Environment Plan

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Environment Plan

Otway Geophysical and Geotechnical Seabed Assessment

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THE THREE WHATS
What can go wrong?
What could cause it to go wrong?
What can I do to prevent it?

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Acronyms

Terms/acronym	Definition/expansion
3DTZSS	3D Transitions Zone Seismic Survey
ADIOS	Automated Data Inquiry for Oil Spills
AFMA	Australian Fisheries Management Authority
AHO	Australian Hydrographic Office
ALARP	as low as reasonably practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANSI	American National Standards Institute
APPEA	Australian Petroleum Production and Exploration Association
ASAP	as soon as practicable
Bass Strait CZSF	Bass Strait Central Zone Scallop Fishery
Beach	Beach Energy Limited
BIA	biologically important area
BOM	Bureau of Meteorology
CHIRP	compressed high-intensity radar pulse
CMT	Crisis Management Team
COLREG	Convention on the International Regulations for Preventing Collisions at Sea
CPT	cone penetrometer test
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTD	conductivity, temperature and depth
DAWR	Department of Agriculture and Water Resources
DELWP	Department of Environment, Land, Water and Planning
DPIPWE	Department of Primary Industries, Parks, Water and Environment
DJPR	Department of Jobs, Precincts and Regions
DotEE	Department of the Environment and Energy
DP	dynamic positioning
EEZ	Exclusive Economic Zone
EIA	environmental impact assessment
EMBA	environment that may be affected
EMT	Emergency Management Team
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPO	environment performance outcome
EPS	environment performance standard

ERT	Emergency Response Team
ESD	ecologically sustainable development
ETBF	Eastern Tuna and Billfish Fishery
HFO	heavy fuel oil
HSE	Health, Safety and Environment
HSEMS	Health, Safety and Environment Management System
IC	Incident Commander
IAPP	International Air Pollution Prevention
IMO	International Maritime Organisation
IMS	invasive marine species
JASCO	JASCO Applied Sciences
JRCC	Joint Rescue Coordination Centre
KEF	Key Ecological Features
Lattice	Lattice Energy Limited
MARPOL	International Convention for the Prevention of Pollution from Ships
MBES	multi-beam echo sounder
MC	Measurement criteria
MNES	Matters of National Environmental Significance
MO	Marine Order
MOC	Management of Change
MODU	Mobile Offshore Drilling Unit
NatPlan	National Plan for Maritime Environmental Emergencies
NEBA	Net Environmental Benefit Analysis
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OGUK	Oil and Gas UK
OPEP	Oil Pollution Emergency Plan
OPGGSA	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPGGS(E)R	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Commonwealth)
Origin	Origin Energy Resources Limited
OSTM	oil spill trajectory modelling
OWR	oiled wildlife response
PK	peak pressure level
PK-PK	peak-to-peak pressure level
PMS	planned maintenance system
POLREP	Marine Pollution Report
PSZ	Petroleum Safety Zone
PTS	permanent threshold shift
RMS	Root mean square

ROV	remotely operated underwater vehicle
SBES	single beam echo sounder
SBP	sub-bottom profiler
SBTF	Southern Bluefin Tuna Fishery
SEEMP	Ship Energy Efficiency Management Plan
SEL	sound exposure level
SEMR	South-east Marine Region
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SITREP	Situation Reports
SIV	Seafood Industry Victoria
SMP	Scientific Monitoring Program
SMPEP	Shipboard Marine Pollution Emergency Plan
SMS	scientific monitoring study
SPF	Small Pelagic Fishery
SPL	sound pressure level
SSS	side scan sonar
SVP	Sound Velocity Profiler
TTS	temporary threshold shift
USBL	ultra-short baseline
Woodside	Woodside Petroleum Ltd

1 Overview of the activity

Lattice Energy Limited (Lattice), who are wholly owned by Beach Energy Limited (Beach), proposes to undertake geophysical and geotechnical seabed assessments within eight titles in the Otway Basin in Commonwealth waters. The seabed assessment is required to inform the future drilling of offshore subsea gas wells and potential tie-ins to connect the new gas development wells to the existing Thylacine platform and associated pipeline. At its closest point, the seabed assessment area is approximately 25 km from the township of Port Campbell, Victoria.

The proposed seabed assessments will be carried out over two phases, the first commencing September 2019 and the second commencing around March 2020. The seabed assessments are estimated to take between five to 12 days for each proposed drilling area and up to seven days for each of the tie-in flowline and umbilical corridors.

Geophysical methods proposed include:

- Multi beam echo sounder (MBES).
- Side scan sonar (SSS).
- Sub bottom profiler (SBP).
- Magnetometer.

Geotechnical sampling includes:

- Piston coring or vibracoring.
- In situ Cone Penetrometer Testing (CPT).
- Seabed grab sampling.

Seabed imagery at the well locations and along the flowline and umbilical corridors will be undertaken using a camera placed overboard via a tether and/or by a remotely operated underwater vehicle.

1.1 Environment Plan summary

This Otway Geophysical and Geotechnical Seabed Assessment Environment Plan (EP) Summary has been prepared from material provided in this EP. The summary consists of the following as required by Regulation 11(4) of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS(E)R:

EP Summary Material Requirement	Relevant Section of EP Containing EP Summary Material
The location of the activity	Section 4.1 (pages 24-26)
A description of the receiving environment	Section 5 (pages 34-43) and Appendix B
A description of the activity	Section 4 (pages 24-33)
Details of the environmental impacts and risks	Section 7 (pages 54-95)
The control measures for the activity	Section 7.5 (pages 96-99)
The arrangements for ongoing monitoring of the titleholder's environmental performance	Section 8.10 (page 109), Section 8.20 (pages 116-117) and Section 8.22 (pages 117-119)

EP Summary Material Requirement	Relevant Section of EP Containing EP Summary Material
Response arrangements in the oil pollution emergency plan	Section 7.4 (pages 86-95) and Section 8.16 (pages 111-115)
Consultation already undertaken and plans for ongoing consultation	Section 9 (pages 120-138)
Details of the titleholders nominated liaison person for the activity	Section 2.2 (page 15)

2 Introduction

This document has been prepared to meet the requirements of an EP under the OPGGS(E)R. It addresses the activities to be undertaken during the Otway geophysical and geotechnical seabed assessments (referred to as the seabed assessments), located in Commonwealth waters of the Otway Basin off the coast of Victoria.

The seabed assessments will be undertaken within titles held by Lattice which is wholly owned by Beach. Figure 2-1 details the titles in which the seabed assessments will be undertaken.

2.1 Background

Beach has been contributing to ensuring natural gas supply through the Otway offshore natural gas development. To date, three development phases have been completed to support natural gas supply via the Otway Gas Plant:

- Phase 1: Otway Gas Plant and unmanned Thylacine offshore platform;
- Phase 2: Inlet Gas Compression; and
- Phase 3: Geographe Subsea Development.

To maintain continued economic natural gas production, further phases to develop additional offshore wells are being planned. The activities associated with the next development phases, Phase 4 and 5, of the Otway offshore natural gas development are:

- seabed assessments (scope of this EP);
- drilling of offshore subsea gas wells;
- inspections and modifications to existing seabed gas production infrastructure; and
- tie-ins to connect the new gas development wells to the Thylacine platform and associated pipeline.

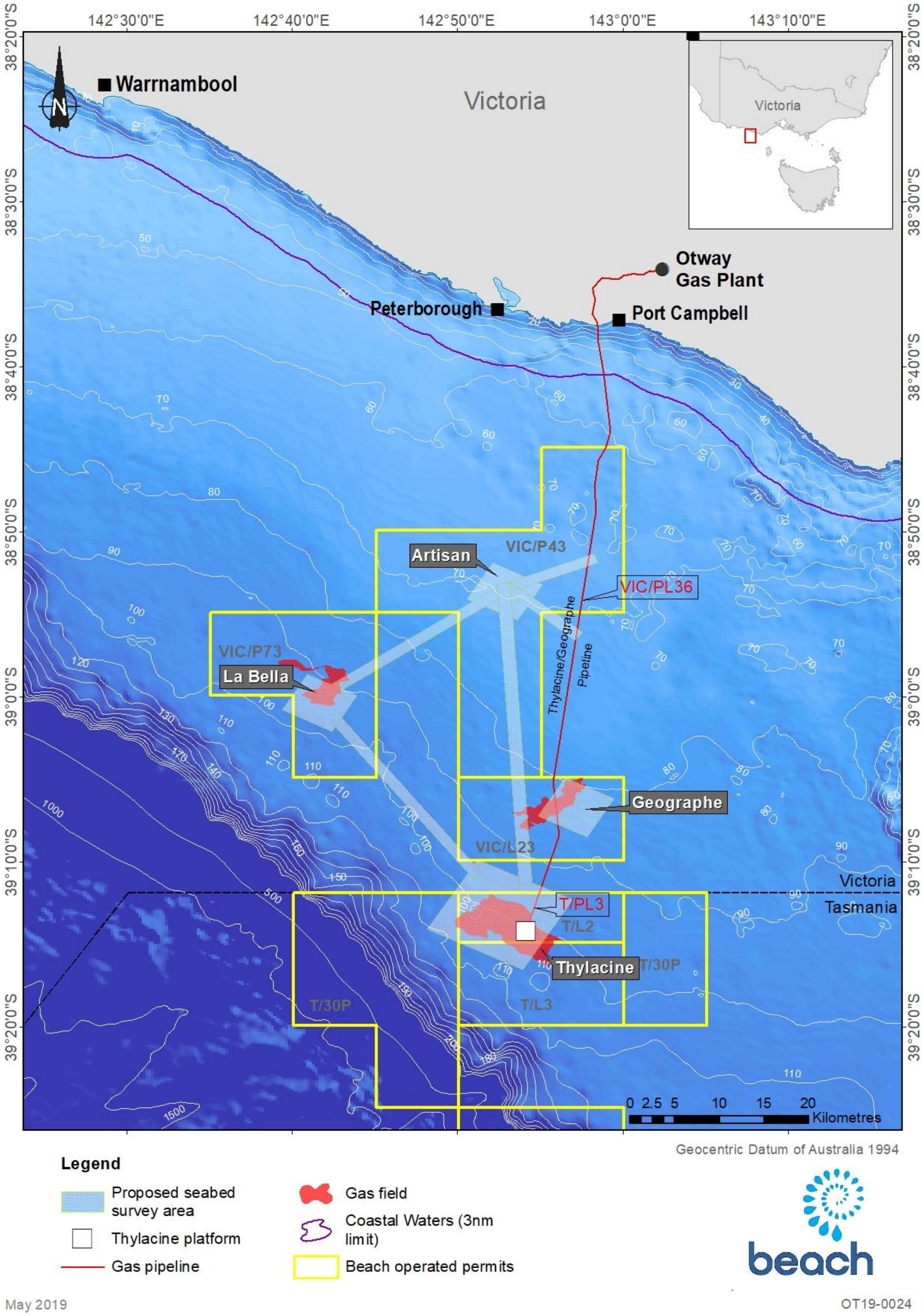

Figure 2-1: Beach titles relevant to the activity

2.2 Titleholder and liaison person details

The titleholder Lattice Energy Limited, is wholly owned by Beach.

Beach is an ASX listed oil and gas exploration and production company headquartered in Adelaide, South Australia. Beach has operated and non-operated, onshore and offshore, oil and gas production assets from five producing basins across Australia and New Zealand and is a key supplier to the Australian east coast gas market.

Beach's asset portfolio includes ownership interests in strategic oil and gas infrastructure, as well as a suite of high potential exploration prospects. Beach's gas exploration and production portfolio includes acreage in the Otway, Bass, Cooper/Eromanga, Perth, Browse and Bonaparte basins in Australia, as well as the Taranaki and Canterbury basins in New Zealand (Figure 2-2).

Table 2-1 details the titleholder and the liaison person for the titles applicable to the activity.

Beach shall notify the Regulator (National Offshore Petroleum Safety and Environmental Management Authority [NOPSEMA]) of a change to the titleholder, a change in the titleholder's nominated liaison person or a change in the contact details for either the titleholder or the liaison person during the proposed Otway seabed assessments, in accordance with Regulation 15(3) of the OPGGS(E)R.

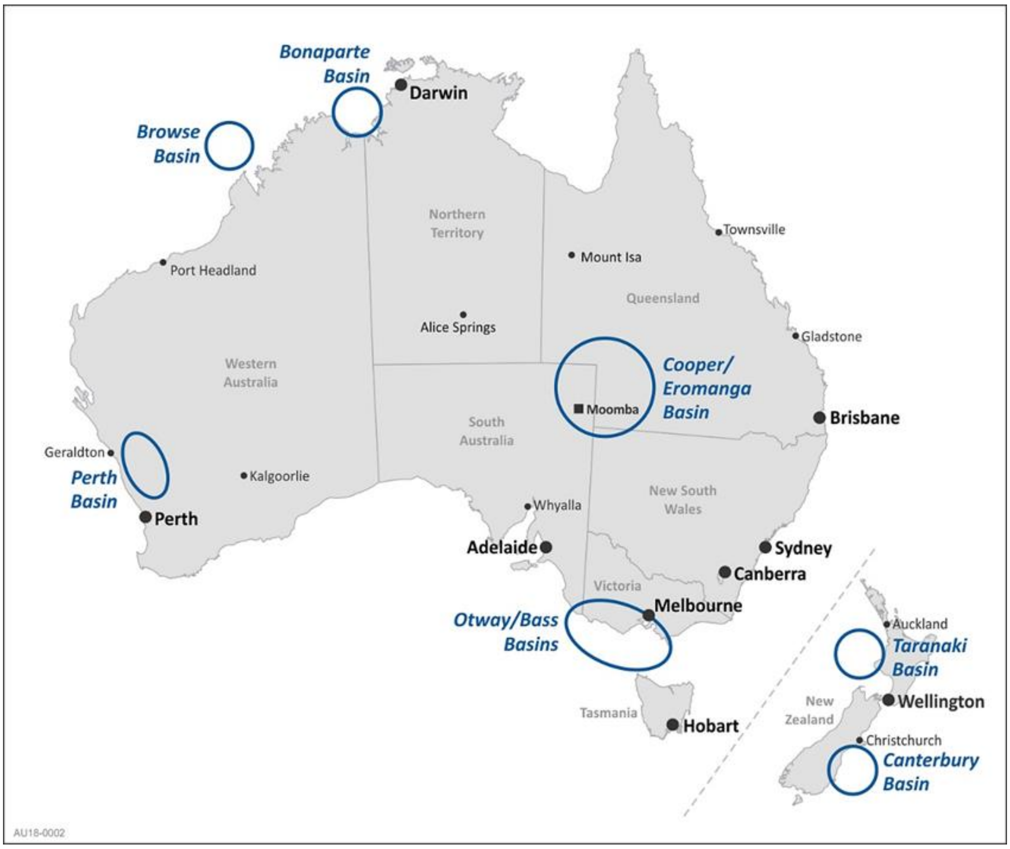

Figure 2-2: Beach operations

Table 2-1: Details of titleholder and liaison person

Petroleum Title(s)	Details	
VIC/L23, VIC/P43, VIC/P73, T/30P, T/L2 & T/L3, T/PL3, VIC/PL36	Titleholder	Lattice Energy Limited
	Business address	25 Conyngham Street Glenside South Australia 5065
	Telephone number	(08) 8338 2833
	Fax number	(08) 8338 2336
	Email address	info@beachenergy.com.au
	Australian Company Number	Lattice Energy Limited (ACN: 007 845 338)
Titleholder Liaison Person		
Wayne Mothershaw Seismic Acquisition and Survey Lead	Business address	25 Conyngham Street Glenside South Australia 5065
	Telephone number	(08) 8338 2833
	Fax number	(08) 8338 2336
	Email address	wayne.mothershaw@beachenergy.com.au

3 Environmental requirements

This section provides information on the requirements that apply to the activity, in accordance with Regulation 13(4) of the OPGGS(E)R. Requirements include relevant laws, codes, other approvals and conditions, standards, agreements, treaties, conventions or practices (in whole or part) that apply to the jurisdiction that the activity takes place in.

The activity is planned solely within Commonwealth waters. Commonwealth legislation (including relevant international conventions) and other requirements relevant to the seabed assessments are summarised in Table 3-1.

3.1 EPBC Act management plans

Table 3-2 details the recovery plans, threat abatement plans and species conservation advices applicable to species identified to be relevant to the area where the seabed assessments are planned to be undertaken (this is further detailed in Section 5). Where an applicable threat or management advice has been identified this is addressed in Section 7.

Table 3-1: Commonwealth environmental legislation relevant to the seabed assessments

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
Australian Maritime Safety Authority Act 1990	This Act facilitates international cooperation and mutual assistance in preparing and responding to a major oil spill incident and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies. Requirements are affected through AMSA who administers the National Plan for Maritime Environmental Emergencies (NatPlan). **Application to activity**: AMSA is the designated Control Agency for oil spills from vessels in Commonwealth waters. *These arrangements are detailed in Section 8.16.*	• International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 • Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 • International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 1969 • Articles 198 and 221 of the United Nations Convention on the Law of the Sea 1982	Australian Maritime Safety Authority (AMSA)
Australian Ballast Water Management Requirements (DAWR, 2017)	The Australian Ballast Water Management Requirements set out the obligations on vessel operators with regards to the management of ballast water and ballast tank sediment when operating within Australian seas. **Application to activity**: Provides requirements on how vessel operators should manage ballast water when operating within Australian seas to comply with the Biosecurity Act. *Table 7-2 details these requirements in relation to the management of ballast water.*	• International Convention for the Control and Management of Ships' Ballast Water and Sediments (adopted in principle in 2004 and in force on 8 September 2017)	Department of Agriculture and Water Resources (DAWR)
Biosecurity Act 2015 Biosecurity Regulations 2016	This Act replaced the *Quarantine Act 1908* in 2015 and is the primary legislation for the management of the risk of diseases and pests that may cause harm to human, animal or plant health, the environment and the economy. The objects of this Act are to provide for: (a) managing biosecurity risks; human disease; risks related to ballast water; biosecurity emergencies and human biosecurity emergencies; (b) to give effect to Australia's international rights and obligations, including under the International Health Regulations, the Sanitary and Phytosanitary Agreement and the Biodiversity Convention.	• International Convention for the Control and Management of Ships' Ballast Water and Sediments (adopted in principle in 2004 and in force on 8 September 2017)	DAWR

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	Application to activity: The Biosecurity Act and regulations apply to 'Australian territory' which is the airspace over and the coastal seas out to 12 Nm from the coast line. For the activity the Act regulates vessels entering Australian territory regarding ballast water and hull fouling. *Biosecurity risks associated with the activity are detailed in Table 7-2.*		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	This Act applies to actions that have, will have or are likely to have a significant impact on matters of national environmental or cultural significance. The Act protects Matters of National Environmental Significance (MNES) and provides for a Commonwealth environmental assessment and approval process for actions. There are eight MNES, these being: • World heritage properties; • Ramsar wetlands; • Listed Threatened species and communities; • Listed Migratory species under international agreements; • Nuclear actions; • Commonwealth marine environment; • Great Barrier Reef Marine Park; and • Water trigger for coal seam gas and coal mining developments. **Application to activity**: Petroleum activities are excluded from within the boundaries of a World Heritage Area (Sub regulation 10A(f). *The activity is not within a World Heritage Area.* The EP must describe matters protected under Part 3 of the EPBC Act and assess any impacts and risks to these. *Section 5 describes matters protected under Part 3 of the EPBC Act.* The EP must assess any actual or potential impacts or risks to MNES from the activity. *Section 7 provides an assessment of the impacts and risks from the activity to matters protected under Part 3 of the EPBC Act.*	• 1992 Convention on Biological Diversity and 1992 Agenda 21 • Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 • Agreement between the Government and Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974 • Agreement between the Government and Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 • Agreement between the Government of Australia and the Government of the Republic of Korea on The Protection of Migratory Birds 2006 • Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (Ramsar) • International Convention for the Regulation of Whaling 1946 • Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979	Department of the Environment and Energy (DotEE)
Environment Protection and Biodiversity	Part 8 of the regulations provide distances and actions to be taken when interacting with cetaceans.	-	DotEE

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
Conservation Regulations 2000	**Application to activity**: The interaction requirements are applicable to the activity in the event that a cetacean is sighted. *Section 7 details how these requirements will be applied.*		
Historic Shipwrecks Act 1976	The Act protects the heritage values of shipwrecks and relics (older than 75 years) in Australian Territorial waters from the low water mark to the outer edge of the continental shelf (excluding the State's internal waterways). Under Section 4 of the Act, all shipwrecks 75 years of age and older are declared historic and accorded permanent protection. Other shipwrecks may be declared historic and granted this protection on an individual basis according to particular merit. This Act prohibits damage, interference, removal or destruction of a shipwreck and also contains provisions for the declaration of a protected zone around a historic shipwreck. **Application to activity**: Provisions under the Act are applicable to the activity in the event of removal, damage or interference to shipwrecks or relics declared to be historic under the legislation, the activity is proposed with declared protection zones, or there is the discovery of shipwrecks or relics during the undertaking of the activity. *Section 5 details that there are no historic shipwrecks or declared protection zones near or within the environment that may be affected (EMBA). If any historical shipwrecks and relics are located during the seabed assessments, they will be reported as per Table 8-3.*	Agreement between the Netherlands and Australia concerning old Dutch Shipwrecks 1972	DotEE
National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry 2009	The guidance document provides recommendations for the management of biofouling hazards by the petroleum industry. **Application to activity**: Applying the recommendations within this document and implementing effective biofouling controls can reduce the risk of the introduction of an introduced marine species. *Sections 7 details the requirements applicable to vessel activities.*	• Certain sections of MARPOL • International Convention for the Safety of Life at Sea 1974 • Convention on the International Regulations for Preventing Collisions at Sea (COLREG) 1972	DAWR
Navigation Act 2012	This Act regulates ship-related activities and invokes certain requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) relating to equipment and construction of ships. Several Marine Orders (MO) are enacted under this Act relating to offshore petroleum activities, including: • MO 21: Safety of navigation and emergency procedures. • MO 30: Prevention of collisions.	• Certain sections of MARPOL • International Convention for the Safety of Life at Sea 1974 • COLREG 1972	AMSA

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	• MO 31: Vessel surveys and certification. **Application to activity**: The relevant vessels (according to class) will adhere to the relevant MO with regard to navigation and preventing collisions in Commonwealth waters. *Sections 7 details the requirements applicable to vessel activities.*		
Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGSA) OPGGS(E)R	The Act addresses all licensing, health, safety, environmental and royalty issues for offshore petroleum exploration and development operations extending beyond the three-nautical mile limit. Part 2 of the OPGGS(E)R specifies that an EP must be prepared for any petroleum activity and that activities are undertaken in an ecologically sustainable manner and in accordance with an accepted EP. **Application to activity**: The OPGGS Act provides the regulatory framework for all offshore petroleum exploration and production activities in Commonwealth waters, to ensure that these activities are carried out: • Consistent with the principles of ecologically sustainable development as set out in section 3A of the EPBC Act. • So that environmental impacts and risks of the activity are reduced to as low as reasonably practicable (ALARP). • So that environmental impacts and risks of the activity are of an acceptable level. *Demonstration that the activity will be undertaken in line with the principles of ecologically sustainable development, and that impacts and risks resulting from these activities are ALARP and acceptable is provided in Section 7.*	-	NOPSEMA
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	This Act regulates Australian regulated vessels with respect to ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc. **Application to activity**: All ships involved in petroleum activities in Australian waters are required to abide to the requirements under this Act. Several MOs are enacted under this Act relating to offshore petroleum activities, including: • MO 91: Marine Pollution Prevention – Oil.	• Various parts of MARPOL	AMSA

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	• MO 93: Marine Pollution Prevention – Noxious Liquid Substances. • MO 94: Marine Pollution Prevention – Harmful Substances in Packaged Forms. • MO 95: Marine Pollution Prevention – Garbage. • MO 96: Marine Pollution Prevention – Sewage. • MO 97: Marine Pollution Prevention – Air Pollution. *Sections 7 details the requirements applicable to vessel activities.*		
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Under this Act, it is an offence for a person to engage in negligent conduct that results in a harmful anti-fouling compound being applied to or present on a ship. The Act also provides that Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria. **Application to activity**: All ships involved in offshore petroleum activities in Australian waters are required to abide to the requirements under this Act. The MO 98: Marine Pollution Prevention – Anti-fouling Systems is enacted under this Act. *Sections 7 details the requirements applicable to vessel activities.*	• International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001	AMSA

Table 3-2: Recovery plans, threat abatement plans and species conservation advices relevant to the activity

Relevant Plan/Advice	Applicable Threats or Management Advice
National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011–2016	The recovery plan is a co-ordinated conservation strategy for albatrosses and giant petrels listed as threatened. • **Marine pollution**: Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented. • **Marine debris**: Evaluate risk of marine debris (including risk of entanglement and/or ingestion) and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Sternula nereis nereis* (Fairy Tern)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Fairy tern. • **Marine pollution:** Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Calidris canutus* (Red Knot)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Red knot.

Relevant Plan/Advice	Applicable Threats or Management Advice
	• **Marine pollution**: Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern)	• None identified.
National Recovery Plan for Gould's Petrel (*Pterodroma leucoptera leucoptera*)	• None identified.
National Recovery Plan for the Orange-bellied Parrot (*Neophema chrysogaster)*	The recovery plan is a co-ordinated conservation strategy for the orange-bellied parrot. • **Illuminated boats and structures**: Evaluate risk of lighting on vessels and offshore structures.
Approved Conservation Advice for the Blue Petrel *(Halobaena caerulea)*	• None identified.
Wildlife Conservation Plan for Migratory Shorebirds – 2015	• None identified.
National Recovery Plan for the Australian Grayling (*Prototroctes maraena*)	The recovery plan is a co-ordinated conservation strategy for the Australian grayling. • **Poor water quality and siltation**: Typically, from onshore sources. • **Impact of introduced fish**: Typically, from onshore sources.
Recovery Plan for the White Shark (*Carcharodon carcharias*)	The overarching objective of this recovery plan is to assist the recovery of the white shark in the wild throughout its range in Australian waters. **Threats**: • None identified.
Recovery Plan for Marine Turtles in Australia, 2017-2027	The long-term recovery objective for marine turtles is to minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act Threatened species list. **Threats** • Chemical and terrestrial discharge. • Marine debris. • Light pollution. • Habitat modification. • Vessel strike. • Noise interference. • Vessel disturbance.
Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle)	See above for Recovery Plan for Marine Turtles in Australia, 2017-2027.

Relevant Plan/Advice	Applicable Threats or Management Advice
Conservation Management Plan for the Blue Whale, 2015-2025	The long-term recovery objective for blue whales is to minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list. **Threats** • Noise interference: Evaluate risk of noise impacts and, if required, appropriate mitigation measures are implemented. • Vessel disturbance: Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Balaenoptera borealis* (Sei Whale)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the sei whale. **Threats** • Noise interference: Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance: Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Megaptera novaeangliae* (Humpback Whale)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the humpback whale. **Threats** • Noise interference: Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance: Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.
Conservation Management Plan for the Southern Right Whale 2011-2021	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the Southern right whale. **Threats** • Noise interference: Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance: Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.
Approved Conservation Advice for *Balaenoptera physalus* (Fin Whale)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the fin whale. **Threats** • Noise interference: Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance: Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.

4 Description of the activity

This section provides a description of the petroleum activity, including the details of the location in which the activities will occur, in accordance with Regulation 13(1) of the OPGGS(E)R.

The objectives of the seabed assessments are to:

- Identify potential seabed debris, obstructions and hazards which could interfere with the positioning and anchoring of the moored Mobile Offshore Drilling Unit (MODU) and subsea infrastructure placement.
- Identify and map the nature and distribution of geomorphological features types (canyons, scarps, vents, pinnacles etc.) in the operational area using side scan sonar (SSS) and multi-beam echo sounder (MBES).
- Identify sub-seabed features and lithology to assist determination of anchor holding capability/limitations and subsea infrastructure locations using sub-bottom profiler (SBP) investigations.
- Accurately measure water depth and map seabed topography across the operational area.
- Collect seabed sediment gravity core samples to correlate sub-bottom conditions that may have implications for the MODU anchor holding performance and subsea infrastructure placement.
- Conduct an in-situ cone penetrometer test (CPT) to suitable depth of interest for anchor holding analysis and subsea infrastructure location selection.
- Obtain seabed imagery using a remotely operated underwater vehicle (ROV) or drop camera.
- Collect benthic sediment grab samples at proposed well locations.

4.1 Activity location and timing

4.1.1 Operational area

The proposed seabed assessment areas are shown in Figure 4-1. The locations of these areas may change but will be within the operational area as defined within Figure 4-1. Coordinates for the operational area are provided in Table 4-2.

The seabed assessment areas for the proposed well locations are detailed in Figure 4-1 and Table 4-1 details the size of the areas. The seabed assessment area size is to account for the well site locations and rig mooring anchor pattern. Due to the close proximity of the proposed Thylacine wells, the seabed assessment will be undertaken within one large area.

At the time of writing this EP the location of the T/30P exploration well is not known other than it will occur within the portion of the T/30P title within the defined operational area (Figure 4-1).

Seabed assessments will also occur along the proposed flowline route from the La Bella well to the Artisan well and then to two locations at Offshore Otway Gas Pipeline to assess options for connecting the flowline to the pipeline, and along the proposed umbilical routes from the Artisan well to the Thylacine platform, and from the La Bella well to the Thylacine Platform (Figure 4-1). The seabed assessment corridors for these areas will be 1 km wide.

For the purposes of this EP, activities performed by the vessel when outside the operational area are not covered by the OPGGS(E)R and therefore not addressed within this EP.

Table 4-1: Seabed assessment area size

Seabed Assessment Area	Size km
Artisan	4.5 x 5
La Bella	4.5 x 5
Geographe	5 x 5
Thylacine	9 x 9.5
T/30P	4.5 x 5

Table 4-2: Geospatial coordinates of the operational area (GDA94 * EPSG-Aus/MGA zone 52)

Figure 3-1 Label	Longitude	Latitude
A	142°35'13.2"E	38°54'57.6"S
B	142°45'10.8"E	38°54'54"S
C	142°45'10.8"E	38°51'7.2"S
D	142°58'33.6"E	38°51'7.2"S
E	142°58'33.6"E	39°4'51.6"S
F	143°0'28.8"E	39°4'51.6"N
G	143°0'28.8"E	39°11'52.8"S
H	143°5'16.8"E	39°11'52.8"S
I	143°5'16.8"E	39°19'55.2"S
J	142°40'12"E	39°19'55.2"S
K	142°40'12"E	39°1'37.2"S
L	142°35'13.2"E	38°59'56.4"S

4.1.2 Activity timing

Seabed assessments will be carried out over two phases, the first is anticipated to start in September 2019 and the second in March 2020, contingent on the availability of a suitable vessel, weather and the receipt of environmental approvals. The first phase will cover all locations with the exception of T/30P. The second phase will cover T/30P and any areas that may not have been completed during the first phase.

The seabed assessments timings are estimated to be five days each for the Artisan, La Bella, Geographe and T/30P areas, 12 days for the Thylacine area, and seven days for each of the 1 km wide flowline and umbilical corridors. Timings will be dependent on weather and equipment downtime.

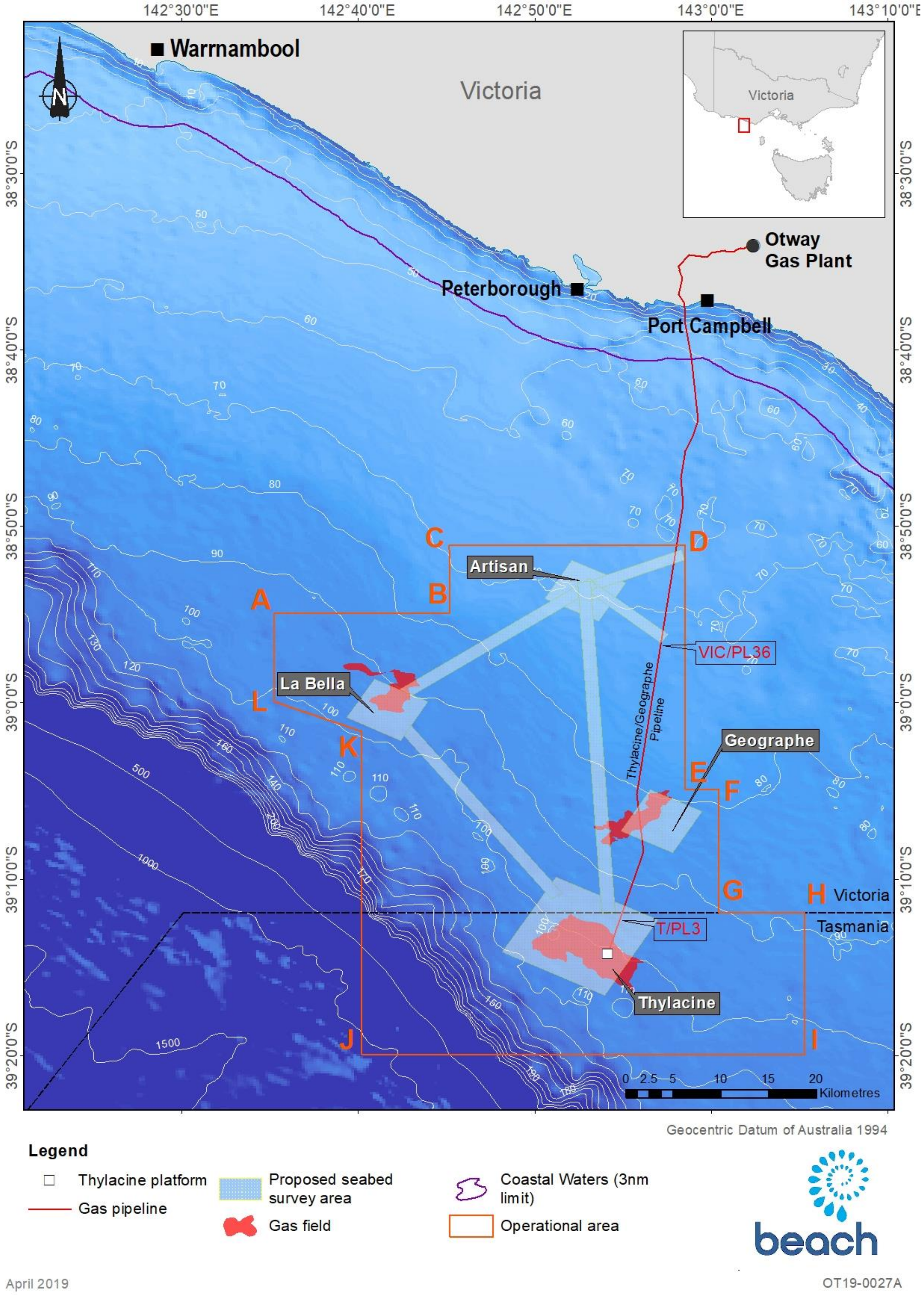

Figure 4-1: Geotechnical and geophysical seabed assessment areas and defined operational area

4.2 Seabed assessment activities

The seabed assessment activities will involve geophysical and geotechnical investigations. Seabed imagery will also be taken using a camera placed overboard via a tether and/or by ROV.

4.2.1 Geophysical investigations

Geophysical investigations to be undertaken are described in Table 4-3 and the vessel and equipment set up detailed in Figure 4-2. These investigations are designed to support MODU anchoring calculations and detect hazards on or below the seabed so that they can be avoided when determining the placement of the MODU and placement of subsea infrastructure.

Line spacing will consist of nominal 100 m spaced primary lines with crosslines spaced at 500 m. The survey will be acquired in two passes to provide seabed depth and image information for anchor positioning. The line spacing will achieve a 20% overlap of adjacent swathes of processed data.

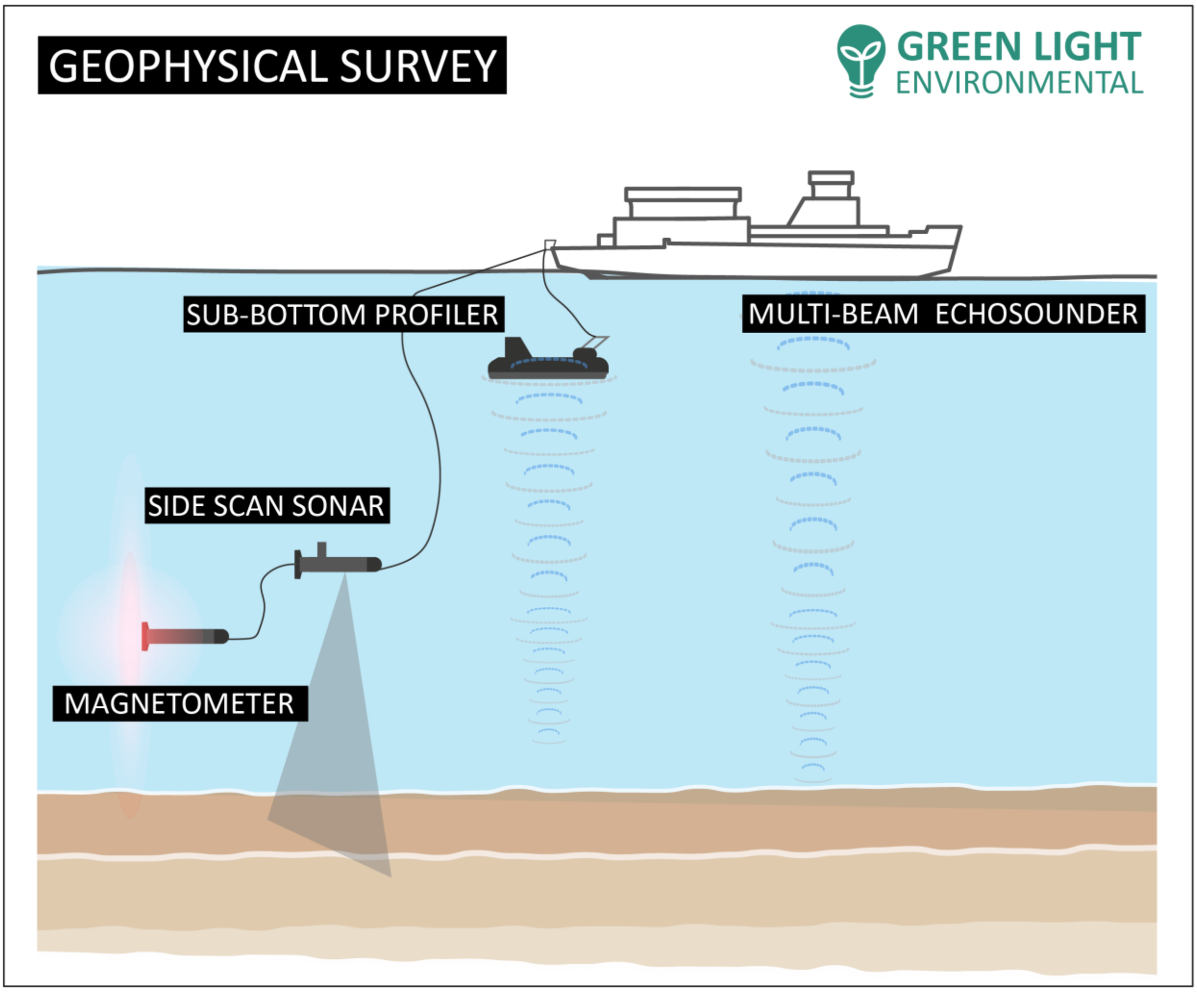

Figure 4-2: Geophysical survey equipment

4.2.2 Geotechnical activities

A description of the proposed geotechnical investigation is outlined in Table 4-4 and the vessel and equipment set up detailed in Figure 4-3.

Geotechnical methods collect detailed information on the properties of the seabed and the underlying shallow sediments to build up a picture of the local geology of the area. The collected sediments are photographed, described and tested to determine the load bearing properties of the seabed at potential MODU anchoring locations and validate the results of the geophysical investigations.

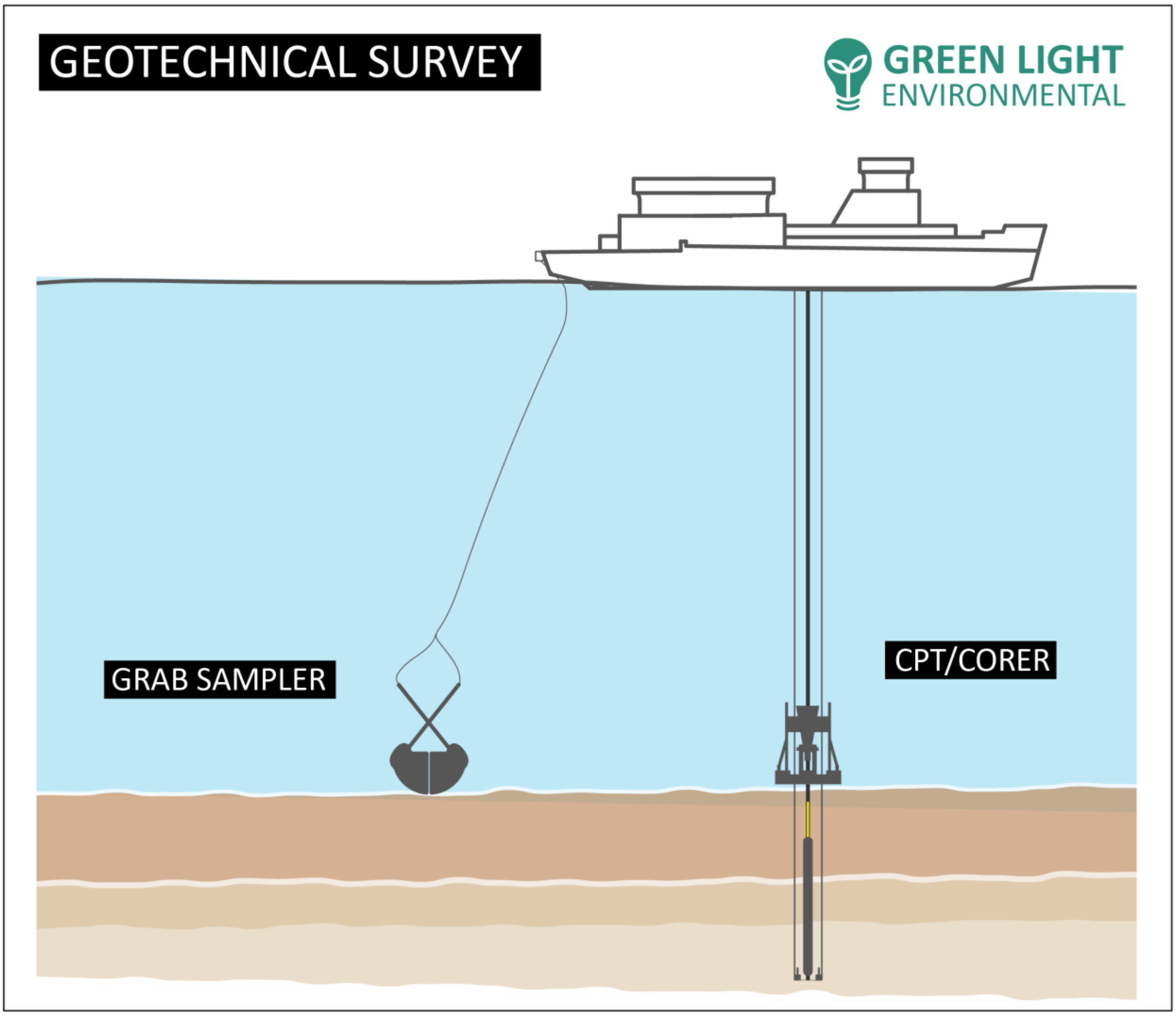

Figure 4-3: Geotechnical and environmental sampling equipment

4.3 Survey vessel

A vessel will be used to undertake the seabed assessments. The vessel will travel at approximately 4–5 knots (7–9 km/hr) when undertaking the geophysical assessments and stationery when undertaking the geotechnical assessments.

The vessel will hold station using dynamic positioning (DP) or propellers as water depths are too deep for anchoring. The use of support vessels is not required. Vessel refuelling will occur at port. Mobilisation of crew to the vessel and any crew change will be at port.

4.4 Remotely operated underwater vehicle

A ROV is a tethered underwater vehicle deployed from a vessel. ROVs are unoccupied, highly manoeuvrable and operated by a crew aboard the vessel. They are linked by either a neutrally buoyant tether or often when working in rough conditions or in deeper water a load carrying umbilical cable is used along with a tether management system. The ROV will be equipment at a minimum with a camera and lights.

Table 4-3: Description of geophysical assessment activities

Activity	Purpose	Activity Details
Multi-beam echo sounder (MBES)	The purpose of the MBES investigation is to undertake detailed measurements of bathymetry in the operational area.	A MBES mounted on the vessel hull is likely to be used. A MBES acquires a wide swath (strip) of bathymetry data perpendicular to the vessel track and provides total seabed coverage with no gaps between vessel tracks. MBES systems are available for all water depths between 1 m and 12,000 m. A MBES transmits a broad acoustic pulse from a transducer over a swath across track. The MBES then forms a series of received beams that are each much narrower and form a 'fan' (with a half-angle of 30-60°) across the seabed, perpendicular to the vessel track. The transducer(s) then 'listen' for the reflected energy from the seabed. The fans of seabed coverage produce a series of strips along each track, which are lined up side-by-side to generate two dimensional georeferenced bathymetric maps of the seabed.
Side scan sonar (SSS)	Detects hazards such as existing pipelines, lost shipping containers, boulders, debris, unmarked wrecks, reefs and craters.	The SSS method of surveying generates oblique acoustic images of the seabed by towing a sonar 'towfish.' The towfish is provided with power and digital telemetry services and towed from the vessel using a reinforced or armoured tow cable. The towfish is equipped with a linear array of transducers that emit, and later receive, an acoustic energy pulse in a specific frequency range. Typically, a dual-channel, dual-frequency SSS is used. SSS is similar to MBES but operates at a wider fan angle. The acoustic energy received by the SSS tow vehicle (backscatter) provides information as to the general distribution and characteristics of the surficial sediment and outcropping strata, as for MBES. Shadows result from areas of no energy return, such as shadows from large boulders or sunken ships, and aid in interpretation of the sonogram image. The SSS towfish is constructed of stainless steel and is a cylindrical torpedo-like device and is typically towed 10-15 m above the seabed depending on water depth and the frequency range. The SSS is towed and operated at the same time as the MBES.
Sub-bottom profiler (SBP)	An SBP is used to investigate the layering and thickness of the uppermost seabed sediments. The SBP must be able to provide imagery that penetrates to a minimum depth of at least 30 m below the seabed.	**Compressed High-Intensity Radar Pulse (CHIRP)** Very high frequency systems including pingers, parametric echo sounding and CHIRP – produce a swept-frequency signal. CHIRP systems usually employ various types of transducers as the source. The transducer that emits the acoustic energy also receives the reflected signal. CHIRP signals typically penetrate only about 5-10 m in to the seabed and provide the best resolution, but lowest penetration. A CHIRP is normally hull mounted when used for shallow water operations but may also be towed in a similar fashion to the SSS.
		High-frequency boomers Consist of a circular piston moved by electro-magnetic force (comprising an insulated electrical coil adjacent to a metal plate). The high voltage energy that excites the boomer plate is stored in a capacitor bank. A shipboard power supply generates an electrical pulse that is discharged to the electrical coil causing a magnetic field to repel a metal plate. This energetic motion generates a broadband, high amplitude impulsive acoustic signal in the water column that is directed vertically downward. A boomer system offers a penetration depth of up to 100 m below the seabed. Boomers are mostly surface towed but may also be towed below the surface to avoid sea surface wave noise and movement.

Activity	Purpose	Activity Details
		The receiver for the boomer system is usually a hydrophone or hydrophone array consisting of a string of individual hydrophone elements located within a neutrally buoyant synthetic hydrocarbon filled tubing. They typically contain eight to 12 hydrophone elements evenly spaced in a tube that is 2.5 to 4.5 m in length and 25 mm in diameter. The SBP system is towed and operated at the same time as the MBES and SSS. The survey is likely to be undertaken in two passes in conjunction with the MBES and SSS.
Magnetometer	This equipment detects large and small metallic objects on or below the seabed (e.g. buried pipelines, petroleum wellheads, shipwreck debris and dropped objects such as unexploded ordinance, cables, anchors, chains) that may not be identified by acoustic means.	A magnetometer sensor is housed in a towfish and is towed as close to the seabed as possible and sufficiently far away from the vessel to isolate the sensor from the magnetic field of the vessel. A magnetometer measures the ambient magnetic field using nuclear magnetic resonance technology, applied specifically to hydrogen nuclei. The magnetometer survey will be conducted simultaneously with the MBES, SSS and SBP, as it can be powered using the same tow cable and power supply. The magnetometer towfish is constructed of stainless steel and is a cylindrical torpedo-like type device. A magnetometer is capable of a sampling rate of at least 1 Hz with a sensitivity of at least 1 nanotesla.
Ultra-Short Baseline (USBL) Positioning System	This equipment is designed for positioning towfish in water depths up to 3,000 m.	A complete USBL system consists of a transceiver, which is mounted on a pole under a vessel, and a transponder or responder on a towfish. A computer, or "topside unit", is used to calculate a position from the ranges and bearings measured by the transceiver. An acoustic pulse is transmitted by the transceiver and detected by the subsea transponder, which replies with its own acoustic pulse. This return pulse is detected by the shipboard transceiver. The time from the transmission of the initial acoustic pulse until the reply is detected is measured by the USBL system and is converted into a range.
Sound Velocity Profiler (SVP) and Conductivity, Temperature and Depth (CTD)	This equipment is used to determine the speed of sound in water; in addition to CTD data.	The probe is fitted with a digital time of flight sound velocity sensor, conductivity sensor, a temperature compensated piezo-resistive pressure transducer, and a temperature sensor.

Table 4-4: Description of geotechnical assessment activities

Activity	Purpose	Activity Details
Coring	Coring provides samples for undertaking geological analysis of formations below the seabed.	**Vibrocoring** Vibrocoring is a technique for collecting core samples in unconsolidated sediments by using a vibrating device to drive a coring tube into the seabed. Typically, two large electrical motors power two concentric weights, which produce the necessary vibration. Once the unit is on the sea floor, the high-power vibrator motors are engaged and drive the core barrel with PVC liner into the seabed. The corers are lowered by winching a cable wire from the vessel at approximately 1-2 m/s, so the duration of lowering and recovery operations in the sample area will be short (20-30 seconds at each site). Sampling itself is of a very short duration at each location (typically 5-10 minutes) and given the small area, may only take a few hours in total. A minimum of four gravity drop seabed samples shall be taken equally spaced around a 1 km radius of each wellsite location, including the centre of the MODU location. Coring will also be undertaken along the umbilical routes. Coring samples are used to ground truth the geophysical data.
		Piston (or gravity) coring A piston corer is normally used on soft, unconsolidated sediments. The coring unit is deployed from the side of the vessel. A piston corer is lowered by wire rope to the seabed. It has a trigger device that hits the seabed before the core barrel and releases the corer allowing it to freefall. As the barrel enters the sediment, a special internal piston creates a vacuum and helps to draw the core into the barrel. Core catchers prevent the sediment from coming out of the coring tube. This suction reduces compaction of the sample in the inner sleeve. Sampling itself is of a very short duration at each location and given the small area, this testing may only take a few hours in total. A minimum of four gravity drop seabed samples shall be taken equally spaced around a 1 km radius of each wellsite location, including the centre of the MODU location. Coring will also be undertaken along the umbilical routes. Coring samples are used to ground truth the geophysical data.
Seabed grab sampling	Seabed grab sampling provides samples for undertaking geological analysis of unconsolidated seabed sediments.	Grab sampling is a process of collecting small samples of surface sediments from the seafloor. Only surface sediments are collected as the sampler has no ability to penetrate to depth. Seabed samples are to be taken at four locations around each well location to identify infauna compositions. The samples are planned to be taken using a grab sampler deployed from the vessel. Each grab sample typically covers a spatial area of <1 m^2.

Activity	Purpose	Activity Details
Cone Penetrometer Test (CPT)	CPT determines soil strength and helps to delineate soil stratigraphy.	CPT involves the in-situ measurement of the resistance of ground to continuous penetration. This process involves lowering a frame to the seabed and pushing the CPT unit into the sediment at a steady penetration rate (usually 2 cm per second). The CPT unit consists of a rod up to 25 m long that has a small cone at its base (with typical cone tips having a cross-sectional area of 2, 5, 10 or 15 cm^2). The CPT measures resistance to the push and these measurements allow high quality interpretation of ground conditions and pore pressure dissipation testing. A seabed frame is lowered to the seabed with the CPT unit integrated into it and operated remotely. A CPT typically takes 2-2.5 hours to complete. When the required penetration depth is reached, all equipment is withdrawn from the seabed. A small hole will remain in the seabed, which will eventually collapse and infill with the movement of seabed sediments. This can be very rapid if the seabed consists of unconsolidated sediments. As for coring, a minimum of four gravity drop seabed samples shall be taken equally spaced around a 1 km radius of each wellsite location, including the centre of the MODU location. This ground truths the geophysical data and provides soil strength data that can be used for geotechnical analysis.

5 Existing environment

In accordance with Regulation 13(2) of the OPGGS(E)R, this section provides regulatory context, description of the environment that may be affected (EMBA), regional setting and a summary of the key physical, ecological and social receptors in the operational area and the EMBA. A detailed description of the environment is provided in Appendix B for all physical, ecological, socio-economic and cultural receptors present in the operational area and EMBA.

Threatened species recovery plans, threat abatement plans and species conservation advices relevant to the receptors identified in this section are detailed in Table 3-2.

5.1 Regulatory context

The OPGGS(E)R define 'environment' as the ecosystems and their constituent parts, natural and physical resources, qualities and characteristics of areas, the heritage value of places and includes the social, economic and cultural features of those matters. In accordance with the Regulations, this document describes the physical, ecological, and social components of the environment.

A greater level of detail is provided for those particular values and sensitivities as defined by the Regulations 13(3) of the OPGGS(E)R which states that particular relevant values and sensitivities may include any of the following:

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:

    a. Commonwealth marine area within the meaning of that Act; or

    b. Commonwealth land within the meaning of that Act.

With regards to 13(3)(d) and (e) more detail has been provided where listed Threatened or Migratory species have a spatially defined biologically important area (BIA) or habitat critical to survival – as they are spatially defined areas where aggregations of individuals of a regionally significant species are known to display biologically important behaviours such as breeding, foraging, resting or migration.

With regards to 13(3)(f) more detail has been provided (Appendix B) for Key Ecological Features (KEFs) as they are considered as conservation values of the Commonwealth marine area; no Australian Marine Parks (AMPs) were identified within the EMBA during the seabed assessment.

5.2 Environment that may be affected

For this EP the existing environment description and impact assessment has been undertaken on the EMBA. The largest EMBA has been identified from a maximum credible hydrocarbon spill event that may occur during a vessel collision. For the activities under this EP, the EMBA is based on hydrocarbon exposure for the accidental release of marine diesel oil from a vessel collision (Section 7.3). Details on the Automated Data Inquiry for Oil Spills (ADIOS II) modelling used to determine the EMBA is detailed in Section 7.3.3.2.

5.2.1 Regional environmental setting

The EMBA is located in the South-east Marine Region (SEMR), which extends from the south coast of New South Wales to Kangaroo Island in South Australia and around Tasmania.

There are significant variations in seafloor features throughout the SEMR including seamounts, canyons, escarpments, soft sediments and rocky reefs, which support high levels of biodiversity and species endemism. Compared to other marine areas, the SEMR is relatively low in nutrients and primary production. There are areas of continental shelf, which includes Bass Strait, which have rocky reefs and soft sediments that support a wide range of species. The shelf break increases currents, eddies and upwelling, and the area is especially biodiverse, including species that are fished recreationally and commercially. There are seafloor canyons along the continental shelf which provide habitat for sessile invertebrates such as temperate corals.

The SEMR has a high diversity of species and also a large number of endemic species. The fish fauna in the region includes around 600 species, of which 85% are thought to be endemic. Additionally, approximately 95% of molluscs, 90% of echinoderms, and 62% of macroalgae (seaweed) species are endemic to these waters (Director of National Parks, 2013).

5.2.2 Physical, ecological, socio-economic and cultural receptors

The following tables list the presence of physical (Table 5-1), ecological (Table 5-2) and socio-economic and cultural (Table 5-3) receptors that may occur within the EMBA.

Examples of values and sensitivities associated with each of the ecological or social receptors have been included in the tables. These values and sensitivities have been identified based on:

- Presence of listed Threatened or Migratory species or Threatened Ecological Communities identified in the EPBC Protected Matter search (Appendix A).
- Presence of BIAs and habitats critical to the survival of the species.
- Presence of important behaviours (e.g. foraging, roosting or breeding) by fauna, including those identified in the EPBC Protected Matter search (Appendix A).
- Important linkage to other receptors (e.g. nursery habitat, food source, commercial species).
- Important benefit to human activities (e.g. recreation and tourism, aesthetics, economic benefit).

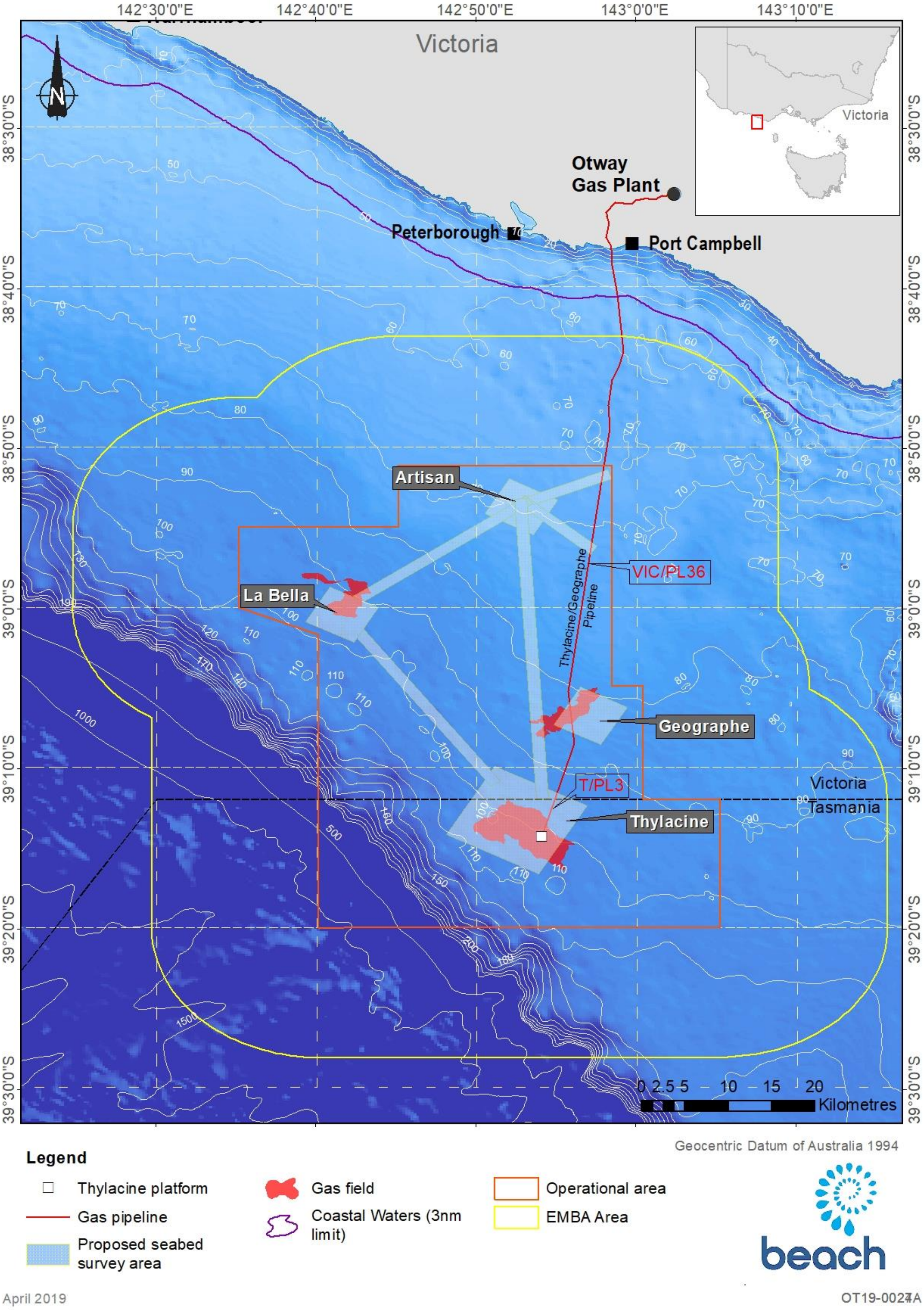

Figure 5-1: Environment that may be affected

Table 5-1: Presence of physical receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities	Present	EMBA
Shoreline	Rocky	• Foraging habitat (e.g. birds) • Nesting or breeding habitat (e.g. birds, pinnipeds) • Haul-out sites (e.g. pinnipeds)	-	Not present. The EMBA does not include the onshore/nearshore environment.
	Sandy	• Foraging habitat (e.g. birds) • Nesting or breeding habitat (e.g. birds, pinnipeds) • Haul-out sites (e.g. pinnipeds)	-	
	Artificial structure	• Sessile invertebrates	-	
Mangroves	Intertidal/subtitle habitat, mangrove communities	• Nursery habitat (e.g. crustaceans, fish) • Breeding habitat (e.g. fish)	-	Not present. The EMBA does not include the onshore/nearshore environment.
Saltmarsh	Upper intertidal zone, saltmarsh habitat, habitat for fish and benthic communities	• Nursery habitat (e.g. crustaceans, fish) • Breeding habitat (e.g. fish)	-	Not present. The EMBA does not include the onshore/nearshore environment.
Soft sediment	Predominantly unvegetated soft sediment substrates	• Key habitat (e.g. benthic invertebrates)	✓	The seabed assessment will be conducted in water depths approximately 60-1000 m depth. In the shallow Otway Shelf (0-70 m depth) are exhumed limestone substrates that host dense encrusting mollusc, sponge, bryozoan and red algae assemblages. During video surveys, only in waters shallower than approximately 20 m, was an area of significant, high profile reef and associated high density macroalgae dominated epibenthos encountered. Seagrass and hard coral are not expected to be present. The Middle Otway Shelf (70-130 m depth) is a zone of large tracts of open sand with little or no epifauna to characterise the area: infaunal communities and bivalves, polychaetes and crustaceans dominate in the open sand habitat. *See Appendix B.2.1 for more detail.*
Seagrass	Seagrass meadows	• Nursery habitat (e.g. crustaceans, fish) • Food source (e.g. fish, turtles)	-	
Algae	Macroalgae	• Nursery habitat (e.g. crustaceans, fish) • Food source (e.g. birds, fish)	✓	
Coral	Soft coral communities	• Nursery habitat (e.g. crustaceans, fish) • Breeding habitat (e.g. fish)	✓	

Table 5-2: Presence of ecological receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
Plankton	Phytoplankton and zooplankton	• Food source (e.g. fish, cetaceans, marine turtles)	✓	Present. Phytoplankton and zooplankton are widespread throughout oceanic environments. *See Appendix B.3.2 for more detail.*
Seabirds	Birds that live or frequent the ocean	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	Present. 29 seabird and shorebird species (or species habitat) may occur within the EMBA; with breeding, foraging and roosting behaviours identified. The EMBA intersects foraging BIAs for a number of albatross (Antipodean albatross, black-browed albatross, Buller's albatross, Campbell albatross, Indian yellow-nosed albatross, shy albatross, wandering albatross); wedge-tailed shearwater; common diving-petrel and short-tailed shearwater. Roosting and breeding for a variety of bird species, wader birds and terns, occurs in eastern Victoria outside the EMBA. *See Appendix B.3.5.1 for more detail.*
Marine invertebrates	Benthic and pelagic invertebrates	• Food source (e.g. fish)	✓	Present. A variety of invertebrate species may occur within the EMBA, including sponges and arthropods.
		• Commercial species	✓	Present. Commercially important species (e.g. rock lobster, giant crab) may occur within the EMBA. *See Appendix B.3.3 for more detail.*
Fish	Fish	• Listed Threatened species	✓	Present. One threatened fish species (or species habitat) may occur within the EMBA: • Australian grayling. *See Appendix B.3.5.2 for more detail.*

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
	Sharks and rays	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	Present. Three shark species (or species habitat) may occur within the EMBA: • porbeagle shark; • shortfin mako shark; and • white shark. The EMBA is within a distribution BIA for the white shark. No habitat critical to the survival of the species or behaviours were identified. *See Appendix B.3.5.2 for more detail.*
	Pipefish, seahorse, seadragons	• Listed marine species	✓	Present. 26 syngnathid species (or species habitat) may occur within the EMBA. No important behaviours or BIAs have been identified. *See Appendix B.3.5.2 for more detail.*
Marine reptiles	Marine turtles	• Listed marine species • Listed Threatened species • Listed Migratory species	✓	Present. Three marine turtle species (or species habitat) may occur within the EMBA: • loggerhead turtle; • green turtle; and • leatherback turtle. No BIAs or habitat critical to the survival of the species occur within the EMBA. *See Appendix B.3.5.5for more detail.*
Marine mammals	Pinnipeds	• Listed marine species	✓	Present. Two pinniped species (or species habitat) may occur within the EMBA: • long-nosed fur-seal; and • Australian fur-seal. No BIAs or habitat critical to the survival of the species occur within the EMBA. *See Appendix B.3.5.4 for more detail.*

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
	Whales	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	Present. 22 whale species (or species habitat) may occur within the EMBA. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The EMBA intersects a foraging BIA for the pygmy blue whale. *See Appendix B.3.5.3 for more detail.*
	Dolphins	• Listed marine species • Listed Migratory species	✓	Present. Six dolphin species (or species habitat) may occur within the EMBA: • Risso's dolphin; • dusky dolphin; • southern right whale dolphin; • Indian Ocean bottlenose dolphin; • common dolphin; and • bottlenose dolphin. No important behaviours or BIAs have been identified. *See Appendix B.3.5.3 for more detail.*

Table 5-3: Presence of socio-economic and cultural receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
Commonwealth Marine Area	KEF	• High productivity • Aggregations of marine life	✓	Present - West Tasmania Canyons. The West Tasmanian Canyons are located on the relatively narrow and steep continental slope west of Tasmania. This location has the greatest density of canyons within Australian waters where 72 submarine canyons have incised a 500 km-long section of slope (Heap & Harris, 2008). Submarine canyons modify local circulation patterns by interrupting, accelerating, or redirecting current flows that are generally parallel with depth contours. The West Tasmania Canyons are not within the operational area. *See Appendix B.1 for more detail.*
	AMP	• Aggregations of marine life	-	Not present.
State Parks and Reserves	Marine Protected Areas	• Aggregations of marine life	-	Not present.
Wetlands of International Importance	Ramsar Wetlands	• Aggregation, foraging and nursery habitat for marine life	-	Not present.
Commercial Fisheries	Commonwealth-managed	• Economic benefit	✓	Present. The Commonwealth-managed fisheries that overlap the EMBA are: • Bass Strait Central Zone Scallop Fishery (Bass Strait CZSF); • Eastern Tuna and Billfish Fishery (ETBF); • Eastern Skipjack Fishery; • Small Pelagic Fishery (SPF); • Southern and Eastern Scalefish and Shark Fishery (SESSF); • Southern Bluefin Tuna Fishery (SBTF); and • Southern Squid Jig Fishery. Based on data within the ABARES Fishery Status Reports 2013 to 2017 (Patterson et al. 2018, 2017, 2016, 2015 and Georgeson et al. 2014) the following have catch effort within the EMBA: • ETBF; • SESSF; and • Southern Squid Jig Fishery. *See Appendix B.4.7 for more detail.*

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
	Victorian State-managed	• Economic benefit	✓	Present. The Victorian State-managed fisheries that overlap the EMBA are: • Rock Lobster Fishery; • Giant Crab Fishery; • Abalone Fishery; • Scallop (Ocean) Fishery; • Wrasse (Ocean) Fishery; and • Snapper Fishery. Based on data from Seafood Industry Victoria (SIV) 2014 to 2018 the following have catch effort within the EMBA: • Rock Lobster Fishery; and • Giant Crab Fishery. *See Appendix B.4.8 for more detail.*
	Tasmanian State-managed	• Economic benefit	-	Not present. Based on data on the Tasmanian Department of Primary Industries, Parks, Water and environment and the Fishery Assessment Reports there has been no catch effort within the EMBA.
Recreational Fisheries	State-managed	• Community • Recreation	-	Not present. Recreational fishing is popular in Victoria largely centred within Port Phillip Bay and Western Port, outside of the EMBA. *See Appendix B.4.6 for more detail.*
Recreation and Tourism	Various human activities and interaction	• Community • Recreation • Economic benefit	-	Not present. There are no features within the EMBA to attract recreation users or tourism. The distance offshore and prevailing sea state of the area is not conducive to offshore vessel-based tourism. *See Appendix B.4.4 and Appendix B.4.5 for more detail.*
Industry	Shipping	• Community • Economic benefit	✓	Present. The SEMR is one of the busiest shipping regions in Australia and Bass Strait is one of Australia's busiest shipping routes. Commercial vessels use the route when transiting between ports on the east, south and west coasts of Australia, and there are regular passenger and cargo services between mainland Australia and Tasmania.

Receptor Type	Receptor Description	Values and Sensitivities		EMBA
				See Appendix B.4.1 for more detail.
	Petroleum exploration and production	• Economic benefit	✓	Present. Petroleum exploration has been undertaken within the Otway Basin since the early 1960s. The Cooper Energy Casino-Henry fields and pipeline and Minerva field and pipeline are within the EMBA. *See Appendix B.4.2 for more detail.*
Heritage	Maritime	• Shipwrecks	-	Not present.
	Cultural	• World Heritage Properties • Commonwealth Heritage Places • National Heritage Places	-	Not present.

6 Environmental impact and risk assessment methodology

6.1 Overview

This section outlines the environmental impact and risk assessment methodology used for the assessment of the seabed assessment activities. The methodology is consistent with the Australian and New Zealand Standard for Risk Management (AS/NZS ISO 31000:2018, *Risk Management – Principles and Guidelines*). Figure 6-1 outlines this risk assessment process.

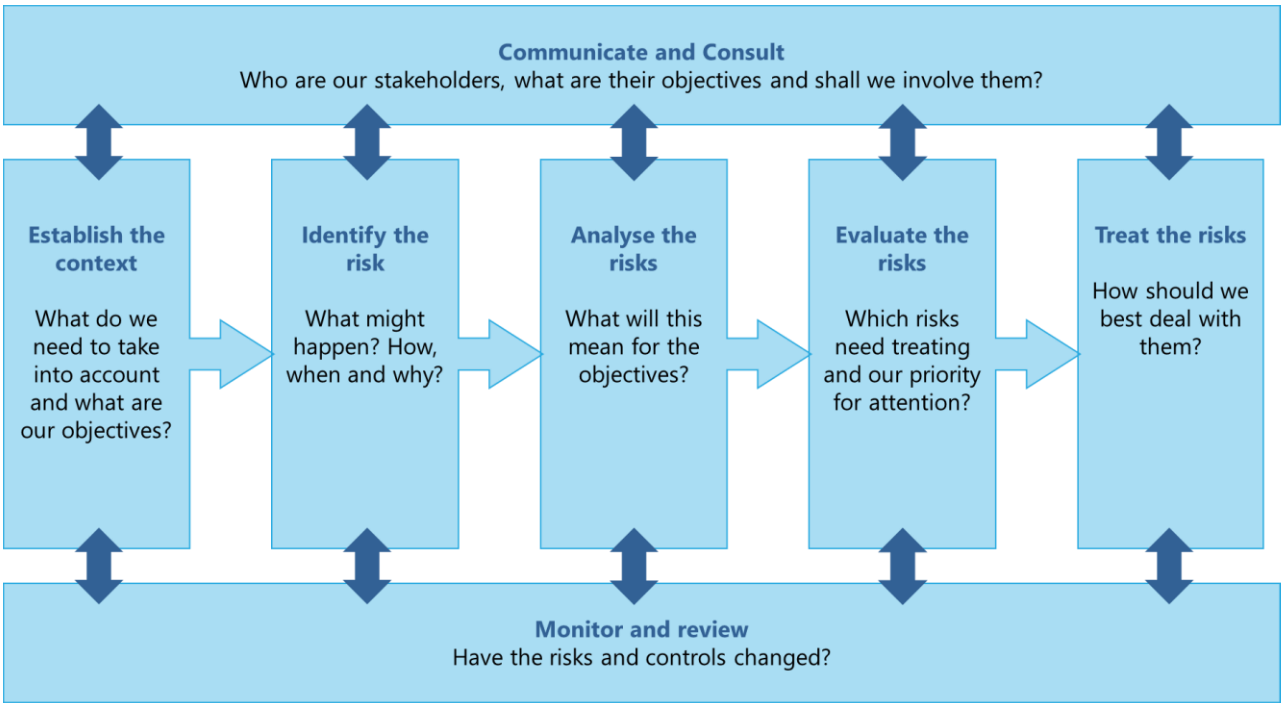

Figure 6-1: Risk assessment process

6.1.1 Definitions

Definitions of the term used in the risk assessment process are detailed in Table 6-1.

Table 6-1: Risk assessment process definitions

Term	Definition

Activity	Refers to a 'petroleum activity' as defined under the OPGGS(E)R as:
	• petroleum activity means operations or works in an offshore area undertaken for the purpose of:
	  ◦ exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or
	  ◦ discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act.

Consequence	The consequence of an environmental impact is the potential outcome of the event on affected receptors (particular values and sensitivities). Consequence can be positive or negative.
Control measure	Defined under the OPGGS(E)R as a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks.

Term	Definition
Emergency condition	An unplanned event that has the potential to cause significant environmental damage or harm to MNES. An environmental emergency condition may, or may not, correspond with a safety incident considered to be a Major Accident Event.
Environmental aspect	An element or characteristic of an operation, product, or service that interacts or can interact with the environment. Environmental aspects can cause environmental impacts.
Environmental impact	Defined under the OPGGE(E)R as any change to the environment, whether adverse or beneficial, that wholly or partially results from an activity.
Environmental performance outcome	Defined under the OPGGS(E)R as a measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks will be of an acceptable level.
Environmental performance standard	Defined under the OPGGS(E)R as a statement of the performance required of a control measure.
Environmental risk	An unplanned environmental impact has the potential to occur, due either directly or indirectly from undertaking the activity.
Likelihood	The is the chance of the impact occurring.
Measurement criteria	Is a verifiable mechanism for determining control measures are performing as required.
Operation	Refers to a component or task undertaken to facilitate a petroleum activity. Each operation is likely to have one or more associated environmental aspects.
Residual risk	The risk remaining after control measures have been applied (i.e. after risk treatment).

6.2 Communicate and consult

In alignment with Regulation 11A(2) of the OPGGS(E)R, during the development of this EP, Beach has consulted with relevant person(s) (stakeholders) to obtain information in relation to their activities within the operational area and potential impacts to their activities. This information is used to inform the EP and the risk assessment undertaken for the activity. Stakeholder consultation is an iterative process that continues throughout the development of the EP and for the duration of a petroleum activity as detailed in Section 9.

6.3 Establish the context

Context for the risk assessment process is established by:

- understanding the regulatory framework in which the activity takes place (described in the Section 3, 'Environmental Requirements');
- identifying the environmental aspects of the activity (and associated operations) that will or may cause environmental impacts or may present risks to the environment (based upon the 'Activity Description' in Section 4);
- identifying the environment that may be affected, either directly or indirectly, by the activity (based upon the 'Existing Environment' as described in Section 5); and
- understanding the concerns of stakeholders and incorporating those concerns into the design of the activity where appropriate (outlined in Section 9, 'Stakeholder Consultation').

6.4 Identify the potential impacts and risks

Potential impacts (planned) and risks (unplanned) associated with the environmental aspects of activity are identified in relation to the EMBA, either directly or indirectly, by one or multiple aspects of the activity i.e., identifying the cause-effect pathway by which environmental and social receptors may be impacted. Table 7-1 details the aspects identified for the activity.

6.5 Analyse the potential impacts and risks

This involves determining the possible contributing factors associated with the impact or risk. Each possible cause should be identified separately particularly where controls to manage the risk, differ. In this way, the controls can be directly linked to the impact or risk.

6.6 Establish environmental performance outcomes

Environmental performance outcomes are developed to provide a measurable level of performance for the management of environmental aspects of an activity to ensure that environmental impacts and risks will be of an acceptable level. Environmental performance outcomes have been developed based on the following:

- ecological receptors: MNES: Significant Guidelines 1.1 to identify the relevant significant impact criteria. The highest category for the listed threatened species or ecological communities likely to be present within the EMBA is used, for example: endangered over vulnerable.
- Commercial fisheries: Victorian Fisheries Authority core outcome of sustainable fishing and aquaculture (https://vfa.vic.gov.au/about).
- marine users: OPGGS Act 2006 (Cth) Section 280.

6.7 Evaluate and treat the potential impacts and risks

The following steps are undertaken using the environmental risk assessment matrix (Table 6-2) to evaluate the potential impacts and risks:

- identify the consequences of each potential environmental impact, corresponding to the maximum credible impact;
- for unplanned events, identify the likelihood (probability) of potential environmental impacts (i.e., the probability of the event occurring);
- for unplanned events, assign a level of risk to each potential environmental impact using the risk matrix.
- identify control measures to manage potential impacts and risks to as low as reasonably practicable (ALARP) (Section 6.9) and an acceptable level (Section 6.10); and
- establish environmental performance standards for each of the identified control measures.

6.8 Monitor and review

Monitoring and review activities are incorporated into the impact and risk management process to ensure that controls are effective and efficient in both design and operation. This is achieved through the environmental performance outcomes, environmental performance standards and measurement criteria that are described for each environmental hazard. Additional aspects of monitoring and review are described in the Implementation Strategy (Section 8).

Table 6-2: Environmental risk assessment matrix

Environmental Risk Assessment Matrix								
Consequence Rating	Natural Environment	Reputational and/or Community damage / impact / social / cultural heritage	Likelihood of Occurrence					
			Remote (1) <1% chance of occuring within the next year. Occurance requires exceptional circumstances. Exceptionally unlikely event in the long-term future. Only occur as a 100 year event.	Highly Unlikely (2) >1% chance of occuring within the next year. May occur but not anticipated. Could occur years to decades.	Unlikely (3) >5% chance of occuring in the next year. May occur but not for a while. Could occur within a few years.	Possible (4) >10% chance of occuring within the next year. May occur shortly but a ditict probability iot won't. Could occur within months to years.	Likely (5) >50% chance of occuring within the next year. Balance of probability that it will occur. Could occur within weeks to months.	Almost Certain (6) 99% chance of occuring within the next year. Impact is occuring now. Could occur within days to weeks.
Catastrophic (6)	Long-term destruction of highly valued ecosystem or very significant effects on endangered species or habitats (formally managed).	Irreparable damage or highly valued items or structures of great cultural significance. Negative international or prologed national media (e.g. 2 weeks)	High	High	Severe	Severe	Extreme	Extreme
Critical (5)	Significant impact on highly valued (formally managed) species or habitats to the point of eradication or impairment of ecosystem. Widespread long-term impact.	Major irreparable damage to highly valued structures / items of cultural significance. Negative national media for 2 days or more. Significant public outcry.	Medium	Medium	High	Severe	Severe	Extreme
Major (4)	Very serious environmental effects, such as dosplacement of species and partial impairment of ecosystem (formally managed). Widespread medium and some long-term impact.	Significant damage to items of cultural significance. Negative national media for 1 day. NGO adverse attention.	Medium	Medium	Medium	High	Severe	Severe
Serious (3)	Moderate effects on biological or physical environment (formally managed) and serious short-term effects but not affecting ecosystem functions.	Permanent damage to items of cultural significance. Negative State media. Heightened concern from local community. Criticism by NGOs.	Low	Medium	Medium	Medium	High	Severe
Moderate (2)	Minor short-term damage to area of limited significance (not formally managed). Short-term effects but not affecting ecosystem functions.	Some damage to items of cultural significance. Minor adverse local public or media attention and complaints.	Low	Low	Medium	Medium	Medium	High
Minor (1)	No lasting effects. Low-level impacts on biological and physical environment to an area of low significance (not formally managed).	Low level repairable damage to commonplace structures. Public concern restricted to local complaints.	Low	Low	Low	Medium	Medium	Medium

6.9 Demonstration of ALARP

Beach's approach to demonstration of ALARP includes:

- systematically identify and assess all potential environmental impacts and risks associated with the activity;
- where relevant, apply industry 'good practice' controls to manage impacts and risks;
- assess the effectiveness of the controls in place and determine whether the controls are adequate according to the 'hierarchy of control' principle;
- for higher order impacts and risks undertake a layer of protection analysis and implement further controls if both feasible and reasonably practicable to do so.

NOPSEMA's EP decision making guideline (NOPSEMA, 2018) states that in order to demonstrate ALARP, a titleholder must be able to implement all available control measures where the cost is not grossly disproportionate to the environmental benefit gained from implementing the control measure.

There is no universally-acceptance guidance to applying the ALARP principle to environmental assessments. For this EP, the guidance provided in NOPSEMA's EP decision making guideline (NOPSEMA, 2018) guideline has been applied, and augmented where deemed necessary.

The level of ALARP assessment is dependent upon the:

- residual impact and risk level (high versus low); and
- the degree of uncertainty associated with the assessed impact or risk.

The following section details how the guidance provided in NOPSEMA's EP decision making guideline (NOPSEMA, 2018).

6.9.1.1 Residual impact and risk levels

Lower-order environmental impacts and risks

NOPSEMA defines lower-order environmental impacts and risks as those where the environment or receptor is not formally managed, less vulnerable, widely distributed, not protected and/or threatened and there is confidence in the effectiveness of adopted control measures.

Impacts and risks are considered to be lower-order and ALARP when, using the environmental risk assessment matrix (Table 6-2), the impact consequence is rated as 'minor' or 'moderate' or risks are rated as 'low', 'medium' or 'high.' In these cases, applying 'good industry practice' (as defined in Section 6.9.1.3) is sufficient to manage the risk.

Higher-order environmental impacts and risks

NOPSEMA defines higher-order environmental impacts and risks as those that are not lower order risks or impacts (i.e., where the environment or receptor is formally managed, vulnerable, restricted in distribution, protected or threatened and there is little confidence in the effectiveness of adopted control measures).

Impacts and risks are considered to be higher-order when, using the environmental risk assessment matrix (Table 6-2), the impact consequence is rated as 'serious', 'major', 'critical' or 'catastrophic', or when the risk is rated as 'severe' or 'extreme'. In these cases, further controls must be considered as per Section 6.9.1.4 and 6.9.1.5.

An iterative risk evaluation process is employed until such time as any further reduction in the residual risk ranking is not reasonably practicable to implement. At this point, the impact or risk is reduced to ALARP. The determination of ALARP for the consequence of planned operations and the risks of unplanned events is outlined in Table 6-3.

Table 6-3: ALARP determination for consequence (planned operations) and risk (unplanned events)

Consequence ranking	Minor	Moderate	Serious	Major	Critical	Catastrophic
Planned operation	Broadly acceptable	Tolerable if ALARP		Intolerable		
Residual impact category	Lower order impacts		Higher order impacts			
Risk ranking	Low	Medium	High	Severe	Extreme	
Unplanned event	Broadly acceptable	Tolerable if ALARP		Intolerable		
Residual risk category	Lower order risks			Higher order risks		

6.9.1.2 Uncertainty of impacts and risks

In addition to the evaluation of residual impacts and risks as described above, the relative level of uncertainty associated with the impact or risk is also used to inform whether the application of industry good practice is sufficient to manage impacts and risks to ALARP, or if the evaluation of further controls is required.

In alignment with NOPSEMA's ALARP Guidance Note (NOPSEMA, 2015), Beach have adapted the approach developed by Oil and Gas UK (OGUK) (OGUK, 2014) for use in an environmental context to determine the assessment technique required to demonstrate that potential impacts and risks are ALARP (Figure 6-2). Specifically, the framework considers impact severity and several guiding factors:

- activity type;
- risk and uncertainty; and
- stakeholder influence.

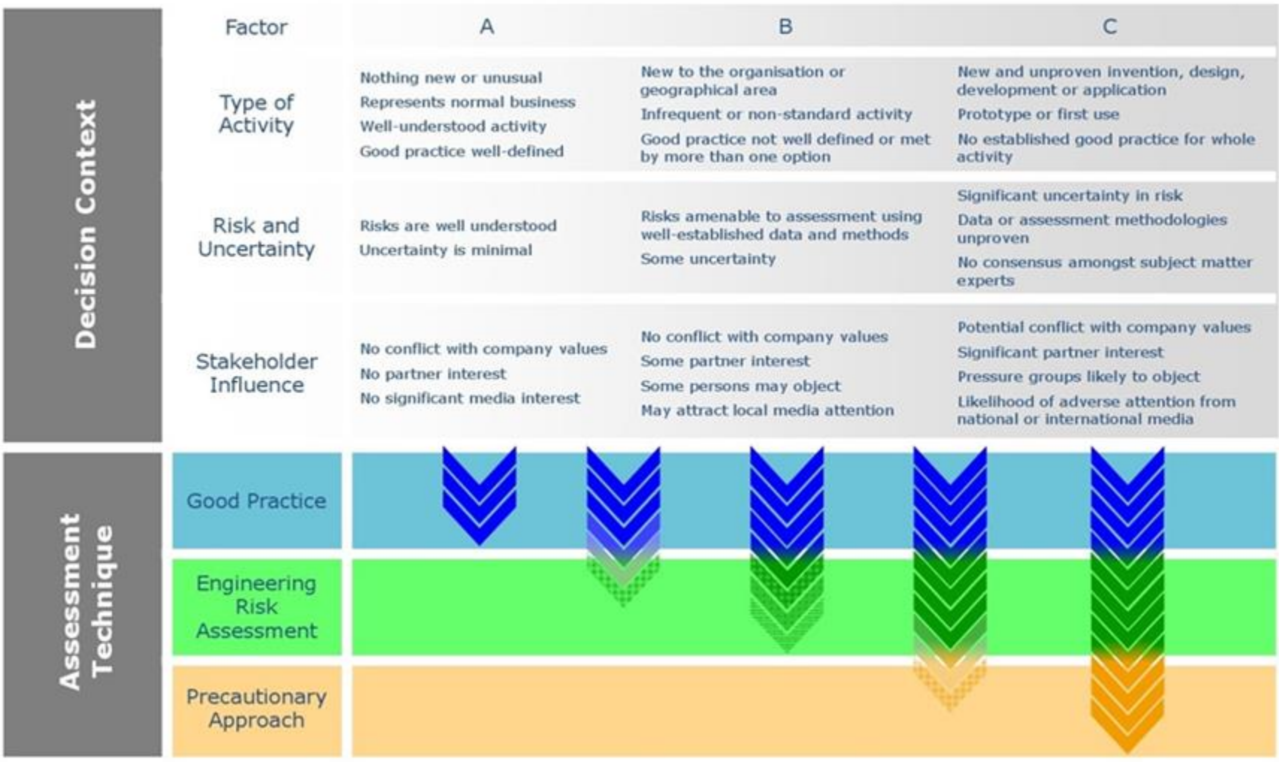

Figure 6-2: OGUK (2014) decision support framework

A **Type A** decision is made if the risk is relatively well understood, the potential impacts are low, activities are well practised, and there are no conflicts with company values, no partner interests and no significant media interests. However, if good practice is not sufficiently well-defined, additional assessment may be required.

A **Type B** decision is made if there is greater uncertainty or complexity around the activity and/or risk, the potential impact is moderate, and there are no conflict with company values, although there may be some partner interest, some persons may object, and it may attract local media attention. 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 typically involves sufficient complexity, high potential impact, uncertainty, or stakeholder influence to require a precautionary approach. In this case, relevant good practice still must be met, additional assessment is required, and the precautionary approach applied for those controls that only have a marginal cost benefit.

In accordance with the regulatory requirement to demonstrate that environmental impacts and risks are ALARP, Beach has considered the above decision context in determining the level of assessment required.

The levels of assessment techniques considered include:

- good practice;
- engineering risk assessment; and
- precautionary approach.

6.9.1.3 Good practice

OGUK (2014) 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 Australian policies;
- relevant Australian Government guidance;
- relevant industry standards and/or guidance material; and
- relevant international conventions.

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

6.9.1.4 Engineering risk assessment

All potential impacts and risks that require further assessment are subject to an 'engineering risk assessment'. Based on the various approaches recommended in OGUK (2014), Beach 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 control can be seen and the reason for the benefit understood.

6.9.1.5 Precautionary approach

OGUK (2014) states that if the assessment, considering all available engineering and scientific evidence, is insufficient, inconclusive, or uncertain, then a precautionary approach to impact and risk 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.

6.10 Demonstration of acceptability

Regulation 13(5)(c) of the OPGGS(E)R requires demonstration that environmental impacts and risks are of an acceptable level.

Beach considers a range of factors when evaluating the acceptability of environmental impacts and risks associated with its activities. This evaluation works at several levels, as outlined in Table 6-4, which is based on Beach's interpretation of the NOPSEMA EP content requirements (NOPSEMA, 2016).

Table 6-4: Acceptability criteria

Test	Question	Acceptability demonstration
Policy compliance	Is the proposed management of the impact or risk aligned with Beach's Environmental Policy?	The impact or risk must be compliant with the objectives of the company policies.
Management system compliance	Is the proposed management of the impact or risk aligned with Beach's Health, Safety and Environment Management System (HSEMS)?	Where specific Beach procedures, guidelines, expectations are in place for management of the impact or risk in question, acceptability is demonstrated.
Stakeholder engagement	Have stakeholders raised any concerns about activity impacts or risks, and if so, are measures in place to manage those concerns?	Stakeholder concerns must have been adequately responded to and closed out.
Laws and standards	Is the impact or risk being managed in accordance with existing Australian or international laws or standards?	Compliance with specific laws or standards is demonstrated.
Industry practice	Is the risk being managed in line with industry practice?	Management of the impact or risk complies with relevant industry practices.
Environmental context	Is the impact or risk being managed pursuant to the nature of the receiving environment (e.g. sensitive or unique environmental features generally require more management measures to protect them than environments widely represented in a region)?	The proposed impact or risk controls, environmental performance objectives and standards must be consistent with the nature of the receiving environment.
Environmentally Sustainable Development (ESD) Principles	Is the impact or risk being managed such that the activity can be carried out in a manner consistent with the principles of ESD?	Activity must be carried out in a manner consistent with the relevant ESD principles.

6.10.1 Ecologically sustainable development

Section 3A of the EPBC Act defines ecologically sustainable development (ESD), which is based on Australia's National Strategy for Ecological Sustainable Development (1992) that defines ESD as:

'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased.'

Relevant ESD principles and how they are applied by Beach:

- Decision making processes should effectively integrate both long term and short term economic, environmental, social and equitable considerations. This principle is inherently met through the EP development process, as such this principal is not considered separately for each acceptability evaluation.
- 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. If there is, the project shall assess whether there is significant uncertainty in the evaluation, and if so, whether the precautionary approach should be applied.
- 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 EP risk assessment methodology ensures that potential impacts and risks are ALARP, where the potential impacts and risks

are determined to be serious or irreversible the precautionary principle is implemented to ensure the environment is maintained for the benefit of future generations. Consequently, this principal is not considered separately for each acceptability evaluation.

- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision making. Beach considers if there is the potential to affect biological diversity and ecological integrity through the risk assessment process.

7 Environmental impact and risk assessment

7.1 Overview

In accordance with Regulation 13(5)(6) of the OPGGS(E)R, this section presents the impact and risk assessment for the environmental hazards identified for the seabed assessment activities using the methodology described in Section 6. Potential impacts (planned) and risks (unplanned) associated with the environmental aspects of activity are identified in Table 7-1 within lower order impacts and risk assessed in Table 7-2 and higher order impacts and risk assessed in 7.2, 7.3 and 7.4.

Table 7-1: Activity and aspect relationship

	Seabed disturbance	Underwater noise	Atmospheric emissions	Light	Planned marine discharges	Physical presence	Invasive marine species	Waste	Minor spill	Loss of diesel – vessel collision
Geotechnical operations	X									
Geophysical operations		X								
Vessel operations		X	X	X	X	X	X	X	X	X
Spill response		X	X	X	X	X	X	X	X	

Table 7-2: Seabed assessment environmental impact and risk ratings, control identification, ALARP and acceptability assessment

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
Geotechnical activities	Seabed disturbance	Change in habitat	Benthic habitat (soft sediment, macroalgae, soft corals) Marine invertebrates	As described in Table 5-1, there are few known or likely sensitive ecological seabed features within the operational area (depth ~60-1000 m). The vessel will hold station using DP or propellers as water depths are too deep for anchoring. Core samples may be up to 24 m in depth; however, the seabed surface disturbance will be less than 0.5 m^2. Post coring activities, impacts are expected to be localised and temporary with no long-term changes to habitat. Surveys of previous seabed disturbance from oil and gas activities indicate that recovery of benthic fauna in soft sediment substrates occurs within six to 12 months of cessation of the activity (URS, 2001).	Minor (1)	A	None identified	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach Health, Safety and Environment Management System (HSEMS) and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • No relevant good practice controls have been identified due to the low risk from geotechnical activities. • No potential significant impact to MNES. • Activity will not result in serious or irreversible damage. • The environmental impact assessment (EIA) demonstrates consistency with the principles of ESD.	Acceptable
Geophysical activities	Underwater noise and vibrations	Injury/mortality to fauna Behavioural disturbance	Further assessment required (Section 7.2).									
Vessel operations	Atmospheric emissions	Change in air quality	Seabirds	Minor emissions are predicted from the vessel undertaking the activity. Offshore winds will rapidly disperse atmospheric emissions when they are discharged into the environment. The operational area overlaps foraging BIAs for a number of albatross, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. The impacts on air quality is predicted to be localised to the emission point and can be expected to be reduced to background levels close to the source. No habitat critical to the survival of birds occur within the operational area. Atmospheric emissions are not identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). Climate change is; however, vessel emissions would not be significant enough to impact on climate change.	Minor (1)	A	CM#1: MO 97: Marine Pollution Prevention – Air Pollution	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not impact the long-term survival and recovery of albatross and giant petrel populations breeding and foraging as per the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). • The EIA demonstrates consistency with the principles of ESD.	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
			Coastal settlements	There are no coastal settlements within the operational area or at a distance where impacts from air emissions would occur.	N/A							
Vessel operations	Light emissions	Change in fauna behaviour	Seabirds	A change in ambient light levels could result in a localised light glow. This can lead to changes in fauna behaviour, through attraction of light-sensitive species such as seabirds and in turn affecting predator-prey dynamics. Light glow from the vessel is likely to be limited to the operational area and temporary in nature as the vessel moves through the water. The operational area overlaps foraging BIAs for a number of albatross species, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. Light emissions are identified as a threat in National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). However, impacts from vessel light emissions will be localised and temporary; limited to the operational area.	Minor (1)	A	None identified	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • No legislative requirements in relation to lighting were identified. • No relevant good practice controls have been identified due to the low risk from light emissions to seabirds. • Activity will not impact the long-term survival and recovery of albatross and giant petrel populations breeding and foraging as per the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). • The EIA demonstrates consistency with the principles of ESD.	Acceptable
			Fish	High levels of light may attract fish which are then preyed upon. Light glow from the vessel is likely to be limited to the operational area and temporary in nature as the vessel moves through the water. The threatened Australian grayling may be present in the area; however, light is not identified as a threat to this species in the National Recovery Plan for the Australian Grayling (*Prototroctes maraena)* (DSE, 2008). Commercial fish species may be present in the operational area but light from a vessel undertaking offshore activities would be the equivalent as for a fishing vessel, hence impacts to commercial fish species are unlikely.	Minor (1)	A	None identified	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • No legislative requirements in relation to lighting were identified. • No relevant good practice controls have been identified due to the low risk from light emissions to fish. • Activity will not impact the recovery of the Australian grayling as per the National Recovery Plan for the Australian Grayling (*Prototroctes maraena)* (DSE, 2008). • The EIA demonstrates consistency with the principles of ESD.	Acceptable
			Marine turtles	Artificial light can disrupt turtle nesting and hatching behaviours. There are no turtle nesting beaches or coastline within the operational area (>25 km from coastline), therefore no impact is expected.	N/A							

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
			Whales and dolphins	There is no evidence to suggest that artificial light sources adversely affect the migratory, feeding or breeding behaviours of cetaceans. Cetaceans predominantly utilise acoustic senses to monitor their environment rather than visual sources (Simmonds et al., 2004), so light is not considered to be a significant factor in cetacean behaviour or survival.	N/A							
Vessel operations	Planned discharges: Cooling water Brine Treated bilge Sewage and greywater	Change in water quality	Plankton Fish Marine turtles Marine mammals	Waste water discharges can result in localised impact on water quality from increased temperature, salinity, nutrients, chemicals and hydrocarbons leading to toxic effects to marine fauna. Vessel waste water discharges would be of low volume during in-water activities of short duration (days to weeks per seabed survey). Open marine waters are typically influenced by regional wind and large-scale current patterns resulting in the rapid mixing of surface and near surface waters thus it is expected that any waste water discharges would disperse quickly over a small area. Juvenile lifecycle stages are most vulnerable; however, recovery will be rapid (UNEP, 1985). The threatened Australian grayling maybe present in the area. The National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE, 2008) identifies poor water quality as a threat to this species; however, this is associated with onshore waterways. Commercial fish species may be present in the operational area; however, as the discharge disperse quickly over a small area, impacts are not predicted. The operational area is also within the distribution BIA for white shark, although no critical habitats or behaviours are known to occur. Sharks will be transient through the area thus impacts are not predicted. The Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013) does not identify vessel discharges or equivalent as a threat. No turtle BIAs are located within the operational area though listed Threatened species may occur. Chemical and terrestrial discharge is identified as a threat to turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) though not specifically from vessels. As these species would be transient in the area and impacts are predicted to be to be localised and temporary. Marine mammals can actively avoid plumes, limiting exposure. The operational area overlaps the pygmy blue whale foraging BIA. The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015) does not identify discharges from vessels as a threat to the recovery of these species.	Minor (1)	A	CM#2: Offshore Environmental Chemical Assessment Process CM#3: *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* CM#4: Preventative Maintenance System	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not impact the recovery of the Australian grayling as per the National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE, 2008). • Activity will not impact on the recovery of marine turtles as per the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a). • Activity will not impact the recovery of the white shark as per the Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013). • Activity will not impact the recovery of the blue whale as per the Conservation Management Plan for the Blue Whale, 2015-2025 (Commonwealth of Australia, 2015). • The EIA demonstrates consistency with the principles of ESD.	Acceptable
Vessel operations	Planned discharge: Food waste	Change in fauna behaviour	Seabirds Fish	Periodic discharge of macerated food scraps to the marine environment will result in a temporary increase in nutrients in the water column that is expected to be localised to waters surrounding the	Minor (1)	A	CM#5: MO 95: Marine Pollution Prevention - Garbage	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				vessel during in-water activities of short duration (days to weeks per seabed assessment). The operational area overlaps foraging BIAs for a number of albatross, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. No habitat critical to the survival of seabirds occur within the operational area. Marine pollution is identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011); however, as the discharge would be sporadic and for a short duration marine pollution impacts or changes to behaviour are not expected. The threatened Australian grayling maybe present in the area. The National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE, 2008) identifies poor water quality as a threat to this species; however, this is associated with onshore waterways. Commercial fish species may be present in the operational area, however as the discharge would be sporadic and for a short duration changes to behaviour is not expected.							HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not impact the recovery of the Australian grayling as per the National Recovery Plan for the Australian Grayling (*Prototroctes maraena)* (DSE, 2008). • Activity will not impact the long-term survival and recovery of albatross and giant petrel populations breeding and foraging as per the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). • The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Planned Discharges: Food waste Sewage and greywater	Change in aesthetic value	Recreation and tourism	Sewage discharges will be rapidly diluted, with impacts limited to the operational area. No recreation and tourism expected within the operational area due to lack of features.	N/A							
Vessel operations	Underwater sound emissions: continuous	Change in fauna behaviour	Fish Marine turtles	Vessels will emit noise from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment. Studies of underwater noise generated from propellers of support vessels when holding position indicate highest measured levels up to 182 dB re 1 µPa, with levels of 120 dB re 1 µPa recorded at 3–4 km (Hannay et al., 2004). Popper et al. (2014) details that risks of mortality and potential mortal injury, and recoverable injury impacts to fish with no swim bladder (sharks) and turtles is low and that temporary threshold shift (TTS) in hearing may be a moderate risk near (tens of metres) the vessel. For fish with a swim bladder risks of mortality and potential mortal injury impacts is low with a cumulative exposure guideline for recoverable injury and TTS which is not applicable as there are not areas of site-attached species within the operational area. Behavioural impacts are more likely such as moving away from the vessel. There are no habitats or features within the operational area that would restrict fish, whale sharks or turtles from moving away from the vessel. The threatened Australian grayling maybe present in the area. The National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE,	Minor (1)	A	None identified	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • No legislative requirements in relation to vessel noise in relation to fish and turtles were identified. • No relevant good practice controls have been identified due to the low risk from vessel sound emissions to fish and marine turtles. • Activity will not impact the recovery of the Australian grayling as per the National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (DSE, 2008). • Activity will not impact the recovery of the white shark as per the Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013).	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				2008) does not identify noise impacts as a threat to this species. The operational area is within a distribution BIA for the white shark though no habitat critical to the survival of the species or behaviours were identified. The Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013) does not identify noise impacts as a threat. Three marine turtle species (or species habitat) may occur within the operational area though no BIAs or critical habitat to the survival of the species were identified. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) identified noise interference as a threat; however, disturbance impacts to individuals are predicted which will not impact on turtles at a population level.							• Activity will not impact the recovery of marine turtle species as per the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a). • The EIA demonstrates consistency with the principles of ESD.	
			Pinnipeds	Vessels will emit noise from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment. Studies of underwater noise generated from propellers of support vessels when holding position indicate highest measured levels up to 182 dB re 1 µPa, with levels of 120 dB re 1 µPa recorded at 3–4 km (Hannay et al., 2004). Two species of pinniped (or species habitat) may occur within the operational area; the long-nosed fur-seal and the Australian fur-seal. No BIAs or habitat critical to the survival of the species were identified for pinnipeds. Onset thresholds for TTS and permanent threshold shift (PTS) for seals for non-impulsive noise (vessels) suggested by NMFS (2018) are as cumulative sound exposure levels over a period of 24 hours. These cannot be compared to the sounds level recorded by Hannay et al., (2004) or McCauley (1998; 2004) which report sound pressure levels. However, based on the lack of BIAs or critical habitat for pinnipeds within the operational area or within 4 km where vessel noise levels would dissipate to 120 dB re 1 µPa (Hannay et al., 2004) which is the recommended threshold for behavioural disruption for continuous noise for marine mammals (NMFS, 2013), impacts are likely to only result in behavioural changes such as avoidance of the area rather than TTS or PTS impacts. Continuous vessel noise from the vessel is not expected to be any higher than that generated by existing shipping traffic within the region. Temporary behavioural impacts to these species are not expected to result in a significant change to behaviours or natural movement that would result in further impact to individuals or local population levels.	Moderate (2)	A	CM#6: Wildlife (Marine Mammals) Regulations 2009	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not result in serious or irreversible damage to pinnipeds. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
			Whales and dolphins	Vessels will emit noise from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment. Studies of underwater noise generated from propellers of support vessels when holding position	Moderate (2)	A	CM#7: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				indicate highest measured levels up to 182 dB re 1 µPa, with levels of 120 dB re 1 µPa recorded at 3–4 km (Hannay et al., 2004). Six dolphin species may occur within the operational area. No important behaviours or BIAs have been identified. 22 whale species (or species habitat) may occur within the operational area. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The operational area intersects a foraging BIA for the pygmy blue whale. Onset thresholds for TTS and PTS for cetaceans for non-impulsive noise (vessels) suggested by NMFS (2018) are as cumulative sound exposure levels over a period of 24 hours. These cannot be compared to the sounds level recorded by Hannay et al., (2004) or McCauley (1998; 2004) which report sound pressure levels. Foraging behaviours and two BIAs are within the operational area or within 4 km where vessel noise levels would dissipate to 120 dB re 1 µPa (Hannay et al., 2004) which is the recommended threshold for behavioural disruption for continuous noise for marine mammals (NMFS, 2013). Thus, impacts are likely to result in behavioural changes such as avoidance of the area rather than TTS or PTS impacts. The Conservation Management Plan for the blue whale and for the Southern right whale and Conservation Advice for the sei whale, fin whale and humpback whale identify noise interference as a threat. However, continuous vessel noise is not expected to be any higher than that generated by existing shipping traffic within the region. Temporary behavioural impacts to these species are not expected to result in a significant change to foraging behaviours or natural movement that would result in further impact to individuals or local population levels.							HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not impact the recovery of the blue whale as per the Conservation Management Plan for the Blue Whale, 2015-2025 (Commonwealth of Australia, 2015). • The EIA demonstrates consistency with the principles of ESD.	
			Fisheries	Commercial fish species may be present in the operational area but noise from a vessel undertaking offshore activities would be the equivalent as for a fishing vessel, hence impacts to commercial fish species are unlikely.	N/A							
Vessel operations	Physical presence: collision with marine fauna	Injury/mortality to fauna	Sharks and rays Marine turtles Marine mammals	Marine fauna species most susceptible to vessel strike are typically characterised by one or more of the following characteristics: • commonly dwells at or near surface waters; • often slow moving or large in size; • frequents areas with a high levels of vessel traffic; and • fauna population is small, threatened, or geographically concentrated in areas that also correspond with high levels of vessel traffic. Impacts will be limited to the operational area.	Moderate (2)	A	CM#7: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	None identified	Highly Unlikely (2)	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements.	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				Three marine turtle species (or species habitat) may occur within the operational area though no BIAs or critical habitat to the survival of the species were identified. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) identified vessel strike as a threat. Two species of pinniped (or species habitat) may occur within the operational area; the long-nosed fur-seal and the Australian fur-seal. No BIAs or habitat critical to the survival of the species were identified for pinnipeds. 22 whale species (or species habitat) may occur within the operational area. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The operational area intersects a foraging BIA for the pygmy blue whale. The Conservation Management Plan for the blue whale and for the southern right whale and Conservation Advice for the sei whale, fin whale and humpback whale identify vessel strike as a threat. The occurrence of vessel strikes is very low with no incidents occurring during the activities to date associated with the Beach development and operations. If an incident occurred, it would be restricted to individual fauna and not have impacts to local population levels.							• Good practice controls have been defined. • Activity will not impact the recovery of marine turtle species as per the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a). • Activity will not impact the recovery of the blue whale as per the Conservation Management Plan for the Blue Whale, 2015-2025 (Commonwealth of Australia, 2015). • The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Physical presence	Displacement of other marine users	Recreation and tourism Recreational fisheries Commercial fisheries	Due to the distance that the activity is offshore and no emergent features within the operational area recreational fishing and tourism is unlikely. Based on data within the ABARES Fishery Status Reports 2013 to 2017 (Patterson et al. 2018, 2017, 2016, 2015 and Georgeson et al. 2014) the Commonwealth EETBF, SESSF and Southern Squid Jig Fishery have catch effort within the operational area. Based on SIV data from 2014 to 2018 the Rock Lobster Fishery and Giant Crab Fishery have catch effort in the area with a maximum of four fishers. During stakeholder consultation, up to six fishers have identified they may fish in the operational area. Stakeholders have raised concerns in relation to displacement of their fishing activities. Displacement impacts will be minor based on: • The largest area (Thylacine) to be surveyed will take 12 days. • Look-ahead information will be provided to fisher allowing them to avoid the vessel and fish in other parts of the operational area. • The first phase of the activity, which will take the longest, will be undertaken within September to December. The closed season for the rock lobster and crab fisheries is: Females = 1 Jun to 15, Nov, Males = 15 Sept to 15 Nov. Thus, the period of overlap will be 4 weeks for these fisheries. • Permanent exclusion zones are not required.	Minor (1)	A	CM#8: Ongoing consultation	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • Stakeholder objections or claims have been raised, however, impacts to stakeholders are minor and do not Interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined to alert relevant stakeholders of the seabed assessment activities. • Activity will not result in serious or irreversible damage. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
			Shipping	The operational area includes major shipping routes; however, vessels activities associated with the Otway Gas Development have been ongoing for over 10	Minor (1)	A	CM#8: Ongoing consultation	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy.	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				years and to date there has been no interactions or incidents.							• The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined to alert relevant stakeholders of the seabed assessment activities. • Activity will not result in serious or irreversible damage. • The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Unplanned release: waste	Injury/mortality to fauna	Seabirds Marine turtles Marine mammals	Transfer of waste will only occur in port. Waste accidently released to the marine environment may lead to injury or death to individual marine fauna through ingestion or entanglement. Impacts will be restricted in exposure and quantity and will be limited to individual fauna and not have impacts to local population levels. The operational area overlaps foraging BIAs for a number of albatross species, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. No habitat critical to the survival of birds occur within the operational area. Marine debris is identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011). Three marine turtle species (or species habitat) may occur within the operational area though no BIAs or critical habitat to the survival of the species were identified. The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017a) identified marine debris as a threat. Two species of pinniped (or species habitat) may occur within the operational area; the long-nosed fur-seal and the Australian fur-seal. No BIAs or habitat critical to the survival of the species were identified for pinnipeds. 22 whale species (or species habitat) may occur within the operational area. Foraging behaviours were identified for some species (sie, blue, fin and pygmy right whales); no other important behaviours were identified. The operational area intersects a foraging BIA for the pygmy blue whale. The Conservation Management Plan for the blue whale and for the southern right whale and Conservation Advice for the sei whale, fin whale and humpback whale do not identify marine debris as threat.	Minor (1)	A	CM#5: MO 95: Marine Pollution Prevention - Garbage	None identified	Remote (1)	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not result in serious or irreversible damage. • No potential significant impact to MNES. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
Vessel and ROV operations	Unplanned release: Minor spill	Change in water quality	Plankton Marine fauna	Minor spills <200 L may occur from:	Minor (1)	A	CM#9: ROV pre-dive inspections	Electric ROV – not always available.	Remote (1)	Low	• The proposed management of the impact is aligned with the Beach Environment Policy.	Acceptable

Activity	Aspect	Potential Impact	Receptor	Consequence Evaluation	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
	(hydrocarbon or chemical)			• vessel equipment, bulk storage or package chemical leak (deck spill); and • ROV hydraulic hose leak. Given the small volumes and the low-toxicity hydrocarbons and chemicals that could be discharged, minor spills are expected to rapidly dissipate and dilute in the high energy environment of the Otway Basin. Impacts to water quality are expected to be temporary and localised and thus will not impact on plankton and marine fauna that maybe transient within the operational area.			CM#10: Spill containment CM#11: Shipboard Marine Pollution Emergency Plan (SMPEP), or equivalent				• The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not result in serious or irreversible damage. • No potential significant impact to MNES. • The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Introduction of invasive marine species (IMS)	Change in ecosystem dynamics	Marine ecology Fisheries	IMS or pathogens may become established where conditions are suitable, and these species may have impacts on local ecological and economic values. Establishment of introduced marine species is mostly likely to occur in shallow waters in areas where large numbers of vessels are present and are stationary for an extended period. The vessel to be used is based in Victoria reducing the risk of introduced species being present as ballast or biofouling. The operational area does not present a location conducive to marine pest survival because it is located in deep waters with the majority of the operational area in water greater than 60 m, with limited stationary vessel periods.	Serious (3)	A	CM#12: MO 98: Marine pollution – anti-fouling systems CM#13: Australian Ballast Water Management Requirements CM#14: National Biofouling Management Guidance for the Petroleum Production and Exploration Industry	None identified	Remote (1)	Low	• The proposed management of the impact is aligned with the Beach Environment Policy. • The proposed management of the impact is aligned with the Beach HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • Activity will not result in serious or irreversible damage. • No potential significant impact to MNES or stakeholders. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
Vessel operations	Loss of marine diesel from vessel collision	Change in water quality	Further assessment required (Section 7.3).									
Vessel and aerial operations	Spill response	Disturbance to benthic habitat Waste generation, disposal and management Displacement of other marine users	Further assessment required (Section 7.4).									

7.2 Geophysical activities underwater noise and vibration

7.2.1 Hazards

Underwater noise and vibration propagation from geophysical activities may impact biological receptors such as:

- marine invertebrates including commercial species such as squid, rock lobster and giant crab;
- fish (with and without swim bladders) including commercial species such as sharks and scalefish;
- marine reptiles; and
- marine mammals.

7.2.2 Known and potential environmental impacts

Potential impacts of underwater sound emissions from geophysical activities to receptors are:

- behavioural changes; and
- auditory impairment, permanent threshold shift (PTS) and temporary threshold shift (TTS).

7.2.3 Impact evaluation and risk assessment

To assess potential impacts to receptors from underwater sound emissions associated with the geophysical seabed assessment JASCO Applied Sciences (JASCO) was commissioned to undertake acoustic modelling to predict received underwater sound levels. The modelled received sound levels where then compared to defined noise effect criteria, as determined by scientific research and academic papers, for the identified receptors. The full modelling report by JASCO (McPherson and Wood, 2017) is available in Appendix C with an update technical note available in Appendix D (Wood and McPherson, 2019). The updated technical note provides additional modelling undertaken for potential alternative geotechnical sources and to provided ranges to impact thresholds defined by NMFS (2018) for cetaceans and pinnipeds.

Sound metric terminology

Sound travels as a wave with the amplitude of the wave related to the amount of acoustic energy it carries, or how loud the sound will appear to be. Figure 7-1 shows a representative sound wave and the sound measures used in this assessment. Table 7-3 provides definitions of the sound measures and other sound related terms used in this assessment.

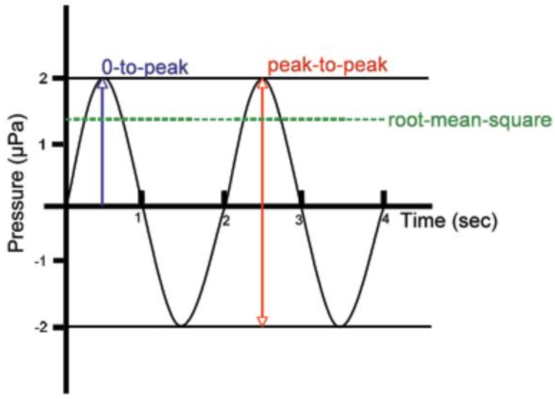

Figure 7-1: Representative sound wave and sound measures

Table 7-3: Sound terminology

Term	Definition
0-to-peak or Peak sound pressure level (PK)	The peak pressure, also called the 0-to-peak pressure, is the range in pressure between zero and the greatest pressure of the signal. It is represented by PK and the unit dB re 1 µPa and summarised as dB PK.
Peak-to-peak sound pressure level (PK-PK)	The peak-to-peak pressure is the range in pressure between the most negative pressure and the most positive pressure of the signal. It is represented by PK-PK and the unit dB re 1 µPa or dB re 1 $\mu Pa^2 m^2$ and summarised as dB PK-PK.
Permanent threshold shift (PTS)	Permanent loss of hearing sensitivity caused by excessive noise exposure.
Received sound levels	The sound level measured at a receiver.
Root mean square sound pressure level (RMS)	The root-mean-square pressure is the square root of the average of the square of the pressure of the sound signal over a given duration. It is represented by sound pressure level (SPL) and the unit dB re 1 µPa and summarised as dB SPL.
Sound exposure level (SEL)	A measure of the sound energy that considers both received level and duration of exposure. SEL is specified in terms of either single pulse (SEL) or a defined accumulation period (SEL_{cum}). For this assessment 24hrs has been used for the accumulation period and is shown as SEL_{24h}. Units are dB re 1 $\mu Pa^2 \cdot s$ or dB re 1 $\mu Pa^2 m^2 s$.
Source sound level	The sound pressure level or sound exposure level measured 1 metre from a theoretical point source that radiates the same total sound power as the actual source.
Temporary threshold shift (TTS)	Temporary loss of hearing sensitivity caused by excessive noise exposure.

Acoustic modelling

Based on a review of the geophysical equipment to be used for the seabed assessment it was identified that the boomer and SBP were most relevant to the assessment of potential impacts to receptors, due to their operating frequencies and source sound levels. The modelling approach accounted for the acoustic emission characteristics of a representative boomer (AP3000) and SBP (Edgetech X-star system) both towed at 3 m depth. The boomer and SBP geophysical survey sources planned for use had not been decided at the time of the modelling study, therefore JASCO chose commonly used representative systems for each source, with levels derived from previous JASCO field measurement campaigns of such sources. Since the modelling was commissioned the geophysical survey sources planned to be used have been narrowed to three suppliers. JASCO was again commissioned to review these geophysical survey sources to compare against the original modelling. This review is documented in Appendix D and summarised as follows:

- The proposed SBP is the Edgetech X-star system, which is the same source as considered in the modelling study. The system is equipped with an SBP-216 towfish. The transducer installed on the SBP-216 towfish transmits a chirp pulse that spans an operator-selectable frequency band. The lower and upper limits of the sonar's frequency band are 2 and 16 kHz, respectively, providing a sound pressure level (SPL) of 191.7 dB re 1 µPa @ 1 m.

- Alternative boomers to the AP3000 boomer modelled being considered by Beach include the AA251, AA300 and AA301 boomers. The modelled AP3000 signature was based upon scaling the signature of an AA202 single boomer plate. The frequency spectrum components of these potential sources are very similar to the modelled AP3000, and they will also exhibit a similar beam pattern. The peak source pressure level of the alternative boomers is slightly higher than the AP3000, which has a peak source pressure level of 210.8 dB re 1 μPa^2m^2, with that for the AA251 being of 212 dB re 1 μPa^2m^2 and for the AA301 being 215 dB re 1 μPa^2m^2. This results in slightly greater ranges to peak (PK) thresholds for high-frequency cetaceans, however criteria for other mammal auditory groups are not reached. There is also an increase in distance to PK-PK sound levels of interest, however the resulting ranges are still small, with no PK-PK sound level applied in the impact assessment exceeded more than 18 m from the source. However, as both the Boomer and SBP are both towed at 3 m, the maximum depth at which the sound level of 202 dB re 1 µPa will be reached will be 21 m. As the shallowest modelling site of interest (Artisan) has a depth of 71 m, no PK-PK sound levels of interest for benthic invertebrates will be reached at the seafloor. Despite the differences in peak source pressure level between the modelled and potential alternative boomers, it is estimated to be only a very minor change in the per-pulse source sound exposure level (SEL), partly due to the length of the impulse from these alternative sources. Due to minor changes expected in term of per-pulse SEL, the modelling results presented in McPherson and Wood (2017) for SEL_{24h} from the AP3000 boomer are considered to be appropriate approximations of the potential sound fields and ranges to SEL_{24h} impact criteria for the alternative boomers.

The modelling study assessed six locations as detailed in Figure 7-2. Table 7-4 details the relevant seabed assessment locations for the modelled sites. The La Bella well site was not modelled but as is in the same water depth as Site 3: G3, this location would be applicable for this assessment. Modelling was also not undertaken for the hot-tap, sub-sea infrastructure and umbilical locations; however, as the water depths and seabed structure are similar to the areas modelled the received noise levels from the assessment would be applicable.

Table 7-4: Acoustic modelling locations applicable to the seabed assessment locations

Modelled Location	Water Depth (m)	Seabed Assessment Location
Site 1: THY MID PT	100.5	Thylacine
Site 2: MURCH DDIP	129.5	T/30P
Site 3: G3	85	Geographe
Site 4: ARTISAN	71.6	Artisan
Site 5: VICP69 NTH	72.8	N/A
Site 6: VICP69 MEEKI	79.1	N/A

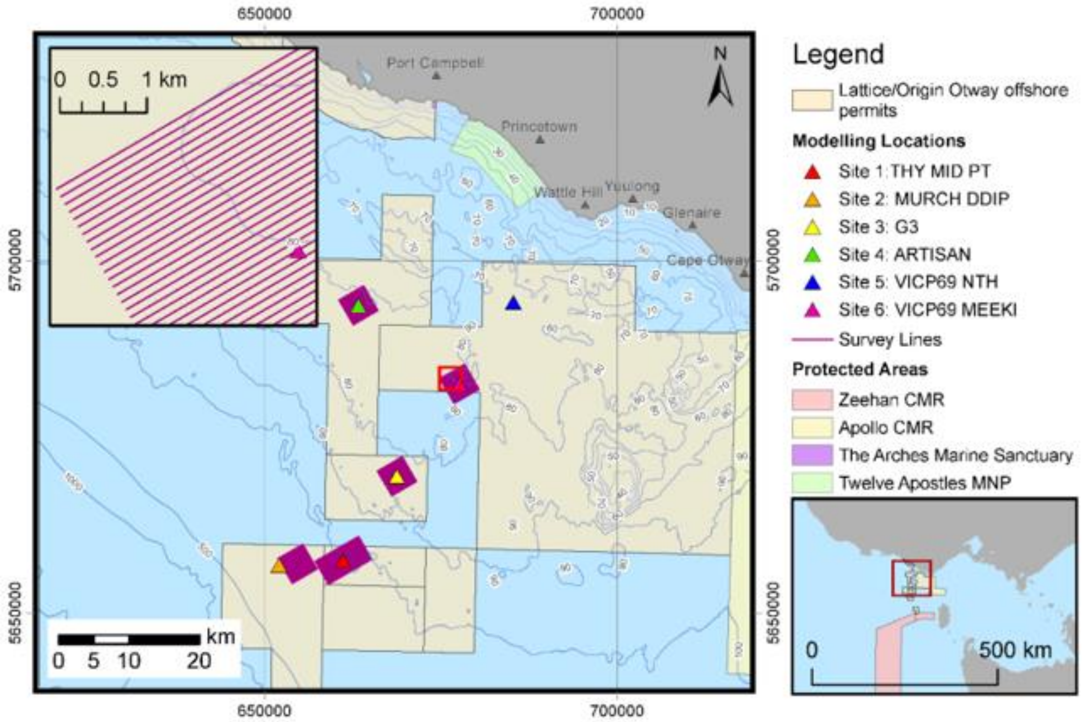

Figure 7-2: Noise modelling locations

Noise effect criteria

To assess whether an impact may occur modelled received sound levels were compared to receptor noise effect criteria. These criteria are based on published scientific research and papers as detailed in Table 7-5 and within the relevant receptor section. In lieu of any noise criteria specific to geophysical surveys, criteria that is applied to seismic surveys have been used.

Table 7-5: Effect criteria used and the applicable results for representative single pulse sites and for accumulated SEL scenarios

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Invertebrates: effect at the seafloor	186–190 dB SEL 192–199 dB SEL_{24h} 209–212 dB PK-PK	Not reached Not reached Not reached	Not reached Not reached Not reached	Day et al. 2016
Invertebrates: no effect at the seafloor	202 dB PK-PK	Not reached	Not reached	Payne et al. 2008
Lobster: no effect at the seafloor	183 dB SEL	Not reached	Not reached	McCauley and Duncan 2016
Squid: behavioural	166 dB SPL	36	Not reached	McCauley et al. 2000
Fish (swim bladder): mortality/potential mortal injury	>207 dB PK or 207 dB SELcum[1]	1.6 Not reached	0.3 Not reached	Popper et al. 2014

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Fish (swim bladder): recoverable injury	>213 dB PK or >216 dB SELcum[1]	0.6 Not reached	0.1 Not reached	Popper et al. 2014
Fish (no swim bladder): mortality/ potential mortal injury	>213 dB PK or >219 dB SELcum[1]	0.6 Not reached	0.1 Not reached	Popper et al. 2014
Fish (no swim bladder): recoverable injury	>213 dB PK or >216 dB SELcum[1]	0.6 Not reached	0.1 Not reached	Popper et al. 2014
Fish (swim bladder or no swim bladder): TTS	>186 dB SELcum[1]	Not reached	Not reached	Popper et al. 2014
Turtle: behavioural	166 dB SPL	36	Not reached	NSF 2011
Turtle: mortality/potential mortal injury	>207 dB PK or 210 dB SELcum[1]	1.6 Not reached	0.3 Not reached	Popper et al. 2014
Marine mammals: behavioural	160 dB SPL	145	2	NMFS 2013
Low-frequency cetaceans: PTS (humpback and pygmy blue whales)	219 dB PK 183 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	NMFS 2018
Low-frequency cetaceans: TTS (humpback and pygmy blue whales)	213 dB PK 168 dB SEL_{24h}	Not reached 10	Not reached 10	NMFS 2018
Mid-frequency cetaceans: PTS (dolphins, beaked whales, sperm whales)	230 dB PK 185 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	NMFS 2018
Mid-frequency cetaceans: TTS (dolphins, beaked whales, sperm whales)	224 dB PK 170 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	NMFS 2018
High-frequency cetaceans: PTS (pygmy and dwarf sperm whales)	202 dB PK 155 dB SEL_{24h}	4.5 Not reached	0.6 Not reached	NMFS 2018
High-frequency cetaceans: TTS (pygmy and dwarf sperm whales)	196 dB PK 140 dB SEL_{24h}	8.9 Not reached	1.2 Not reached	NMFS 2018
Phocid pinnipeds: PTS (seals)	218 dB PK 185 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	NMFS 2018
Phocid pinnipeds: TTS (seal)	212 dB PK 170 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	NMFS 2018

Note 1: Popper et al. 2014 do not defined an accumulation period. For this assessment 24 hrs was used based on the independent, expert peer review by Popper (Santos, 2018) that concluded that a 24-hour period to assess SELcum and any associated effects is likely to be conservative for assessing the potential effects to fish.

7.2.3.1 Marine invertebrates

There has been a number of comprehensive reviews of seismic noise impacts to invertebrates such as Carroll et al., (2017) and Edmonds et al., (2016). Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. There are currently no defined noise effect criteria for invertebrates and hence the results from the Day et al. (2016) study on acoustic impacts from seismic exposure on southern rock lobsters (*Jasus edwardsii*) are typically used. 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:

- single-pulse SEL: 186–190 dB re 1 µPa^2.s
- accumulated SEL: 192–199 dB re 1 µPa^2.s
- peak-peak pressure: 209–212 dB re 1 µPa.

Payne et al (2007) found no effects to the American lobster (*Homarus americanus*) in righting time or haemolymph biochemistry but a possible reduction in calcium after exposure to received noise levels of 202 dB re 1 µPa (PK-PK). Thus, the Payne et al (2007) level is applied as a no effect criteria. This assessment also used the no effect level proposed by McCauley and Duncan (2016) for rock lobsters of accumulated SEL 183 dB re 1 µPa^2.s.

Table 6-4 details that the sound levels from the representative boomer and SBP do not reach any of the effect or no effect criteria for invertebrates at the seafloor.

McCauley et al. (2000) assessed the effects of air gun noise on caged squid (*Sepioteuthis australis*). No sub-lethal injury or mortality as a result of exposures in this study was observed. Several squid showed alarm responses to the start-up of an airgun by firing their ink sacs and/or jetting away from the source, but this was not observed for similar or greater levels if the signal was ramped up. General habituation was observed with a decrease in alarm responses with subsequent exposures. During the trial the squid showed avoidance to the airgun by keeping close to the water surface at the end of the cage furthest from the airgun (within the sound shadow). McCauley suggests a threshold of 166 SPL would give an indication of the extent of disruption of a seismic survey by significant alteration in swimming patterns. Table 6-4 details that the noise effect criteria at which an alteration of swimming patterns may occur is predicted within 36 m of the boomer and not reached for the SBP.

Based on the modelling no mortality or injury effects to invertebrates including commercial squid, rock lobster and giant crab species are predicted.

7.2.3.2 Fish

Noise effect criteria for fish are based on the presence of a swim bladder. Typically, site-attached and demersal fish have a swim bladder, whereas pelagic fish do not. As noise effect criteria for sharks does not currently exist, they are assessed as fish without swim bladders. Noise effect criteria used in this assessment for fish are from the American National Standards Institute (ANSI) accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al., 2014). These guidelines defined quantitative effect criteria 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.

Table 6-4 details the noise effect criteria from Popper et al., 2014 and the distances at which modelling estimated they could be reaced for fish with and without a swim bladder. In summary:

- The noise effect criteria for mortality/potential mortal injury is predicted for fish with a swim bladder at a maximum distance of 1.6 m and for fish without a swim bladder at 0.6 m.

- The noise effect criteria for recoverable injury is predicted for fish with a swim bladder and without a swim bladder at a maximum distance of 0.6 m.
- The noise effect criteria for TTS for fish with and without a swim bladder was not reached.

Studies to date have not shown mortality in relation to potential impact to fish from impulsive noise, though prolonged or extreme exposure to high-intensity, low-frequency sound, may lead to physical damage such as threshold shifts in hearing or barotraumatic ruptures (Carroll et al., 2017). Based on the modelling and that the geophysical surveys will not result in prolonged or extreme exposure to fish it is unlikely that injury impacts to fish would occur.

The operational area does not overlap any areas where site-attached fish species are likely to be present, thus it would be expected that any impacts to fish, including sharks, would be limited to behavioural impacts such as startle response or avoidance behaviour as the vessel moves through an area. Thus, behavioural impacts to fish would be temporary and unlikely to have a significant impact on individuals or at a population level.

7.2.3.3 Marine turtles

Noise effect criteria used in this assessment for injury to turtles are from the ANSI accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al., 2014). Table 6-4 details the noise effect criteria from Popper et al. 2014 and the distances at which modelling estimated they could be reached. In summary:

- The noise effect criteria for injury to turtles were not reached for the SBP.
- The noise effect criteria for injury to turtles for the boomer is predicted at a maximum distance of 1.6 m for the peak sound pressure level (PK) while the noise effect criteria based on the sound exposure level (SEL) is not reached.

Based on limited data regarding noise levels that illicit a behavioural response in turtles, the United States National Marine Fisheries Service criterion of 166 dB re 1 µPa (SPL) is typically applied (NFS, 2011). For the boomer this noise effect criteria is predicted at a maximum distance of 36 m but was not reached for the SBP.

Three marine turtle species may occur within the operational area. No BIAs or habitat critical to the survival of the species occur within the operational area. Impacts to turtles within the area where the survey is occurring are likely to be restricted to avoidance behaviour as the vessel moves through an area and unlikely to result in any injury due to the very small distance (1.6 m) within which noise levels reach the noise effect criteria for injury. Thus, behavioural impacts to turtles would be temporary and unlikely to have a significant impact on individuals or at a population level.

7.2.3.4 Marine mammal injury and behaviour

Noise effect criteria used in this assessment for impacts to marine mammals are from:

- The United States National Marine Fisheries Service (NMFS, 2013) acoustic threshold for behavioural effects in marine mammals of 160 dB re 1 µPa (SPL).
- National Marine Fisheries Service (NMFS, 2018) thresholds for the onset of PTS and TTS. These criteria as details in Table 6-4 are based on dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted $_{24h}$ refers to the accumulation period for calculating SEL. The peak sound pressure level (PK) criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to the marine mammal species hearing group.

Table 6-4 details the noise effect criteria and the distances at which modelling estimated they could be reached. In summary:

- The acoustic threshold for behavioural effects in marine mammals is predicted at a maximum of 2 m for the SBP and 145 m for the boomer.
- The NMFS (2018) thresholds for the onset of PTS were predicted to be reached only for high frequency cetaceans at a maximum distance of 0.6 m for the SBP and 4.5 m for the boomer for the peak sound pressure level (PK). The threshold based on the sound exposure level (SEL) metric is not reached.
- The NMFS (2018) thresholds for the onset of TTS were predicted to be reached only for high frequency cetaceans at a maximum distance of 1.2 m for the SBP and 8.9 m for the boomer for the peak sound pressure level. The threshold based on the sound exposure level (SEL) metric is not reached.

Twenty-two whale species may occur within the operational area with foraging behaviours identified for some species (sei, blue, fin and pygmy right whales). The operational area also intersects a foraging BIA for the pygmy blue whale (Figure B-10-8). Foraging is likely linked to the Bonney Upwelling with pygmy blue whales typically foraging in the area between January and April (DoE, 2015). Thus, there may be a period of overlap with the second phase of the seabed assessments which are planned to start in March 2020 and will take ~ 5 – 10 days. However, impacts to pygmy blue whales or any marine mammals within the area where the survey is occurring are likely to be restricted to avoidance behaviour as the vessel moves through an area and unlikely to result in any injury due to the very small distance (8.9 m) within which noise levels reach the noise effect criteria for injury. For whales that may be feeding, the area of disturbance is extremely small at 145 m and unlikely to restrict feeding activity in the area as the vessel moves through. Thus, behavioural impacts to marine mammals would be highly localised and temporary and unlikely to have a significant impact on individuals or at a population level.

7.2.4 Control measures, ALARP and acceptability assessment

Control, ALARP and acceptability assessment: Underwater noise and vibration	
ALARP Decision Context and Justification	**ALARP Decision Context: Type B** On the basis of the impact assessment completed, Beach considers the control measures described for the use of geophysical equipment are appropriate to manage the impact and risk of underwater noise and vibration. Distances to noise effect criteria are very small and, in most cases, are not reached. The maximum distance is 145 m for the criteria for cetacean behaviour which could lead to cetaceans moving away from the vessel. During stakeholder engagement the following were raised and addressed: • Whether seismic surveys would be undertaken which they are not. • The impact of noise levels in relation to the rock lobster research undertaken by Day et al. 2016, which are not reached at the seafloor.
Control Measures	**Source of good practice control measures**
CM#6: Wildlife (Marine Mammals) Regulations 2009	Vessels adhere to the distances and vessel management practices for seals as per the Wildlife (Marine Mammals) Regulations 2009.
CM#7: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels adhere to the distances and vessel management practices of EPBC Regulations (Part 8).

Control, ALARP and acceptability assessment: Underwater noise and vibration			
Additional Controls Assessed			
Control	**Control Type**	**Cost/Benefit Analysis**	**Control Implemented?**
Implementation of the EPBC Act Policy 2.1 controls.	Good Practice	Geophysical equipment operates at significantly lower source levels than a commercial seismic array, and thus the resulting sound levels are proportionally lower at comparable distances. EPBC Act Policy 2.1 was developed for seismic surveys with the aim of the policy to provide: • Practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations. • A framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours. • Provide guidance to both proponents of seismic surveys and operators conducting seismic surveys about their legal responsibilities under the EPBC Act. Modelling has shown that received noise levels and distances to noise effect criteria are significantly lower than those for seismic surveys with the largest distance being 145 m for the behavioural noise effect criteria for marine mammals. The distances proposed in the policy to minimise the risk of acoustic injury to whales and risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours of 1 km, for the low power zone, and 500 m, for the shut-down zone, are significantly larger than the modelled distances of 145 m for the noise effect criteria for behavioural disturbance and 8.9 m for the noise effect criteria for TTS. As the vessel is moving the distance from the vessel to any marine mammal will exceed the small distances within which noise levels reach the noise effect criteria within seconds. Based on the small distances within which the noise effect criteria for marine mammals are met, the implementation of the policy doesn't not afford any further benefit.	No
Avoidance of pygmy blue whale foraging timing	Good Practice	The operational area intersects a foraging BIA for the pygmy blue whale. Foraging is likely linked to the Bonney Upwelling with pygmy blue whales typically foraging in the area between January and April (DoE, 2015). Thus, there may be a period of overlap with the second phase of the seabed assessments which are planned to start in March 2020 and will be for the T/30P and potentially La Bella areas and hence will take ~ 5 – 10 days. The second phase timings have been selected based on seafaring conditions in the	No

Control, ALARP and acceptability assessment: Underwater noise and vibration			
		Otway area to ensure the assessments can be undertaken in a safe manner. Impacts to pygmy blue whales while foraging are predicted to be restricted to avoidance behaviour as the vessel moves through an area as per any other vessel as distances to any noise effect criteria are very small at a maximum of 145 m. Due to the small period of overlap with the foraging period and that any impacts would be avoidance of a very small area from the vessel a change in timing does not afford any further benefit.	
Timing of activity to avoid peak fishing periods	Good Practice	The operational area overlaps a number of fisheries where there is a low level of fishing activity and data from VFA does not indicate any peak fishing periods with the exception of the crab and rock lobster fisheries who fish outside of the regulated closed seasons of Females = 1 Jun to 15, Nov, Males = 15 Sept to 15 Nov. The first phase of the activity, which will take the longest, will be undertaken within September to December, with the aim to be September and November. Thus, the period of overlap for the first phase will be a maximum of 4 weeks for these fisheries. For the 2nd phase of the activity, which is likely to commence in March, this will be for the T/30P and potentially La Bella areas and hence will take ~ 5 – 10 days. The phase timings have been selected based on seafaring conditions in the Otway area to ensure the assessments can be undertaken in a safe manner. Due to the small period of overlap with fisheries further restrictions in the timing comes at a cost to Beach without a significant benefit to the fishers as impacts can be managed via ongoing consultation and communication of fishers and Beach's activities.	Part
Substitution of equipment.	Engineering Risk Assessment	Equipment has been selected to meet the objective of the seabed surveys. Modelling has shown that the equipment to be used generates very low received noise levels and distances to noise effect criteria are very low with the largest distance being 145 m for the behavioural noise effect criteria for marine mammals. Thus, there is no benefit in changing the equipment as it is unlikely to significantly reduce the distance within which the noise effect criteria are met, and the levels received by receptors are predicted as unlikely to have a significant impact on individuals or at a population level.	No
Consequence Rating	Moderate (2)		
Likelihood of Occurrence	N/A		
Residual Risk	Low		
Acceptability Assessment			
Policy compliance	The proposed management of the impact is aligned with the Beach Environment Policy.		

Control, ALARP and acceptability assessment: Underwater noise and vibration	
Management system compliance	Vessels activities will be undertaken in accordance with the Beach HSEMS as detailed in Section 8 Implementation Strategy.
Stakeholder engagement	During stakeholder engagement, questions were raised as to whether seismic surveys would be undertaken which they are not. No concerns were raised in relation to the geophysical survey equipment.
Laws and standards	Vessels will comply with: • EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans. • Wildlife (Marine Mammals) Regulations 2009.
Industry practice	Vessel movements and geophysical survey activities are normal marine practice in the oil and gas industry.
Environmental context	Whilst noise and vibration are associated with the use of geophysical seabed assessment equipment, the impact assessment process indicates that noise will not result in death, injury or significant behavioural effects to marine fauna. This is in alignment with relevant conservation advice and recovery plans for EPBC species that may occur in the operational area including the pygmy blue whale, marine turtles and white shark. Impacts to commercial invertebrate and fish species were not predicted.
Environmentally Sustainable Development principles	The activities were evaluated as having the potential to result in a Moderate (2) consequence thus is not considered as having the potential to result in serious or irreversible environmental damage. Consequently, no further evaluation against the principles of ESD is required.
Monitor and review	Impacts associated with noise and vibration levels from the seabed assessment geophysical activities are considered to be 'Low'. Therefore, the monitoring of underwater noise and vibration emission is not proposed.
Acceptability outcome	**Acceptable**

7.3 Loss of marine diesel from vessel collision

7.3.1 Hazards

Marine diesel oil is used in offshore vessels. A collision between a Beach contracted vessel and third-party vessel has the potential to result in a spill of fuel.

7.3.2 Known and potential environmental impacts

The known and potential environmental impacts of a diesel spill are:

- temporary decrease in marine water quality;
- toxicity effects and/or physical oiling of marine fauna; and
- habitat damage where the spill reaches shoreline.

7.3.3 Impact evaluation and risk assessment

7.3.3.1 Characteristics of diesel oils

Diesel oils are generally considered to be low viscosity, non-persistent oils, which are readily degraded by naturally occurring microbes.

Diesel oils are considered to have a higher aquatic toxicity in comparison to many other crude oils due to the types of hydrocarbon present and their bioavailability. They also have a high potential to bio-accumulate in organisms.

Marine diesel is a medium-grade oil (classified as a Group II oil) used in the maritime industry. It has a low density, a low pour point and a low dynamic viscosity (Table 7-6), indicating that this oil will spread quickly when spilled at sea and thin out to low thicknesses, increasing the rate of evaporation.

Due to its chemical composition, approximately 40% will generally evaporate within the first day, with the remaining volatiles evaporating over 3-4 days depending upon the prevailing conditions. Diesel shows a strong tendency to entrain into the upper water column in the presence of moderate winds and breaking waves (>12 knots) but floats to the surface when conditions are calm, which delays the evaporation process. Table 7-7 shows the boiling point ranges for the diesel used in the spill modelling.

Table 7-6: Physical characteristics of marine diesel oil

Parameter	Characteristics
Density (kg/m^3)	829 at 15°C
API	37.6
Dynamic viscosity (cP)	4.0 at 25°C
Pour point (°C)	-14
Oil category	Group II
Oil persistence classification	Light-persistent oil

Table 7-7: Boiling point ranges of marine diesel oil

Characteristic	Volatiles (%)	Semi-volatiles (%)	Low volatiles (%)	Residual (%)
Boiling point (°C)	<180	180 – 265	265 – 380	>380
Marine diesel oil	6.0	34.6	54.4	5
	Non-Persistent			Persistent

On release to the marine environment, diesel would be distributed over time into the following components:

- surface;
- entrained (non-dissolved oil droplets that are physically entrained by wave action);
- dissolved (principally the aromatic hydrocarbons);

- evaporated; and
- decayed.

Of these components, surface hydrocarbons, entrained hydrocarbons and dissolved aromatics have the most significant impact on the marine environment. These are discussed in further detail below.

7.3.3.2 Modelling results – vessel collision spill

A spill of 40 m^3 was modelled using ADIOS II. The spill volume is consistent with the AMSA technical guidance (AMSA, 2015) for determining spill scenarios for shipping operations, which indicates the basis of volume calculation is the volume of the largest fuel tank. The worst-case spill volume assumes complete loss of inventory from one tank on the largest potential vessel, using representative metocean conditions during the proposed survey period (Table 7-8).

Table 7-8: Modelled average characteristics for the Otway Basin (summer)

	Current	**Wind**	**Water Temperature**	**Salinity**
Details	0.25 m/s	7.7 m/s	14°C	35 ppt
Direction	East	South-east	-	-

Relevant findings are:

- The surface life for an instantaneous diesel spill of 40 m^3 from a worst-case vessel collision incident is estimated at 12 hours (Figure 7-3).
- In this time, surface diesel may travel up to 14.7 km, based on an estimate in which the surface spill will travel at 100% of the speed and direction of ambient currents, and 3% of speed and direction of local winds.
- Shorelines are not predicted to be impacted.

A schematic depicting these environmental factors used to determine the spatial extent of the EMBA has been depicted in Figure 7-4.

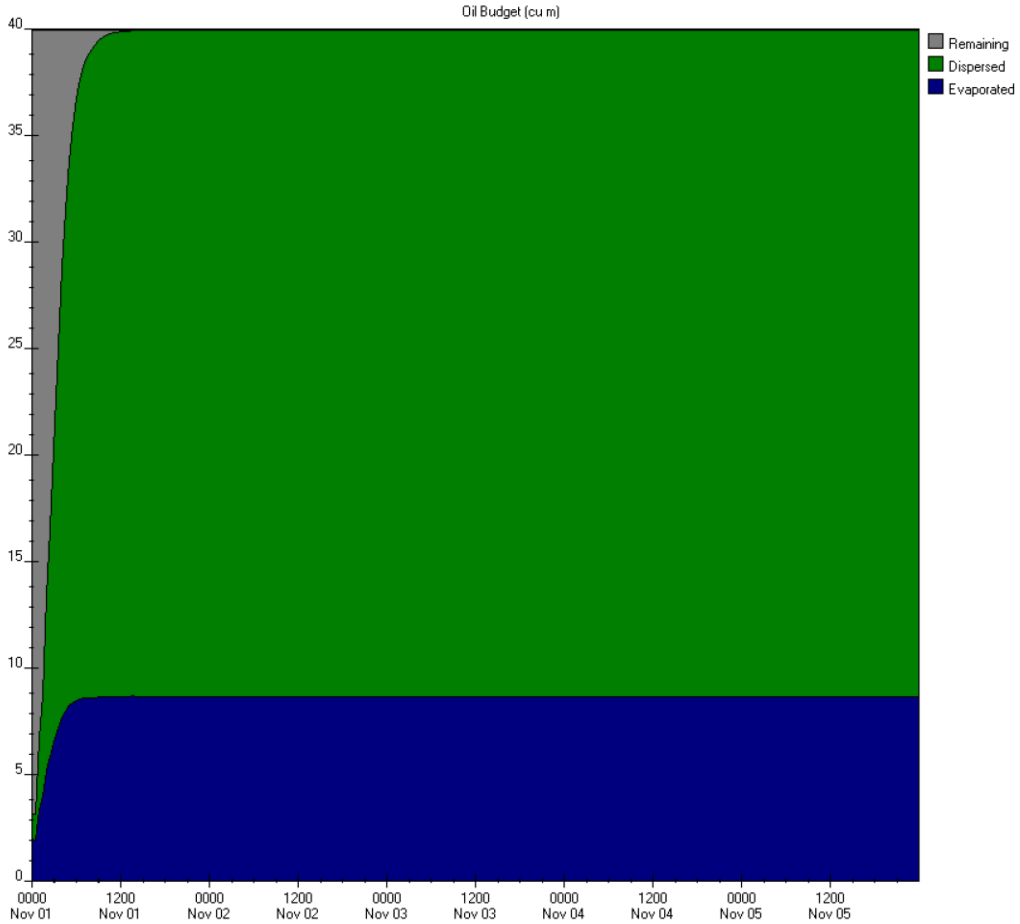

Figure 7-3: Percentage of oil remaining from a 40 m^3 of diesel spill due to vessel collision

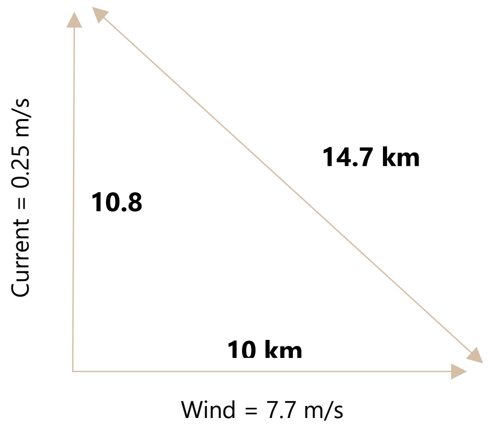

Figure 7-4: Travel distance of 40 m^3 of diesel spill due to vessel collision

Due to rapid and high levels of evaporation when spilt at sea, the environmental effects of diesel spills are generally short-term. When spilt at sea, diesel will spread and thin out quickly, with 10 m^3 predicted to be lost by evaporation within 6 hours, depending upon sea temperature and winds (Figure 7-3). Diesel oils also have low viscosities and can result in hydrocarbons becoming physically dispersed as fine droplets into the water column when winds exceed

10 knots. Droplets of diesel oil that are naturally dispersed will be sub-surface and will behave quite differently to surface oil. Diesel droplets move solely with the currents while dispersed in the water, while on the surface are affected by both wind and currents. Natural dispersion of diesel reduces the hydrocarbons ability to evaporate into the air (RPS, 2017).

Although evaporation reduces the 'quantity of hydrocarbons on the water surface, it increases the quantity of hydrocarbons in the atmosphere available to be inhaled. This increased hydrocarbon vapour exposure can affect any air breathing marine fauna (RPS, 2017).

The different diesel product compositions, together with different environmental conditions during marine spills (sea temperature, wind and sea states) can vary the quantities of hydrocarbons lost to the atmosphere due to evaporation (but generally ranges between 40-65%). Dispersion into the sea by the action of wind and waves can result in 25 to 50% of the loss of hydrocarbons from surface slicks and dissolution (solubility of hydrocarbons) can account for 1-10% loss from the surface (RPS, 2017).

7.3.4 Ecological impacts of diesel spills

The environmental effects of diesel spills are not as visually obvious as those of heavier fuel oils or crude oils. Diesel oils are considered to have a higher aquatic toxicity in comparison to many other crude oils and condensates due to the types of hydrocarbons present and that dispersed droplets of diesel can be more bio-available to marine organisms. Diesel oils have components with the potential to bio-accumulate in organisms and have high water solubility along with a higher potential to naturally entrain into the water column than heavy fuel oils (HFO).

The potential environmental impacts to receptors within the EMBA are discussed in Table 7-9 to Table 7-12.

Table 7-9: Consequence evaluation to ecological receptors within the EMBA – sea surface

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
Marine fauna	Seabirds	Several listed Threatened, Migratory and/or listed marine species have the potential to be rafting, resting, diving and feeding within the spill area. There are several foraging BIAs that are present within the area potentially exposed to surface hydrocarbons for albatross, petrel, and shearwater species. However, foraging BIAs are typically large broad areas (e.g. Antipodean albatross, BIA covering the coastal area to the 200 Nm zone from Adelaide to Sydney). The birds can feed via surface skimming or diving – both exposing the bird to any oil on the water surface. No breeding activity occurs in oceanic waters.	When first released, diesel has higher toxicity due to the presence of volatile components. Individual birds making contact close to the spill source at the time of the spill may be impacted; however, it is unlikely that many birds will be affected as sea surface oil is only predicted for the first 12 hours. Seabirds rafting, resting, diving or feeding at sea have the potential to encounter areas where hydrocarbons concentrations are greater than 10 g/m^2 and due to physical oiling may experience lethal surface concentrations. As such, acute or chronic toxicity impacts (death or long-term poor health) to birds are possible but unlikely for a diesel spill as the number of birds would be limited due to the small area and brief period of exposure above 10 g/m^2. Therefore, potential impact would be limited to individuals, with population impacts not anticipated.
	Marine reptiles	There may be marine turtles in the area predicted to be exposed to surface oil. However, there are no BIAs or habitat critical to the survival of the species within this area.	Marine turtles are vulnerable to the effects of oil at all life stages. Marine turtles can be exposed to surface oil externally (i.e. swimming through oil slicks) or internally (i.e. swallowing the oil). Ingested oil can harm internal organs and digestive function. Oil on their bodies can cause skin irritation and affect breathing. The number of marine turtles that may be exposed to surface diesel is expected to be low as there are no BIAs or habitat critical to the survival of the species present; however, turtles may be transient within the EMBA. Sea surface oil is only predicted for the first 12 hours limiting the period when oiling may occur. Therefore, potential impact would be limited to individuals, with population impacts not anticipated.
	Marine mammals (pinnipeds)	There may be pinnipeds in the area predicted to be exposed to surface oil. However, there are no BIAs or habitat critical to the survival of the species within this area.	Pinnipeds are vulnerable to sea surface exposures given they spend much of their time on or near the surface of the water, as they need to surface every few minutes to breathe. Exposure to surface oil can result in skin and eye irritations and disruptions to thermal regulation. Fur seals are particularly vulnerable to hypothermia from oiling of their fur. The number of pinnipeds that may be exposed to surface diesel is expected to be low as there are no BIAs or habitat critical to the survival of the species present; however, pinnipeds may be transient within the EMBA. Sea surface oil is only predicted for the first 12 hours limiting the period when oiling may occur. Therefore, potential impact would be limited to individuals, with population impacts not anticipated.

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
	Marine mammals (cetaceans)	Several threatened, migratory and/or listed marine cetacean species have the potential to be migrating, resting or foraging within the area predicted to be exposed to surface oil. Known BIAs are present for foraging for pygmy blue whales within the EMBA.	Physical contact by individual whales with a surface diesel spill is unlikely to lead to any long-term impacts. Given the mobility of whales, only a small proportion of the migrating population would surface in the affected areas, resulting in short-term and localised consequences, with no long-term population viability effects. If whales are foraging at the time of the spill, a greater number of individuals may be present in the area where sea surface oil is present, however due to the short duration of the surface exposure above the impact threshold (~12 hours), this is not likely.
	Marine mammals (dolphins)	There may be dolphins in the area predicted to be exposed to surface oil. However, there are no BIAs or habitat critical to the survival of the species within this area.	As for whales, physical contact by individual dolphins with a surface diesel spill is unlikely to lead to any long-term impacts. Given their mobility, only a small proportion of the population would surface in the affected areas. If dolphins are foraging at the time of the spill, a greater number of individuals may be present in the area where sea surface oil is present, however due to the short duration of the surface exposure above the impact threshold (approximately 12 hours), this is not likely.

Table 7-10: Consequence evaluation to socio-economic receptors within the EMBA – sea surface

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
Human systems	Recreation and tourism (including recreational fisheries)	Marine pollution can result in impacts to marine-based tourism from reduced visual aesthetic. Diesel is known to rapidly spread and thin out on release and consequently, a large area may be exposed to hydrocarbon concentrations greater than 1 g/m^2.	Visible surface hydrocarbons have the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. Given the nature of the oil, it is expected to rapidly weather offshore (within 15 km of the spill area) and unlikely to be visible from onshore. The closest shoreline being approximately 7.5 km from the extent of the spill.
	Industry (shipping)	Shipping occurs within the area predicted to be exposed to surface hydrocarbons.	Vessels may be present in the area where sea surface oil is present, however, due to the short duration of the surface exposure (approximately 12 hours) deviation of shipping traffic would be unlikely.
	Industry (oil and gas)	There are no oil and gas platforms located within the area predicted to be exposed to surface hydrocarbons.	No impact as there are no oil and gas platforms located within the area predicted to be exposed to surface hydrocarbons.

Table 7-11: Consequence evaluation to physical and ecological receptors within the EMBA – in water

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
Marine fauna	Plankton	Plankton are likely to be exposed to entrained hydrocarbons. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest.	Relatively low concentrations of hydrocarbon are toxic to both plankton [including zooplankton and ichthyoplankton (fish eggs and larvae)]. Plankton risk exposure through ingestion, inhalation and dermal contact. Plankton are numerous and widespread but do act as the basis for the marine food web, meaning that an oil spill in any one location is unlikely to have long-lasting impacts on plankton populations at a regional level. Once background water quality conditions have re-established, the plankton community may take weeks to months to recover (ITOPF, 2011a), allowing for seasonal influences on the assemblage characteristics.
	Marine invertebrates	In-water invertebrates of value have been identified to include squid, crustaceans (rock lobster, crabs) and molluscs (scallops, abalone). Several commercial fisheries for marine invertebrates are within the area predicted to be exposed may include: • Southern Squid Jig Fishery; • Victorian Rock Lobster Fishery; and • Victorian Giant Crab Fishery.	Acute or chronic exposure through contact and/or ingestion can result in toxicological risks. However, the presence of an exoskeleton (e.g. crustaceans) reduces the impact of hydrocarbon absorption through the surface membrane. Invertebrates with no exoskeleton and larval forms may be more prone to impacts. Localised impacts to larval stages may occur which could impact on population recruitment that year.
	Fish	Entrained hydrocarbon droplets can physically affect fish exposed for an extended duration (weeks to months). Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest. Several fish communities in these areas are demersal and therefore more prevalent towards the seabed, which is not likely to be exposed. Therefore, any impacts are expected to be highly localised. The Australian grayling spends most of its life in fresh water, with parts of the larval or juvenile stages spent in coastal marine waters, therefore it is not expected to be present in offshore waters in large numbers. There is a known distribution and foraging BIA for the white shark in the EMBA, however, it is not	Pelagic free-swimming fish and sharks are unlikely to suffer long-term damage from oil spill exposure because dissolved/entrained hydrocarbons in water are not expected to be sufficient to cause harm (ITOPF, 2011a). Subsurface hydrocarbons could potentially result in acute exposure to marine biota such as juvenile fish, larvae, and planktonic organisms, although impacts are not expected cause population-level impacts. Impacts on fish eggs and larvae entrained in the upper water column are not expected to be significant given the temporary nature of the resulting change in water quality, and the limited areal extent of the spill. As egg/larvae dispersal is widely distributed in the upper layers of the water column it is expected that current induced drift will rapidly replace any oil affected populations.

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
		expected that this species spends a large amount of time close to the surface where thresholds may be highest.	
	Marine mammals (pinnipeds)	Localised parts of the foraging range for New Zealand fur-seals and Australian fur-seals may be temporarily exposed to low concentrations of entrained diesel in the water column.	Exposure to low/moderate effects level hydrocarbons in the water column or consumption of prey affected by the oil may cause sub-lethal impacts to pinnipeds. However, due to the temporary and localised nature of the spill, their widespread nature, the low-level exposure zones and rapid loss of the volatile components of diesel in choppy and windy seas (such as that of the EMBA), is it not anticipated to result in long-term population viability effects.
	Marine mammals (cetaceans and dolphins)	Several cetacean and dolphin threatened, migratory and/or listed marine species have the potential to be migrating, resting or foraging within an area predicted to be exposed to entrained hydrocarbons. Known BIAs are present for foraging behaviour for the pygmy blue whale. Cetacean exposure to entrained hydrocarbons can result in physical coating as well as ingestion (Geraci and St Aubin, 1988). Such impacts are associated with 'fresh' hydrocarbon; the risk of impact declines rapidly as the diesel weathers.	The potential for impacts to cetaceans and dolphins would be limited to a relatively short period following the release and would need to coincide with migration to result in exposure to a large number of individuals. However, such exposure is not anticipated to result in long-term population viability effects.
Marine ecosystem	KEF	The West Tasmanian Canyons are located on the relatively narrow and steep continental slope west of Tasmania (Figure B-10-2). Eight submarine canyons surveyed in Tasmania, Australia, by Williams et al., (2009) displayed depth-related patterns with regard to benthic fauna, in which the percentage occurrence of faunal coverage visible in underwater video peaked at 200-300 m water depth (see Appendix B.1).	The depth of the canyons located within the southern portion of the EMBA range from 200m – 1,500m. The exposure of benthic infauna to a diesel spill at these depths is not anticipated.

Table 7-12: Consequence evaluation to socio-economic receptors within the EMBA – in water

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
Human system	Commercial and recreational fisheries	Due to their higher solubility and ease of entrainment/ dispersion into the water column, diesel spills can have a greater ecological impact in comparison to other floating oil slicks and are known to taint seafood. According to the International Maritime Organisation (IMO), diesel oil has a Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection rating of 3 for acute toxicity (damage to living organisms) and 4 for bioaccumulation/ tainting (4 = high potential to bioaccumulate, 5 is the highest). In-water exposure to entrained diesel may result in a reduction in commercially targeted marine species, resulting in impacts to commercial fishing and aquaculture. Actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (NOAA, 2002) which can have economic impacts to the industry. Several commercial fisheries operate in the EMBA and overlap the spatial extent of the water column hydrocarbon predictions.	Any acute impacts are expected to be limited to small numbers of juvenile fish, larvae, and planktonic organisms, which are not expected to affect population viability or recruitment. Impacts from entrained exposure are unlikely to manifest at a fish population viability level. Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of diesel would only be in place 1-3 days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

7.3.5 Control measures, ALARP and acceptability assessment

Control, ALARP and acceptability assessment: Loss of marine diesel from vessel collision	
ALARP Decision Context and Justification	**ALARP Decision Context: Type B** Vessel have been used for activities within the Otway offshore natural gas development for many years with no incident. Vessel activities are well regulated with associated control measures, well understood, and are implemented across the offshore industry. During stakeholder engagement, no concerns were raised regarding the acceptability of impacts from these events. However, if a diesel spill occurred from a vessel collision this could attract public and media interest. Consequently, Beach believes that ALARP Decision Context B should be applied.
Control Measures	**Source of good practice control measures**
CM#8: Ongoing consultation	Under the *Navigation Act 2012*, the Australian Hydrographic Service (AHS) are responsible for maintaining and disseminating hydrographic and other nautical information and nautical publications such as Notices to Mariners. AMSA also issue AUSCOAST warnings. Relevant details in relation to the vessel activity will be provided to the AHS and AMSA and to relevant stakeholders to ensure the presence of the vessel is known in the area. See Section 9.7 Ongoing Stakeholder Consultation.
	Under the *OPGGS Act 2006* there is provision for ensuring that petroleum activities are carried out in a manner that doesn't interfere with other marine users to a greater extent than is necessary or the reasonable exercise of the rights and performance of the duties of the titleholder. Beach ensures this is achieved by conducting suitable consultation with relevant stakeholders. Consultation with potentially affected fisheries ensures the risk of interaction with these users is limited.
CM#11: SMPEP (or equivalent)	In accordance with MARPOL Annex I and AMSA's MO 91 [Marine Pollution Prevention – oil], a SMPEP (or equivalent, according to class) is required to be developed based upon the Guidelines for the Development of Shipboard Oil Pollution Emergency Plans, adopted by IMO as Resolution MEPC.54(32) and approved by AMSA. To prepare for a spill event, the SMPEP details: • response equipment available to control a spill event; • review cycle to ensure that the SMPEP is kept up to date; and • testing requirements, including the frequency and nature of these tests. In the event of a spill, the SMPEP details: • reporting requirements and a list of authorities to be contacted; • activities to be undertaken to control the discharge of hydrocarbon; and • procedures for coordinating with local officials. Specifically, the SMPEP contains procedures to stop or reduce the flow of hydrocarbons to be considered in the event of tank rupture.
CM#15: MO 21: Safety and emergency arrangements	AMSA MO 21 [Safety of navigation and emergency procedures] gives effect to SOLAS regulations dealing with life-saving appliances and arrangements, safety of navigation and special measures to enhance maritime safety.
CM#16: MO 30: Prevention of collisions	AMSA MO 30 [Prevention of collisions] requires that onboard navigation, radar equipment, and lighting meets industry standards.
	All vessels contracted to Beach will have in date certification in accordance with AMSA MO 31 [Vessel surveys and certification].

Control, ALARP and acceptability assessment: Loss of marine diesel from vessel collision			
Additional Controls Assessed			
Control	**Control Type**	**Cost/Benefit Analysis**	**Control Implemented?**
Eliminate or substitute the use of diesel.	Good Practice	The use of diesel for fuel for vessels and machinery cannot be eliminated. Substituting for another fuel, i.e. HFO or bunker fuel oil, would have a higher environmental impact than diesel.	No
Exclusion zone established around the operational area during the seabed assessment.	Good Practice	The duration of the seabed assessments at specific locations will be short in duration and the vessel transient. The exclusion of vessels from this area would cause greater impact on socio-economic receptors, such as fisheries and shipping.	No
Smaller vessel used for the seabed assessment.	Engineering Risk Assessment	The vessels proposed for the seabed assessment and their vessel tank sizes are considerably smaller than vessels used for other petroleum activities, such as seismic surveys and support vessels, within the Otway Basin.	N.
Consequence Rating	Moderate (2)		
Likelihood of Occurrence	Highly Unlikely (2)		
Residual Risk	Low		
Acceptability Assessment			
Policy compliance	The proposed management of the impact is aligned with the Beach Environment Policy.		
Management system compliance	Activities will be undertaken in accordance with the Implementation Strategy (Section 8).		
Stakeholder engagement	No objections or claims have been raised during stakeholder consultation regarding the potential for diesel spills.		
Laws and standards	Vessels will comply with: • MO 21 (Safety of navigation and emergency procedures); • MO 30 (Prevention of collisions); • MO 31 (Vessel surveys and certification); • MO 91 (Marine pollution prevention – oil); and • *Navigation Act 2012*.		
Industry practice	The use of vessels to support exploration of the offshore environment is considered to be standard industry practice.		
Environmental context	Diesel is a medium-grade oil that has a low density, a low pour point and a low dynamic viscosity, indicating that this oil will spread quickly when spilled at sea and thin out to low thicknesses, increasing the rate of evaporation. In the marine environment diesel will tend to spread rapidly in the direction of the prevailing wind and waves. Evaporation is the dominant process contributing to the fate of spilled diesel from the sea surface and will account for >50% reduction of net hydrocarbon balance. In addition, a proportion of the diesel will entrain under the water surface particularly when wind speed and resultant wave action increase. Because of the nature of diesel to spread quickly to a thin surface layer, small amounts over a relatively large area will become entrained. As such, entrained oil at		

Control, ALARP and acceptability assessment: Loss of marine diesel from vessel collision	
	concentrations above impact thresholds will be limited to a localised area around the vessel. Long-term impacts to physical, ecological and socio-economic receptors that come in contact with the diesel both on the sea surface and in-water are unlikely. Shoreline impacts are not predicted.
Environmentally Sustainable Development principles	The activities were evaluated as having the potential to result in a Moderate (2) consequence thus is not considered as having the potential to result in serious or irreversible environmental damage. Consequently, no further evaluation against the principles of ESD is required.
Monitoring and reporting	Impacts as a result of a hydrocarbon spill will be monitored and reported in accordance with the Section 7.4.
Acceptability outcome	**Acceptable**

7.4 Oil spill response

This section presents the risk assessment for oil spill response options as required by the OPGGS(E)R.

7.4.1 Response option selection

Not all response options and tactics are appropriate for every oil spill. Different oil types, spill locations, and volumes require different response options and tactics, or a combination of response options and tactics, to form an effective response strategy.

Table 7-13 provides an assessment of the available oil spill response options, their suitability to the potential spill scenarios and their recommended adoption for the identified events.

7.4.2 Hazards

The following activities have been identified for responding to a vessel collision oil spill event:

- mobilisation and demobilisation of spill response personnel, plant and equipment; and
- handling, treatment and/or relocation of affected fauna (oiled wildlife response).

Table 7-13: Suitability of response options for a vessel collision resulting in a diesel spill

Response Option	Description	Vessel Collision Scenario Assessment	Option Viable?	Strategic Net Benefit?
Source Control	Limit flow of hydrocarbons to environment.	Achieved by vessel SMPEP.	✓	✓
Monitor and Evaluate	Direct observation: marine; aerial; vector calculations; and oil spill trajectory modelling. To maintain situational awareness, all monitor and evaluate options are suitable.	Diesel spreads rapidly to thin layers. Manual calculation based upon weather conditions will be used at the time to provide guidance to aerial observations. Oil spill trajectory modelling may also be used to forecast impact areas.	✓	✓
Assisted Natural Dispersion	The dispersion of hydrocarbon surface slicks can be facilitated through agitation of the water surface. Typically, this is done using vessel propellers, fire hoses or by towing equipment through the slick.	Diesel will evaporate and disperse rapidly. Unless surface slick remains thick and is threatening sensitive resources this response is unlikely to provide net environmental benefit analysis (NEBA).	✓	-
Chemical Dispersants	Breakdown surface spill and draw droplets into upper layers of water column. Increases biodegradation and weathering and provides benefit to sea-surface air breathing animals.	Although "conditional" for Group II oil, the size of potential spill volume and the natural tendency of spreading into very thin films is evidence that dispersant application will be an ineffective response. The dispersant droplets will penetrate through the thin oil layer and cause 'herding' of the oil which creates areas of clear water and should not be mistaken for successful dispersion (see ITOPF, 2011b).	-	-
Containment and Recovery	Booms and skimmers to contain surface oil where there is a potential threat to environmental sensitivities.	Low viscosity property allows for efficient containment by boom and recovery by oleophilic skimmers (i.e. komara disc skimmer) with ~90% hydrocarbon to water recovery rate. The normal sea state of the Otway Basin does not provide significant opportunities to utilise this equipment.	-	-
Protection and Deflection	Booms and skimmers deployed to protect environmental sensitivities.	No shoreline impact is predicted.	-	-
Shoreline Assessment and Clean-up	Shoreline clean-up is a last response strategy due to the potential environmental impact.	No shoreline impact is predicted.	-	-

Response Option	Description	Vessel Collision Scenario Assessment	Option Viable?	Strategic Net Benefit?
Oiled Wildlife Response (OWR)	Consists of capture, cleaning and rehabilitation of oiled wildlife. May include hazing or pre-spill captive management.	Given limited size and rapid spreading of the diesel spill, large scale wildlife response is not expected. However, individual birds could become oiled in the vicinity of the spill. OWR is viable and would be initiated for any oiled wildlife that could be captured.	✓	✓
Scientific Monitoring	Scientific monitoring is undertaken to understand and quantify the nature of short term and long-term environmental impacts and subsequent recovery.	Given the size and rapid dispersion of a diesel spill scientific monitoring would only be implemented to demonstrate to stakeholders that the impacts from the spill were short-term and localised as predicted. Thus, water sampling and impacts fish may be triggered.	✓	✓

7.4.3 Known and potential environmental risks

Known and potential environmental impacts as a result of undertaking oil spill response include:

- impacts to the existing environment as a result of aerial/vessel operations;
- restricted public access to marine environment; and
- damage to onshore environmental sensitivities from the establishment of OWR response centres (if required).

7.4.4 Source control

Source control arrangements from vessel failures includes:

- closing water tight doors;
- checking bulkheads;
- determining whether vessel separation will increase spillage;
- isolating penetrated tanks; and
- tank lightering.

Implementation of source control for vessels is detailed within the below documents, and is not discussed further:

- Vessel-specific Shipboard Marine Pollution Emergency Plan (SMPEP) or equivalent;
- Vessel Specific Safety Case or Safety Management Plan and/or management systems; and
- National Plan for Maritime Environmental Emergencies (NatPlan).

7.4.5 Monitor and evaluate

Ongoing monitoring and evaluation of the oil spill is a key strategy for maintaining situational awareness and to complement and support the success of other response activities. In some situations, monitoring and evaluation may be the primary response strategy where the spill volume/risk reduction through dispersion and weathering processes is considered the most appropriate response (i.e. vessel diesel spills). Due to the limited diesel carrying capacity of the proposed vessel and the remote offshore location, a vessel collision spill will likely result in a Level 1 or 2 incident. Higher levels of surveillance such as aerial surveillance, oil spill trajectory modelling and deployment of satellite tracking drifter buoys will only be undertaken for Level 2/3 spills. However, aerial observations and oil spill trajectory modelling has been included in this EP in the event the vessel monitoring is not effective to inform the response.

Monitor and evaluate Type 1 operational monitoring includes the following:

- vessel observation;
- aerial observation;
- computer-based tools:

- oil spill trajectory modelling (OSTM);
- vector analysis (manual calculation); and
- ADIOS II.

There are no significant or non-routine health and safety risks associated with monitoring and evaluation activities. Note that in the event of a vessel collision, the damaged vessel would not be able to conduct vessel surveillance activities, and other vessels may be prioritised to complete tasks that are not directly related to the oil spill response, such as transfer of injured personnel to a nearby facility or to shore, or search and rescue operations.

7.4.5.1 Response implementation, resource requirements and availability

In the event of an accidental event that resulted in a diesel spill to the waters surrounding the survey vessel, Beach would be responsible for undertaking operational monitoring (unless AMSA as Control Agency directs otherwise; see Section 8.16.2) with the primary objective of spill surveillance and tracking. This monitoring will be implemented to:

- determine the extent and character of a spill;
- track the movement and trajectory of surface diesel slicks;
- identify areas/ resources/ fauna potentially affected by surface slicks; and
- determine sea conditions/ other constraints.

Operational monitoring will commence immediately from the survey vessel. If safe and practicable to do so, the Vessel Master will monitor and document the progress of the oil spill, including location, movement and extent. This operational monitoring will continue throughout the response process until response termination or until advised otherwise by the Control Agency.

This oil spill monitoring will enable the necessary information to be provided to the Control Agency (AMSA) via a Marine Pollution Report (POLREP) to determine and plan appropriate response actions under NatPlan (if this plan is activated). Operational monitoring and observation in the event of a spill will inform an adaptive spill response and scientific monitoring of relevant key sensitive receptors, including wildlife and fisheries.

Operational monitoring will be restricted to daylight hours only, when surface slicks will be visible from the vessel. The information gathered from this monitoring will be passed on to AMSA, via the POLREP form, but also via ongoing Situation Reports (SITREPs) following the initial spill notification.

Vessel surveillance can also be conducted from any offshore vessel under Beach’s control which may be engaged immediately in the event of a spill depending on the time of day.

Aerial surveillance may be undertaken from specially mobilised aircraft. Due to the short timeframe of the spill being visible, it may not be feasible to get trained observers, as it will take up to 48 hours to mobilise a trained observer. In that situation an observer will be provided with sufficient information such as the AMSA Identification Oil-on-Water Guide. The frequency of flights will be sufficient to ensure that the information collected during each flight (i.e. observer log and spill mapping) meets the information needs to validate dispersion of the spill.

Manual calculations for a rough estimate of spill trajectory will be used for an initial calculation with OSTM modelling to provide an accurate spill trajectory for the current weather conditions and type/volume of hydrocarbon spill. In the event of a Level 1 spill, the trajectory would be estimated based on manual calculations only due to the rapid predicted natural weathering and small EMBA of the spill. If required, OSTM would be conducted based on real time spill and metocean data and this information would be used to refine the spill response planning and execution. Initial modelling results will be available within two hours of request for modelling.

Table 7-14: Monitor and evaluate resource capability

Strategy	Minimum Requirement	Resource Availability	Comment
Vessel monitoring	1 x vessel	Beach contracted vessel providers	May be utilised for other response strategies.
Aerial monitoring	1 x aircraft (helicopter)	Beach contractor aircraft supplier	A single AW139 is located at either Warrnambool or Tooradin. Typical mobilisation and flight time from Tooradin to site is about 1 hour 30 minutes.
	1 x visual observer	Australian Marine Oil Spill Centre (AMOSC)	AMOSC has five trained observers and AMOSC Core Group have four trained members available within 24-48 hours from call-out via the AMOSC Service Level Statement.
Oil spill trajectory modelling	Access to OSTM contractor via contract to initiate callout on a 24/7 basis.	AMOSC	AMOSC membership provides access to modelling contractor with OILMAP results to be provided within 2 hours and SIMAP results within 4 hours of activation.
Manual Trajectory Calculations and ADIOS II	Current and wind data.	Bureau of Meteorology (BOM) "Meteye" Service	Wind data available online.

7.4.6 Oiled wildlife response

Under the National Plan for Maritime Environmental Emergencies (AMSA, 2019) the Control Agency for an OWR for a vessel spill in Commonwealth waters is AMSA. If an incident which affects wildlife occurs in Commonwealth waters, AMSA may still request support from the Department of Environment, Land, Water and Planning (DELWP) to assess and lead a response if required. DELWPs response to oiled wildlife is undertaken in accordance with the Victorian Wildlife Response Plan for Marine Pollution Emergencies.

The spill is not predicted to enter Victorian state waters.

7.4.6.1 Response implementation, resource requirements and availability

Beach will provide support for the response through the provision of resources to the Control Agency (AMSA). The equipment which Beach can supply or coordinate through external assistance (such as Australian Marine Oil Spill Centre [AMOSC]) includes:

- vessels for transport of wildlife and equipment;
- oiled fauna kits;
- wildlife intake and triage; and
- wildlife cleaning and rehabilitation kits.

AMOSC has wildlife equipment which can be mobilised directly by Beach in the event of a spill where there is a likelihood of oiled wildlife requiring treatment. However, it is noted that the remoteness and typical sea conditions of the Otway offshore area and the logistic constraints associated with finding and collecting oiled wildlife at sea, will limit the feasibility of an offshore wildlife response effort.

Advice will be sought from AMOSC and regulatory agencies to guide any decisions regarding mounting a wildlife response will be based on the risks posed by the spill and safety and feasibility of a response.

Table 7-15: OWR resource capability

Resource	Minimum Requirement	Resource Availability	Comment
Vessel	1 x vessel	Beach contracted vessel providers	May be utilised for other response strategies.
Oiled wildlife response personnel	Trained group of first response personnel: AMOSC Industry Team (mutual aid) - 10 x personnel	AMOSC	Industry team trained for field deployment of spill equipment and are available on an 'as soon as practicable' basis. This group would be expected to be available within 24-48 hours of call-out. These personnel are available through Beach's membership with AMOSC.
Equipment	1 x oiled wildlife kit (Geelong)	AMOSC	Kits can process 50 units per day and Geelong kit available at site within 24 hours of call-out.
	1 x Container (Geelong)	AMOSC	Each container can process approximately 100 units per day. Geelong container available onsite within 24 hours of call-out.
OWR facility establishment and management	1 x Facilities Establishment Group (Dwyertech)	AMOSC Call-off Contract	Current call-off contract has service available within 24 hours of call-out.

7.4.7 Scientific monitoring

The objective of Type 2 scientific monitoring is to assess the impacts of a marine hydrocarbon spill and to help guide restoration and subsequent evaluations of environmental harm and recovery. The final selection of scientific monitoring studies and the detailed nature of these studies will depend on the observed and predicted fate of the spill, including surface and dissolved hydrocarbons, and the receptors that may have been impacted by the spill.

The scientific monitoring studies (SMSs) that may be initiated following a diesel spill include:

- SMS1 - Monitoring hydrocarbon fate and distribution in water; and
- SMS2 - Monitoring hydrocarbon contamination and exposure of fish.

7.4.7.1 Implementation, resource requirements and availability

The objectives, triggers for study initiation, methods, resources required, timeframes for mobilisation and termination for each of the scientific monitoring studies are presented in Section 8.16.4.

Data from post-spill environmental monitoring studies will form a basis on which to develop any required restoration plans and inform the requirement for any subsequent detailed scientific studies required to assess long-term effects.

Monitoring activities will continue until it is demonstrated that residual constituents do not pose a significant risk to human or ecological health.

7.4.8 Impact evaluation and risk assessment

Impacts and risks associated with operation of vessel surveillance and monitoring (in responding to a hydrocarbon spill) are similar to those discussed for routine vessel use. Therefore, the relevant 'aspects' in Table 7-2 should be referred to for a detailed evaluation and assessment for any oil spill response activities, including:

- Vessel operations – Atmospheric emissions;
- Vessel operations – Light emissions;
- Vessel operations – Planned discharges: cooling water, brine, treated bilge, sewage and greywater;
- Vessel operations – Planned discharge: food waste;
- Vessel operations – Underwater sound emissions: continuous;
- Vessel operations – Physical presence: collision with marine fauna;
- Vessel operations – Physical presence;
- Vessel operations – Accidental release: waste, minor spill (hydrocarbon or chemical); and
- Vessel operations – Introduction of IMS.

This section therefore assesses the impact from additional activities, including OWR.

Oiled wildlife response

Untrained resources capturing and handling native fauna may cause distress, injury and death of the fauna. AMSA as the Control Agency for a vessel spill in Commonwealth waters will managed any OWR and Beach will only undertake OWR if directed by AMSA.

7.4.9 Control measures, ALARP and acceptability assessment

Control, ALARP and acceptability assessment: Oil spill response	
ALARP Decision Context and Justification	**ALARP Decision Context: A** The purpose of implementing spill response activities is to reduce the severity of impacts from an oil spill to the environment. However, if the strategies do more harm than good (i.e. they are not having a net environmental benefit) then the spill response is not ALARP.
Control Measures	**Source of good practice control measures**
CM#6: Wildlife (Marine Mammals) Regulations 2009	Vessels adhere to the distances and vessel management practices for seals as per the Wildlife (Marine Mammals) Regulations 2009.
CM#7: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels adhere to the distances and vessel management practices of EPBC Regulations (Part 8).

Control, ALARP and acceptability assessment: Oil spill response			
CM#8: Ongoing consultation	Consultation in the event of a spill will ensure that relevant government agencies support the response strategies thus minimising potential impacts and risks to sensitivities.		
CM#18: Emergency response preparedness	Emergency response capability will be maintained in accordance with the EP, and related documentation.		
CM#19: Monitor and evaluate response management	Monitor and evaluate response activities will be managed in accordance with the nature and scale of the spill, using appropriate response methodologies.		
CM#20: OWR response management	OWR will be managed by relevant regulatory Authorities.		
CM#21: Scientific monitoring management	Scientific monitoring will be managed in accordance with the Scientific Monitoring Programs (SMPs) to achieve scientific objectives.		
Additional Controls Assessed			
Control	**Control Type**	**Cost/Benefit Analysis**	**Control Implemented?**
Monitor and evaluate: Satellite tracking buoys.	Good Practice	The surface life for a vessel diesel spill is estimated at 12 hours thus tracking buoys are not required for such a short-lived spill.	No
Monitor and evaluate: Utilise additional vessels for spill observations during initial response stages.	Engineering Risk Assessment	Beach has existing contracts in place to support its maritime requirements. The contract for the Otway Basin currently resides with a number of service providers that have completed the Beach contracts and procurement process. A single vessel is expected to be sufficient for the initial stages of the response planning and using additional platforms is not considered to provide a considerable environmental benefit.	No
Monitor and evaluate: Night-time monitoring - infrared	Engineering Risk Assessment	Side looking airborne radar, systems are required to be installed on specific aircraft or vessels. The costs of sourcing such vessels/aircraft is approximately $20,000 per day. Infrared may be used to provide aerial monitoring at night time, however the benefit is minimal given trajectory monitoring (and infield monitoring during daylight hours) will give good operational awareness and the surface spill will only be visible for approximately 12 hours. In addition to this, satellite imagery may be used at night to provide additional operational awareness.	No
OWR: Pre-positioning of oiled wildlife response resources.	Precautionary approach	Oiled wildlife response equipment containers for first strike activities are positioned in Geelong. Positioning the equipment any closer to the potential spill area is not considered to provide a considerable environmental benefit considering that oiled wildlife is unlikely based on the rapid dispersion of a diesel spill.	No
Consequence Rating	Moderate (2)		
Likelihood of Occurrence	Highly Unlikely (2)		
Residual Risk	Low		

Control, ALARP and acceptability assessment: Oil spill response	
Acceptability Assessment	
Policy compliance	The proposed management of the impact is aligned with the Beach Environment Policy.
Management system compliance	Activities will be undertaken in accordance with the Implementation Strategy (Section 8).
Stakeholder engagement	No stakeholder concerns have been raised with regards to impacts of the spill response activities on relevant persons. During any spill response, a close working relationship with key regulatory bodies will occur and thus there will be ongoing consultation with relevant persons during response operations.
Laws and standards	Response has been developed in accordance with: • OPGGSA; • AMSA Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA, 2015); and • NOPSEMA (2017).
Industry practice	Proposed activities are consistent with industry practice and based on current NOPSEMA guidance notes.
Environmental context	While some response strategies may pose additional risk to sensitive receptors, to not implement response activities may potentially result in greater negative impact to the receiving environment and a longer recovery period. Response activities will be undertaken in accordance with controls which reduce and/or prevent additional risks. The mutual interests of responding and protecting sensitive receptors from further impact due to response activities will be managed using a NEBA during response strategy planning in preparedness arrangements, as well as during a response.
Environmentally Sustainable Development principles	The activities were evaluated as having the potential to result in a Moderate (2) consequence thus is not considered as having the potential to result in serious or irreversible environmental damage. Consequently, no further evaluation against the principles of ESD is required.
Monitoring and reporting	Impacts will be monitored in accordance with Section 8.16.
Acceptability outcome	**Acceptable**

7.5 Environmental performance outcomes, Environmental performance standards and measurement criteria

In accordance with Regulation 13(7) of the OPGGS(E)R, this section provides the EPOs, EPSs and measurement criteria for the control measures identified.

Table 7-16: Seabed assessment control measures, EPOs, EPSs and measurement criteria

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
Undertake the activity in a manner that will not: • Result in a substantial change in water and air quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health.	CM#1: MO 97: Marine Pollution Prevention – Air Pollution	• Low-sulphur (<3.5% m/m) marine-grade diesel used. • Vessels with diesel engines>130 kW must be certified to emission standards (e.g. International Air Pollution Prevention [IAPP]). • Vessels implement their Ship Energy Efficiency Management Plan to monitor and reduce air emissions (as appropriate to vessel class).	Bunker receipts Ship Energy Efficiency Management Plan (SEEMP) records. Certification documentation.	Vessel Master
	CM#2: Offshore Environmental Chemical Assessment Process	• Chemicals used as a component of a planned vessel discharge will meet the requirements of the Beach Chemical Assessment Process.	Completed and approved chemical assessment.	Offshore Project Manager
	CM#3: *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*	• Bilge water treated via a MARPOL (or equivalent) approved oily water separator and only discharge if oil content less than 15 ppm. • Sewage discharged at sea is treated via a MARPOL (or equivalent) approved sewage treatment system. • Food waste only discharged when macerated to ≤25 mm and vessel greater than 3 Nm from land.	Oil record book. Garbage record book.	Vessel Master

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
	CM#4: Preventative Maintenance System	• Equipment used to treat planned vessel discharges maintained in accordance with preventative maintenance system. • Combustion equipment maintained in accordance with preventative maintenance system.	PMS records.	Vessel Master
	CM#5: MO 95: Marine Pollution Prevention - Garbage	• Waste handled according to vessel waste management plan. • Waste with potential to be windblown stored in covered containers. • Waste lost overboard recovered if possible.	Garbage record book. Incident report.	Vessel Master
Undertake the activity in a manner that will not: • Lead to a long-term decrease in the size of a threatened or migratory listed species population.	CM#6: Wildlife (Marine Mammals) Regulations 2009	Vessels adhere to the distances and vessel management practices for seals as per the Wildlife (Marine Mammals) Regulations 2009.	Daily operations report details when whales, dolphins or seals sighted, and the interaction management actions implemented, if required.	Vessel Master
	CM#7: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels adhere to the distances and vessel management practices of EPBC Regulations (Part 8).	Daily operations report details when whales, dolphins or seals sighted, and the interaction management actions implemented, if required.	Vessel Master
Undertake the activity in a manner that will not: • Interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted. • Adversely affect the sustainability of commercial fishing.	CM#8: Ongoing consultation	Notifications for any on-water activities and ongoing consultations undertaken as per Section 9 Stakeholder Consultation.	Notification records.	Offshore Project Manager

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
Undertake the activity in a manner that will not: • Result in a spill of hydrocarbons to the marine environment.	CM#9: ROV pre-dive inspections	ROV pre-dive inspection confirms umbilical in good condition.	ROV checklist.	ROV Operator
	CM#10: Spill containment	Materials and equipment that have the potential to spill onto the deck or marine environment are within a contained area.	Vessel inspection.	Vessel Master
	CM#11: SMPEP, or equivalent	Vessel has a SMPEP (or equivalent appropriate to class) which is: • Implemented in the event of a spill to deck or marine environment. • Tested as per the vessels test schedule. Spill response kits are located in high spill risk areas and routinely checked to ensure adequate.	Vessel SMPEP. Vessel exercise schedule. Vessel inspection.	Vessel Master
	CM#15: MO 21: Safety and emergency arrangements	Vessels will meet the safety measures and emergency procedures of the AMSA MO 21.	Vessel inspection.	Vessel Master
	CM#16: MO 30: Prevention of collisions	Vessels will meet the navigation equipment, watchkeeping and radar requirements of the AMSA MO 30.	Vessel inspection.	Vessel Master
	CM#17: MO 31: Vessel surveys and certification	Vessels will meet survey, maintenance and certification of regulated Australian vessels as per AMSA MO 31.	Vessel certification.	Vessel Master
	CM#18: Emergency response preparedness	Emergency response capability will be maintained in accordance with the EP.	Outcomes of internal audits and tests demonstrate preparedness.	Activity Project Manager
Undertake the activity in a manner that will not: • Result in a known or potential pest species becoming established.	CM#12: MO 98: Marine pollution – anti-fouling systems	Vessel will have a current anti-fouling certificate.	Vessel anti-fouling certificate.	Vessel Master
	CM#13: Australian Ballast Water Management Requirements	Vessel will have a valid Ballast Water Management Plan and ballast water management certificate, if required.	Ballast water records. Vessel Ballast Water Management Plan. Vessel Ballast Water Management certificate.	Vessel Master

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
	CM#14: National Biofouling Management Guidance for the Petroleum Production and Exploration Industry	Vessel will have a low-risk rating based on the WA Department of Fisheries Biofouling Risk Assessment Tool.[1] In-water equipment will be clean of biofouling prior to deployment.	Ballast water records. Vessel Ballast Water Management Plan. Vessel Ballast Water Management certificate. In-water equipment checklist.	Vessel Master
Undertake oil spill response in a manner that will not: • Result in additional impacts to marine environment and oiled wildlife.	CM#19: Monitor and evaluate response management	In the event of a diesel vessel collision spill: • Where possible, the survey vessel will conduct visual observations as soon as practicable after the spill event. • Aerial surveillance initiated within 120 minutes of spill. • OSTM received within 120 minutes of request.	• EMT log. • Vessel Surveillance Report. • Aerial Surveillance Report • Spill Modelling Report	Beach EMT
	CM#20: OWR response management	OWR will be managed by relevant regulatory Authorities and trained personnel.	EMT log.	Beach EMT
	CM#21: Scientific monitoring management	Scientific monitoring will be implemented in accordance with the SMPs.	Records confirm that scientific monitoring have been implemented in accordance with the SMPs.	Beach EMT

[1] The Western Australian Department of Fisheries Biofouling Risk Assessment Tool is used in lieu of a Commonwealth or Victorian tool.

8 Implementation strategy

Regulation 14 of the OPGGS(E)R requires that the environment plan must contain an implementation strategy for the activity. For activities where Lattice is the titleholder, such as in the Otway Basin, Beach follows the Lattice Health, Safety and Environment Management System (HSEMS). However, the Beach's Environmental Policy applies to all of Beach's operations and activities (Figure 8-1).

The Implementation Strategy described in this section provides a summary of the Lattice HSEMS and how it will be applied to effectively implement the control measures detailed in this EP. Specifically, it describes:

- the HSEMS;
- environment-specific roles and responsibilities;
- arrangements for monitoring, review and reporting of environmental performance;
- preparedness for emergencies; and
- arrangements for ongoing consultation.

8.1 Health, Safety, Environmental Management System

The seabed assessments will be undertaken in accordance with the Lattice HSEMS. The HSEMS documents the Environmental Policy, HSE Standards, HSE Directives and the key HSE processes and requirements for activities where Lattice is the titleholder. It provides a management framework for achieving the requirements in a systematic way but allows flexibility to achieve this in a manner which best suits the business. The HSEMS is aligned with the requirements of recognised international and national standards including:

- ISO 14001 (Environmental Management);
- OHSAS 18001 (Occupational Health and Safety);
- ISO 31000 (Risk Management); and
- AS 4801 (Occupational Health and Safety Management Systems).

At the core of the HSEMS are 20 performance standards which detail specific performance requirements for the implementation of the HSE Environmental Policy and management of potential HSE impacts and risks (Table 8-1). Integral to each Performance Standard are a series of HSE Management Commitments and Processes including Directives, Procedures and other support documents which provide detailed information on requirements for implementation along with specific responsibilities. At the business level the system is complemented by asset and site procedures and plans such as this EP.

Whilst Lattice is the titleholder for the activity, the vessel contractor maintains operational control of the vessel as per the requirements of their management system.

The application of HSEMS Performance Standards relevant to the seabed assessments are described in the following sections.

Table 8-1: HSEMS Performance Standards

No	Standard	No	Standard
1	Leadership and Commitment	11	Management of Change
2	Organisation, Accountability, Responsibility and Authority	12	Facilities Design, Construction and Commissioning – Well Engineering Construction Management System (WECS)
3	Planning, Objectives and Targets	13	Contractors, Suppliers, Partners and Visitors
4	Legal Requirements, Document Control and Information Management	14	Crisis and Emergency Management
5	Personnel, Competence, Training and Behaviours	15	Plant and Equipment
6	Communication, Consultation and Community Involvement	16	Monitoring the Work Environment
7	Hazard and Risk Management	17	Health and Fitness for Work
8	Incident Management	18	Environmental Effects and Management
9	Performance Measurement and Reporting	19	Product Stewardship, Conservation and Waste Management
10	Operations	20	Audits, Assessments and Review

Environmental Policy

Beach is committed to conducting operations in an environmentally responsible and sustainable manner.

To fulfil these objectives, to as far as is reasonably practicable, Beach will:

- Maintain and improve the HSE Management System including as appropriate developing applicable environmental standards and procedures;
- Establish environmental objectives and targets and implement programs to achieve them and report on their performance;
- Commit to and comply with relevant laws, regulations and environmental management plans for each activity as required by the appropriate regulating authority, and where adequate laws do not exist, adapting to and applying globally applicable corporate operating standards;
- Commit to identify, assess and control environmental impacts of our operations by achieving proactive management of activities;
- Avoid disturbance of known sites of archaeological, historical and natural significance and protect native flora and fauna in all areas of operation;
- Ensure that incidents, near misses, concerns and complaints are reported adequately, investigated and appropriate procedures implemented;
- Inform all employees and contractors of their environmental and cultural heritage responsibilities including consultation and distribution of appropriate environmental management guidelines, regulations and publications for all relevant activities; and
- Ensure Beach has the resources and the skills necessary to achieve its environmental commitments.
- Application of this policy resides with all employees and contractors sharing responsibility for its implementation.

Operative from: 1 September 2017

Review by: 1 September 2019

Figure 8-1: Beach's Environmental Policy

8.2 Leadership and Commitment (HSEMS Standard 1)

The leadership and commitment standard states that the Board and Executive Management establish the HSE Policy, set expectations and provide resources for successful implementation of the HSE Policy and HSEMS.

8.3 Organisation, Accountability, Responsibility and Authority (HSEMS Standard 2)

This standard states that for directors, managers, supervisors and employees and contractors at all levels, their accountabilities, roles, responsibilities and authority relating to HSE are clearly defined, documented, communicated and understood.

The roles and responsibilities for the implementation, management and review for this EP are detailed in Table 8-2.

Table 8-2: Activity environmental roles and responsibilities

Role	Responsibilities
Chief Executive Officer	Ensure: • Beach has the appropriate organisation in place to be compliant with regulatory and other requirements and this EP. • The HSEMS continues to meet the evolving needs of the organisation.
Activity Project Manager	Ensure: • Compliance with regulatory and other requirements and this EP. • Records associated with the activity are maintained as per Section 8.5.2. • Personnel who have specific responsibilities pertaining to the implementation of this EP or Oil Pollution Emergency Plan (OPEP) know their responsibilities and are competent to fulfil their designated role. • Environmental impacts and risks associated with the activity have been identified and any new or increased impacts or risks are managed via the Management of Change process detailed in Section 8.12. • Incidents are managed and reported as per Section 8.9. • The EP report is submitted to NOPSEMA not more than three months after the anniversary date of the EP acceptance. • Any changes to equipment, systems and documentation where there may be a new or change to an environmental impact or risk or a change that may impact the EP are assessed Management of Change process detailed in Section 8.12. • Oil spill response arrangements for the activity are tested as per Section 8.16.5. • Ensure audits and inspections are undertaken in accordance with Section 8.22.1.
Environment Advisor	• Communicate regulatory and other requirements and the requirements in this EP to persons who have specific responsibilities pertaining to the implementation of this EP or OPEP. • Develop the environmental component of the activity induction. • Provide support in relation to incident management and reporting as per Section 8.9. • Develop the EP environmental performance report. • Review and document any new or change to an environmental impact or risk or a change that may impact the EP as per Section 8.12. • Assess any chemicals that will be discharged offshore as per Section 8.20.1. • Provide support to ensure audits and inspections detailed in Section 8.22.1 are undertaken and any actions from non-conformances or improvement suggestions tracked. • Review and revise the EP as per the requirements in Section 8.22.2 and 8.22.3.
Community Relations Manager	• Undertake stakeholder consultation for the activity.

Role	Responsibilities
	• Record and report to the Activity Manager and Environment Advisor any objections or claims raised by relevant stakeholders. • Maintain a stakeholder consultation log.
Activity Offshore Representative	Ensure: • The activity is carried out in accordance with regulatory requirements and this EP. • Vessel personnel complete the environmental component of the activity induction. • Vessel personnel are competent to fulfil their designated role. • HSE issues are communicated via systems such as the daily report and daily pre-start meetings. • Environmental impacts and risks associated with the activity have been identified and any new or increased impacts or risks are managed via the Management of Change process detailed in Section 8.12. • Environmental incidents are managed and reported as per Section 8.9. • Emissions and discharges identified in Section 8.10.2 are recorded and provided to the Activity Manager. • The Activity Manager is informed of any changes to equipment, systems and documentation where there may be a new or change to an environmental impact or risk or a change that may impact the EP as per Section 8.12. • Chemicals that will or may be discharged offshore are assessed as per Section 8.20.1 prior to use. • Weekly vessel inspections as detailed in Section 8.22.1 are undertaken to ensure ongoing compliance with the EP.
Vessel Master	Ensure: • Vessel operations are carried out in accordance with regulatory requirements and this EP. • Vessel personnel are competent to fulfil their designated role. • Environmental impacts and risks associated with the activity have been identified and any new or increased impacts or risks are managed via the Management of Change process detailed in Section 8.12. • Vessel adheres to the distances and vessel management practices for seals as per the Wildlife (Marine Mammals) Regulations 2009 and whales and dolphins as per the EPBC Regulations (Part 8). • Environmental incidents are reported to the Activity Offshore Representative within required timeframes as per Section 8.9 . • Emissions and discharges identified in Section 8.10.2 are recorded and provided to the Activity Offshore Representative. • The Activity Offshore Representative is informed of any changes to equipment, systems and documentation where there may be a new or change to an environmental impact or risk or a change that may impact the EP as per Section 8.12. • Oil spill response arrangements are in place and tested as per the vessel's SMPEP or equivalent. • Chemicals that will or may be discharged offshore are assessed as per Section 8.20.1 prior to use. • General and hazardous wastes are backloaded to port for disposal to a licenced waste facility. • Weekly vessel inspections as detailed in Section 8.22.1are undertaken to ensure ongoing compliance with the EP.
Vessel personnel	• Complete activity induction. • Report hazards and/or incidents via company reporting processed. • Adhere to vessel's HSEMS and this EP for all tasks. • Undertake tasks safely and without harm to themselves, others, equipment or the environment and in accordance with their training, operating procedures and work instructions. • Seek assistance if required to undertake a task that they are not competent to perform. • Stop any task that they believe to be unsafe or will impact on the environment.

8.4 Planning, Objectives and Targets (HSEMS Standard 3)

This standard recognises that a systematic risk-based approach to the management of HSE is in place as an integral part of business planning, with HSE goals, objectives and targets established and measured. A philosophy of continuous improvement is applied to HSE.

EPOs and EPSs have been established to continually reduce potential environmental impacts and risks to ALARP and an acceptable level. EPOs, EPSs and the measurement criteria by which environmental performance for the activity shall be measured are detailed in Section 7.5.

8.5 Legal Requirements, Document Control and Information Management (HSEMS Standard 4)

This standard specifies that relevant legal and regulatory requirements and voluntary commitments are identified, documented, made accessible, understood and complied with. Effective HSE document control systems are in place to ensure clarity of company expectations and to facilitate efficient and accurate information management.

8.5.1 Legal requirements

Section 3 of this EP contains the Commonwealth legislation applicable to the activity and how it has been applied in this EP.

8.5.2 Document control and information management

In accordance with Regulation 27 of the OPGGS(E)R, documents and records relevant to the EP implementation will be stored and maintained for a period of five years in a way that makes retrieval practicable.

8.6 Personnel, Competence, Training and Behaviours (HSEMS Standard 5)

This standard recognises that employees' competence and appropriate behaviours are critical for the safe control of operations and general company success.

Each employee or contractor with responsibilities pertaining to the implementation of this EP shall have the appropriate competencies to fulfil their designated role.

To ensure that personnel are aware of the EP requirements for the activity all offshore personnel will complete an induction. Records of completion of the induction will be recorded and maintained as per Section 8.5.2. The induction will at a minimum cover:

- description of the environmental sensitivities and conservation values of the operational area and surrounding waters;
- controls to be implemented to ensure impacts and risks are ALARP and of an acceptable level;
- requirement to follow procedures and use risk assessments/ job hazard assessments to identify environmental impacts and risks and appropriate controls;
- requirements for interactions with fishers and/or fishing equipment;
- requirement for responding to and reporting environmental hazards or incidents.
- overview of emergency response and spill management plans; and

- fauna sighting and vessel interaction procedures.

In addition to the activity-specific induction, each employee or contractor with specific responsibilities pertaining to the implementation of this EP shall be made aware of their responsibilities, and the specific control measures required to maintain environmental performance and legislative compliance.

8.7 Communication, Consultation and Community Involvement (HSEMS Standard 6)

This standard specifies that effective, transparent and open communication and consultation with stakeholders is valued and undertaken across the company.

The activity Project Manager has responsibility for ensuring that systems are in place to facilitate the communication of HSE issues this is typically via the daily report and daily pre-start meetings.

Stakeholder consultation specific to the activity is detailed in Section 9.

8.8 Hazard and Risk Management (HSEMS Standard 7)

This standard specifies that HSE hazards and risks associated with the company's activities are identified, assessed and managed to prevent or reduce the likelihood and consequence of incidents.

Section 6 details the impact and risk assessment undertaken to identify and assess the environmental impacts and risks associated with the activity and the control measures that will be implemented to prevent or reduce the likelihood and consequence of incidents.

Risk management processes associated with environmental hazards are manged in accordance with the Environmental Related Risk Procedure and the Risk Management Directive.

As detailed in Section 8.22.2, Beach will undertake a review of this EP to ensure that any changes to activities, controls, regulatory requirements and information from research, stakeholders, industry bodies or any other sources to inform the EP are assessed using risk management tools nominated. The review will ensure that the environmental impacts and risks of the activity continue to be identified and reduced ALARP and an acceptable level.

If revision of this Environmental Management Plan is trigged though change in risk or controls the revision process shall be managed in accordance with Section 8.12 Management of Change.

8.9 Incident Management (HSEMS Standard 8)

The incident management standard requires that all HSE incidents, including near misses, are reported, investigated, and analysed to ensure that preventive actions are taken, and learnings are shared throughout the organisation. Incidents shall be managed in accordance with the Incident Management Directive.

Incident reports and corrective actions are managed using the Beach Enterprise Incident Management System.

Notifiable incidents will be reported as detailed in Section 8.9.1.

8.9.1 Incident Reporting

Notification and reporting requirements for environmental incidents to external agencies are provided in Table 8-3.

Table 8-3: Regulatory incident reporting

Requirement	Timing	Contact
Recordable incident As defined within the OPGGS(E)R a recordable environmental incident is a breach of an EPO or EPS in the EP that applies to the activity that is not a recordable incident.		
As a minimum, the written monthly recordable report must include a description of: • All recordable incidents which occurred during the calendar month; • All material facts and circumstances concerning the incidents that the operator knows or is able to reasonably find out; • Corrective actions taken to avoid or mitigate any adverse environmental impacts of the incident; and • Corrective actions that have been taken, or may be taken, to prevent a repeat of similar incidents occurring. Regulation 26B of the OPGGS(E)R requires a recordable incident report to be submitted if there is a recordable incident, thus nil reports are not required.	Before the 15th day of the following calendar month	• NOPSEMA - submissions@nopsema.gov.au
Reportable incident As defined within the OPGGS(E)R, a reportable incident is an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage. In the context of the Beach Environmental Risk Matrix moderate to significant environmental damage is defined as any incident of actual or potential consequence category Serious (3) or greater. These risks include: • Vessel collision resulting in a loss of containment. • Introduction of marine pests from vessel.		
Verbal notification The notification must contain: • All material fact and circumstances concerning the incident; • Any action taken to avoid or mitigate the adverse environmental impact of the incident; and • The corrective action that has been taken or is proposed to be taken to stop control or remedy the reportable incident.	Within two hours of becoming aware of incident	• NOPSEMA - 08 6461 7090 • NOPSEMA - submissions@nopsema.gov.au • DJPR - operational.reports@ecodev.vic.gov.au • NOPTA – reporting @nopta.gov.au
Written notification Verbal notification of a reportable incident to the regulator must be followed by a written report. As a minimum, the written incident report will include: • The incident and all material facts and circumstances concerning the incident; • Actions taken to avoid or mitigate any adverse environmental impacts; • The corrective actions that have been taken, or may be taken, to prevent a recurrence of the incident; and • The action that has been taken or is proposed to be taken to prevent a similar incident occurring in the future.	Within 3 days of notification of incident	• NOPSEMA - submissions@nopsema.gov.au
Written incident reports to be submitted to NOPTA and DJPR (for incidents in Commonwealth waters).	Within 7 days of written report submission to NOPSEMA	• DJPR - operational.reports@ecodev.vic.gov.au • NOPTA – reporting @nopta.gov.au

Requirement	Timing	Contact
Vessel spill to marine environment All discharges /spills or probable discharges/spills to the marine environment of oil or oily mixtures, or noxious liquid substances in the marine environment from vessels. Reporting info: http://www.amsa.gov.au/forms-and-publications/AMSA1522.pdf.	Verbal notification ASAP	Immediate notification by the Vessel Master to AMSA. Follow-up with Marine Pollution Report (POLREP). • Ph: 1800 641 792 • Email: rccaus@amsa.gov.au • AMSA POLREP: https://amsa-forms.nogginoca.com/public/
AMP - in the event an AMP may be exposed to hydrocarbons	Verbal notification ASAP	• Marine Park Compliance Duty Officer - 0419 293 465 Notification must be provided to the Director of National Parks and include: • titleholder details; • time and location of the incident (including name of marine park likely to be affected); • proposed response arrangement; • confirmation of providing access to relevant monitoring and evaluation reports when available; and • contact details for the response coordinator.
Vessel strike with cetacean	Within 72 hours	• DotEE - online National Ship Strike Database https://data.marinemammals.gov.au/report/shipstrike
	ASAP for cetacean injury assistance	• Department of Environment, Land, Water and Planning (Whale and Dolphin Emergency Hotline) - 1300 136 017 • Seals, Penguins or Marine Turtles 136 186 (Mon-Fri 8am to 6pm) or AGL Marine Response Unit 1300 245 678.
Injury to or death of EPBC Act-listed species	Within seven days	• DotEE - 1800 803 772 • EPBC.Permits@environment.gov.au
Suspected or confirmed Invasive Marine Species introduction	Verbal notification ASAP	• Department of Environment, Land, Water and Planning - 136 186
Identification of any historic shipwrecks or relics	Written notification within 1 week	• Written notification via the notification of discovery of an historic shipwreck or relic online submission form.

8.10 Performance Measurement and Reporting (HSEMS Standard 9)

The performance measurement and reporting standard specifies that HSE performance data is collected, analysed and reported to monitor and evaluate ongoing HSE performance and drive continual improvement.

8.10.1 Annual Performance Report

In accordance with the OPGGS(E)R Regulation 14(2), Beach will submit a report on the environmental performance of the activity to NOPSEMA. Performance will be measured against the EPOs and EPSs described in this EP. The report will be submitted not more than three months after the anniversary date of the EP acceptance by NOPSEMA. The interval between reports will not be more than one year.

8.10.2 Emissions and Discharge Records

In accordance with the OPGGS(E)R Regulation 14(7) emissions and discharges shall be recorded for the duration of the activity. Table 8-4 details the types of emissions and discharges that shall be recorded including the monitoring method and frequency of reporting.

Table 8-4: Emissions and discharges monitoring requirements

Emission / Discharge	Monitoring Parameter	Monitoring Method	Reporting Frequency
Fuel	Volume used	Daily report	Daily

8.11 Operational Control (HSEMS Standard 10)

The intent of this standard is that all activities that have the potential to cause harm to the health and safety of people or the environment are carried out in accordance with plans and procedures to ensure safe work practices.

The activity will be carried out in accordance with this EP.

8.12 Management of Change (HSEMS Standard 11)

This standard requires that all temporary and permanent changes to the organisation, personnel, systems, critical procedures, equipment, products and materials are identified and managed to ensure HSE risks arising from these changes remain at an acceptable level.

Changes to equipment, systems and documentation is in accordance with the Management of Change (MOC) Directive to ensure that all proposed changes are adequately defined, implemented, reviewed and documented by suitably competent persons. This process is managed using an electronic tracking database, which provides assurance that all engineering and regulatory requirements have both been considered and met before any change is operational. The MOC process includes not just plant and equipment changes but also critical documented procedures where there is an HSE impact, regulatory documents and organisational changes that impact personnel in safety critical roles.

Where risk and hazard review processes as nominated in Section 8.8 identify a change in hazards, controls, or risk (See Section 7) and triggers a regulator requirement to revise this EP, the revision shall be defined, endorsed, completed and communicated in accordance with the Management of Change Directive.

8.13 Facilities Design, Construction, Commissioning and Decommissioning (HSEMS Standard 12)

The intent of this standard is to ensure that the assessment and management of HSE risks is an integral part of project design, construction and commissioning to enable sound HSE performance throughout the construction and operational life of the facility. Decommissioning plans are established for new projects and existing facilities.

Section 6 details the assessment and management of environmental impacts and risks for the activity and Section 7 details how the activity will be managed to ensure that the impacts and risks are ALARP and an acceptable level.

8.14 Contractors, Suppliers, Partners and Visitors (HSEMS Standard 13)

The intent of this standard is that contractors, suppliers and partners are assessed for their capabilities and competencies to perform work on behalf of Beach, and to ensure their HSE performance is aligned with these Standards.

Section 8.22.1 details how the vessel contractors will be assessed to ensure they have the capabilities and competencies to implement the control measures identified in Section 7. Training and competency of contractor personal engaged to work on the activity shall be competent in accordance with their Health and Safety Management System.

8.15 Crisis and Emergency Management (HSEMS Standard 14)

The intent of the crisis and emergency response management standard is to ensure that plans, procedures and resources are in place to effectively respond to crisis and emergency situations, to protect the workforce, the environment, the public and customers, and to preserve the company's assets and reputation.

The Beach Crisis and Emergency Management Framework consists of a tiered structure whereby the severity of the emergency triggers the activation of emergency management levels. The emergency response framework contains three tiers based on the severity of the potential impact, as outlined in Figure 8-2. The responsibilities of the Emergency Response Team (ERT), Emergency Management Team (EMT) and Crisis Management Team (CMT) are outlined in Table 8-5.

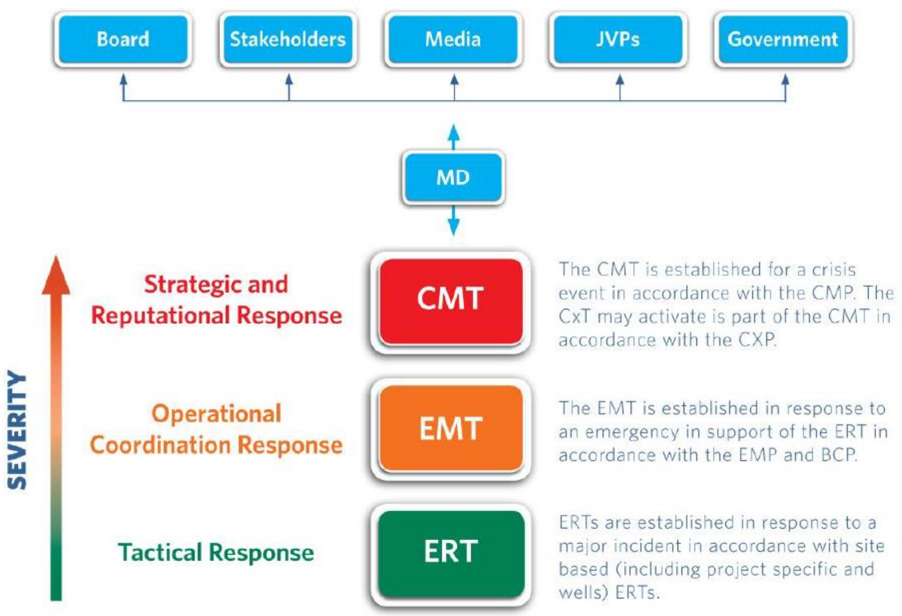

Figure 8-2: Beach Crisis and Emergency Management Framework

Table 8-5: Responsibilities of the Beach CMT and EMT

Team	Base	Responsibilities
CMT	Adelaide head office	• Strategic management of Beach's response and recovery efforts in accordance with the Crisis Management Plan.

		• Provide overall direction, strategic decision-making as well as providing corporate protection and support to activated response teams. • Activate the Crisis Communication Team if required.
EMT	Adelaide, Melbourne and New Plymouth	• Provide operational management support to the ERT to contain and control the incident. • Implement the Business Continuity Plan. • Liaise with external stakeholders in accordance with the site-specific Emergency Response Plan. • Regulatory reporting.
ERT	Site	• Respond to the emergency in accordance with the site-specific ERP.

8.16 Oil Pollution Emergency Plan

Based on the impact and risk assessment an accidental release or spill of oil or other hazardous material would not result in an impact consequence level greater than moderate. Therefore, there is not an oil pollution emergency event associated with this EP for which a standalone Oil Pollution Emergency Plan (OPEP) is required.

Given the nature and scale of the potential spill risks associated with the seabed assessments, any spill from the vessel would be managed by the vessel with ASMA as the Control Agency. Beach would provide support to the vessel contractor and AMSA as detailed in Section 7.4.

In the event of an oil or diesel spill to the sea, AMSA will be immediately notified by the Vessel Master to ensure prompt and appropriate mobilisation of relevant response plans. Section 8.9.1 and Table 8-3 details notification and reporting requirements.

8.16.1 Vessel Shipboard Marine Pollution Emergency Plan

To prepare for a spill event, the vessel Shipboard Marine Pollution Emergency Plan (SMPEP) or equivalent will detail:

- response equipment available to control a spill event;
- review cycle to ensure that the document is kept up to date; and
- testing requirements, including the frequency and nature of these tests.

In the event of a spill, the SMPEP or equivalent details:

- reporting requirements and a list of authorities to be contacted;
- the activities to be undertaken to control the discharge of oil; and
- procedures for coordinating with local officials.

As described in Section 8.22, Beach will evaluate the relevant SMPEP or equivalent document against the impacts and risks identified in this EP prior to the survey commencing to ensure that response capability and procedures are appropriate, the document is up to date including reporting requirements. Beach will ensure that the vessel operator's emergency notification procedures include notification to Beach.

8.16.2 Control Agency

AMSA is the Control Agency in Commonwealth Waters for all shipping (vessel) spills and spills that result from vessels undertaking offshore petroleum activities where the Commonwealth *Navigation Act 1912* applies. The contract vessel operator will conduct the first-strike response as per their SMPEP, or equivalent, with the support of Beach as required, until such time as AMSA or a nominated National Plan agency arrives to assume incident command. Beach will support the contract vessel operator with any applicable resources at Beach's disposal.

The following arrangements relevant to the seabed assessment apply for spills in Commonwealth waters:

- AMSA is the Control Agency for vessel (shipping) spills in Commonwealth Waters.
- First strike response to be undertaken by vessel contractor under the vessel's SMPEP or equivalent.
- Beach would provide support to the vessel contractor and AMSA as detailed in Section 7.4.

8.16.3 Beach EMT activation process

Beach's incident response levels are described in Table 8-6. Given the nature and scope of the seabed assessment activities, any incident that might occur would most likely be a Level 1 or Level 2 event.

Based on the nature of the petroleum activity being undertaken (vessel-based), a Level 1 or Level 2 spill incident would be managed by the contractor vessel operator, as per their emergency plans. Beach will be available to support the contract vessel operator with any available and applicable resources. Examples of this support may include personnel to supplement the contractor's EMT or accessing surveillance capabilities through Beach contracts with AMOSC.

As per Beach's standards, Beach's EMT Incident Commander (IC) would be notified in the event of a spill incident and Beach's EMT would be activated if required by the EMT IC. The Beach Environment Lead would implement any required response strategies as per Sections 7.4.5, 7.4.6 and 7.4.7.

Table 8-6: Overall response level indication

Level 1	**Level 2**	**Level 3**
An incident which is likely to have no adverse impact on the public or the environment. Control of the incident will be through the use of resources normally available at the vessel concerned without the need to mobilise the Beach EMT or seek external assistance.	An incident that cannot be controlled by the use of the vessel resources alone and requires external support and resources to combat the situation; or an incident that can be controlled by the vessel, but which may have an adverse impact on the public or the environment. Beach EMT shall be activated.	An incident likely to have a wide-ranging impact on the public, the environment, and Beach. A level 3 incident may require the mobilisation of external state, national or international resources to bring the situation under control. Beach EMT shall activate the CMT.

8.16.4 Scientific Monitoring Program

The OPGGS(E)R also require the EP to plan for monitoring of impacts to the environment from oil pollution and associated response activities. This Scientific Monitoring Program (SMP) has been developed to meet the requirements of OPGGS(E)R Regulation 14.

8.16.4.1 Scope of the SMP

The only hydrocarbon spill scenario for the seabed assessment is a diesel release from a vessel collision. The risks of a hydrocarbon spill from a vessel collision, and the associated response activities are anticipated to be limited to Level 1 and 2 spill events, with relevant response arrangements described in the EP (Table 7-13).

The geographical scope of the SMP is the EMBA described in Section 5.2 which is wholly in Commonwealth waters.

8.16.4.2 Objectives

In the event of a hydrocarbon spill incident, this SMP will be implemented to determine whether their environmental goals have been met during and after a response (scientific monitoring activities).

Scientific monitoring studies will be undertaken in the event of a Level 2 hydrocarbon spill incident at an appropriate scale, whereby SMSs will be used to characterise the short- (impact) and long- (recovery) term environmental effects from a hydrocarbon release incident. Scientific monitoring will also be used to assess if oil spill response measures have been effective in protecting and/or mitigating environmental sensitivities under threat from an incident.

8.16.4.3 Scientific monitoring studies

In the event of a Level 2 hydrocarbon spill during this activity, the oil spill response, and evaluation of environmental impacts and recovery will be informed by SMS as summarised in Table 8-7 to Table 8-8. Beach has in place a contract with a scientific monitoring consultant with the expertise and resources to undertake this monitoring.

Table 8-7: SMS1 - Monitoring hydrocarbon fate and distribution in water

SMS1 - Monitoring hydrocarbon fate and distribution in water
Objective To determine and document the distribution and concentrations of hydrocarbon in waters due to a spill and response activities and to document recovery to background levels. This assessment may include distribution and concentrations of entrained hydrocarbons in seawater.
Trigger for study initiation Measured hydrocarbons in the water column of ≥10 ppb or modelled dissolved aromatic hydrocarbons of ≥6 pbb, **or** Modelled or, where direct measurement has occurred by the Control Agency, measured surface hydrocarbon thickness of ≥10 g/m^2 in areas where there is potential for contamination of sensitive benthic habitats or receptors (e.g. protected areas, intertidal/subtidal reefs, rock lobster or other benthic fisheries).

SMS1 - Monitoring hydrocarbon fate and distribution in water
Methods As there is relatively little existing baseline data on contamination status of marine waters in the region, the design of these studies would be a combination of control-impact (Keough and Mapstone, 1995) and gradient (Ellis and Schneider, 1997) studies. Trajectory and fate modelling and the results of monitoring conducted by Control Agencies will be used to identify likely fate and concentrations of hydrocarbon in the water column and identify where the multiple impact and reference sites where scientific monitoring will be conducted. Where trigger criteria thresholds are exceeded, triplicate seawater samples will be collected from a number of impact and reference sites. In general, sites will be accessed by vessels, although nearshore shallow water sites may be accessed on foot if conditions allow safe access. Samples will be collected from a range of depths using Niskin bottles or similar remotely triggered samplers. Physico-chemical sampling will be undertaken at the same locations using a hand-held probe. Water samples will be immediately stored in glass bottles supplied by the analytical laboratory and chilled to ≤4ºC or frozen depending on advice from the receiving laboratory. Sample ID, sampler name, location and time/date information will be recorded for each sample taken. Quality Assurance/Quality Control samples will be taken in accordance with ANZECC (2000). Any requirement for preservation of samples will be discussed in advance with the analytical laboratory. Water samples will be transported in chilled containers to a NATA accredited laboratory within 7 days of collection and will be analysed for total petroleum hydrocarbons and polycyclic aromatic hydrocarbon concentrations. All samples will be accompanied by Chain-of-Custody documentation.
Resources required • Vessels (offshore site access) • Trained samplers • Sampling equipment (water & sediment) • Sample storage and chilling facilities • Courier services • Analytical laboratory
Timeframes for mobilisation As far as practicable this study will commence as soon as possible after the initial spill trajectory modelling (within 24-72 hours) depending on weather and sea condition restrictions for safe access to and operation at sample sites. The frequency of sampling will be determined by the results of the first sampling events and will continue as determined by the EMT IC.
Termination criteria Hydrocarbon levels in marine waters are within natural variability of the established baseline condition or no longer pose a risk to environmental sensitivities; and monitoring will only terminate with the approval of the EMT IC.

Table 8-8: SMS2 - Monitoring hydrocarbon contamination and exposure of fish

SMS2 - Monitoring Hydrocarbon Contamination and Exposure of Fish
Objective Determine levels of contamination in commercial fish species (including invertebrates) in shallow waters significantly impacted by surface hydrocarbon contamination or response activities, including confirming safety for human consumption.
Trigger for study initiation Modelled or, where direct measurement has occurred by the Control Agency, measured surface hydrocarbons in the water column of ≥10 ppb or modelled dissolved aromatic hydrocarbons of ≥6 pbb, at depths where there is potential for contamination of sensitive benthic habitats or receptors (e.g. subtidal reefs, rock lobster or other benthic fisheries). **or** Reports of tainted seafood are received.
Methods Sampling will include fisheries resources (including rock lobster, crabs, abalone and/or scallops) from contaminated and clean control locations, with species selection based on the presence and potential for commercial harvest of fisheries from contaminated areas. Study methods will be refined in consultation with fisheries experts and government agencies but are anticipated to include

SMS2 - Monitoring Hydrocarbon Contamination and Exposure of Fish
measurement of total petroleum hydrocarbon concentrations in fish tissues, and biomarker assessment for evidence of exposure to hydrocarbon contamination. Sample identification, sampler name, location and time/date information will be recorded for each sample taken. Preservation and handling of samples will be in accordance with recommendations from the receiving laboratory. Tainting of fisheries resources would be investigated using an olfactory analysis. Trained panellists would determine if they could distinguish between an uncooked sample from a fish captured in an "impacted" location and a sample from a fish captured in a "non-impacted" location. The panellists would not be aware of the origin of the test material, and only requested to identify if differences existed between the portions. Panellists would be asked to provide qualitative comments on the olfactory qualities of the samples. The trial would be repeated after the samples were cooked. Results will be compared to relevant food safety guidelines as well as published literature on concentrations causing tainting or fish health impacts in comparable species to those collected for the study.
Resources required • Vessels • Fishing equipment • Fisheries experts • Food safety experts • Ecotoxicology experts
Timeframes for mobilisation As far as practicable this study will commence as soon as possible after the initial spill trajectory modelling (within 24-72 hours), depending on weather and sea condition restrictions for safe access to and operation at sample sites. As the requirement for this study is partially based on food safety requirements, the exact timing would be determined in consultation with the Commonwealth Department of Agriculture and Water (including Australian Fisheries Management Authority & Fisheries Research and Development Corporation), the DJPR and/or the Department of Primary Industries, Parks, Water and Environment (DPIPWE), and various others (possibly including Commonwealth Scientific and Industrial Research Organisation [CSIRO], State governments, seafood and fishing industry groups, Food Safety Australia New Zealand and expert technical advisors).
Termination criteria Surveys determine 'no statistically significant difference' between fish at impact and control/reference sites 12 months after the incident; or Recovery of hydrocarbon levels in fish/shellfish tissue to acceptable levels no longer pose a risk for seafood consumption and selected key ecological fish processes over two consecutive years. If after two years of consecutive monitoring seafood is fit for human consumption but uncertainty remains in regard to selected key ecological fish process, Beach will review the requirement for ongoing monitoring and alternative termination criteria will be considered via consultation with NOPSEMA, DotEE, DJPR and/or the DPIPWE. Monitoring will only terminate with the approval of the EMT IC.

8.16.5 Testing of spill response arrangements

In accordance with Regulation 14(8A)(8C) of the OPGGS(E)R and HSEMS Standard 16: Crisis and Emergency Preparedness and Response, the response arrangements will be tested:

- when they are introduced;
- when they are significantly amended; and
- not later than 12 months after the most recent test.;

Prior to commencing the seabed assessment activities, spill response arrangements applicable to the survey vessel will be tested. The outcomes of the test will be documented to assess the effectiveness of the exercise against its objectives and to record any lessons and actions. Any actions will be recorded and tracked to completion.

8.17 Plant and Equipment (HSEMS Standard 15)

The intent of this performance standard is that Beach's facilities, plant, equipment, machinery and tools are purchased, designed, constructed, commissioned, operated, maintained, modified and decommissioned in a manner that ensures HSE risks are effectively managed.

Plant and equipment that have been identified as a control measure for the purposed of managing potential environmental impacts and risks from the activity have an associated environmental performance standard that details the performance required of the plant and/or equipment as detailed in Section 7.5.

8.18 Monitoring the Working Environment (HSEMS Standard 16)

The intent of this performance standard is that HSE risks to personnel associated within the working environment are eliminated or reduced to ALARP.

8.19 Health and Fitness for Work (HSEMS Standard 17)

Beach encourages a healthy lifestyle for its employees and provides formal programs to promote health and fitness.

8.20 Environment Effects and Management (HSEMS Standard 18)

The intent of this performance standard is that potential adverse environmental effects resulting from Beach's operations and activities are identified, assessed and monitored and as far as is reasonably practicable, eliminated or minimised.

Section 7 details the assessment undertaken of the activity to identify and assess potential impacts and risks and apply control measure to manages the impacts and risk to ALARP and an acceptable level.

8.20.1 Hazardous Materials Assessment Process

The Hazardous Materials and Secondary Containment Directive detail the process for the assessing and approving hazardous materials such as chemicals that are used on Beach sites or activities. The Directive requires that where a hazardous material will or may be discharged offshore a risk assessment is required. The risk assessment is documented using the Hazardous Material Risk Assessment Form.

Figure 8-3 provides a summary of the Beach offshore chemical environmental risk assessment process. The risk assessment process considers aquatic toxicity, bioaccumulation and persistence data, along with the discharge concentration, duration, frequency, rate, and volume. The assessed level of risk determines the acceptance authority (in accordance with the Risk Management Plan) for approving the material for use. Approval is recorded on the Hazardous Material Risk Assessment Form.

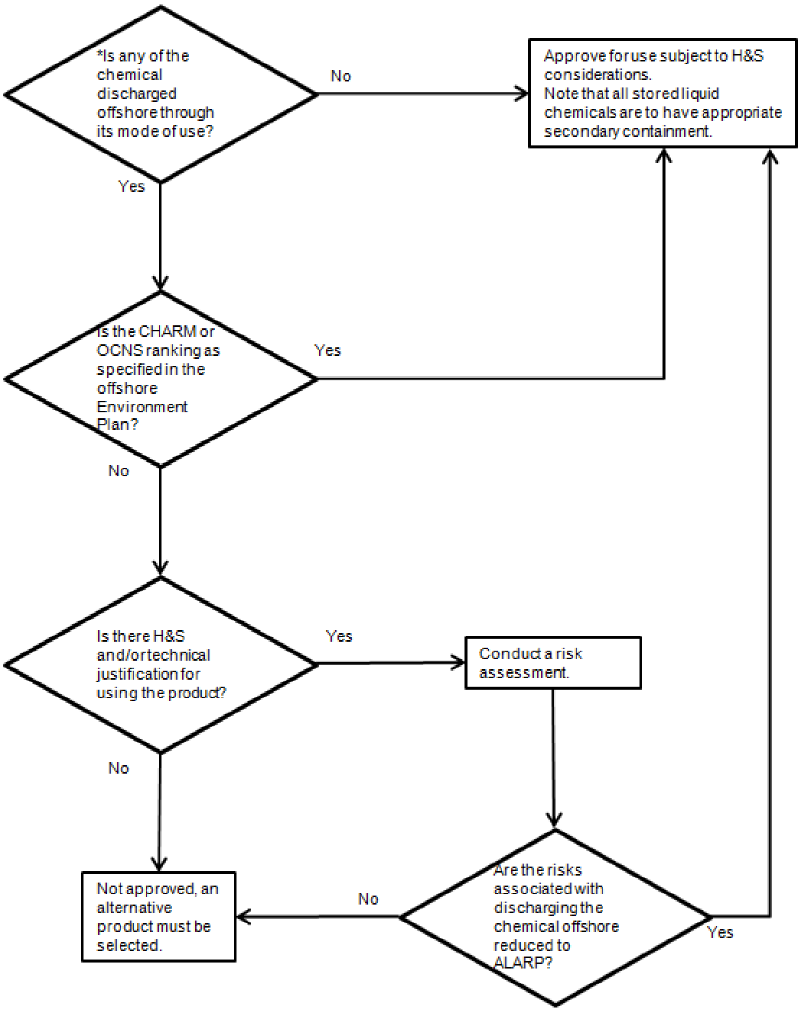

Figure 8-3: Beach offshore chemical environmental risk assessment process summary

8.21 Product Stewardship, Conservation and Waste Management (HSEMS Standard 19)

This standard requires that the lifecycle HSE impacts of Beach's products and services are assessed and communicated to customers and users to enable responsible usage management. Consumption of resources and materials is minimised as far as reasonably practicable. Wastes are eliminated, reduced, recycled and/or reused as far as reasonably practicable or disposed of appropriately.

General and hazardous waste streams generated during the activity are backloaded to port for disposal to a licenced waste facility. Wastewater and putrescible wastes are managed as per MARPOL requirements as detailed in Section 7.

8.22 Audits, Assessments and Review (HSEMS Standard 20)

The audits, assessment and review standard is in place to ensure that HSE performance and systems are monitored and assessed through periodic reports and audits to identify trends, measure progress, assess conformance and drive continual improvement. Management system reviews are conducted to ensure the continuing suitability, adequacy and effectiveness of the HSEMS.

8.22.1 Audits and assessments

Environmental performance will be reviewed in several ways to ensure:

- EPSs to achieve the EPOs are being implemented and reviewed.
- Potential non-compliances and opportunities for continuous improvement are identified.
- Environmental monitoring and reporting requirements have been met.

An annual audit will be undertaken of the EPOs and EPSs in this EP and the requirements detailed in the implementation strategy. The audit will inform the annual performance report submitted to the relevant regulator as per Section 8.10.1.

For offshore activities undertaken by the vessel the following will be undertaken:

- Premobilisation inspection to confirm the requirements of the EP will be met; and
- Weekly inspections throughout the activity to ensure ongoing compliance with relevant EP requirements. Inspection will include, but not be limited to:
  - Spill preparedness such as spill kit checks and SMPEP or equivalent drills;
  - Waste management;
  - Review of any new or changed chemicals that maybe discharged offshore; and
  - Maintenance checks for equipment identified as controls such as oily water separator.

Non-compliances and opportunities for improvements identified via audits, inspections or other means are communicated to the appropriate supervisor and/or manager to report and action in a timely manner. Tracking of non-compliances and audit actions will be undertaken using Beach's incident management system which includes assigning a responsible person for ensuring the action is addressed and closed out.

Non-compliances are communicated via the daily report and pre-start meetings.

8.22.2 Environment Plan review

Beach may determine that a review of the EP is required when one or more of the following occurs:

- Changes to hazards and/or controls identified during the activity.
- Annual environmental performance reporting identifies issues in the EP that require review and/or updating.
- Implementation of corrective actions to address internal audits findings or external inspection recommendations.
- An environmental incident and subsequent investigation identify issues in the EP that require review and/or updating.
- A modification of the activity is proposed that is not significant but needs to be documented in the EP.
- Changes to risk and controls identified through the Risk Management Processes as per Section 8.8.

- New information or changes in information from research, stakeholders, legal and other requirements, and any other sources used to inform the EP.

Where the EP is revised the changes are to be logged in the EP Revision Change Register in Appendix E. Any revisions to the EP are to be assessed against the criteria for submission of a revised EP to NOPSEMA as detailed in Table 8-9 and Management of Change as per Section 8.12 shall be evaluated.

8.22.3 Environment Plan revision

In accordance with Regulation 17 of the OPGGS(E)R, a revision of this EP shall be submitted to NOPSEMA as per the regulatory requirements in Table 8-9.

Table 8-9: Regulatory requirements for submission of a revised EP

OPGGS(E)R	EP Revision Submission Requirements
17(1)	With the regulator's approval before the commencement of a new activity
17(5)	Before the commencement of any significant modification or new stage of the activity that is not provided for in the EP as currently in force.
17(6)	Before, or as soon as practicable after, the occurrence of any significant new or significant increase in environmental impact or risk; or The occurrence of a series of new or a series of increases in existing environmental impacts or risks which, taken together, amount to the occurrence of a significant new or significant increase in environmental impact or risk.
17(7)	A change in titleholder that results in a change in the manner in which the environmental impacts and risks of an activity are managed.

9 Stakeholder consultation

Stakeholder consultation was undertaken in line with current NOPSEMA guidelines on consultation requirements under the OPGGS(E)R.

Beach is committed to open, on-going and effective engagement with the communities in which it operates and providing information that is clear, relevant and easily understandable. Beach welcomes feedback and is continuously endeavouring to learn from experience in order to manage our risks.

9.1 Regulatory requirements

Section 280 of the OPGGSA states that a person carrying out activities in an offshore permit area should not interfere with other users of the offshore area to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person.

In relation to the content of an EP, more specific requirements are defined in the OPGGS(E)R Regulation 11(A). This regulation requires that the Titleholder consult with 'relevant persons' in the preparation of an EP. A relevant person is defined as:

a) each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;

b) each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;

c) the Department of the responsible State Minister, or the responsible Northern Territory Minister;

d) a person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan;

e) any other person or organisation that the titleholder considers relevant.

Regulation 14(9) of the OPGGS(E)R also defines a requirement for ongoing consultation to be incorporated into the Implementation Strategy. In addition, Regulation 16(b) of the OPGGS(E)R requires that the EP contain a summary and full text of this consultation. It should be noted that the full text is not made publicly available for privacy reasons.

9.2 Stakeholder consultation objectives

The objectives of Beach's stakeholder consultation in preparation of the EP were to:

- Identify all relevant persons for stakeholder consultation.
- Engage with stakeholders and the community in an open, transparent, timely and responsive manner.
- Minimise community and stakeholders concern where practicable.
- Build and maintain trust with stakeholders and the local community.
- Demonstrate that stakeholders have been consulted in line with the requirements of the relevant regulations.

The objectives were achieved by:

- Identifying stakeholders whose functions, interests or activities may be affected by the activity.
- Confirming, through consultation, 'relevant persons' (stakeholders) and engaging them at the earliest opportunity.
- Providing sufficient information to allow relevant persons to make an informed assessment of the possible consequences of the activity on their functions, interests or activities.
- Ensuring relevant persons are informed about the process for consultation and their feedback is considered in the development of the EP.
- Ensuring that issues raised by relevant persons are adequately assessed, and where requested or relevant, responses to feedback are communicated back to them.
- Ensuring that relevant person sensitive information is not made publicly available.

9.3 Consultation approach

The approach Beach undertook for the activities was:

- Identify stakeholders that may be potentially affect by the activities by reviewing its stakeholder database and consulting with existing stakeholders to identify other relevant stakeholders. As Beach, through its subsidiary Lattice Energy, has operated in the area since the early 2000s, an extensive database of stakeholders has been built, and engagement has been undertaken in relation to both the current Operating assets and in executing projects such as the Enterprise 3D Transition Zone Marine Seismic survey in 2017 and the Crowes Foot Marine Seismic Survey in 2016.
- Determine the possible consequences of the activities on each stakeholders' functions, interests or activities from previous knowledge, reviewing any public statements by the stakeholder as to how they want to be engaged by oil and gas companies and/or consulting with stakeholders.
- Provide sufficient information, based on possible consequences and the way they would like to be consulted, for the stakeholder to be able to make an informed assessment of the possible consequences of the activity on their functions, interests or activities.
- Allow a reasonable period of time for the stakeholder to review and respond to any information provided, typically two to four weeks.
- Provide further information requested by the stakeholder or that became available during the consultation period and allowed a reasonable time for the stakeholder to review and respond. Depending on the information provided this was between one to four weeks.
- Ensure relevant stakeholders were informed about the consultation process and how their feedback, questions and concerns were considered in the EP.

9.3.1 Fishery specific consultation approach

From reviewing the existing environment, the main stakeholder group for the activity is commercial fishers. Beach, through its subsidiary Lattice Energy, has a substantial history of engagement with local fisheries. For the seabed assessment the consultation strategy for potentially impacted fishers is as follows:

- Engage with Seafood Industry Victoria (SIV) to identify how best to consult with commercial fishers.
- Provide a short information sheet to SIV to mail to their members, including groups such as Victorian Rock Lobster Association and Port Campbell Professional Fishers association. The cover letter requested that fishers identify themselves to SIV if they thought they could be impacted by Beach's activities. The information sheet covered both seabed assessment and drilling programs and a more detailed version was published on Beach's website at https://www.beachenergy.com.au/vic-otway-basin/.
- The mailout was issued on 29 March, with a request that fishers respond by 19 April. To date four fishers have contacted SIV in relation to the Beach activities information.
- Beach also provided information to fishery groups and has been contacted directly by two fishers.
- Where fishers have identified that they may be potentially impacted by the activity the following is undertaken:
  - For fishers who have contacted SIV, Beach will meet with SIV to gather information about the fishers fishing patterns and locations and to establish contact for ongoing consultation throughout the project.
  - For fishers who have contacted Beach directly, Beach engaged its Fisheries Liaison Officer to meet with them and gather information about their fishing patterns and locations and to establish contact for ongoing consultation throughout the project.
  - Where fishers are providing Beach with sensitive fishing data Beach will provide them Beach's privacy policy and obligations.
- Beach is developing a schedule of timing and specific locations for the seabed assessments and once this information is firm (minimum of 4 weeks prior to commencement of the activity) it will be provided to fishers who have identified they fish in the area, SIV, VFA and other relevant fishing groups who have requested further information.
- Beach is conscious that the timing and areas may change slightly, and these will be assessed by Beach to determine if they would materially change the information provided to fishers to identify if they would be potentially impacted by the activity. If there is no material change, in order to minimise confusion for fishers and the time required for engagement, Beach will inform relevant stakeholders of any changes once the seabed assessment locations and timings are firm which at a minimum will be 4 weeks prior to the commencement of the activity. If the changes are material, then updated information will be provided to relevant stakeholders.
- Beach will seek permission from the identified fishers to include them in their SMS messaging system. Once the activity commences, Beach will provide regular (most likely daily) updates on the locations that the vessel will be operating in as well as the expected duration so fishers can plan their fishing activities with the least disruption.
- Beach's position is that the commercial fisheries cover a vast area and the seabed assessments only require access to a relatively small area over a short period of time and so we aim to minimise impact to each other's activities. However, Beach has a stated position that fishers should not suffer an economic loss as a result of our activities. Should a fisher incur additional costs in order to work around our activities, or if they have lost catch or have damaged equipment Beach will assess the claim and ask for evidence of past fishing history and the loss incurred and, where the claim is genuine, will provide compensation. Beach will also ensure that the evidence required is not burdensome on the fisher while ensuring genuine claims are processed.

9.4 Stakeholder identification

Relevant stakeholders were identified by reviewing:

- Social receptors identified in the existing environment section.
- Existing stakeholders within Beach's stakeholder register.
- Reviewing consultation record for previous Otway Basin activities undertaken by Beach and Lattice.
- Commonwealth and State fisheries jurisdictions and fishing effort in the region.
- The Australian Government Guidance Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area.

The Otway Development commenced production in late February 2008. Woodside Energy, the titleholder at the time, undertook significant consultation with the community, non-government organisations and Government departments. Consultation has been ongoing through the change of titleholders to Origin and then Lattice.

In 2017 Lattice commenced consultation in relation to the Otway Development Phase 4 and associated seabed assessment and drilling activities. Beach then commenced consultation with stakeholders in early 2019 when they decided to progress with the Otway Development Phase 4. Consequently, Beach consider that they have effectively identified relevant stakeholders and have a good understanding of issues and areas of concern within the Otway Development area.

Table 9-1 details the relevant stakeholders identified and groups them by the categories listed under OPGGS(E)R Regulation 11A. It should be noted that no fishing effort by Tasmanian fisheries was identified within the operational area.

9.5 Provisions of information

The OPGGS(E)R require titleholders to give each relevant person sufficient information to allow the relevant person to make an informed assessment of the possible consequences of the activity on the functions, interests or activities of the relevant person.

To determine the type of information to provide to a stakeholder an Information Category was developed and is detailed in Table 9-2.

Information has also been provided in relation to the broader Beach Otway Offshore Gas Development which included information on the activity via:

- Community Information Session held in Port Campbell on 13 February 2019.
- Information sheets and information available on the Beach website: https://www.beachenergy.com.au/our-communities/.

9.6 Summary of stakeholder consultation

Table 9-4 provides a summary of the stakeholder consultation undertaken as part of the development of the EP. The summary provides details of the information sent to stakeholders and any response received. It also details the assessment undertaken of any objection or claims. Where an objection or claim was substantiated via evidence such as publicly available credible information and/or scientific or fishing data, this were assessed as per the risk assessment process detail in Section 6 and controls applied where appropriate to ensure impacts and risks are managed to ALARP and an acceptable level.

Stakeholders were provided with feedback as to whether their objection or claim was substantiated, and if not why not, and if it was substantiated how it was assessed and if any additional controls were required to manage the impact or risk to ALARP and an acceptable level. The sections of the EP where any information provided or where any objections or claims were incorporated were provided to the stakeholder so they can find the information once the EP is available on the NOPSEMA website.

Table 9-1: Relevant stakeholders for the activity (refer to Table 8-2 for information category definition)

Stakeholder	Relevance	Information Category
Department or agency of the Commonwealth to which the activities to be carried out under the EP may be relevant		
Australian Fisheries Management Authority (AFMA)	Australian Government agency responsible for the efficient management and sustainable use of Commonwealth fish resources. Activity is within a Commonwealth fishery area. AFMA expects petroleum operators to consult directly with fishing operators or via their fishing association body about all activities and projects which may affect day to day fishing activities.	1
Australian Hydrological Office (AHO)	Australian Government agency responsible for issuing notices to mariners.	2
AMSA JRCC	Australian Government agency responsible for maritime safety, adherence to advice, protocols, regulations. Issue Auscoast warnings	2
Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the EP may be relevant		
DJPR – Victorian Fishery Authority	Activity is within a Victorian fishery area or will impact or potentially impact a Victorian fishery area or resource.	1
The Department of the Responsible State or Northern Territory Minister		
Tasmanian DPIPWE	Regulatory body for oil and gas activities in Tasmanian waters. Required to be notified of reportable incidents. Commencement and cessation notifications are only required for drilling and seismic surveys.	2
DJPR - Earth Resources Regulation	Regulatory body for oil and gas activities in Victorian waters. Required to be notified of reportable incidents. Commencement and cessation notifications are only required for drilling and seismic surveys.	2
A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the EP		
Commonwealth Fisheries Association	Peak association representing commercial fishing in Commonwealth fisheries. Industry Association for the following Commonwealth fisheries that have catch effort within the operational area: • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors). • Southern Squid Jig Fishery.	1
Port Campbell Professional Fisherman's Association	Association representing Port Campbell fishers, primarily rock lobster around Port Campbell and Peterborough. Engagement via SIV see Consultation Record #SIV 07.	1
Portland Professional Fishermen's Association	Association representing Portland fishermen.	1

Stakeholder	Relevance	Information Category
South East Trawl Fishing Industry Association (SETFIA)	SETFIA represents businesses with a commercial interest in the SETF and the East Coast Deepwater Trawl Sector. SETFIA represent the following fisheries that have catch effort within the operational area: • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors).	1
Seafood Industries Victoria (SIV)	Peak body representing professional fishing, seafood processors and exporters in Victoria. SIV primary contact for State fishers. SETFIA represent the following fisheries that have catch effort within the operational area: • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors).	1
Southern Rock Lobster Limited South Australian Rock Lobster Advisory Council Inc. South Eastern Professional Fishermen's Association Inc. Tasmanian Rock Lobster Fishermen's Association	Associations representing state-based commercial rock lobster fishers. Associations are represented by one consultancy and are therefore grouped.	1
Victorian Rock Lobster Association (VRLA)	VRLA represents Victorian rock lobster licence holders. Engagement via SIV see Consultation Record #SIV 07.	1
Warrnambool Professional Fishermen's Association	Association represents Warrnambool fishermen, primarily rock lobster on strip from Warrnambool to Port Campbell. Engagement via SIV see Consultation Record #SIV 07.	1
Any other person or organisation that the titleholder considers relevant		
Otway Gas Plant Community Reference Group	Community Reference Group established for the Otway Gas Plant. No impact to stakeholders' functions, interests or activities due to distance offshore. However, Beach maintain engagement in relation to activities within the Otway area.	3
Tasmanian Rock Lobster Fisherman's Association	The Tasmanian Rock Lobster Fishermen's Association is the peak commercial fishing body recognised under the Act for the rock lobster fishery. The Development Area does not overlap any Tasmanian rock lobster fishery where there is catch effort. However, Beach maintain engagement in relation to activities within the Otway area.	3
Tasmanian Seafood Industry Council (TSIC)	The TSIC is the peak body representing the interests of wild capture fishers, marine farmers and seafood processors in Tasmania. The Development Area does not overlap any Tasmanian fisheries where there is catch effort. However, Beach maintain engagement in relation to activities within the Otway area.	3

Table 9-2: Information category to determine information provided stakeholder

Information Category	Description	Information Type
1	Organisations or individuals whose functions, interests or activities may be impacted by the activity. Representative body for fishers who provide information to their members.	Information Sheet and/or provision of information as per organisations consultation guidance Provision of further information where required Meeting or phone call where required
2	Organisation who receive activity commencement and cessation notices.	Commencement and cessation notices.
3	Organisations or individuals whose functions, interests or activities will not be impacted by the activity but are kept up to date with Beach's activities in the Otway area.	Information Sheet

9.7 Ongoing stakeholder consultation

As the seabed assessment will be undertaken over two phases Beach will continue to consult with stakeholders to keep them informed of the schedule and location coordinates as information becomes available. This will be done via ongoing consultation including commencement and cessation notifications and updates in relation to the seabed assessments and broader Otway Offshore Gas Development project via one-on-one communications, mail outs and provision of information on the Beach website. Beach will use a message media system to provide daily information on the vessel location to stakeholders that have requested this service.

Table 9-4 details the ongoing stakeholder consultation requirements. Records of ongoing stakeholder engagement will be maintained as per Section 8.5.2 Records Management.

9.7.1 Ongoing identification of relevant persons

New or changes to relevant persons will be identified through ongoing consultation with stakeholders including peak industry bodies. Should new relevant persons be identified they will be contacted and provided information about the activity relevant to their functions, interests or activities. If any objections or claims are raised these will be substantiated via evidence such as publicly available credible information and/or scientific or fishing data. Where the objection or claim is substantiated it will be assessed as per the risk assessment process detail in Section 6 and controls applied where appropriate to manage impacts and risks to ALARP and an acceptable level. Stakeholders will be provided with feedback as to whether their objection or claim was substantiated, and if not why not, and if it was substantiated how it was assessed and if any controls were put in place to manage the impact or risk to ALARP and an acceptable level. If the objection or claim triggers a revision of the EP this will be managed as per Section 8.22.2 and 8.22.3. This will also be communicated to the stakeholder.

Table 9-3: Ongoing stakeholder consultation requirements

Stakeholder	Ongoing Stakeholder Requirement	Timing
Relevant stakeholders	Ongoing engagement including: • stakeholder communication of information and addressing queries and concerns via email, phone or meeting; and • updates to Beach website.	As required

Stakeholder	Ongoing Stakeholder Requirement	Timing
General	Public notice in local newspapers (i.e. Warrnambool Standard and The Cobden Timboon Coast Time). To include: • activity description; • activity location; • timing; • how to access the EP and project information; and • Beach contact person.	4 weeks prior to activity commencing
Relevant stakeholders	Stakeholder notification of activity commencement. Notification to include: • type of activity; • location of activity, coordinates and map; • timing of activity: start and finish date and duration; • vessel, vessels details including call sign and contact; and • Beach contact person. Note: coordinates to be provided as degrees and decimal minutes referenced to the WGS 84 datum.	4 weeks prior to activity commencing
AHO	Notification of activity for publication of notice to mariners. Information provided should detail: • type of activity; • size, location and geographical coordinates for area of operation; • area of operation and requested clearance from other vessels; • period that NTM will cover (start and finish date); • vessel and or rig details including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), contact details and calls signs; and • Beach contact person. Only need to update AHO of changes including if activity start or finish date changes. Do not need to provide cessation notification as long as NTM covers period of activity.	3 weeks prior to activity commencing
AMSA - JRRC	Notification of activity for publication of Auscoast warning. Information provided should detail: • type of activity; • size, location and geographical coordinates for area of operation; • period that warning will cover (start and finish date); • vessel and or rig details including vessel name, call-sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone), contact details and calls signs; and • Beach contact person. Only need to update JRCC of changes including if activity start of finish date changes. Do not need to provide cessation notification as long as Auscoast warning covers period of activity.	48 – 24 hrs prior to activity commencing
NOPSEMA DJPR DPIPWE	Regulatory notification of start of activity.	10 days prior to activity commencing

Stakeholder	Ongoing Stakeholder Requirement	Timing
Relevant stakeholders who have requested vessel location information.	Regular (most likely daily) text message of vessel locations to stakeholders who have requested the information.	During activity
NOPSEMA DJPR DPIPWE	Regulatory notification of cessation of activity.	Within 10 days of activity completion

Table 9-4: Summary of stakeholder consultation records and beach assessment of objections and claims

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Australian Communications and Media Authority (ACMA)	27/03/2019	ACMA 01 to ACMA 11	Request for Indigo Central submarine cable coordinates ACMA provided coordinates and a map showing that the cable is ~ 50 km from the Thylacine platform. Beach acknowledge information and note that the planned activities will not interfere with the cable.	Indigo Central Submarine Cable is ~ 50 km from the Thylacine platform and therefore out of the operational area for the seabed surveys.
Australian Fisheries Management Authority (AFMA)	18/04/2019	AFMA 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Email: Introducing Beach Energy and provision of information on the 'Otway Offshore Project and a summary of Beach's review of Commonwealth fisheries in the project area. A review of the AFMA website identified that the operational area where the seabed assessments and drilling activities are planned to occur over the following Commonwealth fisheries: • Bass Strait Central Zone Scallop Fishery; • Eastern Tuna and Billfish Fishery; • Skipjack Tuna Fishery (Eastern); • Small Pelagic Fishery (Western sub-area); • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors); • Southern Bluefin Tuna Fishery; and • Southern Squid Jig Fishery. However, a review of the ABARES Fishery Status Reports 2014 to 2018 identified that only the following have catch effort within the operational area: • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors); and • Southern Squid Jig Fishery. Information has been provided to AFMA and the following fishing associations: • Scallop Fisherman's Association Inc.; • SIV – SIV have sent out the information sheet attached to their members; • Tuna Australia (ETBF Industry Association); and • SETFIA. The main concerns raised by commercial fishers are sound from the seabed assessment and displacement while the activities occur. Sound from the seabed assessment equipment is of significantly lower intensity than for seismic surveys. Sound modelling identified that the sound threshold level for fish was reached at a maximum distance of 1.6 m from the equipment and did not reach the impact threshold for invertebrates at the seafloor. The seabed assessment areas will take up to 12 days for the largest area. Drilling at each location will range from 35 to 90 days with fishers not being able to access a 500 m area around the drill rid. Thus, the area of displacement is small and not for a significant period of time.	Provision of information. No reply.
Australian Hydrographic Office (AHO)	29.03.2019	AHO 01	Rang AHO to clarify requirement for notice to mariners (NTM) requirements. Requirement to notify AHO a minimum of 3 week prior to commencement of the activity information needs to include activity location or area, vessel/rig details including contact details and calls signs, period that NTM will cover (start and finish date). Only need to update AHO if activity start of finish date changes. Do not need to provide cessation notification as long as NTM covers period of activity.	Section 9.7 Ongoing Consultation updated to include AHO requirements.
Commonwealth Fisheries Association	18/04/2019	CFA 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Email: Introducing Beach Energy and provision of information on the 'Otway Offshore Project and a summary of Beach's review of Commonwealth fisheries in the project area. A review of the AFMA website identified that the operational area where the seabed assessments and drilling activities are planned to occur over the following Commonwealth fisheries: • Bass Strait Central Zone Scallop Fishery; • Eastern Tuna and Billfish Fishery; • Skipjack Tuna Fishery (Eastern); • Small Pelagic Fishery (Western sub-area); • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors); • Southern Bluefin Tuna Fishery; and	Provision of information. No reply.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			• Southern Squid Jig Fishery. However, a review of the ABARES Fishery Status Reports 2014 to 2018 identified that only the following have catch effort within the operational area: • SESSF (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors); and • Southern Squid Jig Fishery. Information has been provided to AFMA and the following fishing associations: • Scallop Fisherman's Association Inc.; • SIV – SIV have sent out the information sheet attached to their members; • Tuna Australia (ETBF Industry Association); and • SETFIA. The main concerns raised by commercial fishers are sound from the seabed assessment and displacement while the activities occur. Sound from the seabed assessment equipment is of significantly lower intensity than for seismic surveys. Sound modelling identified that the sound threshold level for fish was reached at a maximum distance of 1.6 m from the equipment and did not reach the impact threshold for invertebrates at the seafloor. The seabed assessment areas will take up to 12 days for the largest area. Drilling at each location will range from 35 to 90 days with fishers not being able to access a 500 m area around the drill rid. Thus, the area of displacement is small and not for a significant period of time.	
Commercial Rock Lobster Fisher	17/04/2019	CRLF 01	Commercial Rock Lobster Fisher rang as fishes around the Thylacine platform and in that region. He is concerned about the impact on his fishing during drilling as he fishes in the 40-50 fathoms region in the deeper water west of the platform. Is often there around January to February. He stops fishing in mid-September (when the rock lobster season ends). The season re-starts on 15th Nov. Beach explained that for the seabed assessments the vessel will be moving around and won't be in a particular area for very long. Beach can engage with him at the time and tell him the vessels location and where we are going to be so we can work around one another. Stakeholder is more concerned around the drill periods because we will be in the one spot for longer and he thinks the exclusion zone will be a few kilometres. Would like to meet with Beach to show where he fishes. Beach said there was time to catch up as the seabed assessments won't start before September and drilling until December.	Stakeholder raised concerns about impacts from exclusion to his fishing areas but specifically in relation to drilling. For the seabed assessments the vessel will be moving and hence will not be in one position for very long. There will be no exclusion zones for the seabed assessments. Stakeholder did not raise concerns specifically in relation to the seabed surveys. Due to the period when he fishers (January and February and against starting 15th Nov. The period of overlap with the seabed assessments would be small and only during November and December if the first phase of the seabed assessment that is planned to start in September takes longer than planned.
Commercial Rock Lobster Fisher	18/04/2019 21/04/2019	CRLF 02 CRLF 03	Phones calls to arrange for Beach FLO to meet with stakeholder.	See Record CRLF 05
Commercial Rock Lobster Fisher	24/04/2019	CRLF 04	Meeting with FLO and stakeholder. Stakeholder and FLO covered Mapping of fishing grounds and seasonal pattern compared with planned works and transit routes by support vessels, displacement and financial loss concerns, neighbouring works by Cooper Energy, exclusion and advisory clearance zones, other fishing operators in area.	See Record CRLF 05 and 06 of letter to stakeholder of record of meeting and details of Beach's arrangements to manage impact to stakeholder to ALARP and an acceptable level.
Commercial Rock Lobster Fisher	9/05/2019	CRLF 05 CRLF 06	Letter from Beach to stakeholder detailing: • Beach's confidentiality/privacy policy. • That in future any coordinates supplied would be expressed in degrees and decimal minutes referenced to the WGS 84 datum, so they can immediately be entered on your GPS plotter. • When Beach activities plotted over the locations the stakeholder fished there is potential for interaction. • In order to minimise impacts to your fishing, Beach will let fishers know expected timings and more precise location coordinates closer to the start of each activity and will also update fishers on a regular (possibly daily) basis of project status and vessel movement. • Beach's aim is to work together to minimise impacts on each other's operational plans, however, should you or any fisher wish to make a claim for loss as a result of our activities to contact Beach – contact details provided. • Beach would validate that the fisher regularly works in that area as well as evidence of the additional costs they have incurred or the loss they have suffered. Beach will then work with them to validate the claim and assess any compensation required. Validation procedures will necessarily involve access to fishing records and other relevant information. • Beach are aware of the issue you raised regarding your colleague's engagement with another Oil & Gas Company's vessel. When our project becomes operational Beach will undertake discussions with our vessel masters so that impacts on fishing and vice versa are as low as reasonably practicable. Beach's FLO will contact you shortly to discuss access to your fishing data and confirm that you would like to be included on our updates about the location of our activities while we are operational.	Beach aims to undertake the activity in a manner that does not unduly impact on fishers. This EP has been updated in response to the claims from this stakeholder as per the following: • Table 9-3 Ongoing stakeholder consultation requirements updated to note that for notifications to stakeholder where coordinates are supplied coordinates are to be expressed in degrees and decimal minutes referenced to the WGS 84 datum. • Stakeholder provided with Beach contact person should they wish to make a claim for loss as a result of Beach's activities. How Beach will deal with any claims is details in Section 9.3.1 Fishery specific consultation approach. • Section 8.6 Personnel, Competence, Training and Behaviours updated to include requirements for interactions with fishers and/or fishing equipment in the activity induction that will be required to be undertaken by all vessel personnel. • Engagement will be ongoing with stakeholder to ensure any impacts can be management to ALARP and an acceptable level.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Commercial Shark Fisher	28/04/2019	CSF 01	Stakeholder rang Beach 1800 number from Beach's Otway Offshore Program 2019 2pp Info Sheet. Stakeholder confirmed they were aware of Beach's upcoming activities. Fisher raised that a boat operating in the Otway area that had asked a shark fisher to pull his nets last week.	Beach provided information to the stakeholder in relation to the vessel that was not a Beach vessel. See Record CSF 02.
Commercial Shark Fisher	29/04/2019	CSF 02	Beach called stakeholder to provide an update on their comments about a boat operating in the Otway area that had asked a shark fisher to pull his nets last week. Beach informed stakeholder that Beach's vessel has not been operating in the region since April 15 and is now located near Wilson's Promontory. Another vessel was operating in the area but was not chartered by Beach. Beach informed stakeholder they had asked their Fisheries Liaison Officer (FLO) to meet with them to understand their fishing patterns and how they may overlap with Beach's proposed activities. Beach can't confirm specific locations and times as yet, but it will be helpful to understand where they fish and when. Stakeholder was comfortable with this as knew the FLO and had met with them before. FLO expected to be able to contact stakeholder by the end of this week (May 3).	Claim in relation to issue with boat operating in the Otway area was not relevant to Beach's activities. See Record CSF 05 for meeting details.
Commercial Shark Fisher	30/04/2019	CSF 03 CSF 04	Meeting coordinated between stakeholder and FLO for 3/05/2019.	See Record CSF 05.
Commercial Shark Fisher	3/05/2019	CSF 05	Meeting with FLO and stakeholder. Stakeholder concern is that Beach's activities would limit access to where he fishes and cause financial loss. If Beach wanted him to shift his fishing activities, Beach should pay him and he would stay out of their way. FLO explained that both Beach's and fishing activities across the same area was legal and that each were obliged under the Offshore Petroleum and Greenhouse Gas Storage Act 2006, to reduce their impact on each other to as low as reasonable practicable. Stakeholder said that to work around each other; good on water communications between his vessel and project vessels, and a common understanding of mandatory exclusion zones and advisory clearance distances around sites was needed. These were sometimes confused by support vessel masters and caused unnecessary displacement of fishing activities. Stakeholder asked does Beach have any arrangements so that he could claim and evidence a loss if that happened? The map in the information he received (BE_OFFSHORE Project 2pp_March_2019) showed the footprint of Beach's proposed work sites across the project lifetime, reference about the duration at each site and a preliminary calendar of events. More precise detail on start-up timing for each site would enable fisher to better assess likely impacts and fishing options at the time the work is taking place. An image of fisher's activities was provided to Beach.	See Record CSF 07 and 08 of letter to stakeholder of record of meeting and details of Beach's arrangements to manage impact to stakeholder to ALARP and an acceptable level.
Commercial Shark Fisher	3/05/2019	CSF 06	Stakeholder provided information to Beach in relation to the Electronic Catch Log System	NA
Commercial Shark Fisher	10/05/2019	CSF 07 CSF 08	Letter from Beach to stakeholder detailing: • Beach's confidentiality/privacy policy. • That in future any coordinates supplied would be expressed in degrees and decimal minutes referenced to the WGS 84 datum, so they can immediately be entered on your GPS plotter. • When Beach activities plotted over the locations the stakeholder fished there is potential for interaction. • In order to minimise impacts to your fishing, Beach will let fishers know expected timings and more precise location coordinates closer to the start of each activity and will also update fishers on a regular (possibly daily) basis of project status and vessel movement. • Beach's aim is to work together to minimise impacts on each other's operational plans, however, should you or any fisher wish to make a claim for loss as a result of our activities to contact Beach – contact details provided. • Beach would validate that the fisher regularly works in that area as well as evidence of the additional costs they have incurred or the loss they have suffered. Beach will then work with them to validate the claim and assess any compensation required. Validation procedures will necessarily involve access to fishing records and other relevant information. • Beach are aware of the issue you raised regarding your colleague's engagement with another Oil & Gas Company's vessel. When our project becomes operational Beach will undertake discussions with our vessel masters so that impacts on fishing and vice versa are as low as reasonably practicable. Transit routes between project sites and Portland are unlikely as our vessel will not be stationed there. • Beach's FLO will contact you shortly to discuss access to your fishing data and confirm that you would like to be included on our updates about the location of our activities while we are operational.	Beach aims to undertake the activity in a manner that does not unduly impact on fishers. This EP has been updated in response to the claims from this stakeholder as per the following: • Table 9-3 Ongoing stakeholder consultation requirements updated to note that for notifications to stakeholder where coordinates are supplied coordinates are to be expressed in degrees and decimal minutes referenced to the WGS 84 datum. • Stakeholder provided with Beach contact person should they wish to make a claim for loss as a result of Beach's activities. How Beach will deal with any claims is details in Section 9.3.1 Fishery specific consultation approach. • Section 8.6 Personnel, Competence, Training and Behaviours updated to include requirements for interactions with fishers and/or fishing equipment in the activity induction that will be required to be undertaken by all vessel personnel. • Engagement will be ongoing with stakeholder to ensure any impacts can be management to ALARP and an acceptable level.
Department of Jobs, Precincts and Regions (DJPR): Earth Resources Regulation	26/04/2019	DJPR-ERR 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's	Provision of information.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
		Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	
Otway Gas Plant Community Reference Group	18/04/2019	CRG 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1& Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Portland Professional Fishermen's Association	17/04/2019	PPFA 01 PPFA 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1& Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Seafood Industries Victoria (SIV)	19/02/2019	SIV 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 and Otway Offshore Map Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach and SIV meeting. Beach presented 2-page information on the upcoming Otway Offshore Project. Beach explained there would be a seabed assessment phase commencing in approx. September 2019 followed by a drilling phase which was expected to commence towards the end of the year and continue for approx. 18 months. Beach showed map to SIV and discussed locations. Beach asked what SIV's preferred way to consult with fishers was. SIV said if Beach provided the Information sheet SIV would arrange for it to be mailed to SIV members, under a cover letter. The letter would ask fishers who were affected or required further consultation to respond within 2 weeks so SIV can validate that they fish in the area and allow Beach to respond to any questions.	Provision of information and agreement to send information to SIV members via SIV.
Seafood Industries Victoria (SIV)	7/03/2019	SIV 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email of discussion at meeting held on the 19/02/2019 in relation to Beach's upcoming Offshore campaign. Beach presented a 2-page information on the upcoming Otway Offshore Project and explained there would be a seabed assessment phase commencing in approx. September 2019 followed by a drilling phase which was expected to commence towards the end of the year and continue for approx. 18 months. Map was shown and briefly discussed locations. Beach asked what SIV's preferred way to consult with fishers was. SIV said if Beach provided the Information sheet, they would arrange for it to be mailed to SIV members with a cover letter. SIV stated they would ask fishers who were affected or required further consultation to respond within 2 weeks so SIV can validate that they fish in the area and allow Beach to respond to any questions. Agreed that SIV would do a mailout of the attached 2-page information sheet and cover letter to SIV members. Beach provided 2-page information sheet and requested that cover letter ask fishers to contact Beach if they fish in the areas where we will be operating. Also, to let them know that further information will be available on our website at beachenergy.com.au/vic-otway-basin/. SIV recommenced two weeks for fishers to respond. Asked to review SIV cover letter prior to mailout.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	19/03/2019	SIV 03 SIV 04	SIV provided cover letter for Beach to review. Beach provided feedback on letter and asked to add a comment about 2 weeks to respond. Also requested to hold off mail out as information sheet was being updated.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	19/03/2019	SIV 05 SIV 06	SIV reply: will include a comment about the 2 weeks but need to know when we are sending. SIV concern about two weeks and putting a specific timeframe on it is that this needs to be an open communication and ongoing consultation - it does not just stop. But we also have 3 other consultation processes going on - so if possible, for more time, then this will be crucial. Beach reply: We also expect the consultation to be open and ongoing. The 2-week timeframe is to allow us to get initial feedback and understand who may be fishing in the areas so that if we need to undertake more specific consultation with them, we understand who they are. We will provide further information closer to the time of the seabed assessments and again prior to commencing drilling. And of course, we will consult with any fisher that requires it during the life of the project.	Two-week timeframe is to allow for initial feedback and understand who may be fishing in the areas so that if required more specific consultation can be undertaken. Beach agrees that stakeholder consultation will be ongoing and stakeholders any issues or concerns raised prior or during the activity will be addressed as per Section 9.7. Further information will be provided closer to the time of the seabed assessments and consultation will be ongoing during the life of the project. EP Section 9.7 details ongoing stakeholder engagement for the activity.
Seafood Industries Victoria (SIV)	22/03/2019	SIV 07	Beach update on status of the information sheet.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	27/03/2019	SIV 08	Beach call to provide update on status of information sheet and also that there were now some additional survey areas, which were for potential tie-ins of wells to the seabed pipeline. SIV asked what this would cover - was VSP	Seabed survey activity does not include vertical seismic profiling (VSP).

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			included? Beach said the surveys would use equipment such as echo sounders, may take seabed grabs and take core samples 6m below the seabed surface. VSP was not included in these surveys. Beach asked if Beach needed to separately email the information sheet to VRLA, Port Campbell Professional Fishers Association or similar organisations. SIV confirmed that they will handle this engagement.	
Seafood Industries Victoria (SIV)	27/03/2019	SIV 09	Beach email to confirm delivery of the information sheets and if in the cover letter you can ask members to let us know if they want further consultation or fish in the affected area by 19th April. We will continue engagement after that time, but we'd like to understand who specifically may be impacted or has concerns so we can plan further engagement with them, and SIV.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	28/03/2019	SIV 10 SIV 11 SIV 12	Organisation of information sheet for mail out to SIV members.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	29/03/2019	SIV 14 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Letter and information sheet sent to approximately 300 SIV members. Dear Victorian Licence Holder and Operators RE: UPCOMING BEACH ENERGY OFFSHORE PROJECTS I am writing to you regarding recent discussions between Seafood Industry Victoria (SIV) and Beach Energy regarding a proposed Seabed Assessment and Drilling Program from 2019 – 2021. Beach Energy have provided SIV with the attached 2-page information sheet which provides detailed information on the activities proposed, the areas they intend to operate and timeframes for the proposed works. There is also further information available at: www.beachenergy.com.au/vic-otway-basin/. Beach Energy have sought SIV to correspond with you to seek your views and issues on the proposed areas, and their interaction with areas in which you operate. If you have any concerns, questions, comments or seek any further information please contact Beach Energy at community@beachenergy.com.au by the 19th April. Alternatively let us know at SIV and we can pass your comments through to Beach Energy. Thank you for your time reading and understanding this information and please do not hesitate to contact me if there are any queries.	Provision of information to SIV for mail out to members.
Seafood Industries Victoria (SIV)	2/04/2019	SIV 15 SIV 16	Emails between Beach and SIV confirming mail out sent.	NA
Seafood Industries Victoria (SIV)	16/04/2019	SIV 17	Beach phone call to see if any response to member mail out. Four fishers have stated they would be fishing out deeper this year, as a result of discussions in the quota meetings held recently. Can Beach provide information on where and when they will be operating? Beach replied it is too early for this information to be available, it will not be available until closer to the time of the activities. Seabed assessments will be undertaken in September and again in about March, with drilling scheduled to commence in December. Are fishers able to inform us of their plans so we can feed that into our planning – it may not be able to be considered but it's good to know so we are aware. SIV replied that could be arranged. The purpose of sending out the flyer was so we can work together, so this is what we expected. Beach - we would expect that, closer to the time, we would send the interested fishers text messages of where our activities are occurring on a daily basis. SIV – I'll discuss with them and come back to you with their plans.	Four fishers had contacted SIV in relation to the information sheet mail-out. These fishers will be fishing deeper this year and seek further information regarding location and timings. Beach met with SIV 3/05/2019 Record VFA 25 to further discuss Beach's activities. Beach will continue ongoing engagement with SIV and any affected fishers as per Section 9.7.1 Fishery specific consultation approach to ensure impacts to fishers are ALARP and an acceptable level.
Seafood Industries Victoria (SIV)	29/04/2019 1/5/2019	SIV18 – SIV 21	Emails to obtain copy of cover letter sent to SIV members.	NA
Seafood Industries Victoria (SIV)	3/05/2019	VFA 25	Meeting between Beach, VFA and SIV. Beach provided VFA with an extract of the current draft of the Seabed Assessment EP chapters related to noise modelling and the identification of fisheries. Beach stepped VFA through the noise modelling at a high level and the conclusions that there was no unacceptable impact to marine fauna. VFA said it was good to have the report and that they would review it in more detail. Beach explained the consultation approach with fishers; engagement had been via SIV who undertook a mailout of a 2-page information sheet (which had also been provided to VFA) to their approx. 300 members. A cover letter had asked for fishers to identify if they felt they would be impacted by the activities. SIV had reported that 4 fishers had come forward and 2 others had contacted Beach directly. Beach will engage with these fishers and SIV as part of on-going consultation and specifically when details of the exact locations and timing of the seabed assessments and drilling were available. Beach would also provide regular/ daily information on the location of vessels and drill rigs to those who wanted to receive that information. VFA was comfortable with this approach. VFA asked about any permanent restrictions on fishing grounds, such as permanent exclusion zones, as this would reduce the available area for fishing. Beach explained that there may be a requirement for some wells to have exclusion zones around the infrastructure that will be installed on the seabed. At this stage the requirements for which wells and any details of the exclusion zones were not yet known. SIV joined the meeting and Beach gave a recap on the consultation that had been undertaken with commercial	Beach provided SIV with an extract of the current draft of the Seabed Assessment EP chapters related to noise modelling and the identification of fisheries. Beach will continue ongoing engagement with SIV and any affected fishers as per Section 9.7.1 Fishery specific consultation approach to ensure impacts to fishers are ALARP and an acceptable level. Beach has engaged directly with the fishers that contacted them. See Records for CRLF and CSF. VFA had raised concerns about loss of fishing area from permanent exclusion zones. The seabed assessments do not require any permanent exclusion zones and as the areas to be assessed are small fishers would only be excluded from an area for a maximum of a few days. See Section 4.1.2 Activity timing. Updated rock lobster and giant crab fishery maps were sent to VFA and SIV. See Record SIV 22 and VFA 27.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			fishers. SIV was also provided with a copy of the draft EP extract. SIV informed VFA that they were happy with the way that Beach had undertaken the consultation and their plans for on-going consultation. Beach discussed with SIV a time when they could catch up to discuss the impacts on the four fishers that had identified themselves but no date was chosen due to current availability. SIV and VFA reviewed the fishing effort maps in the draft Seabed Assessment EP extract and queried the fishing activity for the giant crab map, in the grids located close to shore. Beach informed that the data had been provided by VFA.	
Seafood Industries Victoria (SIV)	10/05/2019	SIV 22 – see VFA 27 for email record.	Beach email providing updated information as discussed at meeting on 3/5/2019 Record VFA 25. In the extract of the EP Beach provided VFA and SIV commented on the fishing effort maps. Beach have reviewed the maps we discussed and are including revised versions in the EP we are submitting shortly. The updated maps were provided which show only the areas where there has been catch effort for rock lobsters and giant crabs within the seabed survey operational area. We have also firmed up the sizes of the seabed assessment survey areas which vary slightly to what was communicated in the Otway Offshore Information Sheet we published. The revised sizes are in the table below. Site survey Survey Type Size in Km Artisan-1 Well 4.5 x 5 Geographe Well 4.5 x 5 La Bella Well 4.5 x 5 Thylacine Well 9 x 9 Artisan to Hot Tap Tee "Y" Pipeline 7 x 1 Artisan to Hot Tap Tee "X" Pipeline 6 x 1 Labella -Artisan Pipeline 18 x 1 Thylacine - Labella Pipeline 23 x 1 Artisan - Thylacine Pipeline 33 x 1 Don' hesitate to let me know if you have any questions. I will contact you next week about setting up a time to meet to discuss in more detail the program and the impacts on the fishers who have come forward as fishing in the area.	Updated rock lobster and giant crab fishery maps showing overlap of fishery effort with the operational area that are presented in this EP where provided to SIV and VFA. Site survey area increases are not material as only a small increase in area compared to that provided by SIV via the information sheet to fishers (Record SIV 14). As the fisher's fish over a large area compared to the seabed assessment areas, it is unlikely that this small increase would exclude fishers who may be impact from identifying themselves to SIV based on the information sheet provided. Meeting will be set up with SIV to discuss the fishing effort of the four fishers who have raised with SIV that they fish in the area. Beach will continue ongoing engagement with SIV and any affected fishers as per Section 9.7.1 Fishery specific consultation approach to ensure impacts to fishers are ALARP and an acceptable level.
SETFIA, SSIA, SPF Stakeholder groups represented by Atlantis Fisheries Group	17/04/2019	SETFIA, SSIA, SPF 01 SETFIA, SSIA, SPF 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. Can you confirm that you are representing SETFIA, SSIA and Small Pelagic Fishery? I would also like to discuss with you whether you would like us to engage with any of members of the associations you represent and will call you tomorrow to discuss this. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
SETFIA, SSIA, SPF Stakeholder groups represented by Atlantis Fisheries Group	18/04/2019	SETFIA, SSIA, SPF 03 SETFIA, SSIA, SPF 04	Follow-up phone call and email.	No response.
Sustainable Shark Fishing Inc (SSFI)	9/04/2019	SSFI 01 SSFI 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Tasmanian Abalone Council Limited	9/04/2019	TACL 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1& Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Tasmania Parks and Wildlife Service for Tasmanian Department of Primary Industries, Parks, Water and Environment	26/04/2019	TD03 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. In January 2018, Beach Energy acquired Origin Energy's gas exploration and production assets in Victoria, Western Australia and New Zealand. With its head office in Adelaide, Beach Energy has been operating in Australia for over 50 years and has extensive experience in the gas industry. We would like to inform you that we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses. The 'Otway Offshore Project' will see up to 9 wells drilled offshore, consisting of exploration and production wells. Further activities in the Otway Basin will be carried out to ensure continued production at the Otway Gas Plant, including seabed site assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. I've attached a brief information sheet and further details are available by visiting our Otway Basin Victoria web page at https://www.beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact us.	Provision of information.
Tasmanian Rock Lobster Fisherman's Association	9/04/2019	TRLFA 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Tasmanian Seafood Industry Council (TISC)	9/04/2019	TSIC 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Tuna Australia (ETBF Industry Association)	17/04/2019	TA 01 TA 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Victorian Fisheries Authority (VFA)	5/02/2019 – 11/02/2019	VFA 01 VFA 02 VFA 03 - 06	Beach email to set up a time to meet. VFA email of acknowledgement. Emails to set up meeting.	NA
Victorian Fisheries Authority (VFA)	25/02/2019	VFA 07	Beach email providing overview of upcoming activities in Victoria including seabed surveys, details include: Offshore activities including: seabed assessments over a series of 4 x 4 km areas; drilling and construction of exploration and production wells; installation of seabed infrastructure for successful wells. The activities will require safe operating zones around each seabed assessment and the drill rig. We will send an information sheet on this project in the next week or so.	Request for information. It is noted that since this email was sent the areas of the seabed assessment have increased (See Section 4.1.1 Operational Area for details). The updates areas are within the fishing grids requested so updated information was not required from VFA.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			To enable us to prepare our different environment plans, including any impacts on commercial fishing activity and mitigation plans that may be required, we need to assess fishing effort in Commonwealth and State managed fisheries. As such we are seeking VFA's support to provide data on Victorian State managed fisheries as follows: Catch data in each of the requested blocks/per block: • By month of year, for the last five years. • By species caught / tonnage of each. • By number of vessels operating. • If number of fishers < 5, return a "yes" in output field. • If no fishers, return a "no" in output field.	
Victorian Fisheries Authority (VFA)	4/03/2019	VFA 08	Beach follow-up email in relation to data request in VFA 07 and request to meet with VFA.	Follow-up of request for information.
Victorian Fisheries Authority (VFA)	6/03/2019	VFA 09 VFA 10 VFA 11	VFA email confirming data request had been sent and emails between Beach and VFA to arrange meeting on 12/03/19.	Follow-up of request for information.
Victorian Fisheries Authority (VFA)	12/03/2019	VFA 12	Meeting. Beach explained proposed offshore activities, discussed information sheet and map. Thanked VFA for providing fishing data and discussed low level of State managed (VFA) fishing activity in the vicinity. General discussion on Total Allowable Commercial Catch (TACC) and new harvest strategy. Beach asked if VFA could advise of any new strategies or research that may be relevant to assessment of any impacts from our operations. Also, that their website does not always show the latest TACC levels or strategies. VFA advised that they won't have much involvement in engagement regarding Beach's activities and mentioned industry representatives. Beach explained ongoing relationship with Seafood Industry Victoria (SIV), and Victorian Rock Lobster Association (VRLA), and that meeting SIV today.	VFA highlighted consultation with industry representatives. Beach is undertaking consultation with industry representatives including SIV, SETFIA and Victorian Rock Lobster Association.
Victorian Fisheries Authority (VFA)	18/04/2019	VFA 13 VFA 14 VFA 15 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email: Provision of information on the 'Otway Offshore Project and upcoming activities including the seabed surveys. In January 2018, Beach Energy acquired Origin Energy's gas exploration and production assets in Victoria, Western Australia and New Zealand. With its head office in Adelaide, Beach Energy has been operating in Australia for over 50 years and has extensive experience in the gas industry. We would like to inform you that we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses. The 'Otway Offshore Project' will see up to 9 wells drilled offshore, consisting of exploration and production wells. Further activities in the Otway Basin will be carried out to ensure continued production at the Otway Gas Plant, including seabed site assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. I've attached a brief information sheet and further details are available by visiting our Otway Basin Victoria web page at https://www.beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact us	Provision of information.
Victorian Fisheries Authority (VFA)	29/04/2019	VFA 16	Email from VFA: There is significant overlap with Victoria's rock lobster and giant crab fisheries. There has been approximately 18t of Giant crab and 40t of Southern Rock lobster taken from within the boundaries of the survey grid provided over past 10 years. Can you please also confirm "coordinates of all locations will be made available to relevant stakeholders after completion of planning" to advise of further overlap with fishing activity. I would also like to be kept informed with the outcomes and recommendations from this section: In preparation of Environment Plans a noise assessment on marine fauna will be completed to identify any potential impacts and mitigation plans that may be required. This will include assessment of any Vertical Seismic Profiling (VSP) as this may be required to validate one exploration well. Please also provide the EP for comment when available.	Beach provided VFA with an extract of the current draft of the Seabed Assessment EP chapters related to noise modelling and the identification of fisheries. See Record VFA 25. This extract provided the information in EP Section Appendix B.4.8 Victorian managed fisheries which details: • Based on information from Seafood Industry Victoria approximately 40 t of southern rock lobster has been caught within the operational area of the last 10 years. This equates to between 1.5 – 1.7% of the total catch over the 10 year period. • Based on information from Seafood Industry Victoria approximately 18 t of giant crab has been caught within the operational area of the last 10 years. The total catch over the last 10 years has been 157.8 t so 18 t equates to This equates to 11% of the total catch being caught in the operational area. A meeting was held with VFA to further discuss Beach's Otway development activities. See Record VFA 25.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Victorian Fisheries Authority (VFA)	30/04/2019 1/05/2019	VFA 17 VFA 18 VFA 19 VFA 20	Emails between Beach and VFA to arrange meeting. Meeting set for 3/5/2019.	See Record VFA 25.
Victorian Fisheries Authority (VFA)	2/05/2019	VFA 21 VFA 22 VFA 23 VFA 24	Beach email: Prior to tomorrow's meeting, can you clarify what you wanted in relation to the noise assessment? Is it just for VSP? VFA email: I am interested in the assessment and mitigation recommendations that follow. What are the outcomes for rock lobster and giant crab? Does this consider the studies that have indicated effects on RL? Beach email: Is the noise assessment (assessment and mitigations) just for the VSP activities? VFA email: I am interested in the assessment for all activities and their impacts.	See Record VFA 25 for details of the information provided to VFA.
Victorian Fisheries Authority (VFA)	3/05/2019	VFA 25	Meeting between Beach, VFA and SIV. Beach provided VFA with an extract of the current draft of the Seabed Assessment EP chapters related to noise modelling and the identification of fisheries. Beach stepped VFA through the noise modelling at a high level and the conclusions that there was no unacceptable impact to marine fauna. VFA said it was good to have the report and that they would review it in more detail. Beach explained the consultation approach with fishers; engagement had been via SIV who undertook a mailout of a 2-page information sheet (which had also been provided to VFA) to their approx. 300 members. A cover letter had asked for fishers to identify if they felt they would be impacted by the activities. SIV had reported that 4 fishers had come forward and 2 others had contacted Beach directly. Beach will engage with these fishers and SIV as part of on-going consultation and specifically when details of the exact locations and timing of the seabed assessments and drilling were available. Beach would also provide regular/ daily information on the location of vessels and drill rigs to those who wanted to receive that information. VFA was comfortable with this approach. VFA asked about any permanent restrictions on fishing grounds, such as permanent exclusion zones, as this would reduce the available area for fishing. Beach explained that there may be a requirement for some wells to have exclusion zones around the infrastructure that will be installed on the seabed. At this stage the requirements for which wells and any details of the exclusion zones were not yet known. SIV joined the meeting and Beach gave a recap on the consultation that had been undertaken with commercial fishers. SIV was also provided with a copy of the draft EP extract. SIV informed VFA that they were happy with the way that Beach had undertaken the consultation and their plans for on-going consultation. Beach discussed with SIV a time when they could catch up to discuss the impacts on the four fishers that had identified themselves but no date was chosen due to current availability. SIV and VFA reviewed the fishing effort maps in the draft Seabed Assessment EP extract and queried the fishing activity for the giant crab map, in the grids located close to shore. Beach informed that the data had been provided by VFA.	Beach provided VFA with an extract of the current draft of the Seabed Assessment EP chapters related to noise modelling and the identification of fisheries. Beach will continue ongoing engagement with SIV and any affected fishers as per Section 9.7.1 Fishery specific consultation approach to ensure impacts to fishers are ALARP and an acceptable level. Beach has engaged directly with the fishers that contacted them. See Records for CRLF and CSF. VFA had raised concerns about loss of fishing area from permanent exclusion zones. The seabed assessments do not require any permanent exclusion zones and as the areas to be assessed are small fishers would only be excluded from an area for a maximum of a few days. See Section 4.1.2 Activity timing. Updated rock lobster and giant crab fishery maps were sent to VFA and SIV. See Record SIV 22 and VFA 27.
Victorian Fisheries Authority (VFA)	9/05/2019	VFA 26	Beach email requesting further fisheries data for grid L13.	Request for information.
Victorian Fisheries Authority (VFA)	10/05/2019	VFA 27	Beach email providing updated information as discussed at meeting on 3/5/2019 Record VFA 25. In the extract of the EP Beach provided VFA and SIV commented on the fishing effort maps. Beach have reviewed the maps we discussed and are including revised versions in the EP we are submitting shortly. The updated maps were provided which show only the areas where there has been catch effort for rock lobsters and giant crabs within the seabed survey operational area. We have also firmed up the sizes of the seabed assessment survey areas which vary slightly to what was communicated in the Otway Offshore Information Sheet we published. The revised sizes are in the table below. Site survey Survey Type Size in Km Artisan-1 Well 4.5 x 5 Geographe Well 4.5 x 5 La Bella Well 4.5 x 5 Thylacine Well 9 x 9 Artisan to Hot Tap Tee "Y" Pipeline 7 x 1 Artisan to Hot Tap Tee "X" Pipeline 6 x 1 Labella -Artisan Pipeline 18 x 1 Thylacine - Labella Pipeline 23 x 1 Artisan - Thylacine Pipeline 33 x 1 Don't hesitate to let me know if you have any questions.	Updated rock lobster and giant crab fishery maps showing overlap of fishery effort with the operational area that are presented in this EP where provided to SIV and VFA. Site survey area increases are not material as only a small increase in area compared to that provided by SIV via the information sheet to fishers (Record SIV 14). As the fisher's fish over a large area compared to the seabed assessment areas, it is unlikely that this small increase would exclude fishers who may be impact from identifying themselves to SIV based on the information sheet provided. Meeting will be set up with SIV to discuss the fishing effort of the four fishers who have raised with SIV that they fish in the area. Beach will continue ongoing engagement with SIV and any affected fishers as per Section 9.7.1 Fishery specific consultation approach to ensure impacts to fishers are ALARP and an acceptable level.

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Victorian Recreational Fishing Peak Body (VR Fish)	9/04/2019	VRFISH 01 VRFISH 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.
Victorian Rock Lobster Association (VRLA)	129/03/2019	VRLA 01 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	VRLA was included in Seafood Industry Victoria's mail-out of 2pp fact sheet to approx. 300 SIV members.	Provision of information. See Record SIV 14.
Victorian Scallop Fishermen's Association Inc	17/04/2019	VSFA 01 VSFA 02 OP19IS#1 - Otway Offshore Program 2019 2pp Info Sheet #1 Link to: OP19IS#2 - Otway Offshore Program 2019 10pp Info Sheet #2	Beach email providing information on Beach's Otway Offshore Project including the seabed surveys. The project is expected to start around September 2019, depending on regulatory approvals, weather windows and availability of contractors. Attached is a brief information sheet and further details are available on the Otway Basin Victoria web page at beachenergy.com.au/vic-otway-basin/ and clicking on the 'Otway Offshore Project Information Sheet' link. As part of our consultation we are engaging with commercial fishing associations on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities and to Beach's offshore development program. In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please don't hesitate to contact me.	Provision of information.

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Appendix A EPBC Act Protected Matters Search Report

Australian Government

Department of the Environment and Energy

EPBC Act Protected Matters Report

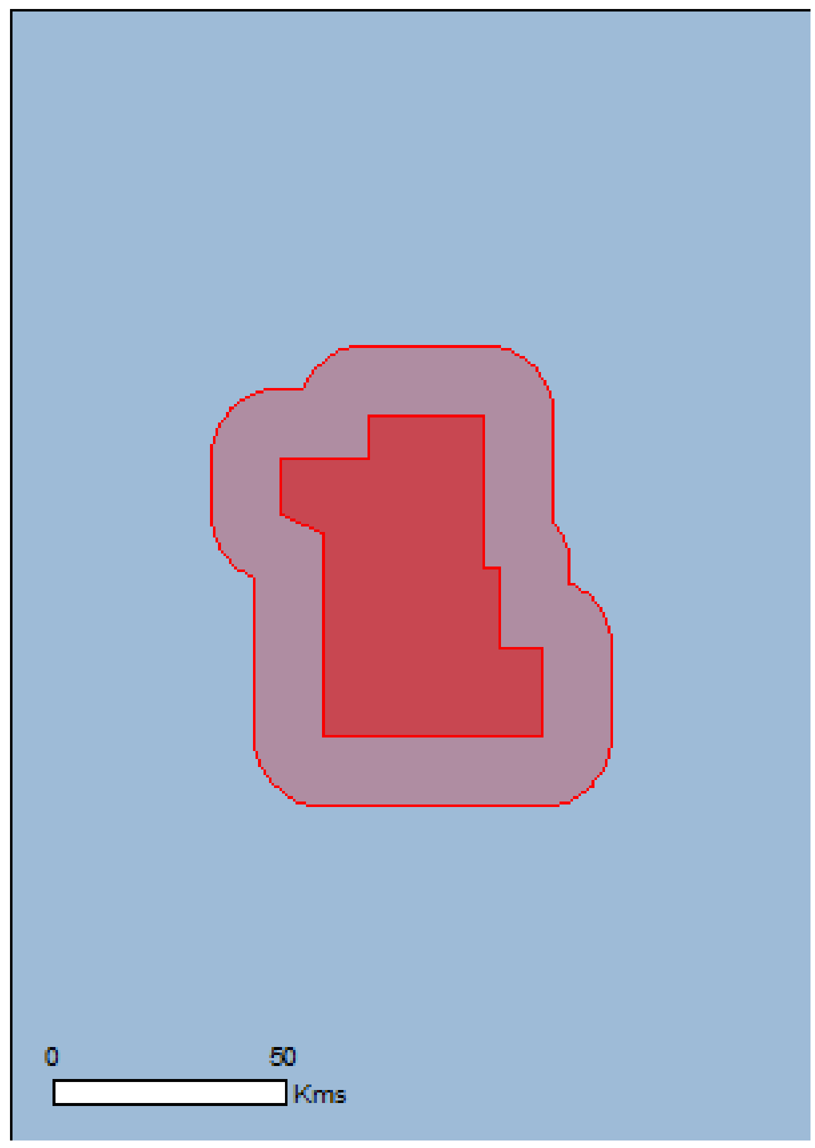
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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.

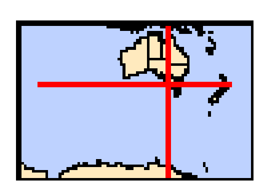
Report created: 05/05/19 14:30:33

- Summary
- Details
  - Matters of NES
  - Other Matters Protected by the EPBC Act
  - Extra Information
- Caveat
- Acknowledgements



Coordinates

Buffer: 15.0Km



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:	35
Listed Migratory Species:	39

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:	60
Whales and Other Cetaceans:	28
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

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

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

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

Name
South-east

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour 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
Halobaena caerulea Blue Petrel [1059]	Vulnerable	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

Name	Status	Type of Presence
		area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Fish		
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely

Name	Status	Type of Presence
		to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	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
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat 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		
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
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour 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
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

Name	Threatened	Type of Presence
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat 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 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 may 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	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		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
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		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
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris 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
Catharacta skua Great Skua [59472]		Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour 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
Halobaena caerulea Blue Petrel [1059]	Vulnerable	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
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed		Foraging, feeding or

Name	Threatened	Type of Presence
Shearwater [1043]		related behaviour likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche sp. nov. Pacific Albatross [66511]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		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
Hypselognathus rostratus Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area
Kaupus costatus Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys semistriatus Halfbanded Pipefish [66261]		Species or species habitat may occur within area
Mitotichthys tuckeri Tucker's Pipefish [66262]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		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
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		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
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal		Species or species

Name	Threatened	Type of Presence
[21]		habitat may occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area

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 musculus		
Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii		
Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata		
Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis		
Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat known to 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
Kogia breviceps		
Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus		
Dwarf Sperm Whale [58]		Species or species

Name	Status	Type of Presence
		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	Species or species habitat likely 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 hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to 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
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

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
West Tasmania Canyons	South-east

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

-38.916 142.587,-38.915 142.753,-38.852 142.753,-38.852 142.976,-39.081 142.976,-39.081 143.008,-39.198 143.008,-39.198 143.088,-39.332 143.088,-39.332 142.67,-39.027 142.67,-38.999 142.587,-38.916 142.587

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Office of Environment and Heritage, New South Wales
- -Department of Environment and Primary Industries, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment, Water and Natural Resources, South Australia
- -Department of Land and Resource Management, Northern Territory
- -Department of Environmental and Heritage Protection, Queensland
- -Department of Parks and Wildlife, Western Australia
- -Environment and Planning Directorate, ACT
- -Birdlife Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -South Australian Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums
- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- Forestry Corporation, NSW
- -Geoscience Australia
- -CSIRO
- -Australian Tropical Herbarium, Cairns
- -eBird Australia
- -Australian Government – Australian Antarctic Data Centre
- -Museum and Art Gallery of the Northern Territory
- -Australian Government National Environmental Science Program
- -Australian Institute of Marine Science
- -Reef Life Survey Australia
- -American Museum of Natural History
- -Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
- -Tasmanian Museum and Art Gallery, Hobart, Tasmania
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix B Existing Environment

The physical, ecological and socio-economic environment in and around the EMBA are described in this section, with any values or sensitivities identified. The EMBA is shown in Figure 5-1, with Section 7.3 detailing the methodology for defining the EMBA boundary.

A search of the EPBC Protected Matters Search Tool (PMST) was undertaken on 5 May 2019 to identify the conservation values within the EMBA. The full PMST report is included in Appendix A and key information included in Table 5-1 to Table 5-3.

Appendix B.1 Conservation values and sensitivities

No Commonwealth or State marine protected area where identified within the EMBA (Figure B-10-1).

The PMST Report identified a Key Ecological Features (KEF) within the EMBA but not the operational area. KEFs are elements of the marine environment, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity of a Commonwealth Marine Area.

The KEF identified within the EMBA is the West Tasmanian Marine Canyons (Figure B-10-2). The West Tasmanian Marine Canyons are located on the relatively narrow and steep continental slope west of Tasmania. This location has the greatest density of canyons within Australian waters where 72 submarine canyons have incised a 500 km-long section of slope (Heap and Harris, 2008). The canyons in the Zeehan Marine Park (>35 km from the EMBA) are relatively small on a regional basis, each less than 2.5 km wide and with an average area of 34 km^2 shallower than 1,500 m. The Zeehan canyons are typically gently sloping and mud-filled with less exposed rocky bottoms compared with other canyons in the south-east marine region (e.g. Big Horseshoe Canyon) (Australian Marine Parks, 2019).

Submarine canyons modify local circulation patterns by interrupting, accelerating, or redirecting current flows that are generally parallel with depth contours. Their size, complexity and configuration of features determine the degree to which the currents are modified and therefore their influences on local nutrients, prey, dispersal of eggs, larvae and juveniles and benthic diversity with subsequent effects which extend up the food chain.

Eight submarine canyons surveyed in Tasmania, Australia, by Williams et al., (2009) displayed depth-related patterns with regard to benthic fauna, in which the percentage occurrence of faunal coverage visible in underwater video peaked at 200-300 m water depth, with averages of over 40% faunal coverage. Coverage was reduced to less than 10% below 400 m depth. Species present consisted of low-relief bryozoan thicket and diverse sponge communities containing rare but small species in 150m to 300 m water depth.

Sponges are concentrated near the canyon heads, with the greatest diversity between 200 m and 350 m depth. Sponges are associated with abundance of fishes and the canyons support a diversity of sponges comparable to that of seamounts. Based upon this enhanced productivity, the West Tasmanian Marine Canyon system includes fish nurseries (blue warehou and ocean perch), foraging seabirds (albatross and petrels), white shark and foraging blue and humpback whales (DotEE, 2015b).

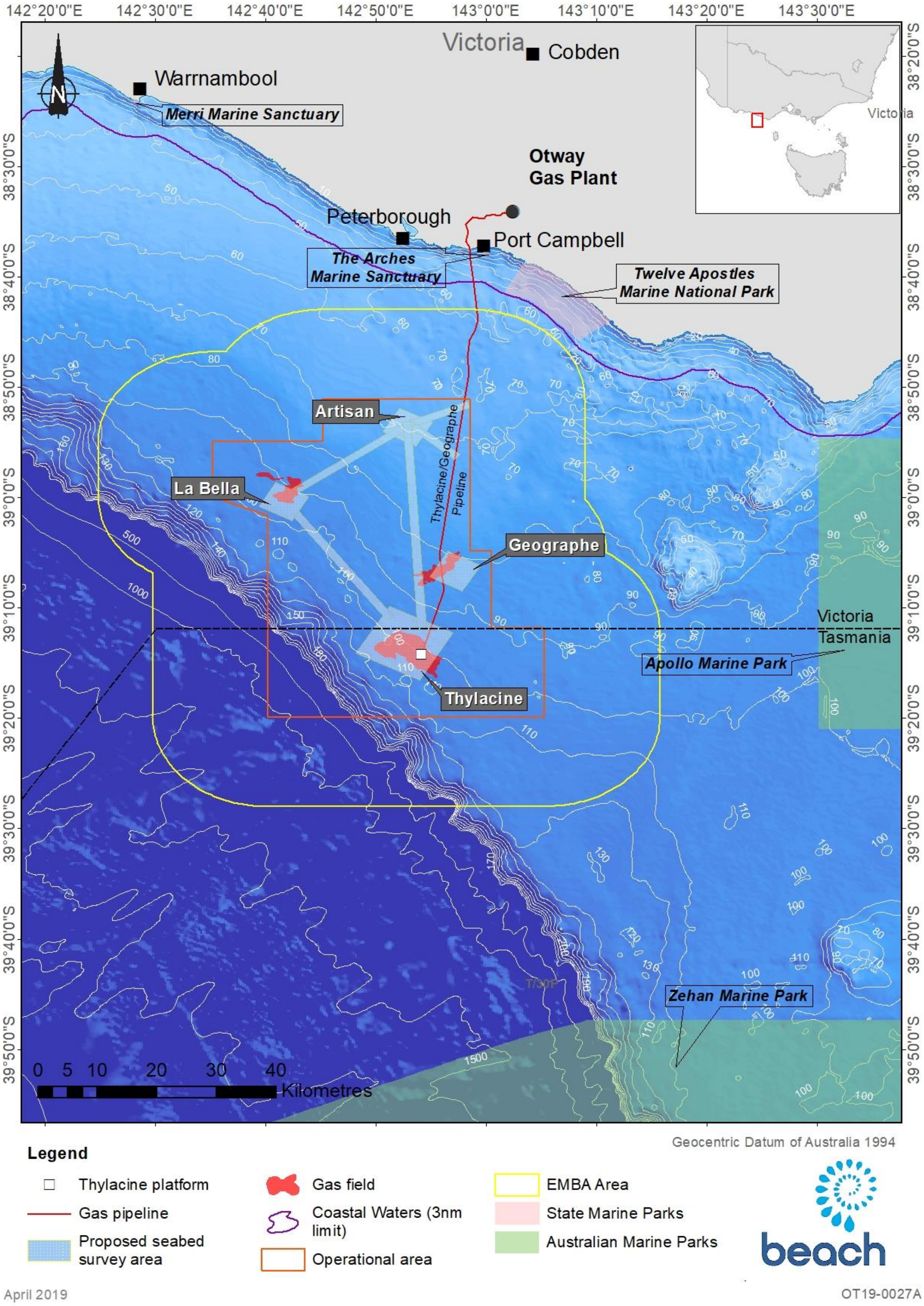


Figure B-10-1: Commonwealth and State Protected Areas

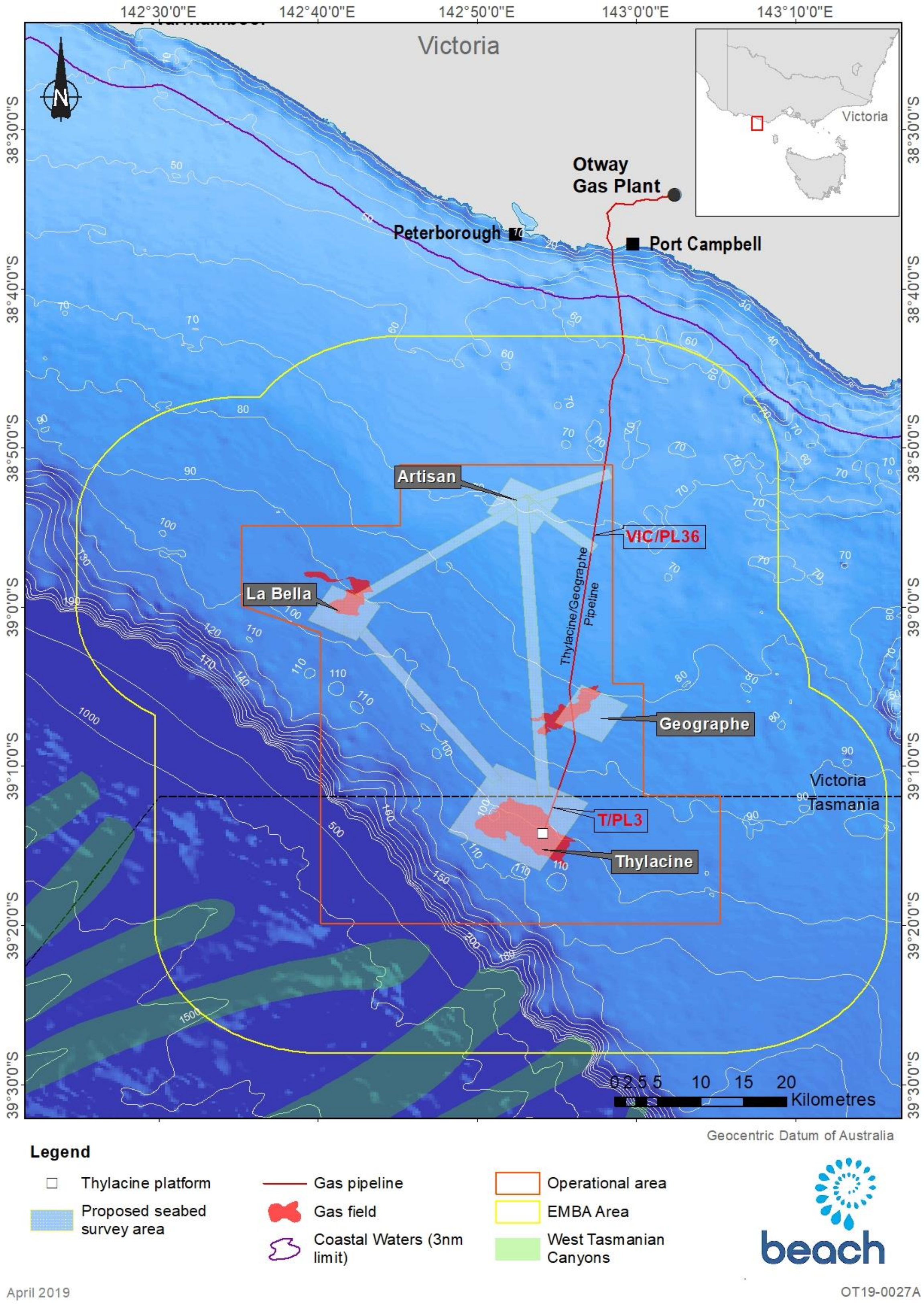


Figure B-10-2: Key ecological feature in the EMBA

Appendix B.2 Physical environment

The physical marine environment of the Otway region is characterised by very steep to moderate offshore gradients, high wave energy and temperate waters subject to upwelling events.

Appendix B.2.1 Otway assessments and surveys

A comprehensive assessment of the coast to continental shelf margin has been undertaken. Roughly 4 km^2 of bathymetric data and video footage was collected of the pipeline right-of-way options from the Otway Gas Project EIS (Woodside, 2003) (refer to Table B-10-1 to Table B-10-5). These data have been supplemented by numerous benthic sampling events; however, data for this assessment have been referenced primarily from Boreen et al., (1993), and the Otway Gas Project EIS (Woodside, 2003).

In 2002, 2003 and 2004, Fugro undertook a number of bathymetric surveys of the two proposed pipeline rights of way: one constructed for the Thylacine Geographe pipeline and one extending from the completed Geographe A well to Flaxman's Hill.

A review of the available geotechnical data was carried out in March 2011 for the Geographe location (Advanced Geomatics, 2011). Overall, the seabed in the Otway operational area slopes to the south at a gentle average gradient of less than 1. However, the local topography is predominantly irregular in nature, varying from gently undulating and locally smooth in areas of increased sediment deposition, to areas of outcropping cemented calcrete features that are from smooth to jagged relief. These areas are covered in marine growth. ROV video survey confirmed the presence of a shallow hard underlying substrate at a depth of 50 mm below the sediment in areas of marine growth (JP Kenny, 2012).

The Flaxman's Hill alignment traverses the Thistle drilling area and the Thylacine Geographe pipeline runs parallel and north east of this area. During 2003, bathymetric data was collected, and the right of way was assessed and recorded using an underwater video camera (CEE Consultants Pty Ltd, 2003).

The Flaxman's Hill pipeline route travels approximately 68 km from the Geographe gas field to the shoreline. Visual assessment of the sea floor was undertaken from a water depth of 99 m to 16 m terminating at Flaxman's Hill. The seabed and indicative biological communities at both areas are detailed in Table B-10-1 to Table B-10-5.

Table B-10-1: Otway margin geomorphology (Boreen et al., 1993)

Zone	Depth (m)	Width (m/km)	Gradient	Features
Shallow Shelf	30 - 70	4 - 28	1.5 - 10	Drops rapidly from strandline to depths of 30 m, characterised by rugged but subdued topography
Middle Shelf	70 - 130	7 - 65	1 - 8.5	Generally smooth topography with occasional rock out crops

Table B-10-2: Thylacine to Geographe seabed morphology and benthic assemblages (CEE Consultants Pty Ltd, 2003)

Depth (m)	Seabed morphology	Benthic assemblage
92	High profile reef stone with deep sand gutters.	Diverse, high density sessile: sponge, coral dominated crinoids common and mobile species
88	Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Diverse, high density sessile: sponge, dominated and mobile species

Table B-10-3: Geographe to Flaxman's Hill seabed morphology and benthic assemblages (CEE Consultants Pty Ltd, 2003)

Depth (m)	Seabed morphology	Benthic assemblage
82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density sessile: sponge, dominated low density mobile species. (small shark)
82	Equal % of exposed low profile limestone and sand. Two reef outcrops. Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Medium density, sessile: sponge, dominated
78	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated Motile: sea urchins dominated
76		Medium density, sessile: sponge, dominated
76		Low - Medium density, sessile: sponge, dominated
70		Diverse, med density sessile, sponge dominated
68		Medium density, sessile: sponge, dominated
65		Diverse, med density sessile, sponge dominated
60		Medium density, sessile: sponge, dominated

Table B-10-4: Geographe to Rifle Range seabed morphology and benthic assemblages (CEE Consultants Pty Ltd, 2003)

Depth (m)	Seabed morphology	Benthic assemblage
82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Very low density sessile; large sponge.
79		Diverse, low – high density sessile
75	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated. Motile: sea urchins dominated
74		Medium density, sessile: sponge, dominated
70		Low - Medium density, sessile: sponge, dominated
67		Diverse, med density sessile, sponge dominated

Depth (m)	Seabed morphology	Benthic assemblage
66	Low profile limestone with sand gutters	Medium density, sessile: sponge, dominated
66	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Diverse, med density sessile, sponge dominated
70	(Pock marks) Data not documented.	Medium density, sessile: sponge, dominated
63	Corse gravel to fine sand	High density sessile: micro algae dominated

Table B-10-5: Nearshore seabed morphology and benthic assemblages

Depth (m)	Seabed morphology	Benthic assemblage
53	Sand	None observed
45		Only sea pens noted
16-30	Very high profile l/stone reef to sand	High density, sessile: sponge, macroalgae (Bull Kelp common)

Appendix B.2.2 Geomorphology, geology, bathymetry and sediments

The south-eastern section of Australia's continental margin comprises the Otway Shelf and the Bonney Coast, Bass Strait, and the western shelf of Tasmania. The 400 km long Otway Shelf lies between 37° and 43.5°S and 139.5°E (Cape Jaffa) and 143.5°E (Cape Otway). The narrowest point is off Portland, where the shelf is less than 20 km wide. It broadens progressively westward, to 60 km of Robe, SA, and eastward to 80 km of Warrnambool. The Otway shelf is comprised of Miocene limestone below a thin veneer of younger sediments.

Boreen et al., (1993) examined 259 sediment samples collected over the Otway Basin and the Sorell Basin of the west Tasmanian margin. Samples were taken during two research cruises (January/February 1987 and March/April 1988) on the *R.V. Rig Seismic* using dredges, corers, grabs and a heat flow probe. Based on assessment of the sampled sediments the authors concluded the Otway continental margin is a swell-dominated, open, cool-water, carbonate platform. A conceptual model was developed which divided the Otway continental margin into five depth-related zones – shallow shelf, middle shelf, deep shelf, shelf edge and upper slope (Figure B-10-3).

In the shallow shelf are exhumed limestone substrates that host dense encrusting mollusc, sponge, bryozoan and red algae assemblages. The middle shelf is a zone of swell-wave shoaling and production of mega-rippled bryozoan sands. The deep shelf is described as having accumulations of intensely bioturbated, fine, bio clastic sands. At the shelf edge and top of slope, nutrient-rich upwelling currents support extensive, aphotic bryozoan/sponge/coral communities. The upper slope sediments are a bioturbated mixture of periplatform bioclastic debris and pelleted foraminiferal/nanno-fossil mud. The lower slope is described as crosscut by gullies with low accumulation rates, and finally, at the base of the slope the sediments consist of shelf-derived, coarse-grain turbidites and pelagic ooze.

Additional data on superficial sediments in the vicinity of the area are also available from studies conducted by the Victorian Museum and environmental studies undertaken for the Otway projects, as described below.

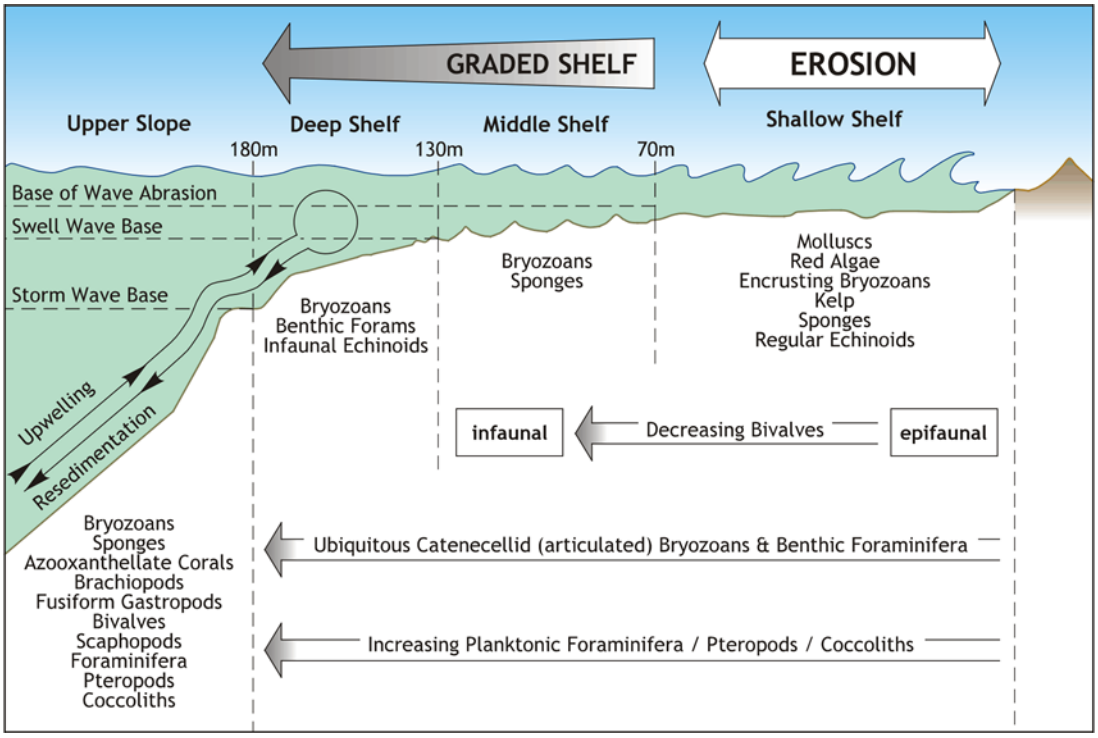


Figure B-10-3: Model of the geomorphology of the Otway Shelf

A sampling survey of the surficial sediments, benthic invertebrates and demersal fishes of Bass Strait was undertaken by the Victorian Museum between 1979 and 1983 (Wilson and Poore, 1987) (Figure B-10-4).

More than 200 sites were sampled with sites 51 through 61, 118, 119, 120, 121, 183, 186 and 192 representative of the area. Sediments were described in the field from a visual impression or according to the classification of Shepard (Shepard, 1954). Carbonate percentage of sediments was also assessed. These samples indicate that surficial sediments throughout the area are dominated by carbonate rich medium to coarse sands (Table B-10-6). Data on benthic invertebrates and demersal fishers has not been summarised and published.

A video survey of the seabed at selected sites along proposed offshore pipeline routes for the Otway Gas Project was undertaken by BBG during 2003 (BBG, 2003) (Figure B-10-5).

BBG (2003) found that the substrate in water depths that predominate in the operational area (between 82 and 66 m) area was predominantly low profile limestone with an incomplete sand veneer that supported a low to medium density, sponge dominated filter feeding community. Fish and other motile organisms were uncommon.

In shallower depths of between 63 and 30 m, the video surveys showed a rippled, sand or sand/pebble substrate with minor sponge dominated benthic communities. The epibenthic organisms were generally attached to outcropping or sub-outcropping limestone pavements. Only in waters shallower than approximately 20 m, was an area of significant, high profile reef and associated high density macroalgae dominated epibenthos encountered. Details of the seabed and benthic epifaunal assemblage are provided in Table B-10-6.

The sampling data from the BSS survey and Otway projects broadly support the findings of Boreen et al., (1993) concerning the subsea features and biological communities likely to dominate the operational area. In summary the seabed of the EMBA can be characterised as a carbonate mid shelf and deeper sections (60 – 70 m) of the shallow shelf with surficial sediments of carbonate rich coarse to medium sands with areas of exposed limestone substrate. The epifauna is dominated by low density, sessile sponge assemblages. Six basalt rises occur in the eastern and south-eastern section of the operational area, the largest of which is the 'Big Reef'.

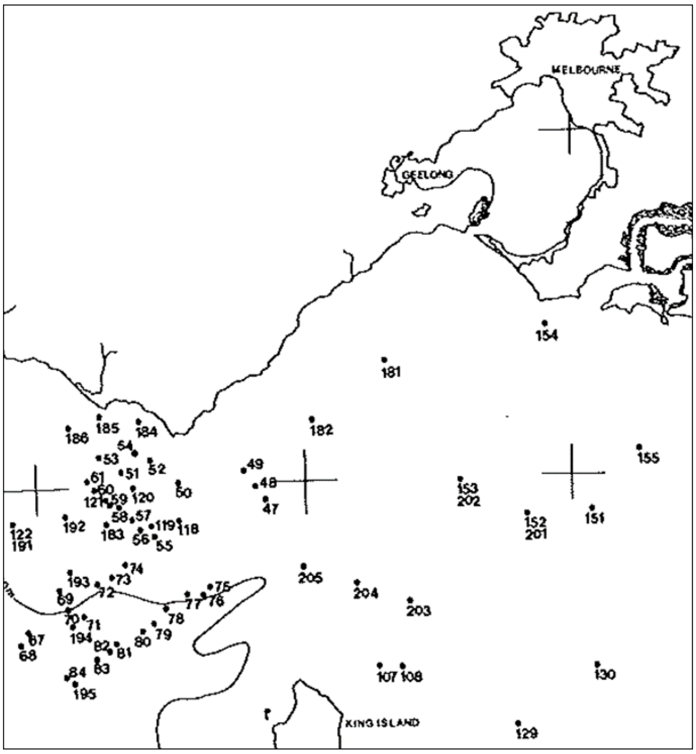


Figure B-10-4: Sampling sites for the Bass Straight survey in the region of the EMBA (Wilson and Poore, 1987)

Table B-10-6: Classification of surficial sediments sampled during the Bass Straight survey in the vicinity of the EMBA (Wilson and Poore, 1987)

Site No.	Depth (m)	Surficial sediments	Carbonate % by weight
51	67	Medium sand	ND
52	49	Coarse sand	72
53	67	Medium sand	45
54	70	Very coarse shelly sand	70
55	85	Coarse carbonate sand	93
56	77	Medium sand	ND
57	59	Coarse sand	97
58	47	Coarse sand	92
59	70	Coarse sand	89
60	79	Medium carbonate sand	100
61	68	Coarse sand	ND
118	95	Fine sand	96
119	92	Fine sand	99

Site No.	Depth (m)	Surficial sediments	Carbonate % by weight
120	84	Medium sand	90
121	84	Medium sand	ND
183	84	Coarse sand	99
186	69	Fine sand	ND
192	81	Medium sand	100

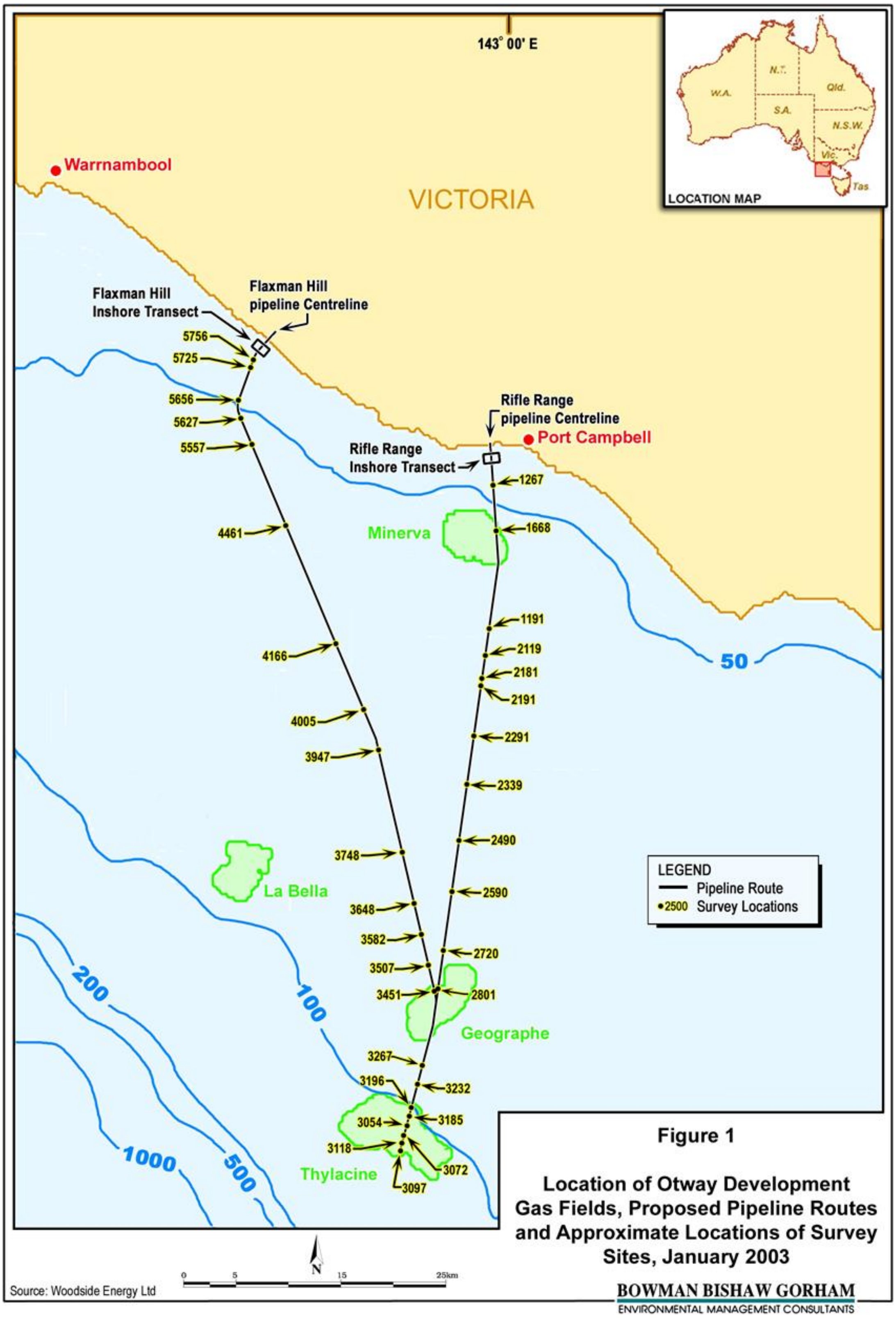


Figure B-10-5: Seabed sites assessed by video survey during 2003 (BBG, 2003)

Table B-10-7: Seabed characteristics and epifaunal assemblage at video survey sites (BBG, 2003)

Site No.	Depth (m)	Seabed type	Benthic Assemblage
3097	99	Bare rippled sand; minor limestone outcrops	Low density sessile; small sponge dominated
3118	99	Low profile limestone reef with sand veneer; isolated areas of raised l/stone	Low density sessile; sponge dominated
3084	99	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3072	99	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3054	98	Mix of low and high profile l/stone; shallow and deep sand	Low density sessile on low l/stone; high density sessile on high l/stone plus fish; sponge dominated
3185	95	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3196	94	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3232	92	High profile reef stone with deep sand gutters.	Diverse, high density sessile: sponge, coral dominated crinoids common and mobile species
3267	88	Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Diverse, high density sessile: sponge, dominated and mobile species
2801	82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Very low density sessile; large sponge.
2720	79		Diverse, low – high density sessile
2590	75	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated. Motile: sea urchins dominated
2490	74		Medium density, sessile: sponge, dominated
2339	70		Low - Medium density, sessile: sponge, dominated
2291	67		Diverse, med density sessile, sponge dominated
2191	66	Low profile limestone with sand gutters	Medium density, sessile: sponge, dominated
2181	66	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Diverse, med density sessile, sponge dominated
1191	63	Coarse gravel to find sand	High density sessile: micro algae dominated
1668	53	Sand	None observed

Appendix B.2.3 Metocean conditions

Appendix B.2.3.1 Climate

The area is typical of a cool temperate region with cold, wet winters and warm dry summers. The regional climate is dominated by sub-tropical high-pressure systems in summer and sub-polar low pressure systems in winter. The low-pressure systems are accompanied by strong westerly winds and rain-bearing cold fronts that move from south-west to north-east across the region, producing strong winds from the west, north-west and south-west.

The day-to-day variation in weather conditions is caused by the continual movement of the highs from west to east across the Australian continent roughly once every 10 days.

Appendix B.2.3.2 Winds

Bass Strait is located on the northern edge of the westerly wind belt known as the Roaring Forties. In winter, when the subtropical ridge moves northwards over the Australian continent, cold fronts generally create sustained west to south-westerly winds and frequent rainfall in the region (McInnes and Hubbert, 2003). In summer, frontal systems are often shallower and occur between two ridges of high pressure, bringing more variable winds and rainfall.

Winds in this section of the Otway basin and western Bass Strait generally exceed 13 knots (23.4 km/h) for 50% of the time. Winds contribute to the predominant moderate to high wave-energy environment of area and are predominantly south-westerly cycling to north-westerly. September is the windiest month, with average wind speeds of 29 km/h (Figure B-10-6).

Appendix B.2.3.3 Tides

Tides are semi-diurnal with some diurnal inequalities (Jones and Padman, 1983), generating tidal currents along a north-east/south-west axis, with speeds generally ranging from 0.1 to 2.5 m/s (Fandry, 1983). The maximum range of spring tides in western Bass Strait is approximately 1.2 m. Sea level variation in the area can arise from storm surges and wave set up (Santos, 2004).

Appendix B.2.3.4 Ocean currents

Ocean currents in Bass Strait are primarily driven by tides, winds and density-driven flows (Figure B-10-7). During winter, the South Australian current moves dense, salty warmer water eastward from the Great Australian Bight into the western margin of the Bass Straight. In winter and spring, waters within the straight are well mixed with no obvious stratification, while during summer the central regions of the straight become stratified.

Furthermore, during winter, the Bass Strait cascade occurs, a wintertime downwelling caused by cooling of the shallow waters of Bass Strait in the Gippsland Basin. Downwelling currents that originate in the shallow eastern waters of Bass Strait flow down the continental slope to depths of several hundred meters or more into the Tasman Sea. Lateral flushing within the strait results from inflows from the South Australian Current, East Australian Current, and sub-Antarctic surface waters.

Surface currents within the permit area have been modelled by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2009 – 2013 inclusive to produce monthly surface currents. These show a rotational aspect because of inflow and outflow to Bass Strait. Although unimodal the currents are stronger from the west in all months excepting February when the currents from the east are the strongest. Minimum currents have been derived as 0.2-0.4 m/s and maximum currents as 0.8-2.0 m/s, with the strongest currents during the months July to October.

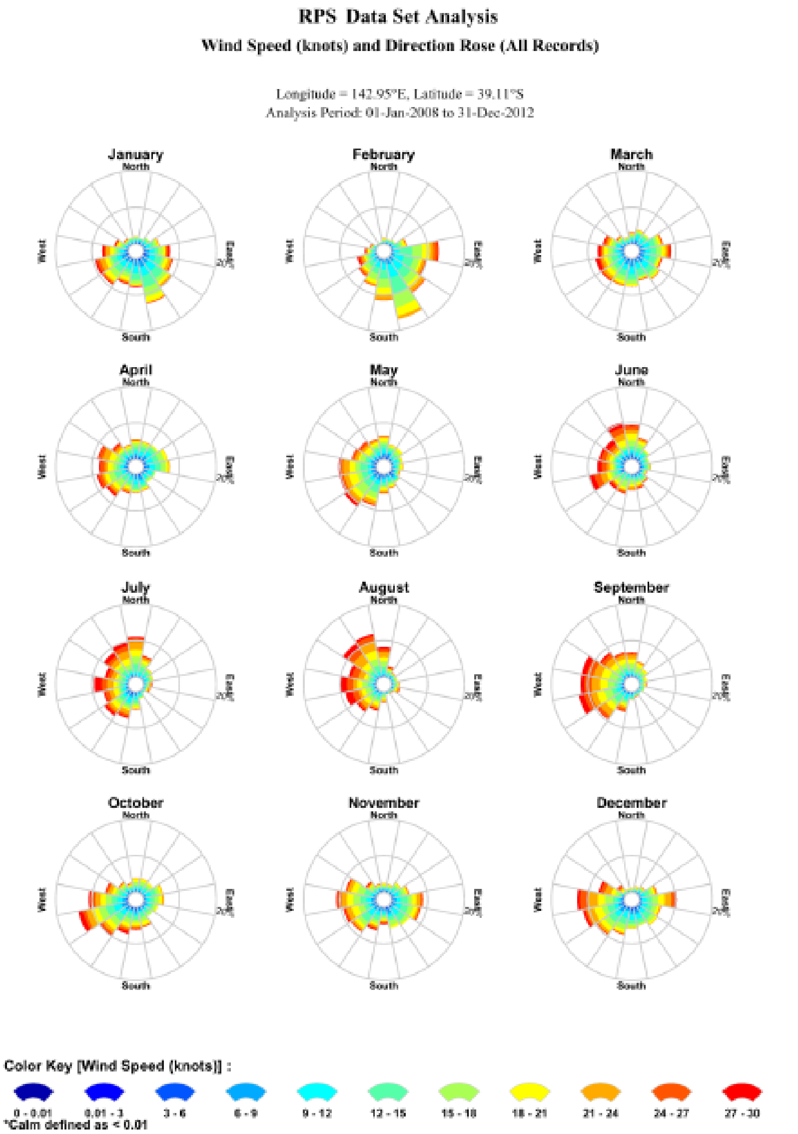


Figure B-10-6: Modelled monthly wind rose distributions (RPS, 2017)

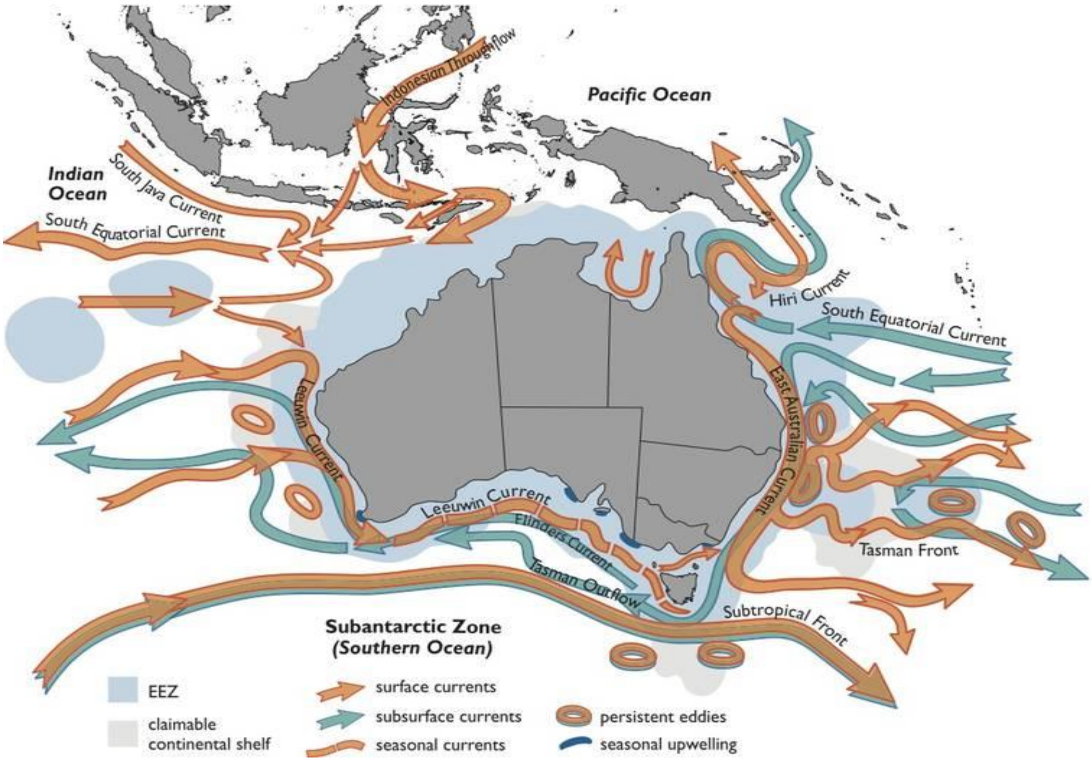


Figure B-10-7: Australian ocean currents

Appendix B.2.3.5 Waves

There are two principal sources of wave energy in the Otway Basin:

- From the westerly swell from the Great Australian Bight and Southern Ocean; and
- From locally generated winds, generally from the west and east.

The Otway area is fully exposed to long period 13 second average south-westerly swell from the Southern Ocean as well as periodic shorter 8 second average period waves from the east. Wave heights from these winds generally range from 1.5 m to 2 m, although waves heights to 10 m can occur during storm events and a combination of wind forcing against tidal currents can cause greater turbulence. The largest waves are associated with eastward-moving low pressure and frontal systems that cross the site every 4 to 6 days in winter.

Appendix B.2.3.6 Sea temperature

The waters have average surface temperatures ranging from 14°C in winter to 21°C in summer. However, subductions of cooler nutrient-rich water (upwellings) occur along the seafloor during mid to late summer, though this is usually masked in satellite images by a warmer surface layer.

The upwelled water is an extension of the regional Bonney Upwelling system, which affects southern Australia because of south-east winds forcing surface water offshore thus triggering a compensatory subduction along the bottom. If the wind is strong enough the water sometimes shoals against the coast. The water originates from a subsurface water flow called the Flinders current and has the characteristics of reheated Antarctic Intermediate Water (Levings and Gill, 2010).

During winter and spring onshore winds cycling from the southwest to northwest mound the surface layer against the land and cause a south-easterly flow along the coast that fills the shelf from the shore outwards to a depth of 500 m deep. Shelf water temperatures at these times range from between 18°C to 14°C with seafloor temperatures warmer in winter than in summer.

Appendix B.2.4 Ambient sound levels

McCauley and Duncan (2001) undertook a desktop review of natural and man-made sea sound sources likely to be encountered in the Otway Basin. They concluded that natural sea sound sources are dominated by wind noise, but also include rain noise, biological noise and the sporadic noise of earthquakes. Man-made underwater sound sources in the region comprise shipping and small vessel traffic, petroleum production and exploration drilling activities and sporadic petroleum seismic surveys.

Ambient sound levels in the Otway Basin have been measured as part of impact assessment activities for the petroleum industry. Acoustic monitoring prior to the development of the Thylacine wells and platform, recorded broadband underwater sound of 93 to 97 dB re 1 µPa (Santos, 2004). An acoustic monitoring program was also undertaken during exploratory drilling of the Casino-3 well in the EMBA. A sound logger located 28.03 km from the drill site did not detect drilling noise and recorded ambient noise that ranged between 90 and 110 dB re 1 µPa (McCauley, 2004). Passive acoustic monitoring commissioned by Origin from April 2012 to January 2013, 5 km offshore from the coastline east of Warrnambool, identified that ambient underwater noise in coastal areas are generally higher than further offshore, with a mean of 110 dB re 1 µPa and maximum of 161 dB re 1 µPa (Duncan et al., 2013).

Recent work using ocean sound recordings stations has also shown that sound from iceberg calving, shoaling and disintegration in Antarctic waters is a major contributor to the overall sound budget of the Southern Ocean. Annually tens of thousands of icebergs drift out from Antarctica into the open waters of the Southern Ocean, creating a ubiquitous natural source of low frequency sound as they calve, shoal and disintegrate (Matsumoto et al., 2014).

For example, Dziak et al., (2013) measured the sounds from the iceberg A53a (~ 55 × 25 km) as it drifted out of the Weddell Sea and through Bransfield Strait during April–June 2007. Sound levels during disintegration of this iceberg were estimated to average ~ 220 dB re 1 µPa. Chapp et al. (2005) acoustically located iceberg B15d (215 km^2) within the Indian Ocean in 2005 and estimated a maximum source level of 245 dB re 1mPa for its tremor signals, generated when the icebergs shoal or collide with other icebergs.

Matsumoto et al., (2014) tracked the sound propagation of two large icebergs, B15a and C19a, which calved off the Ross Ice Shelf in the early 2000s and drifted eastward to the warmer South Pacific Ocean in late 2007. From 2008 to early 2009, the disintegration of B15a and C19a continuously projected loud, low-frequency sounds into the water column which propagated efficiently to lower latitudes, influencing the soundscape of the entire South Pacific basin. The icebergs' sounds were recorded at Juan Fernández Islands (34°S, 79°W) and by a deep-water hydrophone in the northern hemisphere (8°N, 110°W) approximately 10,000 km from the icebergs.

More broadly Matsumoto et al., (2014) concluded that seasonal variations in ocean noise, which are characterized by austral summer-highs and winter-lows, appear to be modulated by the annual cycle of Antarctic iceberg drift and subsequent disintegration. This seasonal pattern is observed in all three Oceans of the Southern Hemisphere.

Spectrogram plotting shows that icebergs' sounds dominate the frequency range below 100 Hz (Matsumoto et al., 2014). Notably this frequency range encompasses the dominant frequencies at which baleen whales vocalize.

Appendix B.2.5 Air quality

Historical air quality data for the region is available from the Environment Protection Authority (EPA) Victoria air quality monitoring stations, and Cape Grim Baseline Air Pollution Station on Tasmania's west coast, which is one of the three premier baseline air pollution stations in the World Meteorological Organisation-Global Atmosphere Watch (WMO-GAW) network, measuring greenhouse and ozone depleting gases and aerosols in clean air environments.

The Victorian air quality data is collected at 15 performance monitoring stations representing predominantly urban and industrial environments in the Port Phillip and Latrobe Valley regions of Victoria. Results are assessed against the requirements of the National Environment Protection (Ambient Air Quality) Measure for the pollutants carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), lead (Pb), particles less than 10 micrometres in diameter (PM10) and particles less than 2.5 micrometres in diameter (PM2.5). The most recent annual air monitoring report shows Victoria's air quality in 2015 was generally good with AAQ NEPM goals and standards being met for carbon monoxide (CO), nitrogen dioxide (NO_2), Ozone (O_3) and sulfur dioxide (SO_2). There were some exceedances for particles.

The Geelong monitoring station is the closest to the EMBA; however, it is situated in an urban environment and is not representative of the clean air environment over the majority of the EMBA. The Cape Grim Baseline Air Pollution Station data is likely a more reliable point of reference for air quality in the EMBA as the air sampled arrives at Cape Grim after long trajectories over the Southern Ocean and is representative of a large area unaffected by regional pollution sources (cities or industry) (CSIRO, 2017). The Cape Grim station monitors greenhouse gases (GHGs), including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and synthetic GHGs such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6).

Historical air quality data from Cape Grim show that most GHGs have shown continuous increases in concentration since the mid-to-late 1970s with carbon dioxide levels increasing by more than 15% since 1976, and concentrations of methane and nitrous oxide increasing by around 20% and 8% respectively since 1978. The increase in methane levels however has slowed recently and CFCs and halons are in decline. Increases have been attributed to anthropogenic causes, for example, fossil fuel consumption and agricultural practices (CSIRO, 2017).

Appendix B.3 Ecological environment

To characterise the ecological environment in which the seabed assessment is to be conducted, a literature search and online resources and databases have been reviewed to identify and assess flora and fauna species known to be present or potentially present in the EMBA. The following information sources were reviewed to assure consistency with previous assessments and to develop an up-to-date overview of the existing environment.

- Online government databases, publications, and interactive mapping tools, such as the SPRAT database provided by the Department of the Environment and Energy (DotEE).
- The DotEE PMST for Matters of National Environmental Significance (MNES) protected under the EPBC Act.
- Published observations, data and statistics on marine mammals.
- Reports from scientific experts and institutions, marine biologist and experts in blue whale and southern right whale populations in the Otway area.
- Woodside's Otway Gas Project Environmental Effects Statement/Environmental Impact Assessment (EES/EIS) (2003) (Woodside, 2003).

- Santos Casino Gas Field Development Environmental Report (2004) (Santos, 2004).
- BHP Billiton's Minerva Environmental Impact Statement and Environmental Effects Statement and Associated Supplemental Environmental Monitoring published research papers (BHP Billiton, 1999).
- Origin Energy's Environment Plans for previous activities in the region.
- The National Conservation Values Atlas (Commonwealth of Australia, 2015).
- Relevant environmental guidelines and publicly available scientific literature on individual species.

Appendix B.3.1 Benthic habitats and species assemblages

The Otway continental margin is a swell-dominated, open, cool-water carbonate platform which can be divided into depth-related zones (Boreen et al., 1993):

- Shallow Shelf: Consisting of exhumed limestone substrates that host encrusting mollusc, sponge, bryozoan and red algae assemblages.
- Middle Shelf: A zone of swell wave shoaling and production of mega-rippled bryozoans sands.
- Deep Shelf: Accumulations of intensely bioturbated, fine bioclastic sands.
- Shelf edge/top of Slope: Nutrient-rich upwelling currents support extensive, aphotic bryozoan/sponge/coral communities.

The dominant benthic habitat throughout the area, as indicated by the sampling and video studies outlined in Appendix B.2.2 is medium to coarse carbonate sands with areas of low relief exposed limestone. A series of basaltic rises occur in the south eastern corner of the operational area. The benthic species assemblages known or likely to be associated with these habitats are described in the following sections.

Appendix B.3.1.1 Carbonate sands and exposed limestone

Boreen et al., (1993) reported that carbonate sands in the Otway middle shelf support a benthic fauna dominated by bryozoans, infaunal echinoids and assemblages of sponges. Other components include bivalves (commonly *Mysella donaciformis* and *Legrandina bernadi*), *Chlamys* sp. scallops and small gastropods. The sand octopus (*Octopus kaurna*) also inhabits sandy sediments. This description is broadly supported by video footage of the Otway pipeline, which also indicates that hard substrates in mid shelf areas in the west of the operational support low to medium density sponge dominated communities.

Within the inner shelf, Boreen et al., (1993) reported that the benthic communities associated with hard limestone substrates were comprised of sponges, encrustlng and branching corailine algae, poysonellid algae, bryozoa, benthic forams, robust sarpullds, brachiopods, bivalves, gastropods, fleshy red algae and kelp.

A benthic survey of inner shelf sediments in the vicinity of the Minerva Gas Field development, directly inshore from the operational area, found the seafloor was composed of course, well-sorted sand (Currie and Jenkins, 1994). This survey identified 196 species and a total of 5,035 individuals comprised of 63% crustaceans, 15% polychaetes, 8% molluscs and 5% echinoderms. The most abundant species were the bivalve *Katlysia* sp. (12.4 individuals/m^2), the sarconid *Triloculina affinis* (8.9 individuals/m^2), the tanaid isopod *Apsuedes* sp. (8.3 individuals/m^2) and the spionid polychaete *Prionospio coorilla* (4.8 individuals/m^2) (Currie, 1995).

Demersal fishes likely to be associated with carbonate sands on the middle and inner shelf include (LCC, 1993) eastern stargazer (*Kathetostoma laeve*), elephant shark (*Callorhynchus milli*), greenback flounder (*Rhombosolea taoarina*), gummy shark (*Mustelus antarcticus*), long-snouted flounder (*Ammotretis rostraus*), saw shark (*Pristiophorus nudipinnis*), southern sand flathead (*Platycephalus bassensis*) and southern school whiting (*Sillago bassensis*).

Appendix B.3.1.2 Basalt rises

There is no published information on the species assemblages of the basalt rises in the south east and east of the operational area, other than general information on their importance as a southern rock lobster fishing area. Following the classification system of Hutchinson et al., (2010) these rises can be classified as deep reefs, defined as rocky habitat at depths greater than 20 m.

In general, deep reef biota is typified by invertebrate animals rather than algae, usually in the form of sessile, filter feeding fauna. Organisms such as sponges, octocorals, bryozoans and ascidians usually dominate rock faces on deep reefs (Hutchison et al., 2010). This is partly due to the ability of species such as sponges to survive in low light conditions that algae is unable to survive in. The most common algae present on deep reefs are encrusting coralline red algae which is able to tolerate low levels of penetrating light (Hutchison et al., 2010).

The distribution of fish fauna is governed by biologically formed habitat structure as well as by food. Fish assemblages typically begin to change at depths greater than 20 m, with the loss of the kelp- associated wrasses and leatherjackets, and the appearance of deeper water fishes such as boarfishes (family Pentacerotidae), splendid perch (*Callanthias australis*) and banded seaperch (*Hypoplectrodes nigroruber*). Schools of barber perch (*Caesioperca razor*) are replaced by the related butterfly perch (*Caesioperca lepidoptera*) (O'Hara et al., 1999). While fish present on shallow subtidal reefs include algavores, omnivores and carnivores, those on deep reefs are typically carnivorous as algae are typically not abundant at depth.

Although common on rocky reefs, sponges, hydrozoans, anthozoans, bryozoans, and ascidians are thought to be largely unpalatable to reef fish. It is therefore likely that fish at these depths are feeding on associated mobile invertebrate fauna. Edmunds et al., (2006) suggests that mobile invertebrate organisms play an ecologically significant role, providing food for carnivorous fishes on deep reefs in Port Phillip Bay, and are likely to include a variety of crustaceans and molluscs.

Information from the few specific studies of specific deep reef habitats in Bass Strait can be assessed to draw broad conclusions about the species assemblages likely to occur on the basalt rises, noting that assemblages of reef species are likely to differ based on geology, habitat structure, exposure to tidal and wave motion and nutrient availability. These studies are generally limited to one off video surveys with little or no temporal replication. More generally little is known about deep reefs in the Bass Strait, or the biology and ecology of organisms that live on them, due in part to difficulties associated with conducting observational work or manipulative experiments in situ.

Beaman et al., (2005) undertook video surveys of the New Zealand Star Bank in the eastern Bass Strait, approximately 600 km east of the operational area. This feature is comprised of granite outcrops between approximately 30 to 40 m water depth, rising from the surrounding relatively flat seabed of mainly unconsolidated quartz sands with variable amounts of shell debris.

Underwater video footage revealed a structurally complex surface of crevices and steep slopes, which is densely covered in erect large and small sponges and encrusting calcareous red algae. Encrusting red algae are usually the greatest occupier of space due to tolerance of low light conditions (< 1% of surface) found at these depths (Andrew, 1999). Mobile benthos observed were crinoids within crevices and the black sea urchin (*Centrostephanus rodgersii*) in low numbers on high slope surfaces and dense encrustations on low relief lower slopes. Underwater video showed a Draughtboard shark (*Cephaloscyllium laticeps*) cruising above the crevices of high-relief granite outcrop as well as schools of butterfly perch feeding on plankton in the water column above the bank.

This study demonstrated a significant difference between communities that live on hard-ground granite outcrops of the New Zealand Star Bank and those which exist on soft substrate surrounding the rocky bank. These granite outcrops support a diverse sessile fauna of large and small sponges, bryozoans, hydroids and ascidians which prefer stable attachment surfaces (Underwood et al., 1991; Andrew 1999; Andrew and O'Neill, 2000). It is likely that similar species assemblages occur within the operational area between the flat carbonate sands of the seabed and the basalt rises.

Edmunds et al., (2006) investigated assemblages of benthic fauna at near shore deep reefs within Central Victoria (Point Addis and Wilsons Promontory) and Port Phillip Bay. The Port Phillip Bay deep reef assemblages were dominated by sponges, occupying 70 to 90% of the rocky substratum. The Point Addis assemblage was dominated by upright sponges (arborescent, massive and flabellate growth forms), but cnidarians including hydroids were entirely absent. Wilson's Promontory had a low coverage of encrusting sponges and hydroids, with high abundances of red and brown algae and the gorgonian fan *Pteronisis* sp. The Port Phillip Heads assemblage was dominated by encrusting sponges, hydroids, ascidians and bryozoans.

In summary, the species assemblages associated with the basalt rises in the south-east and east of the operational area are likely to be significantly different to the species assemblages of the surrounding flat seabed supporting carbonate sands. The depth of the basalt rises is likely to preclude significantly algal growth, with red algae likely to be most abundant. Sponges, hydrozoans, anthozoans, bryozoans, and ascidians are likely to occur though the relative abundances of these groups are not known. Targeting of the rises for rock lobster fishing indicates presence of this species in relatively high densities. The trophic effects of long term targeting of this species at these rises is not known. Site attached fishes are not likely to include kelp-associated wrasses and leatherjackets. Further statements cannot be made with sufficient confidence as site specific data for these rises are not available.

Appendix B.3.2 Plankton

Plankton species are the key component of the food web and support nearly all marine life. Copepods are the most common zooplankton and are some of the most abundant animals on earth. Plankton communities are highly diverse, with members from almost all phyla. Phytoplankton are photosynthetic organisms that drift with ocean currents and are mostly microscopic; however, some gelatinous plankton can be up to 2 m in diameter. Phytoplankton is grazed by zooplankton such as small protozoa, copepods, decapods, krill and gelatinous zooplankton.

The carrying capacity of marine ecosystems (the mass of fish resources) and recruitment of individual stocks is strongly related to plankton abundance, timing and composition. In the EMBA, the seasonal Bonney Coast upwelling is a productivity hotspot, with high densities of zooplankton and are important for fish and whales. Of particular importance in the region is the coastal krill, *Nyctiphanes australis*, which swarms throughout the water column of continental shelf waters primarily in summer and autumn, feeding on microalgae and providing an important link in the blue whale food chain. The fisheries in this region account for half of Australia's total annual catch and the main fishery in the region is sardine, which feeds on plankton, which illustrates the interdependence of the fishing industry on plankton.

There have been relatively few studies of plankton populations in the Otway and Bass Strait regions, with most concentrating on zooplankton. Watson and Chaloupka (1982) reported a high diversity of zooplankton in eastern Bass Strait, with over 170 species recorded. However, Kimmerer and McKinnon (1984) reported only 80 species in their surveys of western and central Bass Strait.

Plankton distribution is dependent upon prevailing ocean currents including the East Australia Current, flows into and from Bass Strait and Southern Ocean water masses. Plankton distribution in the EMBA is expected to be highly variable both spatially and temporally and are likely to comprise characteristics of tropical, southern Australian, central Bass Strait and Tasman Sea distributions.

Appendix B.3.3 Invertebrates

There is a very large number of marine invertebrates in deep waters around Australia. Knowledge of the species in different habitats is extremely patchy; the number of deep-water benthic fauna is large but almost unknown. Throughout the region, a variety of seabed habits support a range of animal communities such as sparse sponges to extensive 'thickets" of lace corals and sponges, polychaete worms and filter feeders (Director of National Parks, 2013).

Characteristics of large species of Crustacea, such as lobster, prawn and crab, which are significant commercial species in southern Australia, are well known. Mollusc species, such as oysters, scallops and abalone are also commercially fished and their biology and abundance are well known. Major fisheries for the blacklip and to a lesser extent, greenlip abalone and scallops have been founded. The cooler waters of southern Australia also support the Maori octopus commercial fishery, which is one of the largest octopuses in Australia (with arm spans longer than 3 m and weighing more than 10 kg. Other molluscs are abundant in southern Australia and Tasmania such as the sea-slug with more than 500 species. Volutes and cowries represent a relic fauna in southern Australia, with several species being very rare and can be highly sought after by collectors.

Echinoderms, such as sea stars, sea urchins and sea cucumbers are also an important fauna species of the southern Australian and Tasmanian waters, with several species at risk of extinction (DPIPWE, 2016)

Studies by the Museum of Victoria found that invertebrate diversity was high in southern Australian waters although the distribution of species was patchy, with little evidence of any distinct biogeographic regions (Wilson and Poore, 1987). Results of sampling in shallower inshore sediments reported high diversity and patchy distribution (Parry et al., 1990). In these areas crustaceans, polychaetes and molluscs were dominant.

Appendix B.3.4 Threatened ecological communities

No threatened ecological communities were identified within the EMBA.

Appendix B.3.5 Threatened and Migratory species

The EPBC PMST report identified the listed Threatened and Migratory species that may be present in the EMBA (Appendix A). A total of 35 Threatened species and 39 Migratory species were identified in the PMST report as potentially occurring within the EMBA. There were also 60 marine species and 28 cetaceans listed under the Act that were identified as potentially occurring within the EMBA.

Appendix B.3.5.1 Birds

A diverse array of seabirds and terrestrial birds utilise the Otway region and may potentially forage within or fly over the EMBA, resting on islands during their migration. Infrequently and often associated with storm events, birds that do not normally cross the ocean are sometimes observed over the Otway shelf, suggesting the birds have been blown off their normal course or are migrating.

Bird species listed by the EPBC Act PMST, as possibly or known to be occurring in EMBA (this includes species or species habitat), are shown in Table B-10-8 and described further in this section.

Table B-10-8: Listed bird species identified in the PMST search

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
Common sandpiper	*Actitius hypoleucos*	-	M	L	SHM
Fork-tailed swift	*Apus pacificus*	-	M	L	SHL
Flesh-footed shearwater	*Ardenna carneipes (Puffinus carneipes in marine listing)*	-	M	L	FL
Australasian bittern	*Botaurus poiciloptilus*	E	-	-	SHK
Sharp-tailed sandpiper	*Calidris acuminata*	-	M	L	SHM
Red knot	*Calidris canutus*	E	M	L	SHM
Curlew sandpiper	*Calidris ferruginea*	CE	M	L	SHM
Pectoral sandpiper	*Calidris melanotos*	-	M	L	SHM
Great skua	*Catharacta skua*	-	-	L	SHM
Antipodean albatross	*Diomedea antipodensis*	V	M	L	FL
Southern royal albatross	*Diomedea epomophora*	V	M	L	FL
Wandering albatross	*Diomedea exulans*	V	M	L	FL
Northern royal albatross	*Diomedea sanfordi*	E	M	L	FL
Blue petrel	*Halobaena caerulea*	V	-	L	SHM
Southern giant-petrel	*Macronectes giganteus*	E	M	L	SHM
Northern giant-petrel	*Macronectes halli*	V	M	L	SHM
Orange-bellied parrot	*Neophema chrysogaster*	CE	-	L	ML
Eastern curlew	*Numenius madagacariensis*	CE	M	L	SHM
Fairy prion	*Pachyptila turtur subantactica*	V	-	L	SHM
Osprey	*Pandion haliaetus*	-	M	L	SHM
Sooty albatross	*Phoebetris fusca*	V	M	L	SHL
Gould's petrel	*Pterodroma leucoptera*	E	-	-	SHM
Soft-plumaged petrel	*Pterodroma mollis*	V	-	L	SHM
Australian fairy tern	*Sternula nereis*	V	-	L	FL
Buller's albatross	*Thalassarche bulleri*	V	M	L	FL
Northern Buller's albatross	*Thalassarche bulleri platei*	V	-	-	FL

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
Shy albatross	*Thalassarche cauta cauta*	V	M	L	FL
White-capped albatross	*Thalassarche cauti steadi*	V	M	-	FL
Grey-headed albatross	*Thalassarche chrysostoma*	E	M	L	SHM
Campbell albatross	*Thalassarche impavida*	V	M	L	FL
Black-browed albatross	*Thalassarche melanophris*	V	M	L	FL
Salvin's albatross	*Thalassarche salvini*	V	M	L	FL
White-capped albatross	*Thalassarche steadi*	V	M	L	FL

Listed Threatened
CE: Critically Endangered
E: Endangered
V: Vulnerable
Listed Migratory
M: Migratory
Listed Marine
L: Listed

Likely Presence
SHM: Species or species habitat may occur within area.
SHL: Species or species habitat likely to occur within area.
SHK: Species or species habitat known to occur within area.
FL: Foraging, feeding or related behaviour likely to occur within area.
ML: Migratory route likely to occur in area.

Albatrosses and giant-petrels are among the most dispersive and oceanic of all birds, spending more than 95% of their time foraging at sea in search of prey and usually only returning to land (remote islands) to breed. The National Recovery Plan for threatened albatross and giant petrels (DESWPaC, 2011a). Only seven species of albatross and the southern and northern giant petrel are known to breed within Australia. Breeding within Australian territory occurs on the isolated islands of Antarctica (Giganteus Island, Hawker Island and Frazier islands) and the Southern Ocean (Heard Island, McDonald Island, Macquarie Island, Bishop and Clerk Islands), as well as islands off the south coast of Tasmania and Albatross Island off the north-west coast of Tasmania in Bass Strait (DSEWPaC, 2011). There are no islands with colonies of threatened marine seabirds within the EMBA. Albatross Island, supporting a breeding population of approximately 5,000 shy albatross (*Thallassarche cauta*), is the closest breeding colony of threatened seabirds to the EMBA.

Albatross and giant petrel species exhibit a broad range of diets and foraging behaviours, hence their at-sea distributions are diverse. Combined with their ability to cover vast oceanic distances, all waters within Australian jurisdiction can be considered foraging habitat, however the most critical foraging habitat is those waters south of 25 degrees where most species spend most of their foraging time. The wandering albatross, antipodean albatross, Buller's albatross, shy albatross, black-browed albatross and Campbell albatross have BIAs for foraging that overlap the EMBA. This BIA is either most or all the South-East Marine Region (Commonwealth of Australia, 2015). Therefore, it is likely that these will be present and forage in the EMBA.

Orange-bellied parrot (*Neophema chrysogaster*) (listed as critically endangered under the EPBC Act) breeds in Tasmania during summer, migrates north across Bass Strait in autumn and spends winters on the mainland. The migration route includes the west coast of Tasmania and King Island. Birds depart the mainland for Tasmania from September to November (Green, 1969). The southward migration is rapid (Stephenson, 1991), so there are few migration records. The northward migration across western Bass Strait is more prolonged (Higgins and Davies, 1996).

The orange-bellied parrot is protected under the National Recovery Plan for the Orange-bellied Parrot (DELWP, 2016). The parrot's breeding habitat is restricted to south-west Tasmania, where breeding occurs from November to mid-

January mainly within 30 km of the coast. The species forage on the ground or in low vegetation (Loyn et al., 1986). During winter, on mainland Australia, orange-bellied parrots are found mostly within 3 km of the coast. In Victoria, they mostly occur in sheltered coastal habitats, such as bays, lagoons and estuaries. They are also found in low samphire herbland dominated by beaded glasswort (*Sarcocornia quinqueflora*), sea heath (*Frankenia pauciflora*) or sea-blite (*Suaeda australis*), and in taller shrubland dominated by shrubby glasswort (*Sclerostegia arbuscula*) (DotEE, 2019a). There are also non-breeding orange-bellied parrots on mainland Australia, between Goolwa in Australia and Corner Inlet in Victoria.

The orange bellied parrot may overfly the coastal waters of the EMBA however the west coast of King Islands and coastal Victoria has been identified as resting and feeding areas. However, parrots rarely land or forage out at sea.

Flesh-footed shearwater is a trans-equatorial migrant widely distributed across the south-western Pacific during breeding season (early September to early May) and is a common visitor to the waters of the continental shelf/slope and occasionally inshore waters. The species breeds in burrows on sloping ground in coastal forest, scrubland, shrubland or grassland. Thirty-nine of the 41 islands on which the species breeds lie off the coast of southern Western Australia, with the remaining two islands being Smith Island (SA) and Lord Howe Island. The flesh-footed shearwater feeds on small fish, cephalopod molluscs (squid, cuttlefish, nautilus and argonauts), crustaceans (barnacles and shrimp), other soft-bodied invertebrates (such as Velella) and offal. The species forages almost entirely at sea and very rarely on land. It obtains most of its food by surface plunging or pursuit plunging. It also regularly forages by settling on the surface of the ocean and snatching prey from the surface ('surface seizing'), momentarily submerging onto prey beneath the surface ('surface diving') or diving and pursuing prey beneath the surface by swimming ('pursuit diving'). Birds have also been observed flying low over the ocean and pattering the water with their feet while picking food items from the surface (termed 'pattering') (DotEE, 2014). This species is likely to be an uncommon visitor to the EMBA.

A number of species listed in Table B-10-8 use coastal shoreline habitats such as Australian fairy tern, Fairy prion, Common diving-petrel, Red knot, Pectoral sandpiper, Fork-tailed swift, Sharp-tailed sandpiper, Curlew sandpiper, Eastern curlew and Australasian bittern. These species are commonly found on coastal shores including beaches and rocky shores and either feed at low tide on worms, crustaceans and molluscs or fish species or feed on aquatic biota (Parks Victoria, 2016). This species are unlikely to be present in the EMBA due to the distance offshore.

Appendix B.3.5.2 Fish

Fish species present in the EMBA are either pelagic (living in the water column), or demersal (benthic) fish. Fish species inhabiting the region are largely cool temperate species, common within the South Eastern Marine Region. The PMST report identified 30 listed fish species that were potentially occurring in the EMBA. Table B-10-9 details the listed fish species identified in the PMST.

Table B-10-9: Listed fish species identified in the PMST search

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
White shark	*Carcharodon carcharias*	V	M	-	SHK
Shortfin mako	*Isurus oxyrinchus*	-	M	-	SHL
Porbeagle, mackerel shark	*Lamna nasus*	-	M	-	SHL
Australian grayling	*Prototroctes maraena*	V	-	-	SHM
Upside-down pipefish	*Heraldia nocturna*	-	-	L	SHM

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
Bigbelly seahorse	*Hippocampus abdominalis*	-	-	L	SHM
Short-head seahorse	*Hippocampus breviceps*	-	-	L	SHM
Briggs' crested pipefish	*Histiogamphelus briggsii*	-	-	L	SHM
Rhino pipefish	*Histiogamphelus cristatus*	-	-	L	SHM
Knife-snouted pipefish	*Hypselognathus rostratus*	-	-	L	SHM
Deep-bodied pipefish	*Kaupus costatus*	-	-	L	SHM
Brushtail pipefish	*Leptoichthys fistularius*	-	-	L	SHM
Australian smooth pipefish	*Lissocampus caudalis*	-	-	L	SHM
Javelin pipefish	*Lissocampus runa*	-	-	L	SHM
Sawtooth pipefish	*Maroubra perserrata*	-	-	L	SHM
Half-banded pipefish	*Mitotichthys semistriatus*	-	-	L	SHM
Tucker's pipefish	*Mitotichthys tuckeri*	-	-	L	SHM
Red pipefish	*Notiocampus ruber*	-	-	L	SHM
Leafy seadragon	*Phycodurus eques*	-	-	L	SHM
Common seadragon	*Phyllopteryx taeniolatus*	-	-	L	SHM
Pug-nosed pipefish	*Pugnaso curtirostris*	-	-	L	SHM
Robust pipehorse	*Solegnathus robustus*	-	-	L	SHM
Spiny pipehorse,	*Solegnathus spinosissimus*	-	-	L	SHM
Spotted pipefish	*Stigmatopora argus*	-	-	L	SHM
Black pipefish	*Stigmatopora nigra*	-	-	L	SHM
Ring-backed pipefish	*Stipecampus cristatus*	-	-	L	SHM
Hairy pipefish	*Urocampus carinirostris*	-	-	L	SHM
Mother-of-pearl pipefish	*Vanacampus margaritifer*	-	-	L	SHM
Port Phillip pipefish	*Vanacampus phillipi*	-	-	L	SHM
Australian long-snout pipefish	*Vanacampus poecilolaemus*	-	-	L	SHM

Listed Threatened
V: Vulnerable
Listed Migratory
M: Migratory
Listed Marine
L: Listed

Likely Presence
SHM: Species or species habitat may occur within area.
SHL: Species or species habitat likely to occur within area.
SHK: Species or species habitat known to occur within area.

White shark

The white shark (*Carcharodon carcharias*) is widely distributed and located throughout temperate and sub-tropical waters with their known range in Australian waters including all coastal areas except the Northern Territory (DotEE, 2010). Studies of white sharks indicate that they are largely transient. However, individuals are known to return to feeding grounds on a seasonal basis (Klimley and Anderson, 1996). Observations of adult sharks are more frequent around fur seal and sea lion colonies, including Wilsons Promontory and the Skerries. Juveniles are known to congregate in certain key areas including the Ninety Mile Beach area (including Corner Inlet and Lakes Entrance) in eastern Victoria and the Portland area of western Victoria).

The distribution BIA for the white shark intersects the EMBA. The known distribution is on the coastal shelf/upper slope waters out to 1000 m and the broader area where they are likely to occur extends from Barrow Island in WA to Yeppoon in NSW. They are more likely to be found between the 60–120 m depth contours than in the deeper waters. There is a known nursery area at Corner Inlet, and they are known to forage in waters off pinniped colonies throughout the SEMR. It is likely that white sharks will be present in the EMBA.

Shortfin mako shark

The shortfin mako shark (*Isurus oxyrinchus*) is a pelagic species with a circum-global oceanic distribution in tropical and temperate seas (Mollet et al., 2000). It is widespread in Australian waters, commonly found in water with temperatures greater than 16°C. Populations of the shortfin mako are considered to have undergone a substantial decline globally. These sharks are a common by-catch species of commercial fisheries (Mollet et al., 2000). Due to their widespread distribution in Australian waters, shortfin mako sharks are likely to be present in the EMBA in low numbers.

Porbeagle shark

The porbeagle shark (*Lamna nasus*) is widely distributed in the southern waters of Australia including Victorian and Tasmanian waters. The species preys on bony fishes and cephalopods and is an opportunistic hunter that regularly moves up and down in the water column, catching prey in mid-water as well as at the seafloor. It is most commonly found over food-rich banks on the outer continental shelf, but does make occasional forays close to shore or into the open ocean, down to depths of approximately 1,300 m. It also conducts long-distance seasonal migrations, generally shifting between shallower and deeper water (Pade et al., 2009). The porbeagle shark is likely to be present in the EMBA in low numbers.

Australian grayling

The Australian grayling (*Prototroctes maraena*) is a dark brown to olive-green fish attaining 19 cm in length. The species typically inhabits the coastal streams of New South Wales, Victoria and Tasmania, migrating between streams and the ocean. Spawning occurs in freshwater, with timing dependant on many variables including latitude and temperature regimes. Most of its life is spent in fresh water, with parts of the larval or juvenile stages spent in coastal marine waters (Department of Sustainability and Environment, 2008a), though its precise marine habitat requirements remain unknown (Department of Sustainability and Environment, 2008b). They are a short-lived species, usually dying after their second year soon after spawning (a small proportion may reach four or five years) (Department of Sustainability and Environment, 2008a).

Australian grayling has been recorded from the Gellibrand River (Department of Sustainability and Environment, 2008b), making it likely that it occurs in coastal waters. As marine waters are not part of the species' spawning grounds, the EMBA is are not likely to represent critical habitat for the species.

Syngnathids

All of the marine ray-finned fish species identified in the EPBC PMST Report are syngnathids, which includes seahorses and their relatives (sea dragon, pipehorse and pipefish). The majority of these fish species are associated with seagrass meadows, macroalgal seabed habitats, rocky reefs and sponge gardens located in shallow, inshore waters (e.g., protected coastal bays, harbours and jetties) less than 50 m deep (Fishes of Australia, 2015). They are sometimes recorded in deeper offshore waters, where they depend on the protection of sponges and rafts of floating seaweed such as Sargassum.

Of the 26 species of syngnathids identified in the EPBC PMST Report, only one (*Hippocampus abdominalis*, big-belly seahorse) has a documented species profile and threats profile, indicating how little published information exists in general regarding syngnathids.

The PMST Report species profile and threats profiles indicate that the syngnathid species listed in the EMBA are widely distributed throughout southern, south-eastern and south-western Australian waters. Therefore, it is unlikely that these species will be present in the EMBA as water depths are greater than 50 m.

Appendix B.3.5.3 Cetaceans

The PMST report identified a number of cetaceans that potentially occur in the EMBA (Table B-10-10). Details of these cetaceans are discussed further in this section.

Table B-10-10: Listed cetacean species identified in the PMST

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
Whales					
Antarctic minke whale	*Balaenoptera bonaerensis*	-	M	L	SHL
Sei whale	*Balaenoptera borealis*	V	M	L	FL
Blue whale	*Balaenoptera musculus*	E	M	L	FK
Fin whale	*Balaenoptera physalus*	V	M	L	FL
Southern right whale	*Balaena glacialis australis*	E	M	L	SHK
Minke whale	*Balaenoptera acutorostrata*	-	-	L	SHM
Arnoux's beaked whale	*Berardius arnuxii*	-	-	L	SHM
Pygmy right whale	*Caperea marginata*	-	M	L	FM
Short-finned pilot whale	*Globicephala macrorhynchus*	-	-	L	SHM
Long-finned pilot whale	*Globicephala melas*	-	-	L	SHM
Pygmy sperm whale	*Kogia breviceps*	-	-	L	SHM
Dwarf sperm whale	*Kogia simus*	-	-	L	SHM
Humpback whale	*Megaptera novaeangliae*	V	M	L	SHL
Andrew's beaked whale	*Mesoplodon bowdoini*	-	-	L	SHM

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
Blainville's beaked whale	*Mesoplodon desirostris*	-	-	L	SHM
Hector's beaked whale	*Mesoplodon hectori*	-	-	L	SHM
Strap-toothed beaked whale	*Mesoplodon layardii*	-	-	L	SHM
True's beaked whale	*Mesoplodon mirus*	-	-	L	SHM
Killer whale, orca	*Orcinus orca*	-	M	L	SHL
Sperm whale	*Physeter macrocephalus*	-	M	L	SHM
False killer whale	*Pseudorca crassidens*	-	-	L	SHL
Curvier's Beaked Whale	*Ziphius cavirostris*	-	-	L	SHM
Dolphins					
Common dolphin	*Delphinus delphis*	-	-	L	SHM
Risso's dolphin	*Grampus griseus*	-	-	L	SHM
Dusky dolphin	*Lagenorhynchus obscures*	-	M	L	SHL
Southern right whale dolphin	*Lissodelphis peronii*	-	-	L	SHM
Indian Ocean bottlenose dolphin	*Tursiops aduncus*	-	-	L	SHL
Bottlenose dolphin	*Tursiops truncates*	-	-	L	SHM

Listed Threatened
E: Endangered
V: Vulnerable
Listed Migratory
M: Migratory
Listed Marine
L: Listed

Likely Presence
SHM: Species or species habitat may occur within area.
SHL: Species or species habitat likely to occur within area.
SHK: Species or species habitat known to occur within area.
FK: Foraging, feeding or related behaviour known to occur within area.
FL: Foraging, feeding or related behaviour likely to occur within area.
FM: Foraging, feeding or related behaviour may to occur within area.

Gill et al. (2015) summarised cetacean sightings from 123 systematic aerial surveys undertaken over western Bass Strait and the eastern Great Australian Bight between 2002 and 2013. This paper does not include sighting data for blue whales, which has previously been reported in Gill et al. (2011).

These surveys recorded 133 sightings of 15 identified cetacean species consisting of seven mysticete (baleen) whale species, eight odontocete (toothed) species and 384 sightings of dolphins (Table B-10-11 and Table B-10-12). Survey effort was biased toward coverage of upwelling seasons, corresponding with pygmy blue whales' seasonal occurrence (November to April; 103 of 123 surveys), and relatively little survey effort occurred during 2008–2011. Cetacean species sighted within the region are described in the following sections.

Table B-10-11: Cetacean species recorded during aerial surveys 2002–2013 in southern Australia

Taxon	Common name	Species group*	Sightings	Individual	Mean group size (+/- SD)
Baleen whales					
Eubalaena australis	Southern right whale	SRW	12	52	4.2 +/- 4.2
Caperea marginata	Pygmy right whale		1	100	100
Balaenoptera physalus	Fin and like fin whale	ROR	7	8	1.1 +/- 0.4
B. borealis	Sei and like sei whale	ROR	12	14	1.3 +/- 0.5
B. acutorostrata	Dwarf minke whale	ROR	1	1	1
B. bonaerensis	like Antarctic minke whale	ROR	1	1	1
Megaptera novaeangliae	Humpback whale	ROR	10	18	1.8 +/- 1.0
Toothed whales					
Physeter macrocephalus	Sperm whale	ODO	34	66	1.9 +/- 2.2
Mesoplodon spp.	Unidentified beaked whales	ODO	1	20	20
Orcinus orca	Killer whale	ODO	6	21	3.5 +/- 2.8
Globicephala melas	Long-finned pilot	ODO	40	1853	46.3 +/- 46.7
Grampus griseus	Risso's dolphin	ODO	1	40	40
Lissodelphis peronii	Southern right whale dolphin	ODO	1	120	120
Tursiops spp.	Bottlenose dolphin	DOL	4	363	90.8 +/- 140.1
	Dolphins	DOL	384	22169	58 +/- 129.6
Unidentified large whales			3	3	1
Unidentified small whales			2	2	1

SRW = southern right whales; ROR = rorquals; ODO = other odontocetes; DOL = dolphins.

Gill et al. (2015) encountered southern right and humpback whales most often from May to September, despite low survey effort in those months. Southern right whales were not recorded between October and May. Fin, Sei, and Pilot whales were sighted only from November to May (upwelling season), although this may be an artefact of their relative scarcity overall and low survey effort at other times of year. Dolphins were sighted most consistently across years. The authors caution that few conclusions about temporal occurrence can be drawn because of unequal effort distribution across seasons and the rarity of most species.

Species of cetacean sighted in the period 31 October to 19 December 2010 during the Speculant 3D Transitions Zone Seismic Survey (3DTZSS) undertaken by Origin Energy, recorded species of common dolphin (*Delphinus spp*.), bottlenose dolphin (*Tursiops spp*.), unidentified small cetaceans and fur seals.

Cetacean species sighted within the region are described in the following sections.

Table B-10-12: Temporal occurrence across months of cetaceans sighted during aerial surveys from November 2002 to March 2013 in southern Australia

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Southern right whale	0	0	0	0	0	0	0	0	0.8	3.1	6.8	8.8
Pygmy right whale*	0	0	0	0	0	0	0	0	19.8	0	0	0
Fin whale	0	0.10	0.14	0.07	0.08	0	0	0	0	0	0	0
Sei whale	0	0.25	0.07	0.04	0.08	0.19	0	0.21	0	0	0	0
Minke whale*	0	0	0.02	0	0	0	0.12	0	0	0	0	0
Humpback whale	0	0.05	0.07	0	0	0	0	0.11	0.99	1.0	0	0.35
Sperm whale	1.7	1.2	0.23	0.53	0.08	0.13	0.75	0.85	0	0	0	0
Unidentified beaked whale*	0	0	0.47	0	0	0	0	0	0	0	0	0
Killer whale	0	0	0.19	0	0	5.0	0	6.0	0	0.68	0	0
Pilot whale	0	59.6	7.0	19.3	4.0	39.5	0	26.3	0	0	0	0
Southern right whale dolphin*	0	59.6	0	0	0	0	0	0	0	0	0	0
Risso's dolphin*	0	0	0	0	1.7	0	0	0	0	0	0	0
Bottlenose dolphin	0	1.5	7.7	0	0	0	0	0	0	0	0	1.1
Dolphins	545.1	120.3	105.0	151.8	105.6	233.4	26.9	257.6	155.8	2.7	0	0

*Species sighted 2 or fewer times.

Note: Numbers denote animals sighted per 1,000 km survey distance for each month, pooled for all years (i.e. the 12-month period from Oct–Sep).

The Bass Strait and the Otway Basin is considered an important migratory path for Humpback, Blue, Southern right, and to some extent the Fin and Sei whales. The whales use the Otway region to migrate to and from the north-eastern Australian coast and the sub-Antarctic. Of particular environmental importance in the Otway is the Bonney Upwelling, the eastward flow of cool nutrient rich water across the continental shelf of the southern coast of Australia that promotes blooms of krill and attracts baleen whales during the summer months.

Origin Energy conducted a survey for cetaceans focused on Origin operations and permit in the Otway basin from June 2012 through March of 2013. Table B-10-13 lists the species present in the area Origin surveyed.

Table B-10-13: Observed cetaceans in Otway Basin

Species	Jun	Jul	Aug	Sep *	Oct	Nov	Dec	Jan	Feb	Mar	Total
Blue whale	0	0	0	0	0	23	70	17	8	2	120
Southern right whale	2	0	12	13	0	0	0	0	0	0	39*
Humpback whale	3	2	0	1	0	1	0	0	0	0	7
Sperm whale	2	0	0	0	4	0	0	3	1	0	10
Pilot whale	0	0	0	0	0	70	0	0	55	0	125
Dolphins	13	298	0	33	54	620	80	672	1526	21	3317
Southern right whale	0	0	0	0	0	120	0	0	0	0	120

*September values averaged over two surveys on 1 and 11 September 2012. Totals include individuals from both September surveys

Blue whale

The blue whale (*Balaenoptera musculus*) is currently listed as an endangered species under the EPBC Act. There are two subspecies of Blue whales that use Australian waters (including Australian Antarctic waters), the pygmy blue whale (*B. m. brevicauda*) and the Antarctic blue whale (*B. m. intermedia*). The Antarctic blue whale subspecies remains severely depleted from historic whaling and its numbers are recovering slowly. For the pygmy blue whale there is uncertainty in the number's pre-exploitation, and their current numbers are not known. The Blue whale has a recovery plan that identifies threats and establishes actions for assisting the recovery of Blue whale populations using Australian waters (Commonwealth of Australia, 2017a).

The blue whale is a cosmopolitan species, found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk and Bering seas.

The pygmy blue whale is mostly found north of 55°S, while Antarctic blue whales are mainly sighted south of 60°S. Pygmy blue whales are most abundant in the southern Indian Ocean on the Madagascar plateau, and off South Australia and Western Australia, where they form part of a more or less continuous distribution from Tasmania to Indonesia. Acoustic monitoring has found the presence of Antarctic blue whales in the Otway region to be rare (Gavrilov, 2012). Both sub-species of Blue whale may, however, be found in Australian waters and reference to Blue whale unless otherwise specified is synonymous to both species.

The Antarctic blue whale was extremely abundant in the past. Approximately 341,830 blue whales were recorded as taken by whaling in the Antarctic and sub-Antarctic in the 20th century, of which 12,618 were identified as pygmy blue whales or are assumed to have been so from their location (Branch et al., 2004). The current global population of blue whales is uncertain but is plausibly in the range of 10,000 to 25,000, corresponding to about 3-11% of the 1911 population size. The global population is listed as Endangered on the IUCN Red List.

Previous observations that the Otway region is an important migratory and feeding corridor for Blue whales arriving from and departing to the east have been confirmed by passive acoustic monitoring and aerial surveys.

Sighting data indicates that Blue whales are seasonally distributed. They concentrate between the Great Australian Bight and Cape Nelson in November, spread eastwards in December and occur widely in the Otway region from January to April and then decrease between May and June show pooled, all seasons Blue whale sightings for each month from November to May for central and eastern areas; these are overlaid on a grid representing the aerial survey effort (10 km x 10 km squares). The aerial survey is displayed as minutes flown per grid square. Thick solid lines represent 50% and 95%

probability contours for Blue whale distribution from density kernel analysis. Dashed lines are central and eastern boundaries.

A number of marine noise assessments of the Otway Basin have been conducted. From February to October 2011 Origin located an array of marine loggers east of the Thylacine platform to document nearby ambient marine noise, detect cetaceans and measure acoustics associated with the Origin 3D Bellerive Marine Seismic Survey. Pygmy and Antarctic blue whales were acoustically detected in the monitored area. Pygmy blue whales were observed from early February to early June being abundant from March to mid-May. Rare calls from Antarctic blue whales were observed in June.

The migratory period for the blue whales into Bass Strait generally commences in November or December (Gill et al., 2011). There had been fewer than 50 sightings of Blue whales in Bass Strait up to the year 1999, but since that time feeding blue whales have been more regularly observed in the Discovery Bay area and more generally along the Bonney coast from Robe to Cape Otway.

The time and location of the appearance of Blue whales in the east generally coincides with the upwelling of cold water in summer and autumn along this coast (the Bonney Upwelling) and the associated aggregations of krill that they feed on (Gill and Morrice, 2003). The Bonney Upwelling generally starts in the eastern part of the Great Australian Bight in November or December and spreads eastwards to the Otway Basin around February as southward migration of the subtropical high-pressure cell creates upwelling favourable winds.

BIAs for the pygmy blue whale have been identified around Australia with the foraging BIA intersecting the EMBA (Figure B-10-8). The known and likely migration routes of the highly mobile pygmy blue whale are also shown in Figure B-10-9. The EMBA intersects a likely migration route (DotEE, 2019b). Breeding occurs in low latitudes (including Indonesia) during the austral winter although there may be more than one breeding habitat given observed females with small calves recorded seasonally moving through Geographe Bay (WA) from September to December (DotEE, 2019b).

Gill et al. (2011) undertook 69 seasonal aerial surveys for blue whales between Cape Jaffa and Cape Otway over six seasons (2001-02 to 2006-07). This study found that the general pattern of seasonal movement of blue whales is from west to east, with whales foraging in between the Great Australian Bight and Cape Nelson in November and spreading further east in December. As shown in Figure B-10-10 the whales are typically widely distributed throughout Otway shelf waters from January through to April (Gill et al., 2011).

Gill et al. (2011) found that across the eastern zone (Cape Nelson to Cape Otway), there were no blue whale sightings in November of any season despite significant effort. Pooled monthly encounter rates increased from 1.6 whales 1,000 km–1 in December, peaked at 9.8 whales 1,000 km–1 in February, dropped slightly to 8.8 whales 1,000 km–1 in March, then declined sharply to a single sighting for May (0.4 whales 1,000 km–1) (Figure B-10-10).

Sighting data are presented geographically in Figure B-10-11 and Figure B-10-12. Data is pooled for all seasons, for central and eastern areas, overlaid on gridded aerial survey effort (10 X 10 km squares), represented as minutes flown per grid square (key, upper right). Thick solid lines represent 50% and 95% probability contours for blue whale distribution from density kernel analysis. Dashed lines are central and eastern boundaries (Gill et al., 2011).

These data indicate that, within the EMBA, blue whales are statistically most likely to first appear during December/January and reach peak number during February/March.

Gill et al. (2011) also identified that 80% of blue whale sightings are encountered in water depths between 50 and 150 m; 93% of sightings occurred in water depths <200 m and 10% of sightings occurred within 5 km of the 200 m isobath in the eastern and central zones. A mean blue whale group size of 1.3±0.6 was observed per sighting with cow-calf pairs observed in 2.5% of the sightings.

Within this broad context it is also important to note that each season seems to have a unique upwelling signature and pattern of blue whale abundance and distribution. Inter-seasonal and inter-area variability in both upwelling intensity and blue whale density can be high and the exact timing and location of first appearance of blue whales in the area can be difficult to predict. Aerial surveys commissioned by Origin undertaken during 2011 and 2012 by the Blue Whale Study found that:

- Between 8 and 25 February 2011, 56 blue whales were sighted during five aerial surveys. Most of the sightings were at inshore areas between Moonlight Head to Port Fairy with whales apparently aggregating along and offshore of the boundary between the runoff plume from major flooding prevalent at the time and adjacent seawater.

- Blue whales were common in the eastern upwelling zone during November and December 2012, months when mean encounter rates over the preceding six seasons were zero (November) or low (December). During November, an estimated 21 individual blue whales were sighted, with most sightings near the 100m isobath or deeper. December 2012 surveys identified 70 blue whales foraging along the edge of the continental shelf west of King Island. This was the largest recorded aggregation of blue whales during any aerial surveys of the Bonney Upwelling since 1999.

- There were no confirmed sightings of blue whales during Origin's Speculant 3DTZDD undertaken during November and December 2010, the Astrolabe 3D seismic survey undertaken during early November 2013 (RPS, 2014) and the Enterprise 3D seismic survey undertaken during late October and early November 2014 (RPS, 2014).

- It is likely that blue whales will be present in the EMBA. The likelihood and extent of the interaction is dependent on broad scale environmental factors affecting the abundance and distribution of blue whale feeding resources.

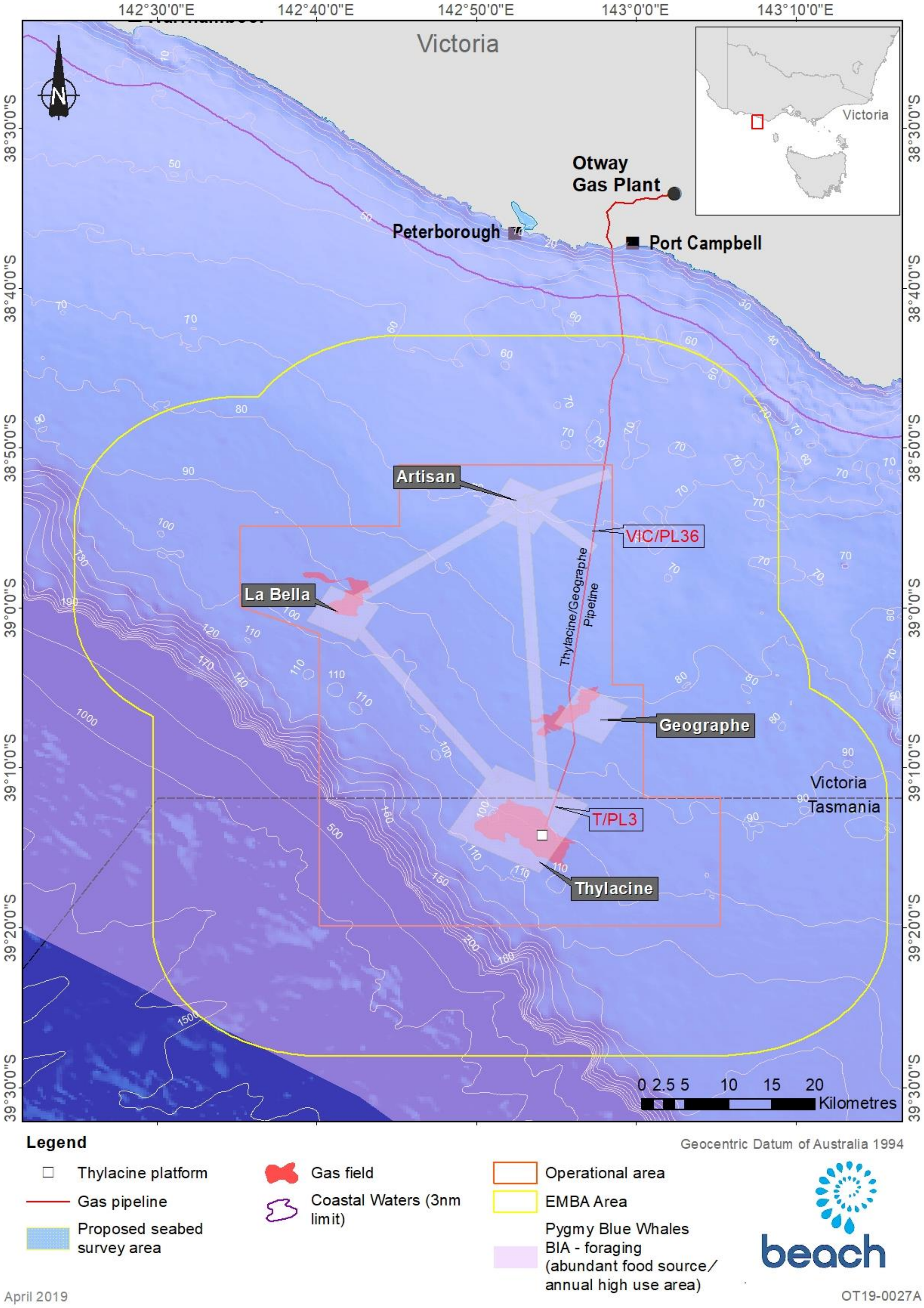
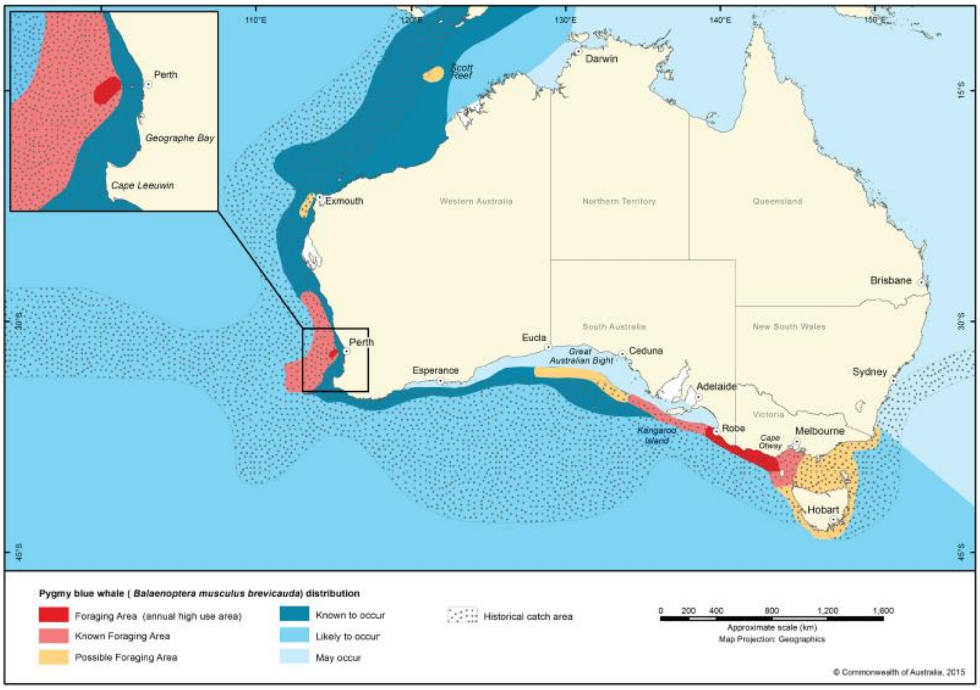


Figure B-10-8: Pygmy blue whale BIA in the EMBA



Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route

Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
May occur	Evidence for the presence of blue whales through strandings or rare observations
Historical catch area	Blue whales were caught during the whaling period based on whaling data

Figure B-10-9: Pygmy blue whale foraging areas around Australia

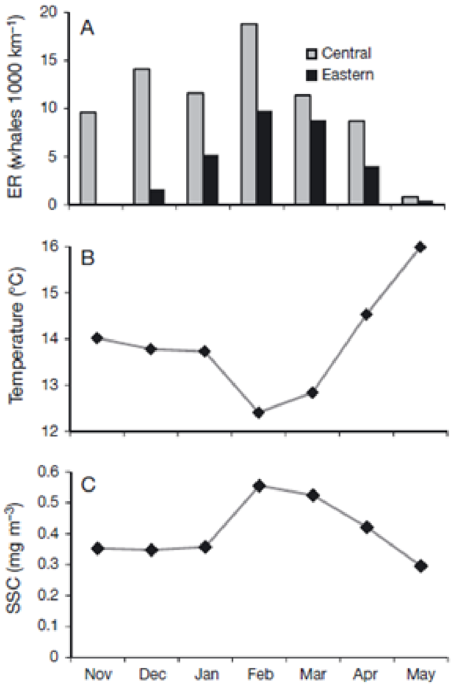


Figure B-10-10: Blue whale encounter rates in the central and eastern study (Cape Nelson to Cape Otway) area by month (Gill et al., 2011)

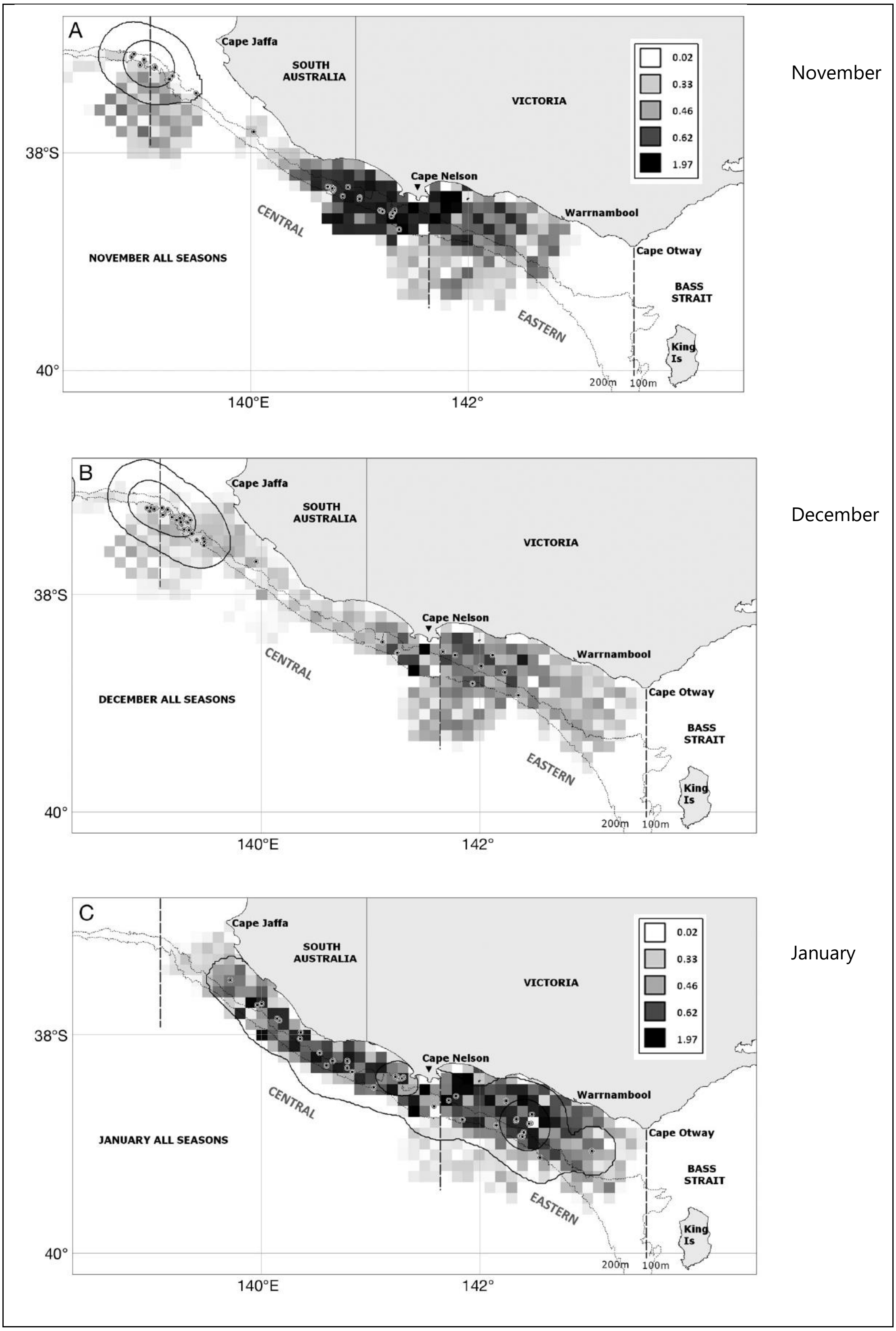


Figure B-10-11: Blue whale sightings in the Otway Basin (Nov, Dec, Jan) (Gill et al., 2011)

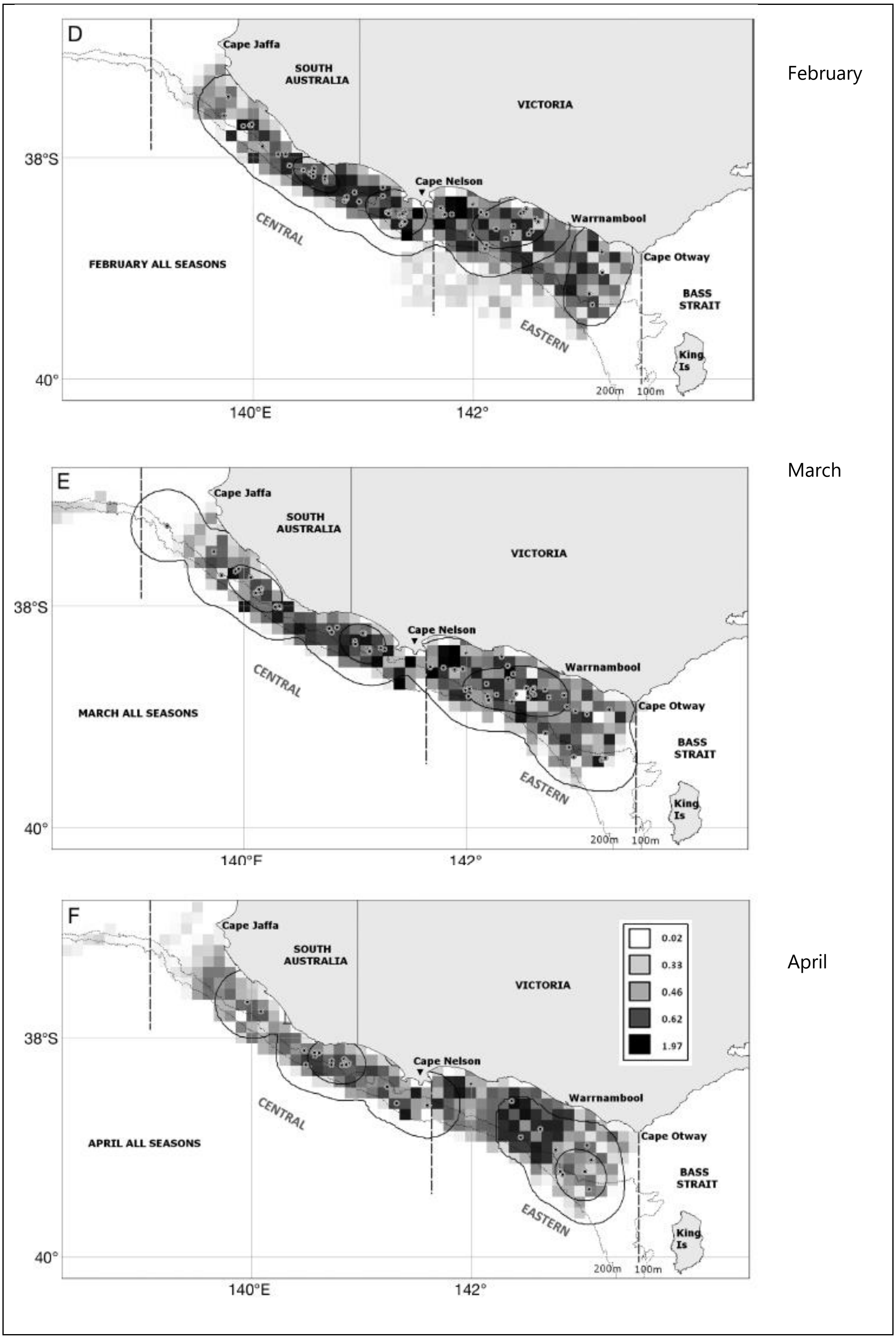


Figure B-10-12: Blue whale sightings in the Otway Basin (Feb, Mar, Apr) (Gill et al., 2011)

Southern right whale

The Southern right whale (*Eubalaena australis*) is listed as endangered under the EPBC Act because they have undergone a severe reduction in numbers as a result of commercial whaling. An initial recovery plan for southern right whales was developed for the period 2005 to 2010; however, a review found that occupancy and abundance are still lower than historic records. Currently the southern right whale has a recovery plan to prioritise research and better predict impacts (Commonwealth of Australia, 2012).

Southern right whales (*Eubalaena australis*) are distributed in the southern hemisphere with a circumpolar distribution between latitudes of 16°S and at least 65°S. The species is pelagic in summer foraging in the open Southern Ocean (Bannister et al., 1996) between 40° and 65°S (Commonwealth of Australia, 2012) and migrates from the subantarctic to lower latitude coastal waters during winter to calve and mate (Mustoe and Ross, 2004). The distribution in winter, at least of the breeding component of the population, is concentrated near coastlines in the northern part of the range.

Southern right whales were hunted extensively by pre-modern whaling starting in the early 17th century, but especially in the 18th and 19th centuries by American and European whalers. The total number processed between 1770 and 1900 is conservatively estimated at about 150,000, of which 48,000-60,000 were taken in the 1830s alone. By the start of modern whaling at the beginning of the 20th century, the species was already rare, and catches thereafter until right whales were legally protected in 1935 totalled only about 1,600 individuals. The hemispheric population in 1770 is estimated at 55,000-70,000 and is estimated to have been depleted to a low of about 300 animals by the 1920s.

Several breeding populations (Argentina/Brazil, South Africa, and Australia) of Southern right whales have shown evidence of strong recovery post whaling, with a doubling time of 10-12 years (Bannister, 2001, Best et al., 2001, Cooke et al., 2001). Recent estimated population sizes (1,600 mature females in 1997, and approximately twice that number in 2007) and the strong observed rate of increase in some well-studied parts of the range, indicate the species, although still scarce relative to its historic abundance, is not considered under threat at the hemispheric level. The population is estimated to be higher now than it was three generations (87 years, assuming a generation time of 29 years; Taylor et al., 2007) ago. The IUCN Red List categorisation for the species is Least Concern.

Major current breeding areas are nearshore off southern Australia, New Zealand (particularly Auckland Islands and Campbell Islands), Atlantic coast of South America (Argentina and Brazil), and southern Africa (mainly South Africa). Small numbers are also seen off central Chile, Peru, Tristan da Cunha (British Overseas Territory), and the east coast of Madagascar (Rosenbaum et al., 2001). The species are regularly present on the Australian coast during winter and spring (Commonwealth of Australia, 2012).

Peak periods for mating in Australian coastal waters are from mid-July through August (Commonwealth of Australia, 2012). Pregnant females generally arrive during late May/early June and calving/nursery grounds are generally occupied until October (occasionally as early as April and as late as November), but not at other times. Calving takes place very close to the coast in Australia, usually in waters less than 10 metres deep.

Female southern right whales show calving site fidelity, generally returning to the same location to give birth and nurse offspring. Female-calf pairs generally stay within the calving ground for 2–3 months. Other population classes stay in coastal areas for shorter and more variable periods, and generally depart the coast earlier then female-calf pairs (Commonwealth of Australia, 2012).

In Australian coastal waters, southern right whales occur along the southern coastline including Tasmania, generally as far north as Sydney (33°53’S, 151°13’E) on the east coast and Perth (31°55’S, 115°50’E) on the west coast. There are occasional occurrences further north, with the extremities of their range recorded as Hervey Bay (25°00’S, 152°50’E) and Exmouth (22°23’S, 114°07’E). Southern right whales generally occur within two kilometres offshore and tend to be distinctly clumped in aggregation areas (Commonwealth of Australia, 2012). Aggregation areas are well known with the largest being (Figure B-10-13):

- Doubtful Island Bay area in WA (38°15'S, 119°32'E)
- Israelite Bay area in WA (33°37'S, 123°53'E)
- Head of Bight in SA (31°28'S, 131°08'E).

Several smaller established areas (regularly occupied) occur at:

- Yokinup Bay in WA (33°53'S, 123°05'E)
- The Warrnambool region in Victoria (38° 25'S, 142°30'E).

Emerging aggregation areas (sporadically used at present) occur at:

- Flinders Bay in WA (34°20'S, 115°15'E)
- Hassell Beach in WA (34°49'S, 118°24'E)
- Cheyne/Wray Bays in WA (34°32'S, 118°55'E)
- Twilight Cove in WA (32°17'S, 126°02'E)
- Fowlers Bay in WA (31°59' 132°28'E)
- Encounter Bay in SA (35°35'S, 138°40'E) (DSEWPaC, 2012b).

A number of additional areas for southern right whales are emerging that might be of importance, particularly to the south-eastern population. In these areas, small but growing numbers of non-calving whales regularly aggregate for short periods of time. These areas include coastal waters off Peterborough, Port Campbell, Port Fairy and Portland in Victoria.

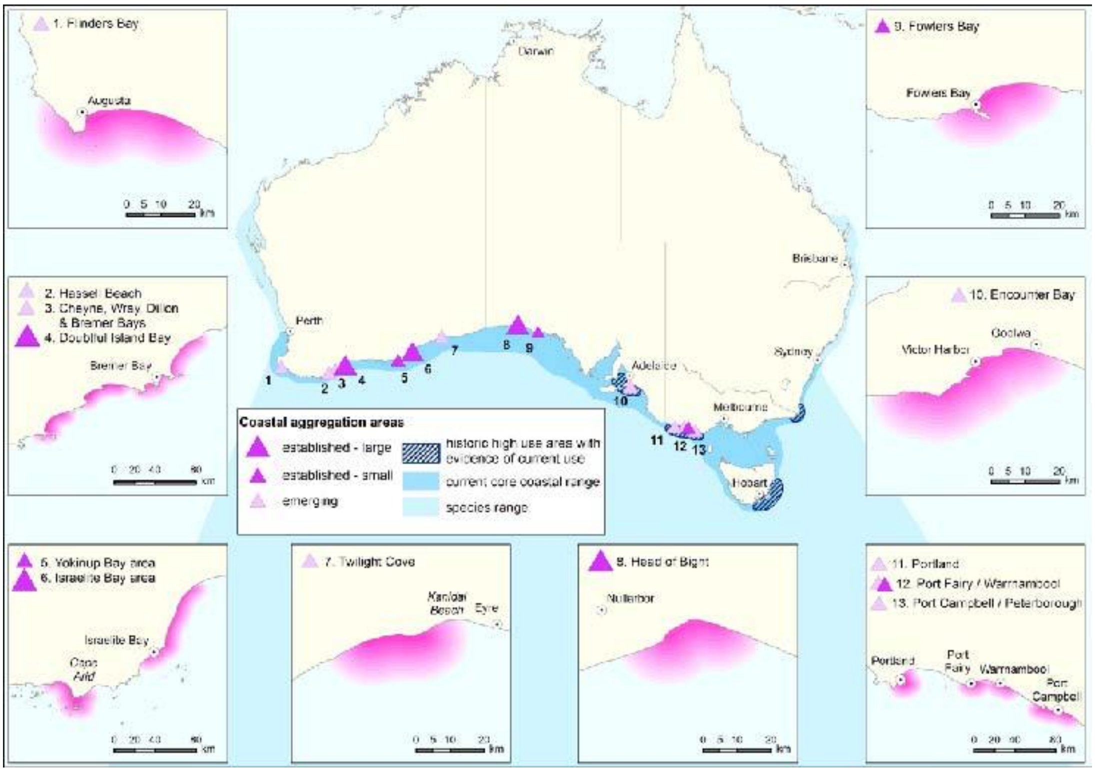


Figure B-10-13: Aggregation areas for southern right whales (DSEWPaC, 2012)

Southern right whales in Australian waters were until recently considered to be one population. It is possible, based on differentiation in mtDNA haplotype but not nuclear gene frequencies, that south-east Australian right whales may be demographically separate from those in south-west Australia, although some genetic transfer is known to occur. The ‘western’ Australian sub-population occupies areas between Cape Leeuwin in Western Australia and Ceduna in South Australia, with an estimated population size of 2,500 individuals. The ‘eastern’ sub-population, consisting of fewer than 300 individuals, can be found along the south eastern coast, including Tasmania and rarely further north than Sydney. Despite the ‘western’ sub-population showing signs of recovery, the ‘eastern’ sub-population is not (Charlton, 2014).

Southern right whales have few natural predators. Calves, juveniles or weakened adults may be killed by sharks, which are common in some Australian calving grounds, or killer whales. Adult southern right whales rarely strand, but small numbers of calves are regularly found dead or stranded near calving grounds (Commonwealth of Australia, 2012).

The foraging ecology of southern right whales is poorly understood, and observations of feeding whales are rare. Southern right whales from Australian populations probably forage between about 40°S and 65°S, generally south of Australia. Feeding whales have been observed in the region of the Sub-Tropical Front 41–44°S in January and December. In that region they mainly consume copepods, while at higher latitudes (south of 50°S), krill is the main prey item. Coastal Australian waters are not generally used for feeding.

As a highly mobile migratory species, southern right whales travel thousands of kilometres between habitats used for essential life functions. Movements along the Australian coast are reasonably well understood, but little is known of migration travel, non-coastal movements and offshore habitat use. Exactly where southern right whales approach and leave the Australian coast from, and to, offshore areas remain unknown (Gill et al., 2015). A defined near-shore coastal migration corridor is unlikely given the absence of any predictable directional movement of southern right whales such as that observed for humpback whales. A predominance of westward movements amongst long-range photo-identification re-sightings may indicate a seasonal westward movement in coastal habitat. More-or-less direct approaches and departures to the coast are also likely. Southern right whales are thought to be solitary during migration or accompanied by a dependent calf or occasionally a yearling offspring.

On the Australian coast, individual southern right whales use widely separated coastal areas (200–1,500 km apart) within a season, indicating substantial coast-wide movement. The longest movements are undertaken by non-calving whales, though calving whales have also been recorded at locations up to 700 km apart within a single season. Such movements indicate that connectivity of coastal habitat is important for southern right whales. Both non-calving and calving whales also move occasionally between Australia and sub-Antarctic New Zealand coastal habitat between years. The winter distribution of whales not appearing on the Australian coast is unknown. It is thought that fewer than 10% of females calving on the coast in any one year use the waters off Victoria, South Australia, NSW and Tasmania (DotEE, 2019c).

Aerial surveys of western Bass Strait and eastern Great Australian Bight undertaken by Gill et al., (2015) detected southern right whales between May and September. A survey in early November 2010 did not observe any whales in the Warrnambool area and it was assumed that cows and calves had already left the calving and aggregation areas (M. Watson, pers. comm., 2010). No southern right whales were encountered during Origin's Enterprise 3D seismic survey undertaken during November 2014 (RPS, 2014), or during spotter flights of the coastline undertaken prior to the survey in late October 2014.

Humpback whale

Humpback whales (*Megaptera novaeangliae*) are present around the Australian coast in winter and spring. Humpbacks undertake an annual migration between the summer feeding grounds in Antarctica to their winter breeding and calving grounds in northern tropical waters. Along the southeast coast of Australia, the northern migration starts in April and May while the southern migration peaks around November and December (DotEE, 2019l). A discrete population of humpback whales have been observed to migrate along the west coast of Tasmania and through Bass Strait, and these animals may pass through the operational area. The exact timing of the migration period varies between years in accordance with variations in water temperature, extent of sea ice, abundance of prey, and location of feeding grounds (DotEE, 2019l). Feeding occurs where there is a high krill density, and during the migration this primarily occurs in Southern Ocean waters south of 55°S (DotEE, 2019l).

Known feeding, resting or calving grounds for humpback whales in the EMBA, although feeding may occur opportunistically where sufficient krill density is present (Commonwealth of Australia, 2015). The nearest BIA which is important habitat for migrating humpback whales is Twofold Bay, a resting area off the NSW coast (Commonwealth of Australia, 2015).

During Origin's Enterprise 3D seismic survey undertaken during early November 2014, 16 humpback whales were sighted (RPS, 2014).

The recovery of humpback whale populations following whaling has been rapid. The Australian east coast humpback whale population, which was hunted to near-extinction in the 1950s and early 1960s, had increased to 7,090±660 (95% CI) whales by 2004 with an annual rate of increase of 10.6±0.5% (95% CI) between 1987–2004 (Noad et al., 2011). The available estimates for the global population total more than 60,000 animals, and global population is categorised on the IUCN Red List as Least Concern.

Sei whale

Sei whales are considered a cosmopolitan species, ranging from polar to tropical waters, but tend to be found more offshore than other species of large whales. They show well defined migratory movements between polar, temperate and tropical waters. Migratory movements are essentially north-south with little longitudinal dispersion. Sei whales do not penetrate the polar waters as far as the blue, fin, humpback and minke whales (Horwood, 1987), although they have been observed very close to the Antarctic continent.

Sei whales move between Australian waters and Antarctic feeding areas; subantarctic feeding areas (e.g. Subtropical Front); and tropical and subtropical breeding areas. The proportion of the global population in Australian waters is unknown as there are no estimates for sei whales in Australian waters.

Sei whales feed intensively between the Antarctic and subtropical convergences and mature animals may also feed in higher latitudes. Sei whales feed on planktonic crustaceans, in particular copepods and amphipods. Below the Antarctic convergence sei whales feed exclusively upon Antarctic krill (*Euphausia superba*).

Sei whales have been infrequently recorded in Australian waters. Sei whales have been sighted 20–60 km offshore on the continental shelf in the Bonney Upwelling (Miller et al., 2012) where opportunistic feeding has been observed between November and May (Gill et al., 2015). Sei whales were reported 200 nautical miles (Nm) south-west of Port Lincoln in December 1995 and a concentration of sei whales were reported at the western end of Bass Strait (Kato et al., 1996). There are no known mating or calving areas in Australian waters. The sei whale is likely to be an uncommon visitor to the EMBA.

The sei whale has been infrequently recorded between November and May (but not during April) during aerial surveys in the region (Gill et al., 2015). There are no known mating or calving areas in Australian waters.

Fin whale

Fin whales are considered a cosmopolitan species and occur from polar to tropical waters and are rarely in inshore waters. They show well defined migratory movements between polar, temperate and tropical waters. Migratory movements are essentially north–south with little longitudinal dispersion. Fin whales regularly enter polar waters. Unlike blue whales and minke whales, fin whales are rarely seen close to ice, although recent sightings have occurred near the ice edge of Antarctica.

There are stranding records of this species from most Australian states, but they are considered rare in Australian waters (Bannister et al., 1996). The fin whale has been infrequently recorded between November and Feb during aerial surveys in the region (Gill et al., 2015).

Fin whales have been sighted inshore in the proximity of the Bonney Upwelling, Victoria, along the continental shelf in summer and autumn months (Gill 2002). Fin whales in the Bonney Upwelling are sometimes seen in the vicinity of blue whales and sei whales.

Fin whales were sighted, and feeding was observed between November-May (upwelling season) during aerial surveys conducted between 2002-2013 in South Australia (Gill et al., 2015). This is one of the first documented records these whales feeding in Australian waters, suggesting that the region may be used for opportunistic baleen whale feeding (Gill et al., 2015).

The sighting of a cow and calf in the Bonney Upwelling in April 2000 and the stranding of two fin whale calves in South Australia suggest that this area may be important to the species' reproduction, perhaps as a provisioning area for cows with calves (Morrice et al., 2004). However, there are no defined mating or calving areas in Australia waters.

As there are no BIAs for the fin whale in the EMBA, they are likely to be uncommon visitors to the EMBA.

Pygmy right whale

The pygmy right whale (*Caperea marginata*) is a little-studied baleen whale species that is found in temperate and sub-Antarctic waters in oceanic and inshore locations. The species, which has never been hunted commercially, is thought to have a circumpolar distribution in the Southern Hemisphere between about 30°S and 55°S. Distribution appears limited by the surface water temperature as they are almost always found in waters with temperatures ranging from 5° to 20°C (Baker, 1985) and staying north of the Antarctic Convergence. There are few confirmed sightings of pygmy right whales at sea (Reilly et al., 2008a). The largest reported group was sighted (100+) just south-west of Portland in June 2007 (Gill et al., 2008).

Species distribution in Australia is found close to coastal upwellings and further offshore it appears that the Subtropical Convergence may be important for regulating distribution (Bannister et al., 1996). Key locations include south-east Tasmania, Kangaroo Island (SA) and southern Eyre Peninsula (SA) close to upwelling habitats rich in marine life and zooplankton upon which it feeds (Bannister et al., 1996).

The pygmy right whale has been observed in surveys in the region however Origin Energy did not observe it during the 2010 Speculant MSS and 2014 Enterprise MSS. Also, there are no BIAs identified in the EMBA. Therefore, it is likely to be an uncommon visitor in the EMBA.

Killer whale

Killer whales (*Orcinus orca*) are thought to be the most cosmopolitan of all cetaceans and appear to be more common in cold, deep waters; however, they have often been observed along the continental slope and shelf particularly near seal colonies (Bannister et al., 1996). The killer whale is widely distributed from polar to equatorial regions and has been recorded in all Australian waters with concentrations around Tasmania. The only recognised key locality in Australia is Macquarie Island and Heard Island in the Southern Ocean (Bannister et al., 1996). The habitat of killer whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters (DotEE, 2019d).

Killer whales are top-level carnivores. Their diet varies seasonally and regionally. The specific diet of Australian killer whales is not known, but there are reports of attacks on dolphins, young humpback whales, blue whales, sperm whales, dugongs and Australian sea lions (Bannister et al., 1996). In Victoria, sightings peak in June/July, where they have been observed feeding on sharks, sunfish, and Australian fur seals (Morrice, 2004; Mustoe, 2008).

The breeding season is variable, and the species moves seasonally to areas of food supply (Bannister et al., 1996; Morrice et al., 2004).

The killer whale has been observed within the region however there are no BIAs in the EMBA. Therefore, it is likely that they would be uncommon visitors in the EMBA.

Minke whale

The minke whale (*Balaenoptera acutorostrata*) is a widely distributed baleen whale that has been recorded in all Australian waters except the Northern Territory. The whales can be found inshore although they generally prefer deeper waters. In summer they are abundant feeding throughout the Antarctic south of 60°S but appear to migrate to tropical breeding grounds between 10°S and 20°S during the Southern Hemisphere winter (Kasamatru, 1998; Reilly et al., 2008). Although the exact location of breeding grounds is unknown, mating occurs between August to September with calving between May and July (Bannister et al., 1996). A few animals have been sighted during aerial surveys of the Bonney upwelling. The minke whale has been observed within the region however there are no BIAs in the EMBA. Therefore, it is likely that they would be uncommon visitors in the EMBA.

Antarctic minke whale

The Antarctic minke whale (*Balaenoptera bonaerensis*) has been found in all Australian states except the Northern Territory and occupies cold temperate to Antarctic offshore and pelagic habitats between 21°S and 65°S (Bannister et al., 1996). In summer the species is found in pelagic waters from 55°S to the Antarctic ice edge. During winter the species retreat to breeding grounds between 10-30°S, occupying oceanic waters exceeding 600 m depth and beyond the continental shelf break (DotEE, 2019e). Mating occurs from June through December, with a peak in August and September and calving occurs during late May and early June in warmer waters north of the Antarctic Convergence (DotEE, 2019e). The species primarily feeds in the Antarctic during summer on Antarctic krill and does not appear to feed much while in the breeding grounds of lower latitudes (DotEE, 2019e).

The Antarctic minke whale has been observed within the region however there are no BIAs in the EMBA. Therefore, it is likely that they would be uncommon visitors in the EMBA.

Long-finned pilot whale

The long-finned pilot whale (*Globicephala melas*) is distributed throughout the northern and southern hemispheres in circumpolar oceanic temperate and subantarctic waters containing zones of higher productivity along the continental slope. They sometimes venture into the shallower waters of the shelf (<200 m) in pursuit of prey species. Stomach contents confirm that squid are the main prey of long-finned pilot whales in Australian waters, although some fish are also taken (DotEE, 2019f). No key localities have been identified in Australia (Bannister et al., 1996) however they are considered reasonably abundant (DotEE, 2019f).

There is some (inconclusive) evidence that suggests the species moves along the edge of the continental shelf in southern Australian waters (Bannister et al., 1996) in response to prey abundance at bathymetric upper slopes and canyons (DoE, 2016g). Records from Tasmania indicate mating occurs in spring and summer with 85% of calves born between September and March although births do occur throughout the year.

No calving areas are known in Australian waters (DotEE, 2019f).

The long-finned pilot whale has been identified in surveys over the Bass Strait and eastern Great Australian Bight; however, there are no BIAs in the EMBA. During works undertaken by Origin Energy, long-finned pilot whales have been seen sporadically, such as, a sighting of approximately 30 whales occurred during the 2014 Enterprise MSS. It is likely that they would be uncommon visitors in to the EMBA.

Sperm whale

The sperm whale (*Physeter macrocephalus*) has a worldwide distribution and has been recorded in all Australian states. Sperm whales tend to inhabit offshore areas with a water depth of 600 m or greater and are uncommon in waters less than 300 m deep (DotEE, 2019f). Key locations for the species include the area between Cape Leeuwin to Esperance (WA); southwest of Kangaroo Island (SA), deep waters of the Tasmanian west and south coasts, areas off southern NSW (e.g., Wollongong) and Stradbroke Island (Qld) (DotEE, 2019f). Concentrations of sperm whales are generally found where seabeds rise steeply from a great depth (i.e., submarine canyons at the edge of the continental shelf) associated with concentrations of food such as cephalopods (DotEE, 2019f).

Females and young males are restricted to warmer waters (i.e., north of 45oS) and are likely to be resident in tropical and sub-tropical waters year-round. Adult males are found in colder waters and to the edge of the Antarctic pack ice. In southern Western Australian waters sperm whales move westward during the year. For species in oceanic waters, there is a more generalised movement of sperm whales' southwards in summer and northwards in winter (DotEE, 2019f).

Sperm whales are prolonged and deep divers often diving for over 60minutes (Bannister et al., 1996) however studies have observed sperm whales do rest at, or just below, surface for extended periods (>1 hr) (Gannier et al., 2002). In addition, female and juvenile sperm whales in temperate waters have been observed to spend several hours a day at surface resting or socialising (Hastie et al., 2003).

The sperm whale has been observed in the region, however the closest recognised BIA for foraging is further east near Kangaroo Island in South Australia. Therefore, it is likely they would be uncommon visitors in the EMBA.

Southern right whale dolphin

The southern right whale dolphin (*Lissodelphis peronnii*) is a pelagic species found in southern Australian waters but generally well offshore in deep water or on the outer edges of the continental shelf between the subtropical and subantarctic convergence (DotEE, 2019h). No key localities have been identified in Australian waters however preferred water temperatures range from approximately 2-20°C (DotEE, 2019h). Of the limited southern right whale dolphin stomachs examined, myctophids and other mesopelagic fish, squid and crustaceans have been recorded, and euphausiids are also thought to be potential prey (DotEE, 2019h). It is unknown whether the southern right whale dolphin is a surface or deep-layer feeder (Bannister et al., 1996).

Calving areas are not known, however there is evidence that the calving season occurs between November to April (DotEE, 2019h).

The Southern right whale has been observed in the region; however, no BIAs have been identified in the EMBA. Therefore, it is likely they would be uncommon visitors in the EMBA.

Dusky dolphin

The dusky dolphin (*Lagenorhynchus obscures*) is rare in Australian waters and has been primarily reported across southern Australia from Western Australia to Tasmania with a handful of confirmed sightings near Kangaroo Island and off Tasmania (DotEE, 2019i). Only 13 reports of the dusky dolphin have been made in Australia since 1828, and key locations are yet to be identified (Bannister et al., 1996). The species is primarily found from approximately 55°S to 26°S, though sometimes further north associated with cold currents. They are considered to be primarily an inshore species but can also be oceanic when cold currents are present (DotEE, 2019i).

Bottlenose dolphin

Bottlenose dolphin (*Tursiops truncates*) has a worldwide distribution from tropical to temperate waters. While the species is primarily coastal, they are also found inshore, on the shelf and open oceans.

They are associated with many types of substrate and habitats, including mud, sand, seagrasses, mangroves and reefs (DotEE, 2019j). Bottlenose dolphins are known to associate with several cetacean species such as pilot whales, white-sided, spotted, rough-toothed and Risso's dolphins, and humpback and right whales (DotEE, 2019j).

There are two forms of bottlenose dolphin, a nearshore form and an offshore form. The nearshore form occurs in southern Australia including the Otway Basin area, while the offshore form is found north of Perth and Port Macquarie in NSW. Most populations are relatively discrete and reside in particular areas, such as individual resident populations in Port Phillip Bay, Westernport Bay, Spencer Gulf, Jervis Bay and Moreton Bay. There may be some migration and exchange between the populations, but it is likely that most encountered near the Victorian coasts are local residents.

The bottlenose dolphin has been observed in the region; however, no BIAs have been identified in the EMBA. Therefore, it is likely they would be uncommon visitors in the EMBA.

Common dolphin

The common dolphin (*Delphinus delphis*) is an abundant species, widely distributed from tropical to cool temperate waters, and generally further offshore than the bottlenose dolphin, although small groups may venture close to the coast and enter bays and inlets. They have been recorded in waters off all Australian states and territories. Stranding statistics indicate that common dolphins are active in Bass Strait at all times of the year, though less so in winter (DotEE, 2019k).

Common dolphins are usually found in areas where surface water temperatures are between 10°C and 20°C, and in habitats also inhabited by small epipelagic fishes such as anchovies and sardines.

In many areas around the world common dolphins show shifts in distribution and abundance, suggesting seasonal migration. The reason for this seasonal migration is unknown however in New Zealand the shift appears to be correlated with sea surface temperature and in South Africa, the species occurrence appears to be correlated with the annual sardine run (DotEE, 2019k). They are abundant in the Bonney Upwelling during the upwelling season, and very scarce outside the season.

Risso's dolphin

Risso's dolphin (*Grampus griseus*) is a widely distributed species found in deep waters of the continental slop and outer shelf from the tropics to temperate regions. The species prefer warm temperate to tropical waters with depths greater than 1,000 m, although they do sometimes extend their range into cooler latitudes in summer (Bannister et al., 1996). They are thought to feed on cephalopods, molluscs and fish. Risso's dolphin has been observed in the region, however no BIAs have been identified in the EMBA. Therefore, it is likely they would be uncommon visitors in the EMBA.

Indian Ocean bottle-nose dolphin

Indian Ocean bottlenose dolphins are found in tropical and sub-tropical coastal and shallow offshore waters of the Indian Ocean, Indo-Pacific Region and the western Pacific Ocean bottlenose dolphins are distributed continuously around the Australian mainland, but the taxonomic status of many populations is unknown. Indian Ocean bottlenose dolphins have been confirmed to occur in estuarine and coastal waters of eastern, western and northern Australia and it has also been suggested that the species occurs in southern Australia (Kemper, 2004).

In south-eastern Australia, inshore Indian Ocean bottlenose dolphins show a high degree of site fidelity to some local areas and appear to belong to relatively small communities or populations (Möller et al., 2002).

Appendix B.3.5.4 Pinnipeds

The PMST report identified two pinnipeds that potentially occur in the EMBA (Table B-10-14).

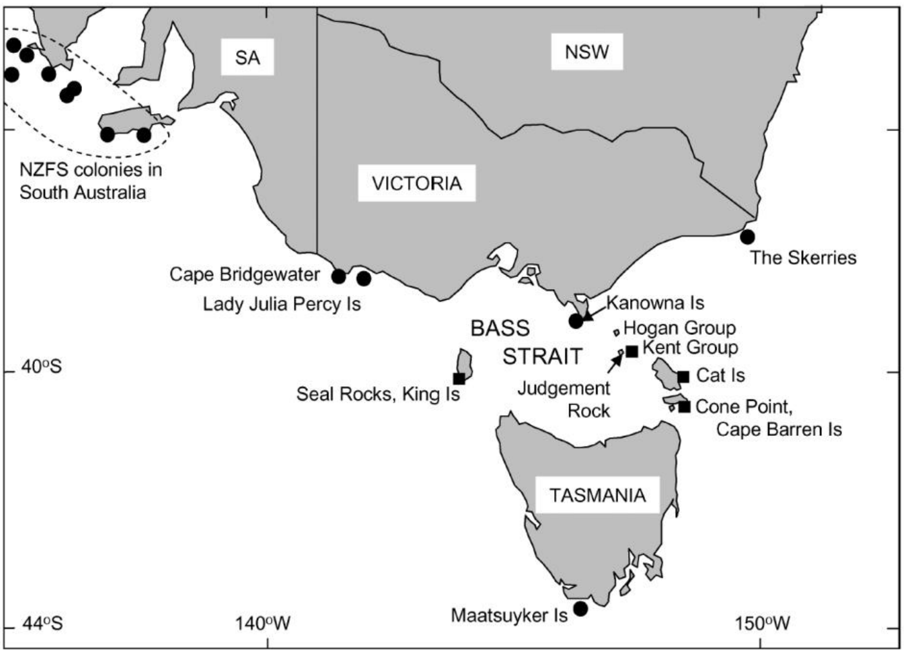
Table B-10-14: Listed pinniped species identified in the PMST search

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
New Zealand fur seal	*Arctocephalus forsteri*	-	-	L	SHM
Australian fur seal	*Arctocephalus pusillus*	-	-	L	SHM
Listed Marine L: Listed		Likely Presence SHM: Species or species habitat may occur within area.			

New Zealand fur seal

New Zealand fur seals (*Arctocephalus forsteri*) are found in the coastal waters and offshore islands of South and Western Australia, Victoria, New South Wales and New Zealand. Population studies for New Zealand fur seals in Australia carried out in 1990 estimated an increasing population of about 35,000. The species breeds in southern Australia at the Pages Islands and Kangaroo Island, which produces about 75% of the total pups in Australia. Small populations are established in Victorian coastal waters including at Cape Bridgewater near Portland, Lady Julia Percy Island near Port Fairy, Kanowna Island (near Wilsons Promontory) and The Skerries in eastern Victoria.

Figure B-10-14 illustrates the current and historic distribution of New Zealand fur seal colonies (Kirkwood et al., 2009). Pups are born from mid-November to January, with most pups born in December (Goldsworthy, 2008). As there are not breeding or haul out sites within the EMBA it is unlikely that New Zealand fur seals would be present in the EMBA.



Filled circles = early 1800s distribution. Filled squares = current distribution

Figure B-10-14: Locations of NZ fur seal breeding colonies in the early 1800s and current colonies (Kirkwood et al., 2009)

Australian fur seal

Australian fur seals (*A. pusillus*) breed on islands of the Bass Strait but range throughout waters off the coasts of South Australia, Tasmania, Victoria and New South Wales. Numbers of this species are believed to be increasing as the population recovers from historic hunting (Hofmeyr et al., 2008). The species is endemic to south-eastern Australian waters.

In Victorian State waters they breed on offshore islands, including Lady Julia Percy Island, Seal Rocks in Westernport Bay, Kanowna and Rag Islands off the coast of Wilson's Promontory and The Skerries off Wingan Inlet in Gippsland. There are important breeding sites on Lady Julia Percy Island and Seal Rocks, with 25% of the population occurring at each of these islands. Their preferred breeding habitat is a rocky island with boulder or pebble beaches and gradually sloping rocky ledges.

Haul out sites with occasional pup births are located at Cape Bridgewater, at Moonlight Head, on various small islands off Wilsons Promontory and Marengo Reef near Apollo Bay. Australian fur seals are present in the region all year, with breeding taking place during November and December.

Research being undertaken at Lady Julia Percy Island indicates that adult females feed extensively in the waters between Portland and Cape Otway, out to the 200 m bathymetric contour. Seal numbers on the island reach a maximum during the breeding season in late October to late December. By early December, large numbers of lactating females are leaving for short feeding trips at sea and in late December there is an exodus of adult males. Thereafter, lactating females continue to alternate between feeding trips at sea and periods ashore to suckle their pups. Even after pups begin to venture to sea, the island remains a focus, and at any time during the year groups may be seen ashore resting (Robinson et al., 2008; Hume et al., 2004; Arnould & Kirkwood, 2007).

During the summer months, Australian fur seals travel between northern Bass Strait islands and southern Tasmania waters following the Tasmanian east coast, however, lactating female fur seals and some territorial males are restricted to foraging ranges within Bass Strait waters. Lactating female Australian fur seals forage primarily within the shallow continental shelf of Bass Strait and Otway on the benthos at depths of between 60 - 80 m and generally within 100 - 200 km of the breeding colony for up to five days at a time.

Male Australian fur seals are bound to colonies during the breeding season from late October to late December, and outside of this they time forage further afield (up to several hundred kilometres) and are away for long periods, even up to nine days (Kirkwood et al., 2009; Hume et al., 2004).

As there are not breeding or haul out sites within the EMBA it is unlikely that Australian fur seal would be present in the EMBA in significant numbers.

Appendix B.3.5.5 Marine reptiles

The PMST report identified three marine turtle species that potentially occur in the EMBA (Table B-10-15). All three species of marine turtles are protected by the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017b). The PMST report identifies that feeding is known to occur in the EMBA for all species. There are no identified BIAs for these reptiles in the EMBA.

Table B-10-15: Listed turtle species identified in the PMST

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
Loggerhead turtle	*Caretta caretta*	E	M	L	SHL
Green turtle	*Chelonia mydas*	V	M	L	SHL
Leatherback turtle	*Dermochelys coriacea*	E	M	L	SHL

Listed Threatened
E: Endangered
V: Vulnerable
Listed Migratory
M: Migratory
Listed Marine
L: Listed

Likely Presence
SHL: Species or species habitat likely to occur within area.

Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) is globally distributed in tropical, sub-tropical waters and temperate waters. The loggerhead is a carnivorous turtle, feeding primarily on benthic invertebrates in habitat ranging from nearshore to 55 m depth (Plotkin et al., 1993).

The main Australian breeding areas for loggerhead turtles are generally confined to southern Queensland and Western Australia (Cogger et al., 1993). Loggerhead turtles will migrate over distances in excess of 1,000 km but show a strong fidelity to their feeding and breeding areas (Limpus, 2008). Loggerhead turtles forage in all coastal states and the Northern Territory, but are uncommon in South Australia, Victoria and Tasmania (Commonwealth of Australia, 2017b). Due to waters depths it is unlikely loggerhead turtles would be present in the EMBA.

Green turtle

Green turtles (*Chelonia mydas*) nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms, although individuals can stray into temperate waters as vagrant visitors. Green turtles spend their first 5-10 years drifting on ocean currents. During this pelagic (ocean-going) phase, they are often found in association with drift lines and floating rafts of Sargassum. Green turtles are predominantly found in Australian waters off the Northern Territory, Queensland and Western Australian coastlines, with limited numbers in New South Wales, Victoria and South Australia. There are no known nesting or foraging grounds for green turtles offshore Victoria; they occur only as rare vagrants in these waters (DotEE, 2019m), therefore it is expected they would only be occasional visitors in the EMBA.

Leatherback turtle

The leatherback turtle (*Dermochelys coriacea*) is a pelagic feeder found in tropical, sub-tropical and temperate waters throughout the world. Unlike other marine turtles, the leatherback turtle utilises cold water foraging areas, with the species most commonly reported foraging in coastal waters between southern Queensland and central NSW, southeast Australia (Tasmania, Victoria and eastern SA), and southern WA (Commonwealth of Australia, 2017b). This species is an occasional visitor to the Otway shelf and has been sighted on a number of occasions during aerial surveys undertaken by the Blue Whale Study Group, particularly to the southwest of Cape Otway. It is mostly a pelagic species, and away from its feeding grounds is rarely found inshore (Commonwealth of Australia, 2017b).

No major nesting has been recorded in Australia, with isolated nesting recorded in Queensland and the Northern Territory. The leatherback turtle is expected to be only an occasional visitor in the EMBA.

Appendix B.4 Socio-economic and cultural environment

This section describes the socio-economic environment within the EMBA.

Appendix B.4.1 Shipping

The south-east marine region is one of the busiest shipping regions in Australia and Bass Strait is one of Australia's busiest shipping routes (Figure B-10-15). Commercial vessels use the route when transiting between ports on the east, south and west coasts of Australia, and there are regular passenger and cargo services between mainland Australia and Tasmania.

Agricultural products and woodchips are transported from the Port of Portland to receiving ports in the Gulf of St Vincent, South Australia, and through Bass Strait to Melbourne and Sydney (NOO, 2014). The Port of Melbourne has over 3,300 vessels calling in to the port every year and is anticipating a doubling in container trade in the next decade (Port of

Melbourne, 2012). Bass Strait is also transited by commercial vessels that may not call into ports on the south coast. There are also numerous minor shipping routes in the area, such as those that service King Island. Grassy is the main shipping port on King Island and is the destination for a weekly shipping service from Melbourne and Devonport.

Appendix B.4.2 Petroleum exploration

Petroleum exploration has been undertaken within the Otway Basin since the early 1960s. Gas reserves of approximately 2 trillion cubic feet (tcf) have been discovered in the offshore Otway Basin since 1995, with production from five gas fields using 700 km of offshore and onshore pipeline. Up to 2015, the DEDJTR reports that 23 PJ of liquid hydrocarbons (primarily condensate) has been produced from its onshore and offshore basins, with 65 PJ remaining, while 85 PJ of gas has been produced (Victoria and South Australia), with 1,292 PJ remaining.

Appendix B.4.3 Petroleum production

There is no non-Beach oil and gas infrastructure within the operational area. The Cooper Energy Casino and Henry gas fields and Casino-Henry pipeline and the Minerva gas field and pipeline are within the northern portion of the EMBA (Figure B-10-16).

Appendix B.4.4 Tourism

Consultation has identified that the key areas of tourism in the region include land-based sightseeing from the Great Ocean Road and lookouts along that road, helicopter sightseeing, private and chartered vessels touring into the Twelve Apostles Marine Park, diving and fishing. Land-based tourism in the region peaks over holiday periods and in 2011, Tourism Victoria reported a total of approximately 8 million visitors to the Great Ocean Road region.

Local vessels accessing the area generally launch from Boat Bay in the Bay of Islands or from Port Campbell. Given the available boat launching facilities in the area (Peterborough and Port Campbell), and the prevailing sea-state of the area, vessel-based tourism is limited.

Appendix B.4.5 Recreational diving

Recreational diving occurs along the Otway coastline. Popular diving sites near Peterborough include a number of shipwrecks such as the Newfield, which lies in 6 m of water and the Schomberg in 8 m of water. Peterborough provides a number of good shore dives at Wild Dog Cove, Massacre Bay, Crofts Bay and the Bay of Islands. In addition, there is the wreck of the Falls of Halladale (4-11 m of water) which can be accessed from shore or via boat.

Consultation with local vessel charterers and providers of SCUBA tank fills has confirmed that diving activity is generally concentrated around The Arches Marine Sanctuary and the wreck sites of the Loch Ard and sometimes at the Newfield and Schomberg shipwrecks. Diving activity peaks during the rock lobster season with the bulk of recreational boats accessing the area launching from Boat Bay at the Bay of Islands or Port Campbell.

Appendix B.4.6 Recreational fishing

Recreational fishing is popular in Victoria and is largely centred within Port Phillip Bay and Western Port, although beach- and boat-based fishing occurs along much of the Victorian coastline. Recreational fishing is unlikely to occur in the EMBA due to the distance offshore.

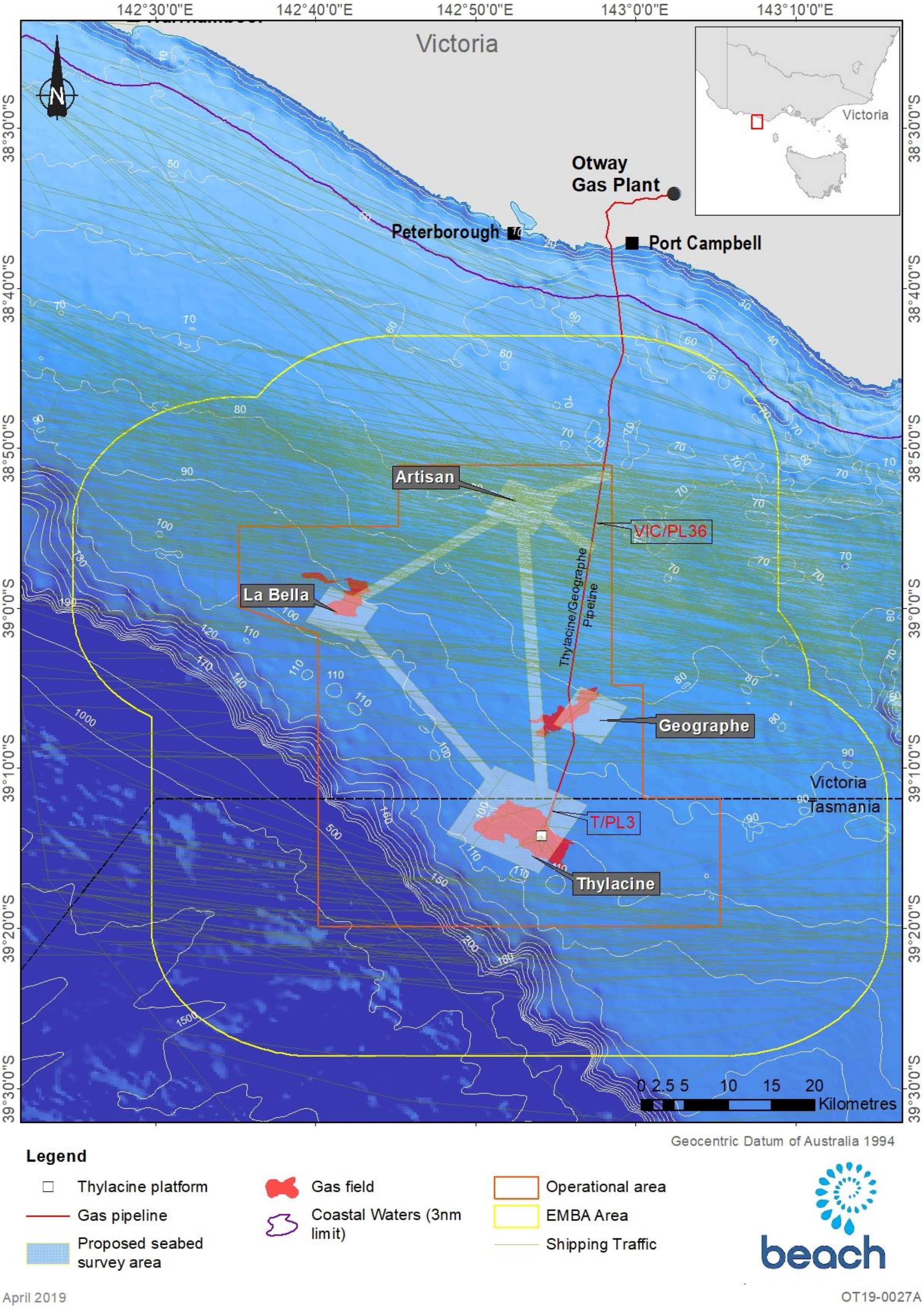


Figure B-10-15: Map of the main shipping lanes in the Bass Strait

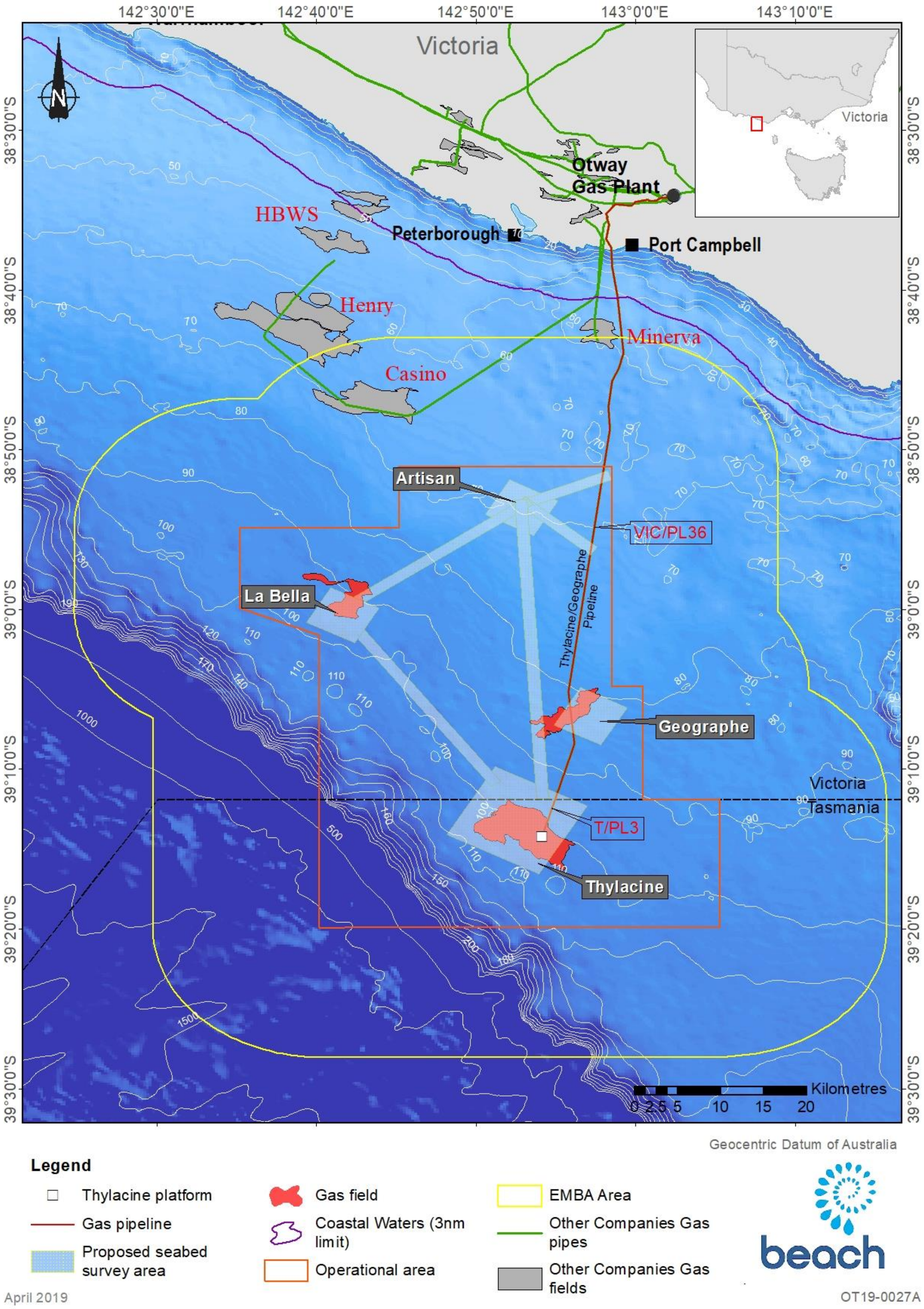


Figure B-10-16: Offshore oil and gas infrastructure in the EMBA

Appendix B.4.7 Commonwealth managed fisheries

A review of the AFMA website identified that the following Commonwealth managed fisheries overlap the EMBA:

- Bass Strait Central Zone Scallop Fishery (Bass Strait CZSF)
- Eastern Tuna and Billfish Fishery (ETBF)
- Skipjack Tuna Fishery
- Small Pelagic Fishery (SPF)
- Southern Bluefin Tuna Fishery (SBTF)
- Southern and Eastern Scalefish and Shark Fishery (SESSF)
- Southern Squid Jig Fishery.

Of these fisheries, the ETBF (Figure B-10-17), SESSF (Figure B-10-18) and Southern Squid Jig Fishery (Figure B-10-19) have catch effort within the EMBA based on ABARES reports 2013 – 2017 (Patterson et al. 2018, 2017, 2016, 2015 and Georgeson et al. 2014) (Table B-10-16). The Skipjack Fishery is not currently active and management arrangements for the fishery are under review.

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery is included in Table B-10-16.

Table B-10-16: Commonwealth managed fisheries within the EMBA

Fishery	Target species	Description	Fishing Effort EMBA
Bass Strait Central Zone Scallop Fishery	Scallops	Fishery operates in the Bass Strait between the Victorian and Tasmanian and starts at 20 Nm from their respective coastlines. Fishing effort is concentrated around King and Flinders Islands. Currently 11 active boats using towed dredges. Fishing season is 1 April to 31 December. Actual catch in 2016 was 2886 tonnes. The major landing ports in Victoria are Apollo Bay and Queenscliff. Total fishery value in 2015 was A$2.8 million. Fishing mortality: not subject to overfishing. Biomass: Not over fished. There has been no fishing effort in the EMBA based on ABARES data 2013 – 2017.	No

Fishery	Target species	Description	Fishing Effort EMBA
Eastern Tuna and Billfish Fishery	Albacore tuna Bigeye tuna Yellowfin tuna Broadbill swordfish Striped marlin	A longline and minor line fishery that operates in water depths > 200 m from Cape York to Victoria. Fishery effort is typically concentrated along the NSW coast and southern Queensland coast. No Victorian ports are used. In 2017 there was some fishing effort in Victoria at low levels. The number of active vessels has decreased within the fishery from around 150 in 2002 to 39 in 2017. Actual catch in the 2016-17 season was 4615 tonnes. Total fishery value in 2016-17 was A$35.7 million. Fishing mortality: not subject to overfishing. Biomass: Not over fished. There has been fishing effort in the T/30P title within the operational area in 2017 based on ABARES data 2013 – 2017 (Figure B-10-17). There has been fishing effort within the EMBA in 2017 based on ABARES data 2013 – 2017.	Yes
Skipjack Tuna Fishery (Eastern)	Skipjack tuna	The Skipjack Tuna Fishery is not currently active and the management arrangements for this fishery are under review. There has been no catch effort in this fishery since the 2008 -2009 season.	No
Small Pelagic Fishery (Western sub-area)	Jack mackerel Blue mackerel Redbait Australian sardine	The Small Pelagic Fishery extends from the Queensland/New South Wales border, typically outside 3 Nm, around southern Australia to near Lancelin, north of Perth. Fishers use midwater trawls and purse seine nets. Geelong is a major landing port. Total retained catch of the four target species was 5713 tonnes in the 2017-18 season. Fishery effort generally concentrated in the near-shore Great Australian Bight to the west and south of Port Lincoln. Fishing mortality: not subject to overfishing. Biomass: Not over fished. There has been no fishing effort in the EMBA based on ABARES data 2013 – 2017.	No
Southern and Eastern Scalefish and Shark Fishery (SESSF) (Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors)	Blue grenadier Tiger flathead Pink ling Silver warehou Gummy shark Eastern school whiting	The Southern and Eastern Scalefish and Shark Fishery stretches south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia. The EMBA is within the Commonwealth South East Trawl Sector, Scalefish Hook Sector and the Shark Hook and Shark Gillnet Sectors. A multi-sector, multi-species fishery that uses a range of gear year-round. Fishing is generally concentrated along the 200 m bathymetric contour. Much of the western portion of the EMBA is closed to shark hook and gillnet fishing, and nearly all of the EMBA is closed to scalefish auto longline fishing. In 2016-17, the fishery value was A$46.4 million. Fishing mortality: not subject to overfishing. Biomass: Not over fished. There has been fishing effort in the EMBA based on ABARES data 2013 – 2017.	Yes
Southern Bluefin Tuna Fishery	Southern bluefin tuna	The Southern Bluefin Tuna Fishery covers the entire sea area around Australia, out to 200 Nm from the coast. Southern bluefin tuna are also commonly caught off the New South Wales coastline. In this area, fishers catch these fish using the longline fishing method. A pelagic longline and purse seine fishery that was worth $38.6 million in 2016-17 (actual catch was 5334 tonnes). The fishery operates year-round. Fishery effort is generally concentrated in the Great Australian Bight and off the southern NSW coast. Fishing mortality: not subject to overfishing. Biomass: Over fished. There has been no fishing effort in the EMBA based on ABARES data 2013 – 2017.	No

Fishery	Target species	Description	Fishing Effort EMBA
Southern Squid Jig Fishery	Gould's squid (arrow squid)	A single species fishery that operates year-round. Portland and Queenscliff are the major Victorian landing ports. Fishing effort is generally concentrated along the 200 m bathymetric contour with highest fishing intensity south of Portland and Warrnambool. In 2016-17, the actual catch of 828 tonnes was worth A$2.24 million. In 2016-17 there were eight active vessels in the fishery. There has been fishing effort in the EMBA based on ABARES data 2013 – 2017.	Yes

Data/information sources: Australian Fisheries Management Authority (www.afma.gov.au), ABARES Fishery Status Reports 2014 to 2018.

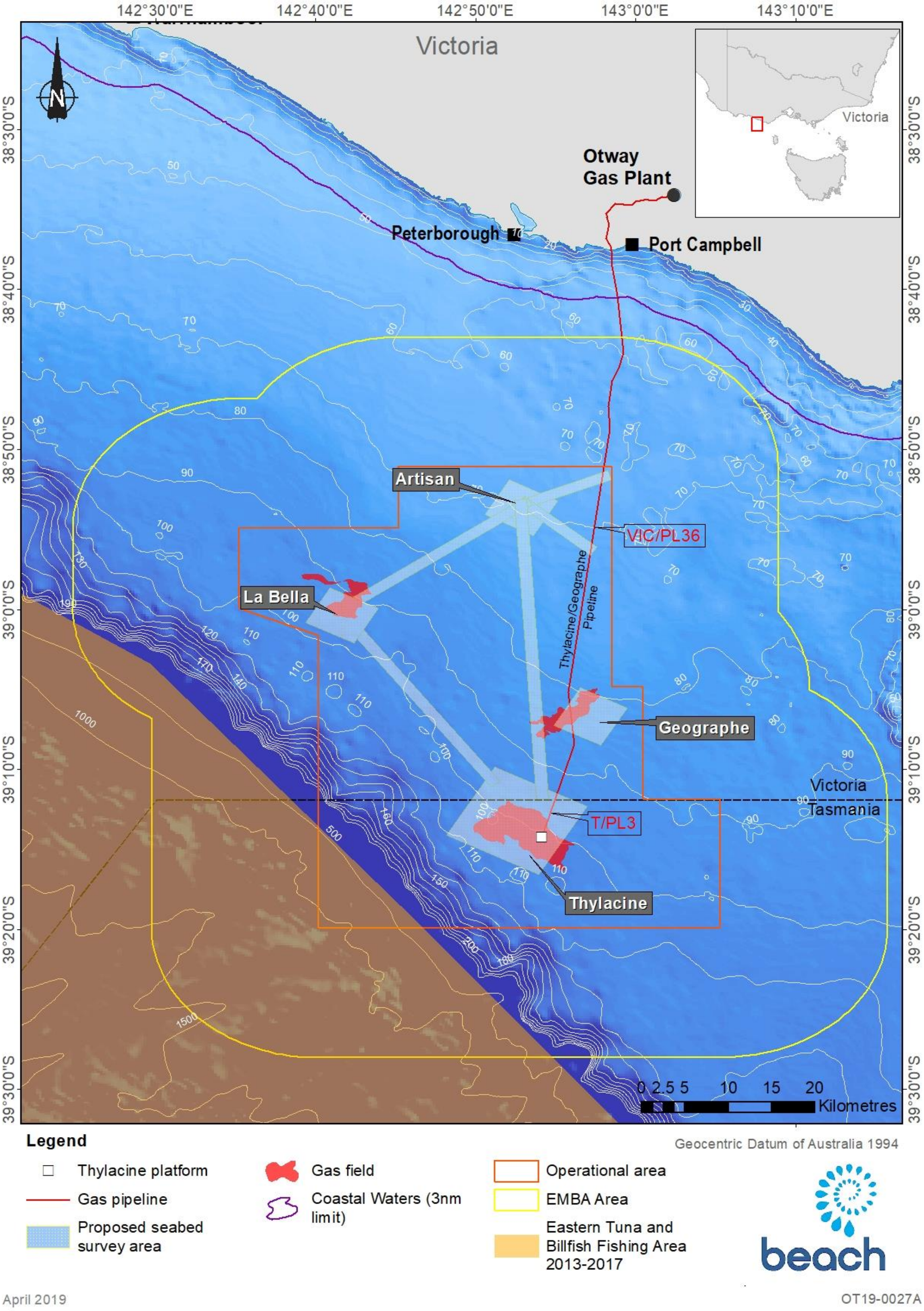


Figure B-10-17: Eastern Tuna and Billfish Fishery catch effort 2013 - 2017

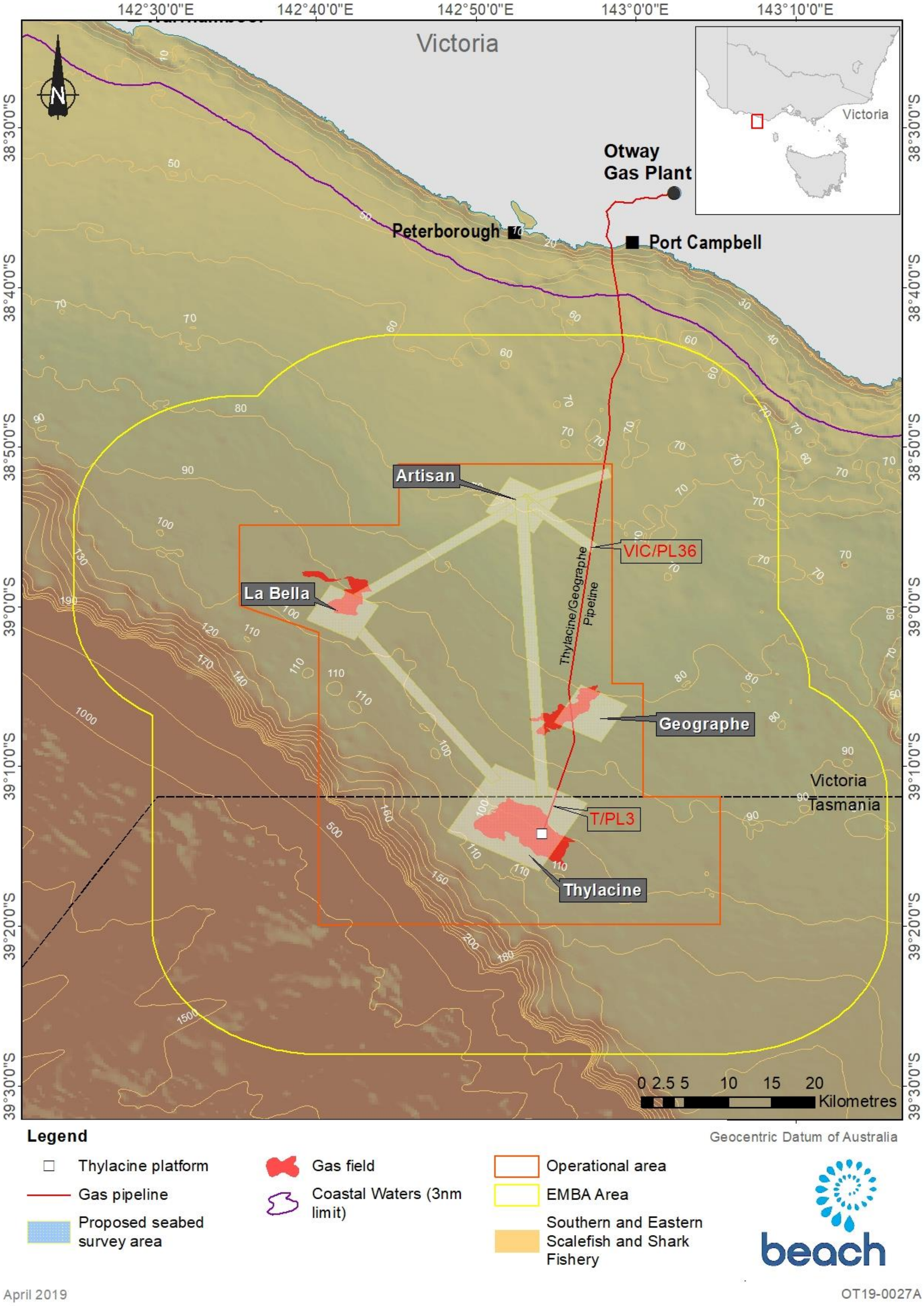


Figure B-10-18: Southern and Eastern Scalefish and Shark Fishery catch effort 2013 -2017

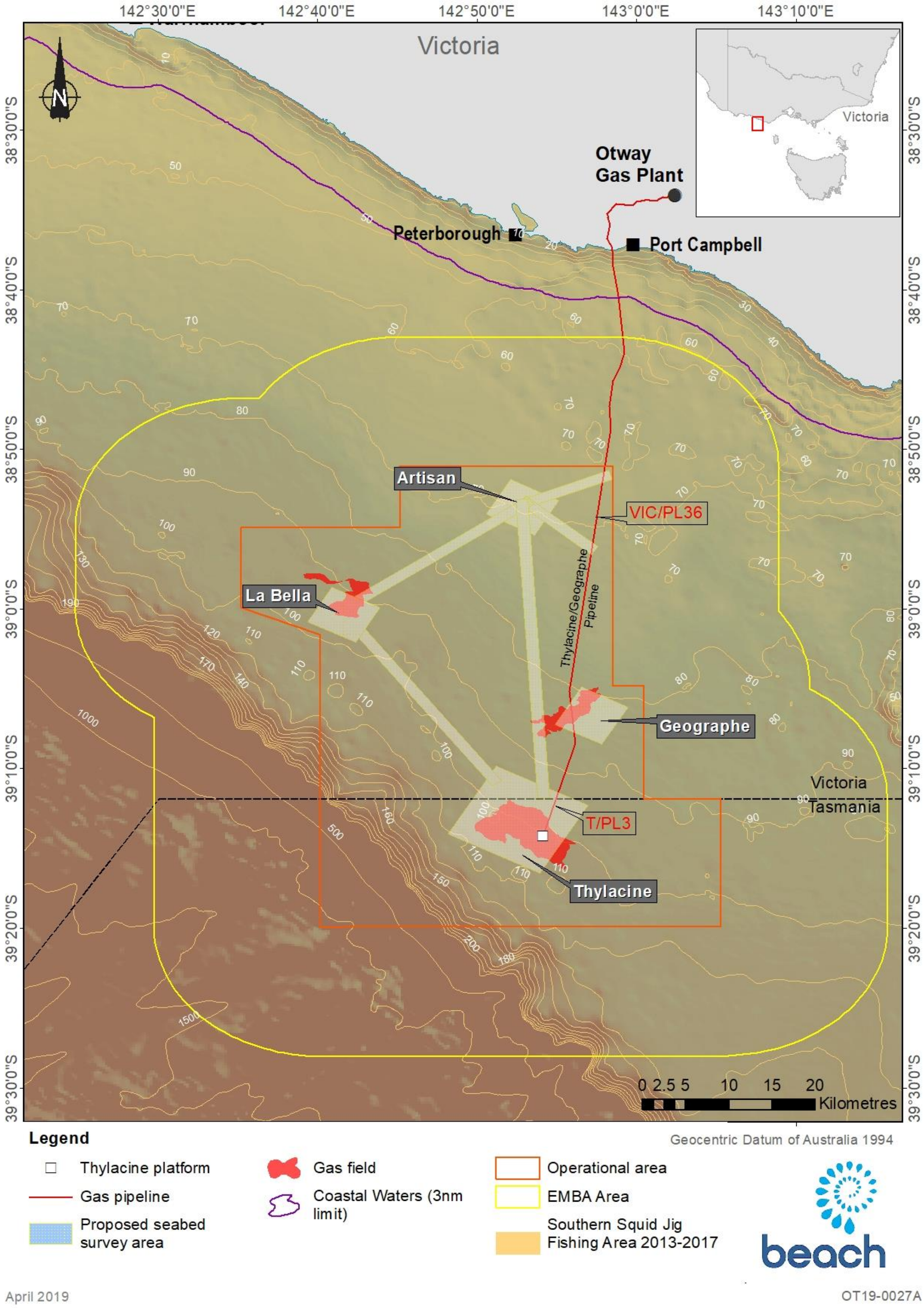


Figure B-10-19: Southern Squid Jig Fishery catch effort 2013 -2017

Appendix B.4.8 Victorian managed fisheries

There are six Victorian state-managed fisheries that overlap the EMBA:

- Rock Lobster Fishery;
- Giant Crab Fishery;
- Abalone Fishery;
- Scallop (Ocean) Fishery;
- Wrasse (Ocean) Fishery; and
- Snapper Fishery.

A description of these fisheries is detailed in (Table B-10-17).

To identify those fisheries that are active within the EMBA monthly catch data by fishery grid area for each species with catch (t) and number of fishers was obtained from VFA for the period of 2014 – 2018. Figure B-10-20 and Figure B-10-21 detail the fishery grid system. Data was requested from VFA for the following grids within the operational area:

- J10; J11; J12
- K10; K11; K12
- L10; L11; L12

From the data obtained from the VFA it was identified that only the Rock Lobster and Giant Crab fisheries have catch effort within the grids within the operational area. This aligns with data obtained from Victorian Fisheries Authority (www.vfa.vic.gov.au) and detailed in Table B-10-17.

The 2014 to 2018 data from the VFA in relation to the Rock Lobster and Giant Crab fisheries is shown in xx and xx. It should be noted that the numbers in each grid are not fishers but shows that a fisher fished in that grid in that month. The same fisher may have fished in a number of grids in a month.

For the Giant Crab Fishery, the data shows:

- There has been no catch effort for giant crab within the operational area in September and October when the first phase of the seabed assessments is planned to occur. Fishing effort increased to one fisher in November 2015.
- During March and April, when the second phase of the seabed surveys is planned to occur, there has been one to two fishers in grid K10 and L11 during 2016 and 2017.
- From 2014 to 2018 the most fishing effort occurs in K10 (maximum one fisher per month for the 11 months fished) and L11 (one fisher per month for the 12 months fished). Grid K10 has a very small portion of the La Bella seabed assessment area and L11 has a small area of the Thylacine seabed assessment area.

For the Rock Lobster Fishery, the data shows:

- There has been catch effort for rock lobster within the operational area in September 2014 and 2018 but none in October. The first phase of the seabed assessments is planned to occur in September and go into October. In 2018 three grids where fished (J12, K11 and K12) with one fisher recorded in each grid.
- During March and April, when the second phase of the seabed surveys is planned to occur, there was no effort within the operational area in 2018. Prior to 2018 there was 1 grid (J12) fished in April 2014 by one fisher, three grids fished in April 2015, five grids fished in March and April 2016 and two grids fished in March and April 2017.
- From 2014 to 2018 the most fishing effort occurs in J12 (maximum one fisher per month for the 10 months fished), K10 (maximum two fishers for one month and the remaining 7 months fished was one fisher per month), K11 (one fisher per month for the eight months fished) and K12 (maximum two fishers for one month and the remaining 9 months fished was one fisher per month).

Table B-10-17: State (Victorian) managed fisheries within the EMBA

Fishery	Target species	Description	Fishing Effort EMBA
Rock Lobster Fishery (western zone)	Southern rock lobster	Victoria's second most valuable fishery with a production value of A$24 million in 2014-15. Since 2009/10, annual quotas have been set at between 230 and 260 tonnes and have been fully caught each year. In the western zone, most catch is landed through Portland, Port Fairy, Warrnambool, Port Campbell and Apollo Bay. Closed seasons operate for male (15 Sept to 15 Nov) and female (1 June to 15 Nov) lobsters. Southern rock lobsters are found to depths of 150 metres, with most of the catch coming from inshore waters less than 100 metres deep. Fishing data from VFA for 2014 – 2018 (Figure B-10-20) show that there is fishing effort within the EMBA. Based on information from Seafood Industry Victoria approximately 40 t of southern rock lobster has been caught within the operational area of the last 10 years. This equates to between 1.5 – 1.7% of the total catch over the 10 year period.	Yes

Fishery	Target species	Description	Fishing Effort EMBA
Giant Crab Fishery	Giant crab	A small fishery operating in western Victoria and closely linked with the Rock Lobster Fishery. Most vessels are used primarily for rock lobster fishing with giant crab taken as by-product. Fishing effort is concentrated on continental shelf edge (~200 m deep). Giant crabs inhabit the continental slope at approximately 200 metres depth and are most abundant along the narrow band of the shelf edge. Closed seasons operate for male (15 Sept to 15 Nov) and female (1 June to 15 Nov) giant crabs. Total landed catch in 2015-16 was 10 tonnes. Fishing data from VFA for 2014 – 2018 (Figure B-10-21) show that there is fishing effort within the EMBA. Based on information from Seafood Industry Victoria approximately 18 t of giant crab has been caught within the operational area of the last 10 years. The total catch over the last 10 years has been 157.8 t so 18 t equates to This equates to 11% of the total catch being caught in the operational area.	Yes
Abalone Fishery (western zone)	Blacklip abalone Greenlip abalone	A highly valuable fishery (A$20 million in 2014-15) that operates along most of the Victorian shoreline, generally to 30 m depth. Abalone are harvested by divers. Total allowable commercial catch limits of blacklip abalone for the western zone are considerably less than the central and eastern zone (for 2017-18 season, 63.2 tonnes compared with 274.0 and 352.5 tonnes, respectively). There are 14 licences in the western zone. The water depths where abalone are fished are closer to shore than the EMBA.	No
Scallop (Ocean) Fishery	Scallops	Extends the length of the Victorian coastline from high tide mark to 20 Nm offshore. Fishers use a scallop dredge. Temporary closures occur when stocks are low to allow scallop beds to recover. Total allowable commercial catch for 2015-16 was set at 135 tonnes. Scallops are mostly fished from Lakes Entrance and Welshpool. Fishing data from VFA for 2014 – 2018 did not identify scallop fishing effort in the EMBA.	No
Wrasse (Ocean) Fishery	Bluethroat wrasse Purple wrasse Small catches of rosy wrasse, senator wrasse and southern Maori wrasse	Extends the length of the Victorian coastline from high tide mark to 20 Nm offshore. Fishers mostly use hook and line. Limited entry fishery with 22 current licences. Total annual catches in 2014-15 and 2015-16 were ~30 tonnes. Fishing data from VFA for 2014 – 2018 did not identify wrasse fishing effort in the EMBA.	No
Snapper Fishery (western stock) (Ocean fishery trawl (inshore) licence)	Snapper	Snapper are caught using lines, nets and haul seine. Over 90% of the catch is from Port Phillip Bay, and around 5% from coastal waters. In 2014-15, 147 tonnes were landed at a value of A$1.38 million. Fishing data from VFA for 2014 – 2018 did not identify snapper fishing effort in the EMBA.	No

Data/information sources: Victorian Fisheries Authority (www.vfa.vic.gov.au), DPI (2015), State Govt of Victoria (2015a, b)

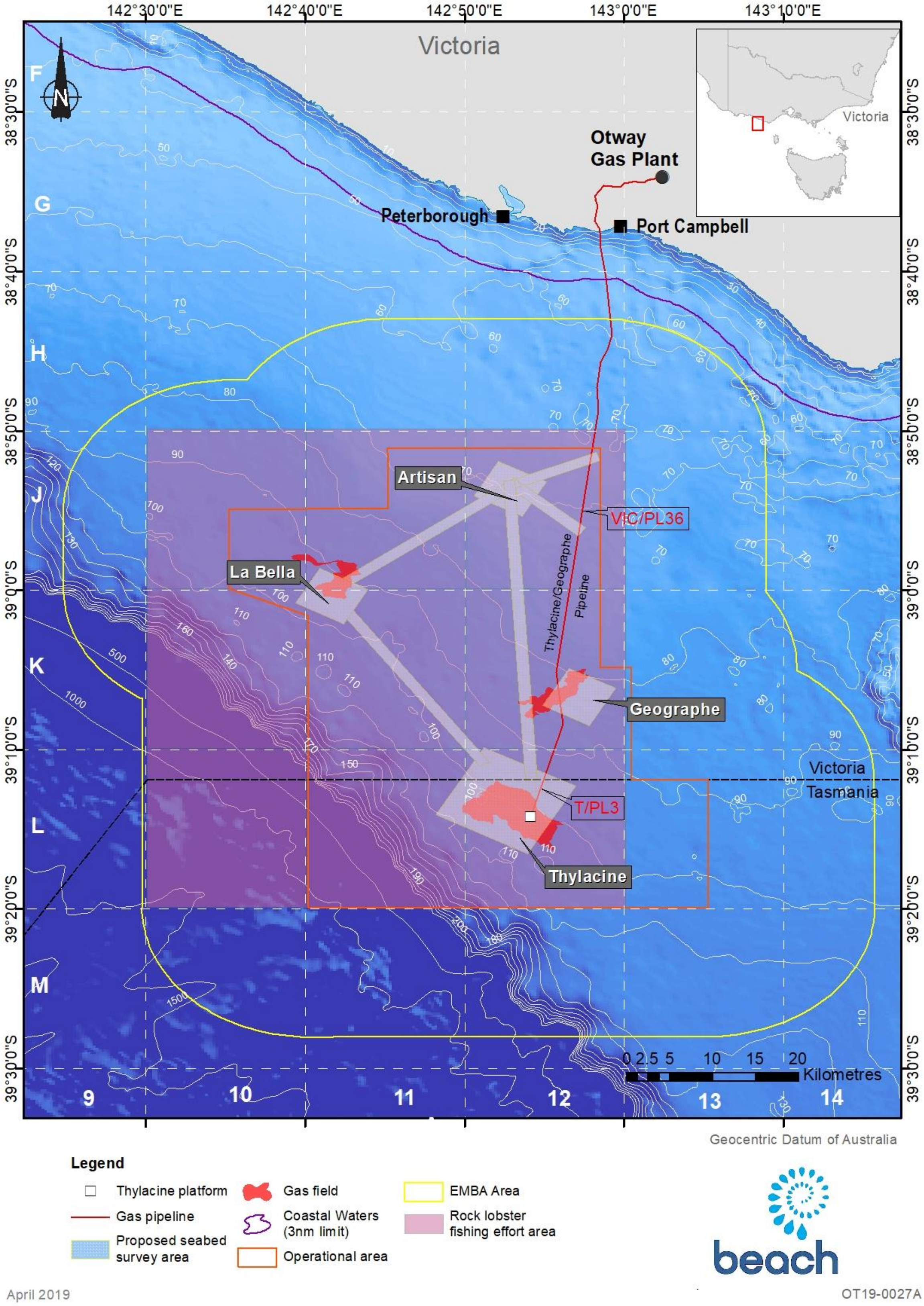


Figure B-10-20: Rock Lobster Fishery catch effort 2014 – 2018

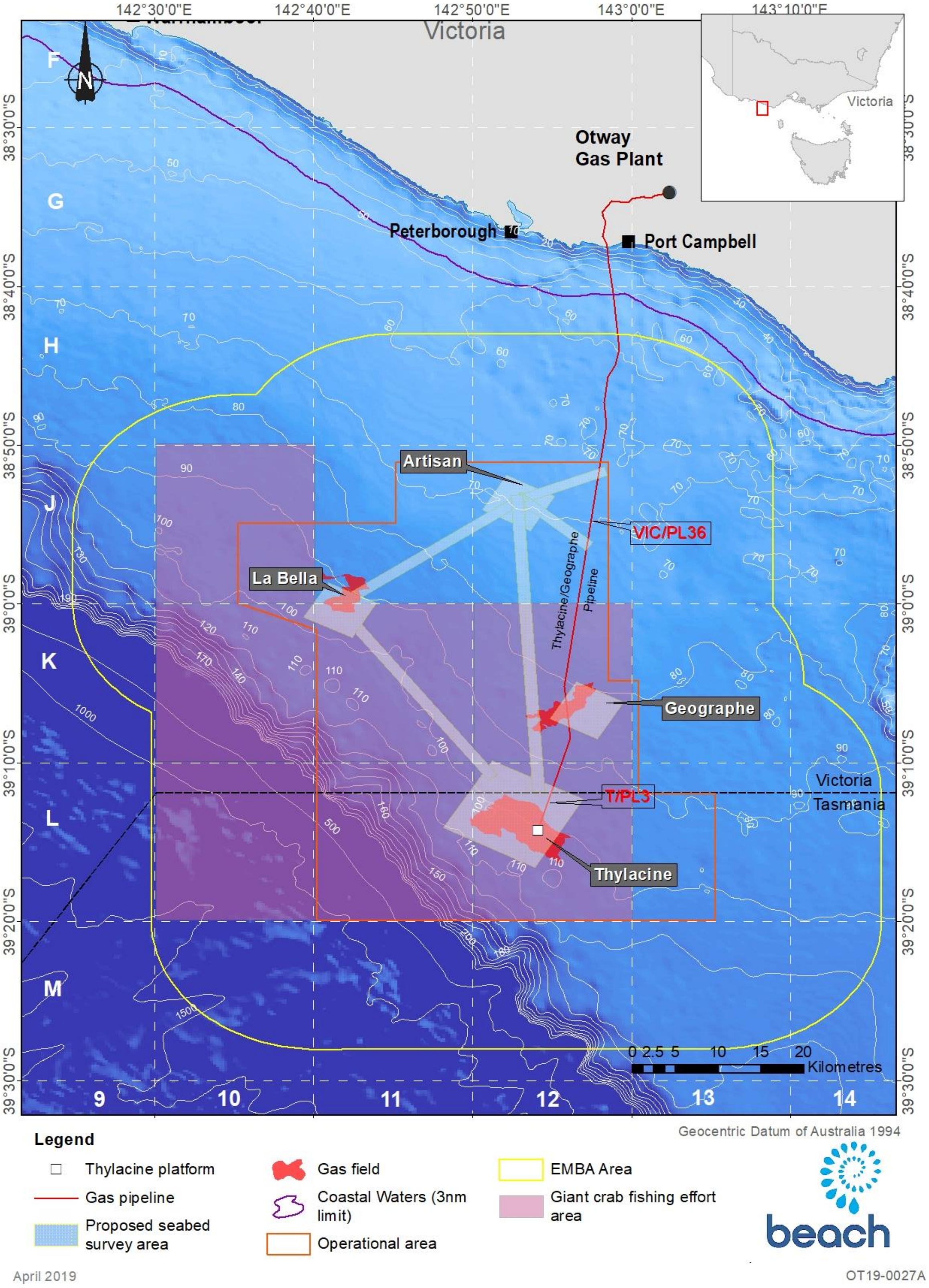


Figure B-10-21: Giant Crab Fishery catch effort 2014 – 2018

Table B-10-18: Giant Crab Fishery Fisher per Grid per Month from 2014 to 2018

Month	J10	La Bella K10	La Bella and umbilical route K11	Geographe and umbilical route K12	L10	Thylacine L11	Thylacine and umbilical route L12
Jan 2014		1					
Feb 2014		1					
Dec 2014		1				1	
Jan 2015		1					
Feb 2015			1				
Nov 2015						1	
Dec 2015	1	1				1	
Jan 2016						1	
Mar 2016						1	
Apr 2016						1	
May 2016		1					
Mar 2017		1				1	
Apr 2017		1				1	
May 2017		1			1	1	
Jun 2017		1			1		
Aug 2017						1	1
Jan 2018						1	
May 2018						1	1
Jun 2018							1
Aug 2018				1			
Dec 2018		1					1

Note: Data only shows those months where there was fishing effort

Table B- 10-19: Rock Lobster Fishery Fisher per Grid per Month from 2014 to 2018

Month	J10	La Bella and flowline route J11	Artisan and flowline and umbilical route J12	La Bella K10	La Bella and umbilical route K11	Geographe and umbilical route K12	L10	Thylacine L11	Thylacine and umbilical route L12
Jan 2014	1	1		1					
Feb 2014	1	1		2	1				
Mar 2014			1						
Jul 2014			1						
Aug 2014					1	1			
Sep 2014	1	1							
Dec 2014	1				1				
Jan 2015			1	1	1				
Feb 2015	1				1	1			
Apr 2015	1				1				1
May 2015	1								
Dec 2015	1			1					
Jan 2016								1	
Feb 2016	1			1					
Mar 2016			1	1		1			
Apr 2016			1		1	1		1	
May 2016	1								
Feb 2017						1			
Mar 2017						1			
Apr 2017	1								
May 2017			1						
Jun 2017			1				1		
Aug 2017						1			1
Dec 2017	1								
Feb 2018	1		1						
Aug 2018	1		1			2			
Sep 2018			1		1	1			
Dec 2018	1			1					

Note: Data only shows those months where there was fishing effort

Appendix B.4.9 References

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Appendix C JASCO Acoustic Modelling Report

Otway Basin Geophysical Operations Acoustic Modelling

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:
Lattice Energy

Authors:
Craig McPherson
Michael Wood

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JASCO Applied Sciences (Australia) Pty Ltd
Unit 1, 14 Hook Street
Capalaba, Queensland, 4157
Tel: +61 7 3823 2620
Mob: +61 4 3812 8179
www.jasco.com

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Executive Summary

Sound models were used to assess underwater noise levels during the proposed Otway Basin Geophysical Survey by Lattice Energy. The modelling approach accounted for the acoustic emission characteristics of a representative boomer and sub-bottom profiler (SBP) both towed at 3 m depth, along with a 450 in^3 vertical seismic profiler (VSP) array operated at a centroid depth of 6 m. The boomer and SBP geophysical survey sources planned for use had not been decided at the time of the modelling study, therefore JASCO chose commonly-used representative systems for each source, with levels derived from previous JASCO field measurement campaigns of such sources. The modelled per-pulse in-beam SEL and SPL source levels of the boomer were 180.0 dB re 1 $\mu Pa^2 \cdot s$ @ 1 m and 200.5 dB re 1 µPa @ 1 m respectively, and for the sub-bottom profiler they were 171.4 dB re 1 $\mu Pa^2 \cdot s$ @ 1 m and 191.7 dB re 1 µPa @ 1 m. The modelling considered source directivity and the area's range-dependent environmental properties.

The modelling study assessed six sites for the representative boomer and sub-bottom profiler, and one site for the VSP operations, focusing on the metrics relevant to benthic invertebrates. Accumulated SEL was modelled for four full surveys of the boomer and SBP operating in tandem. The scenarios considered operational periods of either 51 or 40.2 hours, including turn times.

The analysis considered the maximum distances away from a given source or survey lines at which several effects criteria were reached. The results are summarised below for representative single pulse sites and for accumulated sound exposure level (SEL) scenarios.

Benthic Invertebrates and Fish

- Sound fields from the representative boomer and SBP do not reach any of the assessed thresholds for benthic crustaceans or fish at the seafloor for either single pulse or accumulated SEL scenarios. The sound level drops below the lowest relevant peak-to-peak pressure level (PK-PK) isopleth of 202 dB re 1 µPa at a vertical distance of 11 m below the source, and below the lowest relevant peak pressure level (PK) of 207 dB re 1 µPa within 1.6 m, while the maximum per-pulse SEL isopleth predicted to occur at the seafloor is 155 dB re 1 $\mu Pa^2 \cdot s$ at a maximum horizontal distance of 1 m from the source.
- The SBP is a higher-frequency, more directional, and lower energy source than the boomer; consequently, the ranges are consistently lower. The PK-PK isopleth of 202 dB re 1 µPa is predicted to occur at 1.4 m vertically below the source, while the maximum per-pulse SEL isopleth predicted to occur at the seafloor is 130 dB re 1 $\mu Pa^2 \cdot s$ at a maximum horizontal distance of 6 m.
- The maximum accumulated SEL from the combined operations of the boomer and SBP at the seafloor is not predicted to exceed 170 dB re 1 $\mu Pa^2 \cdot s$ for any single survey. This is below any of the relevant isopleths for benthic invertebrates, including the 183 dB re 1 $\mu Pa^2 \cdot s$ 'no effect' accumulated SEL (McCauley and Duncan 2016). It is also below the threshold for temporary hearing impairment (TTS) in fish. The predicted ranges for the four surveys modelled at similar, due to the identical sources, sound speed profiles, similar depths and geoacoustics.
- The VSP source was modelled with models capable of accounting for all environmental parameters and high propagation angles. The results show that the lowest PK-PK isopleths of interest derived from Day et al. (2016b), 209 dB re 1 µPa, is not reached at the seafloor; and the horizontal range along the seafloor to the 202 dB re 1 µPa PK-PK level from Payne et al. (2007) is 185 m. PK metrics relevant to the Popper et al. (2014) criteria for fish and turtles are also not reached at the seafloor. The maximum per-pulse SEL on the seafloor below the array is 181 dB re 1 $\mu Pa^2 \cdot s$, below the lowest level from Day et al. (2016b) of 186 dB re 1 $\mu Pa^2 \cdot s$.

Marine Mammals and Turtle Behaviour

- Considering the United States (US) National Marine Fisheries Service (NMFS; 2013) acoustic threshold for behavioural effects in marine mammals of 160 dB re 1 µPa (SPL), the boomer could potentially disturb marine mammals at horizontal distances of up to 145 m, and the SBP at 2 m.
- Considering the US NMFS criterion for behavioural effects in turtles of 166 dB re 1 µPa (SPL), the boomer could potentially disturb turtles are horizontal distances of up to 36 m, while this level is not reached for the SBP.

- For the VSP array, sounds exceeded the unweighted per-pulse SEL criterion for the 1 km low-power zone of 160 dB re 1 µPa²·s (DEWHA 2008) within 1.03 km of the 450 in³ array ($R_{95\%}$ distance). The maximum ranges to the marine mammal and turtle behavioural thresholds of 160 and 166 dB re 1 µPa SPL are 2.56 and 1.55 km respectively.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the Otway Basin Geotechnical Operations proposed by Lattice Energy in the Otway Basin. The acoustic modelling evaluated the effects of sounds produced by three sources on marine fauna, with a specific focus on benthic invertebrates. The three sources considered in the modelling were a representative boomer and sub-bottom profiler (SBP) both towed at 3 m, along with a 450 in^3 vertical seismic profiler (VSP) array operated at a centroid depth of 6 m. The boomer and SBP geophysical survey sources planned for use had not been decided at the time of the modelling study, therefore JASCO proposed a commonly used representative for each source, with levels derived from a previous JASCO measurement campaign of such sources. The results are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK) and either per-pulse (i.e., per-pulse) or accumulated sound exposure levels (SEL), as appropriate to each scenario.

Single pulse sound fields for each source were modelled at six representative locations (Table 1, Figure 1), although it is likely that the boomer and SBP will not operate at Site 5. The VSP will only be operated at Site 5. Accumulated SEL was modelled for four full surveys of the boomer and SBP operating in tandem, using the single pulse modelling results from Sites 1, 3, 4 and 6.

Table 1. Location details for modelled sites (UTM zone 54S).

Site #	Site Name	Site Name Acronym	Water depth (m)	Latitude	Longitude	Easting	Northing
1	Thylacine Midpoint	THY MID	100.5	-39.2168	142.8665	661137	5657503
2	Murchinson Downdip	MURCH DDIP	129.5	-39.2249	142.7614	652042	5656787
3	Geographe 3	G3	85	-39.1082	142.9517	668752	5669398
4	Artisan	ARTISAN	71.6	-38.8909	142.8829	663300	5693640
5	Block VICP69, North	VICP69 NTH	72.8	-38.8829	143.1359	685264	5694052
6	Block VICP69, Meeki	VICP69 MEEKI	79.1	-38.9881	143.051	677633	5682538

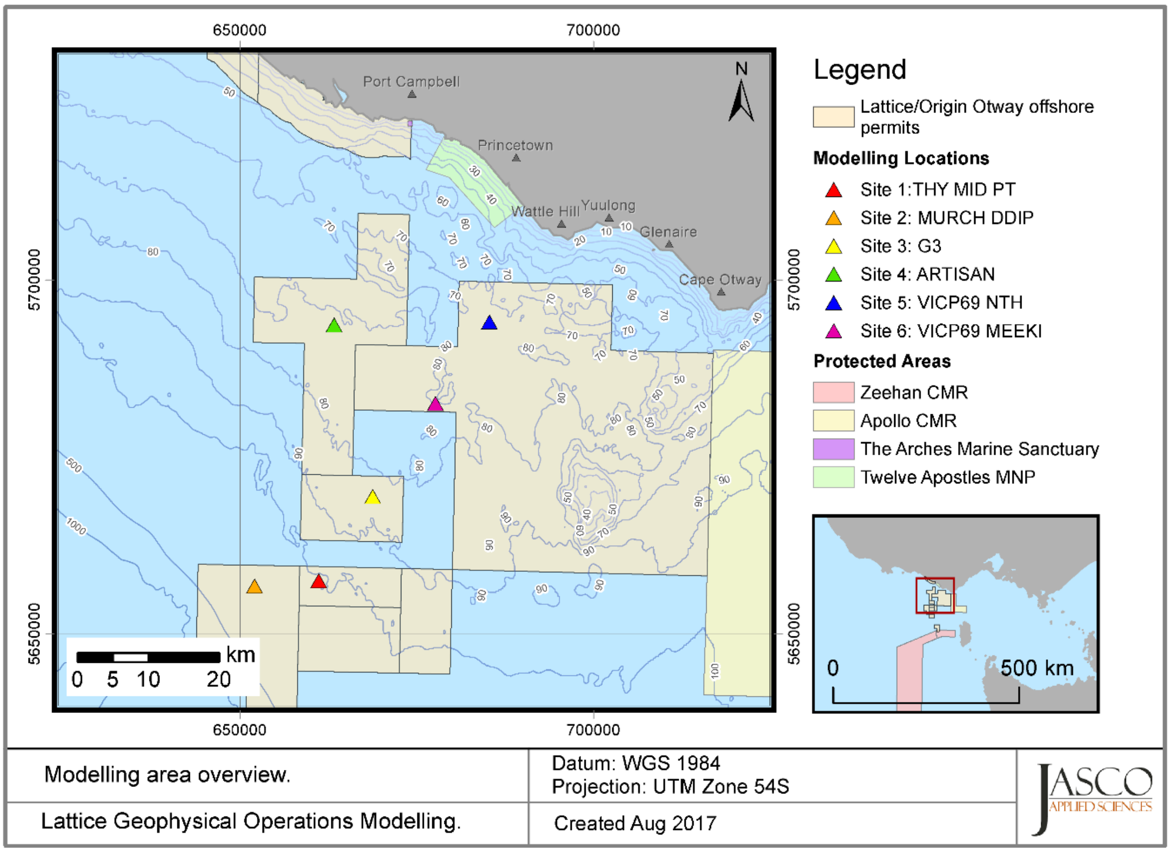

Figure 1. Single pulse modelling site locations and relevant features, including Commonwealth Marine Reserves (CMR), and Marine National Parks (MNP)

2. Noise Effects 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 time over which the pulse rises, how long this occurs for, and its frequency content. Thus, several sound level metrics are commonly used to evaluate noise and its effects on marine life. The metrics applied in this report, including peak pressure level (PK), peak-peak pressure (PK-PK), sound pressure level (SPL), and sound exposure level (SEL), are defined in Appendix A. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI-ASA S1.1 (R2013) and ISO/DIS 18405.2:2017 (2016).

Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have investigated an SEL-based assessment approach for injury in marine mammals, with a handful of key papers published on the topic. The number of studies that investigated the level of disturbance to marine animals by underwater noise has also increased substantially.

We chose the following noise criteria for this study because they include requested thresholds, standard thresholds, thresholds suggested by the best available science (Sections 2.1, 2.2 and 2.3):

1. For comparison to results in Payne et al. (2008), and Day et al. (2016a), the following metrics are reported for benthic crustaceans:
   - Seafloor per-pulse SEL: 186–190 dB re 1 µPa^2.s
   - Seafloor SEL_{24h}: 192–199 dB re 1 µPa^2.s
   - Peak-peak pressure: 202, 209–212 dB re 1 µPa
2. ‘No effect on lobster’ accumulated SEL for the Crowes Foot MSS of 183 dB re 1 µPa^2.s (McCauley and Duncan 2016).
3. Per-pulse threshold for cetaceans (unweighted per-pulse SEL of 160 dB re 1 µPa^2·s) outlined in the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008).
4. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) criterion (NMFS 2013) for marine mammals of 160 dB re 1 µPa SPL for impulsive sound sources.
5. Sound exposure guidelines for fish, fish eggs and larvae, and turtles (Popper et al. 2014).
6. Threshold for turtle behavioural response 166 dB re 1 µPa (SPL) (NSF 2011), applied by the US NMFS.

2.1. Benthic Invertebrates (Crustaceans)

Research is ongoing into the relationship between sound and its effects on crustaceans, 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 airgun array 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 bivalves. Although some impact assessments have estimated areas of potential impacts from seismic surveys based on the results in Day et al. (2016b), current literature does not clearly define an appropriate metric or identify relevant sound levels for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality.

At the seafloor interface 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. Therefore, at this stage, JASCO is not able to define thresholds to inform the impact assessment. Additionally, prediction of particle motion from sources such as low-energy geophysical sources including boomers and sub-bottom profilers is not possible currently due to the lack of source models.

Despite this, the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) has publicly stated that the seafloor levels, sound levels at the seafloor derived from Day et al. (2016b) should be used to assist in the assessment of impacts on scallops and lobster. Therefore, JASCO has used the following metrics in its evaluation:

- Per-pulse SEL: 186–190 dB re 1 μPa^2.s
- Accumulated SEL: 192–199 dB re 1 μPa^2.s
- Peak-peak pressure: 209–212 dB re 1 μPa

Additionally a PK-PK of 202 dB re 1 μPa from Payne et al. (2007) has been included along with an accumulated SEL of 183 dB re 1 μPa^2.s as specified by Lattice Energy based on McCauley and Duncan (2016).

2.2. Marine Mammals

The criteria applied in this study to assess possible effects of impulsive noise on marine mammals are summarised in Table 2 and detailed in Sections 2.2.1 and 2.2.2.

Table 2. The SPL and per-pulse SEL thresholds for acoustic effects on marine mammals.

Hearing group	DEWHA (2008)	NMFS (2013)
		Behaviour
	Unweighted per-pulse SEL (dB re 1 µPa^2·s)	SPL (dB re 1 µPa)
Low-frequency cetaceans	160	160
Mid-frequency cetaceans		
High-frequency cetaceans		
Phocid pinnipeds in water	Not Applicable	
Otariid pinnipeds in water	Not Applicable	

2.2.1. Injury and Hearing Sensitivity Changes

There are two categories of auditory threshold shifts representing reduced hearing ability: permanent threshold shift (PTS), considered a physical injury to an animal's hearing organs, and temporary threshold shift (TTS), a temporary reduction in an animal's hearing sensitivity, understood to be partly a result of receptor hair cells in the cochlea becoming fatigued.

For seismic surveys in Australian waters, the EPBC Act Policy Statement 2.1 determines suitable exclusion zones with an unweighted per-pulse SEL threshold of 160 dB re 1 µPa^2·s (DEWHA 2008). This threshold minimises the likelihood of TTS in mysticetes and large odontocetes. The Policy Statement does not apply to smaller dolphins and porpoises as DEWHA assessed these cetaceans as having relatively low hearing sensitivity to the low frequencies produced by seismic airgun arrays.

2.2.2. Behavioural Response

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds. Their review found that most marine mammals exhibited varying responses between 140 and

180 dB re 1 µPa SPL, but inconsistent results between studies makes choosing a single behavioural threshold difficult. Studies varied in their lack of control groups, imprecise measurements, inconsistent metrics, and that animal responses depended on study context, which included the animal's activity state. To create meaningful quantitative data from the collected information, Southall et al. (2007) proposed a severity scale that increased with increasing sound levels.

NMFS has historically used a relatively simple sound level criterion for potentially disturbing a marine mammal. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for pinnipeds and cetaceans (NMFS 2013).

2.3. Fish, Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a NOAA panel two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

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

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. These effects are not assessed in this report. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

Table 3 lists relevant effects thresholds from Popper et al. (2014). 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 per-pulse of a maximum received level of either 231 dB re 1 µPa (PK) or 205 dB re 1 µPa^2·s (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

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 period. This is done for marine mammals in the Southall et al. (2007) criteria, where it is 24 h or the duration of the activity, whichever longer. Popper et al. (2014) recommend a standard period of time should be applied, where this is either defined as a justified fixed period or the duration of the activity, however also include caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. 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 due to the mobile source, 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 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 source (i.e., speed, duty cycle) (NMFS 2016).

Popper et al. (2014) summaries that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. However in this study the full period of operations has been considered as the accumulation period for SEL.

Table 3. Criteria for seismic noise exposure for fish and turtles, 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
Turtles	210 dB SEL_{24h} or > 207 dB PK	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	> 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 pressure level 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, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

2.3.1. Turtle Behavioural Response

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. McCauley et al. (2000) observed the behavioural response of caged turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 µPa 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). At that time, and in the absence of any data from which to determine the sound levels that could injure an animal, TTS or PTS onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011). Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa^2·s (SEL_{24h}) (Table 3). Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of meters) from the airgun. Both the NMFS criteria for behavioural disturbance (SPL of 166 dB re 1 µPa) and the Popper et al. (2014) injury criteria were included in this analysis, although the analysis did not consider the ranges at which an animal could suffer impairment, as defined by Popper et al. (2014).

3. Methods

This section details the methodology for predicting source levels, modelling sound propagation, and assessing distances to the selected impact criteria.

The environmental parameters used in the propagation models are described in detail in Appendix D. A single sound speed profile that provided the greatest propagation across the year was applied, which occurs during the month of September.

3.1. Acoustic Sources

3.1.1. Boomer: AP3000 Dual-Plate Boomer

The representative boomer system for geophysical survey operations is the AP3000 triple-plate boomer (manufactured by Subsea Systems, Inc.). To estimate the sound field for the boomer source, the specifications of the Applied Acoustics AA202 boomer plate (Applied Acoustics Engineering 2013), a suitable approximation, were taken to represent a single plate, three of which comprise the full system. The boomer plate is 38 cm wide by 38 cm long with a circular baffle. Because the boomer source is a circular piston surrounded by a rigid baffle, it cannot be considered a point-like source (Verbeek and McGee 1995). The beam pattern of a boomer plate shows some directivity for frequencies above 1 kHz. Above this frequency, the acoustic wave's emitted length becomes comparable (of the same order of magnitude) with the baffle size (< 150 cm vs. 35 cm).

The input energy for the AP3000 system is up to 600 J per pulse per plate, or up to 1800 J per pulse from all three plates. The width of the pulse calculated based on the 90% SPL (T_{90}) is 8.1 ms.

JASCO performed a source verification study on an AP3000 system (Martin et al. 2012) with a double-plate configuration operating at maximum input energy of 1000 J. During the study, the acoustic data were collected as close as 8 m to the source and directly below it (Figure 2). By assuming a reduction in pressure in line with spherical spreading laws the data showed that the broadband source level for the system was 197.9 dB 1 µPa @ 1 m SPL and 177.4 dB re 1 µPa^2·s @ 1 m SEL.

The increase in the source level of an AP3000 boomer when in triple-plate configuration, instead of double-plate configuration, was estimated at 2.6 dB because a triple-plate configuration could be used with a higher energy input per pulse (up to 1800 J vs. up to 1000 J for double plate configuration). For modelling, the source level of the AP3000 triple-plated boomer operating at 1800 J per pulse energy was calculated to be 200.5 dB 1 µPa @ 1 m SPL and 180.0 dB re 1 µPa^2·s @ 1 m SEL (Table 4). The power spectrum of the boomer signal was determined directly from the measurement of the boomer signal having compensated the signal for geometric spreading and the change in energy (Figure 3). The 1/3-octave frequency boomer source spectra are shown in Figure 4.

The beamwidth of a boomer plate at each 1/3-octave frequency was calculated based on the standard formula for the beam pattern of a circular transducer (Equation 1). Figure 5 shows a vertical slice for the calculated beam pattern at (a) 1.25 and (b) 16.0 kHz. In order to simplify the acoustic propagation calculations, the beam pattern from the triple-plate system was considered to be equal to the beam pattern from a single plate.

Table 4. Specifications of the AP3000 triple-plate boomer system towed at a depth of 2 m used for the modelling

Specification	Specification	Source
Operating frequency (broad band):	200 Hz–16 kHz;	Estimated from field measurements; Martin et al. (2012)
Beam width	omnidirectional –8°	
Beams	1	

Specification	Specification	Source
Tilt angle (below horizontal plane)	90°	System specification document
Maximum energy input (per pulse):	1800 J	
Peak pressure source level	210.8 dB re 1 µPa @ 1 m	Estimated from field measurements; Martin et al. (2012).
Peak-Peak pressure source level	222.7 dB re 1 µPa @ 1 m	
SPL source level	200.5 dB re 1 µPa @ 1 m	
Pulse length (T_{90})	8.1 ms	
Per-pulse SEL source level	180.0 dB re 1 µPa²•s @ 1 m	

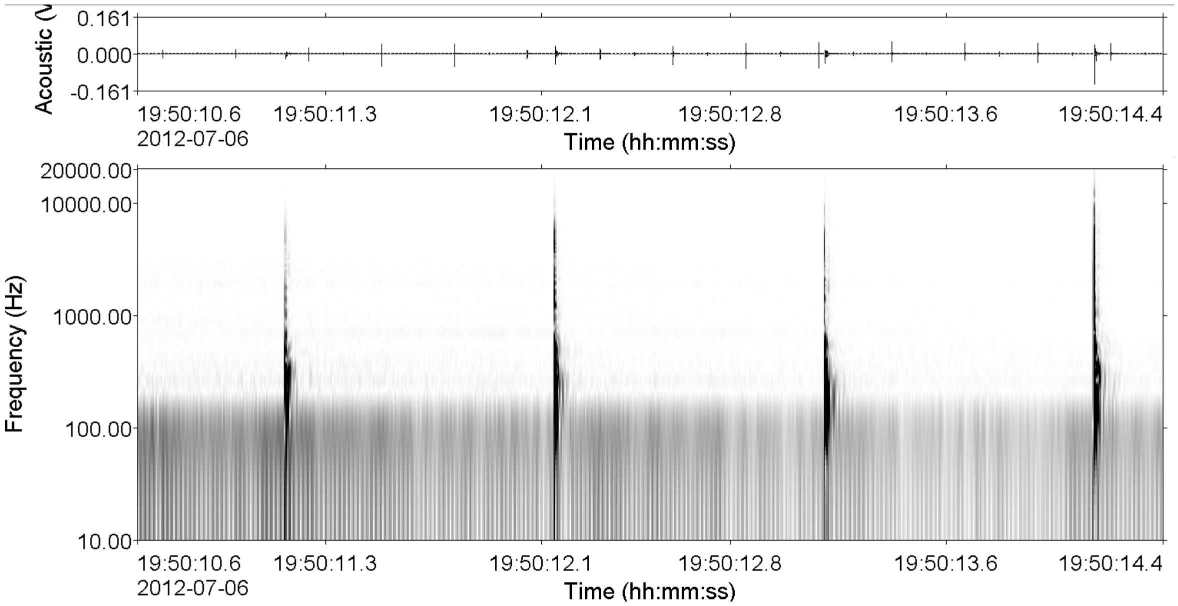

Figure 2. Spectrogram of dual-plate boomer (1000 J) pulses at the closest point of approach. Majority of energy is between 100 and 1000 Hz, with some energy at up to 10 kHz. (131,072 point FFT, 7000 data points, 3500 point overlap, Figure 15 in Martin et al. (2012)).

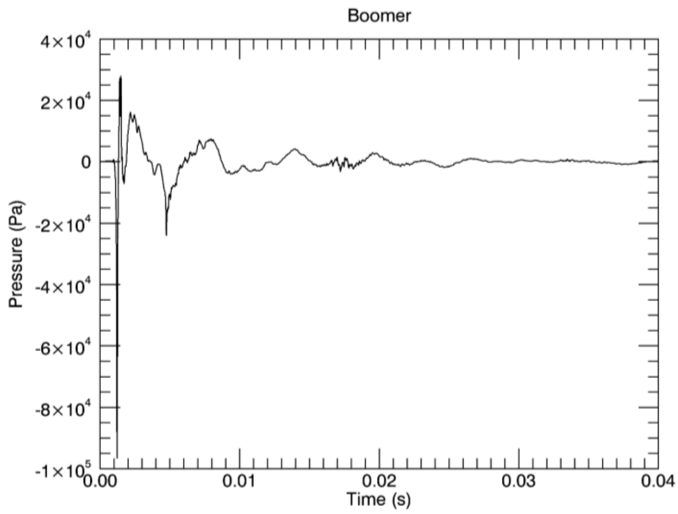

Figure 3. Back-propagated and scaled boomer source signature calculated from measurements (Martin et al. 2012).

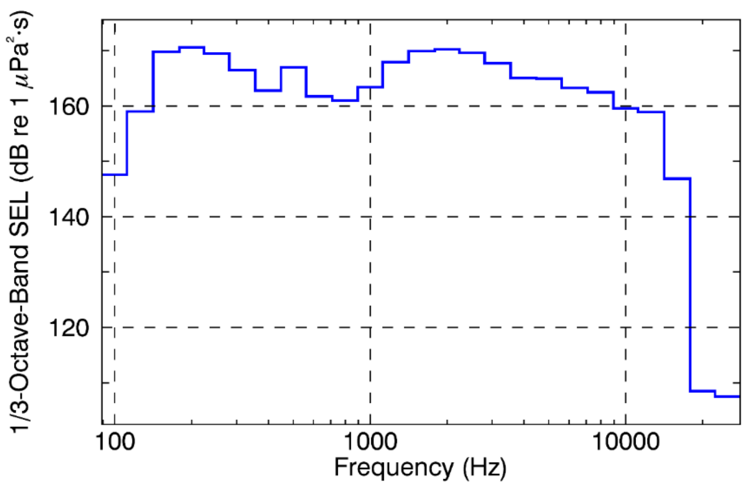

Figure 4. Boomer source spectra calculated from measurements (Martin et al. 2012).

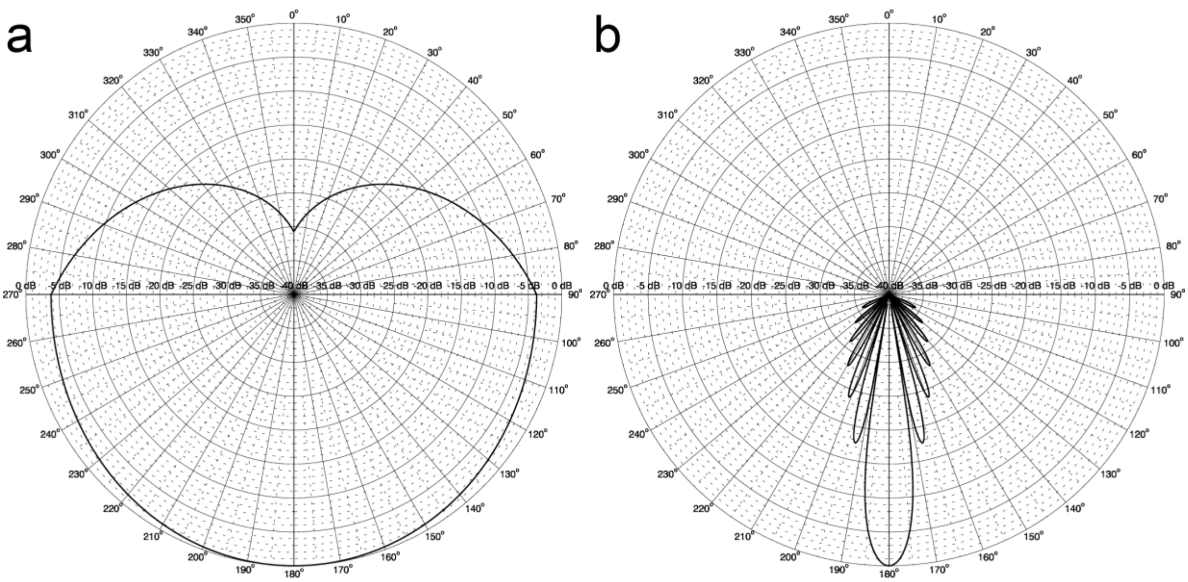

Figure 5. Calculated beam pattern vertical slice for the AA202 boomer plate at (a) 1.25 and (b) 16.0 kHz; across-track direction.

3.1.2. Sub-bottom Profiler: EdgeTech X-Star

The representative sub-bottom profiler system for geophysical survey operations is the EdgeTech X-Star (manufactured by EdgeTech). The system is equipped with a SBP-216 tow-fish. The transducer installed on the SBP-216 tow-fish transmits a chirp pulse that spans an operator-selectable frequency band. The lower and upper limits of the sonar's frequency band are 2 and 16 kHz, respectively. The system projects a single beam directed vertically down. The projected beamwidth depends on the operating frequency, and it can vary in range from 10° to 20°.

The source function was determined by using data obtained from the same measurement campaign as the boomer (Martin et al. (2012).To determine a source function usable for modelling the signal underwent a degree of post-processing. A clip from the recording measured at the closest point of approach was selected for processing (Figure 6). By assuming a point-like source and with no significant reflections or pulse dilation, the source level was determined by back-propagation methods assuming spherical spreading (Figure 7). The SEL band levels were determined from the back-propagated signal and are shown in Figure 8. The calculated source specifications are provided in Table 5. The width of the pulse encompassing 90% of the energy (T_{90}) was 8.1 ms, providing a SPL of 191.7 dB re 1 µPa @ 1 m.

For the purposes of modelling a source depth of 3 m was used, based on the assumed tow depth of a tow-fish. Since the echosounder's transducer projects a circular beam that is aimed vertically down, the source is effectively omnidirectional in the horizontal plane.

Table 5. Specifications of the Edgetech X-Star sub-bottom profiling system towed at a depth of 3 m used for the modelling

Specification	Specification	Source
Operating frequency:	2-16 kHz	System specification document
Beam width	10-20°	
Tilt angle (below horizontal plane)	90°	
Peak pressure source level	197.6 dB re 1 µPa @ 1 m	Estimated from field measurements; Martin et al. (2012).
Peak-Peak pressure source level	204.7 dB re 1 µPa @ 1 m	
SPL source level	191.7 dB re 1 µPa @ 1 m	
Pulse length (T_{90})	8.1 ms	
Per-pulse SEL source level	171.4 dB re 1 µPa^2·s @ 1 m	

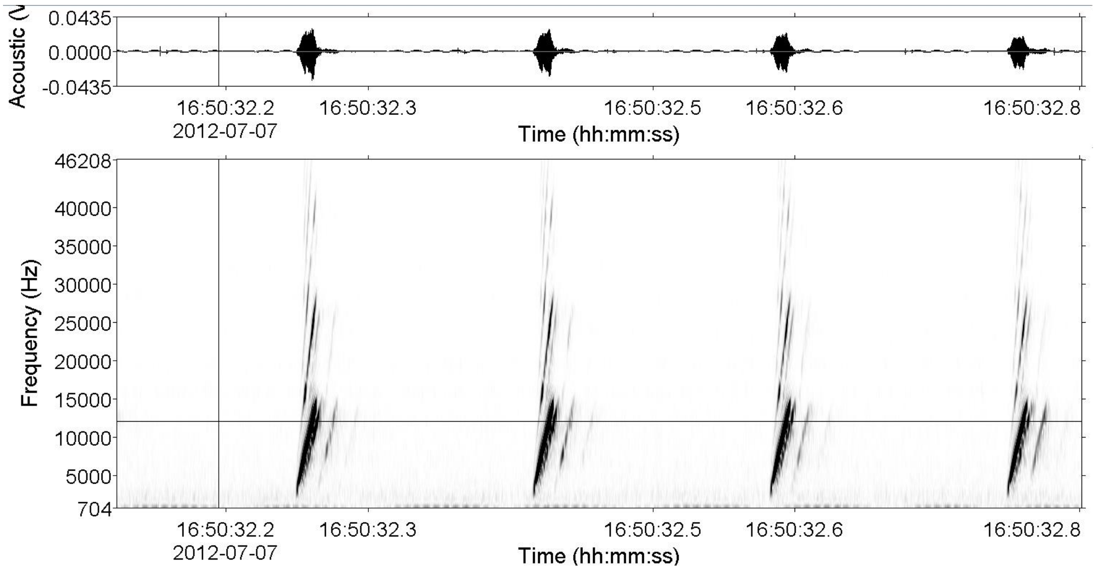

Figure 6. Spectrogram of X-Star SB-216S Sub-Bottom Profiler at closest-point of approach. The centroid frequency of the pulses was approximately 10 kHz, with 90% of the energy between 6 and 13 kHz. Aliased energy is visible above the main pulse. The bottom reflection is visible about 15 ms after the main pulse. (131,072 point FFT, 690 real data points, 345 point overlap.)

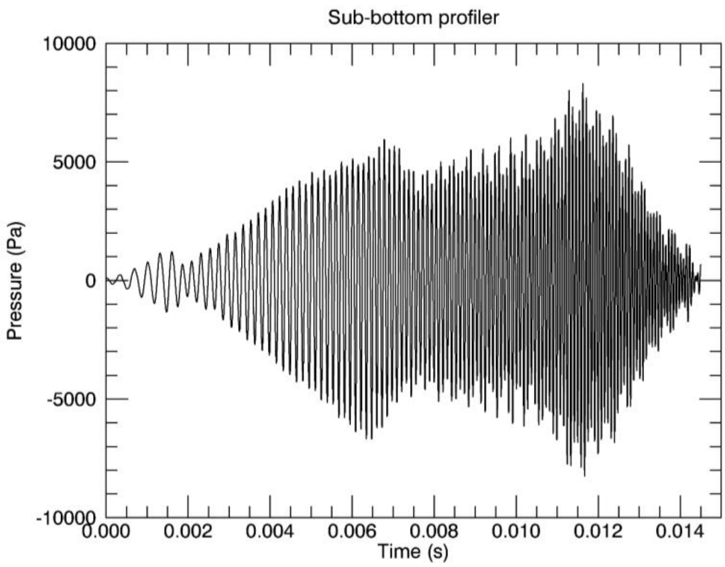

Figure 7. Back-propagated and scaled sub-bottom profiler source signature calculated from measurements (Martin et al. 2012).

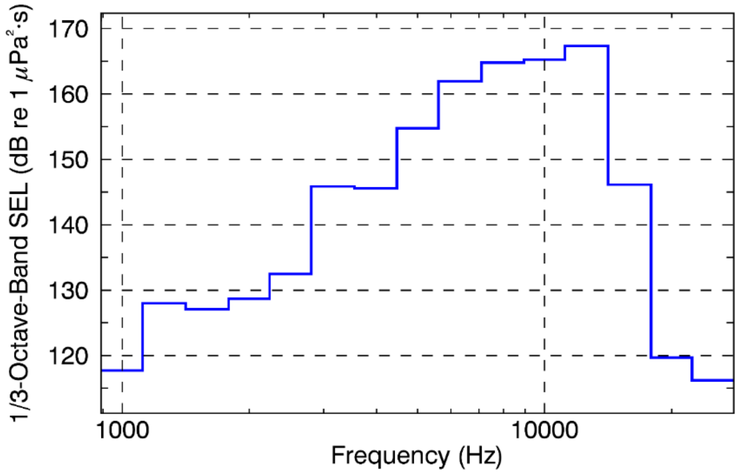

Figure 8. Sub-bottom profiler source spectra calculated from measurements (Martin et al. 2012).

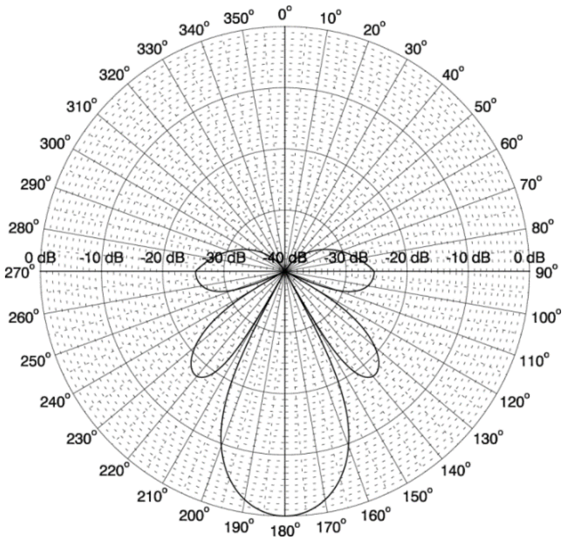

Figure 9. Calculated beam pattern vertical slice for the EdgeTech X-Star sub-bottom profiler at central frequency of 9 kHz.

3.1.3. VSP

The VSP airgun array under consideration is a 450 in^3 array consisting of 3 150 in^3 airguns operated at a centroid depth of 6 m, Figure 10 and Table 6.

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM), which accounts for:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

The array was modelled over AASM's full frequency range, up to 25 kHz. Details of the model are described in Appendix B.

The model considered the following specifications:

- A 450 in^3 firing volume seismic airgun array for VSP.
- Airguns operated at a firing pressure of 2000 psi. The type was not specified, however Bolt 1900 LLX were used for the modelling.

- An array layout consisting of three 150 in³ airguns with a centroid depth of 6.0 m.

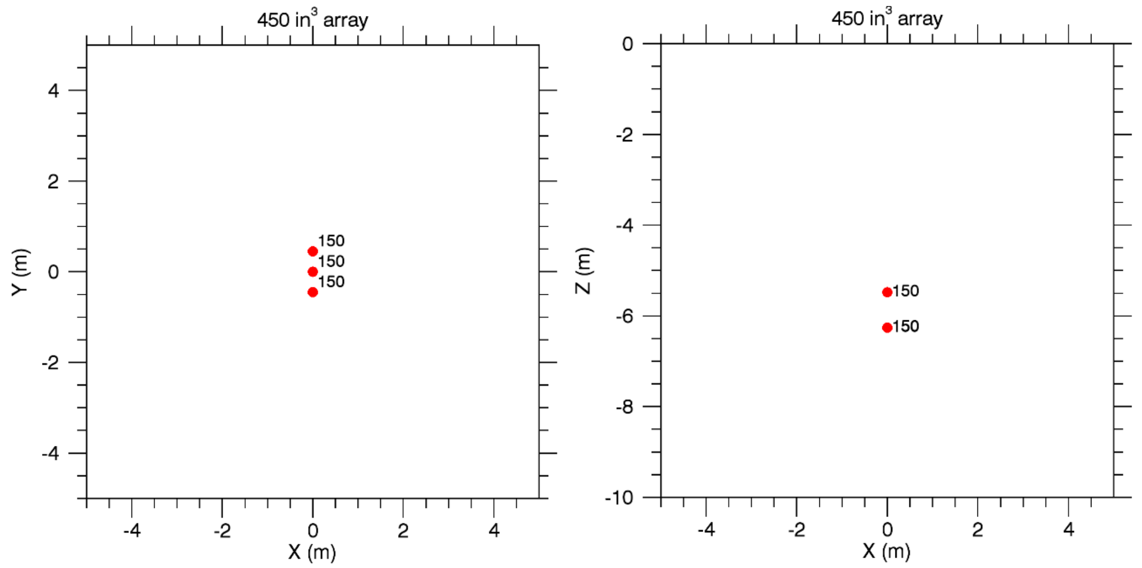

Figure 10. Layout of the modelled 450 in³ VSP array, plan view (left) and side view (right). Centroid operating depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. The convention is that the array is towed in the positive x direction. Also see Table 6.

Table 6. Layout of the modelled 450 in³ VSP array.Centroid operating depth is 6 m. Firing pressure for all guns is 2000 psi. The tow direction is assumed to be in the positive *x* direction.

Gun	*x* (m)	*y* (m)	*z* (m)	Volume (in³)
1	0.0	0	5.48	150
2	0.0	0.45	6.26	150
3	0.0	- 0.45	6.26	150

3.2. Sound Propagation Models

3.2.1. Boomer

The boomer source can be treated as an omnidirectional source for the frequencies of 1000 Hz and lower. For frequencies higher than 1000 Hz, the directionality of the boomer was taken into account. Due The acoustic field projected by the boomer source in 1/3-octave-bands was modelled using two propagation models: for frequencies of 1000 Hz and below MONM-RAM was used, while frequencies above 1000 Hz were modelled using MONM-BELLHOP. These were combined in post processing to determine the acoustic field across the entire frequency range. To determine the maximum range to PK, and PK-PK thresholds, spherical spreading laws were applied to the source level in the downward direction; these are usable due to the short ranges associated with the identified threshold levels within which no appreciable pulse dilation will occur nor reflections.

The acoustic propagation modelling was conducted in terms of PK, PK-PK and SEL units. The conversion to the SPL units was done based on Equation A-5 considering the T_{90} equal to 0.2 ms for the distances from the source less than 20 m, and 10 ms for the distances greater than 20 m from the source.

3.2.2. Sub-bottom Profiler

As the sub-bottom profiler was found only to have significant energy above 1 kHz it was assumed to be directional throughout its operational range. Consequently, MONM-BELLHOP was employed to model the entire frequency range of the SEL acoustic field in terms of 1/3-octave-bands. The ranges to PK and PK-PK levels were determined using spherical spreading laws.

The conversion to the SPL units was done based on Equation A-5 considering the T_{90} equal to 8 ms as determined by the measurement study.

3.2.3. VSP

Four sound propagation models (Appendix C) were used to predict the acoustic field around the VSP array for frequencies from 5 Hz to 25 kHz:

- Range-dependent parabolic equation model (Marine Operations Noise Model, MONM)
- Range-dependent ray tracing model (BELLHOP)
- Full Waveform Range-dependent Acoustic Model (FWRAM)
- Wavenumber integration model (VSTACK).

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.

3.3. Accumulated SEL

3.3.1. Method overview

During a geophysical survey, a new portion of sound energy is introduced into the environment with each pulse from the survey equipment. An accurate assessment of the cumulative acoustic field depends not only on the parameters of each impulse, but also on the number of impulses delivered over a period and the relative position of the impulses. Consideration of the total acoustic energy marine fauna is subjected to over the survey operations is required for comparison to the relevant effect criteria (Section 2).

When there are many pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The offset between the consecutive pulses 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 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.

3.3.2. Scenario definition

Four regions were identified for the cumulative study, each requiring many thousands of individual impulses. In each region a representative single pulse noise field for the relevant source is shifted in space and noise fields summed to provide a composite field. For the Thylacine location, two possible surveys were combined into a single scenario, referred to as Thylacine Combined. This scenario included a total of 38 lines each being 7.025 km in length (total estimated time of 51 h including turns). The other three scenarios, Geographe 3 (G3), Artisan (ARTISAN) and VICP69 Meeki (MEEKI), each featured 41 lines, of 4.0 km length (total estimated time of 40.2 h. Along each line the operating sequence was to alternate between the sub-bottom profiler and the boomer with the vessel travelling at 4.5 knots and a turn time of 30 minutes during which no source would be operated. The proposed areas are shown in Figure 11.

To produce maps of cumulative received sound level distribution and calculate distances to specified sound level thresholds at the seafloor, the sound level was calculated at a subset of points within the modelled region. The radial grids of sound levels of the modelled sites at each point were then resampled (by linear triangulation) to produce a regular Cartesian grid. These grids were transposed geographically to each impulse location along the survey lines. The sound field grids from all impulses were summed, using Equation A-4, to produce the cumulative sound field grid. The produced grids had a cell size of 5 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields.

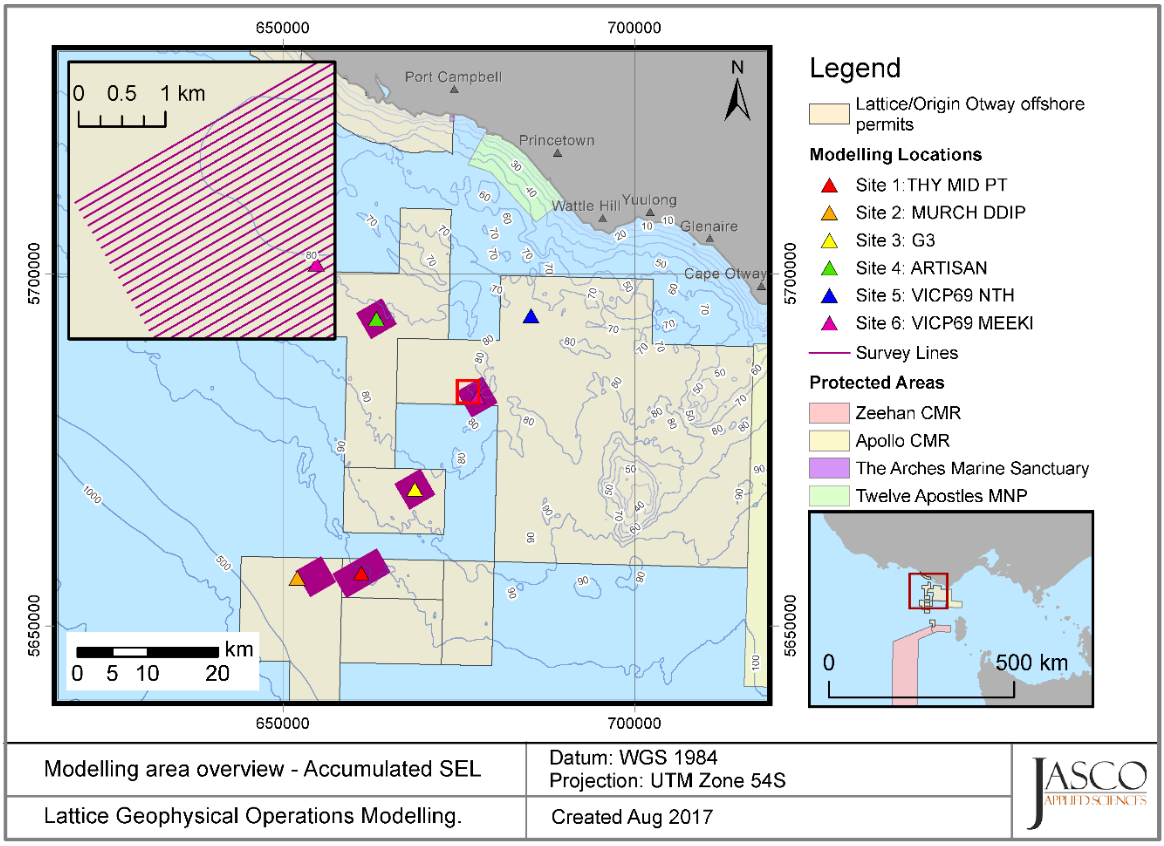

Figure 11. Overview of site surveys (and survey lines) under consideration. The site surveys are referred to by the name of the modelling location located at the same site.

3.4. Geometry and Modelled Regions

The modelled regions were defined based on the anticipated noise footprint of each of the sources. The VSP is significantly louder than either the boomer or the sub-bottom profiler, as well as having greater energy at lower frequencies that would typically propagate further than higher frequencies. The VSP, therefore was modelled in MONM in a series of radial slices with a maximum length of 56 km; the radial slices were 2.5° apart providing a total of 144 individual two-dimensional sound fields that were interpolated onto a regular three-dimensional grid to determine the output metrics. The range step in MONM was 10 m, used across the entire frequency range of 10 to 2000 Hz.

To determine the conversion factor from SEL to SPL, FWRAM was used with four transects modelled (cardinal directions). The Full Waveform Range-dependent Acoustic Model (FWRAM) employs a frequency dependent range step varying from 50 m at 10 Hz to 10 m at 1000 Hz. To calculate the near-field results the VSP was modelled in VSTACK, a wavenumber integration model; results were generated up to a frequency of 1 kHz up to 500 m away. Only a single range-independent transect was modelled using VSTACK.

The boomer and the sub-bottom profiler sources are more strongly directional than the VSP and operate at higher frequencies; consequently, the modelling was principally performed using BELLHOP, the beam-tracing model. The field was modelled in radial slices each 10° apart to provide 36 modelled transects, up to a maximum range of 3.5 km, with a range step of 1 m to provide high-resolution outputs. Where the boomer was omnidirectional (at 1 kHz), MONM was used to generate the contribution; otherwise, BELLHOP was used throughout. These modelling runs were performed separately for each of the six identified single pulse sites.

4. Results

This section presents the model results as distances to sound level thresholds and as sound field contour maps.

4.1. Acoustic Source Levels and Directivity

4.1.1. VSP Array

The pressure signatures of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels of the arrays were modelled with AASM (Section 3.1). Although AASM accounts for the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions in the notional pressure signatures of each airgun, the signal reflected off the water surface (known as surface ghost) is not included in the far-field source signatures; however, the acoustic propagation models account for those surface reflections because they are a property of the propagating medium rather than the source.

The horizontal and vertical overpressure signatures, corresponding power spectrum levels, and the horizontal directivity plots for array is provided in Appendix B.4.

To help compare these results to the outputs of other airgun array source models, Table 7 presents the vertical source level that accounts for the surface ghost, and lists the broadband PK, and per-pulse SEL source levels of the array in the endfire, broadside, and vertical directions.

Table 7. Source level specifications in the horizontal plane for the 450 in^3 VSP array, for a 6 m centroid depth.

Direction	PK (dB re 1 µPa @ 1 m)	SEL (dB re 1 µPa^2·s @ 1 m)	
		10–2000 Hz	2000–25000 Hz
Broadside	237.6	213.6	167.7
Endfire	237.8	213.7	173.4
Vertical (no ghost)	237.6	213.6	171.1
Vertical (with ghost)	237.6	215.7	174.1

4.2. Single Pulse Sound Fields

4.2.1. Tabulated Results

4.2.1.1. Boomer

The single pulse sound fields for the representative boomer (an AP3000 triple plate boomer) are presented in terms of maximum-over depth SPL for marine mammal and turtle behavioural thresholds (Table 8), maximum-over-depth and seafloor per-pulse SEL (Tables 9 and 10), and water column PK-PK and PK (Tables 11 and 12). Water column PK-PK and PK are included as the levels referenced for benthic invertebrates in Section 2.1 are not reached at the seafloor.

Table 8. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled maximum-over-depth marine mammal and turtle behavioural response thresholds.

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
Marine mammal behaviour SPL: 160 dB re 1 µPa	142	139	75	72	140	136	138	134	136	132	145	134
Turtle behaviour, SPL: 166 dB re 1 µPa	36	35	36	35	36	35	36	35	36	35	36	35

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled maximum-over-depth per-pulse SEL isopleths.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
160	7	7	7	7	6	6	7	6	7	7	6	6
155	13	12	12	12	13	12	12	12	12	12	12	12
150	21	21	21	21	21	21	22	21	21	21	22	21
145	38	37	38	37	38	37	39	38	38	37	38	37
140	84	77	70	67	136	134	131	127	134	129	135	129
135	233	226	244	229	226	208	288	208	303	215	253	216
130	768	609	604	504	738	559	868	725	908	671	762	628
125	2070	1500	1810	1220	1900	1380	1740	1490	1810	1520	1880	1310
120	3260	2660	3250	2480	3210	2480	3000	2460	3070	2460	3100	2440

Table 10. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled seafloor per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
160	—	—	—	—	—	—	—	—	—	—	—	—
155	1	1	—	—	—	—	—	—	—	—	—	—

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
150	3	3	2	2	1	1	1	1	1	1	1	1
145	6	5	5	5	4	4	3	3	4	4	4	4
140	62	60	13	12	136	135	131	127	134	130	135	130
135	232	226	243	229	226	208	288	208	303	213	253	209
130	668	607	602	504	634	547	868	636	908	661	762	651
125	1960	1500	1810	1170	1690	1310	1740	1510	1810	1540	1880	1280
120	3240	2580	3230	2410	3060	2380	3000	2330	3070	2390	2920	2370

Table 11. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK-PK isopleths in the water column. The source is operated at 2 m depth, the results are site independent.

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
215	2.4
212	3.4
210	4.3
209	4.8
205	7.6
202	10.8

Table 12. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK isopleths in the water column. The source is operated at 2 m depth, the results are site independent.

PK (dB re 1 µPa)	Vertical Distance from source (m)
213	0.6
210	0.8
207	1.6

4.2.1.2. Sub-bottom Profiler

The single pulse sound fields for the representative sub-bottom profiler (an EdgeTech X-Star SBP-216) are presented in terms of maximum-over depth SPL for marine mammal and turtle behavioural thresholds (Table 13), maximum-over-depth and seafloor per-pulse SEL (Tables 14 and 15), and water column PK-PK and PK (Tables 16 and 17). Water column PK-PK and PK are included as the levels referenced for benthic invertebrates in Section 2.1 are not reached at the seafloor.

Table 13. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled maximum-over-depth applied marine mammal and turtle behavioural response thresholds. A dash indicates the threshold is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
Marine mammal behaviour SPL: 160 dB re 1 µPa	2	2	2	2	2	2	2	2	2	2	2	2
Turtle behaviour, SPL: 166 dB re 1 µPa	—	—	—	—	—	—	—	—	—	—	—	—

Table 14. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled maximum-over-depth per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
145	—	—	—	—	—	—	—	—	—	—	—	—
140	1	1	1	1	1	1	1	1	1	1	1	1
135	4	4	4	4	4	4	4	4	4	4	4	4
130	8	8	8	7	7	7	7	7	7	7	7	7
125	13	12	13	13	11	11	10	10	10	10	11	10
120	16	16	19	18	14	13	13	12	13	13	13	13

Table 15. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled seafloor per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
135	—	—	—	—	—	—	—	—	—	—	—	—
130	—	—	—	—	—	—	5	5	6	6	6	6
125	10	10	13	13	9	9	8	8	8	8	10	9
120	15	14	19	18	13	12	12	12	13	12	13	13

Table 16. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK-PK isopleths in the water column. The source is operated at 3 m depth, the results are site independent.

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
215	0.3
212	0.4
210	0.5
209	0.6
205	1.0

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
202	1.4

Table 17. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK isopleths in the water column. The source is operated at 3 m depth, the results are site independent.

PK (dB re 1 µPa)	Vertical Distance from source (m)
213	0.1
210	0.2
207	0.3

4.2.1.3. VSP

The single pulse results for the 450 in^3 VSP array operating in 72 m of water at Site 5 are presented in terms of maximum-over-depth per-pulse SEL and SPL (Tables 18 and 19), and seafloor per-pulse SEL, PK-PK and PK (Tables 20–22).

Table 18. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 450 in^3 VSP array to modelled maximum-over-depth per-pulse SEL isopleths at Site 5. The 160 dB re 1 µPa^2·s isopleth (bold values) is associated with the DEWHA (2008) criterion.

Per-pulse SEL (dB re 1 µPa²·s)	Distance (km)	
	R_{max}	$R_{95\%}$
190	<0.02	<0.02
180	0.04	0.04
170	0.23	0.22
160	**1.06**	**1.03**
150	3.55	3.10
140	8.76	7.80
130	>23.0	>19.0

Table 19. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 450 in^3 VSP array to modelled maximum-over-depth SPL isopleths at Site 5 The 166 and 160 dB re 1 µPa isopleths (bold values) are associated with the turtle and marine mammal behavioural response thresholds.

SPL (dB re 1 µPa)	Distance (km)	
	R_{max}	$R_{95\%}$
190	<0.04	<0.04
180	0.22	0.21
170	0.89	0.86
166	**1.55**	**1.45**
160	**2.56**	**2.44**
150	6.96	6.24

SPL (dB re 1 µPa)	Distance (km)	
	R_{max}	$R_{95\%}$
140	19.9	16.8
130	>48.0	>42.0

Table 20. Maximum (R_{max}) horizontal distances (in m) from the 450 in^3 VSP array to modelled seafloor per-pulse SEL isopleths at Site 5 using VSTACK. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Distance (m)
185	-
180	35
178	65
176	105
174	145
172	180
170	210

Table 21. Maximum (R_{max}) horizontal distances (in m) from the VSP array at Site 5 to modelled seafloor PK-PK isopleths. A dash indicates the level is not reached.

PK-PK (dB re 1 µPa)	Distance (m)
212	–
210	–
209	–
208	30
207	55
206	75
205	100
202	185

Table 22. Maximum (R_{max}) horizontal distances (in m) from the VSP array at Site 5 to modelled seafloor PK isopleths. A dash indicates the level is not reached.

PK (dB re 1 µPa)	Distance (m)
213	–
207	–
204	20
202	60
200	110

PK (dB re 1 µPa)	Distance (m)
198	165

4.2.2. Maps and Graphs

4.2.2.1. Boomer

Maps of the per-pulse SEL at the seafloor along with vertical slices for the representative boomer are shown for two representative sites, Site 1 (Thylacine Midpoint: Figures 12 and 13) and Site 4 (Artisan: Figures 14 and 15). The shape of the footprint at all six modelled sites (Table 1) is almost identical.

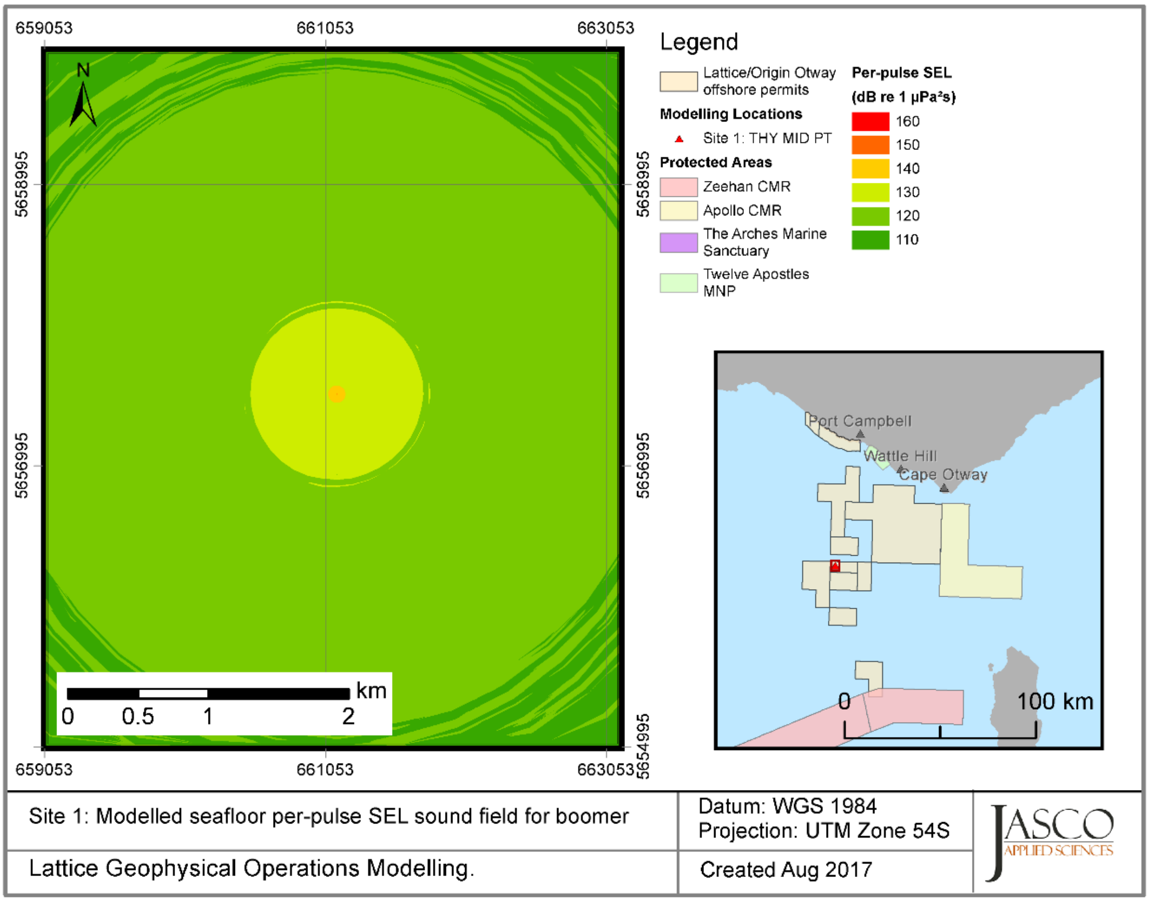

Figure 12. Boomer, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

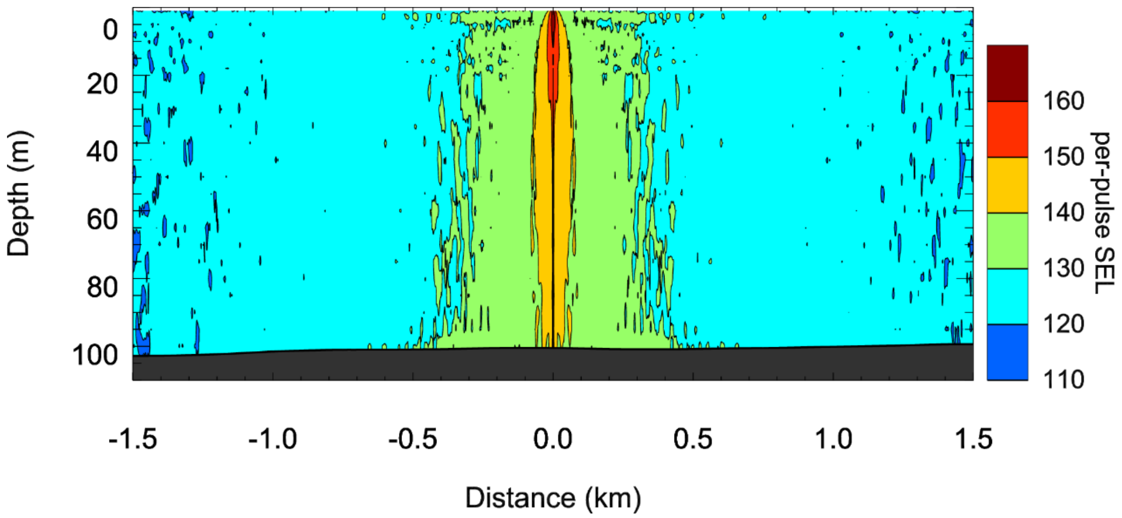

Figure 13. Boomer, Site 1: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

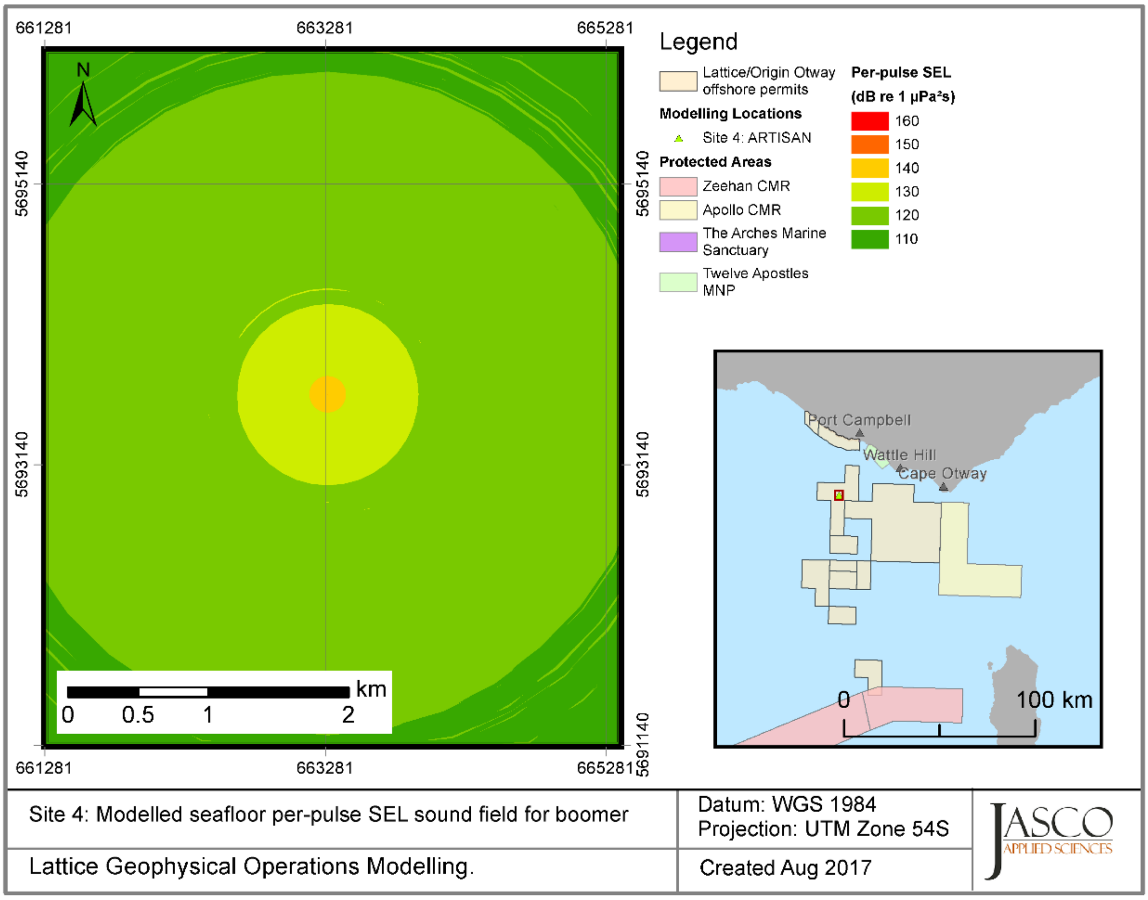

Figure 14. Boomer, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

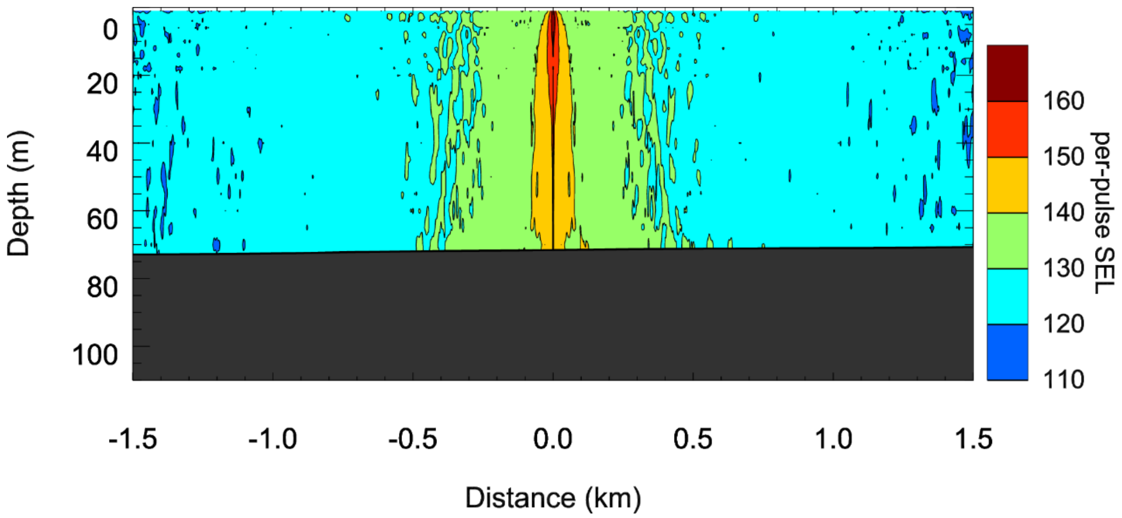

Figure 15. Boomer, Site 4: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

4.2.2.2. Sub-bottom Profiler

Maps of the per-pulse SEL at the seafloor along with vertical slices for the representative SBP is shown for two representative sites, Site 1 (Thylacine Midpoint: Figures 16 and 17) and Site 4 (Artisan: Figures 18 and 19). The shape of the footprint at all six modelled sites (Table 1) is almost identical.

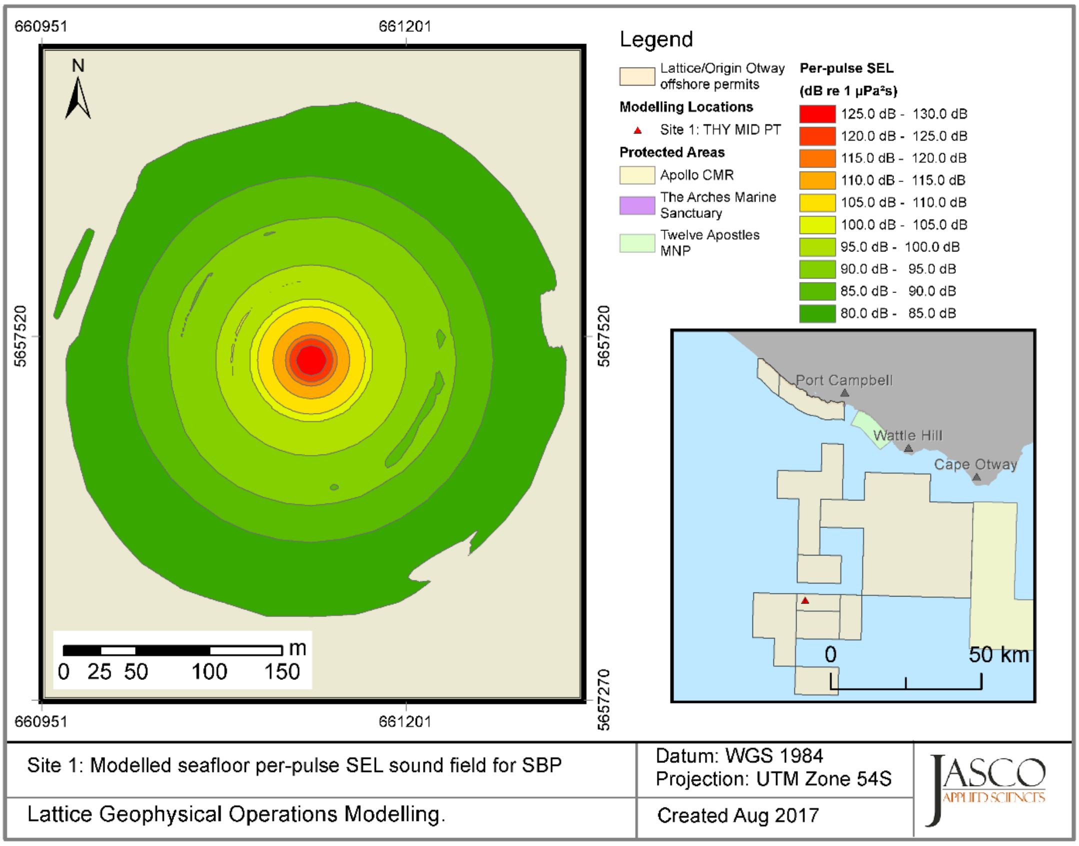

Figure 16. SBP, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

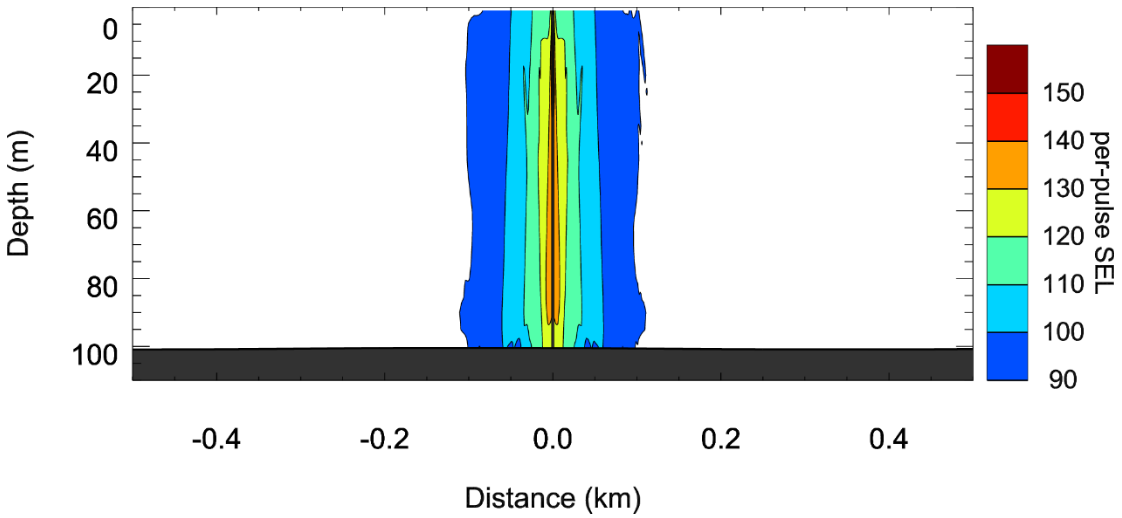

Figure 17. SBP, Site 1: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

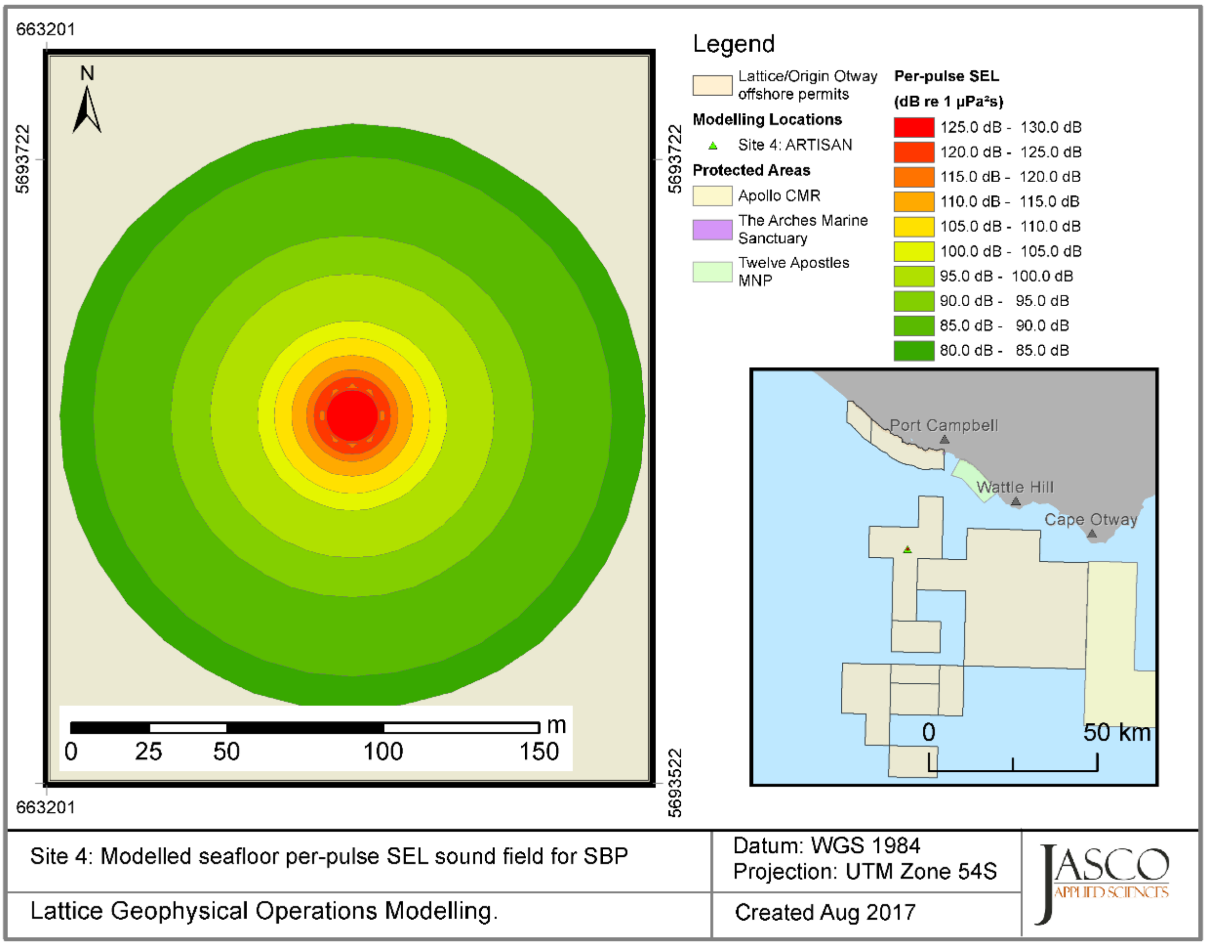

Figure 18. SBP, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

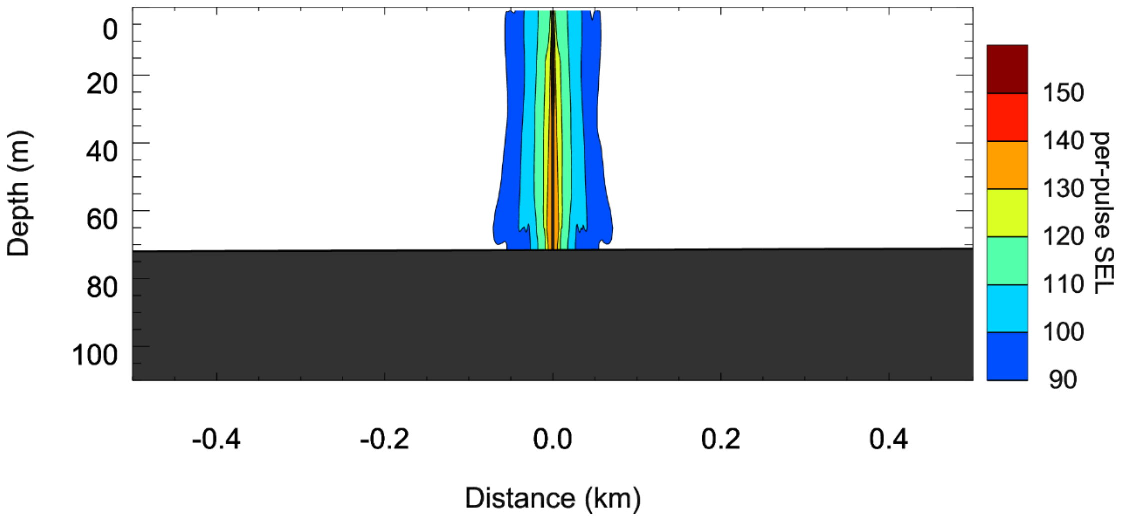

Figure 19. SBP, Site 4: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

4.2.2.3. VSP

Maps of the per-pulse SEL as maximum-over-depth along with vertical slices for the VSP is shown at Site 5, Block VICP69, North (Figures 20 and 21). Additionally, the PK and PK-PK at the seafloor out to 300 m is shown in Figure 22.

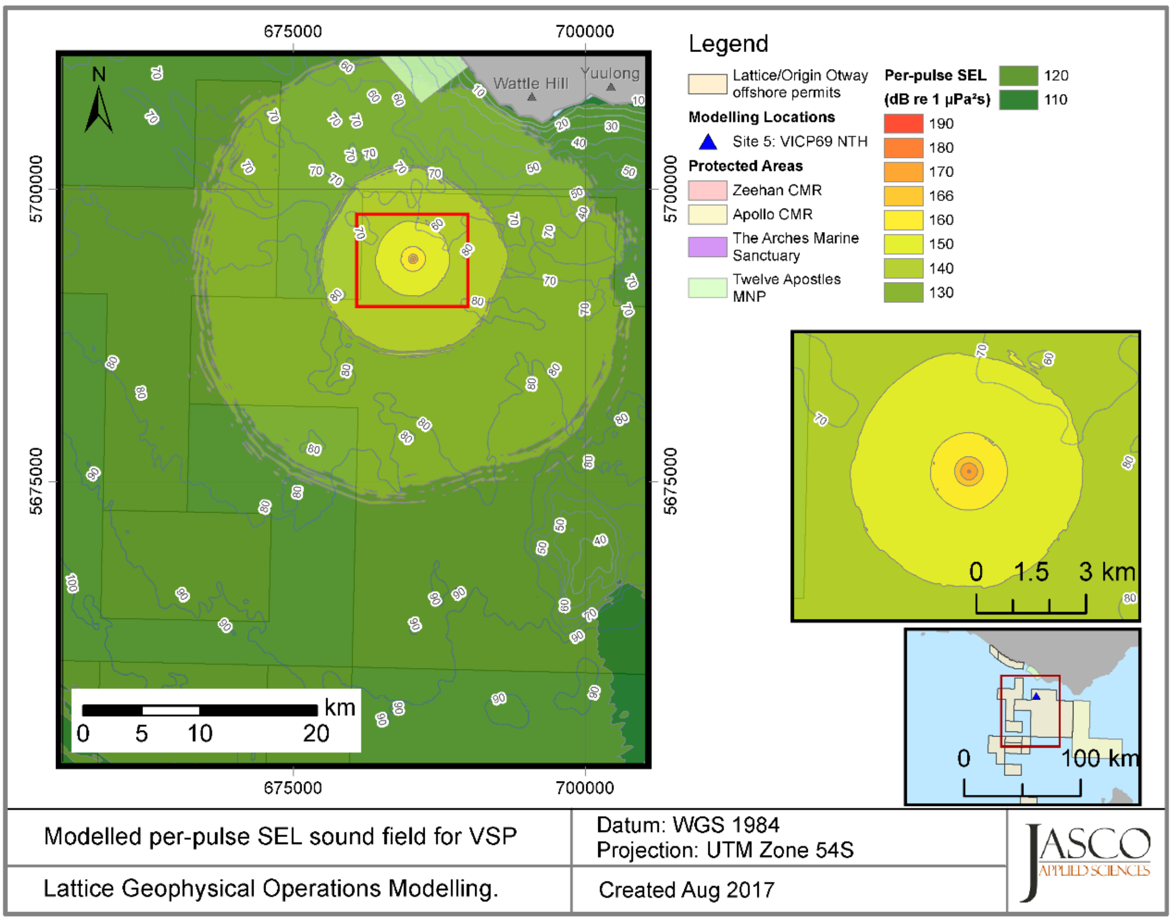

Figure 20. Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 450 in³ VSP array operated at 6 m depth at Site 5.

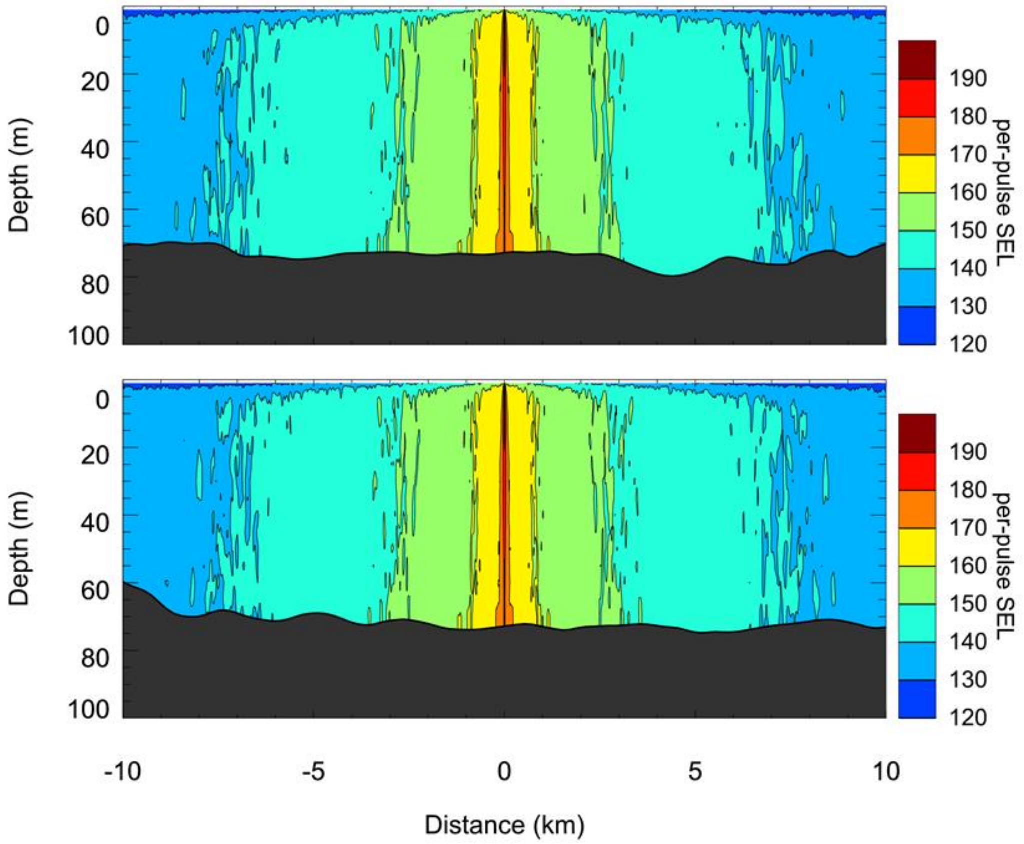

Figure 21. Predicted unweighted per-pulse SEL as vertical slices. Levels are shown in the broadside (top) and endfire directions (bottom). The source depth is 6 m.

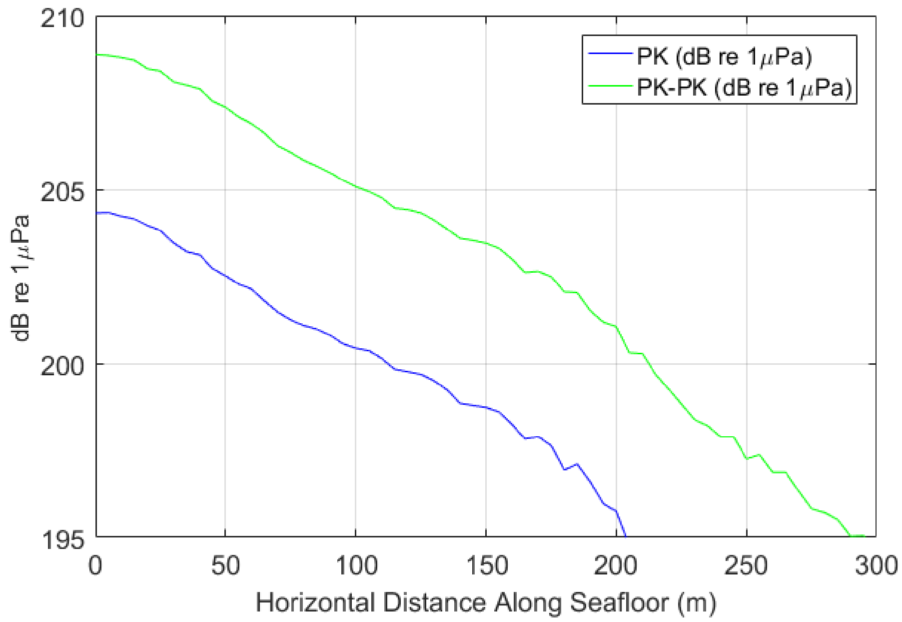

Figure 22. Predicted maximum PK and PK-PK in the endfire direction at the seafloor at Site 5, 72.8 m depth. The source depth is 6 m.

4.3. Accumulated Sound Exposure Levels

4.3.1. Tabulated Results

A cumulative noise study was performed for the four regions, Thylacine Combined, Geographe 3, Artisan, and Block VICP69 Meeki, as indicated in Figure 11. The study involved multiple survey lines with alternating pulses of the boomer and the sub-bottom profiler. Table 23 shows the distances to cumulative SEL thresholds at the seafloor where the accumulation period covers the entire survey.

Table 23. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the survey areas to modelled seafloor cumulative SEL isopleths, and the ensonified area to the specified threshold (in km²). A dash indicates that the level was not exceeded at the seafloor.

SEL (dB re 1 µPa^2·s)	Thylacine Combined			Geographe 3			Artisan			Block VICP69, Meeki		
	R_{max} (km)	$R_{95\%}$ (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)
170	—	—	—	—	—	—	—	—	—	—	—	—
165	0.11	0.05	12.52	0.05	0.05	8.86	0.09	0.05	9.46	0.05	0.05	9.08
160	1.7	1.2	38.9	1.1	0.8	22.7	1.2	0.8	22.7	1.1	0.8	22.7
155	6.9	5.3	189	4.8	4.1	107	4.8	3.9	106	5.5	4.2	114
150	9.6	6.9	287	8.2	6.4	221	8.1	6.4	220	8.3	6.4	221
145	>10	>10	NA	>10	>10	NA	>10	>10	NA	>10	>10	NA

4.3.2. Sound Level Contour Maps

Maps of the accumulated SEL at the seafloor for the combined operations of the boomer and the SBP over the duration of the surveys (described in Section 3.3.2) are shown for the four considered surveys. These are at the Thylacine Combined (Figure 23), Geographe 3 (Figure 24), Artisan (Figure 25) and Block VICP69, Meeki (Figure 26) locations.

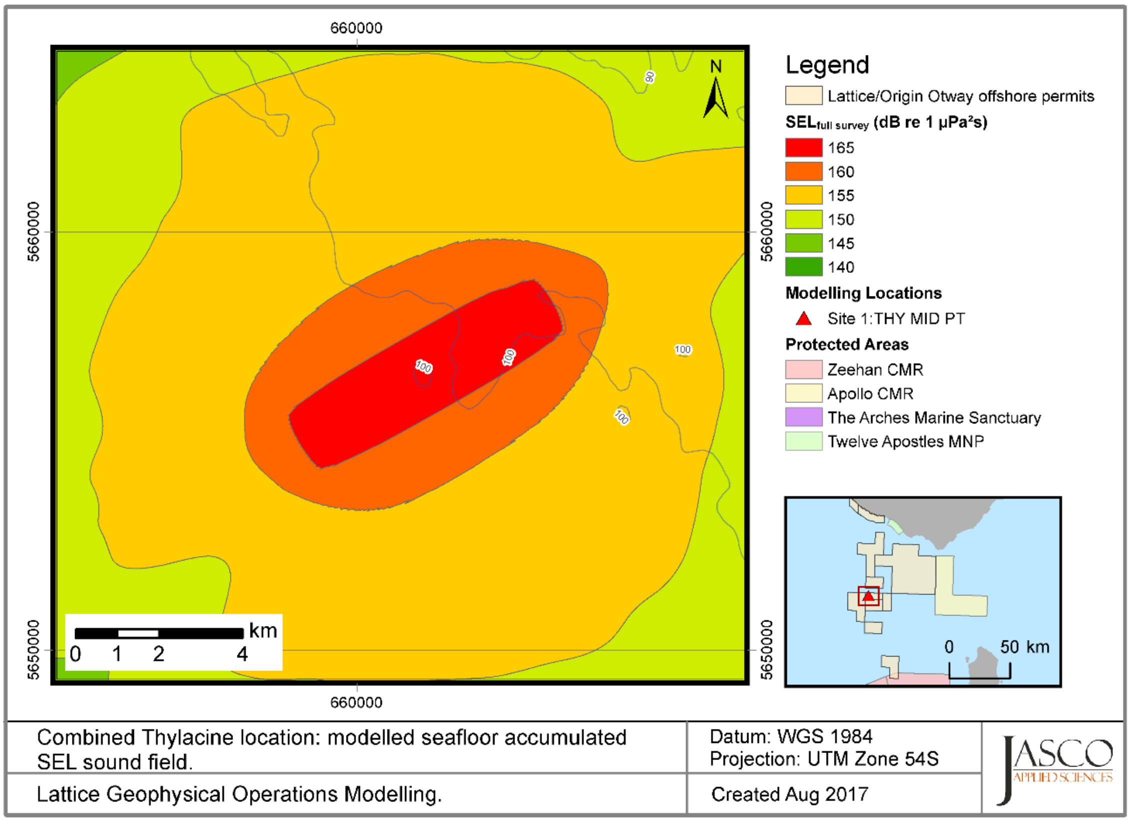

Figure 23. Thylacine Combined location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

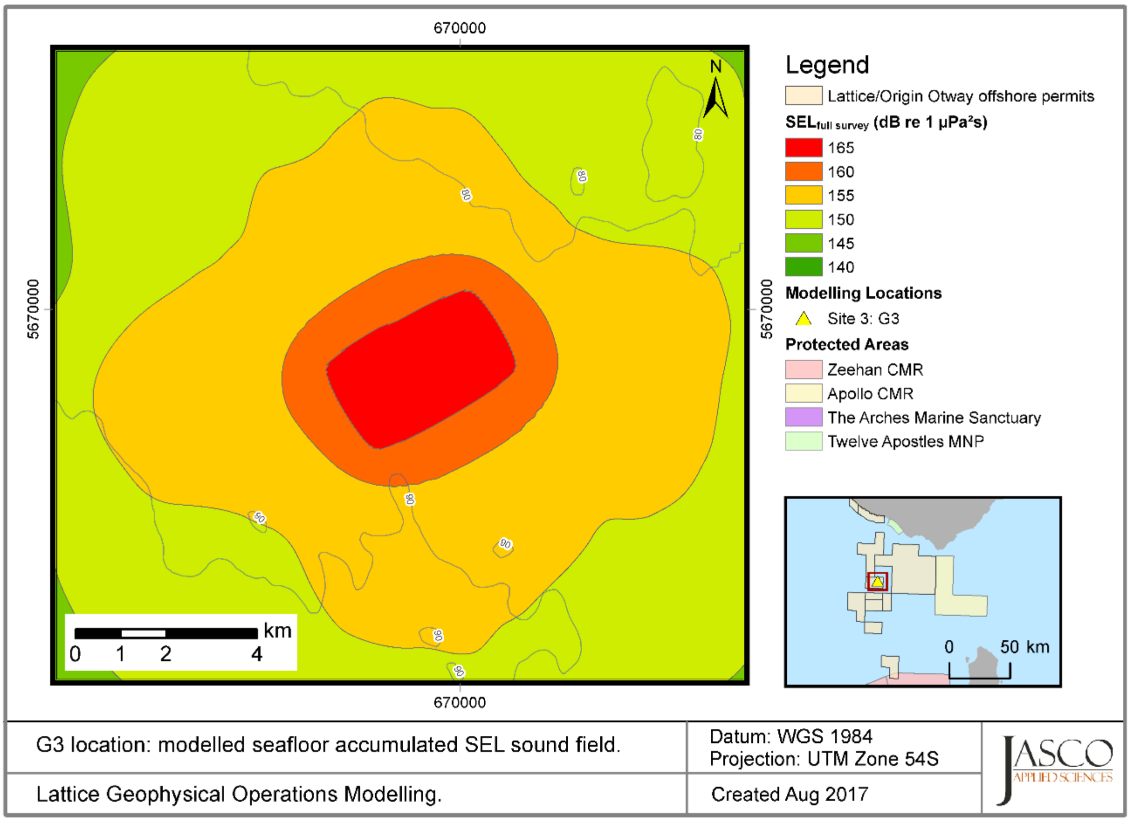

Figure 24. G3 location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

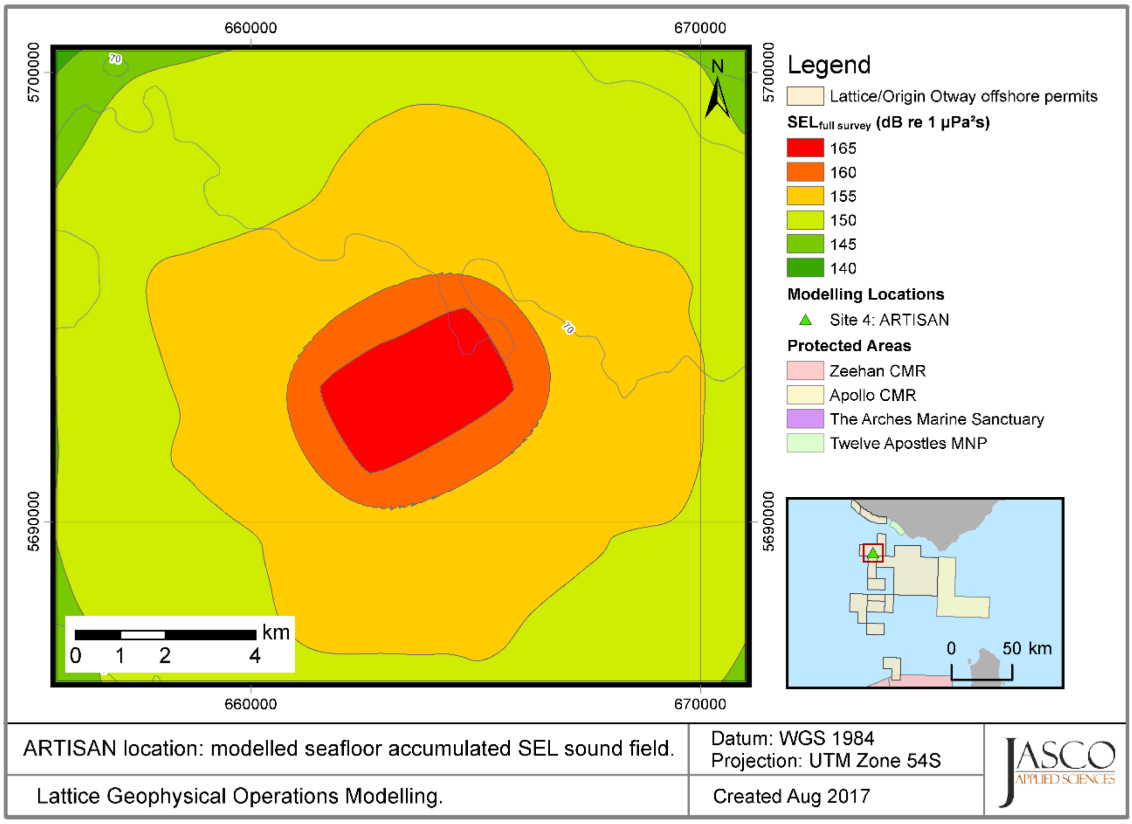

Figure 25. ARTISAN location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

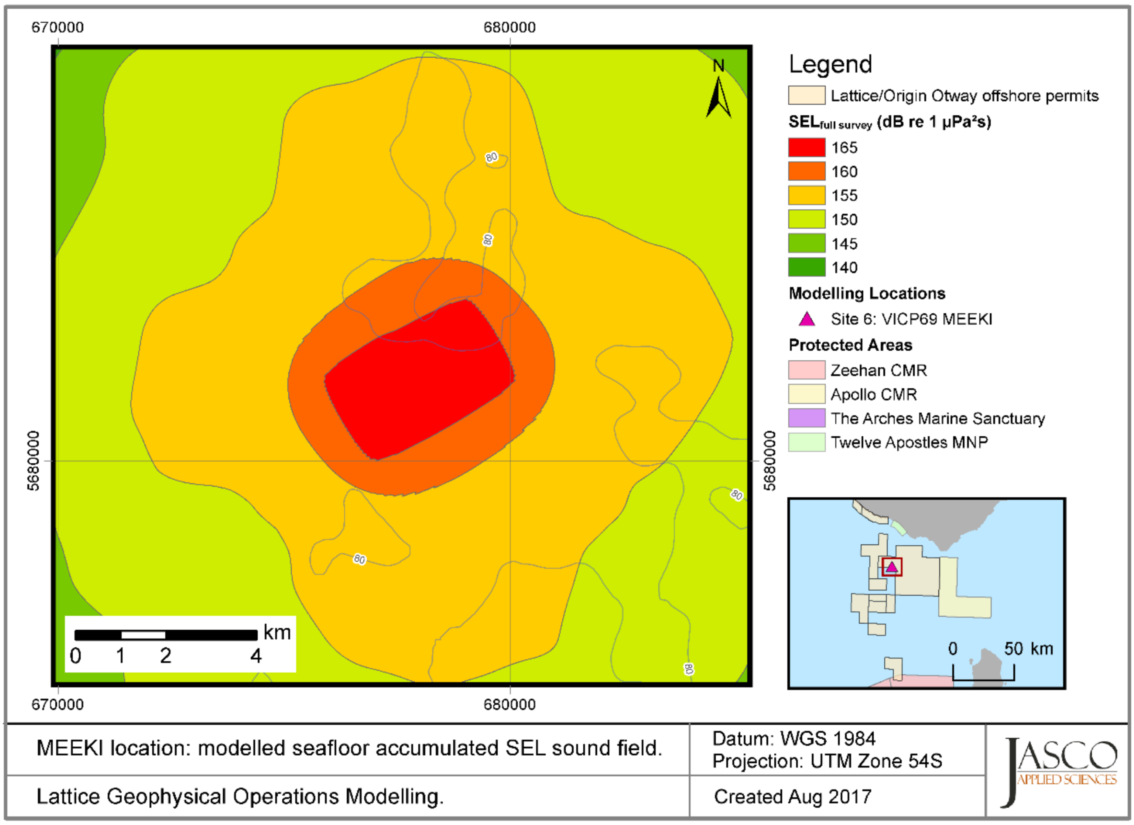

Figure 26. MEEKI location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

5. Discussion and Conclusion

5.1. Overview and source levels

This modelling study predicted underwater sound levels associated with the specified geophysical operations of the VSP, and surveys including boomer and sub-bottom profiler sources. Due to a lack of available literature on source functions for the high-frequency sources, the boomer and the sub-bottom profiler source inputs were determined from a previous JASCO measurement campaign (Sections 3.1.1 and 3.1.2). It was determined that the per-pulse SEL source level of the boomer was 180.0 dB re 1 µPa²·s @ 1 m, and for the sub-bottom profiler it was 171.4 dB re 1 µPa²·s @ 1 m; further metrics for the back propagated source levels are shown in Tables 4 and 5 respectively. The boomer was found to be a relatively broadband source with appreciable energy across the range of 160 Hz to 12.5 kHz (Figure 4). The sub-bottom profiler had the majority of energy at higher frequencies, between 5 kHz and 12.5 kHz.

The 450 in³ VSP was modelled using AASM at a centroid depth of 6 m (Section 3.1.3). The SEL source level of the VSP was 213.7 dB re 1 µPa²·s @ 1 m in the endfire direction, and 213.6 dB re 1 µPa²·s @ 1 m in the broadside direction; further source metrics are shown in Table 7. Most of the acoustic energy is output at lower frequencies, in the tens to hundreds of hertz. Due to the geometry of the array, the VSP is practically an omnidirectional source.

The modelling was performed using a typical September sound speed profile, as the setting most likely to achieve the greatest transmission, such that a precautionary estimation of distances can be made for the surveys (Section D.3.2). The lithography of the regions place Sites 1 & 2 in a region typified by a hard caprock, Sites 3, 4, and 6 in a region with a shallow sand layer over increasingly consolidated calcarenite, and Site 5 with a deeper sand layer over the calcarenite; this is detailed in Section D.3.3. The modelling also accounted for variations in site-specific bathymetry (Section D.3.1)

5.2. Single pulse sound fields

The results for the single pulse sound fields are presented in Section 4.2.

Across all sites, the maximum range for the boomer to exceed the marine mammal behavioural threshold (SPL of 160 dB re 1 µPa) is 145 m (Site 6), and to exceed the turtle behavioural threshold (SPL of 166 dB re 1 µPa) is 36 m, which is consistent across all sites (Table 8). The consistency for the turtle behavioural threshold is due to the levels being reached before influences from the site-dependent environment factors (bathymetry and geoacoustics). The range to the marine mammal behavioural threshold level at Site 2 is significantly shorter than at the other sites; this is due to the greater water depth and consequent lack of constructive noise fields within 150 m horizontally from the source.

The PK-PK ranges for the boomer are shown in Table 11. Due to the high threshold levels, the ranges were calculated assuming an acoustic field that is initially spherically spreading. This is valid where the source can be considered a point source, and there is no influence from reflecting surfaces. Due also to the directionality of the source, the ranges to the thresholds on-axis are going to be significantly greater than those off-axis and thus the vertical ranges from the sources are presented. It is shown that for the triple-plate boomer, the level drops below all relevant isopleths within 11 m of the source. Similar principles apply for PK levels in Table 12; the greatest range to a specified threshold is 1.6 m.

The SBP is a higher-frequency, more directional, and lower energy source than the boomer; consequently, the ranges are consistently lower. Using the generated source levels, the threshold for turtle behaviour is not reached at any horizontal distance from the source, and the marine mammal behavioural threshold is exceeded up to 2 m horizontally from the source (Table 13). Additionally, the ranges to thresholds at the seafloor are accordingly small (Table 15); here it is of note that the 115 and 120 dB re 1 µPa²·s SEL levels are at their greatest ranges at Site 2 due to the greater distance the conical beam may propagate, and thus widen, before reaching the interface.

For the SBP, the PK-PK and PK results were treated in the same way as for the boomer; results are shown for a spherically spreading noise field with the on-axis sound pressure analysed to determine ranges to thresholds. For the identified thresholds of interest for the SBP, the vertical distance does not exceed 1.4 m. In summary, sound fields from the boomer and the SBP do not reach any of the assessed thresholds for benthic crustaceans or fish (Section 2) at the seafloor.

The single pulse results for the VSP operated at Site 5 are shown in Section 4.2.1.3. The source has a significantly higher source level than either the boomer or the sub-bottom profiler. The maximum range to the DEWHA (2008) criterion of 160 dB re 1 µPa²·s SEL is 1.06 km, while the $R_{95\%}$ range is predicted to be 1.03 km. The maximum ranges to the marine mammal and turtle behavioural thresholds of 160 and 166 dB re 1 µPa SPL are 2.56 and 1.55 km respectively. The per-pulse SEL levels at the seafloor were modelled using VSTACK to allow for levels to be determined at high propagation angles. The maximum per-pulse SEL on the seafloor below the array is 181 dB re 1 µPa²·s, therefore the levels from Day et al. (2016b) of 190, 188 and 186 dB re 1 µPa²·s, are not reached at the seafloor.

In the case of the VSP source, PK thresholds of interest are reached at the seafloor and so it was modelled fully with all environmental parameters considered, rather than the spherical spreading approach used for the other two sources. The results show that the lowest isopleth of interest derived from Day et al. (2016b), 209 dB re 1 µPa, is not reached at the seafloor, and the horizontal range along the seafloor to the 202 dB re 1 µPa PK-PK level from Payne et al. (2007) is 185 m. PK metrics relevant to the Popper et al. (2014) criteria for fish are also not reached at the seafloor.

In this modelling study, both the boomer and sub-bottom profiler sources were directed straight down. Consequently, the sound channels constructed as a result of the sound speed profile are unlikely to influence the propagation of sound greatly. It is of note, that if either high-frequency source is directed toward the sea surface then the sound channels are likely to enhance the propagation of these sources. As the VSP is typically a low-frequency source, the fine details in the sound speed profile near the surface are unlikely to influence the propagation.

5.3. Multiple pulse sound fields

The study included modelling to assess the cumulative effect of noise generated for four separate survey areas. The surveys themselves comprise multiple lines along which the boomer and sub-bottom profiler sources are fired alternately. In total, more than 27000 pulses were included for the Thylacine Combined survey over the estimated 51 h of survey, and more than 21000 pulses for each of the other three surveys over the estimated 40.2 h. Sound levels were assessed only at the seafloor with results shown in Table 14. The modelling results show that the SEL at the seafloor did not exceed 170 dB re 1 µPa²·s for any single survey. This is below any of the relevant isopleths for benthic invertebrates, including the 183 dB re 1 µPa²·s 'no effect' accumulated SEL (McCauley and Duncan 2016). Due to the identical sources, and sound speed profiles, and similar depths and geoacoustics, the ranges between the surveys are similar. The greatest ranges are realised for the Thylacine Combined survey; here, the survey is in deeper water than the others as well as featuring the caprock layer that is likely to produce stronger reflections off the sediment layer.

Glossary

3-D
Three-dimensional

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands comprise a one octave-band. One-third-octave-bands become wider with increasing frequency. Also see octave.

90% time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% sound pressure level (SPL(T_{90}))
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

audiogram
A graph of hearing threshold level (sound pressure levels) as a function of frequency, which describes the hearing sensitivity of an animal over its hearing range.

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).

BIA
Biologically Important Area (http://www.environment.gov.au/marine/marine-species/bias)

broadside direction
Perpendicular to the travel direction of a source. Compare to endfire direction.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

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. Also see broadside direction.

ensonified area
The total area ensonified in conjunction with a specified isopleth.

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.

functional hearing group
Grouping of marine mammal species with similar estimated hearing ranges. Southall et al. (2007) proposed the following functional hearing groups: low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seafloor.

hearing threshold
The sound pressure level 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 cetacean
The functional hearing group that represents odontocetes specialised for using 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 cetacean
The functional hearing group that represents mysticetes (baleen whales).

maximum-over-depth (MOD)
The maximum value over all modelled depths above the sea floor.

mid-frequency cetacean
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

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 use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the grey whale (*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). Marine vessels, aircraft, machinery, construction, and vibratory pile driving are examples.

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, characterises these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

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.

peak sound pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: dB re 1 µPa

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

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
The acoustic signal power per unit frequency as measured at a single frequency. Unit: µPa^2/Hz, or µPa^2·s.

power spectrum density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 µPa^2/Hz.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pulsed sound
Discrete sounds with durations less than a few seconds. Sounds with longer durations are called continuous sounds.

received level
The sound level measured at a receiver.

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·s) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A measure related to the sound energy in one or more pulses. Unit: dB re 1 µPa^2·s.

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

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:

$$\text{SPL} = 10\log_{10}\left(p^2/p_0^2\right) = 20\log_{10}\left(p/p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level Unit: dB re 1 µPa.

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 pressure level or sound exposure level measured 1 metre from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 µPa @ 1 m or dB re 1 µPa^2·s.

spectrum
An acoustic signal represented in terms of its power (or energy) distribution versus frequency.

SBP
Sub-bottom profiler.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

transmission loss (TL)
Also called propagation loss, this refers to 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.

VSP
Vertical Seismic Profiler.

wavelength
Distance over which a wave completes one oscillation cycle. Unit: meter (m). Symbol: λ.

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Appendix A. 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 impulsive noise 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 noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level, or peak sound pressure level (PK; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20 \log_{10}\left[\frac{\max(|p(t)|)}{p_0}\right] \tag{A-1}$$

$L_{p,pk}$ is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The root-mean-square (rms) sound pressure level (SPL; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to an rms pressure level and, therefore, not instantaneous pressure:

$$L_p = 10 \log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-2}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalisation, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL. Throughout this study, a fixed time window of 125 ms is used as the integration period.

The sound exposure level (SEL, dB re 1 µPa²·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10 \log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-3}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. 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:

$$L_{E,N} = 10 \log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \tag{A-4}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of M-weighted SEL (e.g., $SEL_{LFC,24h}$). The use of fast, slow, or impulse exponential-time-averaging, or other time-related characteristics should else be specified.

Because the SPL and SEL are both computed from the integral of square pressure, these metrics are related by a simple expression, which depends only on the duration of the 90% energy time window T_{90}:

$$L_E = L_{p90} + 10\log_{10}(T_{90}) + 0.458 \quad \text{(A-5)}$$

where the 0.458 dB factor accounts for the SPL containing 90% of the total energy from the per-pulse SEL.

Appendix B. Acoustic Source Modelling

B.1. Transducer Beam Theory

Mid- and high-frequency underwater acoustic sources for geophysical measurements create an oscillatory overpressure through rapid vibration of a surface, using either electromagnetic forces or the piezoelectric effect of materials. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer, and may be capable of receiving as well as emitting signals. Transducers are usually designed to produce an acoustic wave of a specific frequency, often in a highly directive beam. The directional capability increases with increasing operating frequency. The main parameter characterizing directivity is the beamwidth, defined as the angle subtended by diametrically opposite “half power” (-3 dB) points of the main lobe (Massa 2003). For different transducers, the beamwidth varies from 180° (almost omnidirectional) to a few degrees.

Transducers are usually built with either circular or rectangular active surfaces. For circular transducers, the beam pattern in the horizontal plane (assuming a downward pointing main beam) is equal in all directions. The beam pattern of a rectangular transducer is variable with the azimuth in the horizontal plane.

The acoustic radiation pattern, or beam pattern, of a transducer is the relative measure of acoustic transmitting or receiving power as a function of spatial angle. Directionality is generally measured in decibels relative to the maximum radiation level along the central axis perpendicular to the transducer surface. The pattern is defined largely by the operating frequency of the device and the size and shape of the transducer. Beam patterns generally consist of a main lobe, extending along the central axis of the transducer, and multiple secondary lobes separated by nulls. The width of the main lobe depends on the size of the active surface relative to the sound wavelength in the medium. Larger transducers produce narrower beams. Figure B-1 shows a 3-dimensional (3-D) visualisation of a typical beam pattern for a circular transducer.

The true beam pattern of a transducer can be obtained only by in situ measurement of the emitted energy around the device. Such data, however, are not always available, and for propagation modelling it is often sufficient to estimate the beam pattern of the source based on transducer beam theory. An example of a measured beam pattern is shown in Figure B-2.

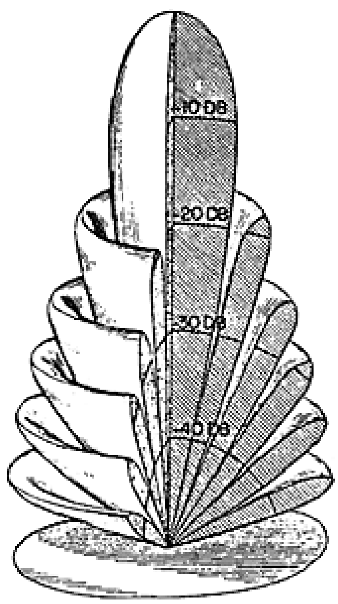

Figure B-1. Typical 3-D beam pattern for a circular transducer (Massa 2003).

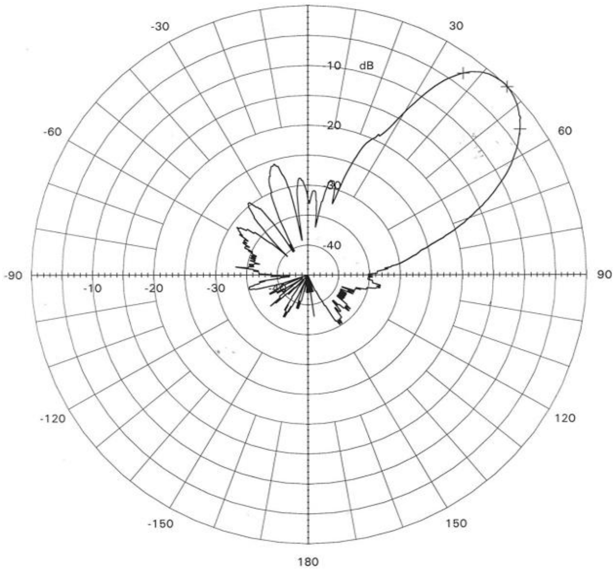

Figure B-2. Vertical cross section of a beam pattern measured in situ from a transducer used by Kongsberg (source: Zykov (2013)).

B.2. Circular Transducers

The beam of an ideal circular transducer is symmetrical about the main axis; the radiated level depends only on the depression angle. In this study, beam directivities were calculated from the standard formula for the beam pattern of a circular transducer (Kinsler et al. 1950, [ITC] International Transducer Corporation 1993). The directivity function of a conical beam relative to the on-axis pressure amplitude is:

$$R(\phi) = \frac{2 \cdot J_1\left(\pi\, D_\lambda \sin(\phi)\right)}{\pi\, D_\lambda \sin(\phi)} \text{ and } D_\lambda = \frac{60}{\theta_{bw}}, \tag{1}$$

where J_1 is the first-order Bessel function, D_λ is the transducer dimension in wavelengths of sound in the medium, θ_{bw} is the beamwidth in degrees, and ϕ is the beam angle from the transducer axis. The beam pattern of a circular transducer can be calculated from the transducer's specified beamwidth or from the diameter of the active surface and the operating frequency. The calculated beam pattern for a circular transducer with a beamwidth of 20° is shown in Figure B-3. The grayscale represents the source level (dB re 1 µPa @ 1 m) and the declination angle is relative to a central vector (0°, 0°) pointing down.

Although some acoustic energy is emitted at the back of the transducer, the theory accounts for the beam power in only the front half-space (ϕ < 90°) and assumes no energy directed into the back half-space. The relative power at these rearward angles is significantly lower, generally by more than 30 dB, and consequently the emission in the back half-space can be estimated by applying a simple decay rate, in decibels per angular degree, which gives a beam power at ϕ = 90° of 30 dB less than that at ϕ = 0°. This is a conservative estimate of the beam power in the back half-space.

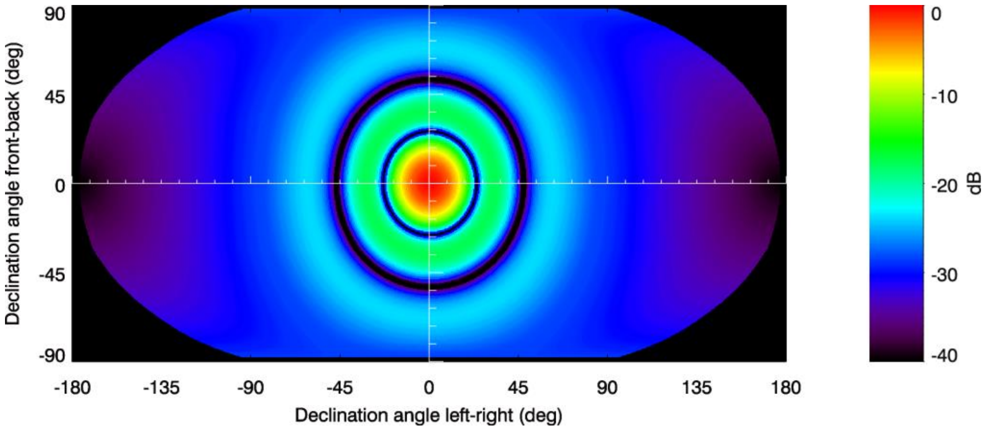

Figure B-3. Calculated beam pattern for a circular transducer with a beamwidth of 20°. The beam power function is shown relative to the on-axis level using the Robinson projection.

B.3. VSP Modelling

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the airgun array 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 Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

Whilst 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 deterministically. Therefore, the high-frequency module of AASM uses a stochastic simulation to predict the sound emissions of individual airguns above 800 Hz, using a multivariate statistical model. The current version of AASM has been tuned to fit a large library of high quality seismic source signature data obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation of 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 1/3-octave-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 to be 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:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \qquad \text{(B-2)}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, an airgun array 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.4. VSP Acoustic Source Levels and Directivity Results

Figure B-4 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signatures and corresponding power spectrum levels for the 3090 in^3 array. The signatures consist 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 is produced at frequencies below 200 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the array, and correspond with the volumes and relative locations of the airguns to each other.

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-5); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.3.

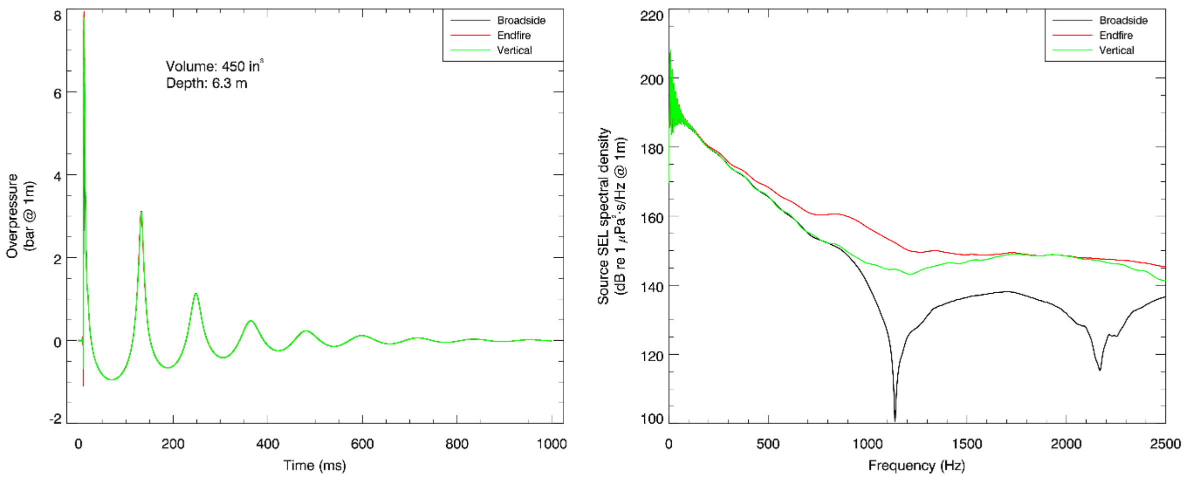

Figure B-4. Predicted source level details for the 450 in^3 VSP array operated at a centroid depth of 6 m. (Left) the overpressure signature and (right) the power spectrum for broadside (perpendicular to tow direction) and endfire (directly aft of the array) directions, and for vertically down.

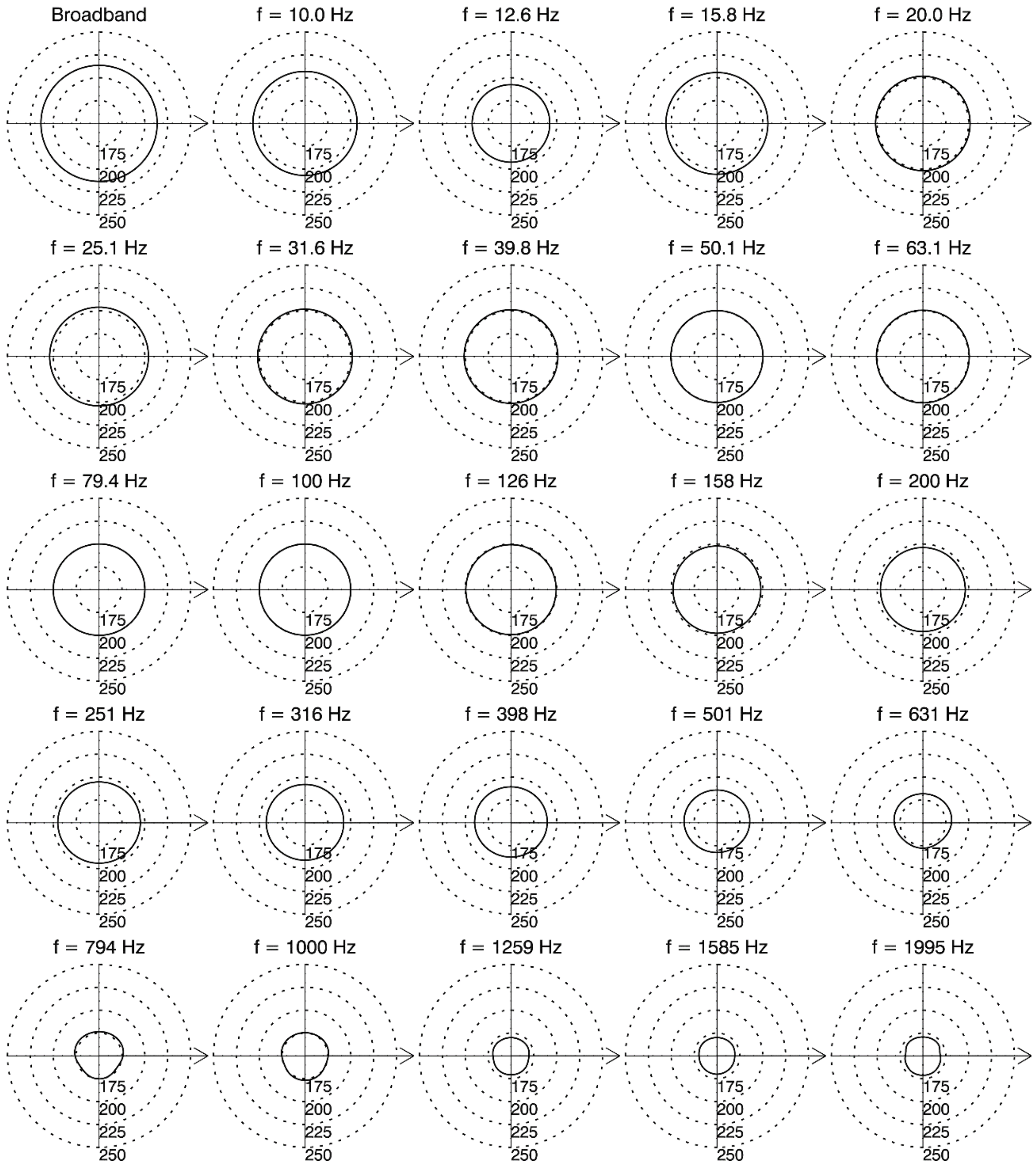

Figure B-5. Directionality of the predicted horizontal source levels for the 450 in^3 array, 5–2000 Hz. Source levels (in dB re 1 µPa^2·s) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. Operating depth is 6 m (see Section 3.1.3).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Underwater sound propagation (i.e., transmission loss) was predicted with JASCO's Marine Operations Noise Model (MONM). This model computes sound propagation at frequencies of 5 Hz to 1.25 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 > 1.25 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

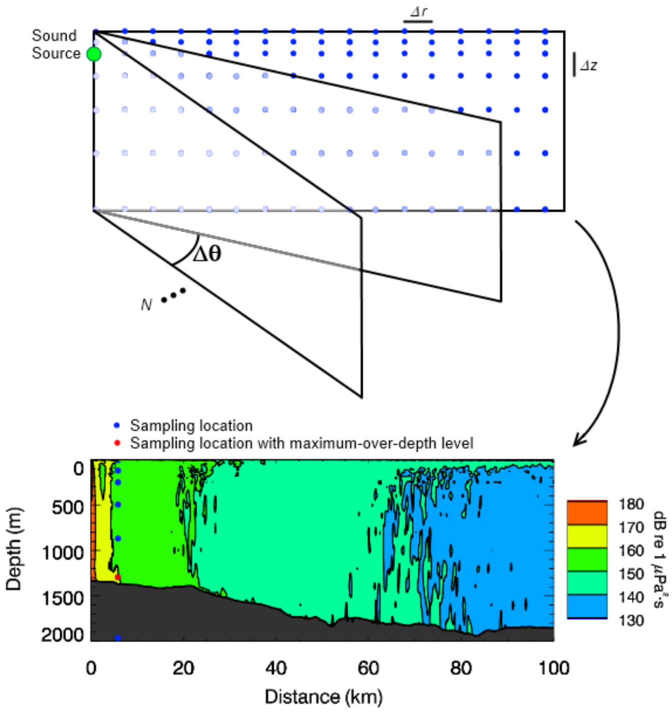

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modelled to include most 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 1/3-octave-band received per-pulse SELs are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received SELs are then computed by summing the received 1/3-octave-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 receiver 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 SELs are presented as colour contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (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, Martin et al. 2015).

C.2. FWRAM

For impulsive sounds from the seismic array, time-domain representations of the pressure waves generated in the water are required to calculate SPL and peak pressure level. Furthermore, the airgun array 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 peak pressure level and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the airgun array 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 solving 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 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.

Appendix D. Methods and Parameters

This section describes the specifications of the airgun array source that was used at all sites and the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

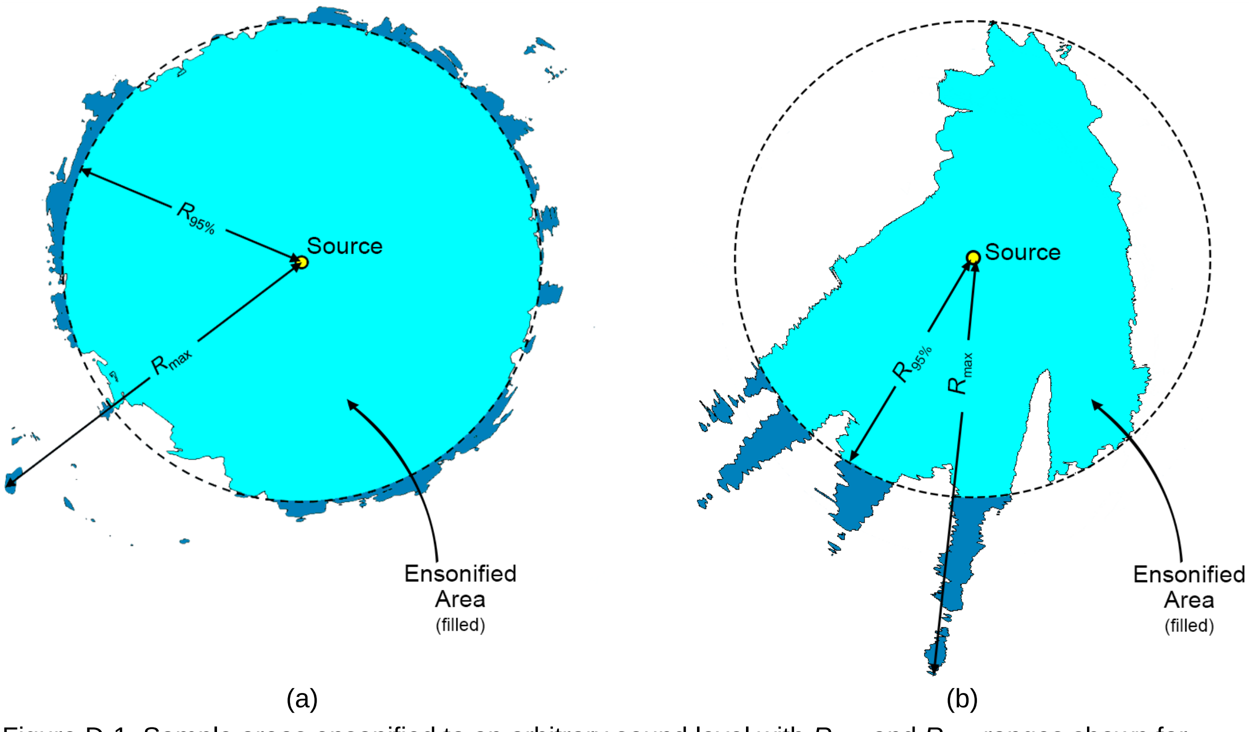

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The SEL of individual sound pulses is an energy-like metric related to the dose of sound received over the pulse's duration. The SPL on the other hand is related to the pulses intensity over a specified time interval (Appendix A). The time interval applied in this report is fixed at 125 ms.

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 affect the numeric relationship between SPL and SEL because the amount of pulse energy within the specified time interval changes. Full-waveform modelling is necessary 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.

The current study, modelled synthetic seismic pulses from 5–1024 Hz with FWRAM (Appendix C.2).

FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL can be calculated from the propagated signal. SPL was calculated using a 125 ms fixed time window positioned to maximise the SPL over the pulse duration. The difference between the SEL and SPL was extracted for all ranges and depths corresponded to those generated in the high spatial-resolution MONM results. The resulting SEL-to-SPL offsets were then averaged in 0.5 km range bins. The final range-dependent conversion function for each site correspond to the 90th percentile curve derived from the SEL-to-SPL offsets along all radials at that site. These range-dependent conversion functions were applied to predicted per-pulse SEL results from MONM and BELLHOP to model SPLs. The range-dependent conversion function for the VSP at Site 5 is shown in Figure D-2.

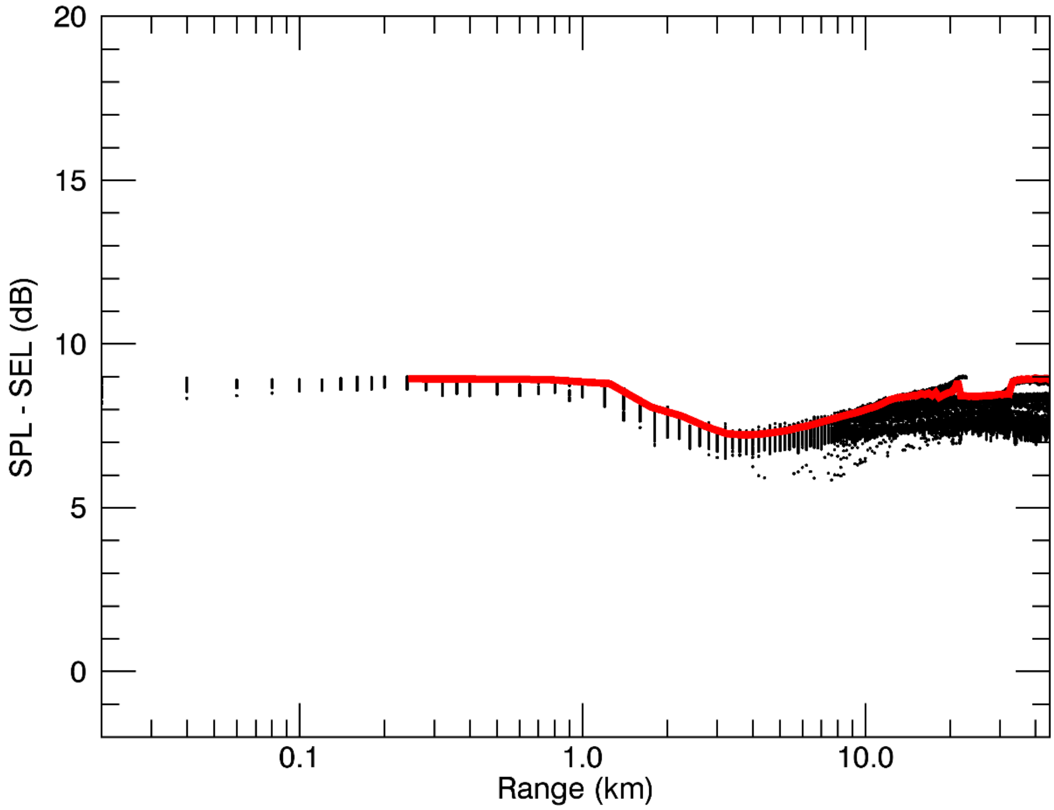

Figure D-2. Conversion Factor applied: Range-dependent conversion function for converting single-pulse SEL to SPL for the 450 in^3 VSP array.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were supplied by the client. The bathymetric data was re-gridded onto a Cartesian grid with a regular grid spacing of 50 × 50 m; this grid was used for all modelled sites in this study.

D.3.2. 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 temperature and salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981).

The sound speed profiles across the year were calculated across the area encompassing all sites, with the median sound speed at each depth retained for comparison. It was found that the sound speed profile for September provided the greatest propagation and is consequently used for the modelling. Since the profiles did not extend to the maximum water depth in the modelling area, they were supplemented with a deeper nearby offshore profile.

The final profile features a sound channel at 70 m, as well as a surface duct that may allow for enhanced high frequency propagation. Due to the bathymetry of the modelling region, most propagation is within the top two-hundred metres. At greater depths, the profile is downwardly refracting until 1300 m depth. The sound speed profile used throughout the modelling is shown in Figure D-3.

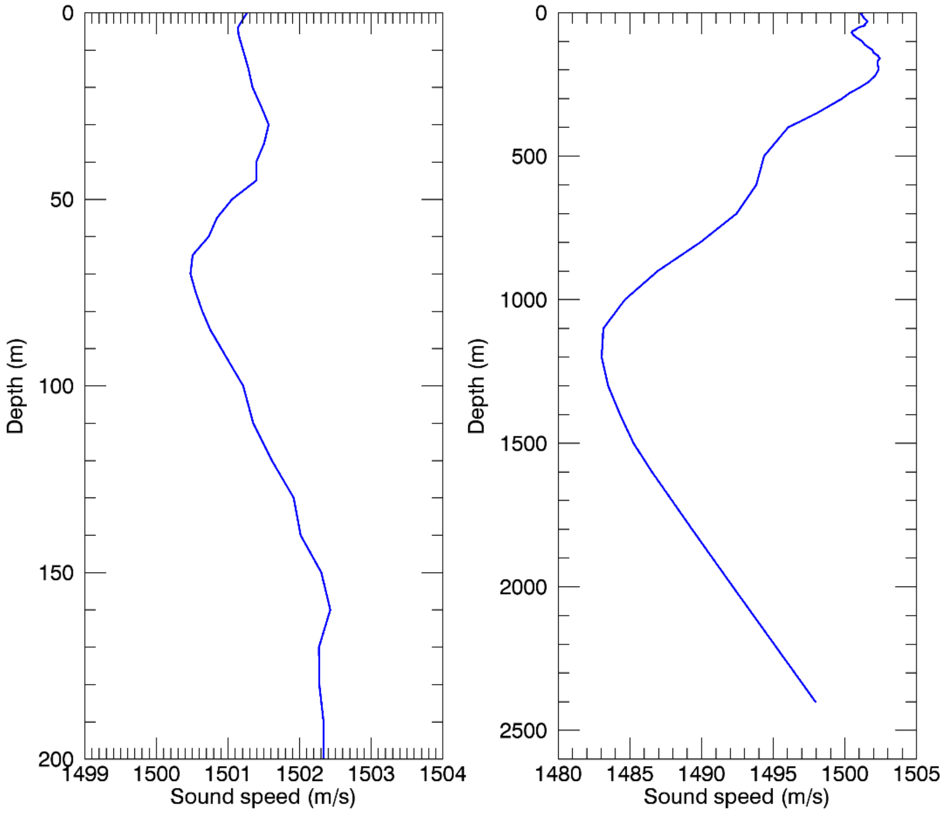

Figure D-3. The sound speed profile for September across the modelling region for the first 200 m (left), and over the entire range of depths (right). The profile was calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Each of the models used in this study utilise a single geoacoustic profile for each site. The geoacoustics determine how sound is reflected from the seabed, as well as how it is coupled into the sediment layers. The geoacoustic description for Site 5 are taken from a ground truthing report due to its proximity to the location (Duncan 2017). The geoacoustic profiles for the other sites were generated using lithographic descriptions from the geotechnical reports supplied by the client. Sites 1 and 2 located towards the south of the region were found typically to feature a well-cemented calcarenite caprock over a softer calcarenite layer. Sites 3, 4, and 6 typically exhibited a sand layer that sat above increasingly cemented calcarenite. In all cases, the calcarenite layer was found to extend to many hundreds of metres below the seafloor.

Geoacoustic values for Calcarenite have been taken from Duncan et al. 2013; where the calarenite is indicated to be increasingly consolidated with depth, the properties have been linearly interpolated. The geoacoustic parameters for sand are generated using models proposed by Hamilton (Hamilton 1980). The three final geoacoutics profiles used for the modelling are presented in Tables D-1 to D-3.

Table D-1. Geoacoustic profile used as the input to the models at Sites 1 & 2.

Depth below seafloor (m)	Material	Density (g/cm³)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0-1	Well-cemented carbonate caprock	2.7	2600	0.5	1200	0.5
1-20	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
20-40		2.3	2120	0.34	960	0.316
40-60		2.4	2240	0.38	1020	0.362
60-80		2.5	2360	0.42	1080	0.408
80-10		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Table D-2. Geoacoustic profile used as the input to the models at Sites 3, 4, & 6.

Depth below seafloor (m)	Material	Density (g/cm³)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0-0.5	Coarse carbonate sand	2.03	1803.1	0.85	300	6.2
0.5-20	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
20-40		2.3	2120	0.34	960	0.316
40-60		2.4	2240	0.38	1020	0.362
60-80		2.5	2360	0.42	1080	0.408
80-100		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Table D-3. Geoacoustic profile used as the input to the models at Site 5.

Depth below seafloor (m)	Material	Density (g/cm³)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0	Coarse carbonate sand	2.03	1802.2	0.85	300	6.2
20		2.07	1836.27	0.84	320	6.5
20-36	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
36-52		2.3	2120	0.34	960	0.316
52-68		2.4	2240	0.38	1020	0.362
68-84		2.5	2360	0.42	1080	0.408
84-100		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Appendix D JASCO Acoustic Modelling Technical Note

Technical Note

Supplemental modelling results for *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures*

From: Michael Wood and Craig McPherson
JASCO Applied Sciences (Australia) Pty Ltd

Date: 02 April 2019

Document: 01777

This technical note provides additional modelling results that supplement the original report: *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures* (McPherson and Wood 2017).

Tabulated ranges are provided to impact thresholds defined by NMFS (2018) for cetaceans and pinnipeds from operations involving the boomer and sub-bottom profiler (SBP) sound sources, and from the 450 in^3 vertical seismic profiling (VSP) array.

The sound exposure level (SEL) results for the different auditory classes of marine mammal are frequency-weighted in accordance with NMFS (2018); the weighting functions are described in Appendix A; peak pressure levels (PK) are unweighted.

Results are presented for the Boomer and SBP in Section 1, and for the VSP in Section 2, while Section 3 discusses potential alternative sources for the study.

1. Boomer and SBP

1.1. Impact ranges from PK for high-frequency cetaceans

The ranges to identified impact thresholds for high-frequency cetaceans from the PK levels of the Boomer and SBP are shown in Table 1. The threshold levels for the equivalent effect in low- and mid-frequency cetaceans are appreciably higher, and thus were not reached.

Table 1. Maximum ranges to identified impact thresholds due to PK levels defined by NMFS for high-frequency cetaceans from SBP and Boomer operations.

PK Threshold Level dB re 1 µPa	Effect	SBP Range (m)	Boomer AP3000 Range (m)
202	PTS	0.6	2.8
196	TTS	1.2	5.5

1.2. Maximum ranges to impact thresholds from SEL_{24h} for marine mammals

The ranges to recommended impact thresholds from the Boomer and SBP are presented in Table 2. In all cases, the frequency-weighted levels are not high enough to reach the impact thresholds except for TTS in low-frequency cetaceans; the maximum range in this case is 10 m from the acoustic centre of the source.

Table 2. Maximum ranges to identified impact thresholds due to frequency-weighted SEL_{24h} levels defined by NMFS from SBP and Boomer operations.

Auditory group	Effect	Frequency-weighted Threshold Level dB re 1 µPa²·s	Artisan Range (m)	G3 Range (m)	Meeki Range (m)	Thy Comb Range (m)
Low-frequency Cetaceans	PTS	183	—	—	—	—
	TTS	168	10	<10	<10	<10
Mid-frequency Cetaceans	PTS	185	—	—	—	—
	TTS	170	—	—	—	—
High-frequency Cetaceans	PTS	155	—	—	—	—
	TTS	140	—	—	—	—
Phocid pinnipeds	PTS	185	—	—	—	—
	TTS	170	—	—	—	—
Otariid pinnipeds	PTS	203	—	—	—	—
	TTS	188	—	—	—	—

2. VSP

The ranges to recommended impact thresholds resulting from the VSP are presented in Table 3. Results assume both stationary source and receivers. Results are frequency-weighted in accordance with NMFS (2018). Maximum ranges are shown for 1, 5, 10, 15, 25, 144, and 360 impulses within a 24-hour period. Ranges up to 2.5 km calculated using 1 m resolution modelling on 5 m resolution gridded sound fields; ranges greater 2.5 km calculated using 10 m resolution modelling on 25 m resolution gridded sound fields.

Table 3. Maximum ranges to identified impact thresholds due to frequency-weighted SEL_{24h} defined by NMFS from VSP operations assuming different numbers of impulses during a 24-hour period.

Auditory group	Effect	Frequency-weighted Threshold Level dB re 1 µPa²·s	Number of impulses						
			1 R_{max} (m)	5 R_{max} (m)	10 R_{max} (m)	15 R_{max} (m)	25 R_{max} (m)	144 R_{max} (m)	360 R_{max} (m)
Low-frequency Cetaceans	PTS	183	11	30	45	56	72	323	738
	TTS	168	81	335	625	924	1227	3051	4743
Mid-frequency Cetaceans	PTS	185	—	—	—	—	—	—	—
	TTS	170	—	—	—	—	—	<10	<10
High-frequency Cetaceans	PTS	155	—	—	—	<10	<10	18	32
	TTS	140	<10	21	29	36	51	149	256
Phocid pinnipeds	PTS	185	—	—	—	<10	<10	21	34
	TTS	170	<10	22	32	40	55	222	409
Otariid pinnipeds	PTS	203	—	—	—	—	—	—	—
	TTS	188	—	—	—	—	—	<10	14

3. Comparison of sources

Beach Energy solicited tenders for the geophysical survey, and received three responses which proposed alternative equipment to that considered in McPherson and Wood (2017). These three responses have been evaluated, with the findings summarised below.

The primary sources of concern are the boomer and sub-bottom profiler, with other the potential sources for this project such as multi-beam echo sounders and side-scan-sonars being high frequency devices only, with centre frequencies over 100 Hz. As no mid-frequency multi-beam sonars are being considered, the potential for overlap between marine fauna hearing ranges and multi-beam sonar signals of concern is extremely limited.

The proposed sub-bottom profiler is the Edgetech X-star system, which is the same source as considered in the modelling study. Alternative boomers suggested as potential sources instead of the AP3000 include the AA251, AA300 and AA301. The modelled AP3000 signature was based upon scaling the signature of an AA202 single boomer plate. The frequency spectrum components of these potential sources are very similar to the modelled AP3000, and they will also exhibit a similar beam pattern. The peak source pressure level of the alternative boomers is slightly higher than the AP3000, which has a peak source pressure level of 210.8 dB re 1 $\mu Pa^2 m^2$, with that for the AA251 being of 212 dB re 1 $\mu Pa^2 m^2$ and AA301's 215 dB re 1 $\mu Pa^2 m^2$. This results in slightly greater ranges to PK thresholds for high-frequency cetaceans (Table 4), however criteria for other mammal auditory groups are not reached. There is also an increase in distance to PK-PK sound levels of interest, however the resulting ranges are still small, with no PK-PK sound level applied in the impact assessment exceeded more than 18 m from the source (Table 5). However, as both the Boomer and SBP are both towed at 3 m, the maximum depth at which the sound level of 202 dB re 1 µPa will be reached will be 21 m. As the shallowest modelling site of interest (Artisan, Table 1 in McPherson and Wood (2017)) has a depth of 71 m, no PK-PK sound levels of interest for benthic invertebrates will be reached at the seafloor.

Despite the differences in peak source pressure level between the modelled and potential alternative boomers, there is estimated to be only a very minor change in the per-pulse source sound exposure level (SEL), partly due to the length of the impulse from these alternative sources. Due to minor changes expected in term of per-pulse SEL, the modelling results presented in McPherson and Wood (2017) for SEL_{24h} are considered to be appropriate approximations of the potential sound fields and ranges to SEL_{24h} impact criteria.

Table 4. Maximum ranges to identified impact thresholds due to PK levels defined by NMFS for high-frequency cetaceans for the modelled boomer (AP3000) and two potential alternative boomers.

PK Threshold level dB re 1 µPa	Effect	Boomer AP3000 Range (m)	Boomer AA251 Range (m)	Boomer AA301 Range (m)
202	PTS	2.8	3.2	4.5
196	TTS	5.5	6.3	8.9

Table 5. Maximum ranges to identified PK-PK sound levels for the modelled boomer (AP3000) and two potential alternative boomers.

PK-PK dB re 1 µPa	Boomer AP3000 Range (m)	Boomer AA251 Range (m)	Boomer AA301 Range (m)
215	2.4	2.8	3.9
212	3.4	3.9	5.5
210	4.3	4.9	7.0
209	4.8	5.5	7.8
205	7.6	8.7	12.4
202	10.8	12.4	17.5

References

[NMFS] National Marine Fisheries Service. 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 pp. https://www.fisheries.noaa.gov/webdam/download/75962998.

Finneran, J.J. 2015. *Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores*. Technical report by SSC Pacific, San Diego, CA.

Finneran, J.J. 2016. *Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise*. Technical Report for Space and Naval Warfare Systems Center Pacific, San Diego, CA. 49 pp. http://www.dtic.mil/dtic/tr/fulltext/u2/1026445.pdf.

McPherson, C.R. and M.A. Wood. 2017. *Otway Basin Geophysical Operations Acoustic Modelling*. Document Number 01473. Technical report by JASCO Applied Sciences for Lattice Energy.

Appendix A.

NMFS (2018) Frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The auditory weighting functions for marine mammals are applied in a similar way as A-weighting for noise level assessments for humans. The new frequency-weighting functions are expressed as:

$$G(f) = K + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \quad \text{(A-1)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group. Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions recommended by NMFS (2018).

Functional hearing group	a	b	f_1 (Hz)	f_2 (Hz)	K (dB)
Low-frequency cetaceans	1.0	2	200	19,000	0.13
Mid-frequency cetaceans	1.6	2	8,800	110,000	1.20
High-frequency cetaceans	1.8	2	12,000	140,000	1.36
Phocid pinnipeds in water	1.0	2	1,900	30,000	0.75
Otariid pinnipeds in water	2.0	2	940	25,000	0.64

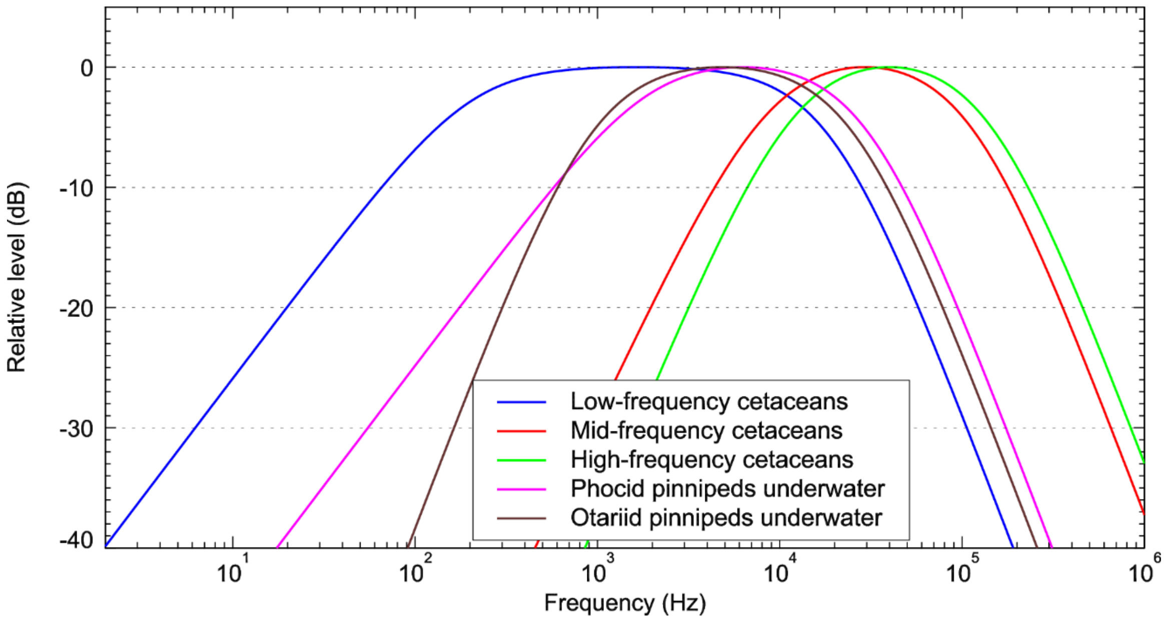

Figure A-1. Auditory weighting functions for the functional marine mammal hearing groups as recommended by NMFS (2018).

Appendix E EP Revision Change Register

Any changes to the EP should be assessed against the OPGGS(E)R revision submission criteria detailed in Table 8-9.

Date	EP Revision	Section Revised	Changes	MOC No.	EP Submission Required