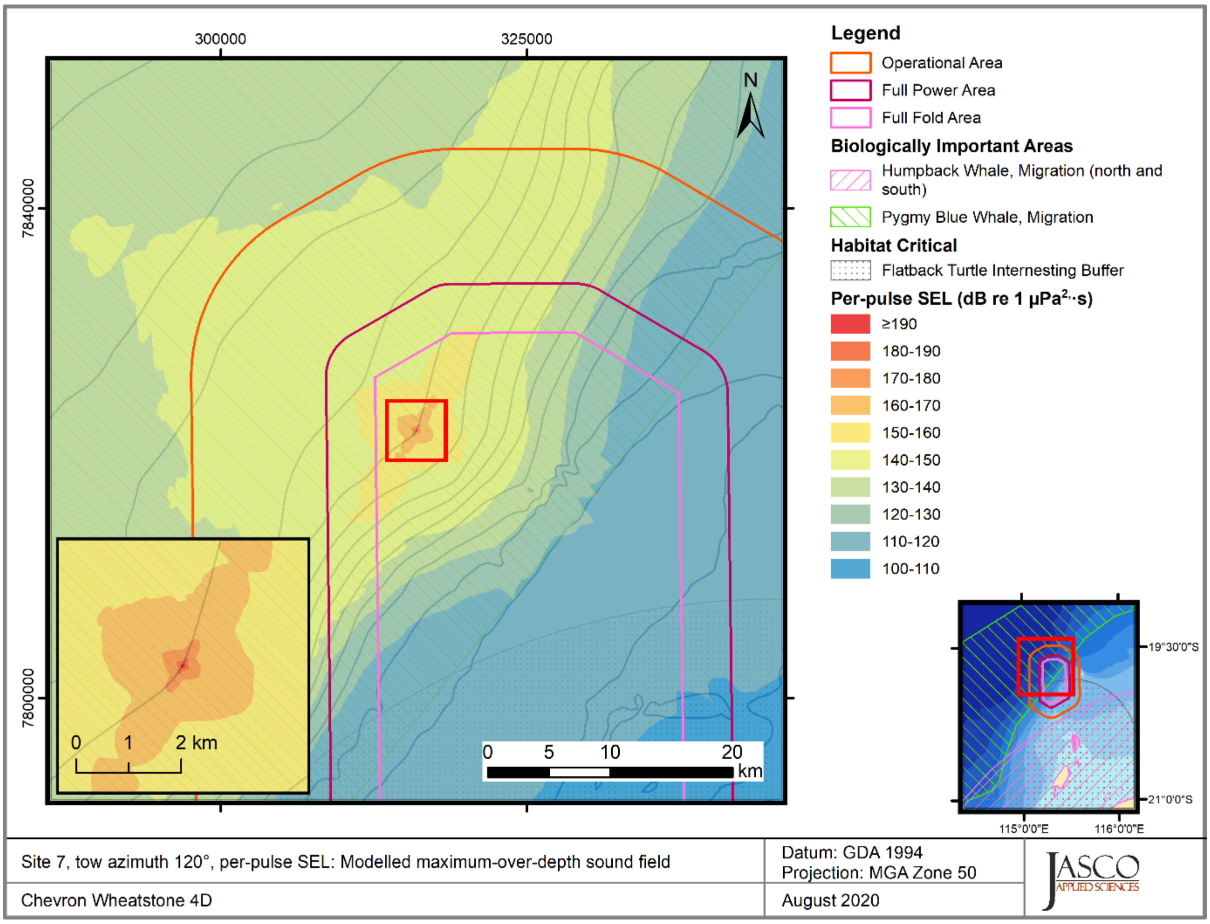

Figure D-7. Site 7, tow azimuth 120º, per-pulse SEL: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

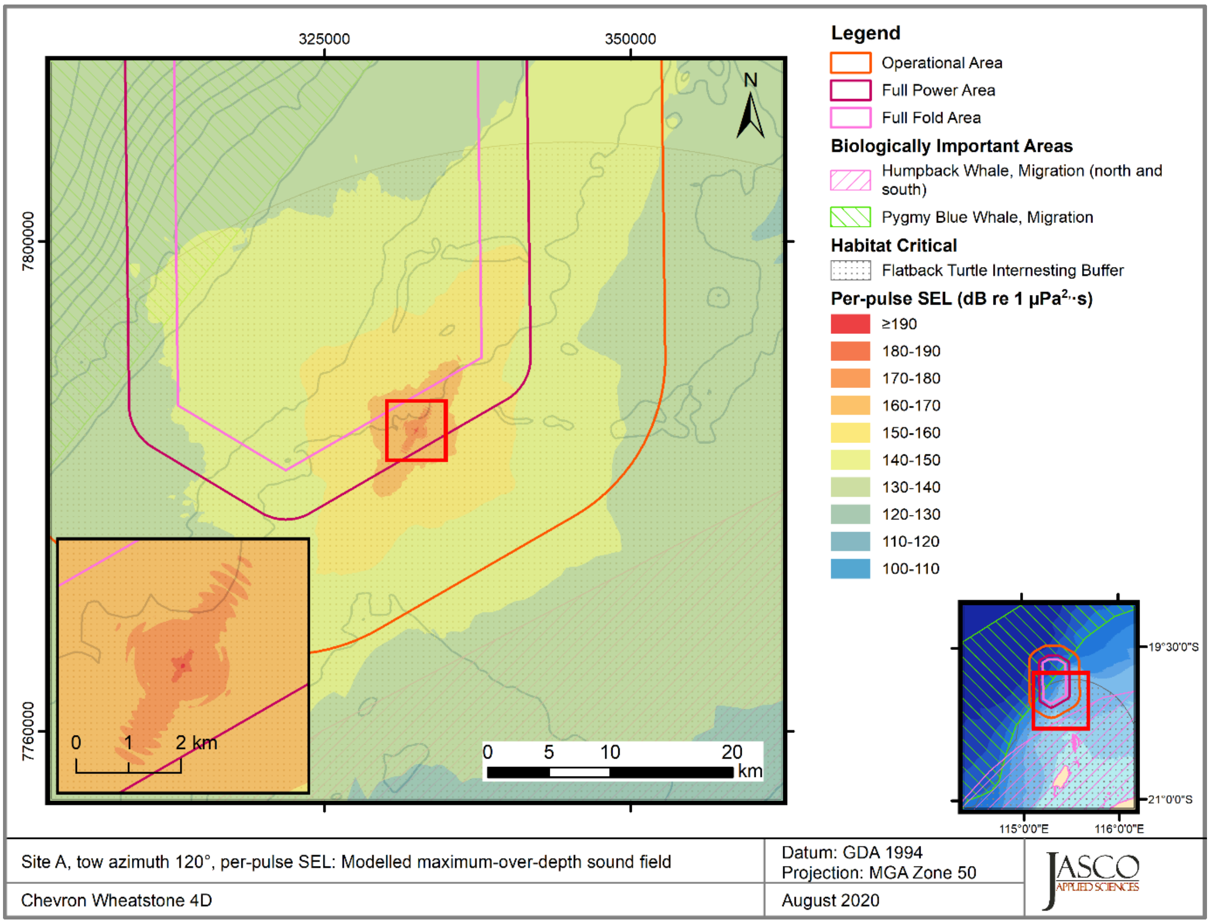

Figure D-8. *Site A, tow azimuth 120º, per-pulse SEL*: Sound level contour map showing the unweighted maximum-over-depth sound field in 10 dB steps, and the isopleth low-power zone.

appendix e pygmy blue whale exposure assessment

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Wheatstone 4D MSS Pygmy Blue Whale Exposure Modelling

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Wheatstone 4D MSS

Pygmy Blue Whale Exposure Modelling

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Wheatstone 4D Survey

Pygmy Blue Whale Exposure Modelling

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Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences performed an acoustic exposure analysis study of pygmy blue whales near a migratory Biologically Important Area (BIA) where it intersected the planned survey operations for the Wheatstone 4D Marine Seismic Survey (MSS). Previously, acoustic modelling was conducted for this survey to determine ranges to acoustic exposure thresholds representing the best available science for potential injury, impairment and behavioural reactions of marine fauna including marine mammals, turtles, and fish (Matthews et al. 2020).

The aim of the present study was to employ animal movement (animat) modelling simulations in conjunction with these previously computed three-dimensional sound fields to predict the range at which pygmy blue whales are expected to be exposed above threshold criteria for permanent threshold shift (PTS), temporary threshold shift (TTS) and behavioural reponse. To achieve this, the JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to integrate the sound fields with species-typical behaviour. JASMINE results provide a probabilistic estimate of sound exposure, which can be compared to acoustic thresholds to determine ranges.

Animat modelling focussed on migrating pygmy blue whales in the migratory BIA. The behaviour of pygmy blue whales (*Balaenoptera musculus brevicauda*) was modelled with a migration bias of 38 degrees during the north bound migration and reversed 180 degrees for modelling the south bound migration. The two behaviours observed during migration (migratory dives and exploratory dives) were modelled together, and the model did not include any potential aversion. Both of these approaches were chosen to present conservative results due to the limited data available.

To generate statistically reliable probability density functions, and thus range estimates, model simulations were run with animat densities of 2 animats/km^2. The modelling results are not related to real-world density estimates for pygmy blue whales within the migratory BIA, as the number of animals potentially exposed is not calculated.

Two exposure modelling scenarios were simulated, with each simulation run for a period of 5 days. On each day, a 24 hour segment of the planned seismic track lines was run. Using the distribution of ranges of animats predicted to be exposed to sound levels above threshold, the 95th percentile exposure range ($ER_{95\%}$) was computed. Noise effect metrics included peak pressure level (PK), sound exposure levels (SEL), and sound pressure level (SPL), The results of the animat analysis predicted that the $ER_{95\%}$ of migrating pygmy blue whales potentially exposed to sound levels above the U.S National Marine Fisheries Service (NMFS) (2018) PTS and TTS criteria were up to 0.06 km and 12.50 km, respectively, considering both PK and SEL_{24h} metrics. For both PTS and TTS, the maximum $ER_{95\%}$ to SEL threshold was greater than the maximum $ER_{95\%}$ to PK threshold. The maximum $ER_{95\%}$ for exposures above the U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) behavioural threshold was 12.43 km.

The estimated 95th percentile ranges for all scenarios were lower than comparable ranges to threshold reported in Matthews et al. (2020). This was expected because previous modelling efforts did not incorporate both moving sources and moving receivers, but rather assumed that, as per the NMFS (2018) criteria, SEL_{24h} is a cumulative metric that reflects the dosimetric effect of noise levels within 24 hours considering that an animal is consistently exposed to such noise levels at a fixed position.

1. Introduction

JASCO Applied Sciences (JASCO), performed an acoustic exposure analysis study for pygmy blue whales (*Balaenoptera musculus brevicauda*) in association with the planned Wheatstone 4D Marine Seismic Survey (MSS) within the pygmy blue whale migration Biologically Important Area (BIA).

This report describes the modelled predictions of sound levels that individual pygmy blue whales may receive during the seismic survey. Sound exposure distribution estimates are determined by moving large numbers of simulated animals (animats) through a modelled time-evolving sound field, computed using specialised sound source and sound propagation models. This approach provides the most realistic prediction of the maximum expected root-mean-square sound pressure level (SPL, L_p), peak pressure level (PK, L_{pk}), and the temporal accumulation of sound exposure level (SEL, L_E) that are now considered the most relevant sound metrics for the assessment of effects. The most recent science in the peer-reviewed literature regarding sound propagation and animal movement modelling was used.

Matthews et al. (2020) conducted a detailed sound modelling study, and the resulting sound fields were used to predict animat sound exposures. The acoustic modelling locations from that study that were used in the current analysis are provided in Table 1.

Table 1. Location details for the single impulse modelled sites reported in Matthews et al. (2020).

Site	Latitude (S)	Longitude (E)	UTM Zone 50		Water depth (m)	Tow direction (°)
			X (m)	Y (m)		
1	19° 56' 03.3456" S	115° 26' 08.5946" E	336285	7795031	82	60
2	19° 55' 21.1646" S	115° 19' 17.9753" E	324332	7796213	126	
3	19° 45' 32.2431" S	115° 22' 01.9962" E	328926	7814368	200	
2	19° 55' 21.1646" S	115° 19' 17.9753" E	324332	7796213	126	120
3	19° 45' 32.2431" S	115° 22' 01.9962" E	328926	7814368	200	
4	19° 40' 51.5469" S	115° 22' 06.4766" E	328974	7823000	400	
5	19° 39' 42.2812" S	115° 20' 02.9133" E	325354	7825095	600	
6	19° 38' 47.8390" S	115° 18' 25.4959" E	322500	7826741	800	
7	19° 41' 24.5095" S	115° 14' 39.2009" E	315957	7821857	1000	

2. Exposure Modelling Scenarios

For the planned Wheatstone 4D MSS, source and propagation modelling were conducted (Matthews et al. 2020) to generate sound fields which are used in conjunction with animal movement modelling. Separate exposure modelling scenarios were simulated for both Scenario 1 and Scenario 2 . Each of the scenarios considered a total of 5 days of survey tracks. The migratory BIA partially overlaps the Scenario 2 tracks, while the Scenario 1 tracks are located completely outside the BIA. Simulated animats are seeded only within the BIA to represent the spatial distribution of this species. Exposure modelling simulation extents and animat seeding area are shown in Figure 1.

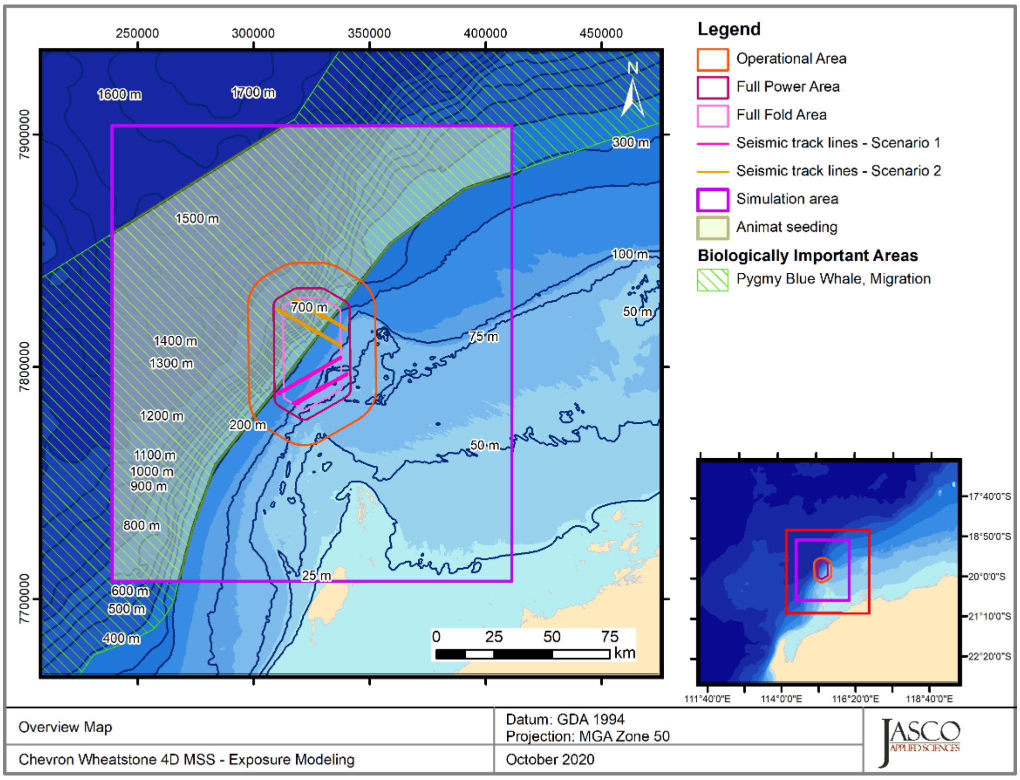

Figure 1. Animat modelling simulation extent, BIA seeding area, and modelled source tracks.

3. Noise Effect Criteria

The noise effect criteria which were considered for pygmy blue whales during acoustic modelling included metrics related to the behavioural response and impairment of pygmy blue whales (SPL, SEL, and PK). The acoustic modelling report, Matthews et al. (2020), provides further details on the noise effect criteria (Matthews et al. 2020). The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405.2:2017 (2017).

The noise criteria considered are:

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the US National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals (Table 2).
2. Marine mammal behavioural threshold based on the NOAA (2019) criterion of 160 dB re 1 µPa SPL (L_p) for impulsive sound sources (Table 2).

Table 2. Unweighted SPL and PK, and weighted SEL_{24h} thresholds for acoustic effects on marine mammals.

Hearing group	NOAA (2019)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans		183	219	168	213
Mid-frequency cetaceans	160	185	230	170	224
High-frequency cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS and TTS onset.
L_p–denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s.
Subscripts indicate the designated marine mammal auditory weighting.

4. Methods

4.1. Animal Movement and Exposure Modelling

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats (virtual marine mammals) to sound arising from the seismic activity. Sound exposure models like JASMINE integrate the predicted sound field with biologically meaningful movement rules for each marine mammal species (here: pygmy blue whales) that result in an exposure history for each animat in the model. In JASMINE, the sound received by the animats is determined by the proposed seismic activity. As illustrated in Figure 2, animats are programmed to behave like the marine animals that may be present in the 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. An individual animat's sound exposure levels are summed over a specified duration, to determine its total received energy, and then compared to the threshold criteria. For PK and SPL metrics, the maximum exposure is evaluated against single impulse threshold criteria. For additional information on JASMINE, see Appendix A.

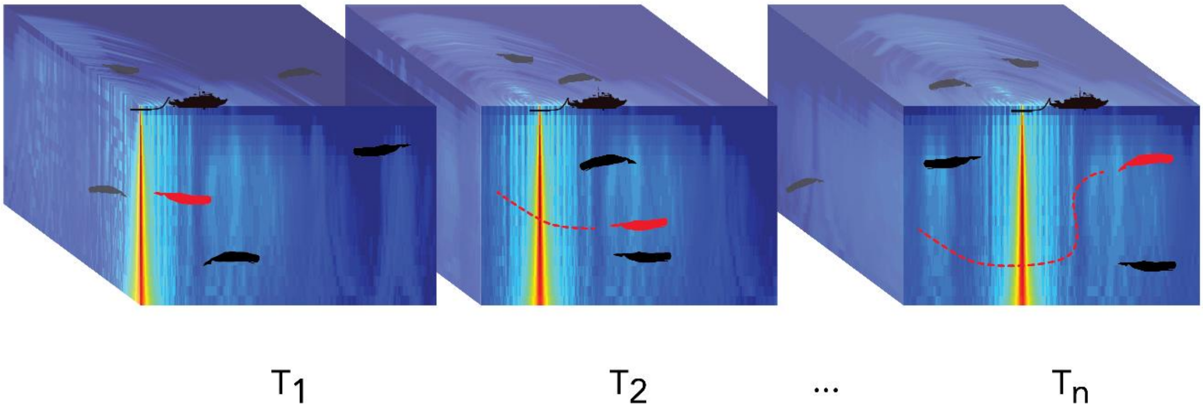

Figure 2. Cartoon of animats in a moving sound field. Example animat (red) shown moving with each time step (Tx). The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

The exposure criteria for impulsive sounds (described in Section 3) were used to determine the number of animats exceeding thresholds. To generate statistically reliable probability density functions, model simulations were run with animat densities of 2 animats/km^2, as this increases the probability of encounter, and thus more robust exposure range estimates. The modelling results are not related to real-world density estimates for pygmy blue whales within the migratory BIA, as the number of animals potentially exposed is not calculated. To evaluate PTS, TTS and behavioural response, exposure results were obtained using detailed behavioural information for migrating pygmy blue whales (described in Section 4.2). The simulation was run for a representative period of 5 days for each modelling scenario, with the spatial distribution of animats restricted to the BIA.

The seismic source was modelled as a vessel towing an airgun array at a speed of 4.5 knots, with each of the two arrays emitting sound every 37.5 m, resulting in an overall inter-pulse-interval of 18.75 m. The simulated source track followed a racetrack configuration with a turn distance of 7.5 km. At the time and location of each seismic pulse, the modelled source location with the most similar water depth was selected for exposure modelling. The track lines for each scenario along with the acoustic modelling locations are shown in Figure 3. Note that the Scenario 2 aquisition lines partially overlap the BIA area while the closest point of approach of the Scenario 1 aquisition lines is approximately 1.3 km. The acquisition lines used for exposure modelling were selected to match those used in the 24 h SEL modelling (Matthews et al. 2020). The same 24 h track segments were run for 5 consecutive days to provide a larger sample size, and thus enable more robust statistical sampling.

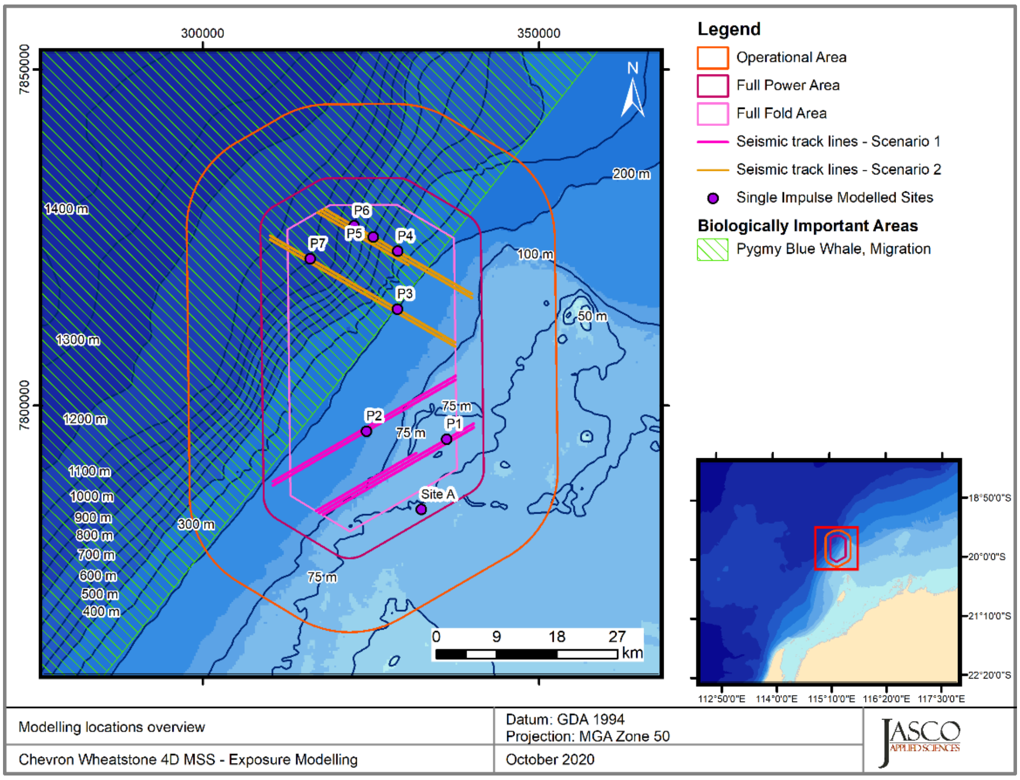

Figure 3. Seismic source tracks used in Scenarios 1 and 2, modelled acoustic source locations, and the BIA seeding area for migratory pygmy blue whales.

4.1.1. Exposure-based range estimation

The results from the animal movement and exposure modelling provided a way to estimate ranges to effect thresholds. The range to the closest point of approach (CPA) for each of the animats was recorded. The $ER_{95\%}$ (95% Exposure Range) is the horizontal range that includes 95% of the animat CPAs that exceeded a given effect threshold (Figure 4). Within the $ER_{95\%}$ range, there are generally some proportion of animats that do not exceed threshold criteria. The probability that an animat is exposed above threshold within the $ER_{95\%}$ is provided in the results tables.

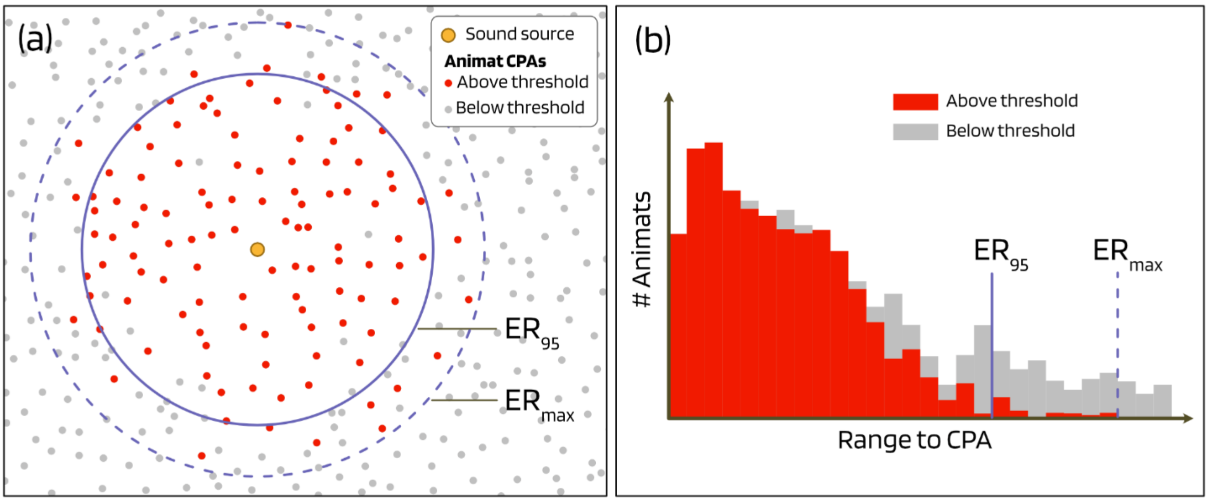

Figure 4. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animats near a sound source. Panel (b) shows the distribution of ranges to animat CPAs from Panel (a). The 95% and maximum exposure ranges ($ER_{95\%}$ and ER_{max}) are indicated in both panels, thus indicating the proportion of animats above and below threshold relative to their range to CPA.

4.2. Pygmy blue whales

4.2.1. Animal behaviour

Detailed information on pygmy blue whales (*Balaenoptera musculus brevicauda*) was derived from a range of sources which utilised multi-sensor tags to record fine-scale diving and movement behaviour (Double et al. 2014, Owen et al. 2016). These tags typically record the depth of the animal along with various movement parameters such as swimming speed and the orientation of the body.

Owen et al. (2016) equipped a sub-adult pygmy blue whale with a multi-sensor tag off Western Australia. They identified dives for their tagged animal as migratory, feeding, or exploratory (i.e. no lunges recorded which would indicate feeding). Pygmy blue whales in the simulation area are presumed to be migrating, and so feeding was not included in the model. Exploratory dives were considered to be part of migratory behaviour, and so 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). 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 (23–320 m range).

The behaviour of migrating pygmy blue whales was modelled to reflect the transition of the animats through the modelling area on a diagonal track. This represents the animals migrating along the west coast of Australia to and from Indonesia (Double et al. 2014). Speed of travel during migration (0.65 ± 0.61 m/s) was calculated from 11 pygmy blue whales tagged in this area (Double et al. 2014).

5. Results

A summary of exposure ranges for migrating pygmy blue whales is included in Table 3. Results include $ER_{95\%}$ exposure ranges calculated for the 160 dB behavioral response threshold and for both TTS and PTS PK and SEL thresholds. Each of the two scenarios are reported separately and the ranges to acoustic thresholds from Matthews et al. (2020) are included for comparison.

Table 3. Summary of animat simulation results for migrating pygmy blue whales. The 95th percentile exposure ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ are provided. For comparison, maximum distances to threshold from previously completed acoustic modelling are also provided.

Threshold		**Maximum distance (km) to threshold from acoustic modelling**	**Scenario 1 (Tow azimuth 60°)**		**Scenario 2 (Tow azimuth 120°)**	
Description	Threshold level (dB)		$ER_{95\%}$ (km)	Probability of exposure (%)	$ER_{95\%}$ (km)	Probability of exposure (%)
TTS, PK	213*	0.07	0	0	0.06	88
TTS, SEL_{24h}	168†	Scenario 1: 95.4 Scenario 2: 64.7	12.50	65	11.33	66
PTS, PK	219*	0.04	0	0	0.03	78
PTS, SEL_{24h}	183†	Scenario 1: 6.6 Scenario 2: 5.9	0	0	0.06	70
Behavioural response	160‡	8.37-13.5	12.43	68	8.62	81

* PK (L_{pk}; dB re 1 µPa)
† LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
‡ SPL (L_p; dB re 1 µPa)

6. Discussion and Conclusion

The estimated sound fields produced by source and propagation models for the seismic survey were incorporated into a sound exposure model to estimate the range within which 95% of the exposure exceedances occur ($ER_{95\%}$), along with the probability that an animat with a closest point of approach within that range would be exposed above the relevant threshold.

The maximum $ER_{95\%}$ to SEL thresholds were 0.06 km for PTS and 12.5 km for TTS. PK thresholds were not exceeded for Scenario 1 since the closest point of approach to the BIA (~1.3 km) was larger than the maximum possible range to threshold. For Scenario 2, which partially overlapped with the BIA, the $ER_{95\%}$ to PK threshold was 0.03 km for PTS and 0.06 km for TTS.

The $ER_{95\%}$ to both the PTS and TTS SEL thresholds are substantially lower than ranges predicted by acoustic modelling (Table 3). Previous modelling efforts were inherently more conservative because they did not incorporate the complex interactions of both a moving sound field and moving receivers, but rather assumed a static receiver. In this case the moving receiver, the animats, were set to simulate the real-world movements of migrating pygmy blue whales within the migratory BIA.

The $ER_{95\%}$ to the 160 dB behavioral response threshold was 12.43 km for Scenario 1 and 8.62 km for Scenario 2 (Table 3). These ranges are similar to the ranges predicted by acoustic modelling, but this is expected because they are based on the single loudest exposures experienced by each of the animats in the simulation.

The probability of exposure within $ER_{95\%}$ in all cases varied between 65 and 88%, indicating that most, but not all, animats exposed within the 95th percentile range were exposed above threshold. This is due to the animats constantly changing their position in three-dimensions as they exhibit their modelled behaviour, and also changing their position in relation to the sound fields, thus potentially limiting the length of time they are within the exposure radius (Figure 4). Probabilities were slightly lower for Scenario 1 since animats were prevented from swimming closer than 1.3 km to the source at any point in the simulation due to the proximity of the BIA boundary to the source.

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Appendix A. Animal Movement and Exposure Modelling

Animal movement and exposure modelling takes into account the movement of both sound sources (if mobile) and animals over time. Acoustic source and propagation modelling are used to generate 3-D sound fields that vary as a function of range, depth, and azimuth. Sound sources are modelled at representative sites and the resulting sound fields are assigned to source locations using the minimum Euclidean distance. The sound received by an animal at any given time depends on its location relative to the source. Because the true locations of the animals within the sound fields are unknown, realistic animal movements are simulated using repeated random sampling of various behavioural parameters. The Monte Carlo method of simulating many animals within the operations area is used to estimate the sound exposure history of the population of simulated animals (animats).

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more simulated animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is much higher than the real-world density to ensure good representation of the PDF. The resulting PDF is scaled using the real-world density.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behaviour. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behaviour model (3MB, Houser 2006) and used to predict the exposure of animats to sound arising from the anthropogenic activities. Animats are programmed to behave like the species likely to be present in the survey area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modelled sound exposure levels are summed over the total simulation duration to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as 3MB (Houser, 2006), but has been extended to be directly compatible with JASCO's Marine Operations Noise Model (MONM) and Full Waveform Range-dependent Acoustic Model acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioural states based on time and space dependent modelled variables such as received levels for aversion behaviour, although aversion was not considered in this study.

A.1. Animal Movement Parameters

JASMINE uses previously measured behaviour to forecast behaviour in new situations and locations. The parameters used for forecasting realistic behaviour are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behaviour of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behaviour states. The probability of an animat starting out in or transitioning into a given behaviour state can in turn be defined in terms of the animat's current behavioural state, depth, and the time of day. In addition, each travel parameter and behavioural state has a termination function that governs how long the parameter value or overall behavioural state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

- **Direction**– determines an animat's choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviours with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).
- **Travel rate**–defines an animat's rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate**–defines an animat's rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate**–defines an animat's rate of travel in the vertical plane during the descent portion of a dive.
- **Depth**–defines an animat's maximum dive depth.
- **Reversals**–determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behaviour is used to emulate the foraging behaviour of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval**–determines the duration an animat spends at, or near, the surface before diving again.

A.1.1. Exposure Integration Time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (L_p) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behaviour collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. For this study, 7 days were modelled, with results for the full period and also scaled down to 24 h.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the source during an operation is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

appendix f description of the environment (CAPL planning area)

description of the environment

CAPL planning area

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description of the environment
CAPL planning area

Document information

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1.0	Issued for use	01 May 2020	A Fertch	D Salins
2.0	Updated with Offshore Areas incorporated into Planning Area	11 September 2020	A Fertch	D Salins
3.0	Annual review	23 July 2021	M Carey	D Smith

Approvals

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Checked:	Duanne Salins Regulatory Approvals Advisor		
Approved:	David Smith HSE Regulatory Affairs Team Lead		

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figures

1 introduction

1.1 Purpose

This document describes the environment within Chevron Australia Pty Ltd's (CAPL's) Planning Area (PA) (Figure 1-1), which is the total area in which CAPL's activities may interact with the environment. This document applies to all CAPL operations and is to be used for each Environment Plan (EP) submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) after this document's initial acceptance.

Each EP will define an environment that may be affected (EMBA) by its specific petroleum activity. The EMBA for each activity will most likely be based on conservative stochastic spill modelling thresholds; based on the knowledge gained from previous stochastic modelling from CAPL's activities, all EMBAs are expected to fall within this PA. If an EMBA from an individual EP extends outside the PA, this document will be revised, and the PA extended to incorporate that EMBA.

1.2 Regulatory context

The Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 detail the information that must be included in an EP. Specifically:

Regulation 13(2) states that the environment plan must:

(a) describe the existing environment that may be affected by the activity; and

(b) include details of the particular relevant values and sensitivities (if any) of that environment.

Regulation 4 defines the environment as:

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

(b) natural and physical resources; and

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

(d) the heritage value of places;

and includes

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

Regulation 13(3) further provides that, without limiting paragraph (2)(b) of Regulation 13(2), particular relevant values and sensitivities may include any of these:

(a) the world heritage values of a declared World Heritage property within the meaning *of the EPBC Act;*

(b) the national heritage values of a National Heritage place within the meaning of that Act;

(c) the ecological character of a declared Ramsar wetland within the meaning of that Act;

(d) the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act;

(e) the presence of a listed migratory species within the meaning of that Act;

(f) any values and sensitivities that exist in, or in relation to, part or all of:

(i) a Commonwealth marine area within the meaning of that Act; or

(ii) Commonwealth land within the meaning of that Act.

Specific to the description of the environment, NOPSEMA's *Environment Plan Content Requirement* guidance (Ref. 1) states:

The level of detail within the plan should be appropriately scaled to the nature of the impacts and risks to the particular values and sensitivities. For example, the environment that may be affected by planned operations will need to be described in a greater level of detail than areas exposed to low levels of hydrocarbon in the unlikely event of a worst-case hydrocarbon release.

Consequently, CAPL has taken the approach that this document provides information suitable for summarising the particular values and sensitivities in order to inform the impact and risk evaluation for CAPL operations. However, if additional information is available for specific locations (typically an operational area for a specific activity) and if this information can be used to further influence or inform the impact and risk assessment, this additional information will be included in the 'Description of the Environment' section of the individual EP.

1.3 Review and revision

The information provided in this document is derived from various referenced desktop sources. As a minimum, this document will be reviewed annually to include any relevant changes to source documents, which may include State (Western Australian [WA])/Commonwealth Management Plans, Recovery Plans, Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) status, or new published research.

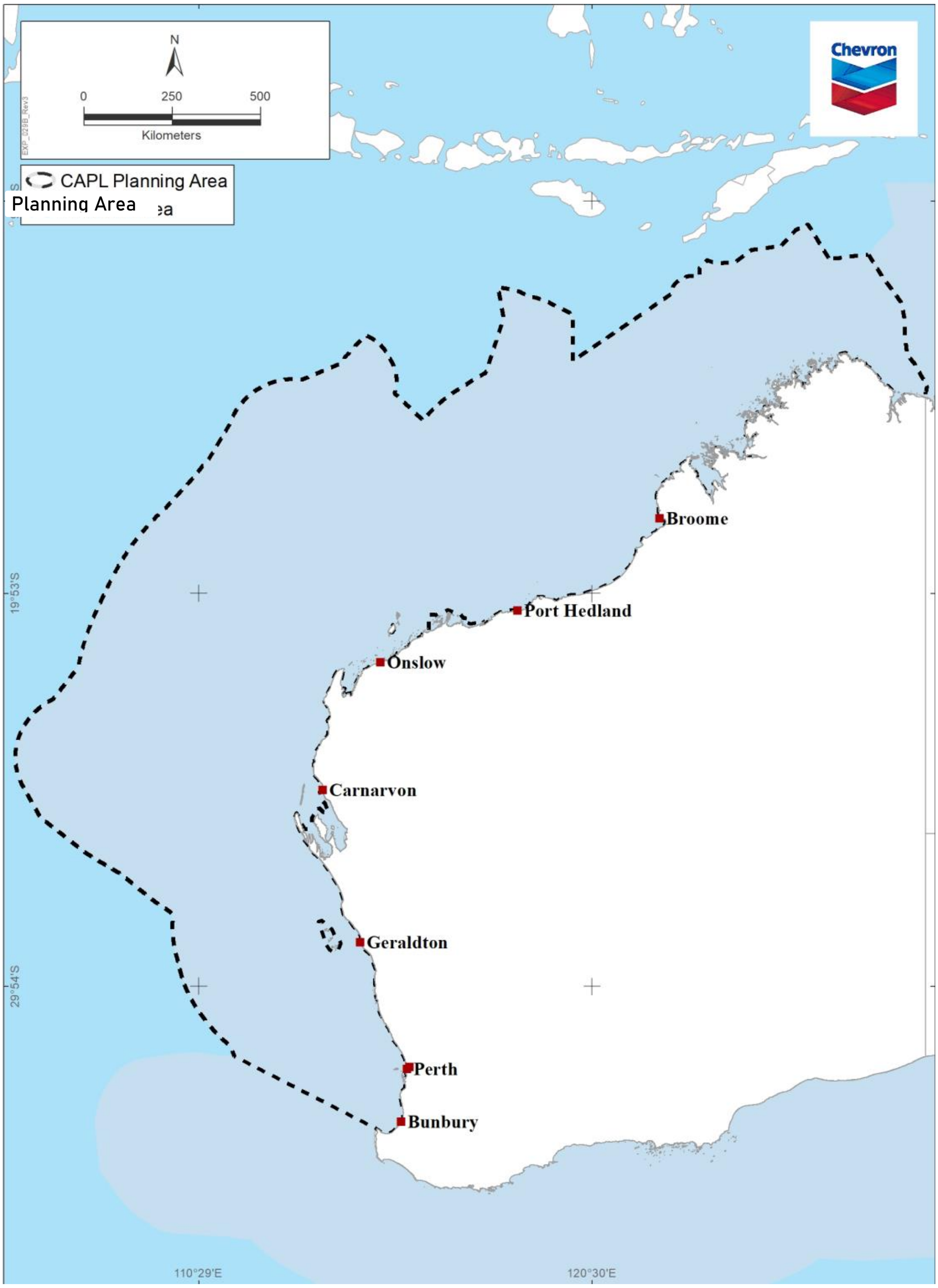


Figure 1-1: CAPL's planning area

2 matters of national environmental significance

2.1 World Heritage properties

Properties nominated for World Heritage listing are inscribed on the list only after they have been carefully assessed as representing the best examples of the world's cultural and natural heritage. At the time of writing this document, Australia has 20 properties on the World Heritage List (Ref. 2; Ref. 3).

The list of Australia's World Heritage areas (Ref. 2) and a protected matters search (Ref. 4; appendix a) show that two World Heritage properties are within the PA. Table 2-1 summarises value of these World Heritage properties (Ref. 2).

Table 2-1: World Heritage properties

World Heritage property	Brief overview of values^
Shark Bay	On the Indian Ocean coast at the most westerly point of Australia, Shark Bay's waters, islands, and peninsulas covering a large area of ~2.2 million hectares (of which about 70% are marine waters) have a number of exceptional natural features, including one of the largest and most diverse seagrass beds in the world. However, it is for its stromatolites (colonies of microbial mats that form hard, dome-shaped deposits, which are said to be the oldest life forms on earth), that the property is most renowned. The property is also famous for its rich marine life including a large population of dugongs and provides a refuge for a number of other globally threatened species.
The Ningaloo Coast	The Ningaloo Coast is located on WA's remote coast along the East Indian Ocean. The property holds a high level of terrestrial species endemism and high marine species diversity and abundance. An estimated 300 to 500 Whale Sharks aggregate annually coinciding with mass coral spawning events and seasonal localised increases in productivity. The marine portion of the nomination contains a high diversity of habitats that includes lagoon, reef, open ocean, the continental slope, and the continental shelf. Intertidal systems such as rocky shores, sandy beaches, estuaries, and mangroves are also found within the property. The most dominant marine habitat is the Ningaloo reef, which sustains both tropical and temperate marine fauna and flora, including marine reptiles and mammals. The main terrestrial feature of the Ningaloo Coast is the extensive karst system and network of underground caves and water courses of the Cape Range. The karst system includes hundreds of separate features such as caves, dolines, and subterranean water bodies and supports a rich diversity of highly specialised subterranean species. Above ground, the Cape Range Peninsula belongs to an arid ecoregion recognised for its high levels of species richness and endemism, particularly for birds and reptiles.

^ Source: Ref. 2.

2.2 National Heritage places

The National Heritage List is Australia's list of natural, historic, and Indigenous places of outstanding significance to the nation. The National Heritage List spatial database (Ref. 5) describes the place name, class (Indigenous, natural, historic), and status.

A search of the National Heritage List spatial database (Ref. 5) and a protected matters search (Ref. 4; appendix a) revealed that several National Heritage places occur in the PA (Table 2-2). The information presented in Table 2-2 outlines the nominator's Summary Statement of Significance sourced from the Australian Heritage Database (Ref. 6).

Table 2-2: National Heritage places

National Heritage place	Class	Summary of significance^
Batavia Shipwreck Site and Survivor Camps Area 1629 – Houtman Abrolhos	Historic	Wrecked on 4 June 1629, the *Batavia* is the oldest of the known Verenigde Oost-Indische Compagnie wrecks on the WA coast. Because of its relatively undisturbed nature, the archaeological investigation of the wreck itself has revealed a range of objects of considerable historical value. The recovered sections of the hull of the *Batavia* have been reconstructed in the Western Australian Maritime Museum and provides information on 17th century Dutch ship building techniques, while the remains of the cargo carried by the vessel have provided economic, and social evidence of the operation of the Dutch port at Batavia (now Jakarta) in the early 17th century.
Dampier Archipelago (including Burrup Peninsula)	Indigenous	The Dampier Archipelago located about 1,550 km north of Perth. On the magnificent Dampier Archipelago in WA, where the striking red earth of the Burrup Peninsula meets the blue Indian Ocean, rock engravings thought to number in the millions and other significant sites are helping us learn more about our Indigenous heritage. Made up of islands, reefs, shoals, channels and straits, and covering a land area of around 400 km^2, the Burrup Peninsula is 27 km long and 4 km wide. Many important native plants, animals and habitats are found in the area. The Archipelago was formed 6-8,000 years ago when rising sea levels flooded what were once coastal plains. The underlying rocks are amongst the oldest on earth, formed in the Archaean period more than 2,400 million years ago. The Dampier Archipelago was included in the National Heritage List on 3 July 2007.
Dirk Hartog Landing Site 1616 – Cape Inscription Area	Historic	Cape Inscription is the site of the oldest known landings of Europeans on the WA coastline, and is associated with a series of landings and surveys by notable explorers over a 250-year period. The first known European landing on the west coast of Australia was by Dirk Hartog of the Dutch East India Company's ship the *Eendracht* at Cape Inscription on 25 October 1616. Hartog left a pewter plate, inscribed with a record of his visit and nailed to a post left standing upright in a rock cleft on top of the cliff. This plate is the oldest extant record of a European landing in Australia. Hartog's discovery had a major impact on world cartography. After leaving the island, he sailed northwards charting the coastline of WA to 22° south. As a result, a known part of the coastline of WA appeared on world maps for the first time, replacing the mythical southern continent of 'Terra Australis Incognita'.
HMAS Sydney II and *HSK Kormoran* Shipwreck Sites	Historic	The naval battle fought between the Australian warship *HMAS Sydney II* and the German commerce raider *HSK Kormoran* off the WA coast during World War II (November 1941) was a defining event in Australia's cultural history. *HMAS Sydney II* was Australia's most famous warship of the time and this battle has forever linked the stories of these warships to each other. The tragic loss of *HMAS Sydney II* and its entire crew of 645 following the battle with *HSK Kormoran* remains Australia's worst naval disaster.
Lesueur National Park*	Natural	The Lesueur National Park (inland from Green Head, WA) contains an exceptional concentration of plant species richness and endemism. It is estimated to contain >900 plant species, including nine plant taxa that are endemic to the National Park and 111 taxa that are endemic to the surrounding region. A further 81 plant taxa are at the northern or southern limit of their distribution, which is significant for the evolution of new species (Ref. 7).

National Heritage place	Class	Summary of significance^
		The Lesueur National Park is one of the most important places in Australia for demonstrating species richness and endemism within the Proteaceae plant family, including the genera of Banksia, *Hakea*, *Dryandra*, *Grevillea*, and *Isopogon* (Ref. 8). The Lesueur National Park contains outstanding species richness and endemism in several other plant families such as: the Fabaceae family, including the genera of *Gastrolobium* (poison pea), *Daviesia* (bitter pea) and *Jacksonia* (dogwood); the Myrtaceae family, including the genera of *Verticordia* (feather flower) and *Melaleuca* (paper bark); the Haemodoraceae family (bloodroots, conostyles and kangaroo paws); the Stylidiaceae family (triggerplants); and the Droseraceae family (sundews) (Ref. 8).
Shark Bay, Western Australia	Natural	Shark Bay is on the most western point of the Australian coast. The region is one of the few properties inscribed on the World Heritage List (see Table 2-1) for all four outstanding natural universal values: • as an outstanding example representing the major stages in the Earth's evolutionary history • as an outstanding example representing significant ongoing ecological and biological processes • as an example of superlative natural phenomena • containing important and significant habitats for in situ conservation of biological diversity. 25% of vascular plants (283 species) are at the limits of their range in Shark Bay. Many vegetation formations and plant species are found only in the interzone area. The area south of Freycinet Estuary contains the unique type of vegetation known as tree heath. There are also at least 51 species endemic to the region and others that are considered new to science. The Shark Bay region is an area of major zoological importance, primarily due to habitats on peninsulas and islands being isolated from the disturbance that has occurred elsewhere. Of the 26 species of endangered Australian mammals, five are found on Bernier and Dorre Islands. These are the Boodie or Burrowing Bettong, Rufous Hare Wallaby, Banded Hare Wallaby, the Shark Bay Mouse, and the Western Barred Bandicoot. The Shark Bay region has a rich avifauna with over 230 species, or 35%, of Australia's bird species having been recorded. A number of birds attain their northern limit here, such as the Regent Parrot, Western Yellow Robin, Blue-breasted Fairy-wren, and Striated Pardalote. The region is also noted for the diversity of its amphibians and reptiles, supporting nearly 100 species. Again, many species are at the northern or southern limit of their range. The area is also significant for the variety of burrowing species, such as the Sandhill Frog, which, apparently, needs no surface water. Shark Bay contains three endemic sand-swimming skinks, and 10 of the 30 dragon lizard species found in Australia. The 12 species of seagrass in Shark Bay make it one of the most diverse seagrass assemblages in the world. Seagrass covers >4,000 km^2 of the bay, with the 1,030 km^2 Wooramel Seagrass Bank being the largest structure of its type in the world. Seagrass has contributed significantly to the evolution of Shark Bay as it has modified the physical, chemical, and biological environment as well as the geology and has led to the development of major marine features, such as Faure Sill. The barrier banks associated with the growth of seagrass over the last 5,000 years has, with low rainfall, high evaporation, and low

National Heritage place	Class	Summary of significance^
		tidal flushing, produced the hypersaline Hamelin Pool and L'Haridon Bight. This hypersaline condition is conducive to the growth of cyanobacteria, which trap and bind sediment to produce various mats and structures including stromatolites. Stromatolites represent the oldest form of life on Earth. They are representative of life forms from ~3,500 million years ago. Hamelin Pool contains the most diverse and abundant examples of stromatolite forms in the world. Shark Bay is renowned for its marine fauna. For example, the Shark Bay population of about 10,000 Dugong is one of the largest in the world, and dolphins abound, particularly at Monkey Mia. Humpback Whales use Shark Bay as a staging post in their migration along the WA coast. This species was reduced by past exploitation from an estimated population of 20,000 on the west coast to 500–800 whales in 1962; the population is now estimated at 2,000–3,000. Green and Loggerhead Turtles are found in Shark Bay near their southern limits; they nest on Dirk Hartog Island and Peron Peninsula beaches. Dirk Hartog Island is the most important nesting site for Loggerhead Turtles in WA. Shark Bay is also an important nursery ground for larval stages of crustaceans, fishes, and medusae (jellyfish).
The Ningaloo Coast	Natural	The integration of the Ningaloo Reef and Exmouth Peninsula karst system as a cohesive limestone structure is at the heart of the natural heritage significance of the Ningaloo Coast. The modern Ningaloo Reef, Exmouth Peninsula karst, and the wave-cut terraces, limestone plains, Pleistocene reef sediments of Exmouth Peninsula, and associated marine, terrestrial, and subterranean ecosystems, including the Muiron Islands, demonstrate a geological, hydrological, and ecological unity, which harmonises the region's present ecosystem functions with its evolutionary history as a time-series of coral reefs and an evolving karst system. The history of coral reefs during the last 26 million years is chronicled in the limestone parapets and wave-cut terraces of Cape Range, which record previous high water levels. Demonstrating late Quaternary deformation at a passive continental margin, the uplifted Neogene wave-cut terraces and fossil reefs that fringe Exmouth Peninsula, and the submerged fossil reef terraces that form the substrate of the modern reef, in immediate juxtaposition with the undeformed modern Ningaloo Reef, contribute to an understanding of the mechanisms that led to the modern character of the west coast of Australia. Archaeological deposits in the rock shelters on Cape Range show Aboriginal people had a comprehensive and sophisticated knowledge of edible and non-edible marine resources between 35,000 and 17,000 years ago. The rock shelters of Exmouth Peninsula are outstanding because they provide the best evidence in Australia for the use of marine resources during the Pleistocene, including their uses as food and for personal adornment. The evidence for standardisation in size and manufacture of the shell beads found at Mandu Creek rock shelter, coupled with the fact they provide the earliest unequivocal evidence for the creation of personal ornaments in Australia, demonstrates a high degree of creative and technical achievement.
The West Kimberley	Natural	The National Heritage listing of the West Kimberley recognises the natural, historic, and Indigenous stories of the region that are of outstanding heritage value to the nation. These and other fascinating stories about the west Kimberley are woven together in

National Heritage place	Class	Summary of significance^
		the following description of the region and its history, including a remarkable account of Aboriginal occupation and custodianship over the course of more than 40,000 years. The Kimberley occupies more than 420,000 km^2 on the north-western margin of the Australian continent. Its rocky coastline edges the Indian Ocean, and off the coast lie thousands of islands, many fringed with coral. The Mitchell Plateau (Ngauwudu) rises to nearly 800 m above sea level at its centre, in places dropping into steep escarpments, and losing altitude as it approaches the sea. Further south, Yampi Peninsula lies in a transitional area between the high rainfall of tropical north Kimberley and the drier conditions characteristic of central WA. These different environments meet in a complex landscape of plains, dissected sandstone plateaus, and rugged mountains. The central Kimberley, which includes the periphery of north Kimberley plateau country and the King Leopold Ranges, is very rugged; the physical structures here were formed by significant geological events, which folded rocks intensely, many thousands of millions of years ago. That such evidence of a distant past can today be seen so clearly in the landscape is due to the region's remarkable geological stability. This stability has also allowed the much more recent appearance of extensive limestone ranges, built from the remains of an extraordinary reef complex which, more than 300 million years ago, rivalled the Great Barrier Reef in size. The ranges have since eroded to form complex networks of caves and tunnels. Dinosaur footprints and tracks are another remarkable remnant of past life in the Kimberley; they are exposed in many places in the Broome sandstone, along the western length of Dampier Peninsula. This coastline is subject to one of the highest tidal ranges in the world, and many of the fossil footprints can only be seen for short periods during very low tides. Inland of Dampier Peninsula, south of the broad floodplains of the Fitzroy River, the distinctive red of the pindan country opens onto a vast expanse of desert. Throughout the Kimberley, where water meets land—in estuaries, mangroves and mudflats, in moist vine thickets, along the banks of rivers and creeks, around waterholes or soaks—there is an abundance of plants and animals, some of which live only in the Kimberley, while others may have travelled from the far side of the world to nest or breed here.

^ Source: Ref. 6.
** Identified in the protected matters search (appendix a) but located inland and thus not expected to be exposed to CAPL's activities.*

2.3 Commonwealth Heritage places

The Commonwealth Heritage List is a list of Indigenous, historic, and natural heritage places owned or controlled by the Australian Government. The Commonwealth Heritage List (Ref. 9) describes the place name, class (Indigenous, natural, historic), and status.

A search of the Commonwealth Heritage List and a protected matters search (appendix a; Ref. 4) revealed that Commonwealth Heritage Places occur in the PA (Table 2-3). The information presented in this table outlines the Nominator's Summary Statement of Significance sourced from the Australian Heritage Database (Ref. 6).

Table 2-3: Commonwealth Heritage places

Commonwealth Heritage place	Class	Summary of significance^
Ashmore Reef National Nature Reserve (External territories list)	Natural	Ashmore Reef (which is an atoll that includes four low-lying uninhabited sand islands) has major significance as a staging point for wading birds migrating between Australia and the northern hemisphere, including 43 species listed on the China–Australia Migratory Bird Agreement (CAMBA) and/or the Japan–Australia Migratory Bird Agreement (JAMBA). The place provides habitat for three species of sea snake; *Aipysurus apraefrontalis*, *A. foliosquama*, and *A. fuscus* with very restricted distributions. *Aipysurus fuscus* is endemic to Ashmore Reef. Ashmore Reef supports extremely high concentrations of breeding seabirds, many of which are nomadic and typically breed on small isolated islands. Breeding colonies of 17 species of seabirds have been recorded. The islands are regarded as supporting some of the most important seabird rookeries on the Sahul Shelf, including large (1,000 to 50,000 breeding pairs) breeding colonies of Sooty Tern (*Sterna fuscata*), Crested Tern (*S. bergii*), Bridled Tern (*S. anaethetus*) and Common Noddy (*Anous stolidus*), and smaller breeding colonies of Little Egret (*Egretta alba*), Eastern Reef Egret (*E. sacra*), Black Noddy (*Anous minutus*), White-tailed Tropic Bird (*Phaethon lepturus*), and Red-tailed Tropic Bird (*P. rubricauda*). The place is also important for providing breeding habitat for Green (*Chelonia mydas*) and Hawksbill Turtles (*Eretmochelys imbricata*). Ashmore Reef exhibits a higher diversity of marine habitats compared with other North West Shelf reefs. The place supports an exceptionally diverse marine fauna, particularly corals (255 species in 56 genera) and molluscs (433 species), and is regarded as having the highest diversity of sea snakes (12 species) in the world. Other highly diverse fauna include birds (78 species), decapod crustaceans (99 species), echinoderms (178 species), and fish (569 species). Species of conservation significance recorded at Ashmore Reef include: the nationally endangered Little Tern (*Sterna albifrons*) and Loggerhead Turtle (*Caretta caretta*), and the nationally vulnerable Green Turtle (*Chelonia mydas*) and Hawksbill Turtle (*Eretmochelys imbricata*). The place also includes species not previously recorded or only rarely recorded in Australia including: three bird species(Brown Hawk Owl [*Ninox scutulata*], White-tailed Tropic Bird [*Phaethon lepturus*], and Black Noddy [*Anous minutus*]); five hermatypic coral species; and 13 fish species. Ashmore Reef is an important scientific reference area for migratory seabirds, sea snakes, and marine invertebrates. It has been the site of several major scientific expeditions and is the subject of ongoing scientific monitoring of biological diversity, fauna populations, and breeding activity. Ashmore Reef is the type locality for two species of sea snake—*Aipysurus apraefrontalis* and *A. foliosquama*. Ashmore Reef is significant for its history of human occupation and use. Although the reef may have been known to the Rottinese people (Rote is an island in modern-day Indonesia) for many centuries, the first description is probably that contained in Eredia (1600) if accepted, this may be the first description of Ashmore Reef, which is now part of Australia. Ashmore Reef is believed to have been visited by fisherman from Rote Island since the early 18th century, as well as by Makassans and Bajau ('Sea Gypsies') and people from the island of Seram. The Ashmore Reef islands were used both for fishing and as a staging point for voyages to the southern reefs off Australia's coast. Occupation by these seafarers, particularly from the area east of Madura (Indonesia), on the islands

Commonwealth Heritage place	Class	Summary of significance^
		occurred intermittently during the 1930s. Visits recommenced in 1947 following World War II and have continued. The islands are also significant for phosphate mining, which lead to their annexation by Great Britain and ultimate transfer to the Australian Government in 1934. Physical evidence of these former occupations exists and would be particularly significant in archaeological terms. Such evidence may include original wells and grave sites and would include evidence of disturbance from early phosphate mining.
Cliff Point Historic Site (WA list)	Historic	The Cliff Point Historic Site, individually significant within the area of Garden Island, is important as it was the first site inhabited by Governor Stirling's party in 1829 when founding the colony of WA, and as WA's first official non-convict settlement. The site was initially occupied by Captain Charles Fremantle before the arrival of Captain Stirling. The party occupied the site for two months before a move was made to the Swan River settlement on the mainland. The Cliff Point Historic Site is important as the site of first settlement in WA and is highly valued by the community for its cultural associations. The Cliff Point Historic Site, also known as Sulphur Town, after *HMS Sulphur* was chosen in 1828 by Governor Stirling to transport settlers to the new colony and is important for its association with Governor Stirling and Captain Charles Fremantle.
Garden Island (WA list)	Natural	Garden Island was the first site occupied by Governor Stirling's party in 1829 when founding the colony of WA; it was also the site of the first official non-convict settlement in WA. The Cliff Point Historic Site on Garden Island, also known as Sulphur Town, was initially occupied by Captain Charles Fremantle before the arrival of Captain Stirling, and is listed separately in the Register (Reg. No. 10657). The party occupied the site for two months before they moved to the Swan River settlement on the mainland. Garden Island, and in particular the Cliff Point Historic Site, is highly valued for its cultural associations as the site of first settlement in WA and is important for its association with Governor Stirling and Captain Charles Fremantle. In 1911, the Commonwealth resumed Garden Island from WA for use as a naval base. The strategic role of Garden Island and Cockburn Sound, which was secured for coastal defence in World War II, is illustrated by defence installations including Challenger or J Gun Battery, and the Scriven, Beacon, and Collie Battery complexes, supported by a range of service structures. Challenger Battery is listed separately in the Register at Reg. No. 18968. The absence of feral predators means that Garden Island provides a significant refuge for animals vulnerable to predation on the mainland. Due to its isolation from the WA mainland, the island is relatively free of disturbance from humans or introduced animals. Species of particular interest include the Tammar Wallaby (*Macropus eugenii*), Carpet Python (*Morelia spilota*), and the Lined Skink (*Lerista lineata*). Populations of the 14 species of reptile and the Tammar Wallaby have been isolated from mainland populations for 6,000–7,000 years. In particular, the population of the Tammar Wallaby on Garden Island is morphologically distinct from all other populations. The vegetation on Garden Island differs in structure and composition from vegetation on nearby Rottnest Island and the adjacent mainland (e.g., eucalypts and banksia, which are common on the mainland, are absent from the island). Due to a low fire frequency, the vegetation on Garden Island is older and denser than that on the mainland. The northern end of the island supports

Commonwealth Heritage place	Class	Summary of significance^
		some of the oldest stands of the rare Rottnest Island Pine (*Callitris preissii*), with most trees dating from the 1920s. Other species that are now rare in the region include the Cheesewood (*Pittosporum phylliraeoides* var. *phylliraeoides*) and Rottnest Teatree (*Melaleuca lanceolata*). The parabolic sand dunes on the western side of Garden Island are among the best-preserved dunes of the Quindalup soil unit, which is widespread in coastal WA. It is likely that Indigenous values exist at this place. The Australian Heritage Commission (AHC) has not yet identified, documented, or assessed these values for National Estate significance.
HMAS Sydney II and *HSK Kormoran* Shipwreck Sites (External territories list)	Historic	The naval battle fought between the Australian warship *HMAS Sydney II* and the German commerce raider *HSK Kormoran* off the WA coast during World War II was a defining event in Australia's cultural history. *HMAS Sydney II* was Australia's most famous warship of the time and this battle has forever linked the stories of these warships to each other. The tragic loss of *HMAS Sydney II* and its entire crew of 645 following the battle with *HSK Kormoran*, remains Australia's worst naval disaster and sent shockwaves throughout the Australian community in November 1941. The battle between *HMAS Sydney II* and *HSK Kormoran* had far-reaching consequences for developing Australia's defences. The loss of *HMAS Sydney II* was the first and most significant in a succession of Australian naval losses that directly threatened the security of Australia and its surrounding seas, having occurred only 17 days before the Japanese launched their attacks in Southeast Asia and the Northern Pacific. The aftermath of the sinking of *HMAS Sydney II* and subsequent warship losses saw a major shift in Australian military and political doctrine away from defending Australia by defending the British Empire to that of direct defence of the Australian mainland and the development of a defence alliance with the United States. The discovery and inspection of *HMAS Sydney II* and *HSK Kormoran* in 2008 has enabled reconciliation of theory and known historical fact concerning the battle with the archaeological evidence present in the remains. This physical evidence was pivotal to the findings of the 2009 *HMAS Sydney II* Commission of Inquiry (Cole Inquiry), and allowed some circumstances of the loss of *HMAS Sydney II* to be better understood. It has also enabled the study of unique technological features that allowed *HSK Kormoran* to avoid identification as a warship when approaching *HMAS Sydney II* until reaching point blank range for the weapons of the time. The surprise achieved by using these technologies was a major factor in the destruction of *HMAS Sydney II*. During the relatively short but conspicuous career of *HMAS Sydney II*, it was commanded by two of the most highly regarded and respected officers serving in the Royal Australian Navy at that time (Captain J.A. Collins and Captain J. Burnett). Their association with *HMAS Sydney II* is significant in both their naval careers and of the ship itself. The 2008 discovery of *HMAS Sydney II* and *HSK Kormoran* has highlighted the ongoing importance of these shipwrecks and their stories to the wider Australian community. The stories of these two ships are not only valued by the family and friends of the servicemen who died but also by veterans, defence personnel, and the Australian community in general. The location, interpretation, and memorialisation of these shipwrecks also provides some closure for the families.
J Gun Battery	Historic	Garden Island is important as the first site occupied by Governor Stirling's party in 1829 when founding the colony of Western

Commonwealth Heritage place	Class	Summary of significance^
(WA list)		Australia and as the first official non-convict settlement in WA. The Cliff Point Historic Site, also known as Sulphur Town, was occupied in the first instance by Captain Charles Fremantle before the arrival of Captain Stirling, and is listed separately in the Register (Reg. No. 10657). The party occupied the site for two months before a move was made to the Swan River settlement on the mainland. Garden Island, and in particular the Cliff Point Historic Site, is highly valued by the community for its cultural associations as the site of first settlement in WA and is important for its association with Governor Stirling and Captain Charles Fremantle. Garden Island was selected as the base for a naval base in 1911 and resumed by the Commonwealth. The strategic role of the island and Cockburn Sound, secured for coastal defence in the Second World War 1939–1945, is illustrated by defences including Challenger or J Battery and the Scriven, Beacon, and Collie Battery complexes, supported by a range of service structures. Challenger battery is listed separately in the Register at Reg. No. 18968. The absence of feral predators means that Garden Island provides a significant refuge for animals vulnerable to predation on the mainland. Due to its isolation from the WA mainland, the island is relatively free of disturbance from humans or introduced animals. Species of particular interest include the Tammar Wallaby (*Macropus eugenii*), Carpet Python (*Morelia spilota*), and the Lined Skink (*Lerista lineata*). Populations of the 14 species of reptile and the Tammar Wallaby have been isolated from mainland populations for 6,000–7,000 years. In particular, the population of the Tammar Wallaby on Garden Island is morphologically distinct from all other populations. The vegetation on Garden Island differs in structure and composition from vegetation on nearby Rottnest Island and the adjacent mainland. For example, eucalypts and banksia, which are common on the mainland, are absent from the island. Due to a low fire frequency, the vegetation on Garden Island is older and denser than that on the mainland. The northern end of the island has some of the oldest stands of the rare Rottnest Island pine (*Callitris preissii*), with most trees dating from the 1920s. Other species that are now rare in the region include the Cheesewood (*Pittosporum phylliraeoides* var. *phylliraeoides*) and Rottnest Teatree (*Melaleuca lanceolata*). The parabolic sand dunes on the western side of the island are among the best-preserved dunes of the Quindalup soil unit, which is widespread in coastal WA. It is likely that Indigenous values exist at this place. The AHC has not yet identified, documented, or assessed these values for National Estate significance.
Lancelin Defence Training Area (WA list)	Natural	The Lancelin Defence Training Area (DTA) is at the northern end of the Swan Coastal Plain, an area of exceptionally diverse flora and fauna. Much of Lancelin is dominated by species-rich Banksia woodlands and Myrtaceous/Proteaceous heaths. The floristic mosaic of *Banksia attenuata – B. menziessi* low woodlands, wet heaths, and low-heath communities represent significant vegetation remnants that are poorly conserved and under-represented in the conservation reserve system. The Lancelin DTA contains wetlands that are important in the hydrogeological system of the region. The Namming freshwater wetland suite contains a high diversity of habitats, is an important breeding site for waterfowl, and acts as a drought refuge for both waterfowl and other fauna.

Commonwealth Heritage place	Class	Summary of significance^
		The Lancelin DTA is close to the boundary of two major zoogeographic regions, the semi-arid Eyrean zone, and the Bassean, or south-western zone of WA. This accounts in part for the high vertebrate fauna richness, particularly for reptiles and frogs, with eight frog species recorded in the large, seasonal Walyengarra Lake. Several species occur at the edge of their distribution range within the place. Reptile species that are at, or near, the southern limit of their distribution in the Lancelin DTA include the skink *Lerista planiventralis* and the snake *Simoselaps littoralis*. Many bird species are at or near their northern limit of distribution here, including the Southern Emu Wren (*Stipiturus malachurus*), and the Spotted Pardalote (*Pardalotus punctata*), while several are at their southern limits, including the Pied Butcherbird (*Cracticus nigrogularis*), and the Pied Honeyeater (*Certhionyx variegatus*). The vegetation community known as Tall Heath—comprising *Calothamnus quadrifidus*, *Dryandra sessilis*, and *Hakea trifurcata*—is near the southern limit of its distribution within the Lancelin DTA. Stands of Tuart (*Eucalyptus gomphocephala*) are significant as this area is close to this restricted species' northern limit. Several flora species found in the place are listed as poorly known or rare (Priority species) in WA, including species that are known from only a few populations that are under threat. The Lancelin DTA occurs within a narrow strip along the central and south WA coast where a number of reptile species have restricted distributions. Species with restricted distributions that occur here include the legless lizards *Aclys concinna*, *Pletholax gracilis*, and *Delma grayii* and the skinks *Ctenotus australis* and *Lerista praepedita.*
Learmonth Air Weapons Range Facility (WA list)	Natural	The geomorphology of Cape Range, of which the Learmonth Air Weapons Range (AWR) Facility is a part, is of considerable importance in documenting sea level and landform changes since the late Cenozoic Era (~1.8 million years ago). A series of emergent reef complexes, which represent several periods of coral reef development, are striking elements of the geomorphology of the western side of the Learmonth AWR Facility and Cape Range. The ages of these reef terraces are key to understanding of the timing of uplift events. The coastal plain of Cape Range contains a network of subterranean waterways, comprising caverns and fissures in the limestone beneath the coastal plain. Of these, Bundera Sinkhole, found within the Learmonth AWR Facility, is the only deep anchialine system known in Australia, and is the only continental anchialine system known in the southern hemisphere. Anchialine systems are cave systems with restricted exposure to open air, with subterranean connections to the sea, and showing marine and terrestrial influences. Anchialine systems are noted both for their relict fauna and their high species richness. The physicochemical environment in Bundera Sinkhole is very complex, and is associated with biogeochemical processes that are likely to be important for maintaining the unique community contained in this system. The cave fauna of Cape Range, including that within the Learmonth AWR Facility at Bundera Sinkhole, is of exceptional biogeographical importance. Much of the fauna developed a long time ago, with a number of species of the aquatic cave fauna (stygofauna) originating in the Tethys Sea ~170 million years ago. Bundera Sinkhole supports several species of aquatic stygofauna, many of which are endemic to the sinkhole or to Cape Range. Many of the stygofauna species have their closest known affinities

Commonwealth Heritage place	Class	Summary of significance^
		with the fauna of anchialine caves on either side of the North Atlantic. This narrow cave is also the only known southern hemisphere site for a crustacean from the class Remipedia (*Lasionectes exleyi*). *L. exleyi* is listed as endangered at both State and Commonwealth levels. This species is widely separated from related species found in the North Atlantic. Bundera Sinkhole is also the only known locality in the southern hemisphere for another crustacean species: *Danielopolina* sp. Nov. Several other crustacean species found in Bundera Sinkhole are likely to have originated from the Tethys Sea, including: *Stygiocaris lancifera* (the Lance-beaked Cave Shrimp); two copepods from the Calanoida order (*Bunderia* sp. and *Stygocyclopia* sp.); and another copepod, *Halicyclops spinifer*. Many of these species also have widely separated distributions (e.g. *Halicyclops* is confined in Australia to Cape Range, but is also found in Iran, Brazil, and India). The Lance-beaked Cave Shrimp is listed as rare or likely to become extinct at the State level. The gastropod *Iravadia* sp. is found in brackish water in Bundera Sinkhole, and represents the first marine/estuarine stygophile recorded from the region. A fish species, the Blind or Cave Gudgeon *Milyeringa veritas*, also occurs here—it is one of only two vertebrate species known in Australasia that is confined to caves. This species is listed as vulnerable at the national level. *Prionospio thalanji* sp. nov., a worm from the Spionidae family, has been described from Bundera Sinkhole. Other species from this genus are predominantly marine, and this is the first global record of a spionid occurring in a cave environment. The ecosystems represented in the caves of the Cape Range and subterranean waterways under the coastal plains of the peninsula, including in the Learmonth AWR Facility at Bundera Sinkhole, are rare in WA. Only a small number of cave ecosystems exist in WA, and Bundera Sinkhole, along with other caves at Cape Range, are the only example in Australia of an orogenic (formed during a mountain building phase) limestone from the Tertiary Period (between 65 million and 1.8 million years ago). Stygofauna throughout the world is of considerable scientific interest, yielding important information concerning the evolution of life on earth. The stygofauna at Cape Range, including species found within the Learmonth AWR Facility at Bundera Sinkhole, give insights into the origin of Australian fauna, changes in climate since the Miocene Epoch, and the biogeographical history of the continent Several species of vertebrate terrestrial fauna at Cape Range, including within the Learmonth AWR Facility, are of biogeographical importance because they form isolated populations, or populations at the limit of their range. The reptile fauna is of particular biogeographical significance, with a number of species or subspecies occurring here with highly restricted distributions. The Learmonth AWR Facility supports six southern reptile species that are at, or close to, their northern geographic limit: *Diplodactylus ornatus*, *Ctenotus fallens*, *Lerista lineopunctulata*, *L. praepedita*, *Morethia lineoocellata*, and *Vermicella littoralis*. All these species are found on the western coastal dunes, and are largely restricted to the coastal corridor. All are endemic to southern WA and restricted to sandy coastal habitats along the western coast. The Learmonth AWR Facility supports several plant species that are either endemic, or mainly limited to the Cape Range peninsula, with at least ten endemic flora species occurring here.

Commonwealth Heritage place	Class	Summary of significance^
Mermaid Reef – Rowley Shoals (WA list)	Natural	Mermaid Reef is characterised by environmental conditions that are rare for shelf-edge reefs and are known only in the Rowley Shoals in WA; these conditions include clear, deep oceanic water and large tidal ranges. Species of conservation significance recorded at the place include the nationally vulnerable Green Turtle (*Chelonia mydas*). The Rowley Shoals provide habitat for species not previously been recorded in WA, including 216 fish species, 39 mollusc species, and seven echinoderm species. The Rowley Shoals are regionally important for their fauna diversity, which includes: corals (184 species in 52 genera); molluscs (260 species); echinoderms (90 species); and fish (485 species). Mermaid Reef, together with Clerke and Imperieuse Reefs, has biogeographical significance due to the presence of species that are at, or close to, the limits of their geographic ranges, including fish known previously only from Indonesian waters (e.g. the apogonid *Cheilodipterus singapurensis*, the pomacentrid *Chrysiptera hemicyanea*, the blenniid *Escenius schroederi*, and several gobiids). The monotypic labrid *Conniella apterygia* is endemic to the region of Rowley Shoals and Seringapatam and Scott Reefs. Mermaid Reef is particularly significant as a stepping-stone in the spread of genetic material from the Indonesian archipelago to the reefs to the south. The Rowley Shoals are important for benchmark studies as they are one of the few places off the north-west coast of WA that have been the site of major biological collection trips by the WA Museum. The Rowley Shoals includes the type locality of several fish, including the genus and species of the wrasse *Conniella apterygia* and the serranid species *Pseudanthias sheni*. The place is one of the best morphological examples of shelf-edge reefs in Australian waters and is important for demonstrating their principal structural and developmental characteristics. A shipwreck off the western edge of Mermaid Reef is believed to be that of the British whaling vessel *Lively*, which was lost in the early 1800s.
Ningaloo Marine Area – Commonwealth Waters (WA list)	Natural	Whale Sharks (*Rhincodon typus*) congregate in the Ningaloo Marine Area after the mass coral spawning each autumn in the adjacent Ningaloo Reef (State waters). The place is an important feeding area for the Whale Shark and one of the few places in the world where they are known to congregate regularly in significant numbers. The place is part of the annual migration route for the endangered (Commonwealth) Humpback Whale. They migrate north to Kimberley (WA) breeding grounds in winter (June–August) and south to Antarctic feeding grounds in summer (August–November). Other Commonwealth listed threatened species found in the place are the endangered Blue Whale, Southern Right Whale (*Eubalaena australis*), Loggerhead Turtle, and Southern Giant Petrel (*Macronectes giganteus*); the vulnerable Fin Whale (*Balaenoptera physalis*), Sei Whale (*B. borealis*), Green Turtle, Hawksbill Turtle, Flatback Turtle, Soft-plumaged Petrel (*Pterodroma mollis*), Great White Shark (*Carcharodon carcharias*), and Grey Nurse Shark (*Carcharias taurus*). Other significant species include the Dugong, Spinner Dolphin (*Stenella longirostris*), Yellow-nosed Albatross (*Diomedea chlororhynchos*) and Osprey (*Pandion haliaetus*). Marine turtle density is exceptionally high in the place; Green Turtles are the most abundant, exceeding the highest densities recorded in the Great Barrier Reef Marine Park (Queensland). The place is on the migratory route of many trans-equatorial wader bird species, and provides valuable feeding grounds for many migratory seabirds, including 11 species protected under JAMBA and/or CAMBA including the Wedge-tailed Shearwater (*Puffinus pacificus*), Wilson's Storm Petrel (*Oceanites oceanicus*), Lesser

Commonwealth Heritage place	Class	Summary of significance^
		Frigatebird (*Fregata ariel*), Crested Tern (*Sterna bergii*), and White-winged Tern (*Chlidonias leucoptera*). The place is an important breeding area for billfish, and is one of the few areas in the world where aggregations of several species (Black Marlin, Blue Marlin, Striped Marlin, and sailfish) occur. The place is an important feeding area for manta rays in autumn and winter and significant for tuna migration and potentially important for juvenile Southern Bluefin Tuna (*Thunnus maccoyii*). The Ningaloo Marine Area provides opportunities for scientific research in many different fields related to aspects of the place's unique and interesting features. Past, current, and ongoing research is being undertaken by academic and research institutions, including: the Department of Biodiversity, Conservation and Attractions (WA), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Institute of Marine Science (AIMS), Murdoch University (WA), University of WA, Edith Cowan University (WA), and James Cook University (Queensland). Areas of research include tourism, marine ecology, whales, marine turtles, Whale Sharks, fish, and oceanography. The Ningaloo Marine Area has many historic associations for European exploration and development of the North West Cape and northern WA, including pearling and whaling activities. To date eight shipwrecks dating from 1811 to 1923 have been discovered in the area. Other Indigenous and non-Indigenous cultural values of National Estate significance may exist in this place, but the AHC has not yet identified, documented, or assessed these values.
Scott Reef and Surrounds – Commonwealth Area (External territories list)	Natural	Scott Reef is a significant component of a disjointed chain of shelf-edge reefs separated from Indonesia by the Timor Trough. It is regionally significant both because of its high representation of species not found in coastal waters off WA and for the unusual nature of its fauna, which has affinities with the oceanic reef habitats of the Indo-West Pacific as well as the reefs of the Indonesian region. Scott Reef is important for its contribution to understanding long-term geomorphological and reef formation processes and past environments—its sedimentary sequence extends back to include sediments from the Triassic Period. The place has biogeographical significance due to the presence of species that are at, or close to, the limits of their geographic ranges, including fish known previously only from Indonesian waters (e.g. *Cheilodipterus singapurensis*, *Chrysoptera hemicyanea*, *Ecsenius schroederi*, and several gobiids). In addition, some coral species may be endemic to Scott Reef. The reef's isolation and large size may predispose it for the evolution of genetically distinct subspecies or endemic species. Several species are currently only known from Scott Reef, including 51 fish species, 14 mollusc species, six echinoderm species, and the seagrass *Thalassia hemprichii*. Scott Reef is of biogeographical significance due to its connectivity in terms of gene flow and coral spore movement to surrounding reefs such as Ashmore Reef and Rowley Shoals. Scott Reef has enormous habitat diversity and is considered a hot spot of fish diversity. Scott Reef is characterised by environmental conditions that are rare for shelf atolls; these conditions include clear, deep oceanic water and large tidal ranges. Scott Reef has nationally vulnerable Green Turtles (*Chelonia mydas*), which are genetically distinct from those on near-coastal sites in WA, from the Lacepede Islands to North West Cape. The sand cays of the place are important habitat for migrating animals in the largely landless expanse of the Timor Sea. They are an important staging area for birds, particularly

Commonwealth Heritage place	Class	Summary of significance^
		migrants to and from Australia. Seventeen of the 25 bird species identified on Scott Reef are on CAMBA and/or JAMBA lists. Scott and Seringapatam Reefs together are regionally important for the diversity of their fauna, which includes corals (224 species in 56 genera); molluscs (279 species); decapod crustacea (56 species); echinoderms (117 species); and fish (558 species). Scott Reef is important for scientific research and benchmark studies due to its great age, the exceptional documentation of its geophysical and physical environmental characteristics, and its use as a site of major biological collection trips and surveys by the WA Museum and AIMS.
Yampi Defence Area (WA list)	Natural	The Yampi Defence Area displays a complex mosaic of landforms in the transition from the sandstone plateaus of the north-west Kimberley, to the broad plains and pindan scrub of the south-west Kimberley. The occurrence of such diverse landscapes within a relatively limited area is unusual. The strong relationship that exists between past orogenic events and the diverse landscape pattern of ridges and valleys is emphasised in the shape of the Yampi Fold Belt, and distinguished by the pronounced ria embayments that characterise the coastline. Landforms originating from rocks within the Yampi Fold Belt and the terrain associated with the Late Devonian Lillybooraroo Conglomerate are of considerable scientific importance. The erosion of the Lillybooraroo Conglomerate, which covers the Yampi Fold Belt, has partially exposed a pre-Devonian land surface, the attributes of which have enormous potential to aid our understanding of long-term geomorphological processes and evolution. Suggestions that the Lillybooraroo Conglomerate remains an original valley fill deposit would attest to very low rates of erosion and long-term landscape stability, reinforcing the scientific importance of the place. The Yampi Defence Area, which is at the crossroads of the Dampierland, Central, and Northern Kimberley biogeographical regions, has a diverse range of ecosystems, displaying an unusual richness of faunal associations and vegetation communities, with >800 plant species (approximately one-third of the described Kimberley flora) being recorded. Previous surveys of the Dampier Peninsula and Walcott Inlet, and the Kimberley Rainforest Survey enable the changing floristic composition to be compared between adjacent areas. On the basis of species richness, indications are that the Yampi Defence Area supports >1,000 species, including undescribed, rare, and fire-sensitive species that are declining elsewhere in the Kimberley. Similarly, the known distributions of vertebrates from the Yampi Peninsula, and locations to the north and south, indicate that a far richer fauna is likely to occur in the place. Fire-protected sandstone communities, typified by healthy mixed-age stands of cypress pine (*Callitris intratropica*) once common throughout the Kimberley are now very rare in northern Australia, and the occurrence of such stands around Secure Bay are important reference sites for similar Kimberley plant communities that are subject to more frequent fire regimes. The extensive sandstone landforms support small isolated patches of rainforest (the south-west limit in the Kimberley of the distribution of rainforest over sandstone), creating important nodes of diversity and refugia that contain many regionally endemic plants, animals, and invertebrates. Granite landforms are of restricted distribution in the Kimberley and mostly occur in drier areas. The high concentration of granite outcrop sequences at Yampi occurs in a higher rainfall zone

Commonwealth Heritage place	Class	Summary of significance^
		resulting in formation of diverse and specialised vegetation communities. Aquatic plants inhabit the ephemeral pools that form in granite depressions, while rock-colonisers populate the granite fissures and scree slopes where run-off water is high. Six plant taxa occur within the place that are endemic to the Yampi Peninsula. Yampi Defence Area is the type locality for the insectivorous plant *Byblis filifolia*, first collected in 1838 during the voyage of *HMS Beagle*. The close juxtaposition of three botanical regions within the place is highlighted by the presence of numerous tropical plant species and several animal taxa that are at the southern edge of their distribution. Merging with these are many arid zone plants at the northern and western edge of their distribution, recognisable as the pindan grades into the taller woodland structure of the north-western Kimberley. The sandstone mesa south of Kimbolton is the southernmost locality for several plant taxa restricted to the fire-protected sandstone ranges of the Kimberley. The diversity of landforms in the place and the resultant high concentration of small refugial habitats support a regionally rich vertebrate fauna and represent the most southerly known extant population of the nationally vulnerable Golden-backed Tree-rat (*Mesembriomys macrurus*) and the most southerly record in the Kimberley of the Sugar Glider (*Petaurus breviceps*). The bird fauna is significant as it represents a suite of species that are at, or near, the southern edge of their range in the semi-humid zone of the Kimberley including the Green-winged Pigeon (*Chalcophaps indica*); the Torres Strait Pigeon (*Ducula bicolor*); and the Little Shrike-thrush (*Colluricincla megarhyncha parvula*). The place is also an important zone of overlap between many northern and southern species and subspecies. The vertebrate fauna shows its closest similarity to those recorded from the wetter areas of the west Kimberley that lie further to the north. The place supports several fauna and flora species that are listed as specially protected, threatened, or having priority status in WA, as well as four fauna species that are nationally vulnerable and one species that is nationally endangered. Other Indigenous and non-Indigenous cultural values of National Estate significance may exist in this place, but the AHC has not yet identified, documented, or assessed these values.

^ Source: Ref. 6.

2.4 Wetlands of international importance (listed under the Ramsar Convention)

At the time of writing this document, Australia has 66 Ramsar wetlands that cover >8.3 million ha. Ramsar wetlands are those that are representative, rare, or unique wetlands, or that are important for conserving biological diversity. These are included on the List of Wetlands of International Importance held under the Ramsar Convention (Ref. 10).

The Ramsar Wetlands of Australia spatial dataset (Ref. 11) shows the Ramsar wetlands within the PA (Table 2-4). The Ramsar Convention defines ecological character as the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time (Ramsar Convention 2005a, Resolution IX.1 Annex A). A summary of the ecological character of the wetlands is described in Table 2-4.

Table 2-4: Ramsar wetlands

Summary of the ecological character of Ramsar wetlands
Ashmore Reef Commonwealth Marine Reserve
Ashmore Reef Commonwealth Marine Reserve is located in the Indian Ocean on the edge of Australia's North West Shelf, ~610 km north of Broome and ~840 km west of Darwin. The Reserve is in Australia's External Territory of Ashmore and Cartier Islands. It is the largest of only three emergent oceanic reefs present within the north-eastern Indian Ocean. The Reserve is comprised of numerous marine habitats and supports a regionally important and diverse range of species. The following summary of ecosystem components, processes and services has been extracted from Hale and Butcher (Ref. 12). **Ecosystem components and processes** • Climate: Arid tropical monsoonal climate. Located outside the main belt of tropical cyclones in the Timor Sea. • Geomorphic setting: Located in an area of high oil and gas reserves, with active hydrocarbon seeps. Geomorphic groups within the site include reef slope, reef crest, reef flat, back reef sands, lagoons and islands. • Tides and currents: Strong seasonal influences of the Indonesian Throughflow and Holloway currents. Internal waves are a feature of the region and Ashmore Reef may act to break these resulting in increased nutrients from the bottom waters. High energy environment with spring tides over 4.5 m and large flushing on tidal cycles. • Water quality: Seasonal variations in temperature and salinity in ocean and lagoon water. Water clarity, turbidity and other water quality parameters remain a knowledge gap. • Vegetation: Five species of seagrass recorded with *Thalassia hemprichii* dominant, comprising over 85% of total cover. Total cover of 470 ha, over 3,000 ha of macroalgae, mostly on reed slope and crest areas. Algae dominated by turf and coralline algae with fleshy macroalgae comprising typically less than 10% of total algae cover. • Marine invertebrates: Ashmore Reef has a diversity of marine invertebrates including hard and soft corals, molluscs, echinoderms and crustaceans. 275 species of hard coral, covering an area of around 700 ha. 39 taxa of soft coral, covering an area of around 300 ha. Total coral cover was low around the time of listing following the 1998 bleaching event but recovered in recent years to baseline levels. Over 600 species of mollusc, including two endemic species. Over 180 species of echinoderm, including 18 species of sea cucumber. Sea cucumber density is highly variable, but on average exceeds 30 per hectare. 99 species of decapod crustacean. • Fish: Over 750 species of fish, including five species of fish and three species of shark listed as threatened. Predominantly shallow water, benthic taxa that are common throughout the Indo-Pacific. Density of small reef fishes is around 20,000 to 40,000 per hectare. Low density of sharks (less than one per hectare). • Seasnakes: Prior to listing there was a high diversity and population, peaking in 1998 with an estimated total population of 40,000 snakes in the site. However, by time of listing in 2002 the site was on a trajectory of decline and diversity and abundance was low. • Turtles: Three species of marine turtle: Green (*Chelonia mydas*), Hawksbill (*Eretmochelyis imbricata*) and Loggerhead (*Caretta caretta*) all of which are listed threatened species. Green Turtles are the most abundant, with a total estimated population of around 10,000. Nesting by two species; Green Turtles and Hawksbill Turtles. • Seabirds and shorebirds: Ashmore Reef supports an abundance and diversity of wetland birds. 72 species of wetland dependent bird recorded within the Ramsar site. 47 species listed under international migratory agreements. Average of around 48,000 seabirds and shorebirds annually. Six species are regularly recorded in numbers greater >1% of the population. Nesting of 20 species, 14 of which regularly breed in the site. • Dugong: Small but significant population, that may breed within the site. Data deficient. **Ecosystem services** • Provisioning services–Freshwater: Indonesian fishers use the freshwater lens at West Island. • Cultural services–Recreation and tourism: Although remote and access is controlled, the site is important for passive recreation such as diving and bird watching.

Summary of the ecological character of Ramsar wetlands
• Cultural services–Cultural heritage and identity: Ashmore Reef has been regularly visited and fished by Indonesians since the early 18th century. West Island contains some archaeological artefacts and graves. • Cultural services–Scientific and educational: The reef has high value for scientific research because it currently received relatively low use and is ecologically unique within the bioregion. • Supporting services–Near-natural wetland types: Ashmore Reef supports a number of largely unmodified wetland types. • Supporting services–Biodiversity: Ashmore Reef is a hotspot of biodiversity within the Timor Province bioregion. Highest biodiversity of reef building corals (275 species from 56 genera). Highest diversity of soft corals (39 taxa). More than 600 species of mollusc. Over 180 species of echinoderm, including 13 species of sea cucumber. Nearly 100 species of decapod crustacean. Over 750 species of finfish. High diversity of seasnakes. • Supporting services–Physical habitat: The site supports large breeding colonies of seabirds. • Supporting services–Priority wetland species: The Ramsar site supports 47 species of shorebirds listed under international migratory bird treaties. • Supporting services–Threatened species: Ashmore Reef supports 62 species listed as threatened at the national and/or international level.
Becher Point Wetlands
The Becher Point Wetlands Ramsar site is a system of about 60 small wetlands located near Rockingham in southwest WA. Over the past 5,000 years Becher Point advanced seaward, or westwards, in response to falling sea levels, with the new terrestrial land forming a stable beachridge plain. As the beachridge plain grew westwards, new wetlands formed to the west of the older wetlands. The older wetlands evolved from simple groundwater systems to more complex wetland systems with different hydrological and ecological character. The Becher Point Wetlands Ramsar site covers the younger wetlands in this progression, with the newest wetlands being <1,000 years old and the oldest ~3,000 years old. The wetlands support sedgelands, herblands, grasslands, open-shrublands, and low open-forests. The sedgelands that occur within the linear wetland depressions of the Ramsar site are a nationally listed threatened ecological community (TEC). At least four species of amphibians and 21 species of reptiles have been recorded on the site. The site also supports the Southern Brown Bandicoot. The site is gazetted as a reserve for conservation of flora and fauna. The site, which includes the Port Kennedy Scientific Park, is used for research, education, and recreation. A formal ecological character description report is currently not available for the Becher Point Wetlands.
Eighty-mile Beach
The Eighty-mile Beach Ramsar site comprises two separate areas: ~220 km of beach and associated intertidal mudflats from Cape Missiessy to Cape Keraudren, and the Mandora Salt Marsh ~40 km to the east. The beach is characterised by extensive (1–4 km wide) intertidal mudflats comprised of fine silt and clay, bounded to the east by a narrow strip of coarse quartz sand and then coastal dunes. The beach is a relatively linear stretch with a few tidal creeks with small extents of the grey mangrove (*Avicennia marina*). Mandora Salt Marsh comprises of a series of floodplain depressions within a linear dune system. The site contains two large seasonal depressional wetlands (Lake Walyarta and East Lake) and a series of small permanent mound springs. The following summary of ecosystem components, processes and services has been extracted from Hale and Butcher (Ref. 13). **Ecosystem components and processes** • Climate: Semi-arid monsoonal with a prolonged dry period. >80% of rainfall in the wet season (December to March). High inter-annual variability. High occurrence of tropical cyclones. • The Beach:

Summary of the ecological character of Ramsar wetlands
– Geomorphology: Extensive intertidal mudflats comprised of fine-grained sediments. Site is backed by steep dunes comprised of calcareous sand. – Hydrology: Macro-tidal regime. No significant surface water inflows. Groundwater interactions unknown (knowledge gap). – Primary production and nutrient cycling: Data deficient, but organic material deposited from ocean currents driving the system through bacterial or microphytobenthos driven primary production. – Invertebrates: Large numbers and diversity of invertebrates within the intertidal mudflat areas. – Fish: Data deficient, but anecdotal evidence of marine fish (including sharks and rays) using inundated mudflats. – Waterbirds: Significant site for stop-over and feeding by migratory shorebirds. Regularly supports >200,000 shorebirds during summer and >20,000 during winter. High diversity with 97 species of waterbird recorded from the beach. Regularly supports >1% of the flyway population of 20 species. – Marine turtles: Significant breeding site for the Flatback Turtle. • Mandora Salt Marsh: – Geomorphology: Wetland formation dominated by alluvial processes. Wetlands were once a part of an ancient estuary. Freshwater springs have been dated at 7,000 years old. – Hydrology: Lake Walyarta, East Lake and the surrounding intermittently inundated paperbark thickets are inundated by rainfall and local runoff. Extensive inundation occurs following large cyclonic events. Salt Creek and the mound springs are groundwater fed systems through the Broome Sandstone aquifer. – Water quality: Most wetlands are alkaline reflecting the influence of soils and groundwater. Salinity is variable, mound springs are fresh, Salt Creek hyper-saline and Lake Walyarta variable with inundation. Nutrient concentrations in groundwater and groundwater fed systems are high. – Primary production and nutrient cycling: Data deficient. However, evidence of boom-and-bust cycle at Lake Walyarta with seasonal inundation. – Vegetation: Inland mangroves (*Avicennia marina*) lining Salt Creek are one of only two occurrences of inland mangroves in Australia. Paperbark thickets dominated by the saltwater paperbark (*Melaleuca alsophila*) extend across the site on clay soils which retain moisture longer than the surrounding landscape. Samphire (*Tecticornia* spp.) occurs around the margins of the large lakes. Freshwater aquatic vegetation occurs at Lake Walyarta when inundated and at the mound spring sites year round. – Invertebrates: Data limited, but potentially unique species – Waterbirds: Significant site for waterbirds and waterbird breeding, particularly during extensive inundation events. 66 waterbirds recorded. Supports >1% of the population of at least two species. Breeding recorded for at least 24 species. **Ecosystem benefits and services** • Provisioning service–Freshwater: The freshwater springs at Mandora Salt Marsh provide drinking water for livestock. • Provisioning service–Genetic resources: Plausible, but as yet no documented uses. • Regulating service– Climate regulation: Plausible, but data deficient. • Regulating service–Biological control of pests: Evidence that many of the shorebirds feed on the adjacent pastoral land and that the incidence of 2.88 million oriental pratincole coincided with locusts in almost plague proportions, upon which the birds fed. • Cultural Services–Recreation and tourism: The beach portion of the site is important for recreational fishing, tourism, bird watching and shell collecting. • Cultural Services–Spiritual and inspirational: Spiritually significant for the Karajarri and Nyangumarta and contain a number of specific culturally significant sites. Site has inspirational, aesthetic and existence values at regional, state and national levels. • Cultural Services–Scientific and educational: Mandora Salt Marsh and Eighty-mile Beach have been the site of a number of significant scientific investigations. In addition, Eighty-mile

Summary of the ecological character of Ramsar wetlands
Beach is a significant site for migratory shorebird monitoring and is currently part of the Shorebirds 2020 program. • Supporting services: As evidenced by the listing of the Eighty-mile Beach Ramsar site as a wetland of international importance. The system provides a wide range of biodiversity related ecological services critical for the ecological character of the site including: – contains exceptionally large examples of wetland types and includes rare wetland types of special scientific interest – supports significant numbers of migratory shorebirds – supports waterbird breeding – supports marine turtles.
Ord River Floodplain
The Ord River Floodplain Ramsar site is located in the northeast of WA, ~8 km east of the town of Wyndham within the Victoria-Bonaparte bioregion. The site covers over 140,000 hectares and lies within the Shire of Wyndham–East Kimberley. The Ord River Floodplain site contains a wide range of wetland types and includes inland and marine components. The Ramsar site comprises: Parry Lagoons, Ord Estuary, and False Mouths of the Ord. The following summary of ecosystem components, processes and services has been extracted from Hale (Ref. 14). **Ecosystem components and processes** • Climate: semi-arid monsoonal; 80% of rainfall in the wet season (December to February); on average evaporation exceeds rainfall in 11 of 12 months • Geomorphology: estuarine reaches of river; tidal flat creek system (False Mouths of Ord); seasonally inundated floodplain with permanent waterholes (Parry Lagoons). • Hydrology: macro-tidal influence; modified flows from dams upstream; low flow during dry season; higher flows in wet season; overbank flows from the Ord River to Parry Lagoons now low frequency; Parry Creek major source of water for Parry Lagoons (and floodplains) • Water Quality: estuary is highly turbid; potentially high nutrient levels from upstream agriculture; estuary is a net exporter of nutrients; salinity in estuary varies seasonally (30–35 ppt in dry season; < 4 ppt in wet); Parry Lagoons predominantly fresh; levels of agrichemicals above ANZECC guidelines detected • Phytoplankton: estuary dominated by diatoms; plankton is predominantly epibenthic • Vegetation: extensive mangroves in intertidal areas – 15 species; saltmarsh at higher elevations; Parry Lagoons characterised by extensive sedge / grass lands (intermittent inundation); aquatic vegetation in permanent waterholes; wooded swamp surrounding • Invertebrates: commercially significant taxa include mud crabs and white banana prawns; data deficient for other communities and populations • Fish: > 50 species (estuarine, marine and freshwater); migratory route for ~17 species; supports threatened taxa listed under the EPBC Act (Freshwater Sawfish, Green Sawfish and Northern River Shark) • Birds: Regularly supports >20,000 waterbirds; breeding recorded for 16 species; regularly supports >1 % of the population of Plumed Whistling Duck and Little Curlew; supports the EPBC listed species the Australian Painted Snipe • Crocodiles: supports Saltwater and Freshwater Crocodiles **Ecosystem services** • Provisioning service–Wetland products: commercial fisheries for a number of species of fish, as well as prawns and crabs; genetic resources - plausible, but as yet no documented uses • Regulating services–Erosion control: mangroves • Regulating services–Climate regulation: plausible, but data deficient • Regulating services–Biological control of pests: support of predators of agricultural pests • Cultural services–Recreation and tourism: site is important for recreational fishing; tourism; bird watching and crocodile watching • Cultural services–Spiritual and inspirational: spiritually significant for the Miriuwung, Gajerrong and contain a number of specific culturally significant sites; site has inspirational,

Summary of the ecological character of Ramsar wetlands
aesthetic and existence values at regional, state and national levels; the site contains a number of non-indigenous historical sites • Cultural services–Scientific and educational: focus of scientific research (e.g. CSIRO investigation) • Supporting services: as evidenced by the listing of the Ord River Floodplain site as a wetland of international importance; the system provides a wide range of biodiversity related ecological services critical for the ecological character of the site including: – supporting diverse habitat types – supporting critical life stages – supporting threatened species – supporting waterbird populations – supporting fish populations.
Peel-Yalgorup System
The Peel-Yalgorup wetland system, in south-western Australia, is located ~80 km south of Perth within the Swan Coastal Plain bioregion. The 26,000 ha site includes shallow estuarine waters, saline, brackish and freshwater wetlands of the Peel Inlet, Harvey Estuary, several lake systems including Lake McLarty and Lake Mealup and the Yalgorup National Park. The following summary of ecosystem components, processes and services has been extracted from Hale and Butcher (Ref. 15). **Ecosystem components and processes** • Peel-Harvey Estuary – Geomorphology: Shallow bar-built estuary. Narrow connection to the Indian Ocean (Mandurah Channel). Organic sediments (black ooze). – Hydrology: Highly seasonal freshwater inflows from direct precipitation and rivers. Limited tidal exchange with the Indian Ocean. Limited groundwater inflows. – Water Quality: High concentrations of nutrients (eutrophic) from catchment. Seasonal variability in salinity. Stratification and deoxygenation of bottom waters. – Acid Sulfide Soils: Monosulphidic black ooze. Exposed via dredging. – Phytoplankton: Winter diatom blooms. Spring Nodularia blooms in the Harvey Estuary. – Benthic Plants: Excessive growth of green macroalgae (Cladophora and/or Chaetomorpha) in the Peel Inlet. Smothering of seagrass. – Littoral Vegetation: Samphire communities around the shorelines. Paperbark communities in the Harvey River delta. – Invertebrates: Commercially significant taxa include blue swimmer crabs and western king prawns. Diverse communities in the estuary and the intertidal zones – Fish: Estuarine and marine species. Migratory route for some species. – Birds: High diversity and abundance of waterbirds. Regularly supports >20,000 waterbirds (maximum recorded 150,000 individuals). Breeding recorded for 12 species. Regularly supports >1% of the population of 11 species. • Yalgorup Lakes – Geomorphology: Shallow depressional wetlands. No defined surface water inflow or outflow channels. – Hydrology: Highly seasonal freshwater in-flows predominantly from groundwater. No surface water outflows. – Water quality: Brackish to hypersaline conditions. Seasonal salinity cycles. Low nutrient concentrations. Some lakes exhibit stratification. Highly alkaline (calcium and bicarbonate). – Benthic microbial community: Thrombolites in Lake Clifton. Cyanobacterial algal mats across the sediment surface in some lakes. – Flora: Small buffer zones. Some areas of paperbark communities. – Fauna: Significant site for waterbirds. Large numbers of Shelduck and Black Swans annually. 1% of population of Banded Stilt, Red-necked Stint, Hooded Plover, Shelduck and Musk Duck. Breeding of eight species.

Summary of the ecological character of Ramsar wetlands
• Lakes McLarty and Mealup – Geomorphology: Shallow depressional wetlands. No defined surface water inflow or outflow channels. – Hydrology: Highly seasonal freshwater inflows predominantly from groundwater. No natural surface water outflows (although there are drains present). – Water quality: Fresh to brackish conditions. Alkaline. – Flora: Typha across parts of each lake. Sedges on the margins. Paperbark community at higher elevations. – Fauna: Important habitat for freshwater invertebrates. Provides habitat for a large diversity and number of waterbirds. Breeding recorded for 12 species of waterbird. **Ecosystem services** • Provisioning services–Wetland products: Commercial fisheries for a number of species of fish, as well as prawns and crabs. • Regulating services–Pollution control and detoxification: Peel Inlet and Harvey Estuary act as sinks for nutrients from the catchment and a mechanism for discharges to the sea. • Regulating services–Climate regulation: Data deficient – plausible but not documented. Regulating service–Flood control: Site acts as a receiver for drainage water from the surrounding floodplain. • Cultural services–Recreation and tourism: The Peel Inlet and Harvey Estuary are important recreational fisheries. Passive recreational activities such as bird watching occur both in the estuarine and wetland areas within the site. The Peel Inlet and Harvey Estuary are important for water based recreational activities and water sports such as boating. • Cultural services–Spiritual and inspirational: Wetlands and estuarine areas are spiritually significant for the Nyoongar and contain a number of specific culturally significant sites. The site has inspirational, aesthetic and existence values at regional, state and national levels. • Cultural services–Scientific and educational: The Peel Inlet and Harvey Estuary are the sites for long-term monitoring dating back several decades. Lake Clifton represents one of very few places at which thrombolites can be studied. • Supporting services–Biodiversity: As evidence by the listing of the Peel-Yalgorup site as a wetland of international importance. The system provides a wide range of biodiversity values including: – supporting a wide range of ecological communities – supporting a number of regionally, nationally and internationally threatened species – supporting a high diversity of species (flora and fauna) – supporting a bio-regionally unique community (thrombolites). • Supporting services–Nutrient cycling: The Peel-Yalgorup system plays a large role in the recycling and discharge of nutrients from the surrounding catchment. Carbon sequestration – data deficient but plausible.
Roebuck Bay
The Roebuck Bay Ramsar site comprises 34,119 ha, mostly occupied by intertidal mudflats. Waters more than 6 m deep at low tide are excluded from the site, which stretches from Campsite (a location on the northern shore of Roebuck Bay) east of the town of Broome, to south of Sandy Point. The soft bottom intertidal mudflats of the northern and eastern shores of Roebuck Bay, and high tide roosts at Bush and Sandy Points are the most biologically significant parts of the site, which was listed for several reasons including, most notably, outstanding shorebird values. The following summary of ecosystem components, processes and services has been extracted from Bennelongia (Ref. 16). **Ecosystem components and processes** • Climate: The climate of the Broome region is semi-arid, monsoonal with a distinct wet (October to February) and dry season (March to September). Cyclonic flooding during the summer wet season results in periodic inundation of Roebuck Plains and drainage of freshwater off the Plains and through the mangroves. • Ocean currents: The Indonesian Flowthrough flows westwards from the Pacific to the Indian Ocean. This in turn provides a mass of warm water to the Leeuwin current off Western Australia as it sweeps south along the west coast and east along the south coast.

Summary of the ecological character of Ramsar wetlands
• Tidal variation: Tides in the vicinity of Broome have a very large range (9.5 m), thus exchange through the Bay is high, tidal velocities are relatively high and large mudflats have developed. • Geomorphology: A megascale irregular curved embayment that contains a wide expanse of intertidal mud and sand flats indented by microscale linear tidal creeks. • Sediment structure: Three main sediment provinces have been identified: northern sands province, eastern silt and clay province and southern sands province. • Hydrology: The Broome Sandstone contains the most utilised (Broome water supply) and hence most threatened groundwater resource in the Canning Basin. The Broome Sandstone is generally an unconfined aquifer recharged by direct infiltration from rainfall. The Broome sandstone will be discharging groundwater to the surface or subsurface at the margins of the Roebuck plains and tidal creek systems. There will also be deep submarine groundwater discharge occurring at or below the low tide mark and within Roebuck deeps. The Broome Sandstone will be discharging groundwater to the coupled Roebuck Bay/Roebuck Plains system from all landward directions. This may create freshwater dependant ecological niches which could be threatened by regional water use or pollution. Roebuck Plains produces large amounts of sheetwash into the bay after large cyclonic events or prolonged wet season rains. This will be an important vector for nutrients, organic carbon and freshwater into the bay. • Water quality: Water quality appears poor, with TP levels, although there is limited information available from similar marine systems for comparison. Consideration has been given to the impact of urban run-off into the marine ecosystem. Agricultural activities may influence water quality from rangeland run-off during flood events. • Littoral vegetation: Along the sea edge there are mangrove communities. Mangrove detritus is a major source of energy for animals in the mangal and, perhaps, some mudflat species. Behind the mangal is an extensive plain of saline grassland that rises to the pindan plains typical of the western desert. Samphire occurs in the wetter zones. On beach dunes spinifex dominates. • Plankton and diatoms: Stable isotopes of carbon and nitrogen have shown that plankton and diatoms are a major source of energy for shellfish in the Bay. • Benthic invertebrates: Roebuck Bay has one of the most diverse arrays of benthic invertebrate infauna for any intertidal ecosystem. Species numbers are dominated by polychaetes. There is a rich assemblage of bivalves that provide an important source of accessible food for shorebirds. The average density of macrobenthic fauna is around 1287 animals per square metre. • Birds: The bay provides important food resources and refuge for migrating arctic shorebirds. A total of 43 species of waterbirds are recorded for the Bay including 22 species listed in migratory bird agreements. • Fish: The mudflats and mangrove creeks are nurseries for at least 4 fish species, for commercial prawn species and for mudcrabs • Marine fauna: Dugongs have been regular and important inhabitants of Roebuck Bay. Earlier records show evidence of Dugongs feeding on extensive seagrass beds in 1986. Loggerhead Turtles and Green Turtles regularly use the Ramsar site as a seasonal feeding area and as a transit area on migration. Flatback Turtles regularly nest in small numbers around Cape Villaret during the summer months. **Ecosystem services** • Provisioning services–Wetland products: Commercial and recreational fisheries for a number of species of fish, prawns and crabs. Aboriginal people continue to make extensive use of the Bay's natural resources. • Regulating Services–Pollution control and detoxification: No data • Regulating Services–Climate regulation: No data • Cultural service–Recreation and tourism: Major tourism and bird-watching venue. Broome is an important destination for national and international tourism. Active recreational fishing and crabbing activities, boating, hovercraft. • Cultural services–Spiritual and inspirational: Site has inspirational and aesthetic values that are both regional and nationally recognised through travel to Broome. Roebuck Bay is spiritually significant to Aboriginal people belonging to the Yawuru and Jukun groups and contains a number of specific culturally significant sites.

Summary of the ecological character of Ramsar wetlands
• Cultural services–Scientific and educational: Many scientific research programs, especially on shorebirds and mudflat invertebrates, have been based at Roebuck Bay. they have often involved Broome Bird Observatory, near Fall Point. • Supporting Services–Biodiversity: Key location in global flyway for migratory waders. Nursery values for prawns and fish. Seagrass beds for Dugong.

2.5 Listed threatened and migratory species

The Species of National Environmental Significance (SNES) database (Ref. 17) stores maps and point distribution information about species related to the EPBC Act.

The Biologically Important Areas (BIAs) of Regionally Significant Marine Species database (Ref. 18) uses the marine bioregional planning program to identify, describe, and map BIAs for protected species under the EPBC Act. BIAs spatially and temporally define areas where protected species display biologically important behaviours (including breeding, foraging, resting, or migration).

The following information was generated from the Biologically Important Areas of Regionally Significant Marine Species database (Ref. 18), the Species of National Environmental Significance (Public Grids) database (Ref. 17), and a protected matters search (appendix a; Ref. 4).

2.5.1 Marine mammals

Table 2-5 lists the threatened and/or migratory marine mammals that may be present within the PA (Ref. 17; Ref. 4; appendix a).

Table 2-6 lists the individual BIAs for marine mammals and their known seasonal presence within the PA (Ref. 18); these are shown in Figure 2-1.

A review of the Conservation Advices and/or Recovery Plans identified key threats associated with threatened and/or migratory marine mammals that may be present within the PA. These threats and relevant management advice are listed in Table 2-7.

Table 2-5: Threatened and/or migratory marine mammals

Common name	Scientific name	Threatened status	Migratory
Antarctic Minke Whale, Dark-shoulder Minke Whale	*Balaenoptera bonaerensis*		Migratory
Sei Whale	*Balaenoptera borealis*	Vulnerable	Migratory
Bryde’s Whale	*Balaenoptera edeni*		Migratory
Blue Whale	*Balaenoptera musculus*	Endangered	Migratory
Fin Whale	*Balaenoptera physalus*	Vulnerable	Migratory
Pygmy Right Whale	*Caperea marginata*		Migratory
Dugong	*Dugong dugon*		Migratory
Southern Right Whale	*Eubalaena australis*	Endangered	Migratory
Dusky Dolphin	*Lagenorhynchus obscurus*		Migratory
Humpback Whale	*Megaptera novaeangliae*	Vulnerable	Migratory

Common name	Scientific name	Threatened status	Migratory
Australian Sea-lion, Australian Sea Lion	*Neophoca cinerea*	Vulnerable	
Australian Snubfin Dolphin	*Orcaella heinsohni*		Migratory
Killer Whale, Orca	*Orcinus orca*		Migratory
Sperm Whale	*Physeter macrocephalus*		Migratory
Indo-Pacific Humpback Dolphin	*Sousa chinensis*		Migratory
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)	*Tursiops aduncus* (Arafura/Timor Sea populations)		Migratory

Table 2-6: BIAs for regionally significant marine mammals

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Australian Snubfin Dolphin	Breeding	Year-round	Known to occur
	Calving	Year-round	Known to occur
	Foraging	Year-round	Known to occur
	Foraging (high density prey)	Year-round	Known to occur
	Foraging likely	Year-round	Known to occur
	Resting	Year-round	Known to occur
Indo-Pacific Humpback Dolphin	Breeding	Year-round	Known to occur
	Breeding	Year-round	Likely to occur
	Calving	Year-round	Known to occur
	Calving	Year-round	Likely to occur
	Foraging	Year-round	Known to occur
	Foraging	Year-round	Likely to occur
	Foraging (high density prey)	Year-round	Known to occur
	Foraging (high density prey)	Year-round	Likely to occur
	Significant habitat	Year-round	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
	Significant habitat – unknown behaviour	Year-round	Likely to occur
Indo-Pacific/Spotted Bottlenose Dolphin	Breeding	Not possible to determine yet	Known to occur
	Calving	Not possible to determine yet	Known to occur
	Foraging	Not possible to determine yet	Known to occur
	Foraging likely	Not possible to determine yet	Known to occur
	Migration likely	Not possible to determine yet	Known to occur
Dugong	Breeding	April/May	Known to occur
	Breeding	Year-round	Known to occur
	Calving	April/May	Known to occur
	Calving	Year-round	Known to occur
	Foraging	April/May	Known to occur
	Foraging	May–September	Known to occur
	Foraging	Year-round	Likely to occur
	Foraging (high density seagrass beds)	April/May	Known to occur
	Foraging (high density seagrass beds)	Year-round	Known to occur
	Migration likely	Year-round	Known to occur
	Nursing	April/May	Known to occur
	Nursing	Year-round	Known to occur
Australian Sea Lion	Foraging (male)	Year-round	Likely to occur
	Foraging (male and female)	Year-round	Known to occur
Blue and Pygmy Blue Whale	Foraging (abundant food source)	Arrive as early as November, with number of animals steadily increasing to peak in March–May. After May the number of whales drops, by late June most animals have	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
		left, although a few acoustic detections are made into July (Ref. 19)	
	Foraging (high-density)	Arrive early as Nov with number of animals increasing to peak in March–May. After May the number of whales drops, late June most animals left, a few acoustic detections are made into July (Ref. 19). Satellite tracking data indicates use mid-March-late April,	Known to occur
	Foraging (on migration)	Arrive early as Nov with number of animals increasing to peak in March–May. After May the number of whales drops, late June most animals left, a few acoustic detections are made into July (Ref. 19). Satellite tracking data indicates use mid-March-late April.	Known to occur
Humpback Whale	Calving	Winter	Known to occur
	Migration	Northern migration, late July to September	Known to occur
	Migration	Winter	Known to occur
	Migration (north)	Northern migration, late July to September	Known to occur
	Migration (north and south)	Northern migration, late July to September	Known to occur
	Migration (north and south)	Northern peak July and southward peak October – November (Ref. 19)	Known to occur
	Migration (north and south)	Southbound peak late Sept to mid-Oct. Northward peak mid-June to mid-July	Known to occur
	Migration (south)	Southbound peak late Sept to mid-Oct	Known to occur
	Nursing	Winter	Known to occur
	Resting	Winter	Known to occur
Pygmy Blue Whale	Distribution		Known to occur
	Foraging		Known to occur
	Foraging area (annual high use area)		Known to occur
	Known foraging area		Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
	Migration	Northern migration (enter Perth canyon January to May; pass Exmouth April to August; continue north to Indonesia). Southern migration (follow WA coastline from October to late December)	Known to occur
		Most use between October and December, peaking in November	Known to occur
Southern Right Whale	Calving buffer	Late autumn, winter, and spring	Known to occur
	Seasonal calving habitat	Late autumn, winter, and spring	Known to occur
Sperm Whale	Foraging (abundant food source)	Summer	Known to occur

Table 2-7: Summary of relevant conservation plans—marine mammals

Species	Relevant Plan / Advice	Key threats / Relevant management advice
Humpback Whale	Conservation Advice for the Humpback Whale 2015–2020 (Ref. 20)	Assessing and addressing anthropogenic noise; shipping, industrial, and seismic surveys • All seismic surveys must be undertaken consistently with the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales. Should a survey be undertaken in or near a calving, resting, foraging area, or a confined migratory pathway then Part B. Additional Management Procedures must also be applied. • For actions involving acoustic impacts (example pile driving, explosives) on Humpback Whale calving, resting, feeding areas, or confined migratory pathways site-specific acoustic modelling should be undertaken (including cumulative noise impacts). • Should acoustic impacts on humpback calving, resting, foraging areas, or confined migratory pathways be identified a noise management plan should be developed. This can include: – the use of shutdown and caution zones – pre- and post-activity observations – the use of marine mammal observers and/or Passive Acoustic Monitoring – Implementation of an adaptive management program following verification of the noise levels produced from the action (i.e. if the noise levels created exceed original expectations). Minimising vessel collisions • Maximise the likelihood that all vessel strike incidents are reported in the national ship strike database. All cetaceans are protected in Commonwealth waters and, the EPBC Act requires that all collisions with whales in Commonwealth waters are reported. Vessel collisions can be submitted to the National Ship Strike Database at https://data.marinemammals.gov.au/report/shipstrike

Species	Relevant Plan / Advice	Key threats / Relevant management advice
		• Ensure the risk of vessel strike on Humpback Whales is considered when assessing actions that increase vessel traffic in areas where Humpback Whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike. • Enhance education programs to inform vessel operators of best practice behaviours and regulations for interacting with Humpback Whales.
Blue Whale	Conservation Management Plan for the Blue Whale 2015–2025 (Ref. 21)	Key threats include: • whaling • climate variability and change • noise interference • habitat modification • vessel disturbance • overharvesting of prey. No relevant management advice has been identified.
Sei Whale	Conservation Advice *Balaenoptera borealis* Sei Whale (Ref. 22)	Assessing and addressing anthropogenic noise: • Once the spatial and temporal distribution (including biologically important areas) of Sei Whales is further defined an assessment of the impacts of increasing anthropogenic noise (including from seismic surveys, port expansion, and coastal development) should be undertaken on this species. Minimising vessel collisions: • Ensure all vessel strike incidents are reported in the national vessel strike database (https://data.marinemammals.gov.au/report/shipstrike).
Fin Whale	Conservation Advice *Balaenoptera physalus* Fin Whale (Ref. 23)	Assessing and addressing anthropogenic noise: • Once the spatial and temporal distribution (including biologically important areas) of Fin Whales is further defined an assessment of the impacts of increasing anthropogenic noise (including from seismic surveys, port expansion, and coastal development) should be undertaken on this species. Minimising vessel collisions: • Ensure all vessel strike incidents are reported in the national vessel strike database
Southern Right Whale	Conservation Management Plan for the Southern Right Whale: A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2011–2021 (Ref. 24)	Key threats include: • entanglement • vessel disturbance • whaling • climate variability and change • noise interference • habitat modification. No relevant management advice has been identified.
Australian Sea Lion	Recovery Plan for the Australian Sea Lion	Key threats include: • interactions with the commercial gillnet fishing sector • mortality due to interactions with the rock lobster industry

Species	Relevant Plan / Advice	Key threats / Relevant management advice
	(*Neophoca cinerea*) (Ref. 25)	• deaths caused by fisheries-related marine debris. Other factors that may be contributing to the lack of recovery include: • habitat degradation and interactions with aquaculture operations • human disturbance to colonies • deliberate killings • disease • pollution and oil spills • prey depletion • climate change. No relevant management advice has been identified.

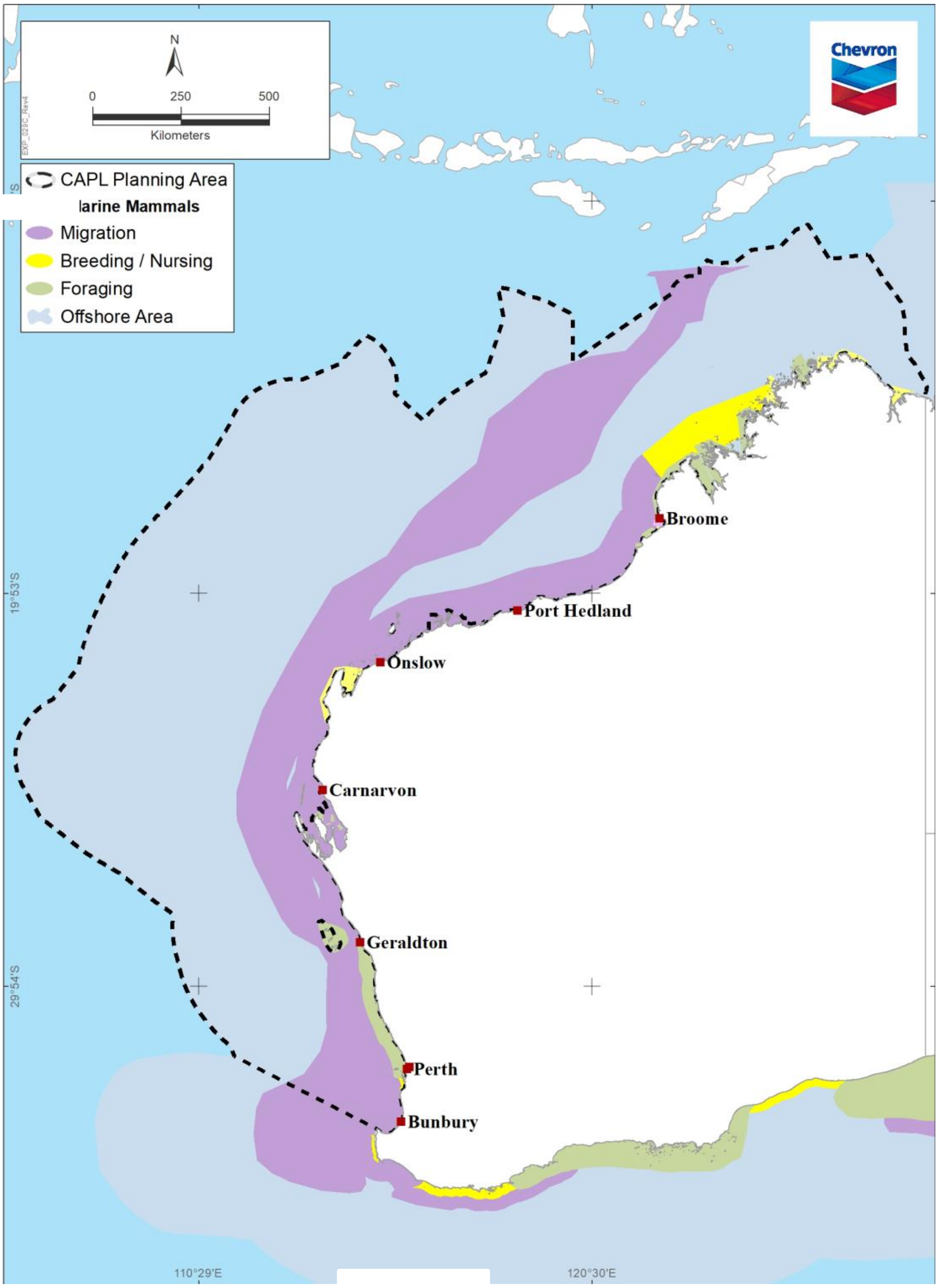


Figure 2-1: BIAs associated with marine mammals

2.5.2 Reptiles

Table 2-8 lists the threatened and/or migratory marine reptile species that may be present within the PA (Ref. 17; Ref. 4; appendix a).

Table 2-9 lists critical nesting habitats within the PA; these are shown on Figure 2-2 (Ref. 26).

Table 2-10 lists the BIAs for marine reptiles and their known seasonal presence within the PA; these are also shown on Figure 2-2 (Ref. 18).

A review of the Conservation Advices and Recovery Plans identified key threats associated with threatened and/or migratory marine reptiles that may be present within the PA. These threats and relevant management advice are listed in Table 2-11.

In addition to the threatened and/or migratory marine reptile species identified in the tables below, an additional 26 listed marine reptile species (all sea snakes except the Freshwater Crocodile [*Crocodylus johnstoni*]) were identified as having the potential to occur within the PA (Ref. 4). Cogger (Ref. 27; Ref. 28) notes that most sea snakes have shallow benthic feeding patterns and are rarely observed in water >30 m deep, indicating that these species are likely to be present in shallow waters.

Table 2-8: Threatened and/or migratory marine reptiles

Common name	Scientific name	Threatened status	Migratory
Short-nosed Seasnake	*Aipysurus apraefrontalis*	Critically Endangered	
Leaf-scaled Seasnake	*Aipysurus foliosquama*	Critically Endangered	
Loggerhead Turtle	*Caretta*	Endangered	Migratory
Green Turtle	*Chelonia mydas*	Vulnerable	Migratory
Salt-water Crocodile, Estuarine Crocodile	*Crocodylus porosus*		Migratory
Leatherback Turtle, Leathery Turtle, Luth	*Dermochelys coriacea*	Endangered	Migratory
Hawksbill Turtle	*Eretmochelys imbricata*	Vulnerable	Migratory
Olive Ridley Turtle, Pacific Ridley Turtle	*Lepidochelys olivacea*	Endangered	Migratory
Flatback Turtle	*Natator depressus*	Vulnerable	Migratory

Table 2-9: Critical habitat for marine turtles

Common name	Location	Seasonal presence	Occurrence descriptor
Loggerhead Turtle	Exmouth Gulf and Ningaloo Coast. 20 km internesting buffer	Nov–May	Known to occur
	Gnaraloo Bay and beaches. 20 km internesting buffer	Nov–May	Known to occur
	Shark Bay, all coastal and island beaches out to the northern tip of Dirk Hartog Island. 20 km internesting buffer	Nov–May	Known to occur
Green Turtle	Mainland east of Mary Island to mainland adjacent to Murrara Island including all offshore islands. 20 km internesting buffer	Nov–Mar	Known to occur
	Ashmore Reef and Cartier Reef. 20 km internesting buffer	Dec–Jan	Known to occur
	Browse Island. 20 km internesting buffer	Nov–Mar	Known to occur
	Scott Reef. 20 km internesting buffer	Nov–Mar	Known to occur
	Adele Island, Lacepede Islands	Nov–Mar	Known to occur

Common name	Location	Seasonal presence	Occurrence descriptor
	Dampier Archipelago. 20 km internesting buffer	Nov–Mar	Known to occur
	Barrow Island, Montebello Islands, Serrurier Island, and Thevenard Island. 20 km internesting buffer	Nov–Mar	Known to occur
	Exmouth Gulf and Ningaloo Coast. 20 km internesting buffer	Nov–Mar	Known to occur
Hawksbill Turtle	Dampier Archipelago, including Delambre Island and Rosemary Island. 20 km internesting buffer	Oct–Feb	Known to occur
	Cape Preston to mouth of Exmouth Gulf including Montebello Islands and Lowendal Islands. 20 km internesting buffer	Oct–Feb	Known to occur
Olive Ridley Turtle	Cape Leveque. 20 km internesting buffer	May–Jul	Known to occur
	Prior Point and Llanggi. 20 km internesting buffer	May–Jul	Known to occur
	Darcy Island. 20 km internesting buffer	May–Jul	Known to occur
	Vulcan Island. 20 km internesting buffer	May–Jul	Known to occur
Flatback Turtle	Cape Domett and Lacrosse Island in the Cambridge Gulf. 60 km internesting buffer	Aug–Sep	Known to occur
	Lacepede Islands. 60 km internesting buffer	Oct–Mar	Known to occur
	Eco Beach – coastal beach near Broome. 60 km internesting buffer	July	Known to occur
	Eighty Mile Beach – coastal beach. 60 km internesting buffer	July	Known to occur
	Cemetery Beach, Port Hedland. 60 km internesting buffer	Oct–Mar	Known to occur
	Mundabullangana Beach. 60 km internesting buffer	Oct–Mar	Known to occur
	Dampier Archipelago, including Delambre Island and Hauy Island. 60 km internesting buffer	Oct–Mar	Known to occur
	Barrow Island, Montebello Islands, coastal islands from Cape Preston to Locker Island. 60 km internesting buffer	Oct–Mar	Known to occur

Table 2-10: BIAs for regionally significant marine reptiles

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Flatback Turtle	Aggregation		Known to occur
	Foraging	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Foraging	January – Flatbacks, Greens	Known to occur
	Foraging	Observations during July, no evidence of turtle activity Oct–Nov for Solitary, Steamboat,	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
		Carey, Preston Islands, and Cape Preston	
	Foraging	Year-round	Known to occur
	Internesting		Known to occur
	Internesting buffer	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Internesting buffer	January – Flatbacks, Greens	Known to occur
	Internesting buffer	Summer	Known to occur
	Internesting buffer	Summer (nesting /internesting), year-round	Known to occur
	Mating	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Migrating Corridor	Summer (nesting/interesting) year-round	Known to occur
	Nesting	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Nesting	January – Flatbacks, Greens	Known to occur
	Nesting	Short summer nesting season, predominantly Nov–Mar with peak in January	Known to occur
	Nesting	Summer	Known to occur
Green Turtle	Aggregation	Early summer	Known to occur
	Aggregation		Known to occur
	Basking	Summer	Known to occur
	Foraging	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Foraging	January – Flatbacks, Greens	Known to occur
	Foraging	March–May	Likely to occur
	Foraging	Observations during July, no evidence of turtle activity Oct–Nov for Solitary, Steamboat, Carey, Preston Islands, and Cape Preston	Known to occur
	Foraging	Summer	Known to occur
	Foraging	Summer / possibly year-round	Known to occur
	Foraging	Year-round	Known to occur
	Foraging	Year-round	Likely to occur
	Foraging		Known to occur
	Internesting	Dec–Feb	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
	Internesting	Peak season Dec–Jan	Known to occur
	Internesting	Summer	Known to occur
	Internesting	Year-round	Likely to occur
	Internesting		Known to occur
	Internesting buffer	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Internesting buffer	January – Flatbacks, Greens	Known to occur
	Internesting buffer	Peak season Dec–Jan	Known to occur
	Internesting buffer	Summer	Known to occur
	Internesting buffer	Summer (nesting /internesting) year-round	Known to occur
	Internesting buffer	Year-round	Known to occur
	Internesting buffer	Year-round	Likely to occur
	Internesting buffer		Known to occur
	Mating	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Mating	Summer	Known to occur
	Mating	Year-round	Likely to occur
	Mating		Known to occur
	Migrating Corridor	Summer (nesting/interesting) year-round	Known to occur
	Nesting	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Nesting	January – Flatbacks, Greens	Known to occur
	Nesting	Peak season Dec–Jan	Known to occur
	Nesting	Summer	Known to occur
	Nesting	Year-round	Known to occur
	Nesting	Year-round	Likely to occur
	Nesting		Known to occur
Hawksbill Turtle	Foraging	Aggregation inside of NW Is. Early in summer	Known to occur
	Foraging	Observations during July no evidence of turtle activity Oct–Nov for Solitary, Steamboat, Carey, Preston Islands, and Cape Preston	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
	Foraging	Year-round	Known to occur
	Foraging	Year-round	Likely to occur
	Internesting	Spring and early summer, peak nesting October	Known to occur
	Internesting buffer	Spring and early summer, peak nesting October	Known to occur
	Internesting buffer	Peak nesting in spring and early summer	Known to occur
	Internesting buffer		Known to occur
	Internesting buffer	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Internesting buffer	Year-round	Known to occur
	Internesting buffer	Year-round	Likely to occur
	Internesting buffer	Peak season Dec–Jan	Likely to occur
	Internesting buffer	Peak nesting in spring and early summer	Likely to occur
	Mating	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Mating	Spring and early summer, peak nesting October	Known to occur
	Mating	Year-round	Known to occur
	Nesting	Green Turtle aggregation inside of NW Is. Early in summer	Known to occur
	Nesting	Peak nesting in spring and early summer	Known to occur
	Nesting	Peak season Dec–Jan	Known to occur
	Nesting	Spring and early summer, peak nesting October	Known to occur
	Nesting	Year-round	Known to occur
	Nesting	Year-round	Likely to occur
	Nesting		Known to occur
Loggerhead Turtle	Foraging	Year-round	Known to occur
	Foraging		Known to occur
	Internesting	Dec–Mar	Known to occur
	Internesting buffer	Dec–Mar	Known to occur
	Internesting buffer	Peak season monitored	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
	Internesting buffer		Known to occur
	Nesting	Dec–Mar	Known to occur
	Nesting	Peak season monitored	Known to occur
	Nesting		Known to occur
Olive Ridley Turtle	Foraging		Known to occur

Table 2-11: Summary of relevant conservation plans—marine reptiles

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
Caretta caretta (Loggerhead Turtle) *Chelonia mydas* (Green Turtle) *Dermochelys coriacea* (Leatherback Turtle, Leathery Turtle, Luth) *Eretmochelys imbricata* (Hawksbill Turtle) *Natator depressus* (Flatback Turtle)	Recovery Plan for Marine Turtles in Australia (Ref. 29)	Key threats include: • climate change and variability • marine debris • chemical and terrestrial discharge • international take • terrestrial predation • fisheries bycatch • light pollution • habitat modification • Indigenous take • vessel disturbance • noise interference • recreational activities • diseases and pathogens. Details regarding relevant threats: • A3: Reduce the impacts from marine debris • A4: Minimise chemical and terrestrial discharge: – Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows, or coral reefs – Quantify the impacts of decreased water quality on stock viability – Quantify the accumulation and effects of anthropogenic toxins in marine turtles, their foraging habitats, and subsequent stock viability. • A8: Minimise light pollution: – Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats – Develop and implement best practice light management guidelines for existing and future developments

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
		adjacent to marine turtle nesting beaches – Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution.
Dermochelys coriacea (Leatherback Turtle, Leathery Turtle, Luth)	Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (Ref. 30)	Key threats include: • incidental capture in commercial fisheries • harvest of eggs and meat • ingestion of marine debris • vessel disturbance / boat strike • predation on eggs by wild dogs (*Canis familiaris*), pigs (*Sus scrofa*) and monitor lizards (*Varanus salvator*) • degradation of foraging areas • changes to breeding sites. No relevant management advice has been identified.
Aipysurus apraefrontalis (Short-nosed Sea Snake)	Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (Ref. 31)	Key threats include: • changes to the inner region of Ashmore Reef (sand encroachment) that has caused coral outcrops that previously supported high densities of sea snakes to be filled in with sand • increases in water temperatures observed in Ashmore and surrounding reefs associated with El Niño events, which may have impacted the species directly or indirectly by contributing to further habitat degradation • oil and gas exploration, including seismic surveys and exploration drilling • incidental catch and death in commercial prawn trawling fisheries. Unsustainable and illegal fishing practices are recognised as the most significant direct and indirect threat to natural processes and biological diversity in the Ashmore Reef region. No relevant management advice has been identified.
Aipysurus foliosquama (Leaf-scaled Sea Snake)	Approved Conservation Advice for *Aipysurus foliosquama* (Leaf-scaled Sea Snake) (Ref. 32)	Key threats include: • changes to the inner region of Ashmore Reef (sand encroachment) – coral outcrops that previously supported high densities of sea snakes are now filled with sand • increases in water temperatures observed in Ashmore and surrounding reefs associated with El Niño events, which may have impacted the species directly or indirectly by contributing to further habitat degradation • oil and gas exploration, including seismic surveys and exploration drilling • incidental catch and death in commercial prawn trawling fisheries. Unsustainable and illegal fishing practices are recognised as

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
		the most significant direct and indirect threat to natural processes and biological diversity in the Ashmore Reef region. No relevant management advice has been identified.

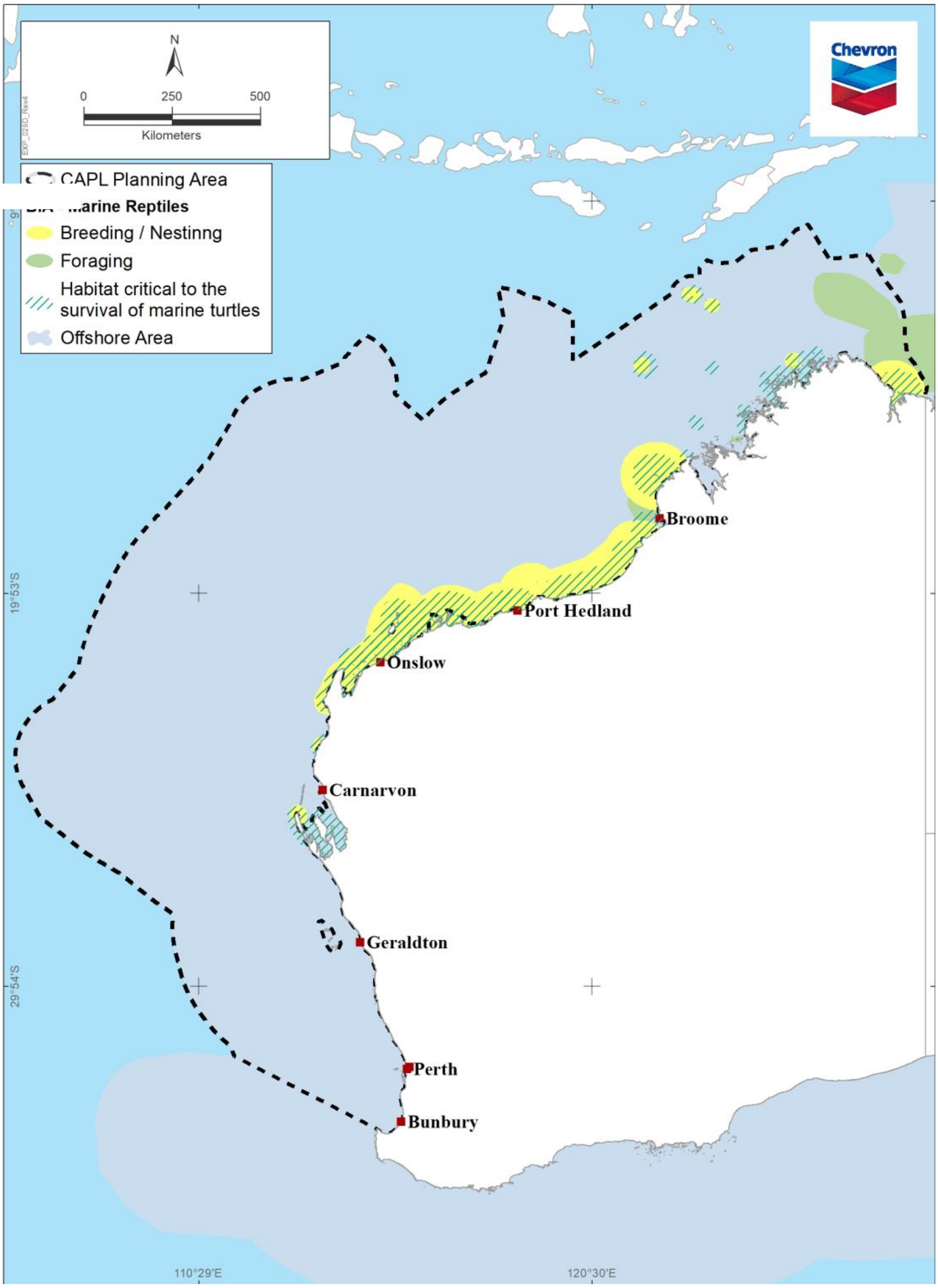


Figure 2-2: BIAs associated with marine reptiles

2.5.3 Fishes, including sharks and rays

Table 2-12 lists the threatened and/or migratory fishes (including sharks and rays) that may be present within the PA (Ref. 17; Ref. 4; appendix a).

Table 2-13 lists the BIAs for fishes (including sharks and rays) and their known seasonal presence within the PA (Ref. 18); these are shown in Figure 2-3.

Within the PA, 61 solenostomid and syngnathid species that are listed marine species have been identified as having the potential to occur (appendix a; Ref. 4).

Almost all syngnathids live in nearshore and inner shelf habitats, usually in shallow coastal waters, among seagrasses, mangroves, coral reefs, macroalgae-dominated reefs, and sand or rubble habitats (Ref. 33; Ref. 34; Ref. 35; Ref. 36). Although two species have been identified in the North-west Marine Region in deeper waters (Winged Seahorse [*Hippocampus alatus*] and Western Pipehorse [*Solegnathus* sp. 2]; Ref. 37), these species were not identified by the SNES search of the PA (Ref. 17).

A review of the Conservation Advices and Recovery Plans identified key threats associated with threatened and/or migratory fishes (including sharks and rays) that may be present within the PA. These threats and relevant management advice are included in Table 2-14.

Table 2-12: Threatened and migratory fishes, including sharks and rays

Common name	Scientific name	Threatened status	Migratory
Narrow Sawfish, Knifetooth Sawfish	*Anoxypristis cuspidata*		Migratory
Grey Nurse Shark (west coast population)	*Carcharias taurus* (west coast population)	Vulnerable	
Oceanic Whitetip Shark	*Carcharhinus longimanus*		Migratory
White Shark, Great White Shark	*Carcharodon carcharias*	Vulnerable	Migratory
Northern River Shark, New Guinea River Shark#	*Glyphis garricki*	Endangered	
Speartooth Shark#	*Glyphis glyphis*	Critically Endangered	
Shortfin Mako, Mako Shark	*Isurus oxyrinchus*		Migratory
Longfin Mako	*Isurus paucus*		Migratory
Porbeagle, Mackerel Shark	*Lamna nasus*		Migratory
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	*Manta alfredi*		Migratory
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	*Manta birostris*		Migratory
Blind Gudgeon*	*Milyeringa veritas*	Vulnerable	
Balston's Pygmy Perch^	*Nannatherina balstoni*	Vulnerable	
Blind Cave Eel*	*Ophisternon candidum*	Vulnerable	

Common name	Scientific name	Threatened status	Migratory
Dwarf Sawfish, Queensland Sawfish	*Pristis clavata*	Vulnerable	Migratory
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish#	*Pristis pristis*	Vulnerable	Migratory
Green Sawfish, Dindagubba, Narrowsnout Sawfish	*Pristis zijsron*	Vulnerable	Migratory
Whale Shark	*Rhincodon typus*	Vulnerable	Migratory

** Subterranean fauna species identified in the Protected Matters Search Report (appendix a; Ref. 4) but not expected to be exposed to CAPL's activities.*

 # Species mainly located inland (freshwater and estuarine habitats) identified in the Protected Matters Search Report but with the potential to be present offshore (neritic and intertidal zones) and exposed to CAPL's activities.

^ Freshwater species located inland identified in the Protected Matters Search Report but not expected to be exposed to CAPL's activities.

Table 2-13: BIAs for regionally significant fishes, including sharks and rays

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Dwarf Sawfish	Foraging	All seasons	Known to occur
	Foraging	Use in dry season to early wet (Dec)	Known to occur
	Foraging		Known to occur
	Juvenile	All seasons	Known to occur
	Nursing	All seasons	Known to occur
	Nursing	Use in dry season to early wet (Dec)	Known to occur
	Nursing		Known to occur
	Pupping	All seasons	Known to occur
	Pupping		Known to occur
Freshwater Sawfish	Foraging	All seasons	Known to occur
	Foraging	Pupping occurs from Jan–May	Known to occur
	Foraging	Pupping occurs from Jan–May, more prevalent during the late wet season when mature animals have more water to manoeuvre in	Known to occur
	Juvenile	Pupping occurs from Jan–May	Known to occur
	Nursing	All seasons	Known to occur
	Nursing	All seasons	Likely to occur
	Pupping	Pupping occurs from Jan–May	Known to occur
	Pupping	Pupping occurs from Jan–May	Likely to occur
	Pupping	Pupping occurs from Jan–May, more prevalent during the late wet season when mature animals	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
		have more water to manoeuvre in	
Green Sawfish	Foraging		Known to occur
	Nursing		Known to occur
	Pupping		Known to occur
Whale Shark	Foraging	Spring	Known to occur
	Foraging (high density prey)	Apr–Jun, autumn	Known to occur
	Foraging		Known to occur

Table 2-14: Summary of relevant conservation plans—fishes, including sharks and rays

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
Pristis zijsron (Green Sawfish, Dindagubba, Narrowsnout Sawfish) *Pristis clavata* (Dwarf Sawfish) *Glyphis garricki* (Northern River Shark) *Glyphis* (Speartooth Shark)	Sawfish and River Sharks Multispecies Recovery Plan (Ref. 38)	Key threats include: • fishing activities including: being caught as bycatch in the commercial and recreational sectors; through Indigenous fishing; and illegal, unreported, and unregulated fishing • habitat degradation and modification. Other potential threats to the species include the collection of animals for display in public aquaria and marine debris. No relevant management advice has been identified.
	Approved Conservation Advice for Green Sawfish (Ref. 39)	The main potential threats to Green Sawfish include: • incidental capture as bycatch and by-product in gillnet and trawl fisheries • illegal capture for fins and rostra • habitat degradation through coastal development. No relevant management advice has been identified.
	Approved Conservation Advice for *Pristis clavata* (Dwarf Sawfish) (Ref. 40)	The main identified threats to Dwarf Sawfish include: • incidental capture as bycatch in commercial and recreational net fishing • illegal, unreported, and unregulated fishing. No relevant management advice has been identified.
	Approved Conservation Advice for *Glyphis garricki* (Northern River Shark) (Ref. 41)	The main identified threats to Northern River Sharks include: • commercial, recreational, and Indigenous fishing activities • IUU fishing • habitat degradation and modification.

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
		No relevant management advice has been identified.
	Approved Conservation Advice for *Glyphis* (Speartooth Shark) (Ref. 42)	The main identified threats to Speartooth Sharks include: • commercial, recreational, and Indigenous fishing activities • IUU fishing • habitat degradation and modification. No relevant management advice has been identified.
Rhincodon typus (Whale Shark)	Conservation Advice for the Whale Shark 2015–2020 (Ref. 43)	The most significant threat to Whale Sharks is intentional and unintentional mortality from fishing outside Australian waters. In Australian waters, threats to the recovery of the species include boat strike from large vessels and habitat disruption from mineral exploration, production, and transportation. Other less-important threats include disturbance from domestic tourism operations, marine debris, and climate change. Limited subsistence hunting of Whale Sharks still occurs in some parts of the world. Ecotourism in these regions could provide an alternative income, which would give these communities the means to stop hunting and a reason to conserve the species. No relevant management advice has been identified.
Carcharias taurus (west coast population) (Grey Nurse Shark [west coast population])	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (Ref. 44)	Key threats include: • commercial fishing • recreational fishing • shark finning • shark control activities • ecotourism • aquarium trade.
Carcharodon Carcharias (Great White Shark)	Recovery Plan for the White Shark (*Carcharodon Carcharias*) (Ref. 45)	Key threats include: • mortality related to being caught accidentally (bycatch) or illegally (targeted) by commercial and recreational fisheries, including issues of post release mortality • mortality related to shark control activities such as beach meshing or drum lining (east coast population). Other potential threats to the species include the impacts of illegal trade in White Shark products; ecosystem effects as a result of habitat modification and climate change (including changes in sea temperature, ocean currents, and acidification); and ecotourism, including cage diving. No relevant management advice has been identified.

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
Milyeringa veritas (Blind Gudgeon)	Approved Conservation Advice for *Milyeringa veritas* (Blind Gudgeon) (Ref. 46)	The main identified threats to the Blind Gudgeon include: • sedimentation from mining and construction • canal development • water abstraction • point source pollution from sewage • landfill • dumping and mining • diffuse pollution from urban development and petroleum infrastructure. No relevant management advice has been identified.
Nannatherina balstoni (Balston's Pygmy Perch)	Approved Conservation Advice for *Nannatherina balstoni* (Balston's Pygmy Perch) (Ref. 47)	The main identified threat to the Balston's Pygmy Perch is habitat alteration and the introduction of exotic fish species. Habitat alteration is likely to occur through any alterations to inflow and increased salinisation, siltation, and eutrophication that occur through changes to flow regimes (regulation and abstraction), road maintenance, mineral sand exploration and mining, groundwater extraction, and agricultural and forestry practices in the uppermost catchment. No relevant management advice has been identified.

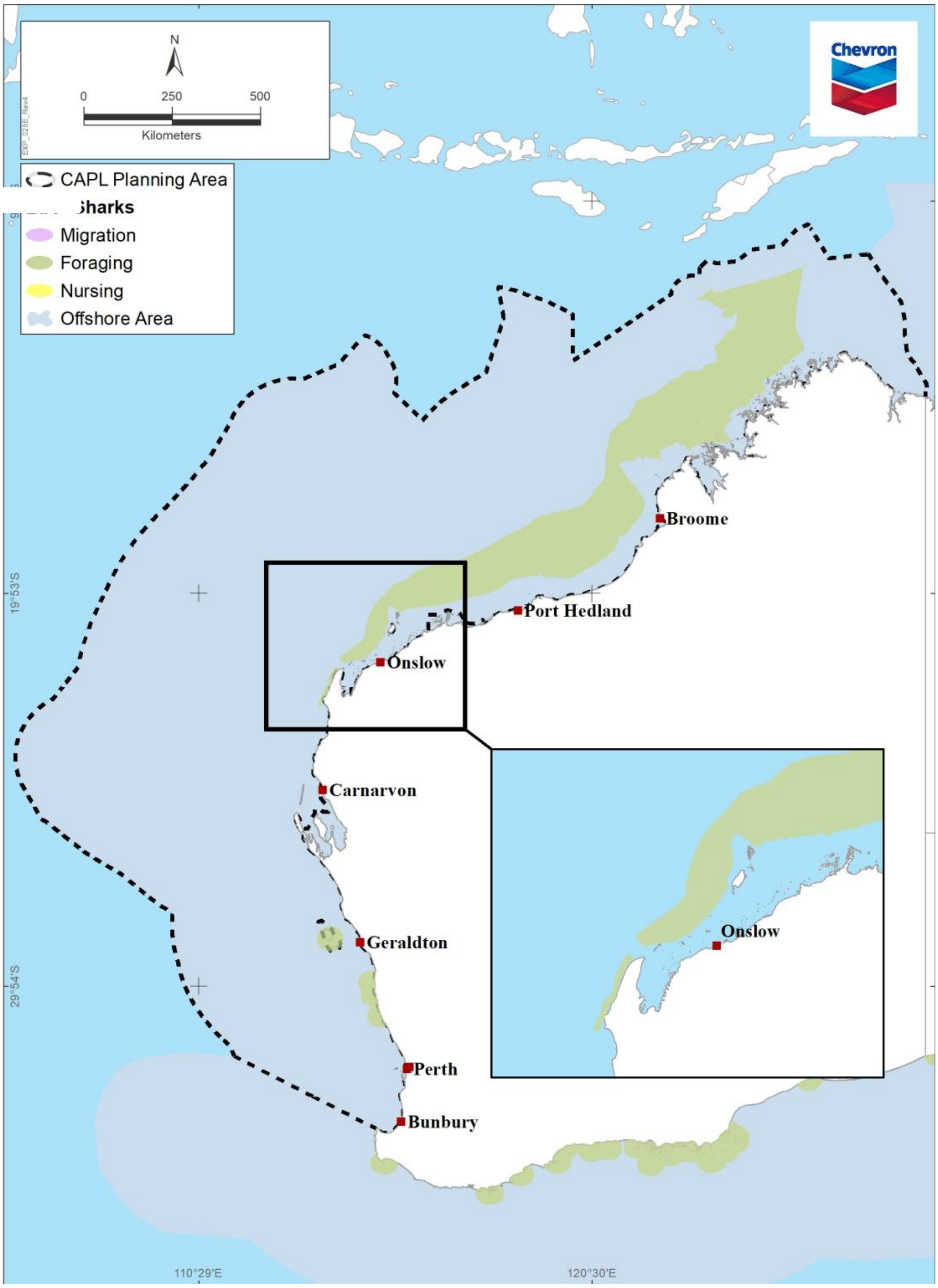


Figure 2-3: BIAs associated with fishes, including sharks and rays

2.5.4 Seabirds and shorebirds

Table 2-15 lists the threatened and/or migratory seabirds and shorebirds that may be present within the PA (Ref. 17; Ref. 4; appendix a).

Table 2-16 lists the BIAs for seabirds and shorebirds and their known seasonal presence within the PA (Ref. 18); these are shown in Figure 2-4.

A review of Conservation Advices and Recovery Plans identified key threats associated with threatened and/or migratory seabirds and shorebirds that may be present within the PA. These threats and relevant management advice are included in Table 2-17.

Table 2-15: Threatened and/or migratory seabirds and shorebirds

Common name	Scientific name	Threatened status	Migratory
Oriental Reed-warbler*	*Acrocephalus orientalis*		Migratory
Common Sandpiper*	*Actitis hypoleucos*		Migratory
Common Noddy	*Anous stolidus*		Migratory
Australian Lesser Noddy	*Anous tenuirostris melanops*	Vulnerable	
Fork-tailed Swift	*Apus pacificus*		Migratory
Flesh-footed Shearwater, Fleshy-footed Shearwater	*Ardenna carneipes*		Migratory
Wedge-tailed Shearwater	*Ardenna pacifica*		Migratory
Ruddy Turnstone*	*Arenaria interpres*		Migratory
Australasian Bittern	*Botaurus poiciloptilus*	Endangered	
Sharp-tailed Sandpiper*	*Calidris acuminata*		Migratory
Sanderling*	*Calidris alba*		Migratory
Red Knot, Knot*	*Calidris canutus*	Endangered	Migratory
Curlew Sandpiper*	*Calidris ferruginea*	Critically Endangered	Migratory
Pectoral Sandpiper*	*Calidris melanotos*		Migratory
Red-necked Stint*	*Calidris ruficollis*		Migratory
Long-toed Stint*	*Calidris subminuta*		Migratory
Great Knot*	*Calidris tenuirostris*	Critically Endangered	Migratory
Streaked Shearwater	*Calonectris leucomelas*		Migratory
Forest Red-tailed Black-Cockatoo, Karrak	*Calyptorhynchus banksii naso*	Vulnerable	
Baudin's Cockatoo, Long-billed Black-Cockatoo	*Calyptorhynchus baudinii*	Vulnerable	
Carnaby's Cockatoo, Short-billed Black-Cockatoo	*Calyptorhynchus latirostris*	Endangered	
Red-rumped Swallow#	*Cecropis daurica*		Migratory
Double-banded Plover*	*Charadrius bicinctus*		Migratory
Greater Sand Plover, Large Sand Plover	*Charadrius leschenaultii*	Vulnerable	Migratory

Common name	Scientific name	Threatened status	Migratory
Lesser Sand Plover, Mongolian Plover	*Charadrius mongolus*	Endangered	Migratory
Oriental Plover, Oriental Dotterel*	*Charadrius veredus*		Migratory
Oriental Cuckoo, Horsfield's Cuckoo	*Cuculus optatus*		Migratory
Amsterdam Albatross	*Diomedea amsterdamensis*	Endangered	Migratory
Tristan Albatross	*Diomedea dabbenena*	Endangered	
Southern Royal Albatross	*Diomedea epomophora*	Vulnerable	Migratory
Wandering Albatross	*Diomedea exulans*	Vulnerable	Migratory
Northern Royal Albatross	*Diomedea sanfordi*	Endangered	
Red Goshawk	*Erythrotriorchis radiatus*	Vulnerable	
Gouldian Finch	*Erythrura gouldiae*	Endangered	
Crested Shrike-tit (northern), Northern Shrike-tit	*Falcunculus frontatus whitei*	Vulnerable	
Lesser Frigatebird, Least Frigatebird	*Fregata ariel*		Migratory
Great Frigatebird, Greater Frigatebird	*Fregata minor*		Migratory
Swinhoe's Snipe*	*Gallinago megala*		Migratory
Pin-tailed Snipe*	*Gallinago stenura*		Migratory
Partridge Pigeon (western)	*Geophaps smithii blaauwi*	Vulnerable	
Oriental Pratincole*	*Glareola maldivarum*		Migratory
Blue Petrel	*Halobaena caerulea*	Vulnerable	
Barn Swallow#	*Hirundo rustica*		Migratory
Caspian Tern	*Hydroprogne caspia*		Migratory
Malleefowl	*Leipoa ocellata*	Vulnerable	
Broad-billed Sandpiper*	*Limicola falcinellus*		Migratory
Asian Dowitcher*	*Limnodromus semipalmatus*		Migratory
Bar-tailed Godwit*	*Limosa lapponica*		Migratory
Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit*	*Limosa lapponica baueri*	Vulnerable	Migratory
Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)	*Limosa lapponica menzbieri*	Critically Endangered	Migratory
Black-tailed Godwit*	*Limosa limosa*		

Common name	Scientific name	Threatened status	Migratory
Southern Giant-Petrel, Southern Giant Petrel	*Macronectes giganteus*	Endangered	Migratory
Northern Giant Petrel	*Macronectes halli*	Vulnerable	Migratory
White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren	*Malurus leucopterus edouardi*	Vulnerable	
White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren	*Malurus leucopterus*	Vulnerable	
Grey Wagtail#	*Motacilla cinerea*		Migratory
Yellow Wagtail#	*Motacilla flava*		Migratory
Eastern Curlew, Far Eastern Curlew*	*Numenius madagascariensis*	Critically Endangered	Migratory
Little Curlew, Little Whimbrel*	*Numenius minutus*		Migratory
Whimbrel*	*Numenius phaeopus*		Migratory
Bridled Tern	*Onychoprion anaethetus*		Migratory
Fairy Prion (southern)	*Pachyptila turtur subantarctica*	Vulnerable	
Osprey*	*Pandion haliaetus*		Migratory
Abbott's Booby	*Papasula abbotti*	Endangered	
Night Parrot	*Pezoporus occidentalis*	Endangered	
White-tailed Tropicbird	*Phaethon lepturus*		Migratory
Red-tailed Tropicbird	*Phaethon rubricauda*		Migratory
Red-necked Phalarope*	*Phalaropus lobatus*		Migratory
Ruff (Reeve) *	*Philomachus pugnax*		Migratory
Sooty Albatross	*Phoebetria fusca*	Vulnerable	Migratory
Pacific Golden Plover*	*Pluvialis fulva*		Migratory
Grey Plover*	*Pluvialis squatarola*		Migratory
Princess Parrot, Alexandra's Parrot	*Polytelis alexandrae*	Vulnerable	
Soft-plumaged Petrel	*Pterodroma mollis*	Vulnerable	
Rufous Fantail#	*Rhipidura rufifrons*		Migratory
Australian Painted Snipe	*Rostratula australis*	Endangered	
Roseate Tern	*Sterna dougallii*		Migratory
Little Tern	*Sternula albifrons*		Migratory
Australian Fairy Tern	*Sternula nereis*	Vulnerable	

Common name	Scientific name	Threatened status	Migratory
Masked Booby	*Sula dactylatra*		Migratory
Brown Booby	*Sula leucogaster*		Migratory
Red-footed Booby	*Sula sula*		Migratory
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Vulnerable	
Tasmanian Shy Albatross	*Thalassarche cauta*		Migratory
Shy Albatross, Tasmanian Shy Albatross	*Thalassarche cauta*	Vulnerable	
White-capped Albatross	*Thalassarche cauta steadi*	Vulnerable	
Campbell Albatross, Campbell Black-browed Albatross	*Thalassarche impavida*	Vulnerable	
Black-browed Albatross	*Thalassarche melanophris*	Vulnerable	Migratory
Crested Tern*	*Thalasseus bergii*		Migratory
Grey-tailed Tattler*	*Tringa brevipes*		Migratory
Wood Sandpiper*	*Tringa glareola*		Migratory
Common Greenshank, Greenshank*	*Tringa nebularia*		Migratory
Marsh Sandpiper, Little Greenshank*	*Tringa stagnatilis*		Migratory
Common Redshank, Redshank*	*Tringa totanus*		Migratory
Painted Button-quail (Houtman Abrolhos)	*Turnix varius scintillans*	Vulnerable	
Masked Owl (northern)	*Tyto novaehollandiae kimberli*	Vulnerable	
Terek Sandpiper*	*Xenus cinereus*		Migratory
** Migratory Wetland Species* *# Migratory Terrestrial Species (unlikely to be encountered in the PA)*			

Table 2-16: BIAs for regionally significant seabirds and shorebirds

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Australian Lesser Noddy	Foraging (provisioning young)	Year-round	Known to occur
Bridled Tern	Foraging (in high numbers)	Almost entirely a breeding visitor, arriving late September or October and leaving between late February and early May	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Brown Booby	Breeding	Breeding Feb–Oct (but mainly in autumn)	Known to occur
Caspian Tern	Foraging (provisioning young)		Known to occur
Common Noddy	Foraging	Breeding visitor in Abrolhos (mid-August to late April) and further north (May to at least November)	Known to occur
	Foraging (provisioning young)	Breeding visitor in Abrolhos (mid-August to late April) and further north (May to at least November)	Known to occur
Fairy Tern	Breeding	Breeding from July to late September; birds from South-West Marine Region (SWMR) dispersing northwards in winter	Known to occur
	Foraging (in high numbers)	Year-round, but southern birds disperse north in winter	Known to occur
Flesh-footed Shearwater	Aggregation	Late April to late June and late August to early November	Known to occur
Greater Frigatebird	Breeding	Breeding in May–June and August	Known to occur
Great-winged Petrel (macroptera race)	Foraging (provisioning young)	Late January to early December	Known to occur
Lesser Crested Tern	Breeding	Breeding Mar–Jun	Known to occur
Lesser Frigatebird	Breeding	Breeding Mar–Sep	Known to occur
Little Penguin	Foraging (provisioning young)		Known to occur
Little Shearwater	Foraging (in high numbers)	Early January to early December, mainly April to November	Known to occur
Little Tern	Breeding	Breeding recorded in June, July, and October	Known to occur
	Resting	Breeding recorded in June, July, and October	Known to occur
Pacific Gull	Foraging (in high numbers)		Former Range
	Foraging (in high numbers)		Known to occur
Red-footed Booby	Breeding	Breeding in May-June	Known to occur

Common name	Behaviour	Seasonal presence	Occurrence descriptor
Roseate Tern	Breeding	Breeding from mid-March to July; Also birds from SWMR dispersing north in winter	Known to occur
	Foraging	Winter	Known to occur
	Foraging (provisioning young)	Winter	Known to occur
	Resting	Breeding from mid-March to July; birds from SWMR dispersing north in winter	Known to occur
Soft-plumaged Petrel	Foraging (in high numbers)	Mainly March to late September	Known to occur
Sooty Tern	Foraging	Late Aug to early May	Known to occur
Wedge-tailed Shearwater	Breeding	Breeding visitor arriving in mid-August and leaving in April in Pilbara and mid-May in Shark Bay	Known to occur
	Foraging (in high numbers)	Mid-August–May	Known to occur
White-faced Storm Petrel	Foraging (in high numbers)		Known to occur
White-tailed Tropicbird	Breeding	Breeding recorded in May and October	Known to occur

Table 2-17: Summary of relevant conservation plans—seabirds and shorebirds

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
Anous tenuirostris melanops (Australian Lesser Noddy)	Conservation Advice for *Anous tenuirostris melanops* Australian Lesser Noddy (Ref. 48)	The main potential threat to breeding colonies is catastrophic destruction of habitat by cyclones. Other threats include: • pollution • oil spills • over-fishing.
Calyptorhynchus banksii naso (Forest Red-tailed Black-Cockatoo) *Calyptorhynchus baudinii* (Baudin's Cockatoo, Long-billed Black-Cockatoo)	Forest Black-Cockatoo (Baudin's Cockatoo *Calyptorhynchus baudinii*) and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) Recovery Plan (Ref. 49)	Key threats are: • killing by illegal shooting • feral honeybees • habitat loss • nest hollow shortage • nest hollow competition.
	Approved Conservation Advice for *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo) (Ref. 50)	The main identified threats to the Forest Red-tailed Black-Cockatoo are: • illegal shooting • habitat loss

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
		• nest hollow shortage and competition from other species • injury or death from *Apis mellifera* (European Honey Bees).
	Conservation Advice *Calyptorhynchus baudinii* Baudin's Cockatoo (Ref. 51)	Key threats include: • habitat loss, disturbance, and modifications • fire • invasive species • competition with native species • illegal killing • phytopathogens and pests • climate change.
Calyptorhynchus latirostris (Carnaby's Cockatoo)	Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (Ref. 52)	Key threats include: • loss of breeding habitat • loss of non-breeding foraging and night roosting habitat • tree health • mining and extraction activities • illegal shooting • illegal taking • climate change • collisions with motor vehicles • disease.
Leipoa ocellate (Malleefowl)	National Recovery Plan for Malleefowl *Leipoa ocellate* (Ref. 53)	Key threats include: • clearing • habitat fragmentation and isolation • grazing • predation • fire (wildfire and intentional burns) • disease, inbreeding, and chemical exposure • climate change.
Macronectes giganteus (Southern Giant Petrel) *Macronectes halli* (Northern Giant Petrel) *Thalassarche carteri* (Indian Yellow-nosed Albatross) *Thalassarche cauta* (Tasmanian Shy Albatross) *Thalassarche cauta* (Shy Albatross)	National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011–2016 (Ref. 54)	Key threats include: • incidental catch resulting from fishing operations • competition with fisheries for marine resources • dependence on discards • marine pollution • climate change • intentional shooting/killing • feral pest species • human disturbance at the nest • parasites and diseases

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
Thalassarche cauta steadi (White-capped Albatross) *Thalassarche impavida* (Campbell Albatross, Campbell Black-browed Albatross) Thalassarche melanophris (Black-browed Albatross)		• loss of nesting habitat • competition for nest space • climate change.
Malurus leucopterus edouardi (White-winged Fairy-wren (Barrow Island)	Approved Conservation Advice for *Malurus leucopterus edouardi* (White-winged Fairy-wren [Barrow Island]) (Ref. 55)	The main potential threats to the White-winged Fairy-wren (Barrow Island) include: • introduction of non-endemic fauna, flora, or pathogens • inappropriate fire regime • vegetation clearing • destruction of birds • degradation of habitat by fire and development.
Malurus leucopterus (White-winged Fairy-wren (Dirk Hartog Island))	Approved Conservation Advice for *Malurus leucopterus* (White-winged Fairy-wren (Dirk Hartog Island)) (Ref. 56)	The main identified threats to the White-winged Fairy-wren (Dirk Hartog Island) are: • fire, which can kill birds and/or destroy habitat • degradation through grazing and trampling of habitat by feral goats (*Capra hircus*) • predation by feral cats (*Felis catus*) and house mice (*Mus* sp.)
Pachyptila turtur subantarctica (Fairy Prion (southern))	Conservation Advice *Pachyptila turtur subantarctica* Fairy Prion (southern) (Ref. 57)	Key threats include: • habitat loss, disturbance, and modification • predation.
Papasula abbotti (Abbott's Booby)	Conservation Advice *Papasula abbotti* Abbott's Booby (Ref. 58)	The Abbott's booby breeds only on Christmas Island. The principal reason for the decline of Abbott's Booby is thought to be the clearance of about a third of the former nesting rainforest habitat.
Pezoporus occidentalis (Night Parrot)	Conservation Advice *Pezoporus occidentalis* Night Parrot (Ref. 59)	There are no known threats to this species.
Polytelis alexandrae (Princess Parrot)	Conservation Advice *Polytelis alexandrae* Princess Parrot (Ref. 60)	Potential threats include: • increased intensity of bushfires • habitat degradation from introduced weeds and herbivores

Species	Relevant Plan / Advice	Key Threats / Relevant Management Advice
		• predation by introduced predators • competition with other bird species • disease • illegal collection.
Pterodroma mollis (Soft-plumaged Petrel)	Conservation Advice *Pterodroma Mollis* Soft-plumaged Petrel (Ref. 61)	Key threats include: • accidental introduction of predators to island populations.
Rostratula australis (Australian Painted Snipe)	Approved Conservation Advice for *Rostratula australis* (Australian Painted Snipe) (Ref. 62)	Key threats include: • habitat loss, disturbance, and modification • invasive weeds • trampling, browsing, or grazing • animal predation or competition • fire.
Sternula nereis (Australian Fairy Tern)	Approved Conservation Advice for *Sternula nereis* (Fairy Tern) (Ref. 63)	Key threats include: • predation by introduced animals • disturbance by humans and direct destruction of nests • increasing salinity in waters adjacent to colonies • irregular water management (flooding nests etc.) • weed encroachment • oil spills.
Turnix varius scintillans (Painted Button-quail (Houtman Abrolhos))	Approved Conservation Advice for *Turnix varia scintillans* (Painted Button-quail (Houtman Abrolhos)) (Ref. 64)	Key threats include: • inappropriate fire regimes • competition for food with, or predation of eggs by, the introduced House Mouse (*Mus musculus*) • introduction of non-endemic fauna, flora or pathogens • grazing and trampling of habitat.
Tyto novaehollandiae kimberli (Masked Owl (northern))	Conservation Advice *Tyto novaehollandiae kimberli* Masked Owl (northern) (Ref. 65)	Potential threats include: • decline in food availability • more intense, frequent, and extensive fires, which may also reduce the availability of large trees and hollows • competition for tree hollows • reduction in suitable habitat.

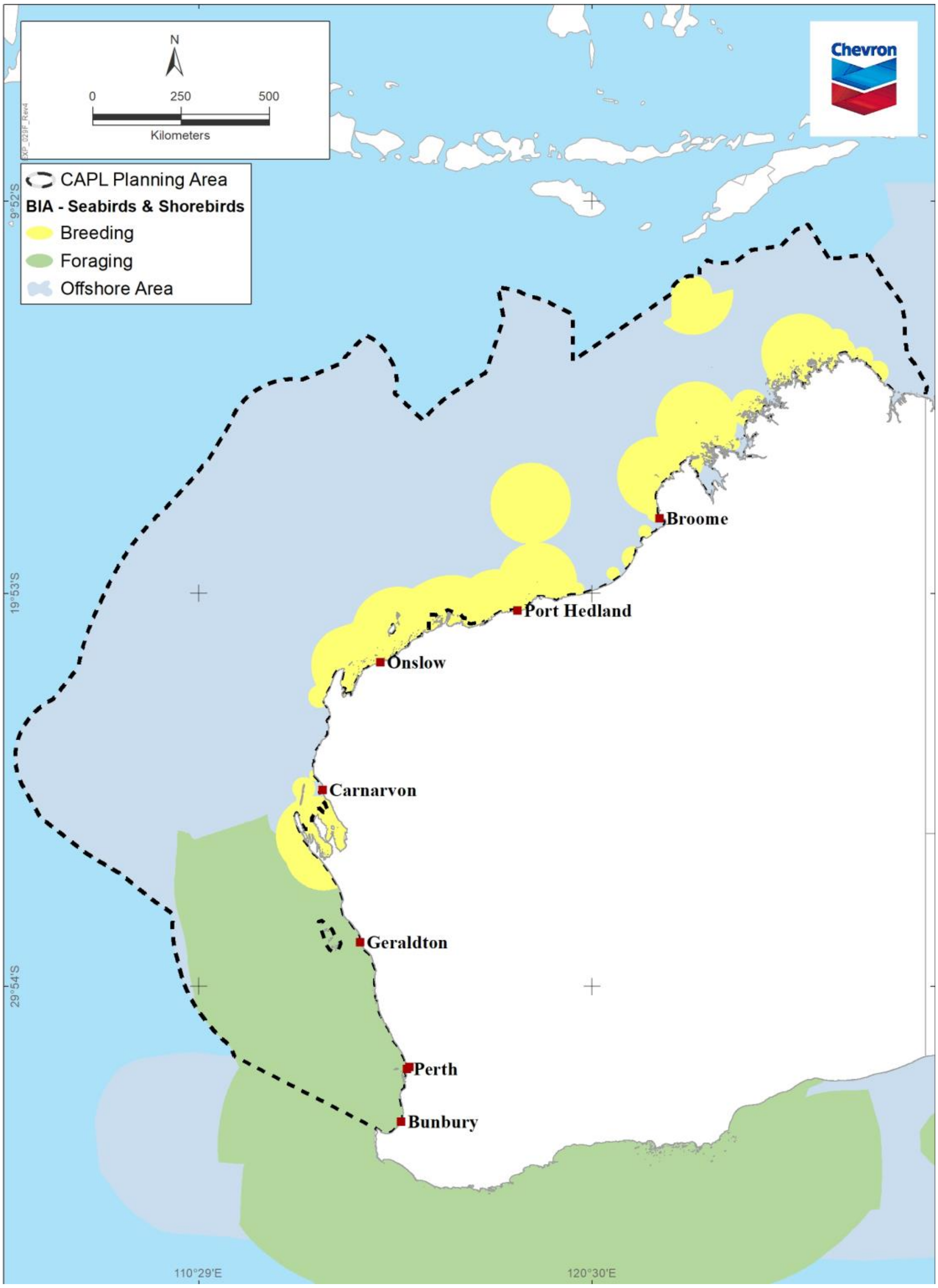


Figure 2-4: BIAs associated with seabirds and shorebirds

2.6 Listed threatened ecological communities

In Australia, three categories exist for listing threatened ecological communities (TECs) under the EPBC Act: critically endangered, endangered, and vulnerable.

In WA, TECs are present in the southwest and in the north around Broome. Table 2-18 summarises these communities (Ref. 66; Ref. 4; appendix a).

Table 2-18: Threatened ecological communities

TEC	Summary of significance
Banksia Woodlands of the Swan Coastal Plain ecological community*	The ecological community is a woodland associated with the Swan Coastal Plain of southwest WA. A key diagnostic feature is a prominent tree layer of banksia, with scattered eucalypts and other tree species often present among or emerging above the banksia canopy. The understorey is a species-rich mix of sclerophyllous shrubs, graminoids, and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range. (Ref. 67)
Monsoon Vine Thickets on the coastal sand dunes of Dampier Peninsula	The Monsoon Vine Thickets on the coastal sand dunes of Dampier Peninsula ecological community represents certain occurrences of Monsoon Vine thickets in the south-west Kimberley region of WA (within the Dampierland bioregion). The ecological community is predominantly restricted to the coastlines of the Dampier Peninsula from Broome in the south to One Arm Point in the north and on the north-eastern coast of the Peninsula from One Arm Point to Goodenough Bay. The coastal dune environment, being largely of sand, has minimal soil development and is susceptible to erosion from various sources including rising tides, strong winds, and cyclonic activity. Tides of the Dampier Peninsula range up to 11 m and are a major factor affecting the coastal environment where the ecological community occurs. (Ref. 68)
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	The Rockingham-Becher Plain has been formed through the accumulation of Holocene sediments and contains a continuous depositional history from 7000 BP to present. Wetlands occur within the swales where the water table is close to or at the ground surface in the wetter months of the year. The most typical form is that of the Becher Suite, which is made up of over 250 very small to small sumplands and damplands, many of which contain occurrences of this community. The present known distribution of the sedgelands in Holocene dune swale community as is ~193 ha and is almost entirely located within linear wetland depressions (swales) occurring between parallel sand ridges of the Rockingham-Becher Plain. Additional occurrences include a small area at Yanchep and a small area at Dalyellup. Holocene dunes with wetlands around Preston Beach, south of Lancelin, and at Cheynes Beach may also contain occurrences of this community. (Ref. 69)
Subtropical and Temperate Coastal Saltmarsh	The Subtropical and Temperate Coastal Saltmarsh ecological community occurs within a relatively narrow margin of the Australian coastline, within the subtropical and temperate climatic zones south of the South-east Queensland IBRA bioregion boundary at 23° 37′ latitude along the east coast and south of (and including) Shark Bay at 26° on the west coast. Coastal saltmarsh occurring on islands within the geographic range is also included within the ecological community. The Coastal Saltmarsh ecological community consists mainly of salt-tolerant vegetation (halophytes) including: grasses, herbs, sedges, rushes, and shrubs. Succulent herbs, shrubs, and grasses generally dominate, and vegetation is generally <0.5 m high (with the exception of some reeds and sedges). (Ref. 70)
Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)*	The Lake Clifton thrombolite community is restricted to Lake Clifton, which occurs within the South West Natural Resource Management Region. This ecological community is situated in the Swan Coastal Plain IBRA Bioregion of WA. Lake Clifton is situated within the Yalgorup National Park and is the northernmost lake in the Peel-Yalgorup Lakes System. The main known occurrence of the ecological community is a stretch, ~15 km long and up to 15 m wide, along the north-eastern shoreline of Lake Clifton. There are other small clusters of thrombolites within the lake, also at the northern end. This structure is the largest known example of a living, non-marine microbialite reef in the southern hemisphere. (Ref. 71)

TEC	Summary of significance
Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community*	The ecological community occurs as woodlands or forests or other structural forms where the primary defining feature is the presence of *Eucalyptus gomphocephala* (Tuart) trees in the uppermost canopy layer. The ecological community includes the assemblage of plants, animals, and other organisms that occur in association with Tuart. The ecological community has a discontinuous distribution in the west of the Swan Coastal Plain, of southwest WA. The Tuart woodlands and forests occur on the Swan Coastal Plain in WA, from Jurien, ~200 km north of Perth, to the Sabina River, near Busselton, 225 km south of Perth. The ecological community occurs mainly on the Spearwood and Quindalup dune systems, which are underlain by Tamala Limestone. (Ref. 72)

** Identified in the protected matters search (appendix a) but located inland and thus not expected to be exposed to CAPL's activities.*

2.7 Commonwealth marine areas

The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone (EEZ) and/or over the continental shelf of Australia, which is not State or Territory waters.

The Commonwealth marine area stretches from three to 200 nautical miles from the coast. Marine protected areas are marine areas that are recognised to have high conservation value (Ref. 73).

2.7.1 Australian Marine Parks

Australian Marine Parks (AMPs), proclaimed under the EPBC Act in 2007 and 2013, are located in Commonwealth waters that start at the outer edge of state and territory waters, generally three nautical miles (~5.5 km) from the shore, and extend to the outer boundary of Australia's EEZ, 200 nautical miles (~370 km) from the shore (Ref. 75).

Table 2-19, Table 2-20, and Table 2-21 summarise the north-west, south-west, and north AMPs present within the PA, including their zones, areas, and International Union for Conservation of Nature (IUCN) categories (Ref. 74; Ref. 4; appendix a).

Table 2-19: Summary of AMPs (North-west Marine Parks)

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
Argo–Rowley Terrace	National Park Zone (II) 36 050 km² Multiple Use Zone (VI) 108 812 km² Special Purpose Zone (Trawl) (VI) 1141 km²	The Argo–Rowley Terrace Marine Park is ~270 km north-west of Broome, WA, and extends to the limit of Australia's EEZ. The Marine Park is adjacent to the Mermaid Reef Marine Park and the WA Rowley Shoals Marine Park. The Marine Park covers an area of 146 003 km² and has	The Marine Park includes examples of ecosystems representative of: • Northwest Transition—an area of shelf break, continental slope, and the majority of the Argo Abyssal Plain. Key topographic features include Mermaid, Clerke, and Imperieuse reefs, which collectively are a biodiversity hotspot • Timor Province—an area dominated by warm, nutrient-poor waters. Canyons are an important feature in this area of the Marine Park and are generally associated with high productivity and aggregations of marine life.

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
		water depths between 220 m and 6000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Argo–Rowley Terrace Marine Park on 9 October 2017.	Key ecological features of the Marine Park are: • Canyons linking the Argo Abyssal Plain with the Scott Plateau—an area likely to result in upwelling of nutrient-rich water and aggregations of marine life • Mermaid Reef and Commonwealth waters surrounding Rowley Shoals—an area of enhanced productivity and high species richness, thought to be facilitated by internal wave action generated by internal tides. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include resting and breeding habitat for seabirds and a migratory pathway for the Pygmy Blue Whale.
Ashmore Reef	Sanctuary Zone (Ia) 550 km² Recreational Use Zone (IV) 34 km²	The Ashmore Reef Marine Park is ~630 km north of Broome and 110 km south of the Indonesian island of Roti. The Marine Park is in Australia's External Territory of Ashmore and Cartier Islands and is within an area subject to a Memorandum of Understanding (MoU) between Indonesia and Australia, known as the MoU Box. The Marine Park covers an area of 583 km² and water depths from <15 m to 500 m. The Marine Park has three vegetated sand cays that are permanently above water: West, Middle, and East islands. The Marine Park was originally proclaimed under the Commonwealth *National Parks and Wildlife Conservation Act 1975* on 16 August 1983 as the Ashmore Reef National Nature	The Marine Park includes examples of ecosystems representative of the Timor Province—a bioregion with a depth range from ~200 m near the shelf break to 5920 m over the Argo Abyssal Plain. The reefs and islands of the bioregion are regarded as biodiversity hotspots. Ashmore Reef is an important feature of the bioregion. Endemism in demersal fish communities of the continental slope is high with two distinct communities identified: one on the upper slope, the other mid slope. Key ecological features of the Marine Park are: • Ashmore Reef and Cartier Island and surrounding Commonwealth waters—areas of enhanced productivity in an otherwise low-nutrient environment, of regional importance for feeding and breeding aggregations of birds and marine life • continental slope demersal fish communities—an area of high-diversity demersal fish assemblages. The marine environment of the Marine Park includes habitats associated with two extensive lagoons, sand flats, shifting sand cays, extensive reef flat, and large areas of seagrass. The reef ecosystems are comprised of hard and soft corals, gorgonians, sponges, and a range of encrusting organisms, with the highest number of coral species of any reef off the Western Australian coast. The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
		Reserve, and proclaimed under the EPBC Act on 14 December 2013; it was renamed Ashmore Reef Marine Park on 9 October 2017.	Marine Park include breeding, foraging, and resting habitat for seabirds; resting and foraging habitat for migratory shorebirds; foraging, mating, nesting, and internesting habitat for marine turtles; foraging habitat for Dugong; and a migratory pathway for Pygmy Blue Whales. Ashmore Reef Ramsar site The Ashmore Reef Ramsar site includes the largest of the atolls in the region. West Island, Middle Island, and East Island represent the only vegetated islands in the region. Ashmore Reef Ramsar site supports internationally significant populations of seabirds and shorebirds, is important for turtles (Green, Hawksbill and Loggerhead) and Dugong, and has the highest diversity of hermatypic (reef-building) corals on the West Australian coast. It is known for its abundance and diversity of sea snakes. However, since 1998 populations of sea snakes at Ashmore Reef have been in decline.
Carnarvon Canyon	Habitat Protection Zone (IV) 6177 km²	The Carnarvon Canyon Marine Park is ~300 km north-west of Carnarvon. It covers an area of 6177 km² with a water depth range of 1500–6000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Carnarvon Canyon Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Central Western Transition — a bioregion characterised by large areas of continental slope; a range of topographic features such as terraces, rises, and canyons; seasonal and sporadic upwelling; and benthic slope communities comprising tropical and temperate species. It includes the Carnarvon Canyon, a single-channel canyon covering the entire depth range of the Marine Park. Ecosystems of the Marine Park are influenced by tropical and temperate currents, deep-water environments, and proximity to the continental slope and shelf. The soft-bottom environment at the base of the Carnarvon Canyon is likely to support species that are typical of the deep sea floor (e.g. holothurians, polychaetes, sea pens). The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. There is limited information about species' use of this Marine Park.
Cartier Island	Sanctuary Zone (Ia) 172 km²	The Cartier Island Marine Park is ~45 km south-east of Ashmore Reef Marine Park and 610 km north of Broome, WA. Both Marine Parks are located in Australia's External Territory of	The Marine Park includes examples of ecosystems representative of the Timor Province—a bioregion with a depth range from ~200 m near the shelf break to 5920 m over the Argo Abyssal Plain. The reefs and islands of the bioregion are regarded as biodiversity hotspots. Endemism of demersal fish communities of the continental slope is high with two distinct communities identified, one on the upper

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
		Ashmore and Cartier Islands and are also within an area subject to a Memorandum of Understanding (MoU) between Indonesia and Australia, known as the MoU Box. The Marine Park covers an area of 172 km² with water depths from <15 m to 500 m. The Marine Park was originally proclaimed under the Commonwealth *National Parks and Wildlife Conservation Act 1975* on 21 June 2000 as the Cartier Island Marine Reserve, and proclaimed under the EPBC Act on 14 December 2013; it was renamed Cartier Island Marine Park on 9 October 2017.	slope, the other mid slope. Key ecological features represented in the Marine Park are: • Ashmore Reef and Cartier Island and surrounding Commonwealth waters—areas of enhanced productivity in an otherwise low-nutrient environment, of regional importance for feeding and breeding aggregations of birds and marine life • Continental slope demersal fish communities—an area of high diversity in demersal fish assemblages. The Marine Park includes an unvegetated sand island (Cartier Island); mature reef flat; a small, submerged pinnacle (Wave Governor Bank); and two shallow pools to the north-east of the island. It is also an area of high diversity and abundance of hard and soft corals, gorgonians (sea fans), sponges, and a range of encrusting organisms. The reef crests are generally algal dominated, while the reef flats feature ridges of coral rubble and large areas of seagrass. The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and foraging habitat for seabirds; internesting, nesting, and foraging habitat for marine turtles; and foraging habitat for Whale Sharks. The Marine Park is important for a range of other species and internationally significant for its abundance and diversity of sea snakes, some of which are listed species under the EPBC Act.
Dampier	National Park Zone (II) 73 km² Habitat Protection Zone (IV) 104 km² Multiple Use Zone (VI) 1074 km²	The Dampier Marine Park is ~10 km north-east of Cape Lambert and 40 km from Dampier extending westwards from the WA state water boundary. The Marine Park covers an area of 1252 km² and a water depth range between <15 m and 70 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Dampier Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. The Marine Park supports a range of species including those listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and foraging habitat for seabirds, internesting habitat for marine turtles, and a migratory pathway for Humpback Whales.

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
Eighty Mile Beach	Multiple Use Zone (VI) 10 785 km²	The Eighty Mile Beach Marine Park is located ~74 km north-east of Port Hedland, adjacent to the Western Australian Eighty Mile Beach Marine Park. The Marine Park covers an area of 10 785 km² and a water depth ranges between less than 15 m and 70 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Eighty Mile Beach Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding, foraging, and resting habitat for seabirds; internesting and nesting habitat for marine turtles; foraging, nursing, and pupping habitat for sawfish; and a migratory pathway for Humpback Whales.
Gascoyne	National Park Zone (II) 9132 km² Habitat Protection Zone (IV) 38 982 km² Multiple Use Zone (VI) 33 652 km²	The Gascoyne Marine Park is located ~20 km off the west coast of the Cape Range Peninsula, adjacent to the Ningaloo Reef Marine Park and the Western Australian Ningaloo Marine Park, and extends to the limit of Australia's EEZ. The Marine Park covers an area of 81 766 km² and water depths between 15 m and 6000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Gascoyne Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of: • Central Western Shelf Transition—continental shelf with water depths up to 100 m, and a significant transition zone between tropical and temperate species • Central Western Transition—characterised by large areas of continental slope; a range of topographic features such as terraces, rises, and canyons; seasonal and sporadic upwelling; and benthic slope communities comprising tropical and temperate species • Northwest Province—an area of continental slope comprising diverse and endemic fish communities. Key ecological features of the Marine Park are: • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula—an area resulting in upwelling of nutrient-rich water and aggregations of marine life • Commonwealth waters adjacent to Ningaloo Reef—an area where the Leeuwin and Ningaloo currents interact resulting in enhanced productivity and aggregations of marine life • Continental slope demersal fish communities—an area of high diversity of demersal fish assemblages on the continental slope

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
			• Exmouth Plateau—a regionally and nationally unique deep-sea plateau in tropical waters. Ecosystems represented in the Marine Park are influenced by the interaction of the Leeuwin Current, Leeuwin Undercurrent, and the Ningaloo Current. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds; internesting habitat for marine turtles; a migratory pathway for Humpback Whales; and foraging habitat and migratory pathway for Pygmy Blue Whales.
Kimberley	National Park Zone (II) 6392 km² Habitat Protection Zone (IV) 5665 km² Multiple Use Zone (VI) 62 411 km²	The Kimberley Marine Park is located ~100 km north of Broome, extending from the Western Australian state water boundary north from the Lacepede Islands to the Holothuria Banks offshore from Cape Bougainville. The Marine Park is adjacent to the Western Australian Lalang-garram/Camden Sound Marine Park and the North Kimberley Marine Park. The Marine Park covers an area of 74 469 km² and water depths from less than 15 m to 800 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Kimberley Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of: • Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and an ancient coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. • Northwest Shelf Transition—straddles the North-west and North Marine Regions and in the Northwest includes shelf break, continental slope, and the majority of the Argo Abyssal Plain and is subject to a high incidence of cyclones. Benthic biological communities in the deeper parts of the bioregion have not been extensively studied, although high levels of species diversity and endemism occur among demersal fish communities on the continental slope. • Timor Province—water depths (of the bioregion) ranging from ~200 m near the shelf break to 5920 m over the Argo Abyssal Plain. The reefs and islands of the bioregion are regarded as biodiversity hotspots. Endemism in demersal fish communities of the continental slope is high; two distinct communities have been identified on the upper and mid slopes. Key ecological features of the Marine Park are: • the ancient coastline at the 125 m depth contour—where rocky escarpments are thought to provide

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
			biologically important habitats in areas otherwise dominated by soft sediments • the continental slope demersal fish communities—characterised by high diversity of demersal fish assemblages. The Marine Park supports a range of species, including protected species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and foraging habitat for seabirds; internesting and nesting habitat for marine turtles; breeding, calving, and foraging habitat for inshore dolphins; calving, migratory pathway, and nursing habitat for Humpback Whales; migratory pathway for Pygmy Blue Whales; foraging habitat for dugong; and foraging habitat for Whale Sharks.
Mermaid Reef	National Park Zone (II) 540 km²	The Mermaid Reef Marine Park is located ~280 km north-west of Broome, adjacent to the Argo–Rowley Terrace Marine Park and ~13 km from the Western Australian Rowley Shoals Marine Park. The Marine Park covers an area of 540 km² and water depths from less than 15 m to 500 m. The Marine Park was originally proclaimed under the Commonwealth *National Parks and Wildlife Conservation Act 1975* on 10 April 1991 as the Mermaid Reef Marine National Nature Reserve, and proclaimed under the EPBC Act on 14 December 2013 and renamed Mermaid Reef Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Transition—an area of shelf break, continental slope, and the majority of the Argo Abyssal Plain. Together with Clerke Reef and Imperieuse Reef, Mermaid Reef is a biodiversity hotspot and key topographic feature of the Argo Abyssal Plain. A key ecological feature of the Marine Park is the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals—an area of enhanced productivity and high species richness thought to be facilitated by internal wave action generated by internal tides in the lagoon. Ecosystems of the Marine Park are associated with emergent reef flat, deep reef flat, lagoon, and submerged sand habitats. The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds and a migratory pathway for the Pygmy Blue Whale.
Montebello	Multiple Use Zone (VI) 3413 km²	The Montebello Marine Park is located offshore of Barrow Island and 80 km west of Dampier extending from the Western	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
		Australian state water boundary, and is adjacent to the Western Australian Barrow Island and Montebello Islands Marine Parks. The Marine Park covers an area of 3413 km² and water depths from <15 m to 150 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Montebello Marine Park on 9 October 2017.	coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. A key ecological feature of the Marine Park is the ancient coastline at the 125 m depth contour where rocky escarpments are thought to provide biologically important habitat in areas otherwise dominated by soft sediments. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds; internesting, foraging, mating, and nesting habitat for marine turtles; a migratory pathway for Humpback Whales; and foraging habitat for Whale Sharks.
Ningaloo	National Park Zone (II) 116 km² Recreational Use Zone (IV) 2319 km²	The Ningaloo Marine Park stretches ~300 km along the west coast of the Cape Range Peninsula, and is adjacent to the Western Australian Ningaloo Marine Park and Gascoyne Marine Park. The Marine Park covers an area of 2435 km² and a water depth range of 30 m to more than 500 m. The Marine Park was originally proclaimed under the *National Parks and Wildlife Conservation Act 1975* on 20 May 1987 as the Ningaloo Marine Park (Commonwealth Waters), and proclaimed under the EPBC Act on 14 December 2013 and renamed Ningaloo Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of: • Central Western Shelf Transition—continental shelf of water depths up to 100 m, and a significant transition zone between tropical and temperate species • Central Western Transition—characterised by large areas of continental slope; a range of topographic features such as terraces, rises, and canyons; seasonal and sporadic upwelling; and benthic slope communities comprising tropical and temperate species • Northwest Province—an area of continental slope comprising diverse and endemic fish communities • Northwest Shelf Province—a dynamic environment, influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. Key ecological features of the Marine Park are: • Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula—an area resulting in upwelling of nutrient-rich water and aggregations of marine life • Commonwealth waters adjacent to Ningaloo Reef—an area where the Leeuwin and Ningaloo currents interact,

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
			resulting in enhanced productivity and aggregations of marine life • Continental slope demersal fish communities—an area of high diversity among demersal fish assemblages on the continental slope. Ecosystems represented in the Marine Park are influenced by interaction of the Leeuwin Current, Leeuwin Undercurrent, and the Ningaloo Current. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and or foraging habitat for seabirds; internesting habitat for marine turtles; a migratory pathway for Humpback Whales; foraging habitat and migratory pathway for Pygmy Blue Whales; breeding, calving, foraging, and nursing habitat for dugong; and foraging habitat for Whale Sharks.
Roebuck	Multiple Use Zone (VI) 304 km²	The Roebuck Marine Park is located ~12 km offshore of Broome, and is adjacent to the Western Australian Yawuru Nagulagun/Roebuck Bay Marine Park. The Marine Park covers an area of 304 km² and a water depth range of less than 15 m to 70 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Roebuck Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Province—a dynamic environment influenced by strong tides, cyclonic storms, long-period swells, and internal tides. The bioregion includes diverse benthic and pelagic fish communities, and ancient coastline thought to be an important sea floor feature and migratory pathway for Humpback Whales. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding and resting habitat for seabirds; foraging and internesting habitat for marine turtles; a migratory pathway for Humpback Whales; and foraging habitat for dugong.
Shark Bay	Multiple Use Zone (VI) 7443 km²	The Shark Bay Marine Park is located ~60 km offshore of Carnarvon, adjacent to the Shark Bay World Heritage Property and National Heritage place. The Marine Park covers an area of 7443 km²,	The Marine Park includes examples of ecosystems representative of: • Central Western Shelf—a predominantly flat, sandy, and low-nutrient area, in water depths 50–100 m. The bioregion is a transitional zone between tropical and temperate species • Central Western Transition—characterised by large areas of continental slope; a range of topographic features such as terraces,

AMP	Zones, IUCN categories, and zone area	Description	Natural values^
		extending from the Western Australian state water boundary, and a water depth range between 15 m and 220 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Shark Bay Marine Park on 9 October 2017.	rises, and canyons; seasonal and sporadic upwelling; and benthic slope communities comprising tropical and temperate species. Ecosystems represented in the Marine Park are influenced by the Leeuwin, Ningaloo, and Capes currents. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include breeding habitat for seabirds, internesting habitat for marine turtles, and a migratory pathway for Humpback Whales. The Marine Park and adjacent coastal areas are also important for Shallow-water Snapper.

^ Source: Ref. 75.

Table 2-20: Summary of AMPs (South-west Marine Parks)

AMP	Zones, IUCN categories and zone area	Description	Natural values^
Abrolhos	Habitat Protection Zone (IV) 23,239 km² Multiple Use Zone (VI) 56,545 km² National Park Zone (II) 2548 km² Special Purpose Zone (VI) 5729 km²	Abrolhos Marine Park is located adjacent to the Western Australian Houtman Abrolhos Islands, covering a large offshore area extending from the Western Australian state water boundary to the edge of Australia's exclusive economic zone. It is located ~27 km south-west of Geraldton and extends north to ~330 km west of Carnarvon. The northernmost part of the shelf component of the Marine Park, north of Kalbarri, is adjacent to the Shark Bay World Heritage Area. The Marine Park covers an area of 88,060 km² and a water depth range between less than 15 m and 6000 m.	The Marine Park includes examples of ecosystems representative of: • Central Western Province—characterised by a narrow continental slope incised by many submarine canyons and the most extensive area of continental rise in any of Australia's marine regions. A significant feature within the area are several eddies that form off the Leeuwin Current at predictable locations, including west of the Houtman Abrolhos Islands • Central Western Shelf Province—a predominantly flat, sandy, and low-nutrient area, in water depths between 50 and 100 m. Significant sea floor features of this area include a deep hole and associated area of banks and shoals offshore of Kalbarri. The area is a transitional zone between tropical and temperate species • Central Western Transition—a deep ocean area characterised by large areas of continental slope, a range of significant sea floor features including the Wallaby Saddle, seasonal and sporadic upwelling, and benthic slope communities comprising tropical and temperate species • South-west Shelf Transition—a narrow continental shelf that is noted for its

AMP	Zones, IUCN categories and zone area	Description	Natural values^
		The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Abrolhos Marine Park on 9 October 2017.	physical complexity. The Leeuwin Current has a significant influence on the biodiversity of this nearshore area as it pushes subtropical water southward along the area's western edge. The area contains a diversity of tropical and temperate marine life including a large number of endemic fauna species.
Geographe	National Park Zone (II) 15 km² Habitat Protection Zone (IV) 21 km² Multiple Use Zone (VI) 291 km² Special Purpose Zone (Mining Exclusion) (VI) 650 km²	The Geographe Marine Park is located in Geographe Bay, ~8 km west of Bunbury and 8 km north of Busselton, adjacent to the Western Australian Ngari Capes Marine Park. The Marine Park covers an area of 977 km², extending from the Western Australian state water boundary, and a water depth range between 15 m and 70 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Geographe Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the South-west Shelf Province—an area of diverse marine life, influenced by the warm waters of the Leeuwin Current. The bioregion includes globally important biodiversity hotspots, such as the waters off Geographe Bay. Key ecological features of the Marine Park are: • Commonwealth marine environment within and adjacent to Geographe Bay—the sheltered waters of Geographe Bay support extensive seagrass beds that in turn provide important nursery habitat for a range of marine species • Western Rock Lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western Rock Lobsters are an important part of the food web on the inner shelf, particularly as juveniles. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for seabirds, a migratory pathway for Humpback and Pygmy Blue Whales, and a calving buffer area for Southern Right Whales.
Jurien	National Park Zone (II) 31 km² Special Purpose Zone (VI) 1820 km²	The Jurien Marine Park is located ~148 km north of Perth and 155 km south of Geraldton, adjacent to the Western Australian Jurien Bay Marine Park. The Marine Park covers an area of 1851 km² of continental shelf, extending from the Western Australian state water boundary, and a water depth	The Marine Park includes examples of ecosystems representative of: • South-west Shelf Transition—consists of a narrow continental shelf that is noted for its physical complexity. The Leeuwin Current has a significant influence on the biodiversity of this nearshore area as it pushes subtropical water southward along the bioregion's western edge. The area contains a diversity of tropical and temperate marine life including a large number of endemic fauna species. Key ecological features of the Marine Park are:

AMP	Zones, IUCN categories and zone area	Description	Natural values^
		range between 15 m and 220 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Jurien Marine Park on 9 October 2017.	• Ancient coastline between 90 m and 120 m depth—high benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment • Demersal slope and associated fish communities of the Central Western Province—an area that provides important habitat for demersal fish communities and is characterised by high species diversity and endemism • Western Rock Lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western Rock Lobsters are an important part of the food web on the inner shelf, particularly as juveniles. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for seabirds, Australian Sea Lions, and White Sharks; and a migratory pathway for Humpback and Pygmy Blue Whales.
Perth Canyon	National Park Zone (II) 1241 km² Habitat Protection Zone (IV) 4352 km² Multiple Use Zone (VI) 1816 km²	The Perth Canyon Marine Park is located ~52 km west of Perth and ~19 km west of Rottnest Island. The Marine Park covers an area of 7409 km² and water depths range between 120 m and 5000 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Perth Canyon Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of: • Central Western Province—characterised by a narrow continental slope incised by many submarine canyons, including Perth Canyon, and the most extensive area of continental rise in any of Australia's marine regions. A significant feature within the area are the several eddies that form off the Leeuwin Current at predictable locations, including the Perth Canyon • South-west Shelf Province—marine life in this area is diverse and influenced by the warm waters of the Leeuwin Current • South-west Transition—significant features of this area include the submarine canyons that incise the northern parts of the slope and the deep-water mixing that results from the dynamics of major ocean currents when these meet the sea floor, particularly in the Perth Canyon • South-west Shelf Transition—consists of a narrow continental shelf that is noted for its physical complexity. The Leeuwin Current has a significant influence on the biodiversity of this

AMP	Zones, IUCN categories and zone area	Description	Natural values^
			nearshore area as it pushes subtropical water southward along the area's western edge. The area contains a diversity of tropical and temperate marine life including a large number of endemic fauna species. Key ecological features of the Marine Park are: • Perth Canyon and adjacent shelf break, and other west coast canyons—unique sea floor features give rise to ecologically important events of localised productivity and aggregations of marine life. The Perth Canyon is prominent among these canyons because of its large size and ecological importance. The upwelling of deep ocean currents in the canyon creates a nutrient-rich cold-water habitat that attracts feeding aggregations of deep-diving mammals, such as Pygmy Blue Whales and large predatory fish that feed on aggregations of small fish, krill, and squid • Demersal slope and associated fish communities of the Central Western Province—an area that provides important habitat for demersal fish communities and is characterised by high species diversity and endemism • Western Rock Lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western Rock Lobsters are an important part of the food web on the inner shelf, particularly as juveniles • Mesoscale eddies—important transporters of nutrients and plankton communities that form at predictable locations off the western and south-western shelf break. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for seabirds, Antarctic Blue, Pygmy Blue, and Sperm Whales; a migratory pathway for Humpback, Antarctic Blue, and Pygmy Blue Whales; and a calving buffer area for Southern Right Whales.
South-west Corner	National Park Zone	The South-west Corner Marine Park is located adjacent to	The Marine Park includes examples of ecosystems representative of:

AMP	Zones, IUCN categories and zone area	Description	Natural values^
	(II) 54 841 km² Habitat Protection Zone (IV) 95 088 km² Multiple Use Zone (VI) 106 602 km² Special Purpose Zone (Mining Exclusion) (VI) 9550 km² Special Purpose Zone (VI) 5753 km²	the Western Australian Ngari Capes Marine Park, covering an extensive offshore area that is closest to Western Australia state waters ~48 km west of Esperance, 73 km west of Albany, and 68 km west of Bunbury, and extends to the edge of Australia's exclusive economic zone. The Marine Park covers an area of 271 833 km² and a water depth range from <15 m to 6400 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed South-west Corner Marine Park on 9 October 2017.	• Southern Province—includes the deepest ocean areas of the Australian EEZ, reaching depths of ~5900 m, and is characterised by a long continental slope incised by numerous, well-developed submarine canyons, and the Diamantina Fracture Zone, a rugged area of deep sea floor comprising seamounts and many ridges and troughs • South-west Transition—the main features of this area are the Naturaliste Plateau, the deepest submarine plateau along Australia's continental margins. The Plateau supports rich and diverse biological communities. Deep-water mixing results from the dynamics of major ocean currents when these meet the sea floor South-west Shelf Province—marine life in this area is diverse and influenced by the warm waters of the Leeuwin Current. A small upwelling of nutrient-rich water off Cape Mentelle during summer increases productivity locally, attracting aggregations of marine life. Key ecological features of the Marine Park are: • Albany Canyon group and adjacent shelf break—a feature consisting of 32 canyons cut deeply into the steep continental slope. The canyons are believed to be associated with small periodic upwellings that enhance productivity and attract aggregations of marine life • Cape Mentelle upwelling—draws relatively nutrient-rich water from the base of the Leeuwin Current, up the continental slope, and onto the inner continental shelf, where it results in phytoplankton blooms at the surface • Diamantina Fracture Zone—a unique sea floor feature consisting of a rugged, deep-water environment of seamounts and many closely spaced troughs and ridges. The ridges and seamounts can affect water dynamics and flow, enhancing productivity, and may act as 'stepping stones' for species dispersal and migration across the region and the wider abyssal plain • Naturaliste Plateau—the combination of this unique sea floor feature's structural complexity, mixed water dynamics, and relative isolation indicate that it supports deep-water

AMP	Zones, IUCN categories and zone area	Description	Natural values^
			communities with high species diversity and endemism • Western Rock Lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western Rock Lobsters are an important part of the food web on the inner shelf, particularly as juveniles • Ancient coastline between 90 m and 120 m depth—high benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for seabirds, Australian Sea Lions, White Sharks, and Sperm Whales; a migratory pathway for Antarctic Blue, Pygmy Blue, and Humpback Whales; and a calving buffer area for Southern Right Whales.
Two Rocks	National Park Zone (II) 15 km² Multiple Use Zone (VI) 867 km²	The Two Rocks Marine Park is located 25 km north-west of Perth, to the north-west of the Western Australian Marmion Marine Park. The Marine Park covers an area of 882 km², extending from the Western Australian state water boundary, and a water depth range from 15 m to 120 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Two Rocks Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the South-west Shelf Transition—an area of narrow continental shelf that is noted for its physical complexity. The Leeuwin Current has a significant influence on the biodiversity of this nearshore area as it pushes subtropical water southward along the area's western edge. The area contains a diversity of tropical and temperate marine life including a large number of endemic fauna species. The inshore lagoons are thought to be important areas for benthic productivity and recruitment for a range of marine species. Key ecological features of the Marine Park are: • Commonwealth marine environment within and adjacent to the west coast inshore lagoons—an area that is regionally important for enhanced benthic productivity, including macroalgae and seagrass communities, and breeding and nursery aggregations for many temperate and tropical marine species • Western Rock Lobster—plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western Rock Lobsters are an important part of the

AMP	Zones, IUCN categories and zone area	Description	Natural values^
			food web on the inner shelf, particularly as juveniles • Ancient coastline between 90 m and 120 m depth—high benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment. The Marine Park supports a range of species including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for seabirds and Australian Sea Lions, a migratory pathway for Humpback and Pygmy Blue Whales, and a calving buffer area for Southern Right Whales.

^ Source: Ref. 76.

Table 2-21 Summary of AMPs (North Marine Parks)

AMP Name	Zones, IUCN categories and zone area	Description	Natural values^
Oceanic Shoals	National Park Zone (II) 406 km² Habitat Protection Zone (IV) 6929 km² Multiple Use Zone (VI) 39 964 km² Special Purpose Zone (Trawl) (VI) 24 444 km²	The Oceanic Shoals Marine Park is located west of the Tiwi Islands, ~155 km north-west of Darwin, Northern Territory and 305 km north of Wyndham, Western Australia. It extends to the limit of Australia's exclusive economic zone. The Marine Park covers an area of 71 743 km² and water depths from <15 m to 500 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Oceanic Shoals Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Transition— a dynamic environment influenced by strong tidal currents, upwellings of nutrient-rich waters, and a range of prominent sea floor features. The pinnacles, carbonate banks, and shoals are sites of enhanced biological productivity. Key ecological features of the Marine Park are: • Carbonate bank and terrace systems of the Van Diemen Rise—an area characterised by terraces, banks, channels, and valleys supporting sponges, soft coral, polychaetes, ascidians, turtles, snakes, and sharks • Carbonate bank and terrace system of the Sahul Shelf—an area characterised by terraces, banks, channels, and valleys, supporting sponges, soft corals, sessile filter feeders, polychaetes, and ascidians • Pinnacles of the Bonaparte Basin—an area that contains the largest concentration of pinnacles along the Australian margin, where local upwellings of nutrient-rich water attract aggregations of fish, seabirds, and turtles • Shelf break and slope of the Arafura Shelf—an area characterised by

AMP Name	Zones, IUCN categories and zone area	Description	Natural values^
			continental slope, patch reefs, and hard substrate pinnacles that support >280 demersal fish species. • The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging and internesting habitat for marine turtles.
Joseph Bonaparte Gulf	Multiple Use Zone (VI) 6346 km² Special Purpose Zone (VI) 2251 km²	The Joseph Bonaparte Gulf Marine Park is located ~15 km west of Wadeye, Northern Territory, and ~90 km north of Wyndham, Western Australia, in the Joseph Bonaparte Gulf. It is adjacent to the Western Australian North Kimberley Marine Park. The Marine Park covers an area of 8597 km² and water depth ranges between <15 m and 100 m. The Marine Park was proclaimed under the EPBC Act on 14 December 2013 and renamed Joseph Bonaparte Gulf Marine Park on 9 October 2017.	The Marine Park includes examples of ecosystems representative of the Northwest Shelf Transition— a dynamic environment influenced by strong tidal currents, monsoonal winds, cyclones, and wind-generated waves. The large tidal ranges and wide intertidal zones near the Marine Park create a physically dynamic and turbid marine environment. The key ecological feature in the Marine Park is the carbonate bank and terrace system of the Sahul Shelf—characterised by terraces, banks, channels, and valleys supporting sponges, soft corals, sessile filter feeders, polychaetes, and ascidians. The Marine Park supports a range of species, including species listed as threatened, migratory, marine, or cetacean under the EPBC Act. Biologically important areas within the Marine Park include foraging habitat for marine turtles and the Australian Snubfin Dolphin.

^ Source: Ref. 77.

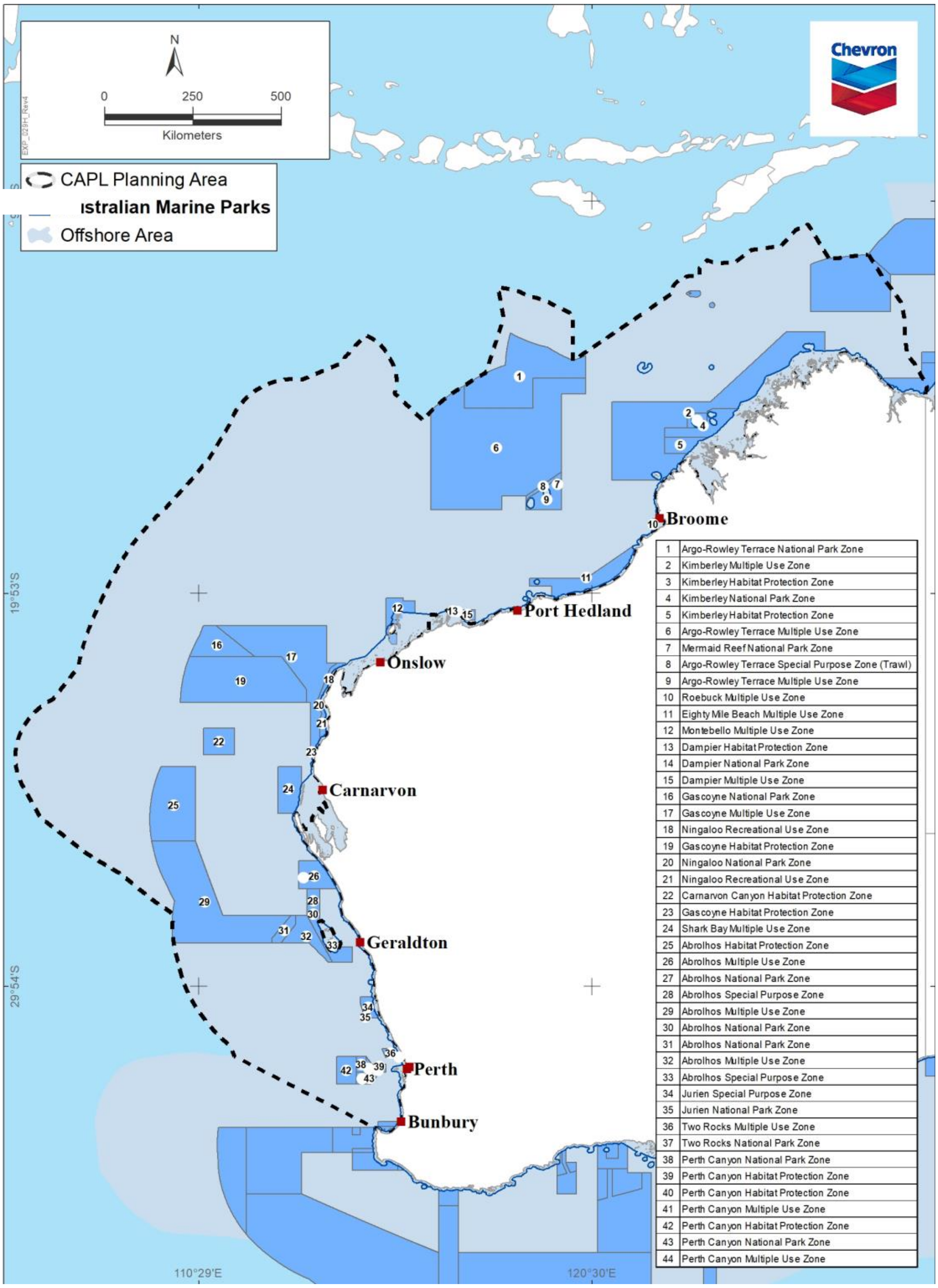


Figure 2-5: Australian Marine Parks

2.7.2 Key ecological features

Key ecological features (KEFs) are elements of the Commonwealth marine environment that are considered to be of regional importance for a region's biodiversity or its ecosystem function and integrity. KEFs meet one or more of these criteria (Ref. 78):

- a species, group of species, or a community with a regionally important ecological role (e.g., a predator, or prey that affects a large biomass or number of other marine species)
- a species, group of species, or a community that is nationally or regionally important for biodiversity
- an area or habitat that is nationally or regionally important for:
  - enhanced or high productivity (such as predictable upwellings—an upwelling occurs when cold nutrient-rich waters from the bottom of the ocean rise to the surface)
  - aggregations of marine life (such as feeding, resting, breeding or nursery areas)
  - biodiversity and endemism (species that only occur in a specific area)
- a unique sea floor feature, with known or presumed ecological properties of regional significance.

KEFs have been identified by the Australian Government on the basis of advice from scientists about the ecological processes and characteristics of the area (Ref. 78).

Table 2-22, Table 2-23, and Table 2-24 list the KEFs located within the PA (Ref. 78; Ref. 4; appendix a).

Table 2-22: Key ecological features of the North-west Marine Bioregion

KEF	Value	Description^
Ancient coastline at 125 m depth contour	Unique sea floor feature with ecological properties of regional significance	Parts of the ancient coastline, particularly where it exists as a rocky escarpment, are thought to provide biologically important habitats in areas otherwise dominated by soft sediments. The topographic complexity of these escarpments may also facilitate vertical mixing of the water column, providing relatively nutrient-rich local environments.
Ashmore Reef and Cartier Island and surrounding Commonwealth waters	High productivity and aggregations of marine life	Ashmore Reef is the largest of only three emergent oceanic reefs present in the north-eastern Indian Ocean and is the only oceanic reef in the region with vegetated islands. Ashmore Reef and Cartier Island and the surrounding Commonwealth waters are regionally important for feeding and breeding aggregations of birds and other marine life; they are areas of enhanced primary productivity in an otherwise low-nutrient environment. Ashmore Reef supports the highest number of coral species of any reef off the west Australian coast.
Canyons linking the Argo Abyssal Plain with the Scott Plateau	High productivity and aggregations of marine life	The canyons linking the Argo Abyssal Plain and Scott Plateau are important features likely to be associated with aggregations of marine life.
Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula	Unique sea floor features with ecological properties of regional significance	The canyons are associated with upwelling as they channel deep water from the Cuvier Abyssal Plain up onto the slope. This nutrient-rich water interacts with the Leeuwin Current at the canyon heads. Aggregations of Whale Sharks, manta rays, sea snakes, sharks, large predatory fish, and seabirds are known to occur in this area.

KEF	Value	Description^
Carbonate bank and terrace system of the Sahul Shelf	Unique sea floor feature with ecological properties of regional significance	Little is known about the bank and terrace system of the Sahul Shelf, but it is regionally important because of its likely ecological role in enhancing biodiversity and local productivity relative to its surrounds. The banks are thought to support a high diversity of organisms (including reef fish, sponges, soft and hard corals, gorgonians, bryozoans, ascidians, and other sessile filter feeders). The banks are known to be foraging areas for Loggerhead, Olive Ridley, and Flatback Turtles. Cetaceans and Green and Freshwater Sawfish are likely to occur in the area.
Commonwealth waters adjacent to Ningaloo Reef	High productivity and aggregations of marine life	The Leeuwin and Ningaloo currents interact, leading to areas of enhanced productivity in the Commonwealth waters adjacent to Ningaloo Reef. Aggregations of Whale Sharks, manta rays, Humpback Whales, sea snakes, sharks, large predatory fish, and seabirds are known to occur in this area.
Continental Slope Demersal Fish Communities	High levels of endemism	The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition, and the Northwest Province is high compared to elsewhere along the continental slope.
Exmouth Plateau	Unique sea floor feature with ecological properties of regional significance	The Exmouth Plateau is a regionally and nationally unique deep-sea plateau in tropical waters. The plateau is a very large topographic obstacle that may modify the flow of deep waters, generating internal tides and may contribute to upwelling of deeper water nutrients closer to the surface, thus serving an important ecological role.
Glomar Shoals	High productivity and aggregations of marine life	The Glomar Shoals are regionally important for their high biological diversity and high localised productivity. Biological data specific to Glomar Shoals is limited; however, the fish of Glomar Shoals are probably a subset of reef-dependent species and anecdotal and fishing industry evidence suggests they are particularly abundant.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	High productivity and aggregations of marine life	The reefs of the Rowley Shoals (including Mermaid Reef) are areas of enhanced productivity and high species richness. Enhanced productivity that contributes to this species richness is thought to be facilitated by the breaking of internal waves in the waters surrounding the reefs, causing mixing and resuspension of nutrients from water depths of 500–700 m into the photic zone. The steep changes in slope around the reef also attract a range of migratory pelagic species such as dolphins, tuna, billfish, and sharks.
Pinnacles of the Bonaparte Basin	Unique sea floor feature with ecological properties of regional significance	As they provide areas of hard substrate in an otherwise relatively featureless environment, the pinnacles are likely to support a high number of species, although a better understanding of the species richness and diversity associated with these structures is required. Covering >520 km^2 within the Bonaparte Basin, this feature contains the largest concentration of pinnacles along the Australian margin. The pinnacles of the Bonaparte Basin are thought to be the eroded remnants of

KEF	Value	Description^
		underlying strata; it is likely that the vertical walls generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish, seabirds, and foraging turtles.
Seringapatam Reef and Commonwealth waters in the Scott Reef Complex	High productivity and aggregations of marine life	Seringapatam Reef and the Commonwealth waters in the Scott Reef complex are regionally important in supporting the diverse aggregations of marine life, high primary productivity, and high species richness associated with the reefs themselves. As two of the few offshore reefs in the north-west, they provide an important biophysical environment in the region.
Wallaby Saddle	High productivity and aggregations of marine life	The Wallaby Saddle may be an area of enhanced productivity. Historical whaling records provide evidence of Sperm Whale aggregations in the area of the Wallaby Saddle, possibly due to the enhanced productivity of the area and aggregations of baitfish.

^ Source: Ref. 79.

Table 2-23: Key ecological features of the North Marine Bioregion

KEF	Value	Description^
Carbonate bank and terrace system of the Van Diemen Rise	Unique sea floor feature with ecological properties of regional significance	The bank and terrace system of the Van Diemen Rise is part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east; it is characterised by terrace, banks, channels, and valleys. The variability in water depth and substrate composition may contribute to the presence of unique ecosystems in the channels. Species present include sponges, soft corals, and other sessile filter feeders associated with hard substrate sediments of the deep channels; epifauna and infauna include polychaetes and ascidians. Olive Ridley Turtles, sea snakes, and sharks are also found associated with this feature.
Pinnacles of the Bonaparte Basin	Unique sea floor feature with ecological properties of regional significance	As they provide areas of hard substrate in an otherwise relatively featureless environment, the pinnacles are likely to support a high number of species, although a better understanding of the species richness and diversity associated with these structures is required. Covering >520 km^2 within the Bonaparte Basin, this feature contains the largest concentration of pinnacles along the Australian margin. The pinnacles of the Bonaparte Basin are thought to be the eroded remnants of underlying strata; it is likely that the vertical walls generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish, seabirds, and foraging turtles.

^ Source: Ref. 80.

Table 2-24: Key ecological features of the South-west Marine Bioregion

KEF	Value	Description^
Ancient coastline at 90–120 m depth	Relatively high productivity and aggregations of marine life, and high levels of biodiversity and endemism	Benthic biodiversity and productivity occur where the ancient coastline forms a prominent escarpment, such as in the western Great Australian Bight, where the sea floor is dominated by sponge communities of significant biodiversity and structural complexity.
Cape Mentelle upwelling	High productivity and aggregations of marine life	The Cape Mentelle upwelling draws relatively nutrient-rich water from the base of the Leeuwin Current, up the continental slope, and onto the inner continental shelf, where it results in phytoplankton blooms at the surface. The phytoplankton blooms provide the basis for an extended food chain characterised by feeding aggregations of small pelagic fish, larger predatory fish, seabirds, dolphins, and sharks.
Commonwealth marine environment surrounding the Houtman Abrolhos Islands	High levels of biodiversity and endemism	The Houtman Abrolhos Islands and surrounding reefs support a unique mix of temperate and tropical species, resulting from the southward transport of species by the Leeuwin Current over thousands of years. The Houtman Abrolhos Islands are the largest seabird breeding station in the eastern Indian Ocean. They support more than one million pairs of breeding seabirds.
Commonwealth marine environment within and adjacent to Geographe Bay	High productivity and aggregations of marine life, and high levels of biodiversity and endemism	Geographe Bay is known for its extensive beds of tropical and temperate seagrass that support a diversity of species, many of them not found anywhere else. The bay provides important nursery habitat for many species. It is also an important migratory area for Humpback Whales.
Commonwealth marine environment within and adjacent to the west coast inshore lagoons	High productivity and aggregations of marine life	These lagoons are important for benthic productivity, including macroalgae and seagrass communities, and breeding and nursery aggregations for many temperate and tropical marine species. They are important areas for the recruitment of commercially and recreationally important fishery species. Extensive schools of migratory fish visit the area annually, including herring, garfish, tailor, and Australian Salmon.
Naturaliste Plateau	Unique sea floor feature with ecological properties of regional significance	The Naturaliste Plateau is Australia's deepest temperate marginal plateau. The combination of its structural complexity, mixed water dynamics, and relative isolation indicate that it supports deep-water communities with high species diversity and endemism.
Meso-scale eddies (several locations)	High productivity and aggregations of marine life	Driven by interactions between currents and bathymetry, persistent meso-scale eddies form in predictable locations within the meanders of the Leeuwin Current. They are important transporters of nutrients and plankton communities and are likely to attract a range of organisms from the higher trophic levels, such as marine mammals, seabirds, tuna and billfish. The eddies play a critical role in determining species distribution, as they influence the southerly range boundaries of tropical and subtropical species, the transport of

KEF	Value	Description^
		coastal phytoplankton communities offshore and recruitment to fisheries.
Perth Canyon and adjacent shelf break, and other west coast canyons	High biological productivity and aggregations of marine life, and unique sea floor features with ecological properties of regional significance	The Perth Canyon is the largest known undersea canyon in Australian waters. Deep ocean currents rise to the surface, creating a nutrient-rich cold-water habitat attracting feeding aggregations of deep-diving mammals, such as Pygmy Blue Whales and large predatory fish that feed on aggregations of small fish, krill, and squid.
Western demersal slope and associated fish communities	Species groups that are nationally or regionally important to biodiversity	The western demersal slope provides important habitat for demersal fish communities, with a high level of diversity and endemism. A diverse assemblage of demersal fish species below a depth of 400 m is dominated by relatively small benthic species such as grenadiers, dogfish, and cucumber fish. Unlike other slope fish communities in Australia, many of these species display unique physical adaptations to feed on the sea floor (such as a mouth position adapted to bottom feeding), and many do not appear to migrate vertically in their daily feeding habits.
Western Rock Lobster	A species that plays a regionally important ecological role	This species is the dominant large benthic invertebrate in the region. The lobster plays an important trophic role in many of the inshore ecosystems of the South-west Marine Region. Western rock lobsters are an important part of the food web on the inner shelf, particularly as juveniles.

^ Source: Ref. 81.

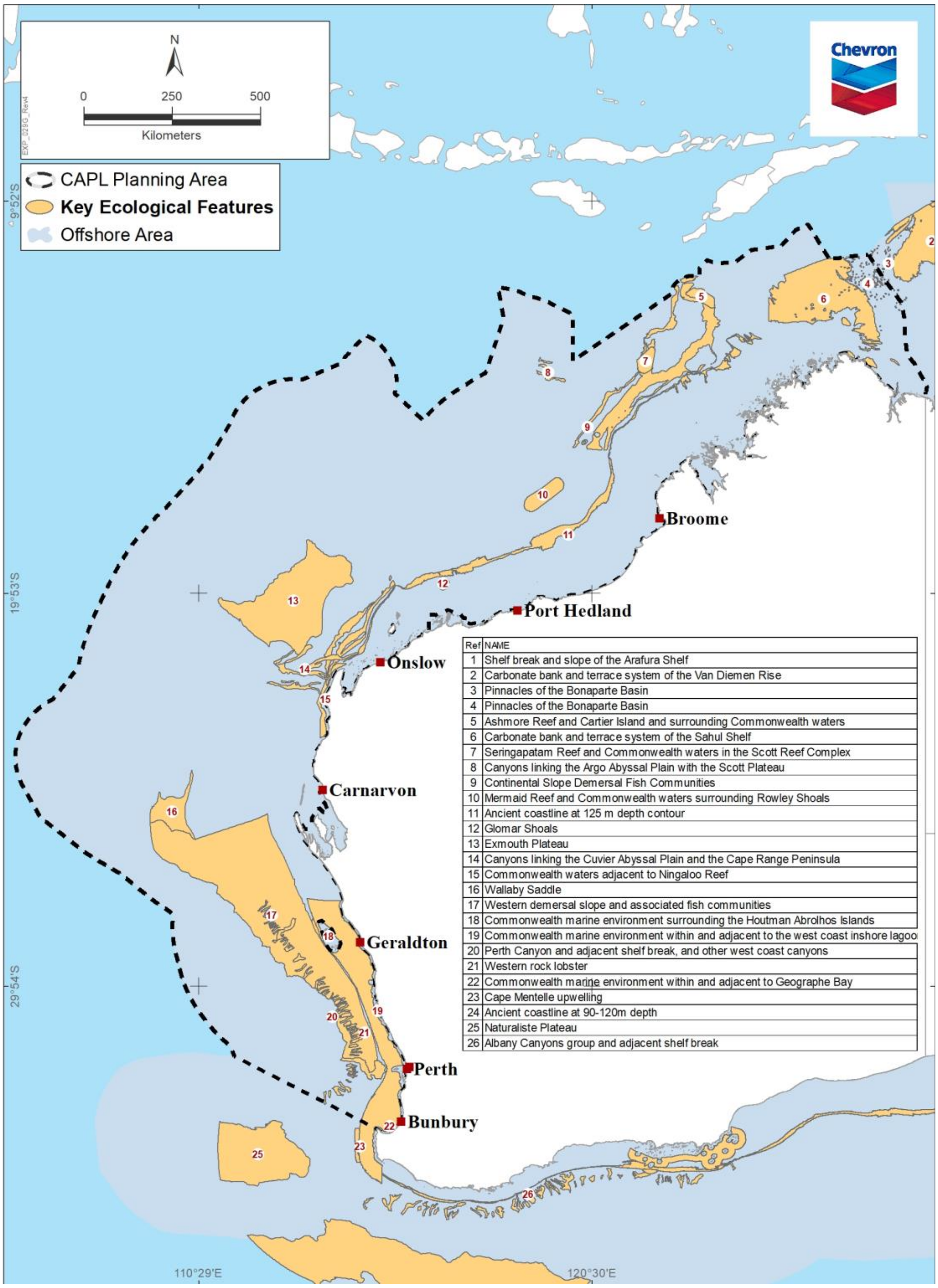


Figure 2-6: Key ecological features

3 Physical environment

3.1 Meteorology

Northwest WA is characterised by an arid, subtropical climate. In summer (between September and March), average daily temperatures range from 21 °C to 36 °C. During winter (May to July), mean daily temperatures range from 14 °C to 29 °C (Ref. 82; Ref. 83). April and August are considered transitional months during which either the summer or winter weather regime may dominate, or conditions may vary between the two (Ref. 83). The area receives relatively low rainfall, although heavy downpours can occur during tropical cyclones and depressions.

Wind patterns in north-west WA are dictated by the seasonal movement of atmospheric pressure systems. During summer, high-pressure cells produce prevailing winds from the north-west and south-west, which vary between 10 and 13 ms^{-1}. During winter, high-pressure cells over central Australia produce north-easterly to south-easterly winds with average speeds of between 6 and 8 ms^{-1}.

The cyclone season in north-west WA runs from November to April, with an average of five tropical cyclones per year (Ref. 84). Summer thunderstorms can have associated winds with gusts exceeding 20 ms^{-1}, but these winds are usually of short duration.

The air quality in the North-west Marine Region is largely unpolluted due to the Region's relative remoteness.

3.2 Oceanography

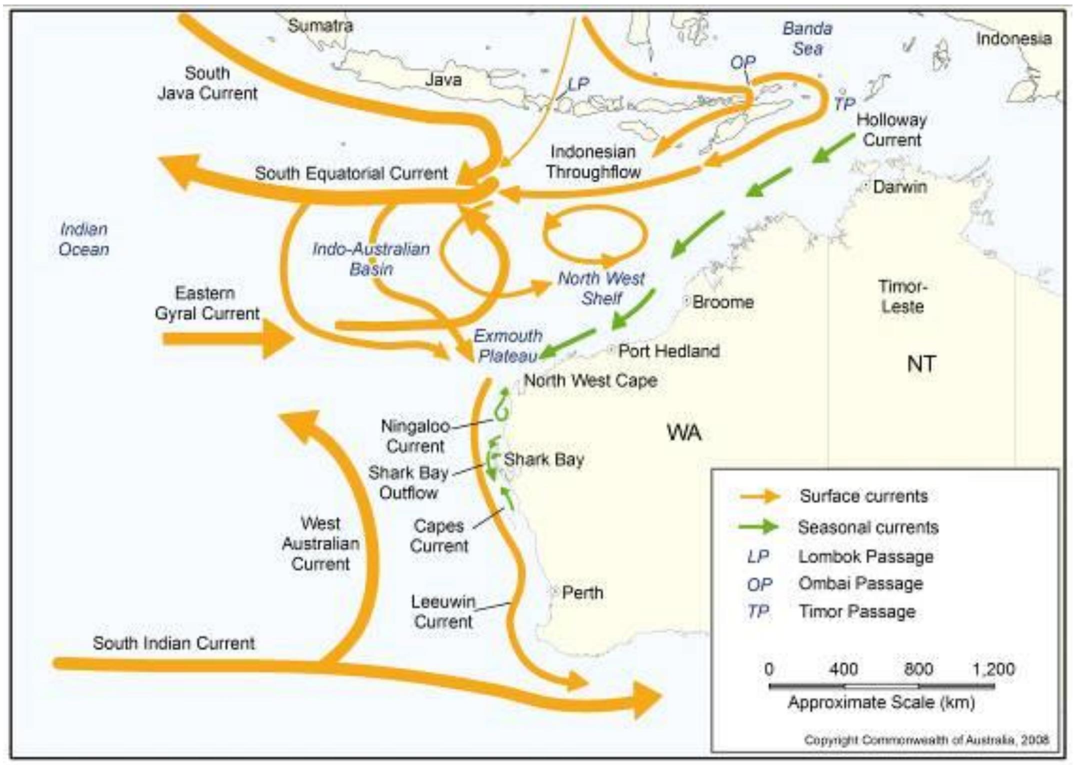
3.2.1 Water temperature

Waters in north-west WA are tropical year-round, with sea surface temperature in open shelf waters reaching ~26 °C in summer, and dropping to ~22 °C in winter. Nearshore temperatures of north-west WA fluctuate through a higher temperature range from ~17 °C in winter to ~31 °C in summer (Ref. 85).

3.2.2 Circulation and currents

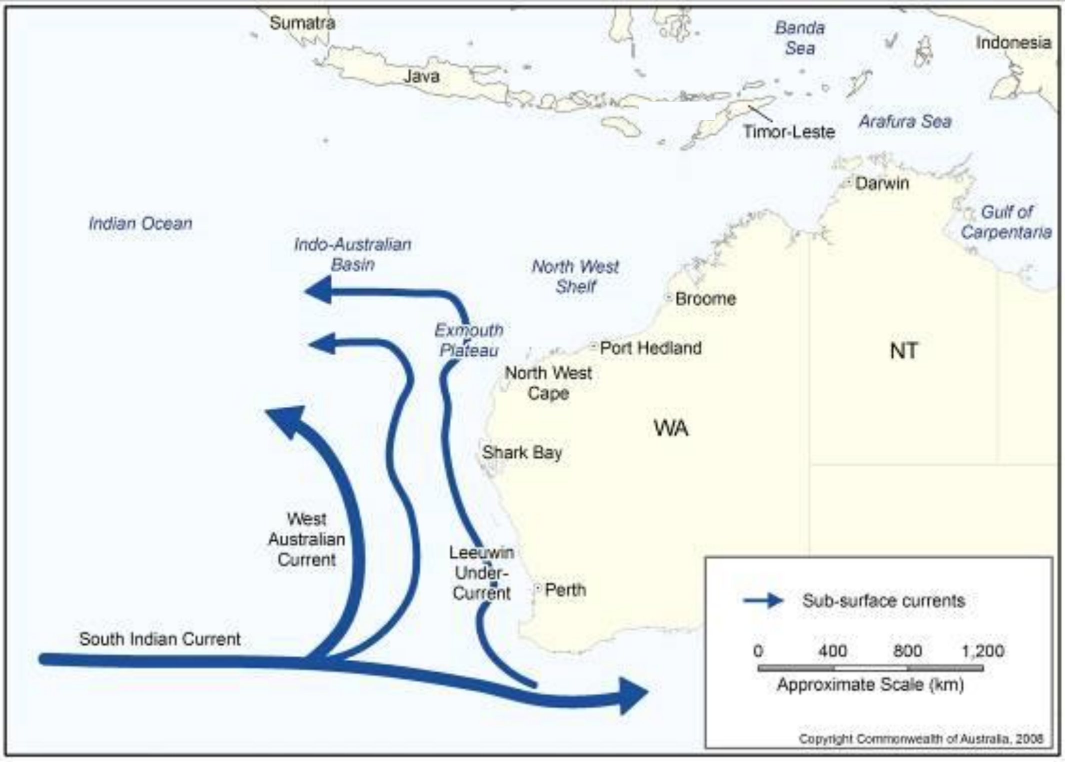
The major surface currents influencing north-west WA flow towards the poles and include the Indonesian Throughflow, the Leeuwin Current, the South Equatorial Current, and the Eastern Gyral Current. The Ningaloo Current, the Holloway Current, the Shark Bay Outflow, and the Capes Current are seasonal surface currents in the region. Below these surface currents are several subsurface currents, the most important of which are the Leeuwin Undercurrent and the West Australian Current. These subsurface currents flow towards the equator in the opposite direction to surface currents (Ref. 79). Figure 3-1 and Figure 3-2 show the main surface and subsurface currents in north-west WA.

Water circulation in north-west WA is strongly influenced by the southward-flowing Indonesian Throughflow. The strength of the Throughflow, and its influence in north-west WA, varies seasonally in association with the north-west monsoon (Ref. 79).



(Source: Ref. 79)

Figure 3-1: Surface and seasonal currents in the region



(Source: Ref. 79)

Figure 3-2: Subsurface currents in the region

3.2.3 Waves

The prevailing oceanic conditions in north-west WA are governed by a combination of sea and swell waves. Local wind-generated seas have variable wave heights, typically ranging from 0 to 4 m under non-tropical cyclone conditions. North-west WA typically experiences a persistent winter swell of ~2 m, generated by low-pressure systems in southern latitudes.

3.2.4 Tides

North-west WA has some of the largest tides along a coastline adjoining an open ocean in the world. Tides increase in amplitude from south to north, corresponding with the increasing width of the continental shelf (Ref. 79). Tidal movements are larger and stronger in the nearshore waters compared to the offshore waters. Tides in the region are broadly categorised as semidiurnal (i.e. two high tides and two low tides per day) with a spring/neap cycle (Ref. 79).

3.3 Marine water quality

3.3.1 Nutrients

North-west WA's surface waters are nutrient-poor due to the Indonesian Throughflow dominating the surface waters of the entire region.

Sporadic and variable nutrient loadings may occur within coastal waters due to changes in river run-off (e.g. Ashburton River), blooms of nitrogen-fixing microbes, tidal mixing, low-frequency circulation, and habitat influences (i.e. mangroves) (Ref. 86).

3.3.2 Turbidity

Water clarity in north-west WA varies according to water movement, depth, and seabed sediment type. Nearshore waters in the region may be relatively turbid as a result of local current-induced resuspension of fine sediments and episodic run-off from adjacent rivers, although there is high spatial and temporal variation. However, some protected coastal areas, such as the lagoon system of the fringing Ningaloo Reef, can be characterised by relatively clear water with low turbidity.

3.3.3 Water chemistry

Salinity varies spatially and temporally in the waters across north-west WA. Water salinity varies between 34.4 and 36.3 g/L in offshore waters around the North West Shelf (Ref. 87).

Wenziker *et al.* (Ref. 87) estimated natural background concentrations for a range of potential contaminants in the waters around the Dampier Archipelago, thus providing baseline information as to the water quality within nearshore waters of the North West Shelf. The contaminants investigated encompassed a range of heavy metals (e.g. cadmium, chromium, copper, lead, mercury, and zinc) and organic chemicals (e.g. polycyclic aromatic hydrocarbons, total petroleum hydrocarbons). The survey identified low background concentrations of metals and organic chemicals, with localised elevations of some contaminants (metals) near the coastal industrial centres and ports (e.g. Dampier). Except for a few select constituents, such as relatively high natural levels of cadmium, the concentrations of metals were low by world standards. Wenziker *et al.* (Ref. 87) recommended that guideline water quality trigger values from the Australian and New Zealand Environment and Conservation Council and Agriculture and

Resource Management Council of Australia and New Zealand (Ref. 88) are suitable for use in the North West Shelf.

3.3.4 Marine geomorphology

The sea floor of north-west WA comprises four general feature types: continental shelf, continental slope, continental rise, and abyssal plain. Most of the region is either continental slope or continental shelf.

3.4 Seabed features

The geomorphology of Australia's continental margin is varied, with several geomorphic features present, including basins, canyons, terraces, seamounts, and plateaus. The key geomorphic features (Ref. 89) that were mapped as potentially occurring within the PA, are:

- abyssal plain/deep ocean floor
- apron/fan
- bank/shoals
- basin
- canyon.

3.5 Marine habitat

The Seamap Australia spatial data layer is a nationally synthesised data product of sea floor marine habitat data (Ref. 90). Australian continental shelf benthic habitat layers in GIS format were collected from various stakeholders around the country, compiled and reviewed by Australian National Data Service and external independent assessors, to produce a national classification of marine habitats.

Seamap Australia spatial data were used to indicate the types of marine habitat present within the PA. Table 3-1 summarises the areas of marine habitat associated with the matters of NES identified in this document.

Table 3-1: Marine habitat and key sensitivities

Matter of national environmental significance	Key sensitivities							Habitat type				
	AMP	KEF	Ramsar wetland	National Heritage	Commonwealth Heritage	World Heritage	TEC	Seagrass	Mangrove	Coral	Saltmarsh	Macroalgae
Ashmore Reef	☒							☒		☒		
Ashmore Reef and Cartier Island and surrounding Commonwealth waters		☒								☒		
Ashmore reef National Nature Reserve			☒							☒		

Matter of national environmental significance	Key sensitivities							Habitat type				
	AMP	KEF	Ramsar wetland	National Heritage	Commonwealth Heritage	World Heritage	TEC	Seagrass	Mangrove	Coral	Saltmarsh	Macroalgae
Ashmore Reef National Nature Reserve					☒					☒		
Carbonate bank and terrace system of the Sahul Shelf		☒								☒		
Carbonate bank and terrace system of the Van Diemen Rise		☒								☒		
Cartier Island	☒							☒		☒		
Commonwealth marine environment in and adjacent to Geographe Bay		☒						☒				
Commonwealth marine environment in and adjacent to the west coast inshore lagoons		☒						☒				☒
Eighty-mile Beach			☒						☒		☒	
Geographe	☒							☒				
Joseph Bonaparte Gulf	☒									☒		
Mermaid Reef – Rowley Shoals					☒					☒		
Ningaloo Coast				☒						☒		
Ningaloo Coast						☒			☒	☒		
Ningaloo Marine Area – Commonwealth Waters					☒					☒		
Oceanic Shoals	☒									☒		
Ord River Floodplain			☒						☒		☒	
Roebuck Bay			☒					☒	☒			
Scott Reef and Surrounds – Commonwealth Area					☒			☒		☒		
Shark Bay						☒		☒				
Shark Bay (Wooramel Seagrass Bank)				☒				☒				
Subtropical and Temperate Coastal Saltmarsh							☒				☒	

Matter of national environmental significance	Key sensitivities							Habitat type				
	AMP	KEF	Ramsar wetland	National Heritage	Commonwealth Heritage	World Heritage	TEC	Seagrass	Mangrove	Coral	Saltmarsh	Macroalgae
The West Kimberley				☒					☒	☒		
Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond)							☒					☒
Two Rocks	☒							☒				☒

3.6 Shoreline type

The Smartline Coastal Geomorphic Map of Australia (Ref. 91) is a detailed map of the coastal landform types—or geomorphology—of continental Australia and most of its adjacent islands. Using the intertidal classifications provided by the Smartline database, the types of shoreline that are present within the PA, their overall length, and percentage present in the PA is listed in Table 3-2.

Table 3-2: Shoreline type and length within PA

Shoreline type	Length (100 kms)
Unclassified	4608.46
Muddy tidal flats	2162.74
Hard bedrock shore	2151.61
Tidal flats (sediment undifferentiated)	1811.23
Sandy beach undifferentiated	966.09
Fine-medium sand beach	400.78
Hard rock cliff (>5 m)	248.45
Tidal sediment flats (inferred from mangroves)	192.49
Beach (sediment type undifferentiated)	161.49
Fine-medium sandy tidal flats	137.94
Sandy shore undifferentiated	102.32
Sandy tidal flats	68.28
Mixed sandy shore undifferentiated	37.96
Hard rocky shore platform	21.59
Artificial shoreline undifferentiated	13.87
Rocky shore (undifferentiated)	8.84
Boulder revetment	6.98
Sandy tidal flats with coarse stony debris	3.87

Shoreline type	Length (100 kms)
Perched sandy beach (undifferentiated)	2.81
Soft ‘bedrock’ shore	0.39
Concrete dock structures	0.23
Coral shingle beach	0.21

4 Socioeconomic environment

4.1 Commercial shipping

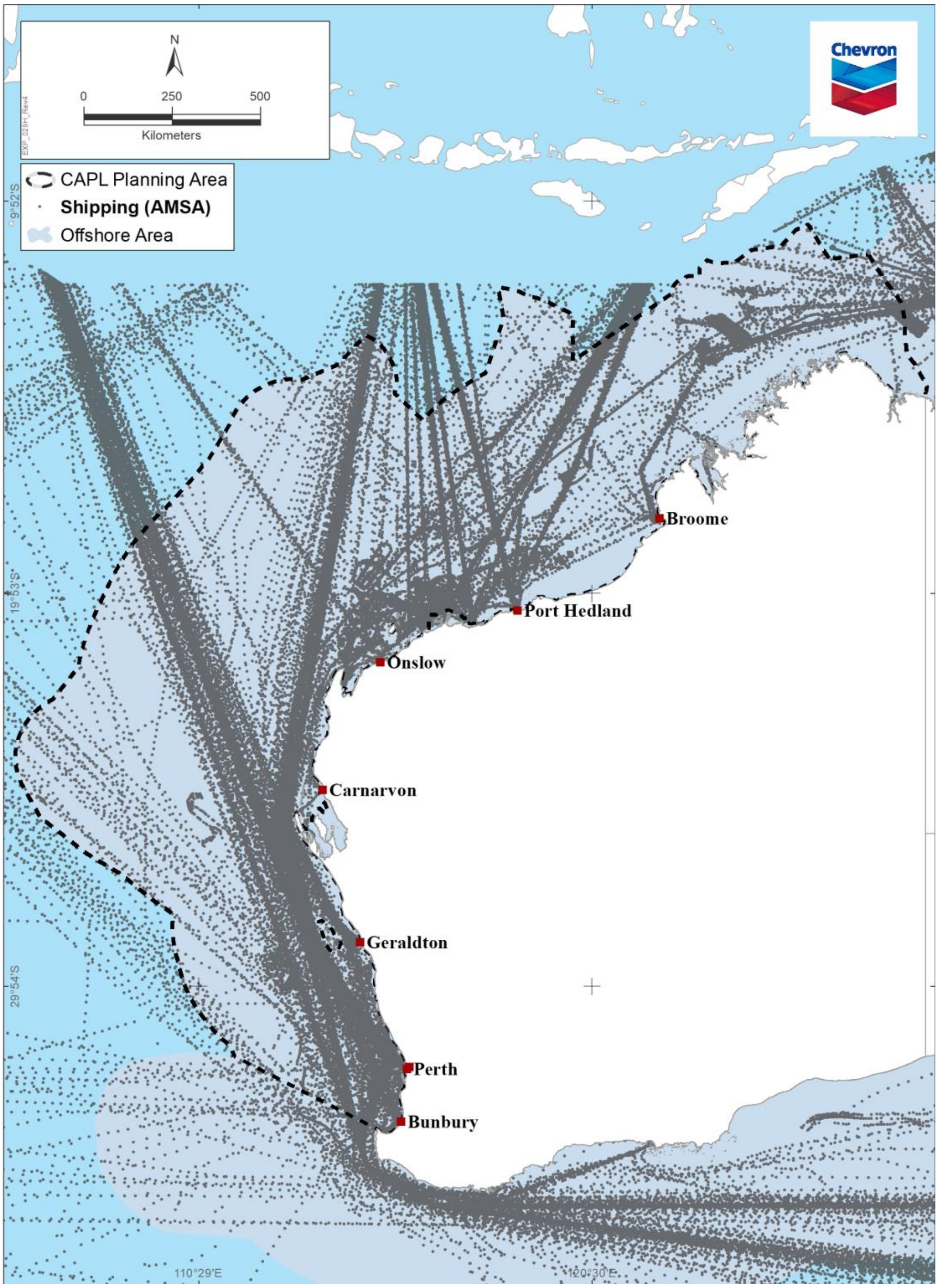
The Australian Maritime Safety Authority (AMSA) uses a satellite automatic identification system (AIS) service that provides AIS data across the Indo-Pacific and Indonesian region. The AIS can send and receive ship information (such as identity, position, course, speed, ship particulars, and cargo information) to and from other ships, suitably equipped aircraft, and shore. It can handle >2,000 reports per minute and updates information as often as every two seconds. Although the AIS is conventionally a line-of-sight radio broadcast system for communication between ships, and between ships and shore stations, recent technological developments have seen satellites adapted for receiving AIS messages from low Earth orbit.

Data provided by shipborne AISs were used to build a point density map from filtered satellite AIS data collected between 1 January 2016 and 31 December 2016 to indicate the level of shipping activity in Australian waters (Ref. 92).

Given the size of the PA, CAPL has reviewed this shipping density information to understand areas within the PA that comprise high activity and are important for the WA economy. Based on this data, the key shipping channels are those between:

- Fremantle, Dampier, and Port Hedland ports to Indonesia
- Fremantle, Dampier, and Port Hedland ports to Timor
- Port of Dampier to various offshore oil and gas developments.

The map also reflects the vessel density in and around known oil and gas facilities and developments within the PA (Figure 4-1).



(Source: Ref. 92)

Figure 4-1: Commercial shipping

4.2 Commercial fishing and aquaculture

Fishing and aquaculture activities are managed under various State and Commonwealth agencies. Table 4-1 and Table 4-2 list and summarise the State and Commonwealth managed fisheries that overlap the PA (Ref. 93; Ref. 94)

Table 4-1: State managed fisheries

Fishery	2019–2020 season summary^
Abalone	The 2019–2020 fishing season reported a commercial catch of 47 t. Catch was below TACC due to low catches in regional areas resulting from economic and accessibility issue.
Abrolhos Islands and Mid-West Trawl	The 2019–2020 fishing season reported a commercial catch of 796 t. Catch within acceptable range. The commercial fishery is in a planned expansion phase.
Broome Prawn	The 2019–2020 fishing season reported a negligible commercial catch. Minimal fishing occurred in 2019.
Cockburn Sound (Crab)	The fishery has been closed since April 2014. In 2019 recruitment and egg production remained below limit reference levels. Decline is consistent with an environmentally limited stock.
Cockburn Sound (Fish Net)	The 2019–2020 fishing season reported a commercial catch of 253 t (nearshore fisheries, total finfish). Metro Zone Garfish fishery closed in 2017. Declines in Garfish and Whitebait consistent with an environmentally limited stock. Review of acceptable catch ranges is required.
Cockburn Sound (Line and Pot)	The Cockburn Sound Line and Pot Managed Fishery record a catch of 32 t during 2018/10.
Exmouth Gulf Prawn	The 2019–2020 fishing season reported a commercial catch of 821 t. All species were within their acceptable catch ranges.
Inner Shark Bay Demersal	The 2019–2020 fishing season reported a commercial catch of 1 t. Incidental catch. Not considered a risk to stocks.
Gascoyne Demersal Scalefish	The 2019–2020 fishing season reported a commercial catch of 33.2 t of Snapper, and 139 t of other demersal species. Snapper spawning biomass was around the limit level. Additional management action undertaken in 2018 including TACC reduction. Management for other demersals adequate.
Kimberley Crab	The 2019–2020 fishing season reported a commercial catch of 7.4 t (Mud Crab). Catch rate: Below threshold, above limit.
Kimberley Gillnet and Barramundi	The 2019–2020 fishing season reported a commercial catch of 47 t (barramundi), and 73 t (total). Catch is above the acceptable range. The level of catch is lower than previous years, and is not considered a risk to stocks as the catch rate remains high.
Kimberley Prawn	The 2019–2020 fishing season reported a commercial catch of 100 t. Banana prawn catch well below acceptable and predicted range. Low effort in 2019.
Mackerel Fishery	The 2019–2020 fishing season reported a commercial catch of 291 t. The Spanish Mackerel catch is within tolerance range due to increased effort in 2019. Nominal catch rates declined in each area.
Marine Aquarium	The 2019 fishing season reported a commercial catch of 11.925 fish.
Nickol Bay Prawn	The 2019–2020 fishing season reported a commercial catch of 254 t. Catch within acceptable range. Banana prawn catches higher than predicted.
Northern Demersal Scalefish	The 2019–2020 fishing season reported a commercial catch of 1,507 t (total), 602 t (Goldband Snapper), 192 t (Red Emperor). Goldband Snapper and Red Emperor catches are above their catch ranges. Catches will be monitored closely in 2020.
Octopus	The 2019–2020 fishing season reported a commercial catch of 453 t. Catch was below TACC due to low catches in regional areas resulting from economic and accessibility issues.

Fishery	2019–2020 season summary^
Onslow Prawn	The 2019–2020 fishing season reported a commercial catch <60 t. Low effort by one boat in 2019.
Pearl Oyster Wildstock	The 2019–2020 fishing season reported a commercial catch of 611,816 oysters (14,022 dive hours). Catch below quota as MOP component was not fully utilised. Catch rates increased from 2018 to 2019.
Pilbara Crab	The 2019 fishing season reported a commercial catch of 19.3 t (Blue Swimmer Crab). Catch rate: Above threshold.
Pilbara Fish Trawl	The 2019–2020 fishing season reported a commercial catch of 2,142 t. Catches are increasing as the demersal scalefish assemblage in the Pilbara region recovers following effort reductions.
Pilbara Trap	The 2019–2020 fishing season reported a commercial catch of 680 t. Catches are increasing as the demersal scalefish assemblage in the Pilbara region recovers following effort reduction.
Pilbara Line	The 2019–2020 fishing season reported a commercial catch of 148 t. Catches are increasing as the demersal scalefish assemblage in the Pilbara region recovers following effort reduction.
Shark Bay Beach Seine and Mesh Net	The 2019–2020 fishing season reported a commercial catch of 175 t. Catch below the acceptable range due to ongoing low levels of effort.
Shark Bay Crab	The 2019–2020 fishing season reported a commercial catch of 529 t. Catch within acceptable range. Spawning and recruitment levels have further increased under the current environmental conditions and harvest levels.
Shark Bay Prawn	The 2019–2020 fishing season reported a commercial catch of 1.214 t. Brown tiger and western king prawn catches below the acceptable range due to lower recruitment levels. Additional management measures were implemented within the season to protect breeding stocks.
Shark Bay Scallop	The 2019–2020 fishing season reported a commercial catch of 657 t (to end of December). . Quota season extended to 30 April. Catch achieved to end of February from Denham Sound is estimated to be 1,370 t and that >90% of the total will be achieved. Northern Shark Bay closed to fishing due to recruitment below limit reference level. Decline is consistent with an environmentally limited stock and continues to be investigated.
Southern Demersal Gillnet & Demersal Longline West Coast Demersal Gillnet & Demersal Longline	The Temperate Demersal Gillnet and Demersal Longline Fishery (TDGDLF) comprises the West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery (WCDGDLF), which operates between 26° and 33°S, and the Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery (JASDGDLF), which operates from 33°S to the WA/SA border. The 2018–2019 fishing season reported a commercial catch of 838 t (sharks and rays) and 132 t (scalefish).
South West Coast Salmon / South Coast Salmon	The 2017–2018 fishing season for the South West Coast Salmon and South Coast Salmon reported a commercial catch of 50 t and 93 t respectively. In 2017, there were ~12 commercial fishers employed in the South Coast Salmon Fishery.
South West Trawl	Only one boat fished in the SWTMF in 2019 for a total of 32 boat days.
Specimen Shell	The 2019 fishing season reported a commercial catch of 7,232 shells.
West Coast Deep Sea Crustacean	The 2019–2020 fishing season reported a commercial catch of 155.7 t. TAC achieved with effort within acceptable range. The standardised catch rate of retained legal crabs is within the acceptable range.

Fishery	2019–2020 season summary^
West Coast Demersal Scalefish	The 2019–2020 fishing season reported a commercial catch of 270 t. Demersal suite catch within range.
West Coast Estuarine	The 2019–2020 fishing season reported a commercial catch of 66 t (Peel Harvey crab), 121 t (Peel Harvey finfish), and 35 t (other West Coast estuaries, crabs, and finfish). Catch and catch rates within acceptable ranges.
West Coast Purse Seine	The 2019–2020 fishing season reported a commercial catch of 527 t (all species). Catch was below quota.
West Coast Rock Lobster	The 2019–2020 fishing season reported a commercial catch of 6400 t. Catch within TACC plus 1.5% water loss i.e. 6400 t.
Western Australian Sea Cucumber	The 2019–2020 fishing season reported a commercial catch of 2 t (Sandfish), and 5 t (Redfish). Limited fishing due to due to planned rotational harvest schedule by industry.

^ *Source: Ref. 95.*

Table 4-2: Commonwealth managed fisheries

Fishery	2018–2019 season summary^
North-West Slope Trawl Fishery	The 2018–2019 fishing season reported a commercial catch of 41.1 t (scampi) and 67.4 t (total), with economic value withheld. The fishery recorded 151 active days comprising 2,869 trawl-hours. Seven permits were in place with four vessels active for the season.
Small Pelagic Fishery	The 2018–2019fishing season reported a commercial catch of 16,093 t. The fishery recorded 197 search-hours with 448 midwater trawl shots. In 2018–2019, 31 entities held quota statutory fishing right (SFRs), with three vessels actively using purse seine methods and one using trawl methods.
Southern Bluefin Tuna Fishery	The 2018–2019fishing season reported a commercial catch of 6,074 t worth an estimated AU$43.41 million. The fishery recorded 1,366 search-hours with 166 shots. In 2018–2019, 82 entities held quota SFRs, with seven vessels actively using purse seine methods and 20 using longline methods.
Western Deepwater Trawl Fishery	The 2018–2019fishing season reported a commercial catch of 53 t with economic value withheld. The fishery recorded 53 active days comprising 492.3 trawl-hours. Four permits were in place with one vessels active for the season.
Western Skipjack Fishery	There has been no fishing effort in the Skipjack Tuna Fishery (STF) since the 2008–2009 fishing season. Variability in the availability of skipjack tuna in the Australian Fishing Zone and the prices received for product influence participation levels in the fishery.
Western Tuna and Billfish Fishery	The 2018–2019fishing season reported a commercial catch of 218 t with the economic value withheld. The fishery recorded 366,821 hooks for the season. 94 entities held quota SFRs, with two vessels actively using pelagic longline and two vessels using minor line methods.

^ *Source: Ref. 96.*

4.3 Recreational fisheries

The WA Department of Primary Industries and Regional Development (DPIRD) conducts state-wide recreational fishing surveys every two years, with the first survey completed in 2011. The survey collects information from more than 3,000 recreational fishers who record their catches in logbooks over a 12-month period with DPIRD also conducting interviews throughout the State and monitoring the number of boat launches and retrievals using cameras at various boat ramps.

Key findings of the 2017–2018 survey report (Ref. 97) are included in Table 4-3.

Table 4-3: Recreational fishing survey outcomes

Component	Number
Number of participants	~6,000
Number of recreational fishing boat licences issued	~135 000
Most popular species	
Blue Swimmer Crab	Number caught ~667 000
School Whiting	Number caught ~259 000
Fishing effort by bioregion	
West Coast	76%
Gascoyne Coast	11%
North Coast	8%
South Coast	5%

Source: Ref. 97

4.4 Underwater cultural heritage

The Australasian Underwater Cultural Heritage Database (Ref. 98) records all known maritime cultural heritage (shipwrecks, aircraft, relics, and other underwater cultural heritage) in Australian waters. Historic shipwrecks and sunken aircraft (older than 75 years) are protected under the Commonwealth *Underwater Cultural Heritage Act 2018*. Shipwrecks and aircraft that have been underwater <75 years, and other types of underwater cultural heritage, can be protected through individual declaration based on an assessment of heritage significance.

Approximately 667 shipwrecks are present within the PA. Given this number, no additional detail is provided in this document. If shipwrecks are present within an EMBA described in a project-specific EP, CAPL will identify and detail the significance of these shipwrecks in that EP.

4.5 Defence

Table 4-4 lists the Australian Department of Defence’s prohibited and training areas that are within the PA (Ref. 99).

Table 4-4: Department of Defence Prohibited and Training Areas

Area Type	Area Name
Practice Areas	Darwin AWR Central
	Learmonth AWR
	North-West Australian Exercise Area
Training Areas	North Australian Exercise Area
	Yampi Field Training Area
	Learmonth AWR
	West Australian Exercise Area

4.6 Tourism

Tourism is an important industry for WA, directly employing 73 200 people and indirectly employing a further 35,600 (Ref. 100). The value of the WA tourism industry is AU$12.9 billion by Gross State Product (Ref. 100). Table 4-5 lists the value of tourism to the state's economy.

Table 4-5: Western Australian Tourism Statistics

	WA Direct Tourism Gross Value Added ($million)	% of WA Direct Tourism Gross Value Added ($million)
Tourism characteristic industries		
Travel agency and tour operator services	$1138	19.1%
Air, water, and other transport	$823	13.8%
Accommodation	$654	11.0%
Cafes, restaurants, and takeaway food services	$552	9.3%
Ownership of dwellings	$370	6.2%
Clubs, pubs, taverns, and bars	$339	5.7%
Motor vehicle hiring	$157	2.6%
Other road transport	$87	1.5%
Casinos and other gambling services	$88	1.5%
Other sports and recreation services	$85	1.4%
Cultural services	$74	1.2%
Rail transport	$64	1.1%
Taxi transport	$56	0.9%
Tourism connected industries		
Automotive fuel retailing	$51	0.9%
Other retail trade	$631	10.6%
Education and training	$384	6.4%
All other industries	$413	6.9%
Total Gross Value Added	**$5966**	**100%**

Source: Ref. 100

5 terms, acronyms, and abbreviations

Table 5-1 defines the acronyms and abbreviations used in this document.

Table 5-1: Term, acronyms and abbreviations

Term, acronym, or abbreviation	Definition
~	Approximately
<	Less/fewer than
>	Greater/more than
AHC	Australian Heritage Commission
AIMS	Australian Institute of Marine Science
AIS	Automatic identification System
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
AU$	Australian dollar
AWR	Air Weapons Range
BIA	Biologically Important Area; a spatially defined area where aggregations of individuals of a species are known to display biologically important behaviours such as breeding, foraging, resting, or migration
BP	Before Present (present = 1950)
CAMBA	China–Australia Migratory Bird Agreement
CAPL	Chevron Australia Pty Ltd
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Diadromous	Fish that spend portions of their life cycles partially in fresh water and partially in salt water
Doline	A shallow depression, either funnel- or saucer-shaped, with a floor covered by cultivated soil, formed by solution in limestone country
DPIRD	Western Australian Department of Primary Industries and Regional Development
DTA	Defence Training Area
EEZ	Exclusive Economic Zone
EMBA	Environment that May Be Affected
Endangered Species	A species that is not critically endangered, but is facing a very high risk of extinction in the wild in the near future.
EP	Environment Plan
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
g/L	Grams per litre
GIS	Geographic Information System
GVP	Gross Value of Product
ha	Hectare
HMAS	His Majesty's Australian Ship (during World War II)
HMS	His (or Her) Majesty's Ship (British)

Term, acronym, or abbreviation	Definition
HSK	Ship of the German Navy (during World War II)
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
IUU	Illegal, unreported, and unregulated
JAMBA	Japan–Australia Migratory Bird Agreement
JASDGDLF	Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery
Karst	An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.
KEF	Key Ecological Feature
km	Kilometre
km^2	Square kilometre
m	Metre
MoU	Memorandum of Understanding
ms^{-1}	Metres per second
NES	[Matters of] National Environmental Significance, as defined in Part 3, Division 1 of the EPBC Act.
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
PA	Planning Area
PDSF	Pilbara Demersal Scalefish Fisheries
Photic zone	The depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur. The depth of the photic zone can be greatly affected by turbidity.
Priority Species	A species that does not meet the criteria for listing as Threatened Fauna or Declared Rare Flora, but which either may be suspected to be threatened; or is not threatened, but is rare and in need of ongoing monitoring; or is dependent on ongoing management intervention to prevent it from becoming threatened.
Prokaryote	A unicellular organism without a nucleus
Sessile	Permanently attached directly to the substratum by its base (i.e. immobile), without a stalk or stem
SFR	Statutory fishing right
SNES	Species of National Environmental Significance
Stochastic	Random
Swale	A low place in a tract of land, usually moister than the adjacent higher land
SWMR	South-West Marine Region
t	Tonne
TDGDLF	Temperate Demersal Gillnet and Demersal Longline Fishery
TEC	Threatened Ecological Community
Trophic	Relating to food or nutrition / nutritive processes
Vulnerable Species	A species is listed as vulnerable under the EPBC Act if it is not critically endangered or endangered and it is facing a high risk of extinction in the wild in

Term, acronym, or abbreviation	Definition
	the medium-term future, as determined in accordance with the prescribed criteria.
WA	Western Australia
WCB	West Coast Bioregion
WCDGDLF	West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery

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The following documentation is either directly referenced in this document or is a recommended source of background information.

Where references and citations have been copied from Government Database sources, the database has been referenced but the references as cited by the databases have not been specified here. For source material, please refer to the governmental databases for specific source references.

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appendix a protected matters search report

Australian Government
Department of Agriculture, Water and the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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

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

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

Coordinates
Buffer: 0.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	2
National Heritage Places:	8
Wetlands of International Importance:	6
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	6
Listed Threatened Species:	139
Listed Migratory Species:	106

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	11
Commonwealth Heritage Places:	11
Listed Marine Species:	197
Whales and Other Cetaceans:	41
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	43

Extra Information

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

State and Territory Reserves:	103
Regional Forest Agreements:	1
Invasive Species:	62
Nationally Important Wetlands:	17
Key Ecological Features (Marine)	24

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
Shark Bay, Western Australia	WA	Declared property
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

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

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Ashmore reef national nature reserve	Within Ramsar site
Becher point wetlands	Within 10km of Ramsar
Eighty-mile beach	Within Ramsar site
Ord river floodplain	Within Ramsar site
Peel-yalgorup system	Within Ramsar site
Roebuck bay	Within 10km of Ramsar

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea
Extended Continental Shelf

Marine Regions [Resource Information]

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

Name
North
North-west
South-west

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Thrombolite (microbialite) Community of a Coastal Brackish Lake (Lake Clifton)	Critically Endangered	Community known to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Breeding known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Geophaps smithii blaauwi Partridge Pigeon (western) [66501]	Vulnerable	Species or species habitat likely to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit [86432]	Critically Endangered	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Malurus leucopterus edouardi White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Malurus leucopterus leucopterus White-winged Fairy-wren (Dirk Hartog Island), Dirk Hartog Black-and-White Fairy-wren [26004]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Name	Status	Type of Presence
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Turnix varius scintillans Painted Button-quail (Houtman Abrolhos) [82451]	Vulnerable	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Milyeringa veritas Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Nannatherina balstoni Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area
Ophisternon candidum Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Insects		
Hesperocolletes douglasi Douglas' Broad-headed Bee, Rottnest Bee [66734]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Bettongia lesueur lesueur Burrowing Bettong (Shark Bay), Boodie [66659]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Conilurus penicillatus Brush-tailed Rabbit-rat, Brush-tailed Tree-rat, Pakooma [132]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isoodon auratus auratus Golden Bandicoot (mainland) [66665]	Vulnerable	Species or species habitat likely to occur within area
Isoodon auratus barrowensis Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Lagorchestes hirsutus bernieri Rufous Hare-wallaby (Bernier Island) [66662]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus dorreae Rufous Hare-wallaby (Dorre Island) [66663]	Vulnerable	Species or species habitat known to occur within area
Lagostrophus fasciatus fasciatus Banded Hare-wallaby, Mermine, Marnine, Munning [66664]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat known to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesembriomys gouldii gouldii Black-footed Tree-rat (Kimberley and mainland Northern Territory), Djintamoonga, Manbul [87618]	Endangered	Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Osphranter robustus isabellinus Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Parantechinus apicalis Dibbler [313]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		within area
Perameles bougainville bougainville Western Barred Bandicoot (Shark Bay) [66631]	Endangered	Species or species habitat known to occur within area
Petrogale concinna monastria Nabarlek (Kimberley) [87607]	Endangered	Species or species habitat known to occur within area
Petrogale lateralis lateralis Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Phascogale tapoatafa kimberleyensis Kimberley brush-tailed phascogale, Brush-tailed Phascogale (Kimberley) [88453]	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat known to occur within area
Pseudomys fieldi Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat known to occur within area
Trichosurus vulpecula arnhemensis Northern Brushtail Possum [83091]	Vulnerable	Species or species habitat likely to occur within area
Xeromys myoides Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat may occur within area
Other		
Idiosoma nigrum Shield-backed Trapdoor Spider, Black Rugose Trapdoor Spider [66798]	Vulnerable	Species or species habitat may occur within area
Kumonga exleyi Cape Range Remipede [86875]	Vulnerable	Species or species habitat known to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Androcalva bivillosa Straggling Androcalva [87807]	Critically Endangered	Species or species habitat may occur within area
Banksia nivea subsp. uliginosa Swamp Honeypot [82766]	Endangered	Species or species habitat may occur within area
Caladenia bryceana subsp. cracens Northern Dwarf Spider-orchid [64556]	Vulnerable	Species or species habitat may occur within area
Caladenia elegans Elegant Spider-orchid [56775]	Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Caladenia hoffmanii Hoffman's Spider-orchid [56719]	Endangered	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Caladenia viridescens Dunsborough Spider-orchid [56776]	Endangered	Species or species habitat may occur within area
Chamelaucium sp. Gingin (N.G.Marchant 6) Gingin Wax [88881]	Endangered	Species or species habitat likely to occur within area
Chorizema varium Limestone Pea [16981]	Endangered	Species or species habitat known to occur within area
Conostylis micrantha Small-flowered Conostylis [17635]	Endangered	Species or species habitat may occur within area
Diuris drummondii Tall Donkey Orchid [4365]	Vulnerable	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Drummondita ericoides Morseby Range Drummondita [9193]	Endangered	Species or species habitat likely to occur within area
Eucalyptus argutifolia Yanchep Mallee, Wabling Hill Mallee [24263]	Vulnerable	Species or species habitat known to occur within area
Eucalyptus beardiana Beard's Mallee [18933]	Vulnerable	Species or species habitat may occur within area
Eucalyptus x phylacis Meelup Mallee [87817]	Endangered	Species or species habitat likely to occur within area
Grevillea batrachioides Mt Lesueur Grevillea [21735]	Endangered	Species or species habitat may occur within area
Grevillea humifusa Spreading Grevillea [61182]	Endangered	Species or species habitat may occur within area
Hemiandra gardneri Red Snakebush [7945]	Endangered	Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Leucopogon obtectus Hidden Beard-heath [19614]	Endangered	Species or species habitat may occur within area
Marianthus paralius [83925]	Endangered	Species or species habitat known to occur within area
Minuria tridens Minnie Daisy [13753]	Vulnerable	Species or species habitat known to occur within area
Pityrodia augustensis Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Seringia exastia Fringed Fire-bush [88920]	Critically Endangered	Species or species habitat may occur within area
Synaphea sp. Fairbridge Farm (D. Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat may occur within area
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat may occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area
Wurmbea calcicola Naturaliste Nancy [64691]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus lancelini Lancelin Island Skink [1482]	Vulnerable	Species or species habitat known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Egernia stokesii badia Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink [64483]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area
Liopholis pulchra longicauda Jurien Bay Skink, Jurien Bay Rock-skink [83162]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Glyphis garricki Northern River Shark, New Guinea River Shark [82454]	Endangered	Breeding known to occur within area
Glyphis glyphis Speartooth Shark [82453]	Critically Endangered	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat known to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Breeding known to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or related behaviour known to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Breeding known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area

Name	Threatened	Type of Presence
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

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

Name
Commonwealth Land -
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH NAVAL HF RECEIVING STATION (H/F Receiving Station, Learmonth, WA)
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - HMAS STIRLING-ROCKINGHAM ;HMAS STIRLING - GARDEN ISLAND
Defence - LEARMONTH - AIR WEAPONS RANGE
Defence - LEARMONTH - RAAF BASE
Defence - LEARMONTH RADAR SITE - TWIN TANKS EXMOUTH
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - LEARMONTH TRANSMITTING STATION
Defence - YAMPI SOUND TRAINING AREA

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Ashmore Reef National Nature Reserve	EXT	Listed place
Garden Island	WA	Listed place
Lancelin Defence Training Area	WA	Listed place
Learmonth Air Weapons Range Facility	WA	Listed place
Mermaid Reef - Rowley Shoals	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place
Scott Reef and Surrounds - Commonwealth Area	EXT	Listed place
Yampi Defence Area	WA	Listed place
Historic		
Cliff Point Historic Site	WA	Listed place
HMAS Sydney II and HSK Kormoran Shipwreck Sites	EXT	Listed place
J Gun Battery	WA	Listed place

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Acrocephalus orientalis Oriental Reed-Warbler [59570]		Species or species habitat known to occur within area
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous minutus Black Noddy [824]		Breeding known to occur within area
Anous stolidus Common Noddy [825]		Breeding known to occur within area
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Breeding known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat likely to occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Breeding known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Breeding known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Phaethon lepturus White-tailed Tropicbird [1014]		Breeding known to occur within area
Phaethon rubricauda Red-tailed Tropicbird [994]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding likely to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Pterodroma macroptera Great-winged Petrel [1035]		Foraging, feeding or related behaviour known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Puffinus assimilis Little Shearwater [59363]		Breeding known to occur within area

Name	Threatened	Type of Presence
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus huttoni Hutton's Shearwater [1025]		Foraging, feeding or related behaviour known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna albifrons Little Tern [813]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Stiltia isabella Australian Pratincole [818]		Roosting known to occur within area
Sula dactylatra Masked Booby [1021]		Breeding known to occur within area
Sula leucogaster Brown Booby [1022]		Breeding known to occur within area
Sula sula Red-footed Booby [1023]		Breeding known to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bhanotia fasciolata Corrugated Pipefish, Barbed Pipefish [66188]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish		Species or species

Name	Threatened	Type of Presence
[66202]		habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus foliosquama Leaf-scaled Seasnake [1118]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus fuscus Dusky Seasnake [1119]		Species or species habitat known to occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus pooleorum Shark Bay Seasnake [66061]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis atriceps Black-headed Seasnake [1101]		Species or species habitat may occur within area
Hydrophis coggeri Slender-necked Seasnake [25925]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis inornatus Plain Seasnake [1107]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Foraging, feeding or related behaviour known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Hyperoodon planifrons Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Indopacetus pacificus Longman's Beaked Whale [72]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon ginkgodens Gingko-toothed Beaked Whale, Gingko-toothed Whale, Gingko Beaked Whale [59564]		Species or species habitat may occur within area

Name	Status	Type of Presence
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Foraging, feeding or related behaviour known to occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Abrolhos	Habitat Protection Zone (IUCN IV)
Abrolhos	Multiple Use Zone (IUCN VI)
Abrolhos	National Park Zone (IUCN II)
Abrolhos	Special Purpose Zone (IUCN VI)
Argo-Rowley Terrace	Multiple Use Zone (IUCN VI)
Argo-Rowley Terrace	National Park Zone (IUCN II)
Argo-Rowley Terrace	Special Purpose Zone (Trawl) (IUCN VI)
Ashmore Reef	Recreational Use Zone (IUCN IV)
Ashmore Reef	Sanctuary Zone (IUCN Ia)
Carnarvon Canyon	Habitat Protection Zone (IUCN IV)
Cartier Island	Sanctuary Zone (IUCN Ia)
Dampier	Habitat Protection Zone (IUCN IV)
Dampier	Multiple Use Zone (IUCN VI)
Dampier	National Park Zone (IUCN II)
Eighty Mile Beach	Multiple Use Zone (IUCN VI)
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Gascoyne	National Park Zone (IUCN II)
Geographe	Multiple Use Zone (IUCN VI)
Geographe	Special Purpose Zone (Mining
Joseph Bonaparte Gulf	Multiple Use Zone (IUCN VI)
Joseph Bonaparte Gulf	Special Purpose Zone (IUCN VI)
Jurien	National Park Zone (IUCN II)
Jurien	Special Purpose Zone (IUCN VI)
Kimberley	Habitat Protection Zone (IUCN IV)
Kimberley	Multiple Use Zone (IUCN VI)
Kimberley	National Park Zone (IUCN II)
Mermaid Reef	National Park Zone (IUCN II)
Montebello	Multiple Use Zone (IUCN VI)
Ningaloo	National Park Zone (IUCN II)
Ningaloo	Recreational Use Zone (IUCN IV)
Oceanic Shoals	Multiple Use Zone (IUCN VI)
Oceanic Shoals	Special Purpose Zone (Trawl) (IUCN VI)
Perth Canyon	Habitat Protection Zone (IUCN IV)
Perth Canyon	Multiple Use Zone (IUCN VI)
Perth Canyon	National Park Zone (IUCN II)
Roebuck	Multiple Use Zone (IUCN VI)
Shark Bay	Multiple Use Zone (IUCN VI)
South-west Corner	Multiple Use Zone (IUCN VI)
South-west Corner	National Park Zone (IUCN II)
South-west Corner	Special Purpose Zone (Mining
Two Rocks	Multiple Use Zone (IUCN VI)
Two Rocks	National Park Zone (IUCN II)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Adele Island	WA
Airlie Island	WA
Balanggarra	WA
Bardi Jawi	WA
Barrow Island	WA
Bedout Island	WA
Beekeepers	WA
Bernier And Dorre Islands	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Boullanger, Whitlock, Favourite, Tern And Osprey Islands	WA
Browse Island	WA
Bundegi Coastal Park	WA
Burnside And Simpson Island	WA
Cape Range	WA
Carnac Island	WA
Coulomb Point	WA
Dambimangari	WA

Name	State
Dirk Hartog Island	WA
Escape Island	WA
Giralia	WA
Gnandaroo Island	WA
Houtman Abrolhos Islands	WA
Jarrkunpungu	WA
Jinmarnkur	WA
Jinmarnkur Kulja	WA
Jurabi Coastal Park	WA
Karajarri	WA
Koks Island	WA
Kooljerrenup	WA
Lacepede Islands	WA
Lancelin And Edwards Islands	WA
Leeuwin-Naturaliste	WA
Len Howard	WA
Lesueur	WA
Lesueur Island	WA
Little Rocky Island	WA
Locker Island	WA
Low Rocks	WA
Lowendal Islands	WA
McLarty	WA
Mealup Point	WA
Mijing	WA
Montebello Islands	WA
Muiron Islands	WA
Nambung	WA
Niiwalarra Islands	WA
Nilgen	WA
North Sandy Island	WA
North Turtle Island	WA
Ord River	WA
Pelican Island	WA
Penguin Island	WA
Rottnest Island	WA
Round Island	WA
Serrurier Island	WA
Southern Beekeepers	WA
Swan Island	WA
Tanner Island	WA
Tent Island	WA
Unnamed WA11883	WA
Unnamed WA26400	WA
Unnamed WA28968	WA
Unnamed WA34039	WA
Unnamed WA36913	WA
Unnamed WA36915	WA
Unnamed WA37168	WA
Unnamed WA37338	WA
Unnamed WA37383	WA
Unnamed WA40322	WA
Unnamed WA40828	WA
Unnamed WA40877	WA
Unnamed WA41080	WA
Unnamed WA41160	WA
Unnamed WA41775	WA
Unnamed WA42030	WA
Unnamed WA44665	WA
Unnamed WA44667	WA
Unnamed WA44669	WA
Unnamed WA44672	WA
Unnamed WA44673	WA
Unnamed WA44677	WA
Unnamed WA44682	WA
Unnamed WA44688	WA
Unnamed WA46982	WA
Unnamed WA46983	WA
Unnamed WA46984	WA
Unnamed WA48205	WA
Unnamed WA48858	WA
Unnamed WA48968	WA
Unnamed WA49994	WA
Unnamed WA51162	WA
Unnamed WA51943	WA
Uunguu	WA
Victor Island	WA
Wanagarren	WA
Wedge Island	WA
Weld Island	WA
Whalebone Island	WA
Whitmore,Roberts,Doole Islands And Sandalwood Landing	WA
Y Island	WA
Yalgorup	WA
Yampi	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pavo cristatus Indian Peafowl, Peacock [919]		Species or species habitat likely to occur within area
Phasianus colchicus Common Pheasant [920]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus exulans Pacific Rat, Polynesian Rat [79]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Andropogon gayanus Gamba Grass [66895]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass		Species or species habitat likely to occur

Name	Status	Type of Presence
[31754]		within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Mimosa pigra Mimosa, Giant Mimosa, Giant Sensitive Plant, ThornySensitive Plant, Black Mimosa, Catclaw Mimosa, Bashful Plant [11223]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Ashmore Reef	EXT
Bunda-Bunda Mound Springs	WA
Bundera Sinkhole	WA
Cape Range Subterranean Waterways	WA
De Grey River	WA
Eighty Mile Beach System	WA
Exmouth Gulf East	WA
Lake MacLeod	WA
Lake Thetis	WA
Learmonth Air Weapons Range - Saline Coastal Flats	WA
Leslie (Port Hedland) Saltfields System	WA
Mermaid Reef	EXT
Ord Estuary System	WA
Rottnest Island Lakes	WA
Shark Bay East	WA
Yalgorup Lakes System	WA
Yampi Sound Training Area	WA

Key Ecological Features (Marine)

[Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Carbonate bank and terrace system of the Van	North
Pinnacles of the Bonaparte Basin	North
Ancient coastline at 125 m depth contour	North-west
Ashmore Reef and Cartier Island and surrounding	North-west
Canyons linking the Argo Abyssal Plain with the	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Carbonate bank and terrace system of the Sahul	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west
Glomar Shoals	North-west
Mermaid Reef and Commonwealth waters	North-west
Pinnacles of the Bonaparte Basin	North-west
Seringapatam Reef and Commonwealth waters in	North-west
Wallaby Saddle	North-west
Ancient coastline at 90-120m depth	South-west
Cape Mentelle upwelling	South-west
Commonwealth marine environment surrounding	South-west
Commonwealth marine environment within and	South-west
Commonwealth marine environment within and	South-west
Naturaliste Plateau	South-west
Perth Canyon and adjacent shelf break, and other	South-west
Western demersal slope and associated fish	South-west
Western rock lobster	South-west

Caveat

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

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

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

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-31.6854 111.3838,-30.4214 110.3839,-28.7096 109.8133,-27.9563 109.7791,-27.0319 108.5808,-26.4157 107.4738,-25.6396 106.4352,-24.5212 105.8532,-23.7338 105.8418,-23.1175 106.1271,-22.5697 106.789,-21.7823 107.3825,-20.0248 107.9645,-18.4156 108.8775,-16.4413 110.7377,-15.2658 111.3996,-14.4327 112.4952,-14.4099 113.1457,-14.0333 114.1043,-13.2686 114.6978,-13.6681 115.2456,-14.7637 115.4852,-15.437 116.2042,-15.049 116.5123,-14.2615 117.7677,-12.8161 118.2231,-12.1161 118.1014,-12.6944 120.0491,-13.9421 120.013,-11.8068 122.8951,-11.3553 123.3054,-11.4466 124.0054,-11.1118 124.5227,-10.9292 125.3748,-10.5336 126.0444,-11.2336 126.5922,-11.2031 127.6573,-10.4119 128.1442,-10.0771 128.1442,-10.0547 128.9033,-15.0663 129.0006,-15.0735 128.0863,-14.7089 128.1617,-13.9731 127.4448,-13.7461 126.9637,-14.1871 126.6423,-14.5893 125.2646,-15.4957 124.4516,-16.4216 124.6089,-16.186 123.5687,-17.1833 123.7342,-16.5875 122.9672,-17.3596 122.1501,-17.9493 122.2039,-19.2063 121.4347,-19.625 120.9721,-20.0762 119.5873,-20.6548 117.4099,-20.3016 116.83,-21.4925 115.4626,-21.8484 114.644,-22.4302 114.3765,-22.6288 113.668,-23.5261 113.755,-24.0899 113.4187,-25.1243 113.5933,-25.9153 113.0411,-26.9189 113.775,-28.0932 114.1696,-29.4877 114.9961,-30.5785 115.0875,-31.7296 115.7179,-33.2752 115.6808,-33.5316 115.0036,-33.4303 110.9954,-31.966 111.5089,-31.6854 111.3838

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-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
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-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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Please feel free to provide feedback via the Contact Us page.

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appendix g sensitive information report