Environment Plan

S4200AH718461

Environment Plan

T/30P Geophysical and Geotechnical Seabed Survey

Review record (record the last 3 revisions here or the revisions required to achieve current approval version)

Revision	Date	Reason for issue	Reviewer/s	Consolidator	Approver
A	15 Nov 2019	Beach Review	ZB	JM	SJ
B	19 Nov 2019	Beach Review	ZB	JM	SJ
0	22 Nov 2019	Submission to NOPSEMA	PW	SJ	ZB

Review due	Review frequency
N/A	N/A

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

Table of contents

Table of figures

List of tables

Acronyms

Terms/acronym	Definition/expansion
2D	2-Dimensional
3DTZSS	3-Dimensional 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
ASAP	as soon as practicable
ASX	Australian Stock Exchange
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 (now the Department of Agriculture)
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
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
MNES	Matters of National Environmental Significance
MO	Marine Order
MOC	Management of Change
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
OPGGS Act	*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
PMST	Protected matters Search Tool
POLREP	Marine Pollution Report
PTS	permanent threshold shift
RMS	Root mean square
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), propose to undertake a geophysical and geotechnical survey (site survey) over a portion of their T/30P permit and open acreage in the Otway Basin in Commonwealth waters (Figure 1-1). At its closest point, the site survey is approximately 76.5 km from the township of Port Campbell, Victoria.

The site survey will take up to 28 days and is proposed to be undertaken between 1 February 2020 to 30 April 2020 or 1 October 2020 to 31 December 2020. Timings of the survey is contingent on the availability of suitable vessels, weather and the receipt of required environmental approvals.

The operational area (OA) is 100 km^2 and within water depths ranging from 150 m to 1,110 m.

The site survey consists of:

- Geophysical survey to obtain bathymetry data and detect seabed hazards using:
    - Multibeam echo sounder;
    - Side-scan sonar;
    - Sub-bottom profiler;
    - Magnetometer;
    - Ultra-Short Baseline Positioning System; and
    - Sound Velocity Profiler and Conductivity, Temperature and Depth profiler.
- High resolution two-dimensional (2D) shallow reflective imaging to inform shallow gas hazards. Equipment for this survey will consist of a sound source of up to 160 in^3 and one 1.2 km streamer towed by a vessel at a speed of approximately 8-9 km/hr (4 – 5 knots).
- Geotechnical survey to collect information on the properties of the seabed and the underlying shallow sediments using:
    - Coring
    - Cone Penetrometer Test
    - Grab samples

1.1 Environment Plan summary

This T/30P Geophysical and Geotechnical Seabed Survey 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 3.2.1
A description of the receiving environment	Section 4 and Appendix B
A description of the activity	Section 3

EP Summary Material Requirement	Relevant Section of EP Containing EP Summary Material
Details of the environmental impacts and risks	Section 6
The control measures for the activity	Section 6.5
The arrangements for ongoing monitoring of the titleholder's environmental performance	Section 7.10 and Section 7.22
Response arrangements in the oil pollution emergency plan	Section 6.4 and Section 7.16
Consultation already undertaken and plans for ongoing consultation	Section 8
Details of the titleholders nominated liaison person for the activity	Section 1.2

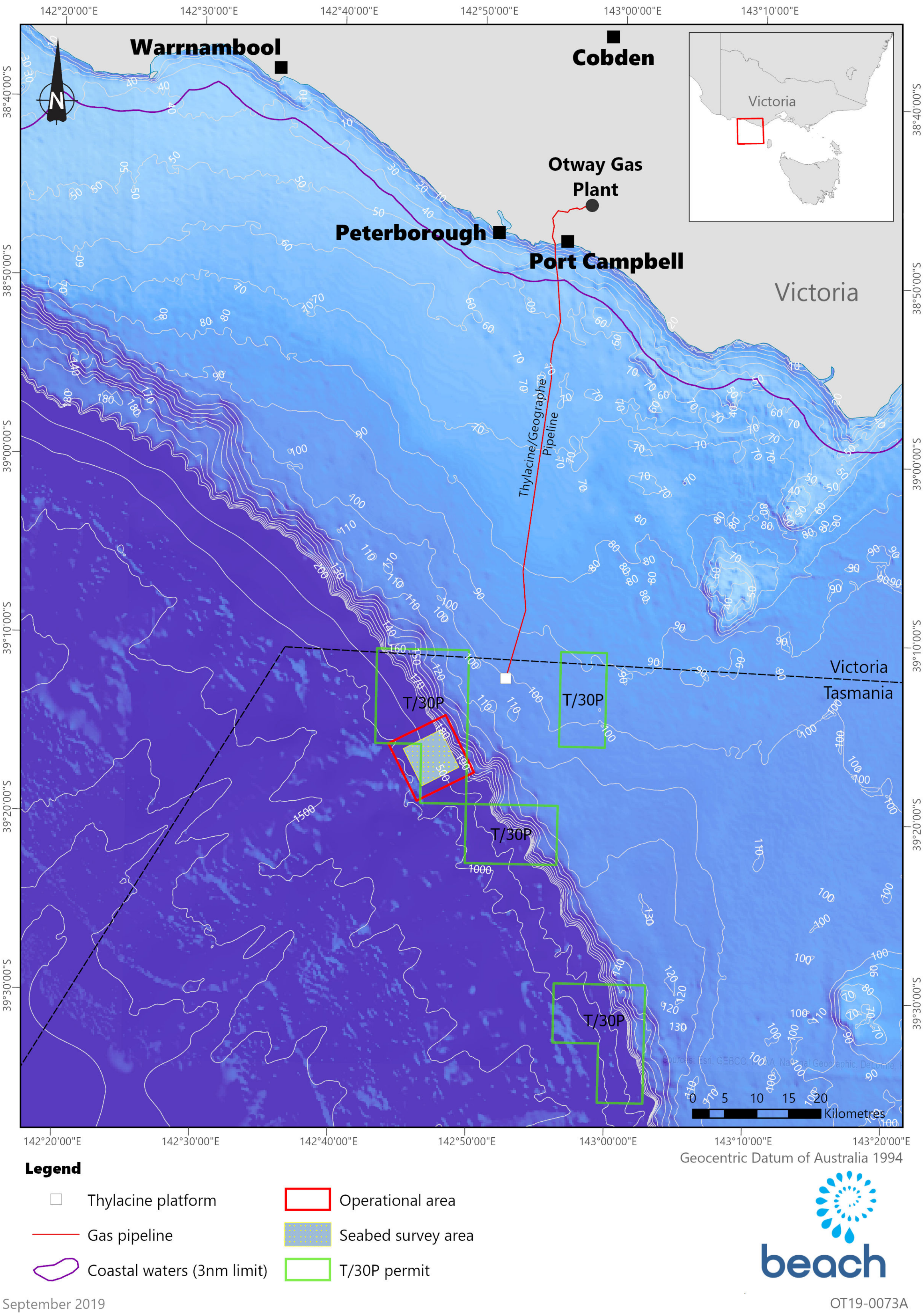

Figure 1-1: T/30P permit and site survey location.

1.2 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 1-2).

Table 1-1 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 for the site survey, in accordance with Regulation 15(3) of the OPGGS(E)R.

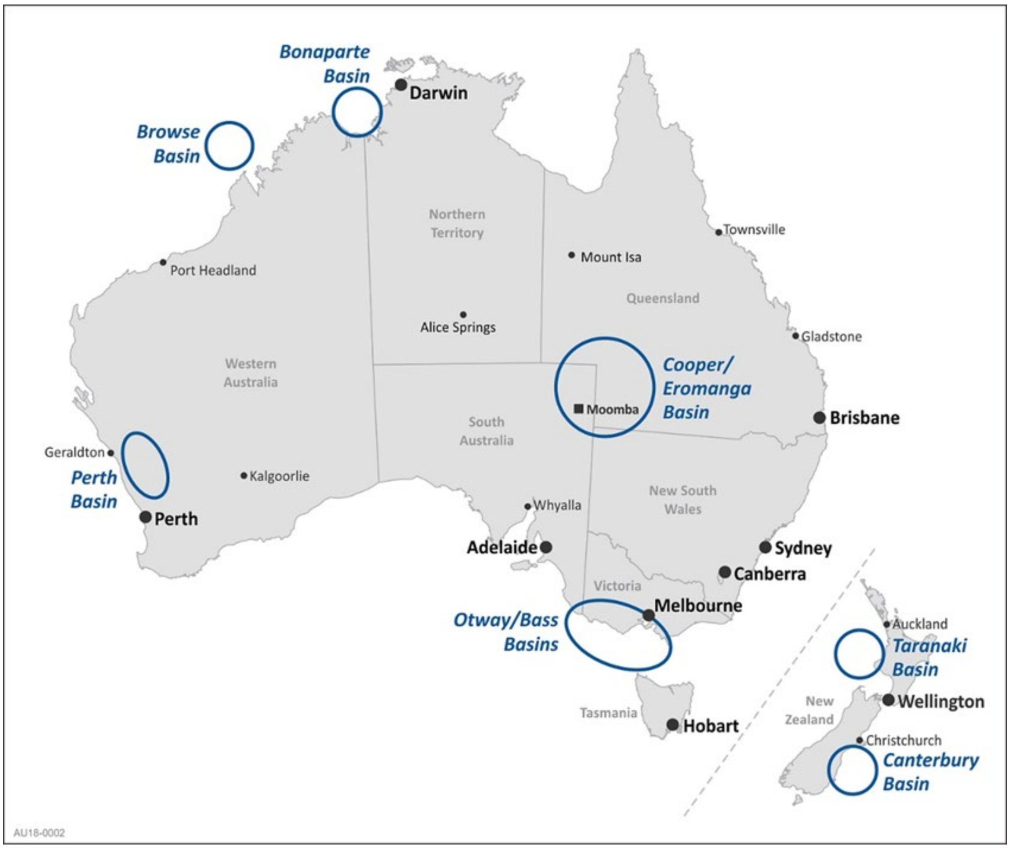

Figure 1-2: Beach operations within Australia and New Zealand

Table 1-1: Details of titleholder and liaison person

Petroleum Title(s)	Details	
T/30P	Titleholder	Lattice Energy Limited
	Business address	Level 8 80 Flinders Street Adelaide South Australia 5000
	Telephone number	(08) 8338 2833
	Email address	info@beachenergy.com.au
	Australian Company Number	Lattice Energy Limited (ACN: 007 845 338)
Titleholder Liaison Person		
Zoe Brooking Manager Marine Surveys and Projects	Business address	Level 8 80 Flinders Street Adelaide South Australia 5000
	Telephone number	(08) 8433 2367
	Email address	Zoe.brooking@beachenergy.com.au

2 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 site survey are summarised in Table 2-1.

2.1 EPBC Act management plans

Table 2-2 details the recovery plans, threat abatement plans and species conservation advices applicable to species that may be present within environment that may be affected (EMBA) by the site surveys' planned and unplanned activities. This is further detailed in Section 4. Where an applicable threat or management advice has been identified relevant to the site survey's planned and unplanned activities, this is addressed in Section 6.

Table 2-1: Commonwealth environmental legislation relevant to the site survey

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 7.16.*	• 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 6-2 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
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)	Department of Agriculture

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 coastline. 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 6-2.*		
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 4 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 6 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)

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
Environment Protection and Biodiversity Conservation Regulations 2000	Part 8 of the regulations provide distances and actions to be taken when interacting with cetaceans. **Application to activity**: The interaction requirements are applicable to the activity if a cetacean is sighted. *Section 6 details how these requirements will be applied.*	-	DotEE
Underwater Cultural Heritage Act 2018	This Act replaces the *Historic Shipwreck Act* 1976. The Act provides for the protection of Australia' underwater cultural heritage. It protects the heritage values of remains of vessels, aircraft and certain associated articles that have been in Commonwealth waters for at least 75 years. Vessels and aircraft that have been underwater less than 75 years, and other types of underwater cultural heritage, can be protected through individual declaration based on an assessment of heritage significance. **Application to activity**: Provisions under the Act are applicable to the activity in the event of removal, damage or interference to items of underwater cultural heritage and/or the activity is proposed within an Underwater Protected Heritage Zone. *Section 4 details that there are no Underwater Protected Heritage Zones within the environment that may be affected (EMBA). If any remains of vessels, aircraft and associated articles are located during the site survey, they will be reported as per Table 7-3.*	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 6 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	Department of Agriculture
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 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: SOLAS and non-SOLAS certification. **Application to activity**: The relevant vessels (according to class) will adhere to the relevant MO regarding navigation and preventing collisions in Commonwealth waters. *Sections 6 details the requirements applicable to vessel activities.*		
Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act) 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 6.*	-	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. • MO 93: Marine Pollution Prevention – Noxious Liquid Substances.	• Various parts of MARPOL	AMSA

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	• MO 94: Marine Pollution Prevention – Packaged Harmful Substances. • MO 95: Marine Pollution Prevention – Garbage. • MO 96: Marine Pollution Prevention – Sewage. • MO 97: Marine Pollution Prevention – Air Pollution. *Section 6 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. *Section 6 details the requirements applicable to vessel activities.*	• International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001	AMSA

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

Relevant Plan/Advice	Applicable Threats or Management Advice
Fish	
Recovery Plan for the White Shark (*Carcharodon carcharias*)	This Plan identifies the actions required to ensure long-term viability of white shark in nature and relevant stakeholders. **Objective** 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** • No applicable threats identified.
Seabirds	
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. **Objective** The overall objective of the 2011-2016 recovery plan is to ensure the long-term survival and recovery of albatross and giant petrel populations breeding and foraging in Australian jurisdiction by reducing or eliminating human related threats at sea and on land. **Threats** • **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. **Objective** None specified. **Threats** • **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. **Objective** None specified. **Threats** • **Marine pollution**: Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented.

Relevant Plan/Advice	Applicable Threats or Management Advice
National Recovery Plan for Gould's Petrel (*Pterodroma leucoptera leucoptera*)	Recovery plan identifies actions to be taken to ensure the long-term viability of the Gould's petrel in nature and relevant stakeholders. **Objective** The overall objective of the Gould's petrel recovery effort is for Gould's petrel to be down listed from endangered to vulnerable by 2011. **Threats** • No applicable threats identified.
Approved Conservation Advice for the Blue Petrel *(Halobaena caerulea)*	Conservation advice provides management actions that can be undertaken to ensure the conservation of the blue petrel. **Objective** None specified. **Threats** • No applicable threats identified.
Wildlife Conservation Plan for Migratory Shorebirds, 2015	The Plan provides a framework to guide the conservation of migratory shorebirds and their habitat in Australia and, in recognition of their migratory habits, outlines national activities to support their appreciation and conservation throughout the East Asian-Australasian Flyway (EAAF). **Objective** The vision of the Plan is to ensure ecologically sustainable populations of migratory shorebirds remain distributed across their range and diversity of habitats in Australia, and throughout the East Asian-Australasian Flyway. **Threats** • No applicable threats identified.
Marine reptiles	
Recovery Plan for Marine Turtles in Australia, 2017-2027	This Plan is a national plan which aims to aid in the recovery of six of the world's seven species of marine turtles; loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), flatback (*Natator depressus*) and hawksbill (*Eretmochelys imbricata*) turtles. **Objective** 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;

Relevant Plan/Advice	Applicable Threats or Management Advice
	• Noise interference; • Vessel disturbance; and • Climate change.
Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the leatherback turtle. **Objective** None specified. **Threats** • Ingestion of marine debris; • Boat strike; • Degradation of foraging areas; and • Climate change.
Marine Mammals	
Conservation Management Plan for the Blue Whale, 2015-2025	This plan superseded previous recovery plan for blue, fin and sei whales developed for the period 2005 to 2010. This revised recovery plan relates solely to blue whales (including both subspecies) and re-evaluate threats and establishes actions for assisting the recovery of blue whale populations using Australian waters. **Objective** 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. **Objective** None specified. **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. **Objective** None specified.

Relevant Plan/Advice	Applicable Threats or Management Advice
	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. **Objective** None specified. **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. **Objective** None specified. **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.

3 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.

3.1 Site survey

The geophysical and geotechnical survey (site survey) is required to inform future drilling of an exploration well and identify potential hazards.

3.1.1 Geophysical survey

A description of the proposed geophysical survey activities is provided in Table 3-3 and vessel equipment set up is shown in Figure 3-1 and Figure 3-2.

The geophysical survey is required to obtain detailed bathymetry measurements and detect hazards on or below the seabed.

Geophysical data will be acquired in two parts:

- Geophysical survey: Collection of bathymetry data and detect hazards (Figure 3-1) using the following:
    - Multibeam echo sounder (MBES);
    - Side-scan sonar (SSS);
    - Sub-bottom profiler (SBP);
    - Magnetometer;
    - Ultra-Short Baseline (USBL) Positioning System; and
    - Sound Velocity Profiler (SVP) and Conductivity, Temperature and Depth (CTD) profiler.
- 2D survey: High resolution two-dimensional (2D) shallow reflective imaging to inform shallow gas hazards (Figure 3-2).

3.1.2 Geotechnical survey

A description of the proposed geotechnical survey activities is provided in Table 3-4 and vessel equipment set up is shown in Figure 3-3.

The geotechnical survey is required to 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 and support geophysical data collected. The collected sediments are photographed, described and tested to determine the load bearing properties of the seabed within the survey area and validate the results of the geophysical survey.

The geotechnical survey consists of:

- Coring
- Cone Penetrometer Test (CPT)
- Grab samples

3.1.3 Vessel activities

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

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 also be at port.

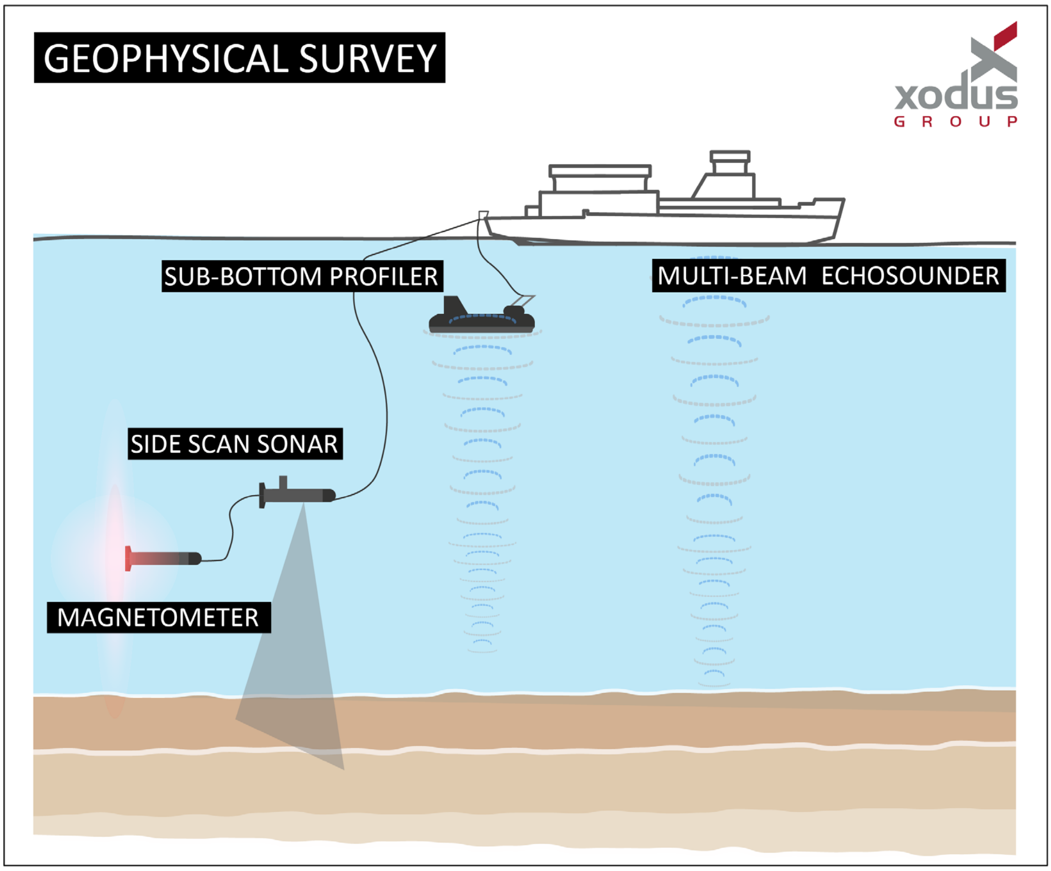

Figure 3-1: Geophysical survey equipment

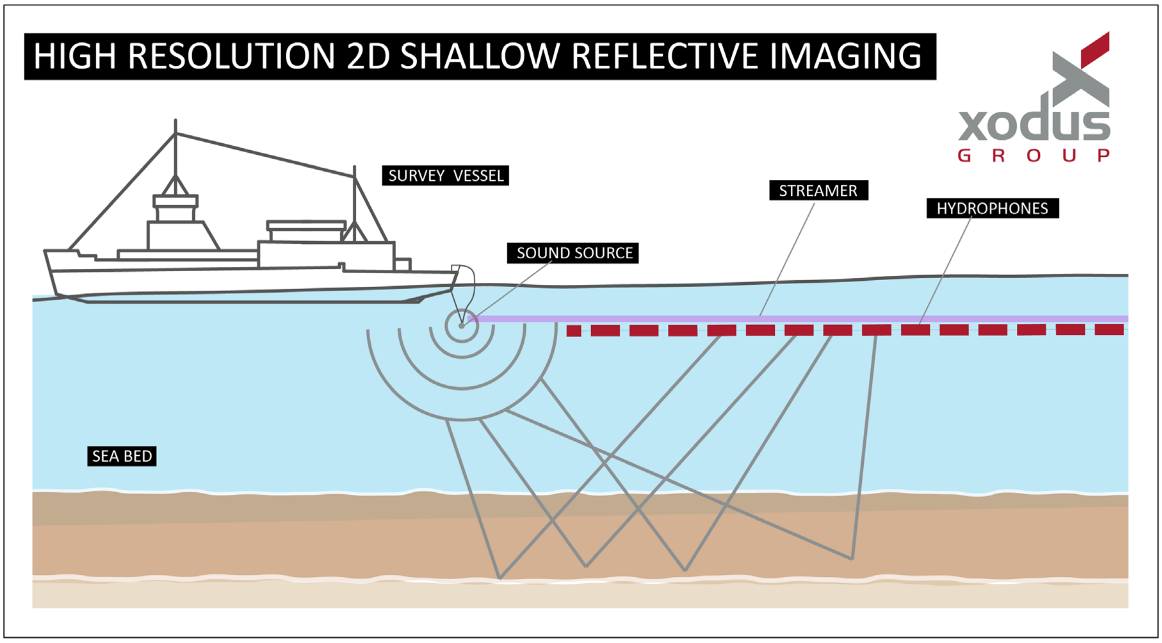

Figure 3-2: 2D survey equipment

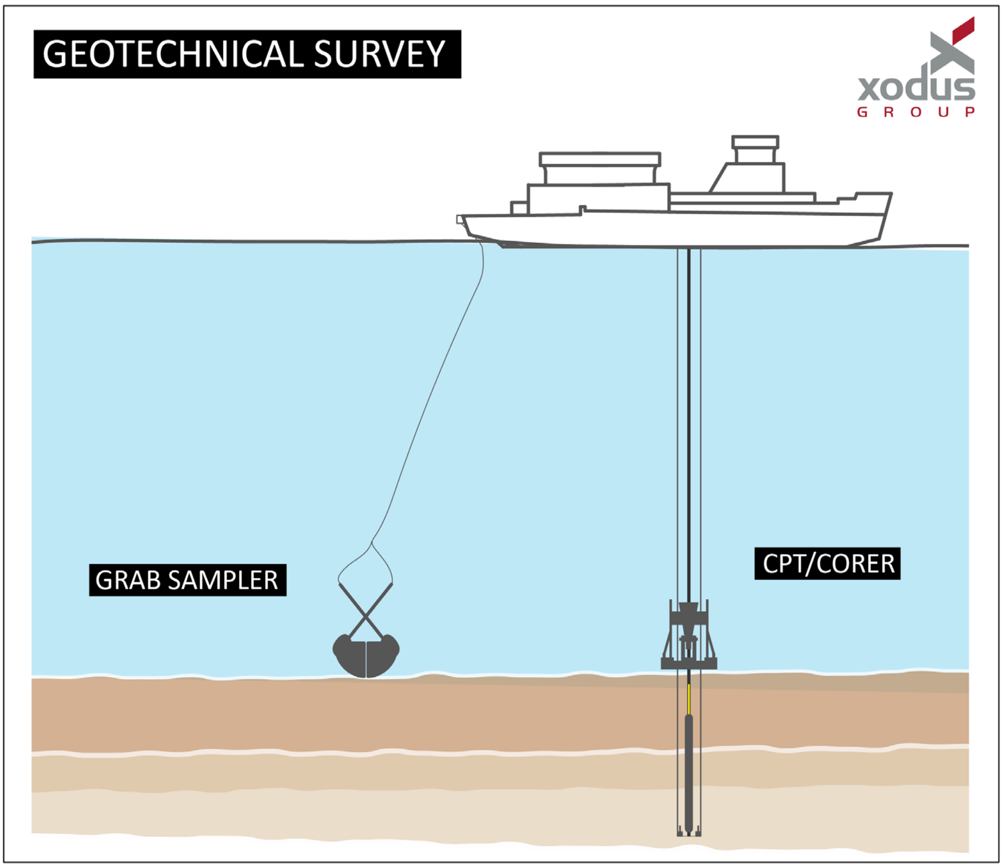

Figure 3-3: Geotechnical survey equipment

3.2 Activity location and timing

3.2.1 Activity location

The location of the site survey is shown in Figure 3-4 and Figure 3-5. Coordinates for the survey and operational areas are detailed in Table 3-1 and the proposed well locations provided in Table 3-2 and Figure 3-5.

Note: drilling of wells is not part of this EP and would be subject to a separate EP. Only one well is proposed with the survey area covering the proposed well location and three relief well locations.

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.

Survey area

The survey area refers to the area where data acquisition will occur. This is a 6 km x 6 km area totalling 36 km^2.

The geotechnical survey will be undertaken at the four well locations detailed in Figure 3-4 and Figure 3-5.

Operational area

The operational area (OA) refers to the area encompassing the survey area. It is where the geophysical and 2D survey vessel will run in and out to ensure there is a full coverage of the survey area and where the vessels will turn for the next survey line. This is a 10 km x 10 km area totalling 100 km^2.

Table 3-1: Survey and operational area coordinates (WGS84)

Figure 3-1 Label	Survey Area		Operational Area	
	Longitude	Latitude	Longitude	Latitude
A	142°43'08.2"E	39°20'20.4"S	142°41'30.1''E	39°19'55.2'S'
B	142°47'08.5"E	39°18'42.5"S	142°47'40.9''E	39°17'26.2''S
C	142°49'14.8"E	39°21'49.1"S	142°50'53.0'E'	39°22'14.1''S
D	142°45'14.3"E	39°23'27.1"S	142°44'41.9''E	39°24'43.3''S

Table 3-2: Well coordinates (WGS84)

Well	Longitude	Latitude	Water Depth (m)
Maughan-1 well	142°46'12''E	39°21'40.68''S	~ 570
Maughan-N relief well	142°46'09.473''E	39°20'09.938''S	~ 403
Maughan SE relief well	142°46'40.775''E	39°21'13.262''S	~ 500
Maughan NE relief well	142°46'36.674''E	39°20'26.812''S	~ 380

3.2.2 Activity timing

The site survey will take up to 28 days based on 21 days of survey time and 7 days for transits and setting up of equipment. The site survey will be undertaken between 1 February and 30 April 2020 or 1 October to 31 December 2020.

The number of days for each site survey component is estimated as:

- Geophysical survey – 7 days
- 2D survey – 8 days
- Geotechnical survey – 6 days

Timings of the surveys is contingent on the availability of a suitable vessel, weather and the receipt of required environmental approvals.

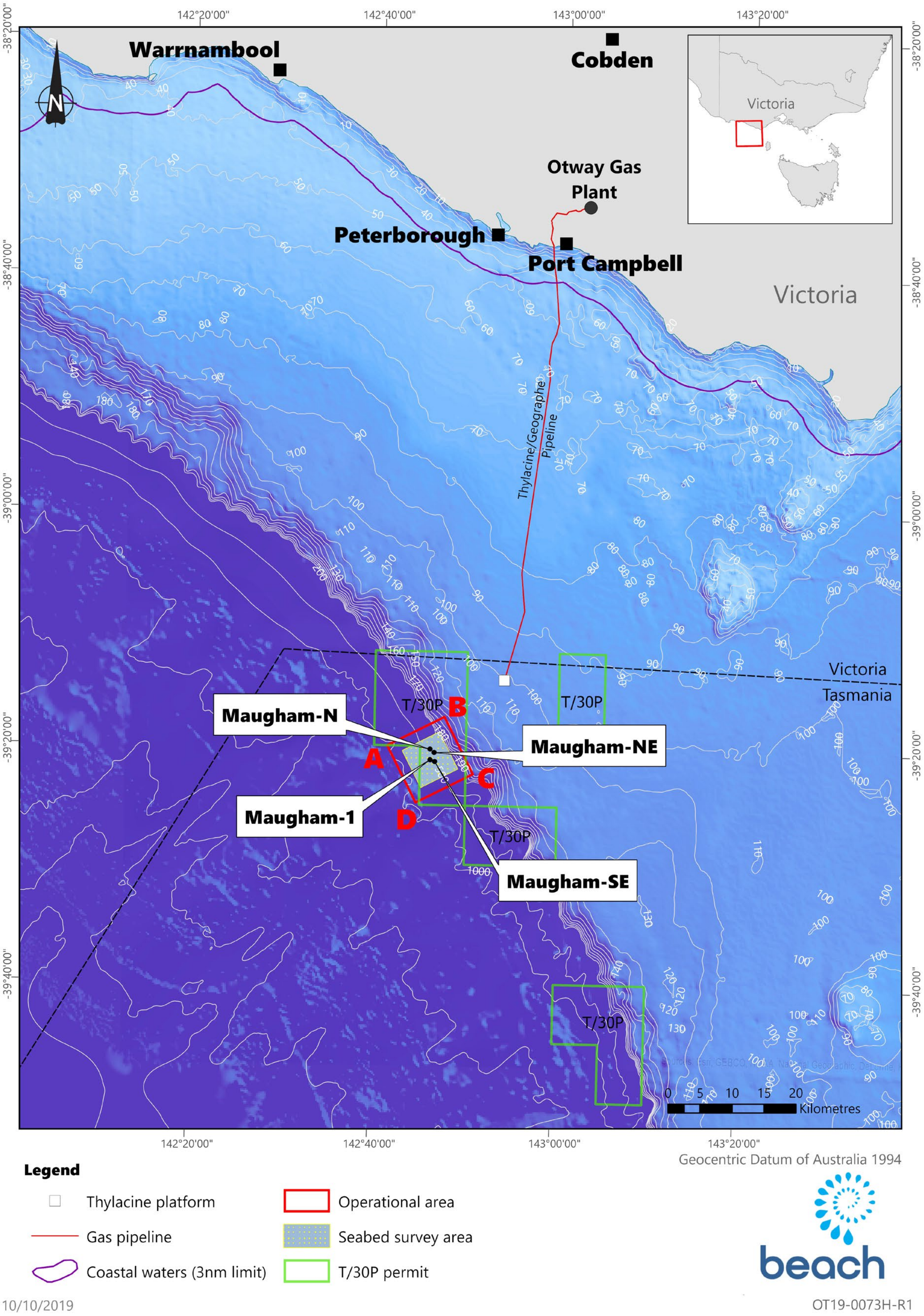

Figure 3-4: Site survey operational area and survey area

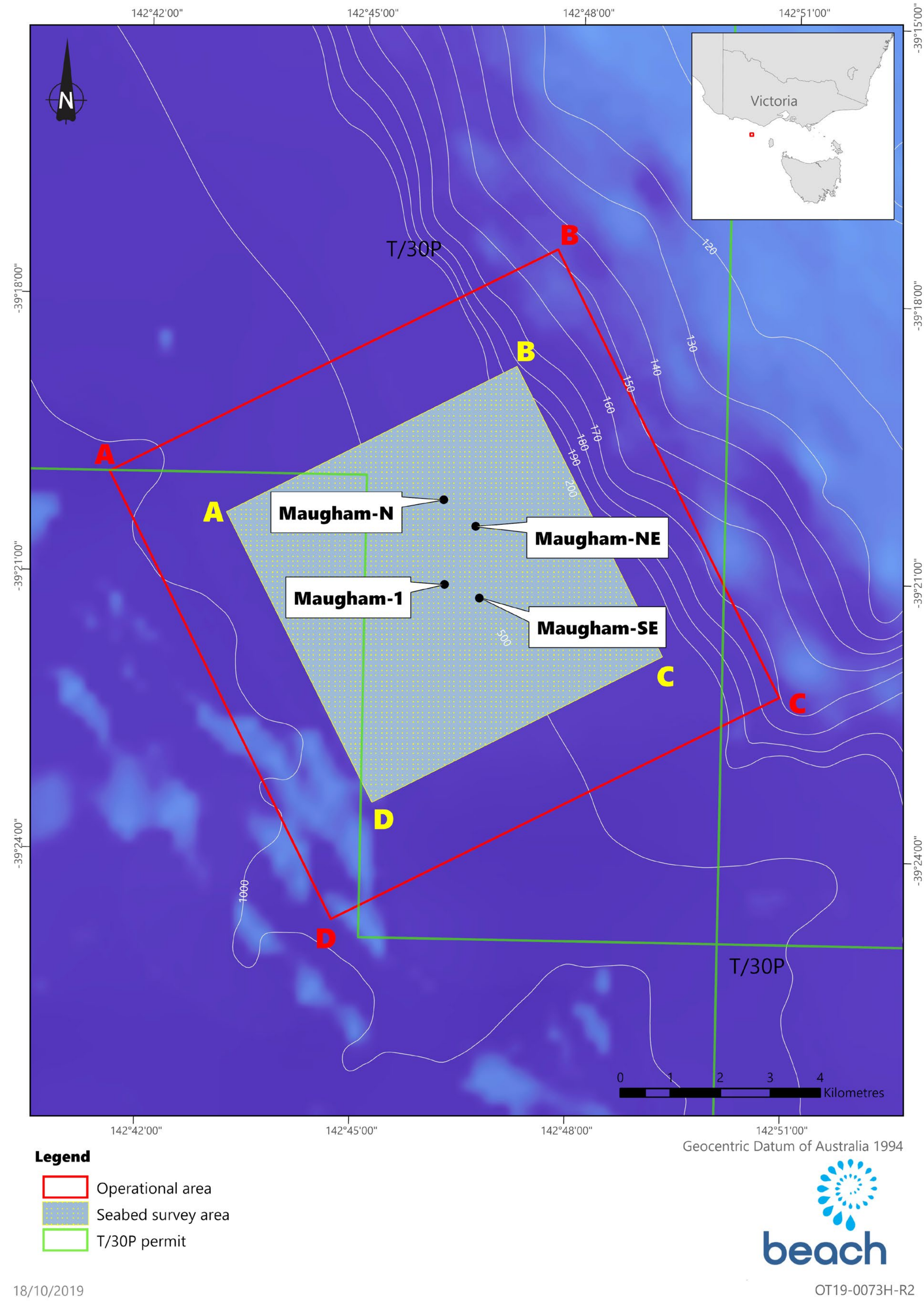

Figure 3-5 Operational area and survey area in relation to potential well locations

Table 3-3: Description of geophysical survey activities

Equipment	Purpose	Activity Details
Geophysical survey		
Multi-beam echo sounder (MBES)	Measure bathymetry.	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 a vessel 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 like MBES but operates at a wider fan angle. The acoustic energy received by the towfish (backscatter) provides information as to the general distribution and characteristics of the surficial sediment and outcropping strata. 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 towfish is constructed of stainless steel and is a cylindrical torpedo-like device. Itis typically towed 10-15 m above the seabed depending on water depth and the frequency range. The SSS is operated at the same time as the MBES.
Sub-bottom profiler (SBP)	investigate the layering and thickness of the uppermost seabed sediments.	**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 into 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 High frequency boomers generate a broadband, high amplitude impulsive acoustic signal in the water column that is directed vertically downward. Boomers are mostly surface towed but may also be towed below the surface to avoid sea surface wave related noise and movement. The receiver for the boomer system is usually a hydrophone or hydrophone array consisting of a string of individual hydrophone elements. 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 SBP survey is likely to be undertaken in two passes in conjunction with the MBES and SSS.

Equipment	Purpose	Activity Details
Magnetometer	Detect metallic objects on or below the seabed (e.g. buried pipelines, petroleum wellheads, shipwreck debris and dropped objects such as unexploded ordnance, cables, anchors, chains) that may not be identified using acoustic techniques.	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. The magnetometer survey will be conducted at the same time as the MBES, SSS and SBP. The magnetometer towfish is constructed of stainless steel and is a cylindrical torpedo-like type device.
Ultra-Short Baseline (USBL) Positioning System	Positioning of 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) profiler	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.
2D survey		
High resolution 2D shallow reflective imaging	Identify shallow gas hazards.	The 2D survey will consist of a sound source and receiver to identify shallow gas. Equipment will consist of a sound source of up to 160 in^3 towed at a depth of approximately 7 m using compressed air to create a pulse of acoustic energy. For the 2D survey the vessel that will traverse a series of pre-determined sail lines at a speed of approximately 8-9 km/hr (4 – 5 knots). As the vessel travels along the sail lines a series of sound pulses (approximately every 10 seconds) will be directed through the water column towards the seabed. The sound is attenuated and reflected at geological boundaries and the reflected signals are detected using hydrophones along a streamer towed behind the survey vessel. Survey parameters are detailed below.

	Parameter								
	No. of streamers	*Streamer length*	*Streamer depth*	*Sail lines*	*Vessel speed*	*Size of acoustic source array*	*Operating pressure*	*Source depth*	*Sound pulse interval*
Value 2D survey	One (solid)	1,200 m	10 – 15 m	100 m 500 m cross lines	~ 8 – 9 km/hr	160 in^3	2,000 psi	7 m	12.4 m

Table 3-4: Description of geotechnical survey activities

Equipment	Purpose	Activity Details
Coring	Obtain core samples for geological analysis of formations below the seabed.	**Vibrocoring, piston or gravity coring** Four cores to depth of 4 m will be taken equally spaced around a 1 km radius of each wellsite location and one core at the well location. Coring may be undertaken by vibrocore, piston or gravity coring. Cores typically cover an area of 0.5 m^2. The corer is lowered by winching a cable wire from the vessel at approximately 1-2 m/s, so the duration of lowering and recovery operations is short (20-30 seconds at each site). Sampling itself is of a short duration, typically 5-10 minutes at each location. 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 seabed, the high-power vibrator motors are engaged and drive the core barrel with PVC liner into the seabed. Piston coring is normally used on soft, unconsolidated sediments. 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. Gravity coring is normally used on soft, unconsolidated sediment. A gravity corer is a general-purpose tool that relies on its weight for penetration into the seafloor. It is lowered to a predetermined height above the seabed using a wire rope before being allowed to freefall. The resulting core enters the internal sleeve and is held in place by a core catcher.
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. 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.

Equipment	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, samples will be taken equally spaced around a 1 km radius of each well location and one at the well location.

4 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) (Figure 4-1), regional setting and a summary of the key physical, ecological and social receptors in the OA 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 OA 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 2-2.

4.1 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) or State protected areas were identified within the EMBA.

4.2 Environment that may be affected (EMBA)

The largest EMBA for the activity has been identified from a maximum credible hydrocarbon spill event. The EMBA is based on hydrocarbon exposure for the accidental release of marine diesel oil from a vessel collision (Section 6.3). This was modelled using the Automated Data Inquiry for Oil Spills (ADIOS II) and reached 15 km from the OA (see Section 6.3.3.2.).

The EMBA is 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.

4.2.1 Physical, ecological, socio-economic and cultural receptors

The following tables detail the presence of physical (Table 4-1), ecological (Table 4-2) and socio-economic and cultural (Table 4-3) receptors that may occur within the OA and EMBA.

The 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 via the EPBC Protected Matter Search Tool (PMST) (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 via the PMST (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).

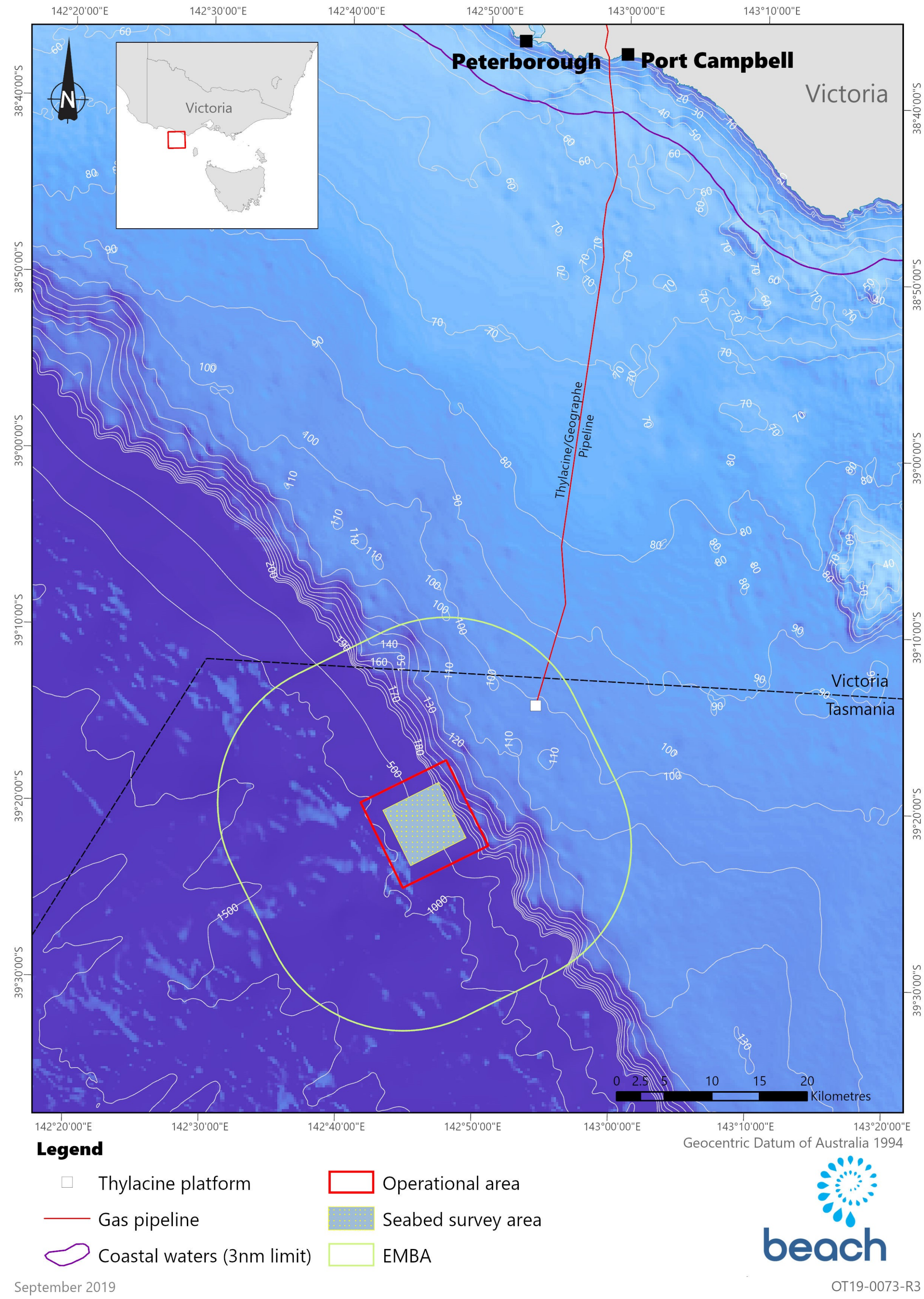

Figure 4-1 Environment that may be affected (EMBA)

Table 4-1: Presence of physical receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities	Present	Operational Area (OA)	EMBA
Shoreline	Rocky	• Foraging habitat (e.g. birds) • Nesting or breeding habitat (e.g. birds, pinnipeds) • Haul-out sites (e.g. pinnipeds)	-	Not present.	Not present.
	Sandy	• Foraging habitat (e.g. birds) • Nesting or breeding habitat (e.g. birds, pinnipeds) • Haul-out sites (e.g. pinnipeds)	-	Not present.	Not present.
	Artificial structure	• Sessile invertebrates	-	Not present.	Not present.
Mangroves	Intertidal/subtitle habitat, mangrove communities	• Nursery habitat (e.g. crustaceans, fish) • Breeding habitat (e.g. fish)	-	Not present.	Not present.
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.	Not present.

Receptor Type	Receptor Description	Values and Sensitivities	Present	Operational Area (OA)	EMBA
Soft sediment	Predominantly low vegetated soft sediment substrates	• Key habitat (e.g. benthic invertebrates)	✓	Water depths in the OA range from 150 - 1,110 m.	Water depths in the EMBA range from 95-1,690 m.
				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. The Deep Otway Shelf (130 – 180 m) sediments consist of accumulations of intensely bioturbated, fine, bio clastic sands. The Upper Slope of Otway Shelf (>180 m) incorporates the edge/ top of the shelf which displays nutrient-rich upwelling currents support extensive, aphotic bryozoan/sponge/coral communities. The upper slope is dominated by bioturbated mixture of periplatform bioclastic debris and pelleted foraminiferal/nannofossil mud. Turbidites and resedimentation features are common. Bioturbation and shelf-derived skeletal content decrease progressively downslope and pelagic muds dominate below 500 m. *See Appendix B.2.1 for more detail.*	
Seagrass	Seagrass meadows	• Nursery habitat (e.g. crustaceans, fish) • Food source (e.g. fish, turtles)	-	Not present due to water depths > 95 m and is beyond light penetrable depths.	
Algae	Macroalgae	• Nursery habitat (e.g. crustaceans, fish) • Food source (e.g. birds, fish)	✓	Algae are widespread throughout oceanic environments.	
Coral, Sponge	Sponge communities, deep water coral communities	• Nursery habitat (e.g. crustaceans, fish) • Breeding habitat (e.g. fish)	✓	The OA and EMBA overlap the West Tasmanian Marine Canyons KEF which is described as supporting diverse sponge communities containing rare but small species in 150 m to 300 m water depth. Sponges are concentrated near the canyon heads, with the greatest diversity between 200 m and 350 m depth. The EMBA overlaps ~ 23 km^2 (0.17%) of the West Tasmanian Canyons. The OA overlaps the West Tasmanian Marine Canyons KEF in water depths starting at ~460 m, while the EMBA overlap starts in 176 m water depth. Boreen et. al. (1993) describes areas of the Otway shelf edge and upper slope (150 to 400 m), with nutrient-rich upwelling currents supporting solitary coral communities. While upper, deeper areas of slope (300 to 500 m) presence of solitary azooxanthellate corals occur. *See Appendix B.3.1 for more detail.*	

Table 4-2: Presence of ecological receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
Plankton	Phytoplankton and zooplankton	• Food source (e.g. fish, cetaceans, marine turtles)	✓	Phytoplankton and zooplankton are widespread throughout oceanic environments. *See Appendix B.3.2 for more detail.*
Marine invertebrates	Benthic and pelagic invertebrates	• Food source (e.g. fish)	✓	A variety of invertebrate species may occur within the OA and EMBA, including sponges, molluscs and arthropods. *See Appendix B.3.3 for more detail.*
		• Commercial species	✓	Commercially important species (e.g. rock lobster, giant crab) may occur within the OA and EMBA. *See Appendix B.3.3 for more detail.*
Fish	Fish	• Species habitat	✓	No threatened fish species (or species habitat) occur within the OA and EMBA: *See Appendix B.3.4.1 for more detail.*
	Sharks and rays	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	Three shark species (or species habitat) may occur within the OA and EMBA: • porbeagle shark; • shortfin mako shark; and • white shark. The OA and EMBA are within a distribution BIA for the white shark. No habitat critical to the survival of the species or behaviours were identified. Table 2-2 details applicable information from the Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013) relevant to the activity. *See Appendix B.3.4.1 for more detail.*
	Pipefish, seahorse, seadragons	• Listed marine species	✓	Present. 26 syngnathid species (or species habitat) may occur within the OA and EMBA. No important behaviours or BIAs have been identified. *See Appendix B.3.4.1 for more detail.*

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
Marine reptiles	Marine turtles	• Listed marine species • Listed Threatened species • Listed Migratory species	✓	Three marine turtle species (or species habitat) may occur within the OA and EMBA: • loggerhead turtle; • green turtle; and • leatherback turtle. No BIAs or habitat critical to the survival of the species occur within the OA and EMBA. Table 2-2 details applicable information from the Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia, 2017) and Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (DEWHA, 2008a). *See Appendix B.3.4.2 for more detail.*
Seabirds	Birds that live or frequent the ocean	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	30 seabird and shorebird species were identified in the PMST which may occur within the OA and EMBA, with migratory, transit and/or foraging behaviours identified. The OA and EMBA intersect foraging BIAs for several 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. No roosting or breeding locations occur within the OA or EMBA. Table 2-2 details applicable information from: • National Recovery Plan for Threatened Albatrosses and Giant Petrels, 2011 – 2016 (DSEWPaC, 2011b); • Wildlife Conservation Plan for Migratory Shorebirds, 2015 (Commonwealth of Australia, 2015c); • National Recovery Plan for Gould's Petrel (*Pterodroma leucoptera leucoptera*) (DEC NSW, 2006); • Approved Conservation Advice for Blue Petrels (*Halobaena caerulea*) (TSSC, 2015c); • Approved Conservation Advice for *Calidris canutus* (Red Knot) (TSSC, 2016); and • Approved Conservation Advice for *Sternula nereis* (Fairy Tern) (DSEWPaC, 2011a). *See Appendix B.3.4.3 for more detail.*

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
Marine mammals	Pinnipeds	• Listed marine species	✓	Two pinniped species (or species habitat) may occur within the OA and EMBA: • New Zealand fur-seal; and • Australian fur-seal. No BIAs or habitat critical to the survival of the species occur within the OA or EMBA. *See Appendix B.3.4.4 for more detail.*
	Whales	• Listed marine species • Listed Threatened species • Listed Migratory species • BIA	✓	22 whale species (or species habitat) may occur within the OA and EMBA. Foraging behaviours were identified for sei, blue, fin, pygmy and southern right whales; no other important behaviours were identified. The OA and EMBA intersect a foraging BIA for the pygmy blue whale. Table 2-2 details applicable information from: • Conservation Management Plan for the Blue Whale, 2015-2025 (Commonwealth of Australia, 2015a); • Conservation Management Plan for the Southern Right Whale 2011 – 221 (Commonwealth of Australia, 2012); • Approved Conservation Advice for *Balaenoptera borealis* (Sei Whale) (TSSC, 2015a); • Approved Conservation Advice for *Megaptera novaengliae* (Humpback Whale) (TSSC, 2015d); and • Approved Conservation Advice for *Balaenoptera physalus* (Fin Whale) (TSSC, 2015b). *See Appendix B.3.4.5 for more detail.*
	Dolphins	• Listed marine species • Listed Migratory species	✓	Five dolphin species (or species habitat) may occur within the OA and EMBA: • Risso's dolphin; • dusky dolphin; • southern right whale dolphin; • common dolphin; and • bottlenose dolphin. No important behaviours or BIAs have been identified. *See Appendix B.3.4.5 for more detail.*

Table 4-3: Presence of socio-economic and cultural receptors within the EMBA

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
Commonwealth Marine Area	KEF	• High productivity • Aggregations of marine life	✓	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 and Harris, 2008). Submarine canyons modify local circulation patterns by interrupting, accelerating, or redirecting current flows that are generally parallel with depth contours. Williams et al. (2009) found depth-related patterns in benthic fauna, which peaked at 200-300 m water depth and then decreases with greater than 400 m. The OA overlaps the West Tasmanian Marine Canyons KEF in water depths starting at ~460 m, while the EMBA overlap starts in 176 m water depth. The EMBA overlaps ~ 23 km^2 (0.17%) of the West Tasmanian Canyons. No specific management plan exists; however West Tasmanian Canyons KEF values are detailed in the South-east Marine Region Profile (Commonwealth of Australia, 2015b). *See Appendix B.1.1 for more detail.*
	AMP	• Aggregations of marine life	-	Not present.
State Parks and Reserves	Marine Protected Areas	• Aggregations of marine life	-	Not present. The EMBA is more than 36 km from closest Marine Protected Areas.
Wetlands of International Importance	Ramsar Wetlands	• Aggregation, foraging and nursery habitat for marine life	-	Not present.
Commercial Fisheries	Commonwealth-managed	• Economic benefit	✓	The Commonwealth-managed fisheries that overlap the OA and 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 from AFMA only the SESSF has catch effort within the OA and EMBA. The ETBF has not had catch effort within the OA and only had catch effort in the EMBA in 2017.

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
				See Appendix B.4.1 for more detail.
	Victorian State-managed	• Economic benefit	✓	The Victorian State-managed fisheries that overlap the OA and EMBA are: • Rock Lobster Fishery; • Giant Crab Fishery; • Abalone Fishery; • Scallop (Ocean) Fishery; • Wrasse (Ocean) Fishery; and Based on data from Seafood Industry Victoria (SIV) 2014 to 2019 the following have catch effort within the OA and EMBA: • Rock Lobster Fishery; and • Giant Crab Fishery. *See Appendix B.4.2 for more detail.*
	Tasmanian State-managed	• Economic benefit	-	Based on data from the Tasmanian Department of Primary Industries, Parks, Water and Environment and the Fishery Assessment Reports there has been no catch effort within the OA and EMBA (Stakeholder Record TDPIPWE_24).
Recreational Fisheries	State-managed	• Community • Recreation	-	Recreational fishing is popular in Victoria largely centred within Port Phillip Bay and Western Port, outside of the OA and EMBA. *See Appendix B.4.3 for more detail.*
Recreation and Tourism	Various human activities and interaction	• Community • Recreation • Economic benefit	-	There are no features within the OA or 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	✓	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. *See Appendix B.4.6 for more detail.*
	Petroleum exploration and production	• Economic benefit	✓	Petroleum exploration has been undertaken within the Otway Basin since the early 1960s. The Beach owned Thylacine/ Geographe pipeline and Thylacine Platform are within the EMBA. Two planned seismic surveys overlap the OA and EMBA.

Receptor Type	Receptor Description	Values and Sensitivities		Operational Area (OA) and EMBA
				See Appendix B.4.7 and Appendix B.4.8 for more detail.
Heritage	Maritime	• Underwater Protected Heritage Zones • Underwater cultural heritage	-	Not present.
	Cultural	• World Heritage Properties • Commonwealth Heritage Places • National Heritage Places	-	Not present.

5 Environmental impact and risk assessment methodology

5.1 Overview

This section outlines the environmental impact and risk assessment methodology used for the assessment of the site survey. 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 5-1 outlines this risk assessment process.

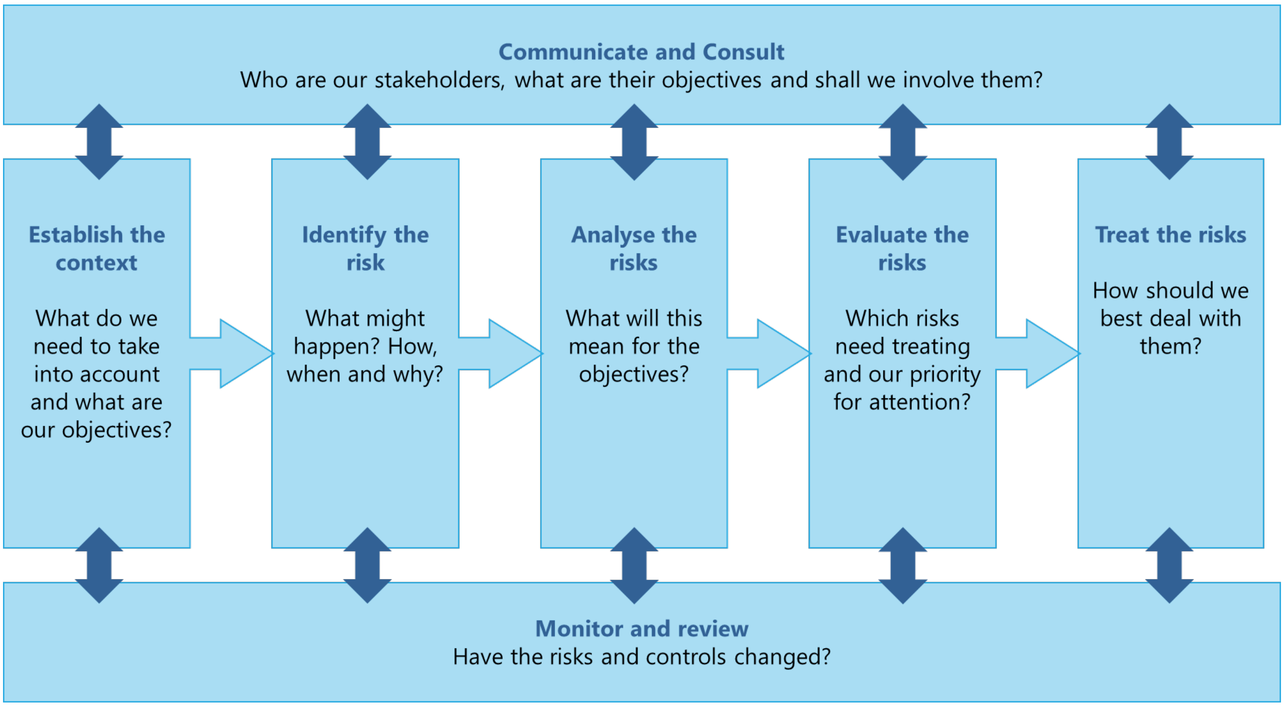

Figure 5-1: Risk assessment process

5.1.1 Definitions

Definitions of the term used in the risk assessment process are detailed in Table 5-1.

Table 5-1: 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).

5.2 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 OA 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 8.

5.3 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 2, '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 3);
- identifying the environment that may be affected, either directly or indirectly, by the activity (based upon the 'Existing Environment' as described in Section 4); and
- understanding the concerns of stakeholders and incorporating those concerns into the design of the activity where appropriate (outlined in Section 8, 'Stakeholder Consultation').

5.4 Identify the potential impacts and risks

Potential impacts (planned) and risks (unplanned) associated with the environmental aspects of the activity are identified in relation to the OA and 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 6-1 details the aspects identified for the activity.

5.5 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.

5.6 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. Where appropriate species recovery plan actions and/or outcomes.
- 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.

5.7 Evaluate and treat the potential impacts and risks

The following steps are undertaken using the environmental risk assessment matrix (Table 5-2) 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 5.9) and an acceptable level (Section 5.10); and
- establish environmental performance standards for each of the identified control measures.

5.8 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 7).

Table 5-2: 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)	Highly Unlikely (2)	Unlikely (3)	Possible (4)	Likely (5)	Almost Certain (6)
			<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.	>1% chance of occuring within the next year. May occur but not anticipated. Could occur years to decades.	>5% chance of occuring in the next year. May occur but not for a while. Could occur within a few years.	>10% chance of occuring within the next year. May occur shortly but a ditict probability iot won't. Could occur within months to years.	>50% chance of occuring within the next year. Balance of probability that it will occur. Could occur within weeks to months.	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

5.9 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-accepted 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).

5.9.1 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 5-2), 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 5.9.3) 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 5-2), 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 5.9.4 and 5.9.5.

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 5-3.

Table 5-3: 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		

5.9.2 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 5-2). Specifically, the framework considers impact severity and several guiding factors:

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

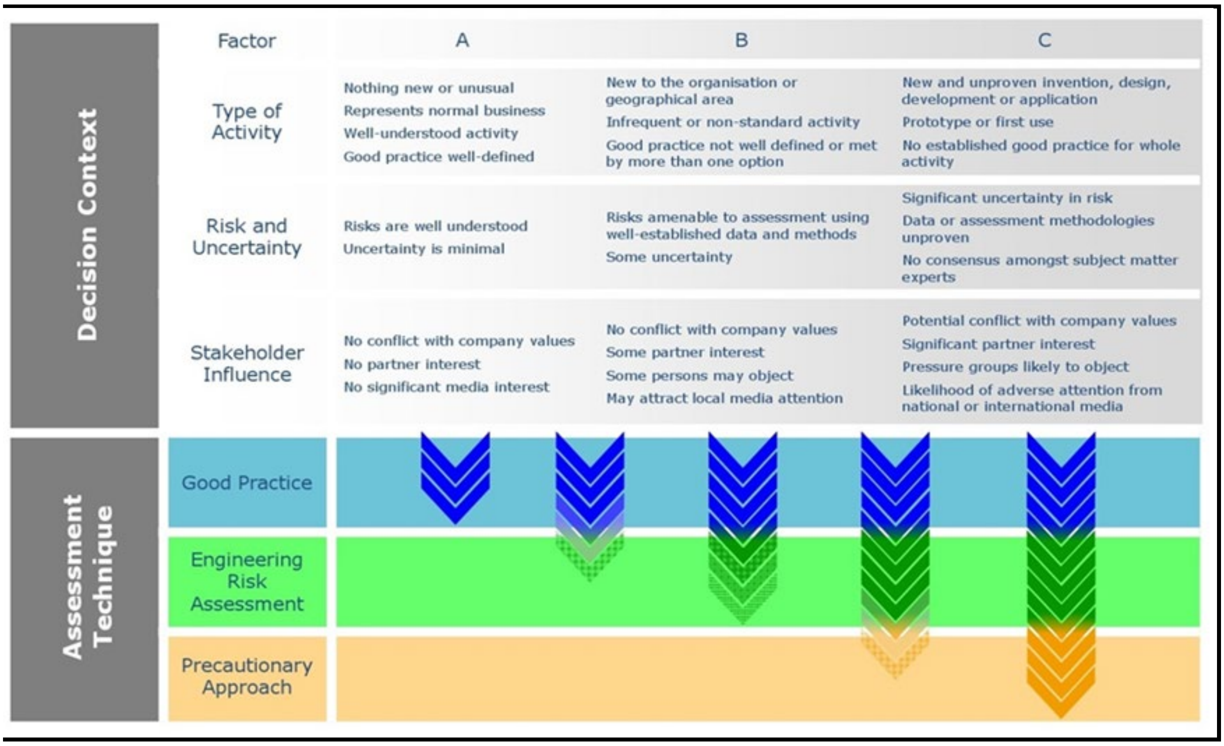

Figure 5-2: OGUK (2014) decision support framework

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.

5.9.3 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.

5.9.4 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.

5.9.5 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.

5.10 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 5-4, which is based on Beach's interpretation of the NOPSEMA EP content requirements (NOPSEMA, 2016).

Table 5-4: 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 the company's Health, Safety and Environment Management System (HSEMS)?	Where specific company 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.

5.10.1 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 (ESDSC, 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 principle 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.

6 Environmental impact and risk assessment

6.1 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 site survey using the methodology described in Section 5. Potential impacts (planned) and risks (unplanned) associated with the environmental aspects of the activity are identified in Table 6-1 with lower order impacts and risks assessed in Table 6-2 and higher order impacts and risks assessed in 6.2, 6.3 and 6.4.

Table 6-1: Activity and aspect relationship

	Seabed disturbance	Underwater acoustic emissions	Atmospheric emissions	Light	Planned marine discharges	Physical presence	Invasive marine .	Waste	Minor spill	Loss of diesel – vessel collision
Geotechnical survey	X									
Geophysical survey		X								
Vessel actvities		X	X	X	X	X	X	X	X	X
Spill response		X	X	X	X	X	X	X	X	

Table 6-2: Site survey environmental impact and risk ratings, control identification, ALARP and acceptability assessment

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
Geotechnical survey	Seabed disturbance	Change in habitat	Benthic habitat (soft sediment, coral and sponges Marine invertebrates	The vessel will hold station using DP or propellers as water depths are too deep for anchoring. Each core sample will have a seabed disturbance area of less than 0.5 m^2 which equates to an area of 2.5m^2 per well based on 5 cores at each well location. Grab samples will also be taken at each core location and will disturbance an area less than 0.1 m^2. Thus, the total disturbance at each well location will be 3.0 m^2. The water depths at the proposed well locations where coring is planned to be undertaken range from 308 m to 570 m (Table 3-2). As described in Table 4-1 and Appendix B.2.1, the wells are within the deeper area of the Otway slope (300 to 500 m) which consists of bioturbated muds with the presence of solitary azooxanthellate corals. The wells also overlap the West Tasmanian Canyons KEF in water depths greater than 460 m. The presence of these canyons influences depth-related patterns in benthic fauna, which peaks at 200-300 m water depth and then decreases with depths greater than 400 m. Impact to benthic habitats and marine invertebrates are predicted to be localised, temporary with no long-term changes to habitat and of low severity based on: • The nature of the benthic habitat at the coring locations, which consists of bioturbated muds with low levels of benthic fauna. • The extent of seabed disturbance which will occur over a very small area of 3.0 m^2 per well totalling an area of 12 m2 for the four wells. This equates to 0.08% of the West Tasmanian Canyons KEF. • The results of surveys of previous seabed disturbance from oil and gas activities indicating 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	CM#1: Geotechnical Scope of Work	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 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. • Good practice controls have been defined. • The predicted level of impact will not modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results. • The environmental impact assessment (EIA) demonstrates consistency with the principles of ESD.	Acceptable
Geophysical survey	Underwater acoustic emissions	Injury/mortality to fauna Behavioural disturbance	Further assessment required (Section 6.2).									
Vessel activities	Atmospheric emissions	Change in air quality	Air quality Seabirds	Minor emissions are predicted from the vessel from the use of diesel combustion engine use during the activity. Offshore winds will rapidly disperse atmospheric emissions when they are discharged into the environment. The OA overlaps foraging BIAs for several albatross, the wedge-tailed shearwater, common diving-petrel	Minor (1)	A	CM#2: 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 HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				and short-tailed shearwater. No habitat critical to the survival of these species occur within the OA. Atmospheric emissions are not identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011b). Climate change is identified as a threat in multiple seabird plans or advices. Air quality impacts are predicted to be localised to the emission point and can be expected to reduce to background levels close to the source. Emissions from the vessel are of a low level and would not be significant enough to impact on climate change.							• The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • The predicted level of impact will not result in a substantial change in air quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health. • The EIA demonstrates consistency with the principles of ESD.	
			Coastal settlements	There are no coastal settlements within the OA or at a distance where impacts from air emissions would occur.	N/A							
Vessel operations	Light emissions	Change in fauna behaviour	Seabirds	As the site survey will be undertaken 24 hours a day lighting is required at night for navigation and to ensure safe operations when working on the vessel. 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 (Commonwealth of Australia, 2019). The OA overlaps foraging BIAs for several albatross species, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. These BIAs are very large typically covering the whole of the SEMR thus a large number of birds are not predicted to be present in the area. Impacts to seabirds are predicted to be limited to individuals and not impact species at a population level as the light emissions will be localised to the OA and temporary in nature as the vessel undertakes the site survey	Minor (1)	A	CM#3: Draft National Light Pollution Guidelines	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 HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • Vessel lighting will meet safety and navigation legislative requirements in relation to lighting. • Relevant good practice controls have been identified. • The predicted level of impact will not lead to a long-term decrease in the size of a Threatened or Migratory listed seabird population or have a substantial adverse effect on a population of seabirds including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • 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 OA. The OA is ~ 76.5 km from the coastline thus lighting impacts to turtles are not predicted.								
Vessel operations	Planned discharges: Cooling water Brine Treated bilge	Change in water quality	Water quality Plankton Fish Marine turtles	Wastewater discharges can result in localised impacts to water quality from increased temperature, salinity, nutrients, chemicals and hydrocarbons which can lead to toxic effects to marine fauna. Vessel wastewater discharges will be of low volume during the survey and of short duration. Open	Minor (1)	A	CM#4: Offshore Environmental Chemical Assessment Process	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 HSEMS and/or procedural requirements.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
	Sewage and greywater		Marine mammals	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 wastewater discharges would disperse quickly over a small area. Discharges with the potential to contain toxic components such as bilge and sewage will be treated prior to discharge. Toxic impacts to water quality and marine fauna are not predicted based on: • The low volumes of wastewater to be discharged. • The low toxicity of waste water discharges. • The rapid dispersion of waste water discharges in the open marine environment. • The localised and temporary nature of any changes in water quality around the point of discharge.			CM#5: *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* CM#6: Preventative Maintenance System				• No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • The predicted level of impact will not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health. • The EIA demonstrates consistency with the principles of ESD.	
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 vessel during the survey. The OA overlaps foraging BIAs for several albatross species, the wedge-tailed shearwater, common diving-petrel, and short-tailed shearwater. No habitat critical to the survival of seabirds occur within the OA. Reliance of fisheries discards is identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011b); however, for survey vessel food waste the discharge would be sporadic and for a short duration thus would not result in seabirds habituating to this food source. Fish may also become attracted to food scraps but as for seabirds the sporadic nature of survey vessel food scraps would not lead to fish habituating to this food source.	Minor (1)	A	CM#7: 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 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. • The predicted level of impact will not lead to a long-term decrease in the size of a threatened or migratory listed seabird or fish population or have a substantial adverse effect on a population of seabirds or fish including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
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 OA. No recreation and tourism expected within the OA due to lack of features.	N/A							
Vessel operations	Underwater acoustic	Change in fauna behaviour	Fish Sharks	Vessels will emit acoustic emissions from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment.	Minor (1)	A	None identified	None identified	N/A	Low	• The proposed management of the impact is aligned with the Beach Environment Policy.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
	emissions: continuous		Marine turtles	Studies of underwater acoustic emissions 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 OA. Behavioural impacts are more likely such as moving away from the vessel. There are no habitats or features within the OA that would restrict fish, sharks or turtles from moving away from the vessel. The OA 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 OA 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, 2017) identified noise interference as a threat; however, avoidance behaviour will not result in a long term impact that could affect the species at a population level. Continuous sound 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.							• The proposed management of the impact is aligned with the HSEMS and/or procedural requirements. • No stakeholder objections or claims have been raised. • No legislative requirements for vessel acoustic emissions in relation to fish and turtles were identified. • No relevant good practice controls have been identified due to the low risk from vessel acoustic emissions to fish and marine turtles. • The predicted level of impact will not lead to a long-term decrease in the size of a Threatened or Migratory listed fish, shark or turtle population or have a substantial adverse effect on a population of fish, shark or turtle including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • The EIA demonstrates consistency with the principles of ESD.	
			Pinnipeds	Vessels will emit acoustic emissions from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment. Studies of underwater acoustic emissions 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). The New Zealand fur-seal and Australian fur-seal may occur within the OA. No haul out areas, BIAs or habitat critical to the survival of the species were identified for pinnipeds within the OA. Onset thresholds for TTS and permanent threshold shift (PTS) for seals for non-impulsive sounds (vessels) suggested by NMFS (2018) are as	Moderate (2)	A	CM#8: 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 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.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				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 haul out areas, BIAs or critical habitat for pinnipeds within the OA or within 4 km where vessel sounds levels would dissipate to 120 dB re 1 µPa (Hannay et al., 2004) which is the recommended threshold for behavioural disruption for continuous sound for marine mammals (NMFS, 2014), impacts are likely to only result in behavioural changes such as avoidance of the area rather than TTS or PTS impacts. Continuous sound 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.							• The predicted level of impact will not have a substantial adverse effect on a population of seals including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • The EIA demonstrates consistency with the principles of ESD.	
			Cetaceans (whales and dolphins)	Vessels will emit acoustic emissions from propeller cavitation, thrusters, hydrodynamic flow around the hull, and operation of machinery and equipment. Studies of underwater acoustic emissions 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). Five dolphin species may occur within the OA. However, no important behaviours or BIAs have been identified. 22 whale species (or species habitat) may occur within the OA. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The OA intersects a foraging BIA for the pygmy blue whale. Onset thresholds for TTS and PTS for cetaceans for non-impulsive sound (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 one BIA are within the OA or within 4 km where vessel sound levels would dissipate to 120 dB re 1 µPa (Hannay et al., 2004) which is the recommended threshold for behavioural disruption for continuous sound for marine mammals (NMFS, 2014). 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 sound is not	Moderate (2)	A	CM#9: 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 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. • The predicted level of impact will not lead to a long-term decrease in the size of a threatened or migratory listed cetacean population or have a substantial adverse effect on a population of cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • The predicted level of impact will not injure or displace blue pygmy whales from the foraging BIA. • The EIA demonstrates consistency with the principles of ESD.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				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. In addition, the Conservation Management Plan for the blue whale requires that anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area. Injury and displacement from the foraging BIA are not predicted for pygmy blue whales from vessel sound based on: • Sound levels from the vessel are not predicted to result in injury to pygmy blue whales. • Sound levels from the vessel may result in a behavioural response which would be as per other vessels transiting through the area. Figure B-9-17 shows that the OA and the pygmy blue whale foraging area are within a busy shipping area. • Vessel sound levels are predicted to dissipate to 120 dB re 1 µPa, the behavioural disruption threshold for continuous sound for marine mammals (NMFS, 2014), within 4 km. • Continuous sound from the vessel is not expected to be any higher than that generated by existing shipping traffic within the region. • The location of the pygmy blue whale foraging area which is not confined and the location of the OA which is approximately 10 km from the outer edge of the high-density foraging BIA. Thus, pygmy blue whales would not be displaced from the foraging area. • The area of overlap between the OA and the high-density foraging BIA which is approximately 0.28% (100 km^2/35,615 km^2). • The short duration of the site survey, which would result in the vessel to be within the area for a maximum of 28 days.								
			Fisheries	Commercial fish species may be present in the OA but acoustic emissions 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	Marine turtles Whales Dolphins	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;	Moderate (2)	A	CM#9: 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.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				• 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. The Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna (Commonwealth of Australia, 2016) identifies cetaceans and marine turtles as being vulnerable to vessel collisions. Three marine turtle species (or species habitat) may occur within the OA 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, 2017) identified vessel strike as a threat. Historically turtles have been recorded as being trapped in the streamer tail buoys; however, turtle guards on streamers are standard equipment, therefore there is no cause effect pathway for entrapment of turtles in streamer buoys. 22 whale species (or species habitat) may occur within the OA. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The OA intersects a foraging BIA for the pygmy blue whale. Five dolphin species may occur within the OA. No important behaviours or BIAs have been identified. 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 to date associated with Beach's activities in the Otway basin which are generally located closer to shore where higher numbers of marine fauna occur. The survey vessel will be slow moving (4.5 – 5 knots) allowing time for fauna to move away. Impacts will be limited to the OA. If an incident occurred, it would be restricted to individual fauna and not have impacts to local population levels.			CM#10: Streamer tail buoy turtle guard				• No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • The predicted level of impact will not lead to a long-term decrease in the size of a Threatened or Migratory listed turtle, whale or dolphin population or have a substantial adverse effect on a population of turtle, whale or dolphin including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Physical presence	Displacement of other marine users Snagging of fishing equipment	Recreation and tourism Recreational fisheries Commercial fisheries	Due to the distance offshore of the activity and the lack of emergent features within the OA recreational fishing and tourism is unlikely. Based on data from AFMA there are currently three licensees within the Commonwealth SESSF that potentially fish in the OA. Over the past 10 years there has been up to licensees (See Appendix B.4.1). The SESSF use trawl, gillnet and hook fishing methods. Only gillnets are left in the water with surface buoys which could be a snagging issue for the geophysical equipment.		A	CM#11: Ongoing consultation CM#13: Geophysical Survey Separation Distance	CM#12: Commercial Fisher Operating Protocol	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 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 or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				Based on information provided by SETFIA (Stakeholder Record SETFIA #83) gillnet fishing does not occur deeper than 183 m (100 fathoms). The OA is within 150 – 1110 m water depths, with the area of overlap with the demersal gillnet fishing area representing ~ 11.7 km². Based on information provided by SETFIA (Stakeholder Record SETFIA #83) physical and nialpeotechi which generally runs along the 700 m depth contour. The OA is within 150 – 1,110 m water depths with the area of overlap with the trawl fishery representing ~ 63.3 km². AFMA (Stakeholder Record AFMA #04) identified that in 2019 there were three operators in the OA and over the last 10 years there have only been seven operators. Based on SIV data from 2014 to 2018 there is potential a low level of catch effort for the Rock Lobster Fishery and Giant Crab Fishery within the OA. For the Rock Lobster Fishery, it is unlikely there is catch effort within the OA as southern rock lobsters are found to depths of 150 m, with most of the catch coming from inshore waters less than 100 metres deep (VFA, 2017). The water depth of the OA is 150 – 1,110 m. Thus, the area of overlap would be minimal. For the Giant Crab Fishery there is the potential for some overlap with the OA as giant crabs inhabit the continental slope at approximately 200 m depth and are most abundant along the narrow band of the shelf edge. The area of overlap with the OA is 16.5 km². Stakeholders have not raised any issues or concerns in relation to displacement of their fishing activities or snagging of equipment. Displacement impacts will be minor and can be managed based on: • The duration of site survey which will take a maximum of 28 days. • The small area (100 km²) of the site survey, resulting in an overlap with fishers which is small compared to the broader fishery area. • Displacement impacts being managed by on-water communication using text messages and radio communication. • Look-ahead information to be provided to fishers allowing them to avoid the vessel and fish in other parts of the OA, if required. • The implementation of Beach's Commercial Fisher Operating Protocol to potentially impacted fishers, whereby fishers should not suffer an economic loss as a result of Beach's activities. Should a fisher incur additional costs in order to work around Beach's activities, or if they have lost catch or have damaged equipment Beach will assess the claim and ask for evidence including past fishing history and the loss incurred and, where the claim is							• Good practice and additional controls have been identified in consultation with stakeholders. • The predicted level of impact is that the activity will not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by titles granted. • The EIA demonstrates consistency with the principles of ESD.	

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				genuine, will provide compensation. Beach will also ensure that the evidence required is not burdensome on the fisher while ensuring genuine claims are processed. • Permanent exclusion zones not required. Two seismic surveys have been identified as overlapping the OA. However, only one has the potential to overlap the survey period if undertaken in February 2020. It has been agreed that the surveys will keep 40 km apart to ensure both Beach and the seismic operators can undertake their activities and are not displaced (Stakeholder Record SG_14). Cumulative impacts to other marine users, such as fishers, from simultaneous surveys will not occur as the surveys will not be undertaken in the same area at the same time. Cumulative impacts to other marine users, such as fishers, from being displaced from several areas is low based on: • One line from the Schlumberger Otway Basin 2DMC Marine Seismic Survey overlaps the OA. This would take ~ 5 – 6 hrs to acquire. • The Spectrum Geo 3D Survey area overlaps the OA. Based on the small area of overlap this would also take ~ 5 – 6 hrs to acquire.								
			Shipping	The OA includes major shipping routes; however, vessels activities associated with the Otway Gas Development have been ongoing for over 10 years and to date there has been no interactions or incidents. While undertaking the 2D survey the vessel will have limited capability to move as it will be towing a 1.2 km streamer. However, this will be limited to a period of 8 days and marine notices will be issued to warn other mariners.	Minor (1)	A	CM#11: 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 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 survey. • The predicted level of impact is that the activity will not interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by titles granted. • The EIA demonstrates consistency with the principles of ESD.	Acceptable
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.	Minor (1)	A	CM#7: 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 HSEMS and/or procedural requirements.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
				The OA overlaps foraging BIAs for several albatross species, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater. No habitat critical to the survival of birds occur within the OA. Marine debris is identified as a threat in the National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016 (DSEWPaC, 2011b) and National Recovery Plan for Gould's Petrel (*Pterodroma leucoptera leucoptera*) (DEC NSW, 2006). Three marine turtle species (or species habitat) may occur within the OA 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, 2017) identified marine debris as a threat. Two species of pinniped (or species habitat) may occur within the OA; the New Zealand fur-seal and 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 OA. Foraging behaviours were identified for some species (sei, blue, fin and pygmy right whales); no other important behaviours were identified. The OA intersects a foraging BIA for the pygmy blue whale. Five dolphin species may occur within the OA. No important behaviours or BIAs have been identified. 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. Unplanned release of waste is uncommon; if waste was lost overboard impacts would be restricted in exposure and quantity and would be limited to individual fauna and not have impacts at population levels.							• No stakeholder objections or claims have been raised. • The impact is being managed in accordance with legislative requirements. • Good practice controls have been defined. • The predicted level of impact will not lead to a long-term decrease in the size of a threatened or migratory listed turtle, whale or dolphin population or have a substantial adverse effect on a population of turtle, whale or dolphin including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • 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 OA does not present a location conducive to marine pest survival because it is in deep waters with most of the OA in water greater than 500 m; in addition, the vessel will have limited stationary vessel periods.	Serious (3)	A	CM#14: MO 98: Marine pollution – anti-fouling systems CM#15: Australian Ballast Water Management Requirements CM#16: 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 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. • The predicted level of impact will not result in a known or potential pest species becoming established.	Acceptable

Activity	Aspect	Potential Impact or Risk	Receptor	Evaluation of Impacts and Risks	Consequence Rating	ALARP Decision Context	Good Practice Control Measure	Additional Control Measures	Likelihood of Occurrence	Residual Risk	Acceptability Assessment	Acceptability Outcome
											• The EIA demonstrates consistency with the principles of ESD.	
Vessel operations	Unplanned release: Minor spill (hydrocarbon or chemical)	Change in water quality	Plankton Marine fauna	Minor spills <200 L may occur from vessel equipment, bulk storage or package chemical leak (deck spill). 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 OA.	Minor (1)	A	CM#17: Spill containment CM#18: Shipboard Marine Pollution Emergency Plan (SMPEP), or equivalent		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 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. • The predicted level of impact will not lead to a long-term decrease in the size of a threatened or migratory listed turtle, whale or dolphin population or have a substantial adverse effect on a population of turtle, whale or dolphin including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution. • 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 6.3).									
Vessel and aerial operations	Spill response	Disturbance to benthic habitat Waste generation, disposal and management Displacement of other marine users	Further assessment required (Section 6.4).									

6.2 Geophysical survey underwater acoustic emissions

6.2.1 Hazards

Underwater acoustic emissions from the geophysical survey may impact biological receptors such as:

- plankton;
- marine invertebrates such as corals, sponges and 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.

6.2.2 Known and potential environmental impacts

Potential impacts of underwater acoustic emissions from geophysical survey to receptors are:

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

6.2.3 Impact evaluation and risk assessment overview

To assess potential impacts to receptors from underwater acoustic emissions associated with the geophysical survey, 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.

This section assesses the geophysical survey and 2D survey and then provides an assessment of any potential cumulative impacts.

6.2.3.1 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 6-1 shows a representative sound wave and the sound measures used in this assessment. Table 6-3 provides definitions of the sound measures and other sound related terms used in this assessment.

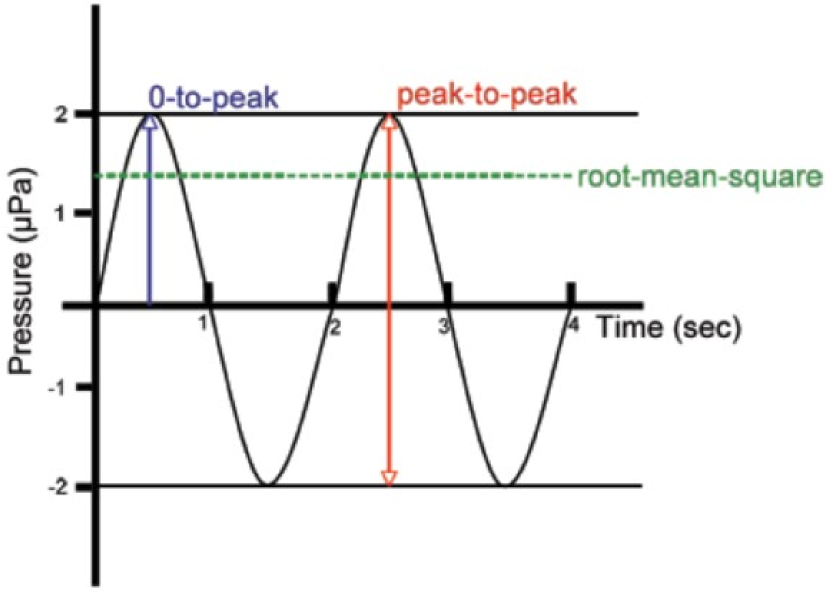

Figure 6-1: Representative sound wave and sound measures

Table 6-3: 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.

6.2.3.2 Geophysical survey acoustic modelling

Based on a review of the geophysical equipment to be used 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. Beach commissioned JASCO to undertake acoustic modelling to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates and corals. Modelling considered 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 have not yet been identified, therefore JASCO chose commonly used representative systems for each source, with levels derived from previous JASCO field measurement campaigns of such sources (McPherson and Wood 2017). The JASCO report is available in Appendix C.

The sound modelling undertaken by JASCO was for several locations for another site survey which included T/30P (Figure 6-2). Based on a review of the sound modelling parameters, it was determined that the Site 2: MURCH DDIP location in 129.5 m water could be applied for this site survey as it is representative of the shallower areas of the site survey. Additional modelling undertaken by JASCO supports this assumption (Koessler and McPherson 2019), whereby it was demonstrated that sound fields diminish as depth increases.

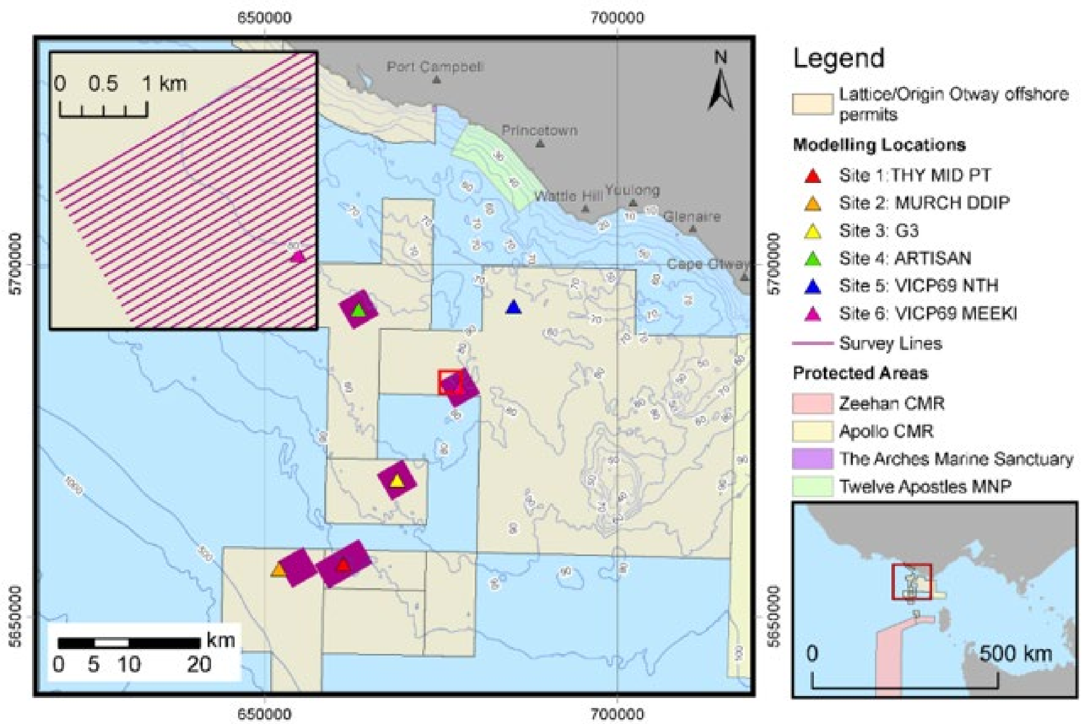

Figure 6-2: Geophysical survey acoustic modelling locations

6.2.3.3 2D survey acoustic modelling

Beach commissioned JASCO to undertake acoustic modelling of underwater sound levels associated with the 2D survey to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates, plankton and corals (Koessler and McPherson 2019). Modelling considered a 160 in^3 sound source, consisting of two 80 in^3 sources, towed at 7 m depth. Single-impulse sound fields were predicted at four defined locations within the survey area, with depths between 194 and 995 m, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 hours (Figure 6-3). The JASCO report is available in Appendix D.

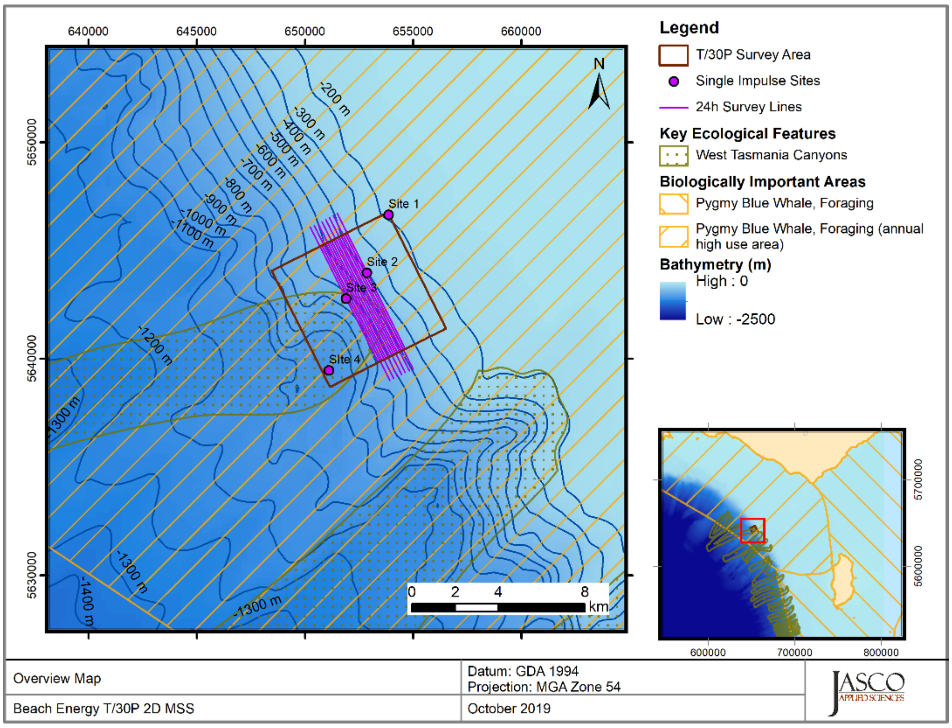

Figure 6-3: 2D survey acoustic modelling locations

6.2.3.4 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 6-4 to Table 6-8. In lieu of any noise criteria specific to geophysical surveys, criteria that is applied to seismic surveys have been used.

6.2.4 Impact evaluation and risk assessment

6.2.4.1 Plankton

Plankton is a collective term for all marine organisms that are unable to swim against a current. This group is diverse and includes phytoplankton (plants) and zooplankton (animals), as well as fish and invertebrate eggs and larvae. There is no scientific information on the potential for noise-induced effect in phytoplankton and no functional cause-effect relationship has been established.

Noise effect criteria for fish eggs and larvae have been established by the American National Standards Institute (ANSI) accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al., 2014). The criteria from Popper et al. (2014) are from a study by Bolle et al. (2012) that indicated no damage was caused by simulated repeated pile driving at 207 dB PK or 210 dB SELcum.

Since the Popper et al. (2014) criteria was established, a study by McCauley et al. (2017) found that after exposure to a seismic source of 150 in^3 zooplankton abundance decreased and mortality in adult and larval zooplankton increased two- to three-fold when compared with controls. Though the study and the results have been questioned by several reviews (Richardson et al., 2017; IAGC 2017) the sound level of 178 dB PK-PK from McCauley et al. (2017) is typically used as a precautionary approach.

Table 6-4 details that the Popper et al. (2014) noise effect criteria for mortality to eggs and larvae is predicted within 1.6 m of the boomer, 0.3 m for the SBP and 20 m for the 2D survey. The McCauley et al. (2017) sound level was not modelled for the boomer and SBP but Table 6-4 details that it is predicted within 1.52 km for the 2D survey.

The OA overlaps a small proportion (0.17%) of the West Tasmanian Marine Canyon KEF which includes fish nurseries (blue warehou and ocean perch). Blue warehou reach reproductive maturity at about 3 years of age. Spawning occurs during winter and early spring with the primary spawning ground located off western Victoria and Tasmania (AFMA, 2019a). Thus, spawning timing is outside the planned survey periods of February to April and October to December. Ocean perch spawn over an extended period from winter to early summer (AFMA, 2019b). Thus, this species may be potentially present within the West Tasmanian Marine Canyon system and spawning if the site survey is undertaken during the October to December 2020 period.

Impacts to ocean perch spawn are not predicted to have a population effect which may in turn impact on the fishery based on:

- The OA overlapping a small proportion (0.17%) of the West Tasmanian Marine Canyon KEF which includes fish nurseries for the species.
- The duration of the 2D survey which will be undertaken over a very short period of 8 days during the spawning season of the ocean perch which potentially extends over a period of 4 months.
- The species fish stock reports that the biomass is not overfished (AFMA, 2018b).
- Any mortality or mortal injury effects to fish eggs and larvae resulting from impulsive sound emissions is expected to be inconsequential compared to natural mortality rates of fish eggs and larvae, which are very high (exceeding 50% per day in some species and commonly exceeding 10% per day). For example, in a review of mortality estimates (Houde and Zastrow 1993), the mean mortality rate for marine fish larvae was M = 0.24, a rate equivalent to a loss of 21.3% per day.

The OA overlaps the pygmy blue whale foraging BIA where they feed on *Nyctiphanes australis*, known as a coastal krill. Impacts to *Nyctiphanes australis* are not predicted to have a population effect which may in turn impact on pygmy blue whales based on:

- The OA overlapping a small proportion (0.28%) of the pygmy blue whale foraging BIA.
- The duration of the 2D survey which will be undertaken over a very short period of 8 days. *Nyctiphanes australis* reproduce throughout the year with three generations produced each year. The main peak spawning period is early spring to late autumn (UTAS, 2019). Thus, the 2D survey overlaps a very small proposition of the *Nyctiphanes australis* reproduction period where it will continue to reproduce.
- McCauley et al. (2017) note that for anthropogenic sources to have significant impacts on an ecological scale on plankton, then the spatial or temporal scale of impact must be large in comparison with the ecosystem concerned. For the 2D survey the spatial and temporal scale of impact is very small.
- Any mortality or mortal injury effects to *Nyctiphanes australis* resulting from impulsive sound emissions is expected to be inconsequential compared to natural mortality rates. Natural mortality estimates for zooplankton are generally high and variable. Tang et al. (2014) reviewed available research and reported zooplankton daily mortality rates of 11.6% (average minimum) to 59.8% (average maximum) but in some instances these authors found that 100% of samples died within a day.

Table 6-4: Effect criteria used and the applicable results for plankton

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	2D Survey Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Plankton: within the water column	178 dB PK-PK	Not modelled	Not modelled	1520	McCauley et al. 2017
Fish eggs and larvae: within the water column	>207 dB PK	1.6	0.3	20	Popper et al. 2014
	>210 dB SELcum[1]	Not reached	Not reached	20	

Note 1: Popper et al. (2014) do not define an accumulation period. For this assessment 24 hrs was used.

6.2.4.2 Marine invertebrates

There have been several comprehensive reviews of impulsive sound 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 and scallops are typically used.

For rock lobsters the study found that sub-lethal effects, relating to impairment of reflexes, damage to the statocysts and reduction in numbers of haemocytes (possibly indicative of decreased immune response function), were observed after exposure to measured received sound levels of 209–213 dB re 1 µPa (PK-PK).

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.

Table 6-5 details that the sound levels from the representative boomer, SBP and 2D survey do not reach the effect or no effect criteria for lobsters at the seafloor.

For scallops the study (Day et al. (2016) found that sub-lethal effects, relating to physiological damage and changes in behaviour and reflexes, were observed after exposure to measured received sound levels of 191 - 213 dB re 1 µPa (PK-PK).

Table 6-5 details that the sound levels from the representative boomer, SBP and 2D survey do not reach these levels at the seafloor.

Based on the modelling no mortality or injury effects to mollusc and invertebrates such as rock lobster, giant crab and scallops predicted.

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 6-5 details that the noise effect criteria at which an alteration of swimming patterns may occur is predicted within 36 m of the boomer, not reached for the SBP and 590 m for the 2D survey.

Thus, the predicted impact would be that squid may avoid the area while the site survey geophysical component is being undertaken. Squid are caught by the Commonwealth Trawl Sector as incidental catch by demersal trawling. Impacts are not predicted to the fishery as:

- Any impacts to squid will be limited to avoidance behavioural where they may move away from the area while the vessel is undertaking the geophysical survey.
- The area of impact is small, as the OA is 10 x 10 km and the distance to the noise effect criteria at which an alteration of swimming patterns may occur is predicted at a maximum of 590 m, compared to the area where trawling is undertaken.
- The duration of the geophysical survey is 7 days and the 2D survey is 8 days.

Solitary azooxanthellate corals and sponges may inhabit the seafloor within the OA. There are currently no peer-reviewed acoustic criteria against which potential noise impacts to coral could be assessed. The most relevant data currently available are results from exposure studies that Woodside conducted during the Maxima 3D and Gigas 2D Pilot Ocean Bottom Cable marine seismic surveys at Scott Reef in Western Australia. Heyward et al. (2018) reviewed the research undertaken at Scott Reef and the analysis detected no effect of seismic activity measured as coral mortality, skeletal damage or visible signs of stress immediately after and up to four months following the 3D marine seismic survey. Maximum received levels were 226 dB re 1 µPa PK. In lieu of a published criterion, 226 dB re 1 µPa PK has been applied as the no effect criteria for this assessment.

Table 6-5 details that the sound levels from the representative boomer, SBP and 2D survey do not reach any of these levels at the seafloor.

Table 6-5: Effect criteria used and the applicable results for invertebrates

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	2D Survey Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Lobster: effect at the seafloor	209–213 dB PK-PK	Not reached	Not reached	Not reached	Day et al. 2016
Lobster: no effect at the seafloor	202 dB PK-PK	Not reached	Not reached	Not reached	Payne et al. 2008
Scallop: effect at the seafloor	191-213 dB PK-PK	Not reached	Not reached	Not reached	Day et al. 2017
Squid: behavioural response	166 dB SPL	36	Not reached	590	McCauley et al. 2000
Coral and sponges: no effect at the seafloor	266 dB PK	Not reached	Not reached	Not reached	Heyward et al. 2018

Note 1: Popper et al. (2014) do not define an accumulation period. For this assessment a 24 hour period was used was used based on the independent, expert peer review by Professor Art 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.

6.2.4.3 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 6-6 details the noise effect criteria from Popper et al., 2014 and the distances at which modelling estimated they could be reached 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 20 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 at a maximum distance of 30 m 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 is predicted at a maximum distance of 660 m for the 2D survey and was not reached for the boomer and SBP.

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).

The TTS noise effect criteria, though predicted to be reached at 660 m from the source, is unlikely to have a significant impact on fish or fish populations as the OA does not have features where site-attached or resident species would be present. Thus, fish are not likely to be confined to one area for 24 hours.

The OA overlaps a small proportion (0.17%) of the West Tasmanian Marine Canyon KEF which includes fish nurseries (blue warehou and ocean perch). As detailed in Section 6.2.4.1 the site survey, if undertaken during October to December 2020, may overlap the ocean perch spawning period. Spawning fish have the potential to congregate in an area for a period.

A recent review of the potential for TTS impacts to fish by Professor Art Popper (Santos 2018) for the Santos Bethany 3D seismic survey noted:

- It is highly unlikely that there would be physical damage to fishes as a result of the survey unless the animals are very close to the source (perhaps within a few meters).
- Most fishes in the Bethany region, being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey.
- If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fishes do show signs of TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.
- Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of it having a significant impact on fish fitness is very low.

The Bethany 3D seismic survey consisted of a 2,380 in^3 array which is significantly bigger than the 160 in^3 proposed for the 2D survey. The survey was also proposed over a bank area in water depths ranging from 20 m to

202 m. Thus, for a 160 in^3 source in water depths ranging from 150 - 1,110 m impacts would be expected to be significantly less than the impacts noted by Popper.

Thus, it would be expected that any impacts to fish, including spawning species and other commercial species, would be limited to behavioural impacts such as startle response or avoidance behaviour as the vessel moves through the area. As per Popper's review it is highly unlikely that there would be physical damage to fishes as a result of a 160 in^3 2D survey and any behavioural impacts to fish would be temporary and unlikely to have a significant impact on individuals or at a population level.

Table 6-6: Effect criteria used and the applicable results for fish

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	2D Survey Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Fish (swim bladder): mortality/potential mortal injury/ recoverable injury	>207 dB PK				Popper et al. 2014
Within water column		1.6	0.3	20	
At seafloor		Not reached	Not reached	Not reached	
Fish (swim bladder): mortality/potential mortal injury	>207 dB SELcum[1]				Popper et al. 2014
Within water column		Not modelled	Not modelled	20	
At seafloor		Not modelled	Not modelled	Not reached	
Fish (swim bladder): recoverable injury	>203 dB SELcum[1]				Popper et al. 2014
Within water column		Not modelled	Not modelled	30	
At seafloor		Not modelled	Not modelled	Not reached	
Fish (no swim bladder): mortality/ potential mortal injury/ recoverable injury	>213 dB PK				Popper et al. 2014
Within water column		0.6	0.1	Not reached*	
At seafloor		Not reached	Not reached	Not reached	
Fish (no swim bladder): mortality/ potential mortal injury	>219 dB SELcum[1]				Popper et al. 2014
Within water column		Not modelled	Not modelled	Not reached*	
At seafloor		Not modelled	Not modelled	Not reached	
Fish (no swim bladder): recoverable injury	>216 dB SELcum[1]				Popper et al. 2014
Within water column		Not modelled	Not modelled	Not reached*	
At seafloor		Not modelled	Not modelled	Not reached	
Fish (swim bladder or no swim bladder): TTS	>186 dB SELcum[1]				Popper et al. 2014
Within water column		Not reached	Not reached	660	
At seafloor		Not reached	Not reached	660	

Note 1: Popper et al. 2014 do not define an accumulation period. For this assessment a 24 hour period was used based on the independent, expert peer review by Professor Art 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.

* indicates the threshold was not reached within the limits of the modelling resolution (20 m).

6.2.4.4 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). For PTS and TTS Finneran et al. (2017) presented revised thresholds considering both PK and frequency weighted SEL.

Table 6-7 details the noise effect criteria from Popper et al. 2014 and Finneran et al. (2017), and the distances at which modelling estimated they could be reached.

In summary:

- The noise effect criteria for injury to turtles was reached at a maximum distance of 20 m for the 2D survey for the peak sound pressure level (PK) and cumulative SEL over 24 hrs.
- The noise effect criteria for PTS was not reached within the limits of the modelling resolution (20 m) for the 2D survey for the peak sound pressure level (PK) and was reached at a maximum distance of 20 m for the cumulative SEL over 24 hrs.
- The noise effect criteria for TTS was not reached within the limits of the modelling resolution (20 m) for the 2D survey for the peak sound pressure level (PK) and was reached at a maximum distance of 50 m for the cumulative SEL over 24 hrs.

Three marine turtle species may occur within the OA. No BIAs or habitat critical to the survival of the species occur within the OA. Thus, injury to turtles from the geophysical survey or 2D survey would be unlikely based on the very small Maximum distance of 50 m at which the injury effect criteria is 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). This criterion has been used as the noise effect criteria for a behavioural response. McCauley et al. (2000) observed the behavioural response of caged green (*Chelonia mydas*) and loggerhead (*Caretta carett*a) turtles to an approaching seismic source. For received levels above 175 dB re 1 µPa the turtles increased their swimming activity and they began to behave erratically, which was interpreted as an agitated state. This received level has been used as the noise effect criteria level for a behavioural disturbance.

Table 6-7 details the distances at which modelling estimated the noise effect criteria for behavioural response and behavioural disturbance.

In summary:

- The noise effect criteria for turtle behavioural response is a maximum of 590 m for the 2D survey.
- The noise effect criteria for turtle behavioural disturbance is a maximum of 130 m for the 2D survey.

Though three marine turtle species may occur within the OA there are no BIAs or habitat critical to the survival of the species occurring within the OA. Impacts to turtles within the survey area are likely to be restricted to avoidance behaviour as the vessel moves through the area. Thus, behavioural impacts to turtles would be temporary and unlikely to have a significant impact on individuals or at a population level.

Table 6-7: Effect criteria used and the applicable results for turtles

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	2D Survey Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Turtle: behavioural disturbance	175 dB SPL	Not modelled	Not modelled	130	McCauley et al. 2000b
Turtle: behavioural response	166 dB SPL	36	Not reached	590	NSF 2011
Turtle: mortality/potential mortal injury	>207 dB PK or 210 dB SELcum[1]	1.6 Not reached	0.3 Not reached	20 20	Popper et al. 2014
Turtle: PTS	232 dB PK 204 dB SEL_{24h}	Not modelled Not modelled	Not modelled Not modelled	Not reached* 20	Finneran et al. 2017
Turtle: TTS	226 dB PK 189 dB SEL_{24h}	Not modelled Not modelled	Not modelled Not modelled	Not reached* 50	Finneran et al. 2017

Note 1: Popper et al. 2014 do not define an accumulation period. For this assessment a period of 24 hours was used based on the independent, expert peer review by Professor Art 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.

* indicates the threshold was not reached within the limits of the modelling resolution (20 m).

6.2.4.5 Marine mammals

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

- 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 6-8 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 6-8 details the noise effect criteria and the distances at which modelling estimated they could be reached.

In summary:

- The noise effect criteria for behavioural effects in marine mammals is predicted at a maximum of 2 m for the SBP, 75 m for the boomer and 1.52 km for the 2D survey.
- For low-frequency cetaceans the noise effect criteria for PTS is only reached for the 2D survey at 80 m for the 24 hr cumulative SEL. The noise effect criteria for TTS is predicted at a maximum of 10 m for the SBP and boomer and 9.55 km for the 2D survey for the 24 hr cumulative SEL. The noise effect criteria for TTS for the single pulse was not reached.
- For mid-frequency cetaceans the noise effect criteria for PTS and TTS is not reached.
- For high-frequency cetaceans the noise effect criteria for PTS is predicted for the single pulse at a maximum of 0.6 m for the SBP, 4.5 m for the boomer and 30 m for the 2D survey. The noise effect criteria for PTS for the 24 hr cumulative SEL was not reached. The noise effect criteria for TTS is predicted for the single pulse at a

maximum of 1.2 m for the SBP, 8.9 m for the boomer and 70 m for the 2D survey. The 24 hr cumulative SEL noise effect criteria for TTS was only predicted at 30 m for the 2D survey.

- For Otariid pinnipeds, such as fur-seals, the noise effect criteria for TTS and PTS where not reached.

The Australian and New Zealand fur-seals may occur in the OA but no BIAs or haul out areas were identified. The noise effect criteria for TTS and PTS for these species was not reached, thus predicted impacts would be limited to behavioural response such as avoidance of area while the geophysical and 2D survey is undertaken. This would not result in any population levels impacts to these species.

Twenty-two whale species may occur within the OA with the following identified:

- Blue whale: foraging, feeding or related behaviour known to occur. The OA overlaps a foraging BIA for the pygmy blue whale (Figure B-9-8). The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) details that anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.
- Fin and sei whales: foraging, feeding or related behaviour likely to occur.
- Pygmy right whale: foraging, feeding or related behaviour may to occur.

High frequency cetaceans

For high frequency cetaceans such as pygmy and dwarf sperm whales that may occur in the OA the maximum distance for the PTS noise effect criteria is 70 m and for TTS is 30 m. It is unlikely that sperm whales would come that close to the vessel or sound source as the distance to the behavioural noise effect criteria is 1.52 km. There are no pygmy and dwarf sperm whales BIAs within 1.52 km of the OA so it is likely that there would be low numbers of these species in the area. With the implementation of soft start procedures and a 500 m shut down zone no PTS or TTS impacts are predicted. Minor behavioural changes may occur such as avoiding the OA for up to 15 days while the geophysical survey and 2D survey occur. As there are no BIAs within 1.52 km of the OA potential impacts are unlikely to lead to behavioural disturbance of significance to the species.

Low frequency cetaceans

For low frequency cetaceans such as blue, fin, sei and pygmy right whales the noise effect criteria for PTS and TTS for the single pulse was not reached. The application of the 24 hr cumulative SEL criteria is not seen as appropriate for the fin, sei and pygmy right whales as there are no BIAs within the noise exposure area and foraging behaviours are identified as opportunistic and unlikely to result in these species being in the noise exposure area over a 24 hour period. Thus, impacts to these species is likely to be restricted to avoidance behaviour as the vessel moves through an area over the 15 day period that the geophysical and 2D survey is undertaken. For those species with no BIAs within 1.52 km (distance to the behavioural noise effect criteria) of the OA, potential impacts are unlikely to lead to behavioural disturbance of significance to the species.

Pygmy blue whales

The OA overlaps a foraging BIA for the pygmy blue whale (Figure B-9-8) and the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) details that anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.

For low frequency cetaceans such as pygmy blue whales the noise effect criteria for PTS and TTS for the single pulse was not reached. As the pygmy blue whale foraging BIA overlaps the OA there is the potential that pygmy blue whales may be within the area for longer periods and hence it is appropriate to apply the 24 hr cumulative SEL criteria to determine the predicted level of impact.

For the boomer and SBP the 24 hr cumulative SEL TTS criteria was only reached at 10 m and thus TTS impacts are not predicted as it is unlikely that a pygmy blue whale would be within 10 m of the source for a period of up to 24 hrs. This would be highly unlikely due to the vessel constantly moving and the mobile nature of these species as they move around according to the local prevalence of krill. The likelihood is further reduced with the implementation of standard controls such as soft starts and use of an experienced marine mammal observer (MMO) to implement the 500 m shut down zone. For the boomer and SBP potential impacts would be restricted to avoidance behaviour within 75 m of the boomer as the vessel moves through an area over the 7 day period that the geophysical survey is undertaken. Thus, with the implementation of standard controls the noise from the geophysical survey in the BIA will be managed such that any blue whale continues to utilise the area without injury or displacement.

Exposure to sufficiently intense sound may lead to an increased hearing threshold in any living animal capable of perceiving acoustic stimuli. If this shift is reversed and the hearing threshold returns to normal, the effect is called a TTS. The onset of TTS is often defined as threshold shift of 6 dB above the normal hearing threshold (Southall et al., 2007). If the threshold shift does not return to normal, the residual shift is called a PTS.

For this assessment PTS is used to predict the level of impact to blue whales in relation to injury as TTS is not considered an injury based on:

- Southall et al. (2007) states that noise-induced PTS represents tissue injury, but TTS does not. Although TTS involves reduced hearing sensitivity following exposure, it results primarily from the fatigue (as opposed to loss) of cochlear hair cells and supporting structures and is, by definition, reversible.
- Southall et al. (2007) also cites Ward (1997) who states where these effects result in TTS rather than a permanent change in hearing sensitivity, they are within the nominal bounds of physiological variability and tolerance and do not represent physical injury.
- Erbe (2012) states TTS is considered auditory fatigue, whereas PTS is considered injury.

PTS or injury to pygmy blue whales could occur within 80 m of the sound source for the 2D survey and is not reached for the boomer and SBP. The PTS noise effect criteria is only reached for the 24 hr cumulative SEL. Thus, a pygmy blue whale would need to be within 80 m of the sound source for 24 hours to meet the PTS noise effect criteria. This is highly unlikely, and the likelihood is further reduced with the implementation of standard controls such as soft starts and use of an experienced marine mammal observer (MMO) to implement the 500 m shut down zone. The ensonification area for the PTS cumulative SEL_{24} was predicted to be 10.2 km^2 which is equivalent to 0.028% of the pygmy blue whale high density foraging BIA (35,615 km^2). Based on the extremely small area of ensonification and implementation of controls, pygmy blue whales would not be within 80 m of an operating sound source for a 24 hour period, thus noise in the BIA will be managed such that any blue whale continues to utilise the area without injury or displacement.

TTS impacts based on the 24 hr cumulative SEL are highly unlikely since the TTS criteria is reached at 9.55 km; however, the behavioural disturbance criteria is reached at 1.52 km. Thus, it is more likely that whales, including foraging pygmy blue whales, would move away from the sound source before being exposed for a 24 hour period. This is supported by EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA, 2008b) that states it is likely that whales in the vicinity of seismic surveying will avoid the immediate area due to an aversive response to the sound. The ensonification area for the TTS cumulative SEL_{24} was predicted to be 229 km^2 which is equivalent to 0.64% of the pygmy blue whale high density foraging BIA (35, 615 km^2). Thus, based on the extremely small area of ensonification and implementation of controls, noise in the BIA will be managed such that any blue whale continues to utilise the area without injury or displacement.

For pygmy blue whales that may be foraging, the area of disturbance is small at 1.5 km and is unlikely to restrict feeding activity in the area or result in displacement of pygmy blue whales from the foraging BIA based on the large area over which foraging takes place compared to the small area where potential disturbance may occur as the vessel moves through the area. The worst case area of impact based on the OA (100 km^2) plus the distance reached to the behavioural disturbance criteria (132.5 km^2 based on an additional 1.5 km around the OA) equates to 0.4% of the pygmy blue whale high density foraging BIA (35,615 km^2). In addition, impacts would be short in duration based on a maximum of 8 days for the 2D survey and would only occur over a very small extent (0.4%) of the pygmy blue whale high density foraging BIA. Impact severity would be low as pygmy blue whales would not be displaced from the BIA as the site survey location is at its closest distance 10 km to the outer edge of the BIA, allowing whales enough space to move away from the sound source while remaining in the BIA. Thus, based on the extremely small area of ensonification and implementation of controls, noise in the BIA will be managed such that any blue whale continues to utilise the area without injury or displacement.

Table 6-8: Effect criteria used and the applicable results for marine mammals

Receptor	Noise Effect Criteria	Boomer Maximum R_{max} Distance (m)	SBP Maximum R_{max} Distance (m)	2D Survey Maximum R_{max} Distance (m)	Noise Effect Criteria Reference
Marine mammals: behavioural	160 dB SPL	75	2	1520	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	Not reached* 80	NMFS 2018
Low-frequency cetaceans: TTS (humpback and pygmy blue whales)	213 dB PK 168 dB SEL_{24h}	Not reached 10	Not reached 10	Not reached* 9550	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	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	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	30 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	70 30	NMFS 2018
Otariid pinnipeds: PTS (fur-seals)	232 dB PK 203 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	Not reached* Not reached*	NMFS 2018
Otariid pinnipeds: TTS (fur-seals)	226 dB PK 188 dB SEL_{24h}	Not reached Not reached	Not reached Not reached	Not reached* Not reached*	NMFS 2018

* indicates the threshold was not reached within the limits of the modelling resolution (20 m).

6.2.4.6 Cumulative impacts

Cumulative impacts can occur from multiple surveys occurring at the same time (simultaneous activities) leading to an increase in predicted noise levels on receptors. It can also occur from repeated surveys within the same area over time particularly to site attached species.

Based on the modelling no mortality or injury effects to invertebrates, which may potentially be site attached, are predicted and the OA does not overlap any areas where site-attached fish species are likely to be present. Thus, cumulative impacts to site attached species from the geophysical and 2D survey being undertaken over the same area are not predicted. As no impacts to site attached species are predicted from the site survey there is no cumulative impact with other surveys expected to occur.

As detailed in Appendix B.4.7, one seismic survey overlaps the OA and may potentially be undertaken within the same period as the site survey.

Figure B-9-18 shows that the Spectrum Geo (now TGS) Otway Deep Marine Seismic Survey acquisition area overlaps a small proportion of the OA. Based on information on the NOPSEMA website the survey is scheduled to be acquire between Oct 2019 and 28 Feb 2020 which overlaps the site survey period by one month (February 2020). As per previous consultation for the Otway Geophysical and Geotechnical Seabed Assessment it was agreed that Spectrum and Beach would maintain a 40 km separation distance between surveys (Stakeholder Record SG_14). Thus, there will not be any simultaneous activities.

6.2.5 Control measures, ALARP and acceptability assessment

Control, ALARP and acceptability assessment: Underwater acoustic emissions	
ALARP Decision Context and Justification	**ALARP Decision Context: Type B** As the site survey is proposed to be undertaken within the pygmy blue whale foraging BIA during a period when they may be foraging further assessment of controls is required to ensure impacts are ALARP and will be of an acceptable level. Consequently, Beach believes that ALARP Decision Context B should be applied.
Control Measures	**Source of good practice control measures**
CM#19: EPBC Act Policy Statement 2.1 Part A	EPBC Act Policy Statement 2.1 was developed for seismic surveys with the aim of the policy Statement 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. Consistent with Part A of EPBC Policy Statement 2.1, the following procedures will be applied: • Pre-start-up visual observations (30 minutes) • Start-up delay procedures • Soft-start procedures (30 minutes) • Operational shut down and low power procedures • Night-time and low visibility procedures • Seismic survey vessel crew induction to include overview of EPBC Policy Statement 2.1 procedures and any additional controls • Cetacean sighting and compliance reports to be submitted to DotEE within 2 months of survey completion
CM#20: EPBC Act Policy Statement 2.1 Part B.1Marine Mammal Observers	As the site survey is proposed to be undertaken within a pygmy blue whale foraging BIA when they may be present in the area, trained and experienced marine mammal observers (MMO) will be used for the geophysical and 2D survey.

Control	Cost/Benefit Analysis	Control Implemented?
Substitution of equipment.	Equipment has been selected to meet the objectives of the site survey. Modelling has shown that the equipment to be used generates very low received noise levels and changing equipment is unlikely to significantly reduce the distance within which the noise effect criteria are met.	No
EPBC Act Policy 2.1 Statement A.1 Pre-survey planning	Ideally, the geophysical and 2D survey would not be planned to be conducted when pygmy blue whales are likely to be within the foraging BIA (Nov to April). However, the survey cannot be conducted from May to the end of September due to poor weather within the Otway offshore area during that period. This leads to significant down time and unsafe conditions of operation. The site survey data is required prior to drilling in December 2020 and if the survey is undertaken in October 2020 there is not enough time to process the data, particularly the 2D survey data. If the drilling rig is delayed the site survey would be undertaken from October 2020 – December 2020. The peak period for pygmy blue whales within OA is February/March. Though the survey will take a maximum of 28 days the period for undertaking the survey between February and April 2020 allows for weather delays as the Otway Basin is known for its rough weather. As the survey will take up to 28 days restricting the survey to April does not allow enough contingency time for shut downs, equipment and/or weather downtime prior to May when typically, extreme weather does not allow for vessel based surveys. The site survey will be scheduled in the following order; geophysical survey, geotechnical survey, 2D survey. The geophysical survey is required to determine the final geotechnical locations. This has the benefit of undertaking the 2D survey later in February when pygmy blue whales' numbers are potentially starting to decline. It will also allow information to be obtained on the number and behaviour of pygmy blue whales within the OA prior to the 2D survey. This information can to inform the adaptive management process to ensure controls are effective in managing impacts to pygmy blue whales if the numbers of pygmy blue whales are higher than anticipated. To ensure sighting data is accurate two MMOs will be on the survey vessel for the geophysical survey.	Yes - CM#21: Pre-survey planning
EPBC Act Policy Statement 2.1 B.2 Night-time/Poor visibility	There is a potential for pygmy blue whales to be foraging within the 10 km x 10 km OA at night. Except for the behavioural noise effect criteria, the single pulse PTS and TTS where not reached for the boomer, SBP or 2D survey. The PTS and TTS 24 hr cumulative SEL was predicted to be reached within 80 m and within 10 km of the vessel respectively for pygmy blue whales. Thus, any additional controls to the standard night-time/low visibility controls to be implemented (CM#19) would be to minimise the likelihood of behaviour disturbance or TTS to foraging pygmy blue whales while undertaking the 2D survey. Suitable controls would be: • Not to undertake at night. This would double the duration of the survey as the vessel equipment cannot be set up to alternate between the geophysical survey and 2D survey. This would increase the duration of impacts for the survey and would increase cost by ~ $100,000 per day but would eliminate the risk of encountering whales while undertaking the 2D survey at night. • Not to undertake the 2D survey at night if there have been three or more pygmy blue whale related shut downs/power downs during the preceding daylight hours. This would double the duration of the survey as the vessel cannot be set up to alternate between the geophysical survey and 2D survey. This would increase the duration of impacts for the survey and could increase cost by ~ $100,000 per day depending on how many nights the vessel could not undertake the 2D survey but would eliminate the risk of encountering whales while undertaking the 2D survey at night.	Yes - CM#22: Night-time/Poor visibility

Control	Cost/Benefit Analysis	Control Implemented?
	• Use of an aircraft with trained whale observers to search the night-time survey area to determine if pygmy blue whales are present. If pygmy blue whales were present the 2D survey would not be able to proceed as the OA is only 10 x 10 km so for the survey vessel to move to a location greater than 9.5 km (distance to the TTS SEL_{24} noise effect criteria) from any pygmy blue whales sighted the vessel would be outside the OA. This would increase survey costs by ~ $10,000 per day but would reduce the likelihood of encountering whales while undertaking the 2D survey at night. • Use of a vessel with a trained MMO to search the night-time survey area to determine if pygmy blue whales are present. If pygmy blue whales were present the 2D survey would not be able to proceed as the OA is only 10 x 10 km so for the survey vessel to move to a location greater than 9.5 km (distance to the TTS SEL_{24} noise effect criteria) from any pygmy blue whales sighted the vessel would be outside the OA. This would increase survey costs by ~ $15,000 per day but would reduce the likelihood of encountering whales while undertaking the 2D survey at night. • Use of Passive Acoustic Monitoring to monitor for pygmy blue whales at night is not considered effective – see EPBC Act Policy Statement 2.1 B.5: Passive Acoustic Monitoring. To achieve an environmental benefit and not have a significant cost to Beach a combination of the above controls will be implemented for night time operations: • The 2D survey will not proceed at night if there has been three or more pygmy blue whale shut down/power downs during the preceding period of day light operations. If there have been less than three pygmy blue whale shut down/power downs during that period, the spotter vessel with an MMO will search the night-time survey area to determine if pygmy blue whales are present. If pygmy blue whales are present within the night-time survey area the 2D survey will not proceed at night. • For daytime low visibility conditions, if the MMO cannot see to 3 km the 2D survey can continue unless there has been three or more pygmy blue whale shut down/power downs during the preceding 24 hrs. The daytime 2D survey can restart when the MMO can see to 3 km after undertaking the pre-start visual observations and soft-start procedures. Three or more shut downs/power downs is seen as an appropriate trigger as this is typically used to indicate that there is an increased likelihood of encountering whales during the survey.	
EPBC Act Policy Statement 2.1 B.3 Spotter vessel and aircraft	Spotter vessels and aircraft can be used to detect the presence and likelihood of encountering whales during day-time and night-time operations. A vessel is more cost effective than an aircraft and as the OA is small (10 km x 10 km) a spotter vessel would be effective in undertaking searches of the day-time and night-time survey area to determine if pygmy blue whales are present. A vessel also allows for ongoing searches where an aircraft would be limited in the number of searches it can take both for safety and cost reasons. • A spotter vessel with one MMO will be used for the 2D survey. • During daylight hours the spotter vessel will be located between 6 – 7 km in front of the survey vessel to allow for a total observation area of 9 – 10 km.	Yes - CM#23: Spotter vessel

Control	Cost/Benefit Analysis	Control Implemented?
	If pygmy blue whales are observed by the spotter vessel the location, number and behaviour (moving or foraging of the whale/s will be communicated to the MMO on the 2D survey vessel.	
EPBC Act Policy Statement 2.1 B.4 Increase Precaution Zones and Buffer Zones	EPBC Act Policy Statement 2.1 details that for important habitats, such as feeding areas, when concentrations of food and whales are likely to occur, an increased low power zone (e.g. 3 km) may be appropriate to ensure that disturbance or displacement of whales does not occur. Thus, for the 2D survey the low power zone will be increased to 2 km which is greater than the distance of 1.52 km in which the behavioural disturbance noise effect criteria is reached. An increased low power zone for the geophysical survey does not have an environmental benefit as noise effect criteria for whales were not reached at a distance greater than 75 m.	Yes - CM#19: EPBC Act Policy Statement 2.1 Part A
EPBC Act Policy Statement 2.1 B.5: Passive Acoustic Monitoring	PAM has limited application for detecting baleen whales such as blue whales due to the types of vocalisations made by these whales (long wavelength). Verfuss et al. (2017) who undertook a review of low visibility monitoring techniques, concluded that PAM works best in low background noise fields as high levels of sound can mask the vocalisations produced by the target species when overlapping in frequency and time. PAM detections of baleen whales during active seismic surveys are extremely low or entirely absent, but the method can work well with many odontocete species. As such PAM is not considered to be appropriate for use in detecting baleen whales such as pygmy blue whales.	No

EPBC Act Policy Statement 2.1 B.6: Adaptive Management	As the OA is within a pygmy blue whale foraging BIA an adaptive management process ensures controls are effective in managing impacts to pygmy blue whales if the numbers of pygmy blue whales and number of pygmy blue whale instigated shut down/power downs are higher than were anticipated during the planning of the survey.
	The adaptive management process is only applied to pygmy blue whales during the 2D survey as noise effect criteria for the boomer and SBP were estimated to reach a maximum distance of 75 m from the source and it is unlikely that whales would come that close to the seismic source.
	The following adaptive management process will be implemented for the 2D survey:
	Pre-planning
	Prior to the 2D survey commencing the MMO data from the geophysical survey will be reviewed to:
	• Identify the likelihood of encountering pygmy blue whales and if there are areas where foraging behaviours are occurring within the OA.
	• Identify if any additional controls are to be implemented to manage impacts and risks to pygmy blue whales to ALARP and an acceptable level. Additional controls may include:
	  ◦ increased pre-start observation periods
	  ◦ increased power down and shutdown zones
	  ◦ change in survey start location and sequence of lines
	The review will be documented and be undertaken with the input of at least one of the MMOs on the survey vessel, survey Project Manager, Environment Advisor, Offshore Survey Representative.
	During the survey:
	If there has been three pygmy blue whale shut down/power downs in a 24 hour period, a review will be undertaken to:
		Yes - CM#24: Adaptive Management

Control	Cost/Benefit Analysis	Control Implemented?
	• Determine if the controls within the EP and any additional controls identified via the pre-planning review will continue to be effective in managing impacts and risks to pygmy blue whales to ALARP and an acceptable level. • Identify if any additional controls are to be implemented to manage impacts and risks to pygmy blue whales to ALARP and an acceptable level. Additional controls may include: ◦ increased pre-start observation periods ◦ increased power down and shut down zones ◦ change in survey sequence of lines If there are three consecutive days on which there are three or more pygmy blue whale shut downs/power downs the 2D survey will not proceed for 24 hours. Depending on when the 24 hour shut down period ceases the night time control may also apply.	

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.
Management system compliance	Site survey will be undertaken in accordance with the Beach HSEMS as detailed in Section 8 Implementation Strategy.
Stakeholder engagement	During stakeholder engagement no objections or claims where raised in relation to acoustic emissions.
Laws and standards	The site survey will comply with EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA, 2008b). The site survey will be managed consistent with the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a). such that anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area.
Industry practice	Geophysical and 2D surveys are normal marine practice in the oil and gas industry.
Environmental context	The impact assessment predicts that acoustic emissions will not result in death, injury or significant behavioural effects to marine fauna or injury or displacement of pygmy blue whales from the foraging BIA. This is in alignment with relevant conservation advice and recovery plans for EPBC species that may occur in the OA 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 site survey was 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 acoustic emissions are for a short duration, over small area and not predicted to have long term impacts to fauna in the area. Therefore, the monitoring of underwater noise and vibration emission is not proposed.
Acceptability outcome	**Acceptable**

6.3 Loss of marine diesel from vessel collision

6.3.1 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.

6.3.2 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.

6.3.3 Impact evaluation and risk assessment

6.3.3.1 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 6-10), 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 6-11 shows the boiling point ranges for the diesel used in the spill modelling.

Table 6-9: 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 6-10: 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.

6.3.3.2 Modelling results – vessel collision spill

A spill of 100 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 6-12).

Table 6-11: 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 100 m^3 from a worst-case vessel collision incident is estimated at 12 hours (Figure 6-4).
- 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 6-5.

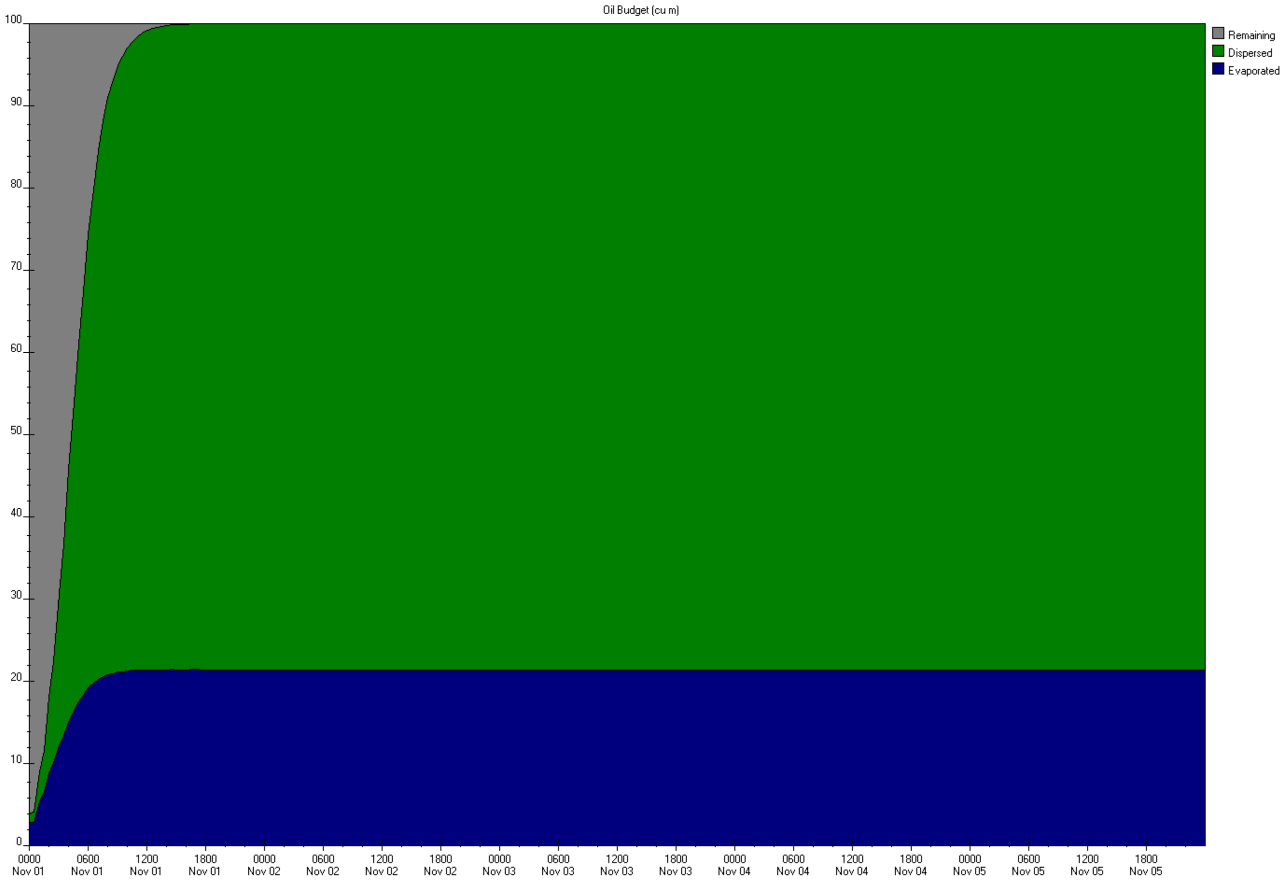

Figure 6-4: Percentage of oil remaining from a 100 m^3 of diesel spill due to vessel collision

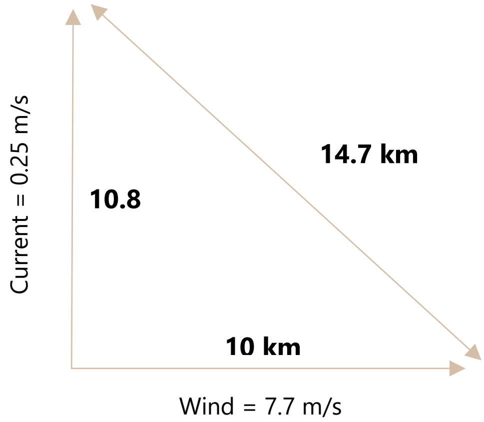

Figure 6-5: Travel distance of 100 m^3 of diesel spill due to vessel collision

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 up to 67 m^3 predicted to be lost by evaporation and dispersion within 6 hours, depending upon sea temperature and winds (Figure 6-4). Diesel oil also has low viscosity which 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).

6.3.4 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 oil is considered to have a higher aquatic toxicity in comparison to many other crude oils and condensates due to the types of hydrocarbons present and the resulting increased bioavailability of dispersed droplets of diesel to marine organisms. Diesel oil has 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 6-13 to Table 6-16.

Table 6-12: 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 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 these 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 turtle species; 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 these 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 pinniped species; 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 (whales)	Several threatened, migratory and/or listed whale species have the potential to be within the area predicted to be exposed to surface oil. A BIA is 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 population would surface in the affected areas, resulting in short-term and localised consequences, with no long-term effects on population viability. 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 these 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 6-13: 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 is approximately 54 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.	Beach's Thylacine platform exists within the EMBA. However due to the nature of the oil and expected rapid weathering offshore, it is unlikely a spill would have significant impact on Beach's platform and its activities.

Table 6-14: 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 been re-established, the plankton community may take weeks to months to recover (ITOPF, 2011a), allowing for seasonal influences on the assemblage characteristics.
	Marine invertebrates	Marine invertebrates of value have been identified to include squid and crustaceans (rock lobster, crabs). 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. Commercial species such as rock lobster and giant crab reside on the seabed which is not likely to be exposed.	Acute or chronic exposure through contact and/or ingestion can result in toxic effects. 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.
	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. There is a known distribution and foraging BIA for the white shark in the EMBA; however, it is not expected that this species spends a large amount of time close to the surface where concentrations may be highest.	Pelagic free-swimming fish and sharks are unlikely to suffer long-term impacts 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.
	Marine mammals (pinnipeds)	Pinnipeds may be in the area 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

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
		However, there are no BIAs or habitat critical to the survival of these species within this area.	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 effects on population viability.
	Marine mammals (cetaceans)	Several Threatened, Migratory and/or listed marine cetacean species may be in the area temporarily exposed to low concentrations of entrained diesel in the water column. A BIA is present for foraging for pygmy blue whales within the EMBA. Dolphins may be in the area temporarily exposed to low concentrations of entrained diesel in the water column. However, there are no BIAs or habitat critical to the survival of the species within this area. 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 would be limited to a relatively short period following the release and is unlikely to result in exposure to many individuals. However, such exposure is not anticipated to result in long-term population viability effects.
Marine ecosystem	KEF	The West Tasmanian Canyons is located on the relatively narrow and steep continental slope west of Tasmania (Figure B-9-2). 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 95 m – 1,690 m. The exposure of the KEF or any benthic infauna to a diesel spill at these depths is not anticipated.

Table 6-15: Consequence evaluation to socio-economic receptors within the EMBA – in water

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
Human systems	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	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.

Receptor Group	Receptor Type	Exposure Evaluation	Consequence Evaluation
		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 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 for 1-3 days after release, therefore physical displacement to vessels is unlikely to be a significant impact.

6.3.5 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#12: Ongoing consultation	Under the *Navigation Act 2012*, the Australian Hydrographic Office (AHO) 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 AHO and AMSA and to relevant stakeholders to ensure the presence of the vessel is known in the area. See Section 8.7 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#18: 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#25: MO 21: Safety and emergency arrangements	AMSA MO 21 gives effect to SOLAS regulations dealing with life-saving appliances and arrangements, safety of navigation and special measures to enhance maritime safety.		
CM#26: MO 30: Prevention of collisions	AMSA MO 30 requires that onboard navigation, radar equipment, and lighting meets industry standards.		
CM#27: MO 31: SOLAS and non-SOLAS certification	All contracted vessels will have in date certification in accordance with AMSA MO 31..		
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	No

Control, ALARP and acceptability assessment: Loss of marine diesel from vessel collision			
		bunker fuel oil, would have a higher environmental impact than diesel.	
Exclusion zone established around the OA during the site survey.	Good Practice	The duration of the site survey 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 site survey.	Engineering Risk Assessment	The vessels proposed for the site survey 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.	No
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 7).		
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 and emergency procedures); • MO 30 (Prevention of collisions); • MO 31 (SOLAS and non-SOLAS 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 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 tendency 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 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 encounter 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.		

Control, ALARP and acceptability assessment: Loss of marine diesel from vessel collision	
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**

6.4 Oil spill response

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

6.4.1 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 6-17 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.

6.4.2 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 6-16: 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 (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.	✓	✓

6.4.3 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).

6.4.4 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).

6.4.5 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.

6.4.5.1 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 7.16.2) 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 6-17: 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	Access to a AW139 with a daylight activation within 2 hours.
	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	Currents and wind data.	Bureau of Meteorology (BOM) "Meteye" Service	Current and wind data available online.

6.4.6 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. DELWP's 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 or Tasmanian state waters.

6.4.6.1 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 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 6-18: 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.

6.4.7 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.

6.4.7.1 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 7.16.4.

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.

6.4.8 Impact evaluation and risk assessment

Impacts and risks associated with operation of vessel surveillance and monitoring (in responding to a hydrocarbon spill) are like those discussed for routine vessel use. Therefore, the relevant 'aspects' in Table 6-2 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.

6.4.9 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#8: 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#9: 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).
CM#11: 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#28: Emergency response preparedness	Emergency response capability will be maintained in accordance with the EP, and related documentation.
CM#29: 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#30: OWR response management	OWR will be managed by relevant regulatory Authorities.
CM#31: Scientific monitoring management	Scientific monitoring will be managed in accordance with the Scientific Monitoring Programs (SMPs) to achieve scientific objectives.

Control, ALARP and acceptability assessment: Oil spill response			
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 several service providers that have completed the Beach contracting and procurement process. A single vessel is expected to be enough for the initial stages of the response planning and using additional vessels 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		
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 7).		
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.		

Control, ALARP and acceptability assessment: Oil spill response	
Laws and standards	Response has been developed in accordance with: • OPGGS Act; and • AMSA Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (AMSA, 2015).
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 7.16.
Acceptability outcome	**Acceptable**

6.5 Environmental performance outcomes, Environmental performance standards and measurement criteria

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

Table 6-19: Site survey 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: • Modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results.	CM#1: Geotechnical Scope of Work	• Geotechnical samples will be undertaken as per the Geotechnical Scope of Work.	Geotechnical report	Survey Offshore Representative
Undertake the activity in a manner that will not: • Result in a substantial change in ambient light, water and air quality which may adversely impact on biodiversity, ecological integrity; social amenity or human health.	CM#2: MO 97: Marine Pollution Prevention – Air Pollution	• Low-sulphur (<0.5% 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#3: Draft National Light Pollution Guidelines	• Vessel lighting will be restricted to that necessary for safe operations.	Vessel inspection	Vessel Master
	CM#4: 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	Survey Project Manager

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
	CM#5: *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
	CM#6: 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.	Planned maintenance system (PMS) records.	Vessel Master
	CM#7: 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. • Injure or displace blue pygmy whales from the foraging BIA. • Have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding,	CM#8: Wildlife (Marine Mammals) Regulations 2009	Vessels, when not undertaking the geophysical, 2D or geotechnical surveys, adhere to the distances and vessel management practices for seals as per the Wildlife (Marine Mammals) Regulations 2009.	Daily operations report details when whales or seals sighted, and the interaction management actions implemented, if required.	Vessel Master
	CM#9: EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels, when not undertaking the geophysical, 2D or geotechnical surveys, adhere to the distances and vessel management practices of EPBC Regulations (Part 8).	Daily operations report details when whales or seals sighted, and the interaction management actions implemented, if required.	Vessel Master
	CM#10: Streamer tail buoy turtle guard	For the 2D survey the streamer tail buoy will have a turtle guard.	Vessel inspection	Vessel Master

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
feeding, migration behaviour, life expectancy) and spatial distribution.	CM#19: EPBC Act Policy Statement 2.1	Prestart visual observations will be undertaken for 30 min to at least 3 km (observation zone) prior to starting the boomer, SBP or 2D acoustic source. Soft start, start-up delay, operations, stop and night time and low visibility procedures will be implemented as detailed in EPBC Act Policy Statement 2.1 Part A. When not collecting data, all acoustic sources will be shut down. For the 2D survey the following precaution zones will be implemented: • Observation zone: 3 km. • Low power zone: 2 km. • Shut down zone: 500m. For the geotechnical survey the following precaution zones will be implemented: • Observation zone: 3 km. • Low power zone: 1 km. • Shut down zone: 500m.	MMO daily report	MMO
	CM#20: Marine Mammal Observer	• Two marine mammal observers (MMO) will be on the vessel when undertaking the geophysical or 2D survey with one MMO on watch during daylight hours. • One MMO will be on the 2D survey spotter vessel. • MMOs will have completed the JNCC Marine Mammal Observer Course or and have a minimum of 10 weeks experience on a seismic survey vessel as an MMO.	MMO resume. MMO daily report	Survey Offshore Representative
	CM#21: Pre-survey planning	The geophysical survey will be undertaken before the 2D survey.	Daily report	Survey Project Manager
		MMO data from the geophysical survey in relation to pygmy blue whales within the OA will be used to inform the adaptive management process detailed in CM#23.	MMO daily report	MMO

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
	CM#22: Night-time/Poor visibility	• The 2D survey will not proceed at night if there has been three or more pygmy blue whale shut down/power downs during the preceding period of day light operations. If there have been less than three pygmy blue whale shut down/power downs during that period, the spotter vessel with an MMO will search the night-time survey area to determine if pygmy blue whales are present. If pygmy blue whales are present within the night-time survey area the 2D survey will not proceed at night. • For daytime low visibility conditions, if the MMO cannot see to 3 km the 2D survey can continue unless there has been three or more pygmy blue whale shut down/power downs during the preceding 24 hrs. The daytime 2D survey can restart when the MMO can see to 3 km after undertaking the pre-start visual observations and soft-start procedures.	MMO daily report	Survey Offshore Representative
	CM#23: Spotter vessel	• A spotter vessel with one MMO will be used for the 2D survey. • During daylight hours the spotter vessel will be located between 6 – 7 km in front of the survey vessel to allow for a total observation area of 9 – 10 km. • If pygmy blue whales are observed by the spotter vessel the location, number and behaviour (moving or foraging of the whale/s will be communicated to the MMO on the 2D survey vessel.	MMO daily report	MMO

	CM#24: Adaptive Management	The following adaptive management process will be implemented for the 2D survey:
		Pre-planning
		Prior to the 2D survey commencing the MMO data from the geophysical survey will be reviewed to:
		• Identify the likelihood of encountering pygmy blue whales and if there are areas where foraging behaviours are occurring within the OA.
		• Identify if any additional controls are to be implemented to manage impacts and risks to pygmy blue whales to ALARP and an acceptable level. Additional controls may include:
		  ◦ increased pre-start observation periods
		  ◦ increased power down and shutdown zones
		  ◦ change in survey start location and sequence of lines
		The review will be documented and be undertaken with the input of at least one of the MMOs on the survey vessel, survey Project Manager, Environment Advisor, Offshore Survey Representative.
		During the survey:
		If there has been three pygmy blue whale shut down/power downs in a 24 hour period, a review will be undertaken to:
		• Determine if the controls within the EP and any additional controls identified via the pre-planning review will continue to be effective in managing impacts and risks to pygmy blue whales to ALARP and an acceptable level.
		• Identify if any additional controls are to be implemented to manage impacts and risks to pygmy blue whales to ALARP and an acceptable level. Additional controls may include:
		  ◦ increased pre-start observation periods
		  ◦ increased power down and shut down zones
		  ◦ change in survey sequence of lines
		• If there are three consecutive days on which there are three or more pygmy blue whale shut downs/power downs the 2D survey will not proceed for 24 hours. Depending on when the 24 hour shut down period ceases the night time control may also apply.
			Adaptive management review report.	Activity Offshore Representative

Environmental Performance Outcome	Control Measure #	Environmental Performance Standard	Measurement Criteria	Responsible Person
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#11: Ongoing consultation	Notifications for any on-water activities and ongoing consultations undertaken as per Section 8 Stakeholder Consultation.	Notification records.	Survey Project Manager
	CM#12: Commercial Fisher Operating Protocol	Beach will implement the requirements within the Commercial Fisher Operating Protocol made available to potentially impacted fishers.	Stakeholder log. Daily report details notifications to fishers and any action required.	Survey Project Manager
	CM#13: Geophysical Survey Separation Distance	Beach will ensure 40 km is maintained from other vessels undertaking geophysical surveys.	Daily report details distance from any vessels undertaking geophysical surveys.	Survey Offshore Representative
Undertake the activity in a manner that will not: • Result in a known or potential pest species becoming established.	CM#14: MO 98: Marine pollution – anti-fouling systems	Vessel will have a current anti-fouling certificate.	Vessel anti-fouling certificate.	Vessel Master
	CM#15: 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
	CM#16: 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

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

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#17: 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#18: 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 located in high spill risk areas and routinely checked to ensure adequate.	Vessel SMPEP. Vessel exercise schedule. Vessel inspection.	Vessel Master
	CM#25: MO 21: Safety and emergency arrangements	Vessels will meet the safety measures and emergency procedures of AMSA MO 21.	Vessel inspection.	Vessel Master
	CM#26: MO 30: Prevention of collisions	Vessels will meet the navigation lighting, equipment, watchkeeping and radar requirements of AMSA MO 30.	Vessel inspection.	Vessel Master
	CM#27: MO 31: SOLA and non-SOLAS certification	Vessels will meet survey, maintenance and certification of regulated Australian vessels as per AMSA MO 31.	Vessel certification.	Vessel Master
	CM#28: Emergency response preparedness	Emergency response capability will be maintained in accordance with the EP.	Outcomes of internal audits and tests demonstrate preparedness.	Survey Project Manager
Undertake oil spill response in a manner that will not: • Result in additional impacts to marine environment and oiled wildlife.	CM#29: 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.	Emergency Management Team (EMT) log. Vessel Surveillance Report. Aerial Surveillance Report Spill Modelling Report	Beach EMT
	CM#30: OWR response management	OWR will be managed by relevant regulatory authorities and trained personnel.	EMT log.	Beach EMT
	CM#31: 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

7 Implementation strategy

Regulation 14 of the OPGGS(E)R requires that the EP 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 7-1).

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.

7.1 Health, Safety, Environmental Management System

The site survey will be undertaken in accordance with the Lattice HSEMS. The HSEMS documents the Environmental Policy, health safety and environment (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 7-1). 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 site survey are described in the following sections.

Table 7-1: 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.

Figure 7-1: Beach's Environmental Policy

7.2 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.

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

HSEMS Standard 2 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 7-2.

Table 7-2: Activity environmental roles and responsibilities

Role	Responsibilities
Chief Executive Officer	Ensures: • 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.
Survey Project Manager	Ensures: • Compliance with regulatory and other requirements and this EP. • Records associated with the activity are maintained as per Section 7.5.2. • 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 7.12. • Incidents are managed and reported as per Section 7.9. • The EP environmental performance 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 7.12. • Oil spill response arrangements for the activity are tested as per Section 7.16.5. • Ensure audits and inspections are undertaken in accordance with Section 7.22.1.
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 7.9. • 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 7.12. • Assess any chemicals that will be discharged offshore as per Section 7.20.1. • Provide support to ensure audits and inspections detailed in Section 7.22.1 are undertaken and any actions from non-conformances or improvement suggestions tracked. • Review and revise the EP as per the requirements in Section 7.22.2 and 7.22.3.
Community Relations Manager	• Undertake stakeholder consultation for the activity. • Record and report to the Activity Manager and Environment Advisor any objections or claims raised by relevant stakeholders. • Maintain a stakeholder consultation log.
Survey Offshore Representative	Ensures: • The activity is carried out in accordance with regulatory requirements and this EP. • Vessel personnel complete the environmental component of the activity induction.

Role	Responsibilities
	• 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. • Initiate the adaptive management review within 2 hours for if the adaptive management trigger reached. • 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 7.12. • Environmental incidents are managed and reported as per Section 7.9. • Emissions and discharges identified in Section 7.10.2 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 7.12. • Chemicals that will or may be discharged offshore are assessed as per Section 7.20.1 prior to use. • Weekly vessel inspections as detailed in Section 7.22.1 are undertaken to ensure ongoing compliance with the EP.
Vessel Master	Ensures: • 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 7.12. • 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 7.9 . • Emissions and discharges identified in Section 7.10.2 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 7.12. • 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 7.20.1 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 7.22.1are undertaken to ensure ongoing compliance with the EP.
Marine mammal observer	• Complete activity induction. • Implement EPBC Policy Statement 2.1 procedures and additional controls detailed in Table 6-20. • Maintain a daily log of cetacean sightings using the DotEE template for seismic surveys. • Produce the final report for submission to DotEE.
Vessel personnel	• Complete activity induction. • Report fauna sightings. • 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.

7.4 Planning, Objectives and Targets (HSEMS Standard 3)

HSEMS Standard 3 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 6.5.

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

HSEMS Standard 4specifies 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.

7.5.1 Legal requirements

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

7.5.2 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.

7.6 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 7.5.2. The induction will at a minimum cover:

- description of the environmental sensitivities and conservation values of the OA 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;
- fauna sighting, including whale identification, fauna reporting and vessel interaction procedures; and

- overview of EPBC Policy Statement 2.1 procedures and controls associated with managing acoustic impacts.

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.

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

HSEMS Standard 6specifies 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 8.

7.8 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 managed in accordance with the Environmental Related Risk Procedure and the Risk Management Directive.

As detailed in Section 7.22.2, 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 Environment Plan is triggered through a change in risk or controls the revision process shall be managed in accordance with Section 7.12 Management of Change.

7.9 Incident Management (HSEMS Standard 8)

HSEMS Standard 8 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 7.9.1.

7.9.1 Incident Reporting

Notification and reporting requirements for environmental incidents to external agencies are provided in Table 7-3.

Table 7-3: Regulatory incident reporting

<table>
<tr><th>Requirement</th><th>Timing</th><th>Contact</th></tr>
<tr><td colspan="3">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 reportable incident.</td></tr>
<tr><td>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.</td><td>Before the 15th day of the following calendar month</td><td>• NOPSEMA - submissions@nopsema.gov.au</td></tr>
<tr><td colspan="3">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.</td></tr>
<tr><td>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.</td><td>Within two hours of becoming aware of incident</td><td>• NOPSEMA - 08 6461 7090
• NOPSEMA - submissions@nopsema.gov.au
• Department of Jobs, Precincts and Regions (DJPR) - marine.pollution@ecodev.vic.gov.au (0409 858 715)
• NOPTA – reporting @nopta.gov.au</td></tr>
<tr><td>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.</td><td>Within 3 days of notification of incident</td><td>• NOPSEMA - submissions@nopsema.gov.au</td></tr>
<tr><td>Written incident reports to be submitted to NOPTA and DJPR (for incidents in Commonwealth waters).</td><td>Within 7 days of written report submission to NOPSEMA</td><td>• DJPR - marine.pollution@ecodev.vic.gov.au
• NOPTA – reporting @nopta.gov.au</td></tr>
</table>

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 as soon as practicable (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 item of underwater cultural heritage such as vessel or aircraft remains and/or associated relics	Written notification within 1 week	• Written notification via the notification of discovery of underwater cultural heritage online submission form.

7.10 Performance Measurement and Reporting (HSEMS Standard 9)

HSEMS Standard 9 specifies that HSE performance data is collected, analysed and reported to monitor and evaluate ongoing HSE performance and drive continual improvement.

7.10.1 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.

7.10.2 Cetacean Sightings Report

In accordance with Part A of EPBC Policy Statement 2.1, Cetacean sighting and compliance reports will be submitted to DotEE within 2 months of survey completion.

7.10.3 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 7-4 details the types of emissions and discharges that shall be recorded including the monitoring method and frequency of reporting.

Table 7-4: Emissions and discharges monitoring requirements

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

7.11 Operational Control (HSEMS Standard 10)

The intent of HSEMS Standard 10 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.

7.12 Management of Change (HSEMS Standard 11)

HSEMS Standard 11 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 7.8 identify a change in hazards, controls, or risk (See Section 6) 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.

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

The intent of HSEMS Standard 12 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.

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

The intent of HSEMS Standard 13 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 the relevant standards.

Section 7.22.1 details how the vessel contractors will be assessed to ensure they have the capabilities and competencies to implement the control measures identified in Section 6. Training and competency of contractor personal engaged to work on the activity shall be competent in accordance with their Health and Safety Management System.

7.15 Crisis and Emergency Management (HSEMS Standard 14)

The intent of HSEMS Standard 14 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 7-2. The responsibilities of the Emergency Response Team (ERT), Emergency Management Team (EMT) and Crisis Management Team (CMT) are outlined in Table 7-5.

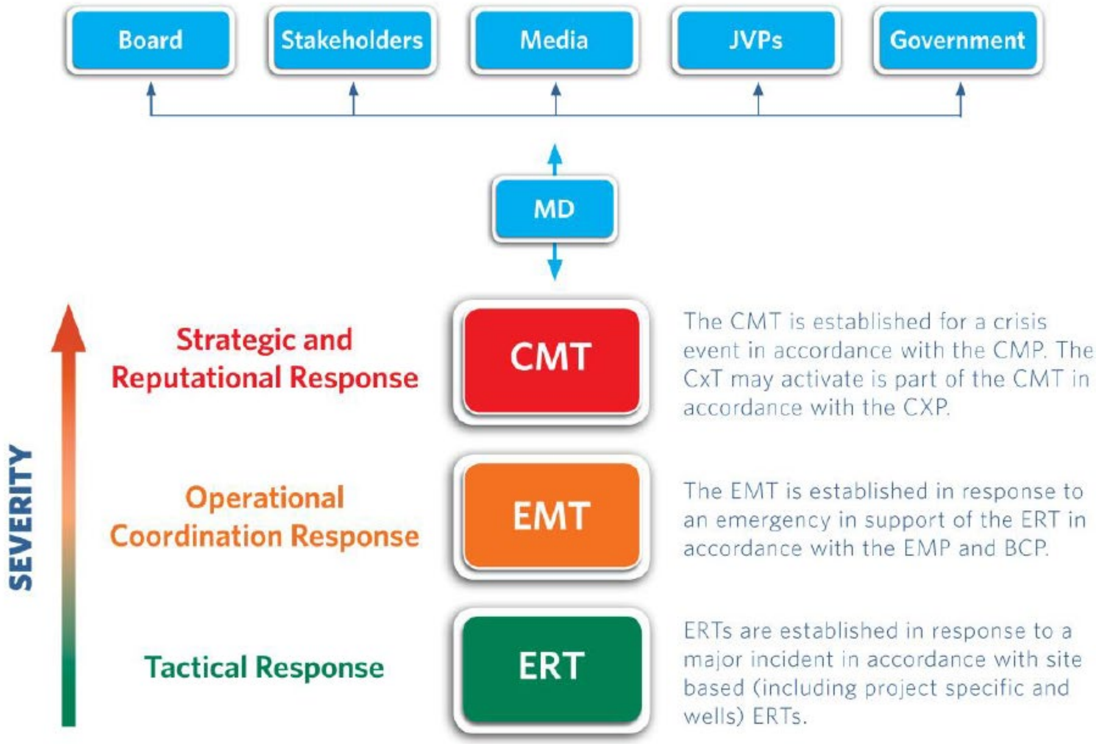

Figure 7-2: Beach Crisis and Emergency Management Framework

Table 7-5: 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.

7.16 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 site survey, any spill from the vessel would be managed by the vessel with AMSA as the Control Agency. Beach would provide support to the vessel contractor and AMSA as detailed in Section 6.4.

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 7.9.1 and Table 7-3 details notification and reporting requirements.

7.16.1 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 7.22, 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.

7.16.2 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 (IC). Beach will support the contract vessel operator with any applicable resources at Beach's disposal.

The following arrangements relevant to the site survey 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 6.4.

7.16.3 Beach EMT activation process

Beach's incident response levels are described in Table 7-6. Given the nature and scope of the site survey, 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 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 6.4.5, 6.4.6 and 6.4.7.

Table 7-6: 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 on 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.

7.16.4 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.

7.16.4.1 Scope of the SMP

The only hydrocarbon spill scenario for the site survey 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 6-17).

The geographical scope of the SMP is the EMBA described in Section 4.2 which is wholly in Commonwealth waters.

7.16.4.2 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 scientific monitoring studies (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.

7.16.4.3 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 SMSs as summarised in Table 7-7 to Table 7-8. Beach has in place a contract with a scientific monitoring consultant with the expertise and resources to undertake this monitoring.

Table 7-7: 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).
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 and 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 event 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 7-8: 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 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 and 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.

7.16.5 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 site survey, 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.

7.17 Plant and Equipment (HSEMS Standard 15)

The intent of HSEMS Standard 15 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 6.5.

7.18 Monitoring the Working Environment (HSEMS Standard 16)

The intent of HSEMS Standard 16 is that HSE risks to personnel associated within the working environment are eliminated or reduced to ALARP.

7.19 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.

7.20 Environment Effects and Management (HSEMS Standard 18)

The intent of HSEMS Standard 18 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.

7.20.1 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 7-3 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.

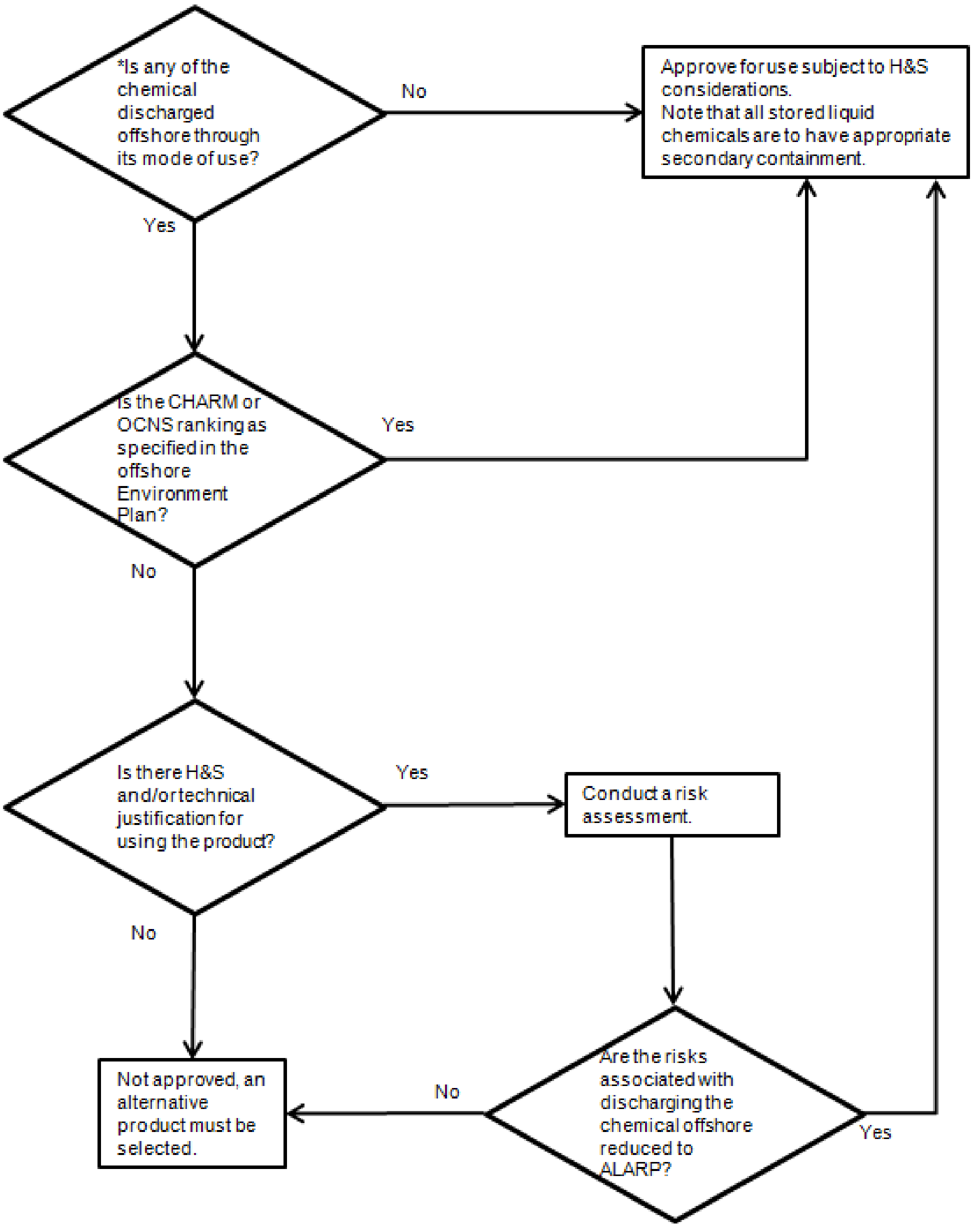

Figure 7-3: Beach offshore chemical environmental risk assessment process summary

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

HSEMS Standard 19 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.

7.22 Audits, Assessments and Review (HSEMS Standard 20)

HSEMS Standard 20 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.

7.22.1 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.

For vessels used for the site survey the following will be undertaken:

- Pre-mobilisation inspection to confirm the requirements of the EP, including EPOs and EPS, 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.

7.22.2 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 risks and controls identified through the Risk Management Process as per Section 7.8.

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

If the site survey is undertaken in October to December 2020 a review of the items in the dot points above will be undertaken a minimum of a month prior to the commencement of the site survey to identify any changes in the internal and/or external context since the EP was written. If any changes are identified in relation to the EP, the EP will be reviewed and updated accordingly. This may include undertaking additional consultation with any new stakeholders identified or putting in place additional arrangements with other oil and gas activities where simultaneous operations may occur to minimise the disturbance to other marine users.

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 7-9 and Management of Change as per Section 7.12 shall be evaluated.

7.22.3 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 7-9.

Table 7-9: 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.

8 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.

8.1 Regulatory requirements

Section 280 of the OPGGS Act 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.

8.2 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 stakeholder concerns 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.

8.3 Consultation approach

The approach Beach undertook for the site survey was:

- Identify stakeholders that may be potentially affected by the activity by reviewing its stakeholder database and consulting with existing stakeholders to identify other relevant stakeholders. Beach, through its subsidiary Lattice Energy, has operated in the area since the early 2000s, and has built an extensive database of stakeholders from ongoing engagement in relation to its existing Otway Gas Development and planed Otway Offshore Project.
- 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 either requested by the stakeholder or that become available during the consultation period and allow a reasonable time for the stakeholder to review and respond. Depending on the information provided this may take between one to four weeks.
- Ensure relevant stakeholders are informed about the consultation process and how their feedback, questions and concerns are considered in the EP.

8.3.1 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 site survey 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 an 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 requests that fishers identify themselves to SIV if they think they could be impacted by Beach's activities.

- Publish the information sheet on Beach's website at https://www.beachenergy.com.au/vic-otway-basin/. The information sheet is available in Appendix F.
- Provide additional information to interested fishery groups. Beach provided information to fishery groups and to date has had response from one fisher. No objections or claims where raised by the stakeholder (Stakeholder Record CSF_20).
- Where fishers have identified that they may be potentially impacted by the activity the following is undertaken:
  - For fishers who have contacted SIV, Beach meet with SIV to gather information about the fishers fishing patterns and locations and to establish contact for ongoing consultation throughout the activity.
  - For fishers who have contacted Beach directly, Beach engage 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 activity.
  - Where fishers are providing Beach with sensitive fishing data Beach provide them Beach's privacy policy and obligations.
  - Beach's Commercial Fisher Operating Protocol (Appendix G) is provided to fishers who have identified that they may be potentially impacted. The protocol details pre-activity and on-water communication processes, including SMS messages and radio communication on Channel 16, data confidentiality and Beach's claim process. The protocol was developed based on feedback from consultation with the fishers for the Otway Geophysical and Geotechnical Survey which commenced in October 2019.
- Beach seek permission from the identified fishers to include them in their SMS messaging system. Once the activity commences, Beach 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 site survey only require access to a relatively small area over a short period of time and so Beach aim to minimise impact to third party 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.

8.4 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 Petroleum Ltd. (Woodside), 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 Resources Limited (Origin) and then Lattice.

In 2017 Lattice commenced consultation in relation to the Otway Development Phase 4 and associated site survey 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 8-1 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 OA (Stakeholder Record TDPIPWE_24).

8.5 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 8-2.

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/.

8.6 Summary of stakeholder consultation

Table 8-4 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 5 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 8-1: 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 Joint Rescue Coordination Centre (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 - Earth Resources Regulation	Regulating the resources industry, attracting and facilitating investment and managing access to the earth resources of Victoria. The Resources branch sits within the Department of Jobs, Precincts and Regions and are the regulator for oil and gas activities within Victorian State waters. No impacts to Victorian waters are predicted. Activity is not within Commonwealth waters adjacent to Victoria. Beach provide information as have ongoing engagement.	3
DJPR - Marine Pollution	Ensuring Victoria is adequately prepared for and effectively responds to a marine pollution incident in State coastal waters up to three nautical miles offshore. No impact to stakeholders' functions, interests or activities as no impacts to Victorian waters or land. Beach provide information as have ongoing engagement.	3
DJPR - Victorian Gas Program	Comprehensive program of scientific research and related activities that assesses the potential for further discoveries of onshore conventional gas and offshore gas in Victoria. Beach provide information as have ongoing engagement.	3
EPA Tasmania	EPA Tasmania is a Division of the Department of Primary Industries, Parks, Water and Environment (DPIPWE) and is responsible for preparedness and responding to oil and chemical spills in Tasmania. The oil spill EMBA does not enter Tasmanian waters. Beach provide information as have ongoing engagement.	3
Victorian Fishery Authority (VFA)	Independent statutory authority established to effectively manage Victoria's fisheries resources. Based on data from Seafood Industry Victoria (SIV) 2014 to 2019 the Rock Lobster Fishery and Giant crab Fishery have catch effort within the OA.	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.	1
A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the EP		
Australian Southern Bluefin Tuna Industry Association (ASBTIA)	ASBTIA is the peak body representing Southern Bluefin Tuna ranching companies in Australia. ASBTIA are relevant if the activity occurs or impacts an area where there is a southern bluefin tuna catch effort, ranching or spawning area. T/30P is not within the southern Bluefin Tuna catch effort, ranching or	3

Stakeholder	Relevance	Information Category
	spawning area. Beach provides information as they have an ongoing engagement.	
The Blue Whale Study	Primary research into the ecology of endangered pygmy blue whales in south-east Australia. The OA overlaps the pygmy blue whale foraging BIA.	1
Commonwealth Fisheries Association (CFA)	Peak association representing commercial fishing in Commonwealth fisheries. Industry Association for the following Commonwealth fisheries that have catch effort within the OA: • Southern and Eastern Scalefish and Shark Fishery (SESSF) (South East Trawl Sector, Gillnet and Shark Hook Sector, Scalefish Hook Sector).	1
Crab and Rock Lobster Fisher (CRLF)	Based on consultation for the Otway Seabed Assessment and Drilling program, may potentially fish in the area.	1
Crab and Shark Fisher (CSF)	Based on consultation for the Otway Seabed Assessment and Drilling program, may potentially fish in the area.	1
Port Campbell Professional Fishermen's Association	Association representing Port Campbell fishers, primarily rock lobster around Port Campbell and Peterborough. Based on data from Seafood Industry Victoria (SIV) 2014 to 2019 the Rock Lobster Fishery has catch effort within the OA Engagement is via SIV.	3
Schlumberger Australia Pty Ltd	Schlumberger is proposing to acquire the Otway Basin 2D Multiclient Marine Seismic Survey. One 2D seismic line of the Otway Basin 2DMC Marine Seismic Survey overlaps the OA.	1
Seafood Industry Victoria (SIV)	Peak body representing professional fishing, seafood processors and exporters in Victoria. SIV primary contact for State fishers.	1
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 OA: • Southern and Eastern Scalefish and Shark Fishery (SESSF) (South East Trawl Sector, Gillnet and Shark Hook Sector, Scalefish Hook Sector).	1
Southern & Eastern Scalefish and Shark Fishery licence holders	The following licence holders were identified by AFMA as potentially fishing in the OA in the last year: • ANZT Fishing Company Pty Ltd • Corporate Alliance Enterprises Pty Ltd • Petuna Sealord Deepwater Fishing Pty Ltd The following licence holders were identified by AFMA as potentially fishing in the OA in the last 10 year: • Gazak Holdings Pty Ltd • Muollo Fishing Pty Ltd • Mures Fishing Pty Ltd • Toberfish Pty Ltd	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. Based on data from Seafood Industry Victoria (SIV) 2014 to 2019 the Rock Lobster Fishery has catch effort within the OA and EMBA.	1

Stakeholder	Relevance	Information Category
Sustainable Shark Fishing Inc (SSFI)	The SSFI represents interests of its Commonwealth-licenced shark gillnet and shark hook members in the Gillnet Hook and Trap Fishery. The site survey is within Commonwealth fishery areas and based on data from AFMA the Southern and Eastern Scalefish and Shark Fishery has catch effort within the area.	1
TGS	TGS (previously Spectrum Geo) are proposing to undertake the Otway Deep 3D marine seismic survey in the Commonwealth waters of the Otway Basin. The TGS Otway Deep Marine Seismic Survey acquisition area overlaps a proportion of the OA.	1
Victorian Rock Lobster Association (VRLA)	VRLA represents Victorian rock lobster licence holders. Based on data from Seafood Industry Victoria (SIV) 2014 to 2019 the Rock Lobster Fishery has catch effort within the OA and EMBA. Engagement via SIV.	1
Warrnambool Professional Fishermen's Association	Association represents Warrnambool fishermen, primarily rock lobster on strip from Warrnambool to Port Campbell. Engagement via SIV.	1
Any other person or organisation that the titleholder considers relevant		
3D Oil	3D Oil Limited propose to undertake the Dorrigo three-dimensional (3D) marine seismic survey (MSS) in the Commonwealth waters of the Otway Basin within Exploration Permit T/49P during Q3 or Q4 2020. The OA does not overlap with 3D Oil operational area and there is a ~40km separation between the OA and the activity of 3D Oil.	3
Cooper Energy	Cooper Energy are an oil and gas exploration and production company with operations in the Otway and Gippsland offshore areas. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Deakin University- School of Life and Environmental Sciences	Academic with interest in marine fauna. No impact to the stakeholder's functions, interests or activities. Beach provide information as have ongoing engagement in relation to marine studies within their operating areas.	3
Eastern Maar Aboriginal Corporation	The Eastern Maar Aboriginal Corporation manages native title rights for the Eastern Maar Peoples. No impact to stakeholders' functions, interests or activities as site survey is not within Eastern Maar lands which extend to the sea off Victoria out to 100 m from the low tide. Beach maintain engagement in relation to activities within the Otway area.	3
ExxonMobil	ExxonMobil have offshore and onshore operations in the Gippsland Basin. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Institute for Marine and Antarctic studies (IMAS)- Fisheries and Aquaculture	IMAS is a collaborative research body in marine and Antarctic science. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Lochard Energy	Owns and operates the Iona Gas Plant and the associated facilities located near Port Campbell. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Ocean Racing Club of Victoria	Club which conducts regular offshore racing. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3

Stakeholder	Relevance	Information Category
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. Beach maintain engagement in relation to activities within the Otway area.	3
Port Campbell Board Riders Association	Local board riding group. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Port Campbell Boat Charters	Dive and fishing charter operators in Port Campbell and Apollo Bay. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3
Port Campbell Surf Life Saving Club	Patrolling Port Campbell beach. No impact on the stakeholder's activities, interests or functions due to distance offshore. Beach maintain engagement in relation to activities within the Otway area.	3
Portland Professional Fishermen's Association	Association representing Portland fishermen. No impact from activity to Victorian fishing catch efforts functions, interests or activities. Beach provide information as have ongoing engagement.	3
SCUBA Divers Federation of Victoria	Amateur organisation representing diving clubs throughout Victoria. No impact to the stakeholders' interest where recreational diving occurs. Beach maintain engagement in relation to activities within the Otway area.	3
Southern & Eastern Scalefish and Shark Fishery licence holders	Three licence holders were identified by AFMA as potentially fishing in the OA in the last year records of correspondence are logged as: • ANZT • CAE • PSDF four licence holders were identified by AFMA as potentially fishing in the OA in the last 10 year records of correspondence are logged as: • GH • MUOLLO • MURES • TB	
Tasmanian Abalone Council Limited	The Tasmanian Abalone Council is the voice of the fishery, representing divers, non-diving quota-holders, processors and exporters. The OA does not overlap the Tasmanian abalone fishery where there is catch effort. Tasmanian DPIPWE have confirmed there is no Tasmanian fishery catch effort within the OA. Beach maintain engagement in relation to activities within the Otway area.	3
Tasmanian Association for Recreational Fishing (TARFish)	TARFish is the fully independent peak body representing the interests of recreational marine fishers in Tasmania. No impact to stakeholders' functions, interests or activities. 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 OA does not overlap the Tasmanian rock lobster fishery where there is catch effort. Tasmanian DPIPWE have confirmed there is no Tasmanian fishery catch effort within the OA. Beach maintain engagement in relation to activities within the Otway area.	3

Stakeholder	Relevance	Information Category
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 OA does not overlap any Tasmanian fisheries where there is catch effort. Tasmanian DPIPWE have confirmed there is no Tasmanian fishery catch effort within the OA. Beach maintain engagement in relation to activities within the Otway area.	3
The Victorian Scallop Fishermen's Association Inc.	The Victorian Scallop Fishermen's Association Inc represents the interests of scallop fishermen operating within Australia's south east waters. Based on data from AFMA and VFA there is no scallop fishing within the OA. Beach maintain engagement in relation to activities within the Otway area.	3
Tuna Australia (ETBF Industry Association)	Represents statutory fishing right owners, holders, fish processors and sellers, and associate members of the Eastern and Western tuna and billfish fisheries of Australia. T Based on data from AFMA there is no catch effort for the Eastern Tuna and Billfish Fishery within the OA. Beach maintain engagement in relation to activities within the Otway area.	3
Victorian Recreational Fishing Peak Body (VR Fish)	Advocate and support sustainable development and growth of recreational fishing. No impact to stakeholders' functions, interests or activities. Beach maintain engagement in relation to activities within the Otway area.	3

Table 8-2: 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

8.7 Ongoing stakeholder consultation

Beach will continue to consult with stakeholders as part of the development and submission of the EP for public comment. If the site survey proceeds consultation will be ongoing including commencement and cessation notifications and updates in relation to the 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 regular (most likely daily) information on the vessel location to stakeholders that have requested this service when the survey is undertaken. Beach will also have the Vessel Master put out daily radio messages on channel 16.

Any objections or claims raised from ongoing consultation will be managed as per Section 8.7.2.

Table 8-4 details the ongoing stakeholder consultation requirements. Records of ongoing stakeholder engagement will be maintained as per Section 7.5.2 Records Management.

8.7.1 Ongoing identification of relevant persons

New or changes to relevant persons will be identified through ongoing consultation with stakeholders including peak industry bodies and the environment plan review process detailed in Section 7.22.2. Should new relevant persons be identified they will be contacted and provided information about the activity relevant to their functions, interests or activities. Any objections or claims raised will be managed as per Section 8.7.2.

8.7.2 Management of objections or claims

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 detailed in Section 5 and controls applied where appropriate to manage impacts and risks to ALARP and acceptable levels. Stakeholders will be provided with feedback as to whether their objection or claim was substantiated, and if not why, and if it was substantiated how it was assessed and if any controls were put in place to manage the to manage impacts and risks to ALARP and an acceptable level. If the objection or claim triggers a revision of the EP this will be managed as per Section 7.22.2 and 7.22.3. This will also be communicated to the stakeholder.

Table 8-3: 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
Relevant stakeholders	Stakeholder notification of site survey commencement. Notification to include: • location of survey, coordinates and map; • timing of activities: expected start and finish date and duration; • sequencing of activities; • vessel, vessels details including call sign and contact; • requested clearance from other vessels; and • Beach contact details. For applicable stakeholders the time of the daily vessel call on Ch 16 VHF will be provided. 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 site survey 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 a Notice to Mariners (NTM) will cover (start and finish date); • vessel 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 details. Only need to update AHO of changes including if activity start or finish date changes. Do not need to provide cessation notification if NTM covers period of activity.	3 weeks prior to activity commencing
AMSA - JRRC	Notification of site survey 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 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 details. Only need to update JRCC of changes including if activity start of finish date changes. Do not need to provide cessation notification if Auscoast warning covers period of activity.	48 – 24 hrs prior to activity commencing
NOPSEMA Tasmanian 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 and expected duration.
	• Daily radio message: via channel 16 at:
	  ◦ 17:00 hours: Notification of the expected location of the vessel for the next day.
	  ◦ 09:00 hours (the next morning): Confirmation of the location of the vessel for the day, or any changes (due to unforeseen circumstances).
	• 'On water' communications via channel 16, where vessels can communicate in real time, if required.
		During activity

NOPSEMA Tasmanian DPIPWE	Regulatory notification of cessation of activity.	Within 10 days of activity completion

Table 8-4: Summary of stakeholder consultation records and Beach assessment of objections and claims

Information sheet Otway Offshore T30P Seabed Info-Sheet_November 2019 is available in Appendix F.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
3D Oil	01/11/2019	3D 02 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; 3D_02_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/vic-otway-basin/. 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 on 1800 797 011 or reply to this email at community@beachenergy.com.au. Beach email asking 3D oil to let Beach know if they are undertaking any activities within the same area during February to April 2020. 3D oil responded: 3D oil cannot envisage any activities that may occur between February and April 2020. The likely project to occur is the Dorrigo 3D project that will be within Q3 or Q4 in 2020.	Provision of information
ANZT – SESSF Licence Holder	01/11/2019	ANZT 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; ANZT_01_OOP Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/vic-otway-basin/. 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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
Australian Fisheries Management Authority (AFMA)	24/10/2019	AFMA 04 AFMA-04 T_30P Survey AFMA Licensee Information.pdf; AFMA-04 Contact Details for AFMA Licensee.pdf	Beach requested licensing information for any Commonwealth fishers who are active within the Beach T/30P Survey area and coordinates of the area were supplied. AFMA replied that currently in 2019 there were 3 operators in this area. Over the last 10 years there were only 7 operators. All operators are in the Southern & Eastern Scalefish and Shark Fishery.	Beach obtained the details of the seven operators and added them to the stakeholder list for T/30P consultation. EP Appendix B4.1 Commonwealth managed fisheries updated with information in relation to Commonwealth fisheries.
Australian Fisheries Management Authority (AFMA)	01/11/2019	AFMA 05 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; AFMA_05_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. Based on a review of the 2013 - 2019 ABARES reports and data from AFMA licensing it was identified that three operators from the Southern and Eastern Scalefish and Shark Fishery have fishing effort in the area in 2019 and there has been a maximum of seven operators over the last 10 years. Beach is consulting directly with these operators. Beach is also consulting with SIV, SETFIA and VFA. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/vic-otway-basin/. 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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	
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 if NTM covers period of activity.	EP Section 8.7 Ongoing Consultation includes AHO requirements.
Australian Southern Bluefin Tuna Industry Association	05/11/2019	ASBT 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; ASBT_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/vic-otway-basin/. 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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
Australian Southern Bluefin Tuna Industry Association	21/11/2019	ASBT 02 ASBT_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Commonwealth Fisheries Association (CFA)	01/11/2019	CFA 04 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; CFA_04_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
Cooper Energy	31/10/2019	CE 11	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project,	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
		CE_11_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	
CAE – SESSF Licence Holder	31/10/2019	CAE 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; CAE_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
CAE – SESSF Licence Holder	21/11/2019	CAE 02 CAE_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Crab and Rock Lobster Fisher (CRLF)	01/11/2019	CRLF 17 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; CRLF_17_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au. Beach email: Based on information you have shared with the Beach Fishing Liaison Officer it does not seem that you fish in the area but if you do please let us know.	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Crab and Rock Lobster Fisher (CRLF)	21/11/2019	CRLF 18 CRLF_18_Beach Energy-Otway Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Crab and Shark Fisher (CSF)	01/11/2019	CSF 19 CSF_19_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au. Beach email: Based on information you have shared with the Beach Fishing Liaison Officer it does not seem that you fish in the area but if you do please let us know.	Provision of information
Crab and Shark Fisher (CSF)	08/11/2019	CSF 20 CSF_20_Otway Offshore Project Additional SeabedAssessment T30P reply.pdf	CSF replied that he does fish in the area. Engagement with the Beach Fisheries Liaison Officer identified that the fisher fishes in areas defined by grid references L11 and M12. Beach Fishing Liaison Officer rang CSF to obtain more information. CSF fishes in the Beach permit areas using gillnets. Also recently geared up the vessel with squid jig gear which will be used during the period January to June during the night. Most squid fishing occurs to the northwest of Beach's area of interest, but it may occur through Beach's permit areas. CSF did not raise any issue specific to the site survey.	No objections or claims were raised by stakeholder. Consultation will be ongoing as per EP Section 8.7 Ongoing stakeholder consultation.
Crab and Shark Fisher (CSF)	21/11/2019	CSF 21 CSF_21_Beach Energy-Otway Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Deakin University - School of Life and Environmental Sciences	31/10/2019	DU 12 DU_12_Otway Offshore Project Additional Seabed Assessment T30Pemail.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/In preparation of our Environment Plan we are keen to understand if you have any questions, concerns or feedback or require any further consultation.	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			Please don't hesitate to contact us on 1800 797 011 or reply to this email at community@beachenergy.com.au.	
Deakin University - School of Life and Environmental Sciences	01/11/2019	DU 13 DU_13_Otway Offshore Project Additional Seabed AssessmentT30P email.pdf	Deakin University informed Beach that the activities undertaken in T/30P need proper study into the impact on marine predators and their prey populations.	Beach have been in discussions with Deakin University about studies to fur-seals and seabirds and potential impacts from acoustic sound emissions. EP Section 6.2 assesses the impacts to marine fauna from acoustic emissions. Seabirds are not identified as a receptor as there is no evidence that acoustic sound emission impact seabirds due to the very small time that they would be underwater. The noise effect criteria were not met for fur-seals and thus any impacts are likely to be limited to behavioural response such as avoidance of area while the geophysical and 2D survey is undertaken.
Deakin University - School of Life and Environmental Sciences	22/11/2019	DU 14 DU_13_Otway Offshore Project Additional Seabed AssessmentT30P email.pdf	Beach email: I apologise for the delay in replying. I have been investigating options for obtaining finance relating to the projects, scholarships and other interesting studies you have proposed. Unfortunately, I have been unable to secure anything significant this financial year. Hopefully one of our consultants has been in contact with you with regards to supporting our Operational and Scientific Monitoring Program (OSMP)? With regards to the proposed 2D seismic survey at T/30P, this is only a short-term study. The majority of the equipment to be used for the seabed assessments are either typical marine equipment used on vessels such as echosounders or have low sound source levels. The sound source for the 2D survey is 160 cu in and the geophysical survey will be undertaken for a maximum of 15 days. Due to the low level of acoustic emissions for the seabed assessment the impact assessment did not identify any impacts to fur seals to seabirds. Impacts identified were limited to a small area and short term behavioural impacts such as avoidance of the vessel as it undertakes the survey. Beach is looking at a larger survey in the Bass Strait in 2020 and is looking at testing some new technology that may reduce acoustic emissions. As this survey will go for a longer period there may be an opportunity to look at a study program for this activity. I will discuss with the survey Project Manager and get back to you.	Response to stakeholder.
Department of Jobs, Precincts and Regions (DJPR): Earth Resources Regulation	01/11/2019	ERR 12 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; ERR_12_Otway Additional Seabed Assessment T30P email.pdf; ERR_12_Otway Additional Seabed Assessmen T30P reply.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au Out of office received.	Provision of information
Department of Jobs, Precincts and Regions (DJPR): Marine Pollution	01/11/2019	MP 19 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; MP_19_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-	Provision of information Beach updated their stakeholder database with the new contact person.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au MP replied change contact person who they cced into the email.	
Department of Jobs, Precincts and Regions (DJPR): Victorian Gas Program	01/11/2019	VGP 03 VGP_03Otway Offshore Project Additional Seabed Assessment T30P.pdf; VGP_03_Otway Project Additional Seabed Assessment T30P reply.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au Out of office received.	Provision of information
Eastern Maar Aboriginal Corporation	01/11/2019	EMAC 04 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; EMAC_04_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; EMAC_04_Otway Offshore Project Additional Seabed Assessment T30P reply.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au Eastern Maar Aboriginal Corporation replied they will respond to Beach's email as soon as they can.	Provision of information
ExxonMobil	01/11/2019	EXM 01 EXM_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
GH – SESSF Licence Holder	01/11/2019	GH 01	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project,	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
		Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; GH_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	
GH – SESSF Licence Holder	21/11/2019	GH 02 GH_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
IMAS (Institute for Marine and Antarctic studies) - Fisheries and Aquaculture	01/11/2019	IMAS 05 IMAS_05_Otway Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; IMAS_05_Otway Additional Seabed Assessment T30P reply.pdf; IMAS_05_Otway Additional Seabed Assessment T30P reply_01.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Lochard Energy	01/11/2019	LE 02 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; LE_02_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
MUOLLO – SESSF Licence Holder	01/11/2019	MUOLLO 01	Beach email: 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'	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
		Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; MUOLLO_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	
MUOLLO – SESSF Licence Holder	21/11/2019	MUOLLO 02 MUOLLO_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
MURES – SESSF Licence Holder	01/11/2019	MURES 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; MURES_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
MURES – SESSF Licence Holder	21/11/2019	MURES 02 MURES_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Ocean Racing Club of Victoria	01/11/2019	ORCV 05 ORCV_05_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	
PSDF – SESSF Licence Holder	01/11/2019	PSDF 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; PSDF_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	Provision of information
PSDF – SESSF Licence Holder	21/11/2019	PSDF 02 PSDF_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Port Campbell Board Riders Association	01/11/2019	PCBRA 02 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; PCBRA_02_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Port Campbell Boat Charters	01/11/2019	PCBC 02 PCBC_02_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	
Port Campbell Surf Life Saving Club	01/11/2019	PCSLSC 02 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; PCSLSC_02_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Portland Professional Fishermen's Association	01/11/2019	PPFA 10 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; PPFA_10_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Schlumberger Australia Pty Ltd	01/11/2019	SLB 19 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; SLB_19_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information. Based on information on the NOPSEMA website the survey period is for Nov – June 2020 within no acquisition in the OA between 1 Nov 2019 to 30 April 2020. Thus, there is no overlap with this survey.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			SLB asked for the shape files of the operational area for T/30P. SLB also replied that they may acquire 2D data in open areas nearby permit T/30P but no plan to ingress the permit. At this stage they are anticipating acquisition to begin in the first week of December 2019 and they should be finished by the first week of March 2020. Beach responded with the shape files for the operational area.	
SCUBA Divers Federation of Victoria	01/11/2019	SCUBA 05 SCUBA_05_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Seafood Industry Victoria	13/11/2019	SIV_51 SIV_51_ Beach T30P Information Sheet Mail Out.pdf	Provision of the T30P Information sheet for mail out to SIV members.	Provision of information
South East Trawl Fishing Industry Association (SETFIA)	01/11/2019	SETFIA 81 SETFIA_81_Report of fishing effort in permit area T30P.pdf	Beach emailed SETFIA to undertake an assessment of fishing effort in the T/30P operational area covered by the grid references L11, M11 and M12 and supplied a map.	Request for information.
South East Trawl Fishing Industry Association (SETFIA)	01/11/2019	SETFIA 82 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; SETFIA_82_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: Beach are planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au. Based on a review of the 2013 - 2019 ABARES reports and data from AFMA licensing it was identified that three operators from the Southern and Eastern Scalefish and Shark Fishery have fishing effort in the area in 2019 and there has been a maximum of seven operators over the last 10 years. Beach is consulting directly with these operators. Beach is also consulting with SIV and VFA. If you would like to meet to discuss please let me know.	Provision of information
South East Trawl Fishing Industry Association (SETFIA)	01/11/2019	SETFIA 83 SETFIA_83_FINAL Report to Beach NRG- OOP trawl & gillnet 1 Nov 2019.pdf SETFIA_83_Final Report OOP trawl & gillnet tracks.pdf	SETFIA provided the final report to Beach on trawl and gillnet fishing activity around Beach Energy's Proposed Otway Offshore Project. The report was commissioned for the Otway Development Area which is further inshore than the T/30P operational area, however, the following information is relevant to fishing activity within the T/30P operational area: Gillnet fishing cannot occur deeper than 183m (100 fathoms). The Deepwater trawl closure generally (but not always) runs along the 700m depth contour.	EP Appendix B4.1 Commonwealth fisheries updated with information provided and Section 6 assessing potential impacts to the trawl fishery.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
South East Trawl Fishing Industry Association (SETFIA)	15/11/2019	SETFIA 84 SETFIA_84_T30P Fishing Data.pdf SETFIA_84_T30P Draft Fishing Report.pdf SETFIA_84_DRAFT Report Beach NRG trawl and gillnetting 21 Nov 2019.pdf	SETFIA reviewed the T/30P map and confirmed there is no gillnet fishing in that area as gillnet fishing does not occur deeper than 183m (100 fathoms). SETFIA will follow-up with trawl fishers in the area. SETFIA provided draft report that details there is trawl effort is between 200 m and the deepwater trawl closure over the OA.	EP Appendix B4.1 Commonwealth fisheries updated with information provided and Section 6 assessing potential impacts to the trawl fishery.
Sustainable Shark Fishing Inc (SSFI)	01/11/2019	SSFI 08 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; SSFI_08_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Sustainable Shark Fishing Inc (SSFI)	21/11/2019	SSFI 09 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf SSFI_09_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf	Beach email to follow-up with you on our email below to see if you have any questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its 'Otway Offshore Project'. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Tasmanian Abalone Council Limited (TACL)	01/11/2019	TACL 07 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TACL_07_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Tasmanian Department of Primary Industries, Parks, Water and Environment	30/09/2019	TDPIPWE 24 TDPIPWE_24_Tasmanian Fishing data request-T30P.pdf; TDPIPWE_24_OT19-0073A T30P Survey Area.pdf	Beach sent TDPIPWE coordinates and a map of the T/30P operational area and asked if they could confirm if there were any Tasmanian commercial fishing within the area. DPIPWE replied that they have reviewed the maps and coordinates and they confirmed there was no fishing in the T/30P area.	EP Table 4-3 updated to detail that no Tasmanian fisheries operate in the area.
Tasmanian Department of Primary Industries,	01/11/2019	TDPIPWE 25	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project,	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
Parks, Water and Environment		Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TDPIPWE_25_Otway Project T30P email.pdf	consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	
Tasmanian Rock Lobster Fisherman's Association	01/11/2019	TRLFA 07 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TRLFA_07_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Tasmanian Rock Lobster Fisherman's Association	21/11/2019	TRLFA 08 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf TRLFA_08_Otway Project Additional Seabed Assessment T30P email.pdf	Beach email to follow-up with you on our email below to see if you have any questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its 'Otway Offshore Project'. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Tasmanian Seafood Industry Council (TSIC)	01/11/2019	TSIC 07 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TSIC_07_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
TGS	26/06/2019	SG 14	Beach email: As discussed on the phone a couple of weeks ago, we will add the 40km separation to our EP, as you are doing for the SLB 2D and vice versa. Can you confirm you will be using the 40km from our survey?	Confirmation that a 40 km separation distance will be applied between the Spectrum Otway Deep Marine Seismic Survey and the Beach Seabed Assessments.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			Spectrum email: I confirm that we will be adhering to a minimum distance of 40km separation from your survey.	This has been included as control measure CM#13 as detailed in Table 6-2. Performance standards for the control measure are detailed in Table 6-20.
TGS	01/11/2019	SG 21 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; SG_21_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
The Blue Whale Study	01/11/2019	BWS 04 BWS_04_Otway Offshore Project Additional Seabed Assessment T30P email.pdf; Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
The Victorian Scallop Fishermen's Association Inc.	01/11/2019	VSFA 08 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; VSFA_08_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
TB – SESSF Licence Holder	01/11/2019	TB 01 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TB_01_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: 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. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au.	
TB – SESSF Licence Holder	21/11/2019	TB 02 TB_02_Beach Energy-OOP Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Tuna Australia - ETBF Industry Association	01/11/2019	TA 08 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; TA_08_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Victorian Fisheries Authority (VFA)	25/02/2019	VFA 11	Beach email providing overview of upcoming activities in Victoria. 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. Beach requested catch effort data for the Victorian State managed fisheries as follows: VFA graticular blocks: • G12; • J10; J11; J12 • K10; K11; K12 • L10; L11; L12 Catch data in each of the above blocks / per block: • By month of year, for the last five years • By species caught / tonnage of each	EP Appendix B.4.2 Victorian managed fisheries updated with data provided by VFA.

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			• 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 VFA provided the data on the 7 March 2019.	
Victorian Fisheries Authority (VFA)	6/03/2019	VFA 09	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)	9/05/2019	VFA 26	Beach email requesting further fisheries data for grid L13.	Request for information.
Victorian Fisheries Authority (VFA)	01/11/2019	VFA 52 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; VFA_52_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	Provision of information
Victorian Fisheries Authority (VFA)	04/09/2019	VFA 53	Beach requested fishing data for the following VFA graticular blocks: • M10, M11, M12 • O30, O31, O32, O33, O34; • P29, P30, P31, P32, P33, P34; • Q30, Q31 We would like to obtain catch data in each of the above 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 VFA provided the information on the 11 Oct 2019. There was no catch effort reports in grids P and Q for 2014 – 2019.	EP Appendix B.4.2 Victorian managed fisheries updated with data provided by VFA.
Victorian Fisheries Authority (VFA)	21/11/2019	VFA 54 VFA_54_Beach Energy-Otway Additional Seabed Assessment T30P email.pdf Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf	Beach email to follow-up to see if you have any further questions or feedback regarding Beach's Seabed Assessment in permit T/30P, for its Otway Offshore Project. See attached for further information and map of the area. We are preparing our Environment Plan for submission to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) shortly, and are keen to understand if you have any further questions, concerns or feedback or require any further consultation. Please contact us at any time on 1800 797 011 or community@beachenergy.com.au if you have any questions, feedback or would like to meet and discuss.	Follow-up on provision of information
Victorian Recreational Fishing Peak Body (VR Fish)	01/11/2019	FISH 08 Otway Offshore T30P Seabed Info-Sheet_November 2019.pdf; VR-FISH_08_Otway Offshore Project Additional Seabed Assessment T30P email.pdf	Beach email: As you are aware, we're planning further development of our Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses, via the 'Otway Offshore Project'. The project, consisting of seabed assessments, pre-drill activities, drilling of offshore gas wells, and subsea infrastructure installation, will see up to 9 wells drilled offshore, consisting of exploration and production wells. In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit. The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel, carried out to determine a suitable location for anchoring and rig placement for drilling operations within the permit. The activity will be undertaken over a portion of the Beach T/30P permit and	Provision of information

Stakeholder Name	Date	Record #	Description	Assessment of Objection or Claim
			outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020, depending on regulatory approvals, weather windows and availability of contractors. I've attached an information sheet with a map for further details. For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/ vic-otway-basin/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 on 1800 797 011 or reply to this email at community@beachenergy.com.au	

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Appendix A EPBC Act Protected Matters Search Report

Australian Government
Department of the Environment and Energy

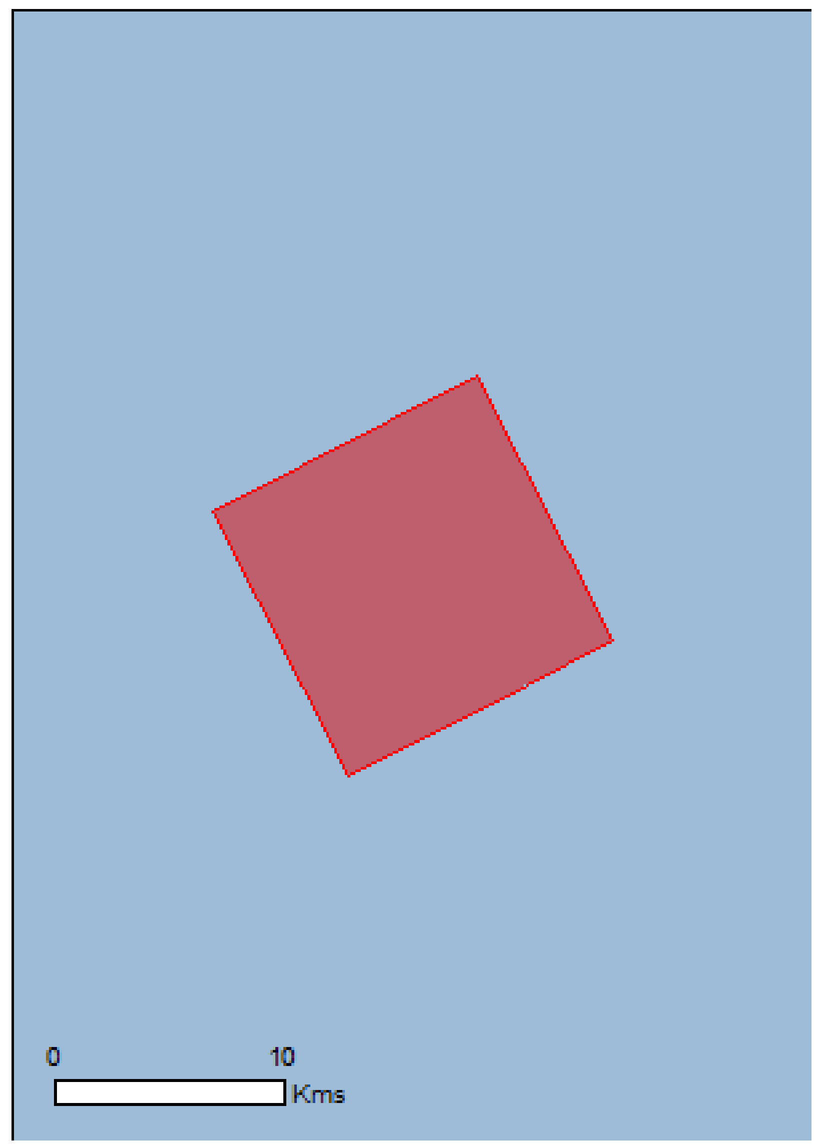
EPBC Act Protected Matters Report

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: 01/10/19 00:16:17



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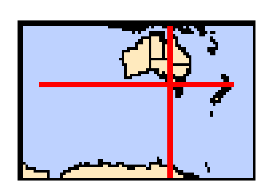

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	32
Listed Migratory Species:	38

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	58
Whales and Other Cetaceans:	27
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		
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 area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		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
Mammals		
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence
		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		
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat may occur within area
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
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

Name	Threatened	Type of Presence
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
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

Name	Threatened	Type of Presence
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

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
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

Name	Threatened	Type of Presence
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
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
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 Shearwater [1043]		Foraging, feeding or related behaviour likely to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat may 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

Name	Threatened	Type of Presence
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 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

Name	Threatened	Type of Presence
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 [21]		Species or species 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

Name	Status	Type of Presence
		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 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

Name	Status	Type of Presence
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 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

-39.332 142.6917,-39.2906 142.7947,-39.3706 142.8481,-39.412 142.745,-39.332 142.6917

Acknowledgements

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

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

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

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

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Appendix B Existing Environment

The physical, ecological and socio-economic environment of the EMBA are described in this section, with any values or sensitivities identified. The EMBA is shown in Figure 4-1, with Section 6.3 detailing the methodology for defining the EMBA boundary.

A search of the EPBC Protected Matters Search Tool (PMST) was undertaken on 1 October 2019 to identify the conservation values within the EMBA. The full PMST report is included in Appendix A and key information included in Table 4-1 to Table 4-3.

Appendix B.1 Conservation values and sensitivities

The following was identified from the PMST search (Appendix A).

The EMBA does not overlap:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of Importance;
- Great Barrier Reef Maine Park;
- Listed Threatened Ecological Communities;
- Commonwealth Land;
- Commonwealth Heritage Areas;
- Critical Habitats;
- Terrestrial Commonwealth Reserves;
- Australian Marine Parks;
- State and Territory Reserves; or
- Nationally Important Westlands.

The EMBA does overlap:

- Commonwealth Marine Area (Appendix B.1);
- Listed Threatened Species (Section Appendix B.3.4);
- Listed Migratory Species (Section Appendix B.3.4);
- Listed Marine Species; and
- Key Ecological Features (Section Appendix B.1.1).

Appendix B.1.1 Key Ecological Features

Key Ecological Features (KEFs) are elements of the marine environment, based on current scientific understanding, are of regional importance for either the region's biodiversity or ecosystem function and integrity of a Commonwealth Marine Area.

The south east region of the West Tasmanian Marine Canyons KEF overlaps the OA and EMBA (Figure B-9-2). 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 in relation 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 150 m 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 (Commonwealth of Australia, 2015b).

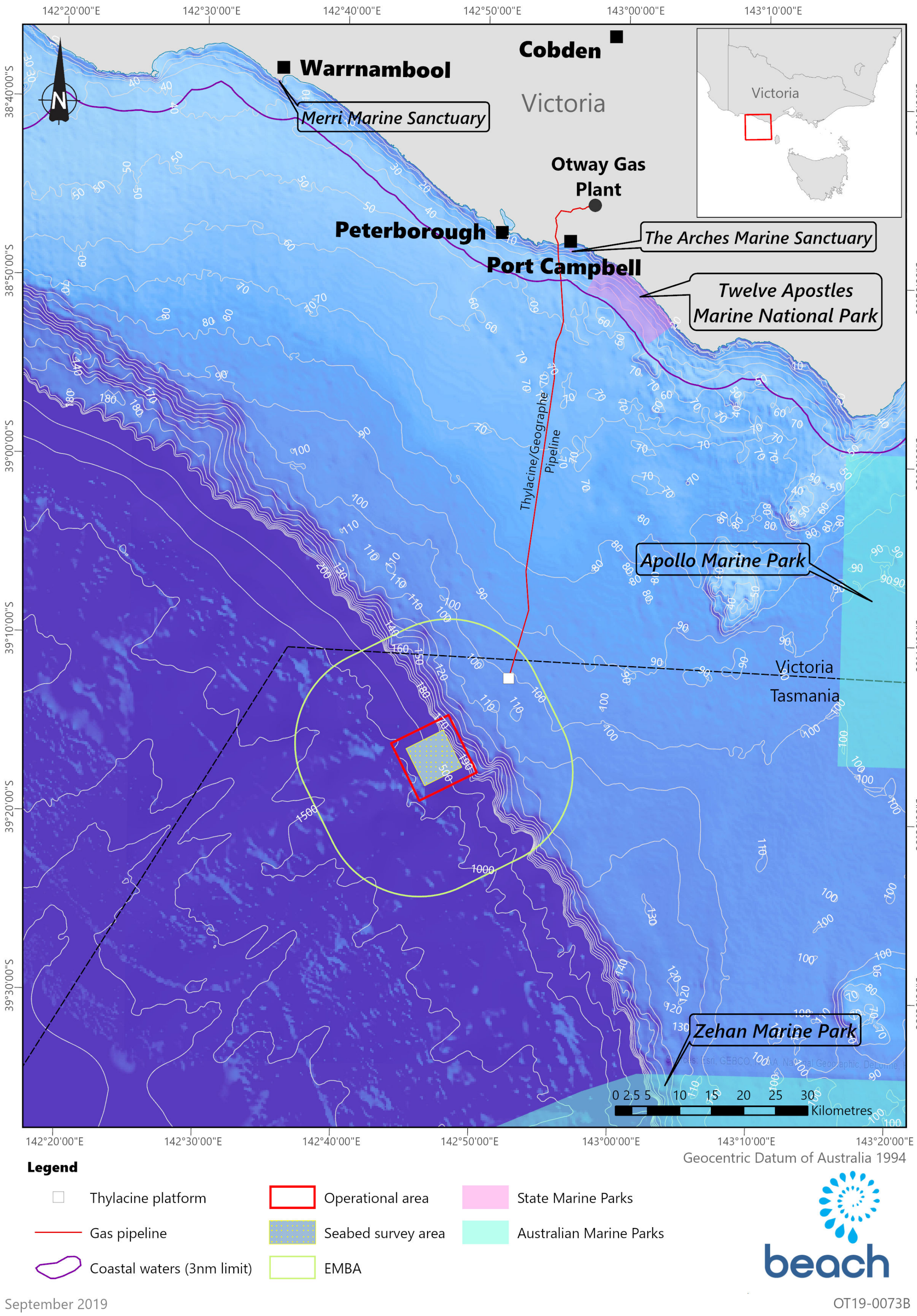


Figure B-9-1: Commonwealth and State Protected Areas

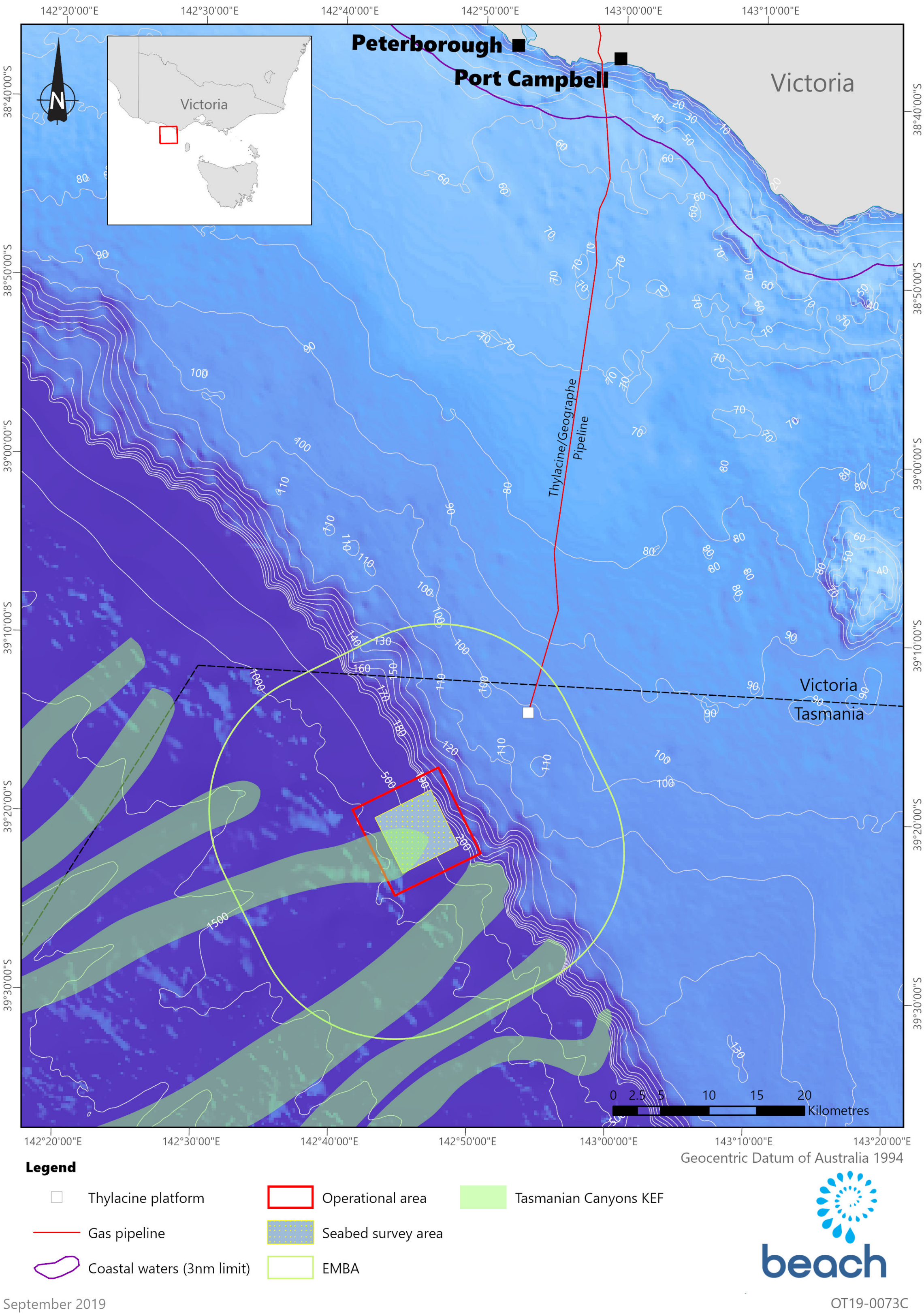


Figure B-9-2: Key ecological feature in the EMBA

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. Water depth of EMBA range from approximately 95 – 1,690 m deep., while water depth of OA range from 150 – 1,110 m deep.

Appendix B.2.1 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 four depth-related zones – shallow shelf, middle shelf, deep shelf and upper slope (Figure B-9-3).

The OA ranges in depth from 150 to 1,110 m and EMBA ranges in depth from 95 to 1,690 m. As such OA and EBMA are within the middle shelf (70 – 130 m), deep shelf (130-180 m) and upper slope (>180 m) depth zones. 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 (>500 m) 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.

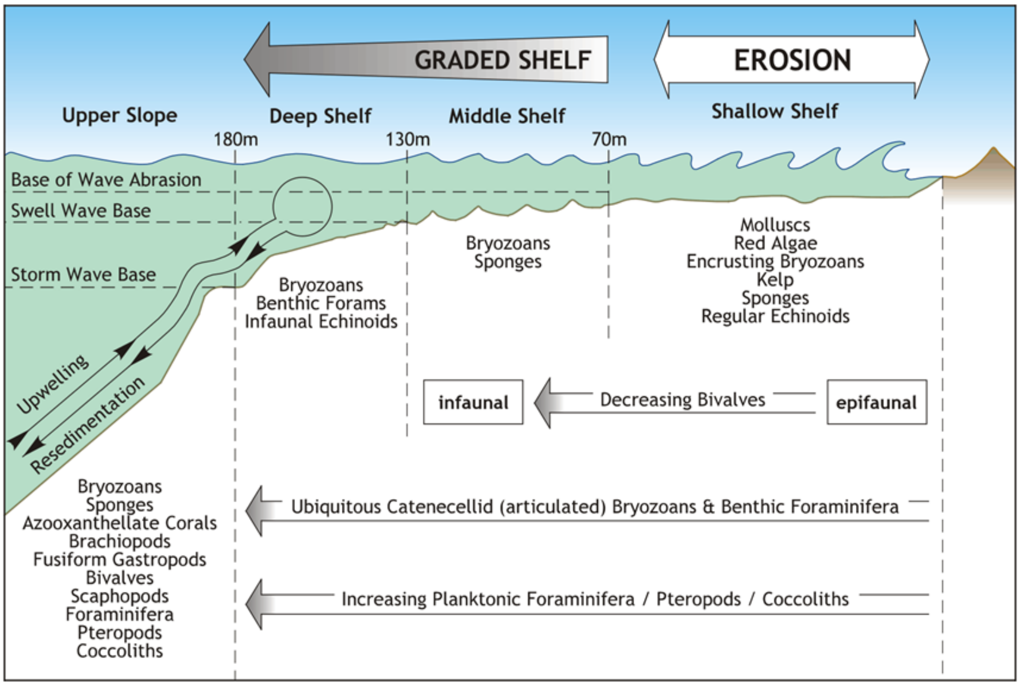


Figure B-9-3: Model of the geomorphology of the Otway Shelf (Boreen et. al. 1993)

Appendix B.2.2 Metocean conditions

Appendix B.2.2.1 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.2.2.2 Winds

The area 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-9-4).

Appendix B.2.2.3 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.2.2.4 Ocean currents

Ocean currents in the area are primarily driven by tides, winds and density-driven flows (Figure B-9-5). 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 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.

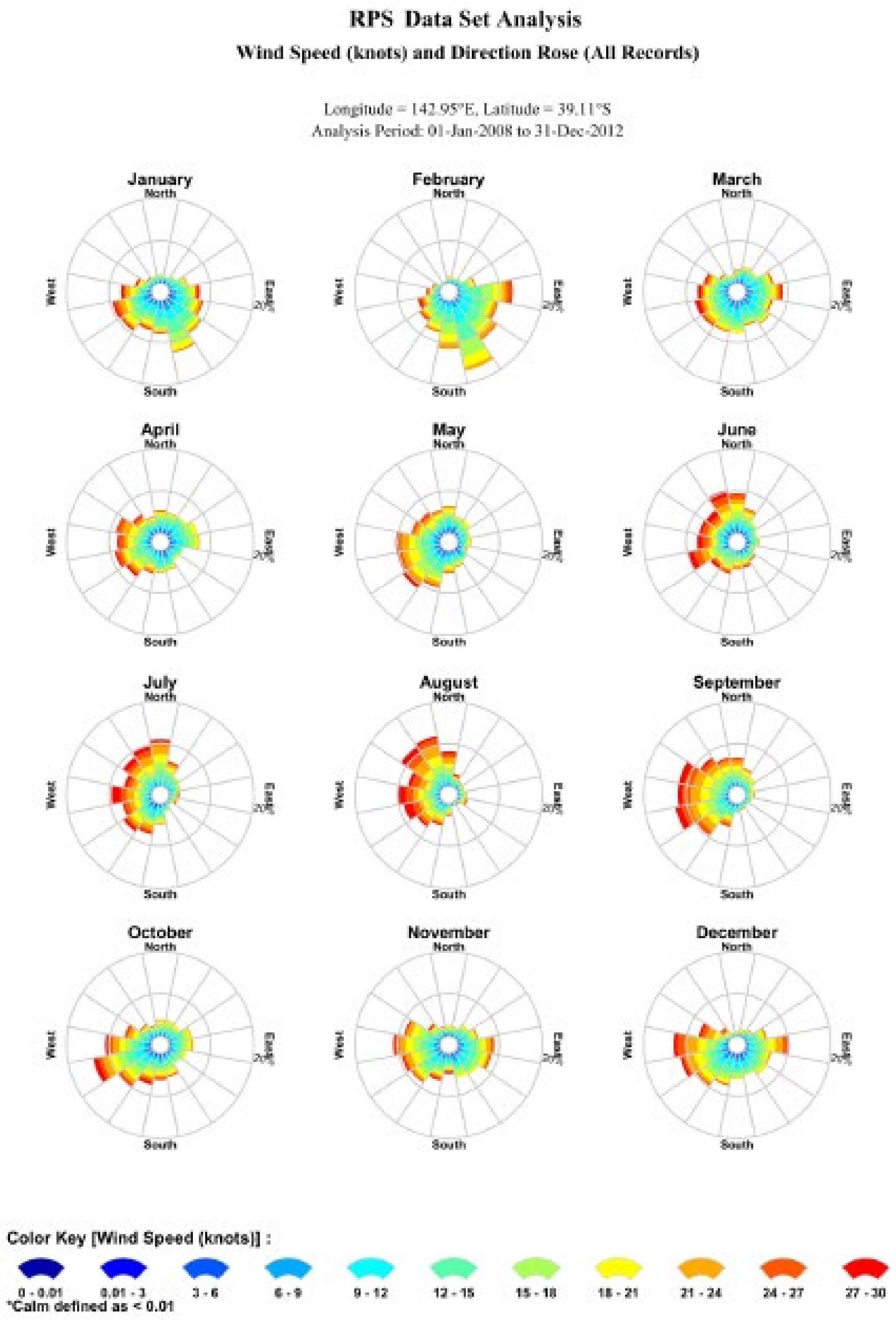


Figure B-9-4: Modelled monthly wind rose distributions (RPS, 2017)

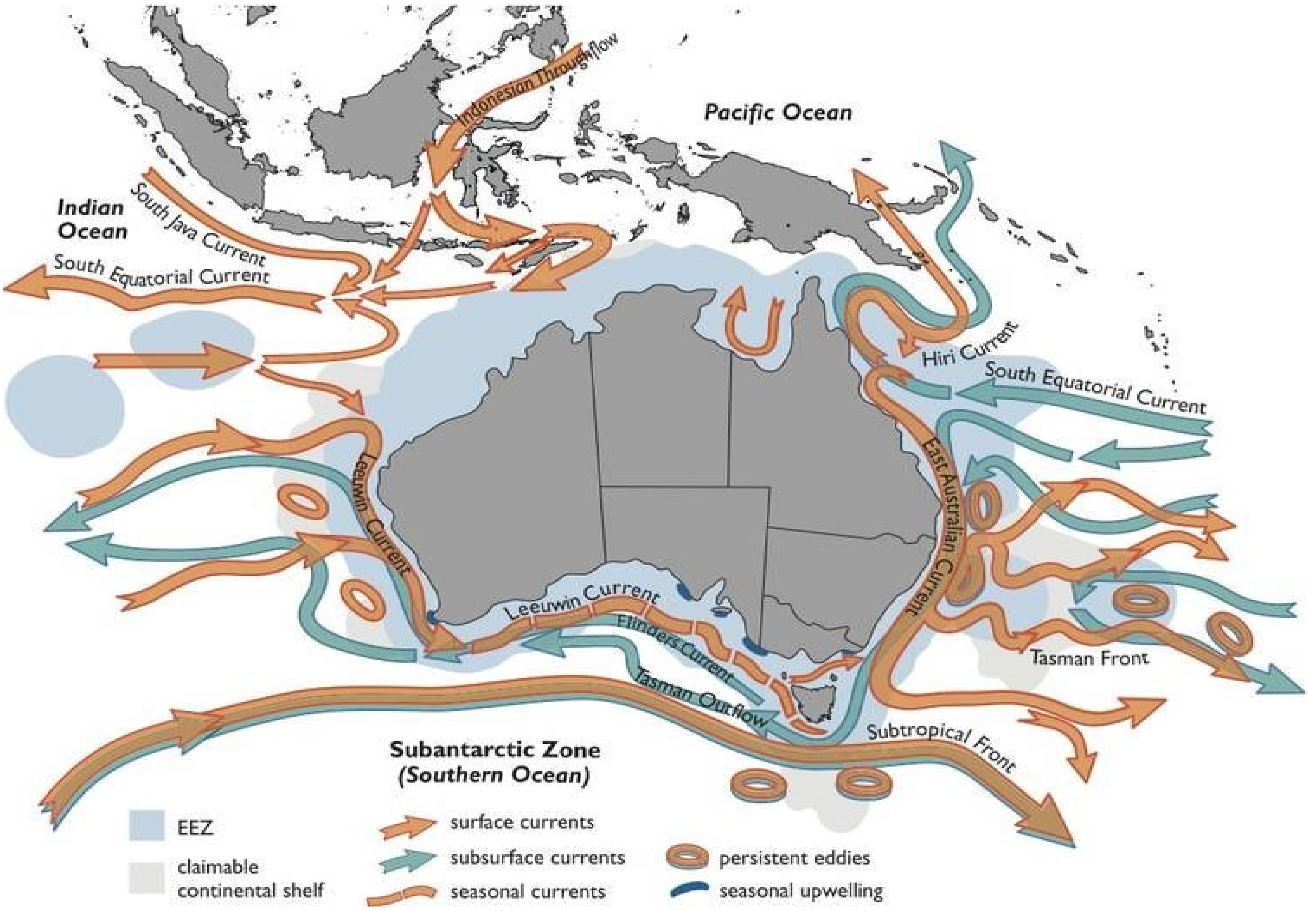


Figure B-9-5: Australian ocean currents

Appendix B.2.2.5 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.2.2.6 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.2.3 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 Otway Basin. A sound logger located 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).

Appendix B.2.4 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 of the OA and EMBA 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. 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, 1999).
- Origin Energy's Environment Plans for previous activities in the region.
- The National Conservation Values Atlas (Commonwealth of Australia, 2015a).
- 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 zone (Boreen et al., 1993). Based on Boreen et. al. (1993), the OA and EMBA are within the:

- Middle Shelf (70 – 130 m);
- Deep Shelf (130 – 180 m); and
- Upper Slope (>180 m).

The Middle Shelf is depositional in nature and is a zone of swell-wave shoaling and production of mega-rippled bryozoan sands. Boreen et. al. (1993) considered study sediment characteristics to be consistent with previously documented waves conditions on the Otway shelf and theoretical models developed which predict movement of coarse-grained sands and rippled bedforms in depths greater than 100 m. The middle shelf zone surveyed by Boreen et al. (1993) was widespread across southern Australia. This seabed area was observed to be mostly thin mobile sand sheets, with well-developed straight crested oscillation ripples frequently colonized by sponges and bryozoans, given provides more stable substrates for communities.

The Deep Shelf is characterised by accumulations of intensely bioturbated, fine bioclastic sands. These sediments are fine-grained skeletal sands, dominated by echinoid, bryozoan, and foraminiferal fragments, The Upper Slope of the Otway shelf (inclusive of shelf edge and top) displays nutrient-rich upwelling currents, and supports extensive, aphotic bryozoan/sponge/coral communities. However, upper slope is dominated by bioturbated mixture of periplatform bioclastic debris and pelleted foraminiferal/nannofossil mud. Turbidites and re-sedimentation features are common. Whereby bioturbation and shelf-derived skeletal content decrease progressively downslope and pelagic muds dominate below 500 m. Boreen et. al. describes areas of Otway shelf edge and upper slope (150 to 400 m), with nutrient-rich upwelling currents supporting solitary coral communities. While upper, deeper areas of the slope (300 to 500 m) are dominated by bioturbated muds with the presence of solitary azooxanthellate corals.

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 Marine 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. A variety of marine invertebrate species are expected to occur within the EMBA, including sponges and arthropods and some commercially important species (e.g. rock lobster, giant crab). Refer to Appendix B.4.1and Appendix B.4.2 for further detail on commercially important invertebrate species. Threatened ecological communities

No threatened ecological communities were identified within the EMBA.

Appendix B.3.4 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 32 Threatened species and 38 Migratory species were identified in the PMST report as potentially occurring within the EMBA. There were also 58 marine species and 27 cetaceans listed under the Act that were identified as potentially occurring within the EMBA.

Appendix B.3.4.1 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-9-1 details the listed fish species identified in the PMST.

Table B-9-1: Listed fish species identified in the PMST search

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

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
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 (DotE, 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.

Syngnathids

All 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). Most 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.3.4.2 Marine reptiles

The PMST report identified three marine turtle species that potentially occur in the EMBA (Table B-9-2). All three species of marine turtles are protected and are covered by the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017). There are no identified BIAs for reptiles in the EMBA.

Table B-9-2: Listed turtle species identified in the PMST

Common name	Species name	EPBC Act status	Likely presence
Loggerhead turtle	*Caretta caretta*	Endangered, Migratory, Listed	Species or species habitat likely to occur within area.
Green turtle	*Chelonia mydas*	Vulnerable, Migratory, Listed	

Common name	Species name	EPBC Act status	Likely presence
Leatherback turtle	*Dermochelys coriacea*	Endangered, Migratory, Listed	

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, 2017). 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 (DotE, 2019g), 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, 2017). 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, 2017).

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.3.4.3 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.

Bird species listed by the PMST, as possibly or known to be occurring in EMBA (this includes species or species habitat), are shown in Table B-9-3. In addition to bird species identified in EPBC Act PMST, the following were identified by National Conservation Values Atlas to have foraging BIAs overlapping EMBA; antipodean albatross; black browed albatross; Buller's albatross; Campbell albatross; common diving petrel; Indian yellow nosed albatross; short tailed shearwater; shy albatross; wandering albatross; and wedge tailed shearwater.

Several species listed in Table B-9-3 use coastal shoreline habitats such as Australian fairy tern, fairy prion, common diving-petrel, red knot, pectoral sandpiper, sharp-tailed sandpiper, curlew sandpiper, eastern curlew. 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). These species are unlikely to be present in the EMBA due to the distance offshore.

Table B-9-3: 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
Flesh-footed shearwater	*Ardenna carneipes (Puffinus carneipes in marine listing)*	-	M	L	FL
Sooty Shearwater	*Ardenna grisea (Puffinus griseus in marine listing)*	-	M	L	SHM
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
Eastern curlew	*Numenius madagacariensis*	CE	M	L	SHM
Fairy prion	*Pachyptila turtur*	V	-	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 (also listed as Thalassarche sp. nov.in Marine listed)*	V	M	L	FL
Northern Buller's albatross	*Thalassarche bulleri platei*	V	-	-	FL
Shy albatross	*Thalassarche cauta cauta*	V	M	L	FL

Common name	Species name	EPBC Act status			Likely presence
		Listed Threatened	Listed Migratory	Listed marine	
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.

Shearwaters

Several shearwaters were identified in EPBC Act PMST and National Conservation Atlas search tool. These include the flesh-footed shearwater (*Ardenna carneipes* or *Puffinus carneipes* in PMST marine listing), sooty shearwater (*Ardenna grisea or Puffinus griseus* in PMST marine listing), short tailed shearwater (*Ardenna tenuirostris*) and wedge tailed shearwater (*Ardenna pacifica*).

DEC NSW (2018) reports that about 10 species have been seen along the NSW coast, diving into the water or skimming across the water surface. Shearwaters feed on fish and employ various fishing techniques, including diving while in flight, diving while swimming on the water's surface, or 'flying' underwater with half-open wings (DEC NSW, 2018). Fish, squid, crustaceans, molluscs and plankton form the main part of the shearwater diet, but some species of shearwater have been observed to follow ships for scraps or scavenge for food at offshore waste-disposal points (DEC NSW, 2018).

Shearwaters are known to be migratory and travel long distances to places such as Antarctica, Siberia, Japan, South America and New Zealand. This migratory behaviour makes shearwaters susceptible to starvation and exhaustion during southerly migrations during periods of strong storm gales or food shortages (DEC NSW, 2018). Breeding adult migration from Northern hemisphere to remote island, cape or coastal mountain breeding sites in the Southern hemisphere, typically occurs during October (DEC NSW, 2018). While non-breeding and immature shearwaters tend to migrate south some months after the breeding adults (DEC NSW, 2018).

Flesh-footed shearwater, sooty shearwater, wedge-tailed shearwaters and short-tailed shearwaters species are reported to breed on islands off the NSW coast each year (DEC NSW, 2018). The flesh-footed shearwater returns from the seas off Japan and Siberia to the same nesting burrows on Lord Howe Island (DotE, 2019a). The sooty shearwater returns from the North Pacific Ocean and Southern Ocean to breed in small numbers on islands south of Port Stephens. Wedge-tailed shearwaters return from the North Pacific to their burrows on islands off the coast of NSW. Short-tailed shearwaters breed on islands along the eastern and southern coastlines of Australia, from the central coast of NSW to Western Australia (DotE, 2019b). These four species of shearwater were also identified in PMST and National Conservation Atlas searches for EMBA. Of these the short-tailed shearwater and wedge-tailed shearwater had foraging BIAs identified which overlap the EMBA. Both species do not have conservation value identified specifically within the South-east marine region in which the EMBA but have conservation value in Temperate East, North-west and South-west and Marine Region.

Given the migratory, foraging and breeding habits of shearwaters, it is likely that shearwaters will be present and forage in the EMBA but are not be reliant on this area. Noting BIAs are broad ranging and typically include large expanses of South-East Marine Region (Commonwealth of Australia, 2015a).

Albatrosses and giant-petrels

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, 2011). 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, 2011b). 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 25 ° S where most species spend most of their foraging time. The antipodean albatross (*Diomedea antipodensis)*, wandering albatross (*Diomedea exulans),* Buller's albatross (*Thalassarche bulleri (also listed as Thalassarche sp. nov.* in PMST Marine listed*)*, shy albatross, Campbell albatross (*Thalassarche impavida),* black-browed albatross (*Thalassarche melanophris)*, common diving-petrel (P*elecanoides urinatrix*) and Indian yellow-nosed albatross (*Thalassarche chlororhynchos bassi*) have foraging BIAs that overlap the EMBA.

Common diving-petrel (P*elecanoides urinatrix*) and Indian yellow-nosed albatross (*Thalassarche chlororhynchos bassi*) were not identified in PMST report but was identified to have foraging BIAs by the National Conservation Atlas search tool. Common diving petrels have been recorded from waters ranging from the subtropics to the subantarctic, usually between 35–55° S (DotEE. 2015). They are widely distributed over southern Australian and New Zealand waters. The species breeds only on islands of south-east Australia, Tasmania, New Zealand and Cook Strait (DotEE. 2015b). The Indian yellow-nosed albatross breeds on the French subantarctic islands and on South Africa's Prince Edward Islands (DotEE. 2015b). At-sea records of Indian yellow-nosed albatross distribution indicate that, for the non-breeding range, birds disperse from their breeding islands and commonly occur off southern Africa and Australia South-east Marine Region and during the winter months, as far south as latitude 45º S (DotEE. 2015b).

Given the migratory, foraging and breeding habits of albatross and petrels, it is likely that they will be present and forage in the EMBA but are not be reliant on this area. Noting BIAs are broad ranging and typically include large expanses of South-East Marine Region (Commonwealth of Australia, 2015a).

Appendix B.3.4.4 Pinnipeds

The PMST report identified two pinnipeds that potentially occur in the EMBA (Table B-9-4).

Table B-9-4: 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-9-6 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.

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.

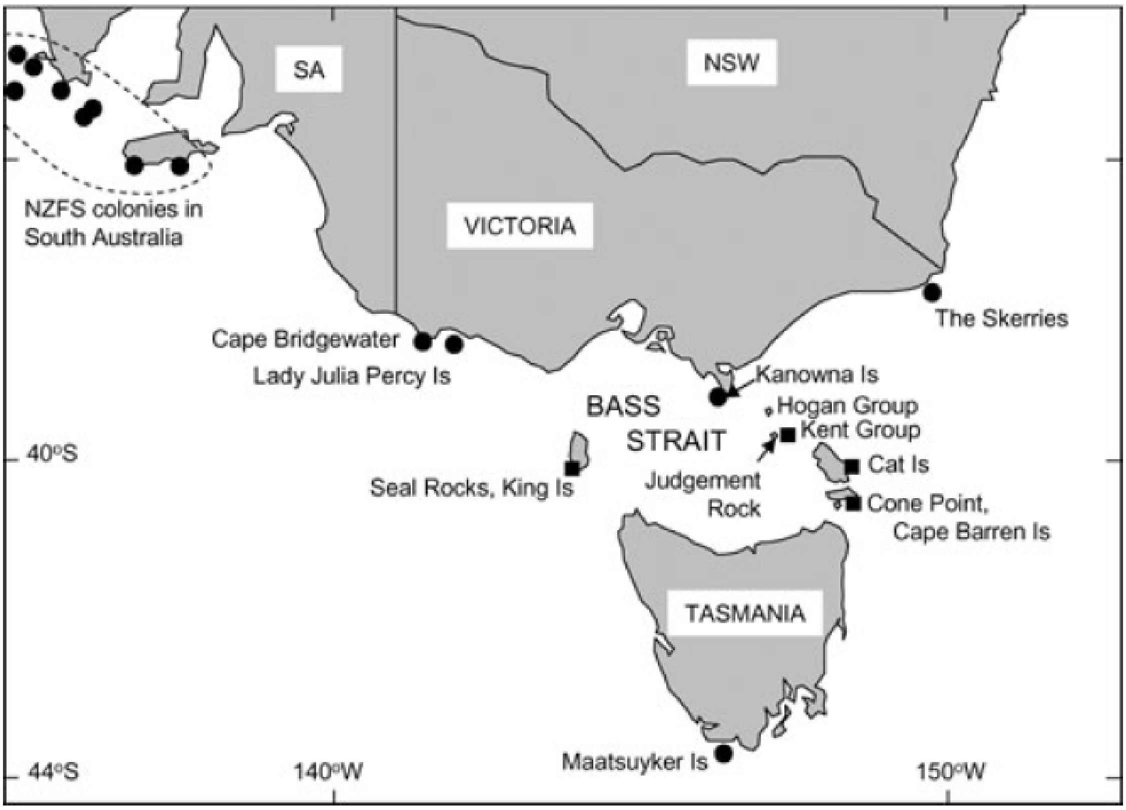
Haul out sites with occasional pup births are located at Cape Bridgewater, at Moonlight Head, on various small islands off Wilsons Promontory and Marengo Reef near Apollo Bay. Australian fur-seals are present in the region all year, with breeding taking place during November and December.

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 and 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.



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

Figure B-9-6: Locations of New Zealand fur-seal breeding colonies in the early 1800s and current colonies (Kirkwood et al., 2009)

Appendix B.3.4.5 Cetaceans

The PMST report identified several cetaceans that potentially occur in the EMBA (Table B-9-5). Details of these cetaceans are discussed further in this section. The only cetacean BIA identified within the EMBA is a pygmy blue whale foraging BIA.

Table B-9-5: Listed cetacean species identified in the PMST

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
Whales					
Minke whale	*Balaenoptera acutorostrata*	-	-	L	SHM
Antarctic minke whale	*Balaenoptera bonaerensis*	-	M	L	SHL
Sei whale	*Balaenoptera borealis*	V	M	L	FL
Southern right whale	*Balaena australis*	E	M	L	SHK
Blue whale	*Balaenoptera musculus*	E	M	L	FK
Fin whale	*Balaenoptera physalus*	V	M	L	FL
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
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

Common name	Species name	EPBC Act status			Likely presence
		Listed threatened	Listed migratory	Listed marine	
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
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.

Bass Strait Cetacean surveys

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-9-6 and Table B-9-7). 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.

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.

Origin Energy conducted a survey for cetaceans focused on Origin operations and permits in the Otway basin from June 2012 through March of 2013. Table B-9-8 lists the species present in the area Origin surveyed.

Table B-9-6: 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	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.

Table B-9-7: 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).

Table B-9-8: 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

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 (DotE, 2019d). 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, 2019d). 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, 2019d).

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.

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, 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).

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. The sei whale is likely to be an uncommon visitor to the EMBA.

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 (DotEE, 2019i). Southern right whales were hunted extensively with 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. 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. Currently the southern right whale has a recovery plan to prioritise research and better predict impacts (Commonwealth of Australia, 2012).

Southern right whales 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 and migrates from the sub Antarctic to lower latitude coastal waters during winter to calve and mate (Bannister et al., 1996).

In winter/spring adult females approach the coast to calve, mate and rest, where they distribute across thirteen primary aggregation areas along the southern coast of Australia (Figure B-9-7) (Bannister, 2017; DSEWPaC, 2012). In Australian coastal waters, Southern right whales occur along the southern coastline of the mainland and Tasmania and generally extend as far north as Sydney on the east coast and Perth on the west coast (DSEWPaC, 2012).

The largest established calving areas in Australia include Head of Bight in SA, and Doubtful Island Bay and Israelite Bay in WA. Smaller but established aggregation areas regularly occupied by Southern right whales include Yokinup Bay in WA, Fowlers Bay in SA and the Warrnambool and Portland in Victoria. Emerging aggregation areas include Flinders Bay, Hassell Beach, Cheyne/Wray Bays, and Twilight Cove in WA, and sporadically occupied areas include Encounter Bay in SA (DSEWPaC, 2012). Southern right whales generally occupy shallow sheltered bays within 2 km of shore and within water depths of less than 10m (Charlton et al., 2019).

Several 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 (Charlton et al., 2019).

Peak periods for mating in Australian coastal waters are from mid-July through August (DSEWPaC, 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 December) (Charlton et al., 2019).

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.

More recent studies on 'western' southern right whale population by Charlton (2019), found peak abundance period to be May-October with highest abundance counts between mid-July and late- August. It can be assumed peak abundance periods between 'eastern' and 'western' populations are similar (Carlton, C., 2019, pers. coms. 9 August).

This species may transit though the EMBA given it is within the broad ranging distribution area, however, whales are more likely to occur further east in identified coastal aggregation BIAs.

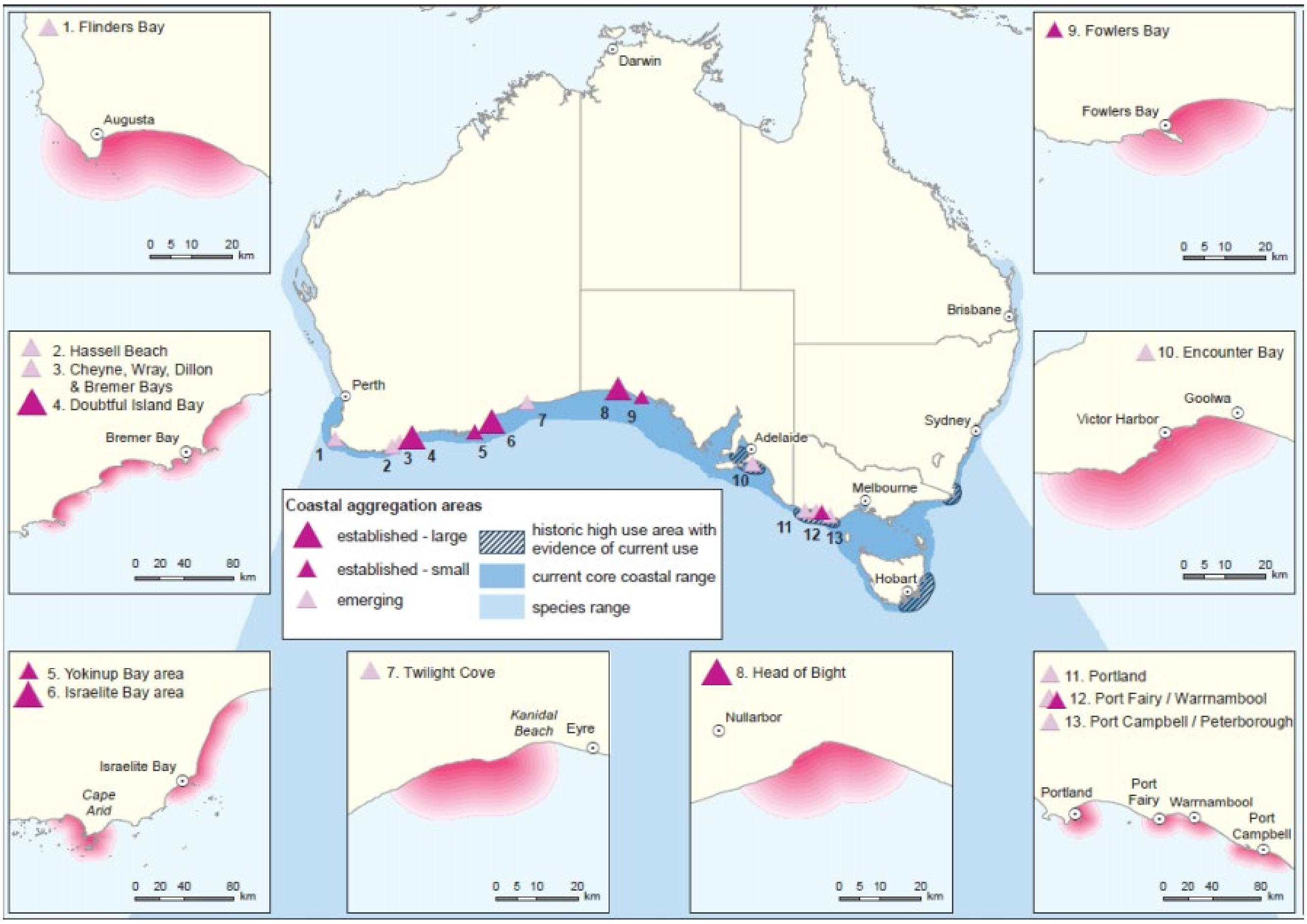


Figure B-9-7: Aggregation areas for southern right whales (DSEWPaC, 2012)

Blue whale

The blue whale (*Balaenoptera musculus*) is 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, 2015c).

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. Recent studies suggest an updated rate of increase in population growth of 12.6 %, consistent with growth rates in waters off the south of Australia (McCauley et al., 2018). The global population is listed as Endangered on the IUCN Red List.

Antarctic blue whales are mainly sighted south of 60°S in Antarctic waters. Little is known about mating behaviour or breeding grounds. The Otway region is an important migratory and foraging area for blue whales, as shown by passive acoustic monitoring and aerial surveys (Gavrilov, 2012; McCauley et al., 2018; Gill et al., 2011).

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.

Several 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. McCauley et al. (2018) suggests that acoustic detection of Antarctic blue whales indicate they predominantly occur along the entire southern coastline.

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-9-8). The known and likely migration routes of the highly mobile pygmy blue whale are also shown in Figure B-9-9 (DotE, 2019e). 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, 2019e).

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-9-10 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-9-10).

Sighting data are presented geographically in Figure B-9-11 and Figure B-9-12. 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 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.

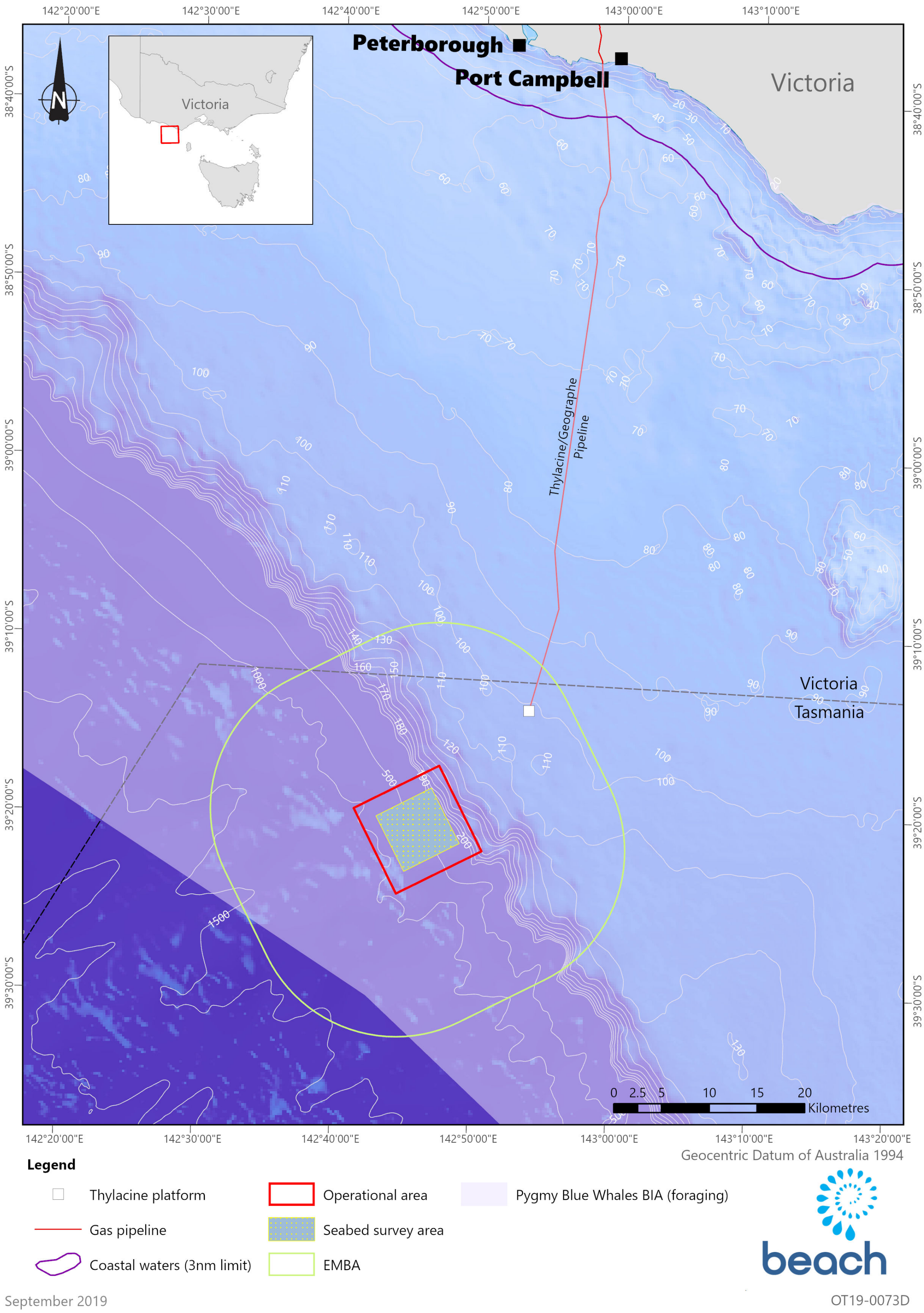
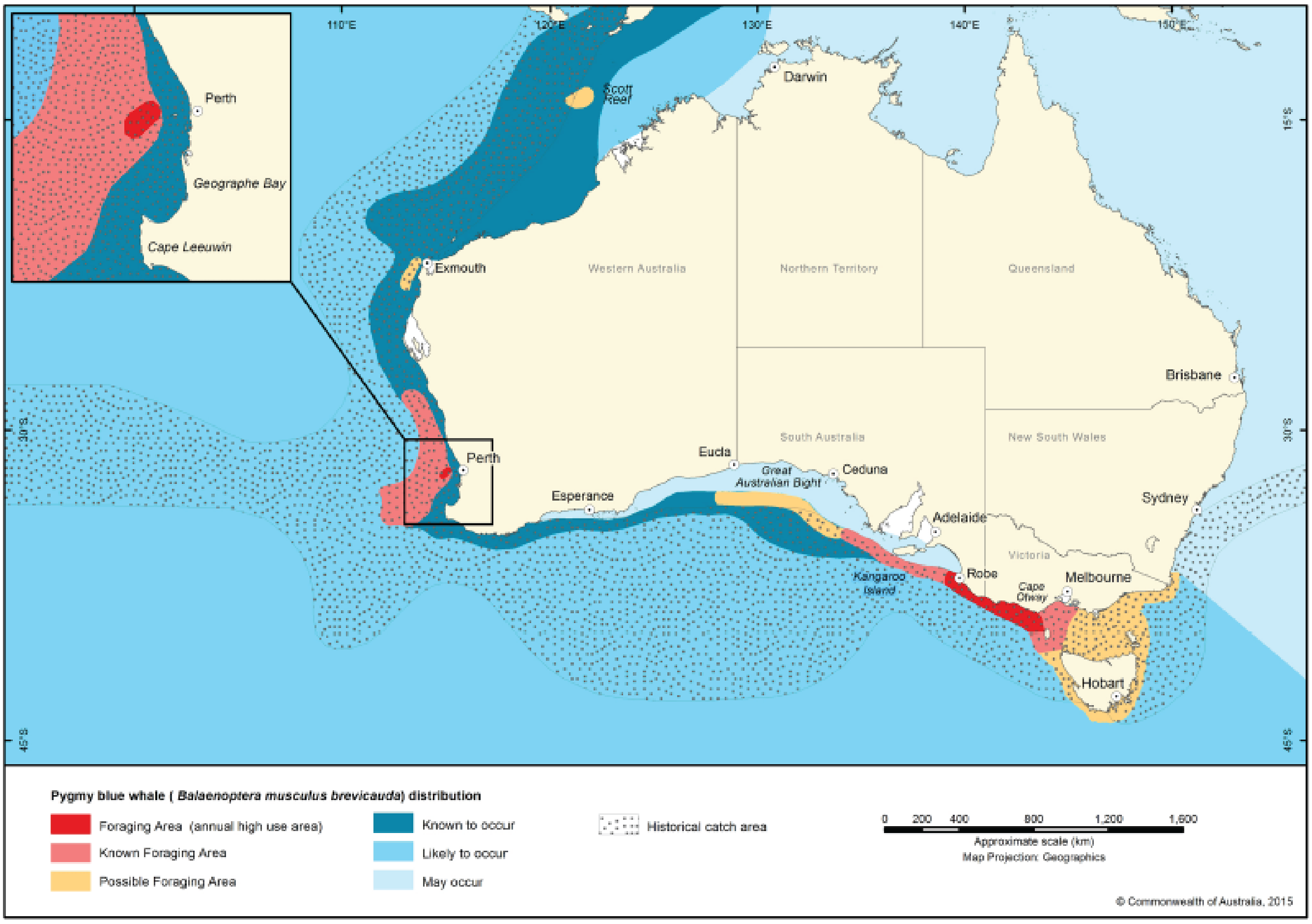


Figure B-9-8: Pygmy blue whale BIA in the EMBA



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 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-9-9: Pygmy blue whale foraging areas around Australia (DotE, 2019e)

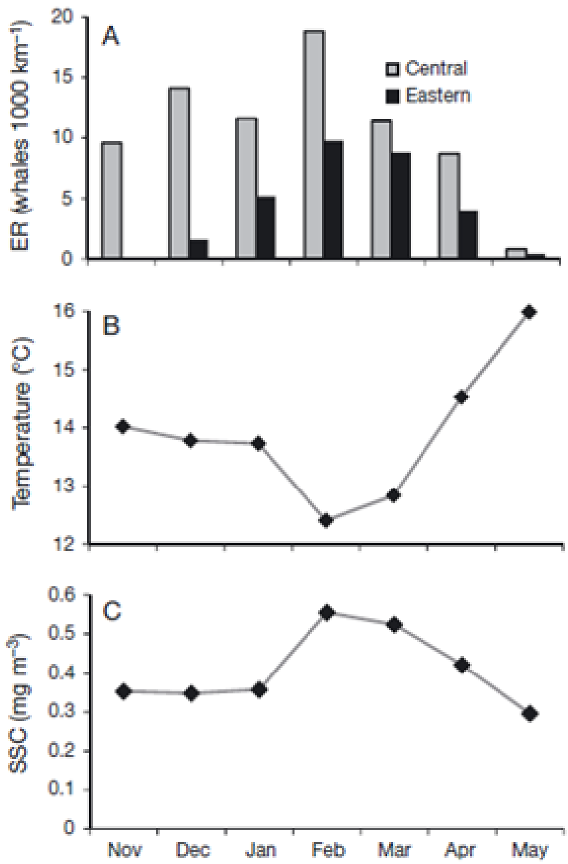
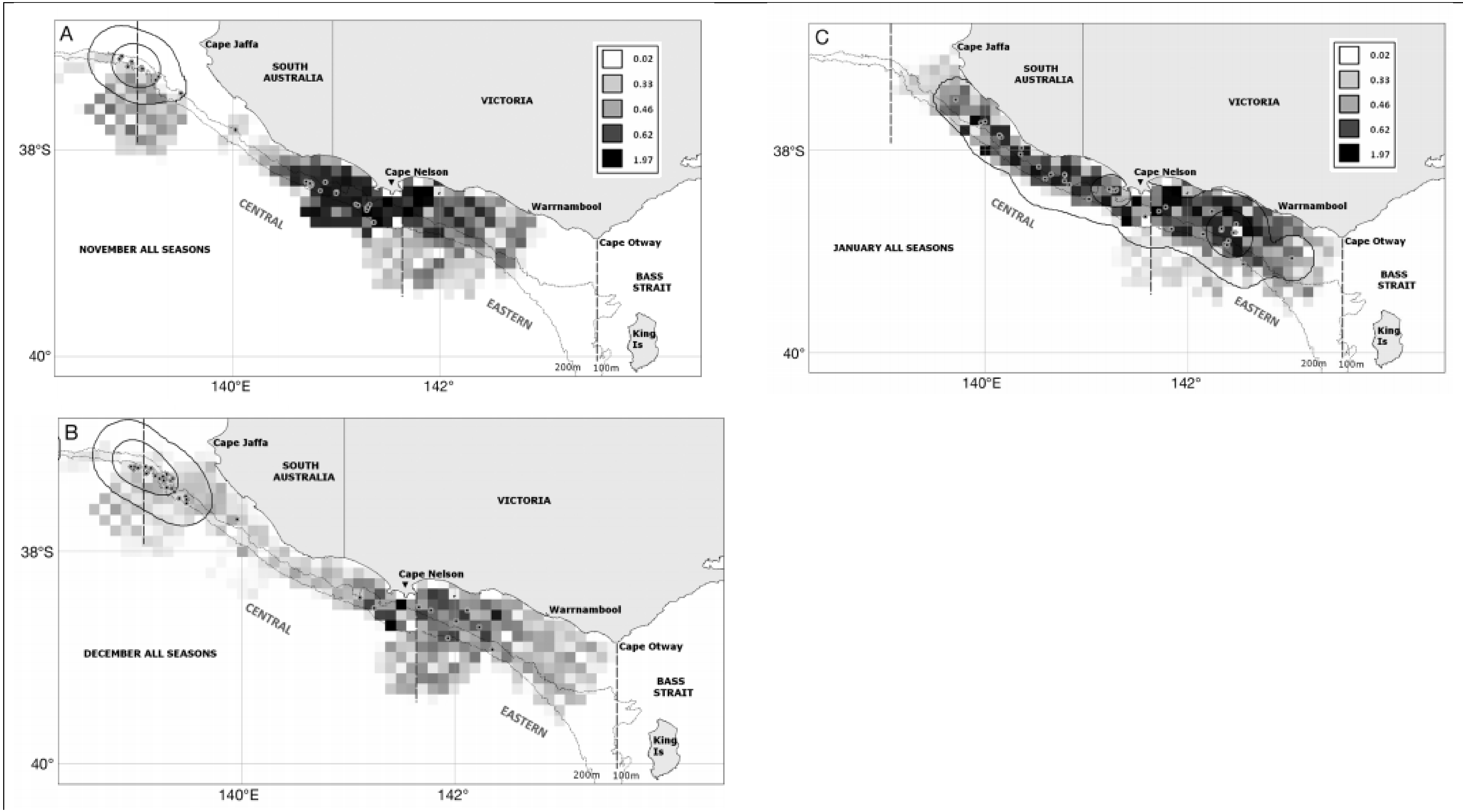


Figure B-9-10: Blue whale encounter rates in the central and eastern study (Cape Nelson to Cape Otway) area by month (Gill et al., 2011)


A
Cape Jaffa
SOUTH AUSTRALIA
VICTORIA
0.02
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Cape Nelson
Warrnambool
CENTRAL
NOVEMBER ALL SEASONS
Cape Otway
BASS STRAIT
EASTERN
King Is
40°
200m
100m
140°E
142°
B
Cape Jaffa
SOUTH AUSTRALIA
VICTORIA
38°S
Cape Nelson
Warrnambool
CENTRAL
DECEMBER ALL SEASONS
Cape Otway
BASS STRAIT
EASTERN
King Is
40°
200m
100m
140°E
142°
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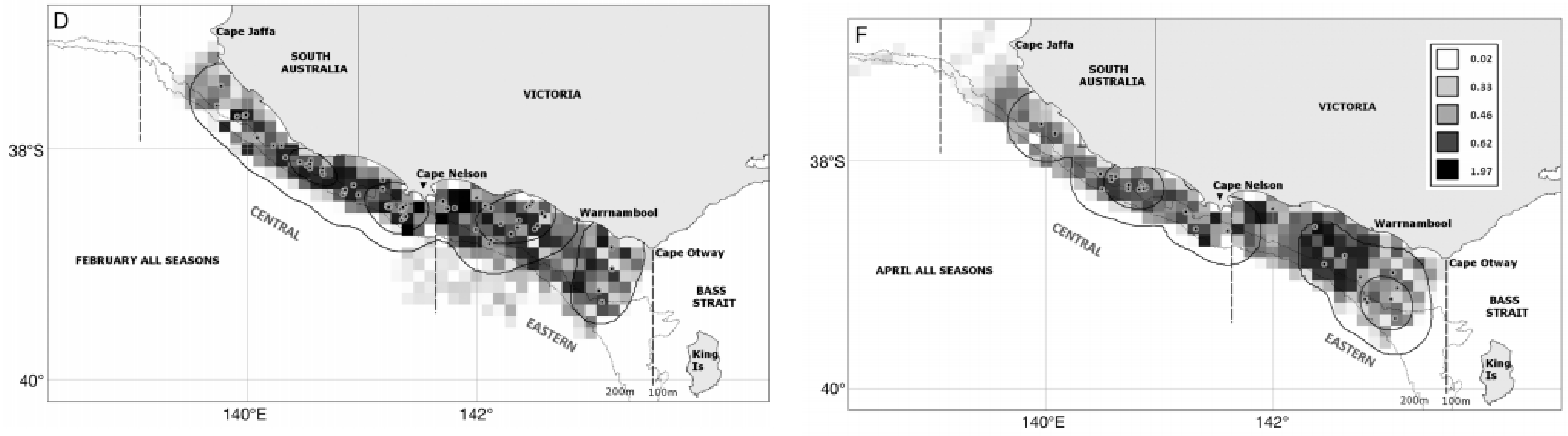
Cape Jaffa
SOUTH AUSTRALIA
VICTORIA
0.02
0.33
0.46
0.62
1.97
38°S
Cape Nelson
Warrnambool
CENTRAL
JANUARY ALL SEASONS
Cape Otway
BASS STRAIT
EASTERN
King Is
40°
200m
100m
140°E
142°

Figure B-9-11: Blue whale sightings in the Otway Basin (Nov, Dec, Jan) (Gill et al., 2011)



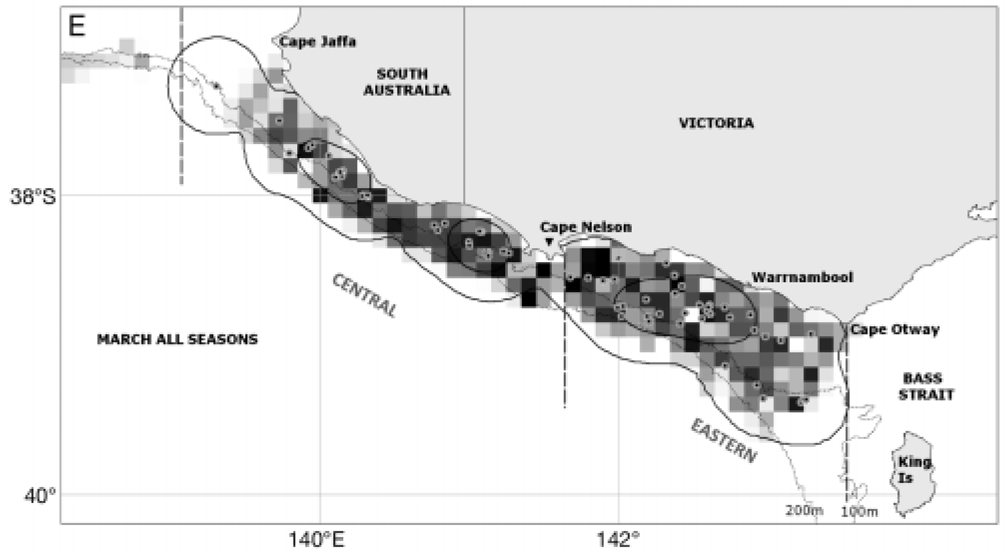


Figure B-9-12: Blue whale sightings in the Otway Basin (Feb, Mar, Apr) (Gill et al., 2011)

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). Given the association of the fin whale with the Bonney Upwelling which is 104 km from EMBA, it is therefore possible but unlikely that they would be a visitor in the EMBA, given no BIAs have been identified to overlap the EMBA.

Arnoux's beaked whale

The Arnoux's beaked whale (Berardius arnuxii) occurs circumglobally in the Southern Ocean from about latitude 34° S southwards to the Antarctic ice, ranging from temperate waters of 10–20 °C to Antarctic waters of between 0–5 °C (DotE, 2019f). The whale is a distinct and well-defined species, separated from its Northern Hemisphere relative Baird's Beaked Whale (Berardius bairdii) (DotE, 2019f). They are gregarious whales, usually forming small groups of up to 16 individuals, with reports of up to 50 animals observed off NSW (DotE, 2019f).

Most sightings of Arnoux's beaked whale have been made in the Tasman Sea and around the East Pacific Rise, in the South Pacific Ocean. No key localities are known in Australian waters (DotE, 2019f).

There are no estimates of Arnoux's Beaked Whale population size, either globally or for Australia, so the proportion of the global population occurring in Australian waters is unknown.

No data have been recorded for any specific breeding parameter of Arnoux's Beaked Whale. There are no known reproductive behaviours that may make Arnoux's beaked whale vulnerable to a threatening process, although a suspected calving interval of three years leads to a slow reproductive capacity (DotE, 2019f).

Due to limited sightings and distribution data of Arnoux's beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in 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., 2008). 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.

Short-finned pilot whale

Short-finned pilot whale (*Globicephala macrorhynchus*) are socially cohesive, forming small groups of between 10 to 30 individuals, but also commonly seen in groups of several hundred animals, often accompanied by dolphins (DotE, 2019j).

The species appears to vary geographically based on incidental sightings data, given no comprehensive global distribution study has been undertaken. There is some evidence of distinct populations of Short-finned pilot whales, particularly off the Pacific coast of Japan and in the eastern Pacific, but no subgroups have formally recognised to date (DotE, 2019j). In the Australian region, short-finned pilot whales occur mainly in tropical (22–32 °C) to temperate (10–22 °C) oceanic waters, approaching coastal seas (DotE, 2019j). Some southern sightings have been reported but these could be a result of observer bias, confusion with the Long-finned Pilot Whale (*G. melas*) or possible influence of warm, south-flowing Indian and Pacific Ocean currents (DotE, 2019j).

The species is reported to prefer deep water and occur mainly at the edge of the continental shelf, and over deep submarine canyons in the Australian region (DotE, 2019j). With the distribution and movements of short-finned pilot whales appearing to be driven by prey availability (DotE, 2019j). In particular, inshore-offshore movements are probably determined by the timing of squid spawning (as outside the squid season short-finned pilot whales are usually found offshore) (DotE, 2019j).

No population estimates are available for short-finned pilot whales in Australian waters, although they are generally considered to be in relatively high abundance (DotE, 2019j). It is likely that the total number of mature short-finned pilot whales within Australian waters is more than 10 000 (DotE, 2019j).

Mating is thought to occurs all year round, resulting in a diffusely seasonal calving period, with peaks in spring and autumn in the Southern Hemisphere (DotE, 2019j). No Short-finned pilot whale calving areas are known for Australian waters (DotE, 2019j). There are no known reproductive behaviours that may make short-finned pilot whales vulnerable to a threatening process, although the five-year calving interval leads to an extremely low reproductive capacity (DotE, 2019j).

Due to limited sightings and distribution data of short-finned pilot whales within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore 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 (DotE, 2019k). No key localities have been identified in Australia (Bannister et al., 1996) however they are considered reasonably abundant (DotE, 2019k).

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 (DotE, 2019k).

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.

Pygmy sperm whale

Pygmy sperm whale (*Kogia breviceps*) tends to occur individually or in small groups of up to six animals (DotE 2019e). This whale is considered to have a cosmopolitan, oceanic distribution, occurring in all three major ocean basins (Pacific, Atlantic and Indian). However, worldwide the pygmy sperm whale is not well studied so very little is known of its behaviour and ecology (DotE, 2019e).

Pygmy sperm whale is thought to occur mostly beyond the continental shelf in tropical and temperate oceans around the world (DotEE, 2019e). No estimates of the global or Australian population size exist, however two sightings and 82 pygmy sperm whale strandings have been reported in Australian territories (DotEE, 2019e). As such Australian distribution is primarily assumed from incidental sightings and stranded animals (DotEE, 2019e).

Pygmy sperm whale breeding areas and habitat are unknown, but are presumed to be oceanic (DotEE, 2019e). Little is known about the mating system of this species, but calving is inferred to occur in winter following an 11-month gestation and a mating season spanning from April through September (DotEE, 2019e). Stranding data of other Kogiidae (sperm whales) do not seem to suggest any strong seasonal changes in distribution, nor any migrations in Australian waters (DotEE, 2019e).

Due to limited sightings and distribution data of short-finned pilot whales within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

Dwarf sperm whale

Dwarf sperm whale (*Kogia simus*) is the smallest of the whales and is smaller than some dolphins. Dwarf sperm whales are often found at the ocean surface in small groups of usually less than five individuals, and occasionally up to ten (DotE, 2019m). Dwarf sperm whales are considered oceanic and live over the continental shelf and slopes off tropical and temperate coasts but approach coastlines more often than pygmy sperm whale relatives (DotE, 2019m).

Dwarf sperm whales occurs in all oceans apart from polar or sub-polar seas. In Australian waters they have been recorded (as stranded animals) in Western Australia, South Australia, Tasmania, New South Wales and the Northern Territory, with only one live sighting report from South Australia (DotE, 2019m).

Abundance estimate for dwarf sperm whales is hazardous due to lack of records of live animals, which may be due to the inconspicuous behaviours, rather than rarity. Further, abundance estimates tend to be based on strandings data, which may create bias for areas of more research effort. However, dwarf sperm whales are not considered abundant in Australian waters as sightings and strandings are rare (DotE, 2019m). The species therefore potentially includes less than 10,000 mature individuals within Australian waters (DotE, 2019m).

Dwarf sperm whale breeding and calving areas currently are unknown but are presumed to be in oceanic temperate and tropical seas (DotE, 2019m). It is thought that mating occurs in summer followed by a 9.5-month gestation period, and thus calving occurs the following spring (DotE, 2019m). However other sources, suggests mating may occurs in December to March, followed by a 12-month gestation (DotE, 2019m).

Due to limited sightings and distribution data of dwarf sperm whales within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

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 (DotE, 2019p). 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 OA. 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 (DotE, 2019p). Feeding occurs where there is a high krill density, and during the migration this primarily occurs in Southern Ocean waters south of 55°S (DotE, 2019p).

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.

Humpback whales' satellite-tagged off Australia's east coast were tracked during three austral summers in 2008/2009, 2009/2010 and 2010/2011 (Andrews-Goff et al., 2018). Of the thirty tagged humpbacks, 21 migrated south along the coastline across into Bass Strait during October. In November the whales then migrated along the east coast (12 whales) and west coast (1 whale) of Tasmania to Antarctic feeding grounds. The state space model used shows both search and transit behaviour revealing new temperate feeding grounds in Bass Strait, the east coast of Tasmania and in the eastern Tasman Sea

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

There are no humpback whale BIAs identified in the EMBA. Therefore, it is likely to be an uncommon visitor in the EMBA.

Andrew's beaked whale

Based on very few sightings of live Andrew's beaked whales (*Mesoplodon bowdoini*) it appears that this species is often solitary but may be found in small groups of up to six individuals (DotE, 2019q).

Andrews' beaked whale is found in the Southern Indo-Pacific Ocean but is known from only 35 specimens. Most records being from strandings from temperate waters of the South Pacific and Indian Oceans, while two strandings recorded from Tristan da Cunha represent the species in the Atlantic Ocean (DotE, 2019q). Andrews' beaked whale is therefore considered to have a southern, circumpolar distribution north of the Antarctic convergence, between 32° S and 54°30' S, with population centres likely to be far from land (DotE, 2019q). Within Australian waters Andrews' beaked whale is known from sightings and strandings in Western Australia, Victoria, Tasmania, and NSW (DotE, 2019q). No key localities are known in Australian waters (DotE, 2019q).

Although there is no population estimate for Andrew's beaked whales, they are not considered abundant as sightings and strandings are rare (DotE, 2019q). Based on limited data available, Andrew's beaked whale appears to prefer deep oceanic temperate waters between 10–20 °C and is presumed to feed at depth on mid- and deep-water squid and fish (DotE, 2019q). As for many species of beaked whale, it is likely that Andrew's beaked whale is also found close to undersea features such as submarine escarpments and sea mounts where prey is believed to aggregate (DotE, 2019q).

The breeding areas and habitat used by Andrew's beaked whale are unknown, but are presumed to be oceanic, although the possible inshore movement of Andrew's beaked whale in spring and summer may be associated with mating and calving (DotE, 2019q). All Australian records for Andrew's beaked whale occurred between January and June (DotE, 2019q).

Due to limited sightings and distribution data of Andrews' beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

Blainville's beaked whale

Blainville's beaked whale (*Mesoplodon desirostris*) is generally inconspicuous and difficult to find at sea. As a result, most knowledge of the species is based stranded specimen data (DotE, 2019r). Blainville's beaked whale is considered to have an oceanic and circumglobally distribution, occurring in low to mid-latitudes in all oceans and both hemispheres, with a preference for deeper (700-1000 m), tropical and warm temperate waters (DotE, 2019r). It's distribution ranges north to Nova Scotia, Wales, Portugal, the western Mediterranean, Japan, Midway Islands, and central California; and south to the Rio Grande do Sul (Brazil), South Africa, Tasmania, and central Chile (DotE, 2019r). It is probably the most widely distributed species of *Mesoplodon* (DotE, 2019r).

Fewer stranding events of Blainville's beaked whale occur in Australia. Australian strandings have been reported in Western Australia (one), Victoria (one), Tasmania (1), NSW (one), Queensland (seven) and Lord Howe Island (one) (DotE, 2019r). Blainville's beaked whale has also been recorded from the northern Tasman Sea and off Point Lookout, Queensland (DotE, 2019r). The extent of occurrence and area of occupancy of Blainville's beaked whale cannot be calculated due to the sparsity of recorded sightings in Australia. The species is, however, considered to occur in one location in Australia, without any severe fragmentation, as deep water is not a barrier to movement in this species.

There are no estimates of the population size of Blainville's beaked whale, either globally or for Australia. Although in the tropical oceans, Blainville's beaked whale is considered one of the more widespread and common beaked whales (DotE, 2019r). However, in Australian waters, Blainville's beaked whales are not considered abundant as sightings and strandings are rare.

In Australia, stranding records exist of Blainville's beaked whale from Northern and Southern Australia (at 40–50° S in Tasmania), except in South Australia and the Northern Territory, however data is insufficient to infer seasonal occurrence or migration (DotE, 2019r). Reported whale strandings on the Australian west and east coasts may be linked to the south-flowing warm currents, such as the Leeuwin and East Australian currents, respectively (DotE, 2019r). As such breeding areas and habitat are unknown, but are presumed to be oceanic (DotE, 2019r). The gestation periods are also unknown, but calves are possibly born in late summer (DotE, 2019r).

Due to limited sightings and distribution data of Blainville's beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

Hector's beaked whale

Hector's beaked whale (*Mesoplodon hectori*) usually occur singly, but groups of two individuals have been observed (DotE, 2019s). Hector's beaked whale distribution is primarily known from a few strandings in Argentina, Chile, the Falkland Islands, South Africa, New Zealand and Australia (DotE, 2019s). As such Hector's beaked whale occurs south of the Tropic of Capricorn and is distributed circumglobally between about 35° S to 55° S (DotE, 2019s).

Hector's beaked whales are thought to prefer deep oceanic waters of cool temperate (between 10–20 °C) to sub-Antarctic (between 1–8 °C) regions (DotE, 2019s). It is presumed to feed at depth on mid- and deep-water squid (DotE, 2019i). As for many species of beaked whale, Hector's beaked whale may also be found close to undersea features such as submarine escarpments and sea mounts where prey is believed to aggregate (DotE, 2019s)

Only a few Hector's beaked whales have been recorded in Australia (one in Western Australia, one in South Australia and two in Tasmania) (DotE, 2019s).

No estimates of population size exist for Hector's beaked whale. However, based on stranding and sighting data, Hector's beaked whale are not considered abundant (DotE, 2019s).

Little is known regarding reproduction in Hector's beaked whales. Gestation period, calving interval, and calving areas are also all unknown (DotE, 2019s).

Due to limited sightings and distribution data of Hector's beaked whales within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

Strap-toothed beaked whale

Strap-toothed beaked whale (*Mesoplodon layardii*) has very few sightings of live animals, however is often reported as solitary but may be found in small groups of up to three individuals (DotE, 2019t). It is thought that the strap-toothed beaked whale is one of the more widespread and common beaked whales in the Southern Ocean and adjoining waters, occurring between approximately 30° S and the Antarctic Convergence (DotE, 2019t). The species has been recorded in Australia, New Zealand, both coasts of South America, the Falklands, Namibia, South Africa, and Kerguelen Island in the Indian Ocean (DotE, 2019t). This whale is thought to occur in areas south of 38° S throughout the year (DotEE, 2019j). While, their occurrence north of 38° S appears to be seasonal, suggesting that the strap-toothed beaked whale may undergo some limited migration to lower latitudes during local winter (DotEE, 2019j). Insufficient data exists to determine proportion of the population undergoing this seasonal movement, and whether this movement is significant (DotE, 2019t).

In Australia, the strap-toothed beaked whale is the most commonly stranded beaked whale in Australia, with 68 events reported prior to 1994, occurring on the southern coast of Western Australia (five), South Australia (27), Victoria (five), Tasmania (13), NSW (14), Queensland (four), as well as on Macquarie Island (two) and Heard Island (one) (DotE, 2019t). The majority of strandings occurring from January to April, indicating a seasonal influx during mid- to late summer with the frequency of strandings suggesting that the strap-toothed beaked whale may be seasonally common off southern Australia (DotE, 2019t). This may indicate that the whale feeds seasonally in zones of higher productivity adjacent to the Australian continental slope, as well as using adjacent waters for calving (DotE, 2019t).

No estimates of global population size exist for the strap-toothed beaked whale, given so few have been reliably identified at sea (DotE, 2019t). However, within Australia they are not considered abundant as sightings and strandings are rare (DotE, 2019t).

Strap-toothed beaked whale breeding areas and habitat are unknown but are presumed to be oceanic. While mating is thought to occur in summer and calves born from summer through autumn (DotE, 2019t).

Due to limited sightings and distribution data of strap-toothed beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

True’s beaked whale

Very little is known about the true’s beaked whales (*Mesoplodon mirus*) social behaviour, but it is assumed to be like most *mesoplodont* characteristics, living primarily on their own, but occasionally seen in small groups of up to about six individuals (DotE, 2019u).

The distribution of true's beaked whale in the Northern Hemisphere appears limited to the North Atlantic, northwards from approximately 30°–50° N (DotEE, 2019k). It occurs from Florida, San Salvadore Island in the Bahamas, and Ilas Canarias north to Nova Scotia and Ireland (DotEE, 2019k). In the Southern Hemisphere, true's beaked whales are known from the Cape Province, South Africa, and Australia (DotE, 2019u). Only a few true's beaked whales have been recorded in Australia, including two strandings from Western Australia, one from Victoria and one from Tasmania, in the period up to 1994 (DotE, 2019u). No key localities are known for true's beaked whales in Australian waters (DotE, 2019u).

True's beaked whales are thought to prefer deep oceanic waters of cool temperate (10–20 °C) regions, rarely enter continental seas (DotE, 2019u). No information on habitat is available, but the only confirmed sighting of live true's beaked whales has been whales travelling parallel to a steep drop-off between 600 and 1000 fathoms (1097–1828 m) (DotE, 2019u). As for many species of beaked whale, true's beaked whale are also found close to undersea features such as submarine escarpments and sea mounts, where prey aggregate (DotE, 2019u).

As there are no estimates of true's beaked whale population size, either globally or for Australia, the proportion of the global population in Australian waters remains unknown (DotE, 2019u). However, they not considered abundant as sightings and strandings are rare (DotE, 2019u).

True's beaked whale breeding areas and habitat are unknown but are presumed to be oceanic (DotE, 2019u).

Due to limited sightings and distribution data of true's beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors 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 (DotE, 2019v).

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.

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 (DotE, 2019y). 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) (DotE, 2019y). 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 (DotE, 2019y).

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 (DotE, 2019y).

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 BIAs for foraging is further east near Kangaroo Island in South Australia. Therefore, it is likely they would be uncommon visitors in the EMBA.

False killer whale

False killer whale *(Pseudorca crassidens)* are highly gregarious, occurring in socially cohesive herds of about 20–50 animals (DotE, 2019x). Large aggregations of between 100 to 800 individuals also occur, apparently representing temporary associations of several smaller herds that have congregated to exploit locally abundant prey (DotE, 2019x).

False killer whales are found worldwide in deep tropical and temperate waters (DotE, 2019x). They are distributed circumglobally between 45° S and 45° N, though do not show significant abundant anywhere (DotE, 2019x). They range north to Maryland, Scotland, southern Japan, Hawaii, and British Columbia and south to Chubut in Argentina, Australia, South Island of New Zealand, Chatham Islands, and Concepción, Chile (DotE, 2019x). Most of the distributional records and available data are a result of strandings (DotE, 2019x). However, eastern distribution in the South Pacific and west to between Chile and Easter Islands (112° W and 91° W) is based on sightings (DotE, 2019x).

False killer whales are reported to prefer deep, offshore waters and sometimes deep coastal waters (DotEE, 2019l). They approach close to land only where the continental shelf is narrow, possibly attracted to zones of enhanced prey abundance along the continental slope (DotE, 2019x). However, off Hawaii, both shallow (less than 200 m) and deep water (greater than 2000 m) habitats have been reported for the species (DotE, 2019x).

There are no estimates of false killer whale population size, either globally or for Australia, so the proportion of the global population in Australian waters is unknown. However, abundance estimates in the large area of the eastern tropical Pacific Ocean indicate a population in the low tens of thousands (DotE, 2019x). While, population estimates of 16,000 have been reported for the coastal waters of China and Japan (DotE, 2019x). Australian population abundance is thought to be low and likely that the total number of mature False Killer Whales within Australian waters is less than 10 000 (DotE, 2019x).

Large-scale movements of false killer whales have been reported, however, genetic research is required to confirm whether distinct stocks exist within ocean basins. (DotE, 2019x). The movement patterns of false killer whales off

Australia are primarily based on stranding data. The trends in strandings suggest there may be a seasonal movement inshore or along the continental shelf on the southern and south-eastern coasts between May and September (DotE, 2019x). Mating and calving occur throughout the year, with no known seasonal pattern, and no calving areas are known for Australian waters (DotE, 2019x).

Due to limited sightings and distribution data of true's beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that they would be uncommon visitors in the EMBA.

Curvier's beaked whale

Curvier's beaked whale *(Ziphius cavirostris)* tends to avoid vessels, resulting in few confirmed sightings of this species (DotE, 2019aa). However, sights of seen Curvier's beaked whale have typically been of lone whales, and few of groups up to seven individuals (DotE, 2019aa).

Cuvier's beaked whales are reported to possibly have the most extensive range and be one of the most abundant of any beaked whale species (DotE, 2019aa). Cuvier's beaked whales has a worldwide distribution in all temperate and tropical waters, occurring between approximately 60° N and 55° S 9 (DotE, 2019aa). The species is absent only from polar waters in both hemispheres (DotE, 2019aa). It is thought that Cuvier's beaked whale may form distinct populations within the different ocean basins they occupy, however further studies are required to confirm (DotE, 2019aa). Estimates of Cuvier's beaked whale abundance have been conducted and it is estimated that there may be between 456 000 and 916 000 breeding adults worldwide, of which between 51 000 and 102 000 (11%) may occur in the Southern Hemisphere (DotE, 2019aa). Noting these estimates are based on based on genetic techniques and lack robustness (DotE, 2019aa). Within Australia it is currently thought that Cuvier's beaked whales form part of a South Pacific regional population group.

Cuvier's beaked whale is known in Australian waters from 31 strandings (prior to 1994), mostly from January to July, suggesting some seasonality of occurrence (DotE, 2019aa). Records of Cuvier's Beaked Whale come from Western Australia (five), South Australia (two), Victoria (three), Tasmania (13), NSW (two), Queensland (three), Northern Territory (one), and Macquarie Island (two) (DotE, 2019aa).

Cuvier's beaked whales are not considered abundant in Australia, as sightings and strandings are rare. The species therefore thought to potentially includes less than 10 000 mature individuals within Australian waters (DotE, 2019aa).

Cuvier's beaked whales are considered to be mostly an oceanic species which appears to be confined to waters within the 10° C isotherm and the 1000 m bathymetric contour (Dote, 2019m). Cuvier's beaked whales have rarely been found close to mainland shores, except in submarine canyons or in areas where the continental shelf is narrow and coastal waters are deep (DotE, 2019aa). Although little is known of the preferred habitat for Cuvier's beaked whales in Australian waters, it is likely that similar shelf-edge habitats are utilised along much of Australia's extensive coastline (DotE, 2019aa).

Genetic data suggests that Curvier's beaked whale may exhibit seasonal latitudinal migrations, similar to Humpback Whales (DotE, 2019aa). Given stranding data from Australia occur mostly from January to July, it suggests some seasonality of occurrence. However, year-round records in some portions of its range (namely Japan and New Zealand) suggest that only a portion of the population undergoes seasonal movement. The mating and calving season is inferred to be all year round, as sightings and strandings suggest no seasonal pattern is evident (DotE, 2019aa). No calving areas are known for Australian waters (DotE, 2019aa).

Due to limited sightings and distribution data of true's beaked whale within the South-eastern marine regions, it is difficult to determine likely presence. However, given no BIAs overlapping the EMBA, it is therefore likely that 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 (DotE, 2019h).

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 (DotE, 2019h). They are abundant in the Bonney Upwelling during the upwelling season, and very scarce outside the season. Given the common dolphins association with the Bonney Upwelling which is 104 km from EMBA, it is therefore possible but unlikely that they would be a visitor in the EMBA, given no BIAs have been identified in the EMBA.

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.

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 (DotE, 2019n). 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 (DotE, 2019n). Therefore, it is possibly but unlikely that they would be a visitor passing through 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 (DotE, 2019o). No key localities have been identified in Australian waters however preferred water temperatures range from approximately 2-20°C (DotE, 2019o). 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 (DotE, 2019o). 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 (DotE, 2019o).

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.

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 (DotE, 2019z). 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 (DotE, 2019z).

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.

Appendix B.4 Socio-economic and cultural environment

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

Appendix B.4.1 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.

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery is included in Table B-9-9.

Of these fisheries, the ETBF (Figure B-9-13) and SESSF (Figure B-9-14) may have catch effort within the EMBA based on ABARES reports 2013 – 2019 (Patterson et al. 2019, 2018, 2017, 2016, 2015 and Georgeson et al. 2014) (Table B-9-9). The ETBF has not had catch effort within the OA and only had catch effort within the EMBA in 2017. 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-9-9.

Engagement with AFMA was undertaken in relation to providing licensing information for any Commonwealth fishers who are active within the OA. AFMA replied that there are currently three active SESSF operators within the OA and over the last 10 years there has been up to 7 operators (Stakeholder Record AFMA_04). These fishers use otter-board trawls in this area (SETFIA, 2019).

Table B-9-9: Commonwealth managed fisheries within the EMBA

Fishery	Target species	Description	Fishing Effort in EMBA
Bass Strait Central Zone Scallop Fishery	Commercial scallops	Fishery operates in the Bass Strait between the Victorian and Tasmanian and starts at 20 Nm from their respective coastlines. In 2018 fishing effort is concentrated on beds east of King Island. Currently 12 active boats using towed dredges. Fishing season is 1 April to 31 December. Actual catch in 2018 was 3,253 tonnes. The major landing ports in Victoria are Apollo Bay and Queenscliff. Total fishery gross value of production in 2017-2018 was A$6.7 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 – 2018.	No
Eastern Tuna and Billfish Fishery (ETBF)	Swordfish, Yellowfin tuna (primary) Albacore tuna, Bigeye tuna, Broadbill, Striped marlin (secondary)	A longline and minor line fishery that operates in water depths > 200 m from Cape York to Victoria. The number of active vessels in the fishery has decreased in the past decade (from around 150 in 2002 to 37 in 2016), likely associated with decline in economic conditions and the removal of vessels through the Securing our Fishing Future structural adjustment package in 2006–07 (Patterson et. al., 2019). Fishery effort is typically concentrated along the NSW coast and southern Queensland coast. No Victorian ports are used. Catch declined from 4,624 tonnes in 2017 to 4,046 tonnes in 2018. Swordfish and yellowfin tuna continue to be the main target species. Fishing mortality: Not subject to overfishing. Biomass: Not over fished. There has been no fishing effort in the OA based on ABARES data 2013 – 2018. There has been fishing effort within the EMBA in 2017 based on ABARES data 2013 – 2018.	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 (west), Blue mackerel (west), Redbait (west), 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 of the western sub-area was 17,750 tonnes in the 2018-19 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 – 2018.	No

Fishery	Target species	Description	Fishing Effort in EMBA
Southern and Eastern Scalefish and Shark Fishery (SESSF) *(South East Trawl Sector, Gillnet and Shark Hook Sector, Scalefish Hook Sector*	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 South East Trawl Sector, Gillnet and Shark Hook Sector and the Scalefish Hook Sector. A multi-sector, multi-species fishery that uses a range of gear year-round. Fishing is generally concentrated along the 200 m bathymetric contour. Within the EMBA trawl, gillnet and hook fishing methods are employed. 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 – 18.	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 – 2018.	No
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. In the OA and EMBA there has been no catch effort for the squid jig fishery from 2013 – 2018. However, the OA and EMBA overlap the area where squid are caught by the Commonwealth Trawl Sector as incidental catch by demersal trawling. There has been no fishing effort in the EMBA based on ABARES data 2013 – 2018.	No

Data/information sources: Australian Fisheries Management Authority (www.afma.gov.au), ABARES Fishery Status Reports 2014 to 2019.

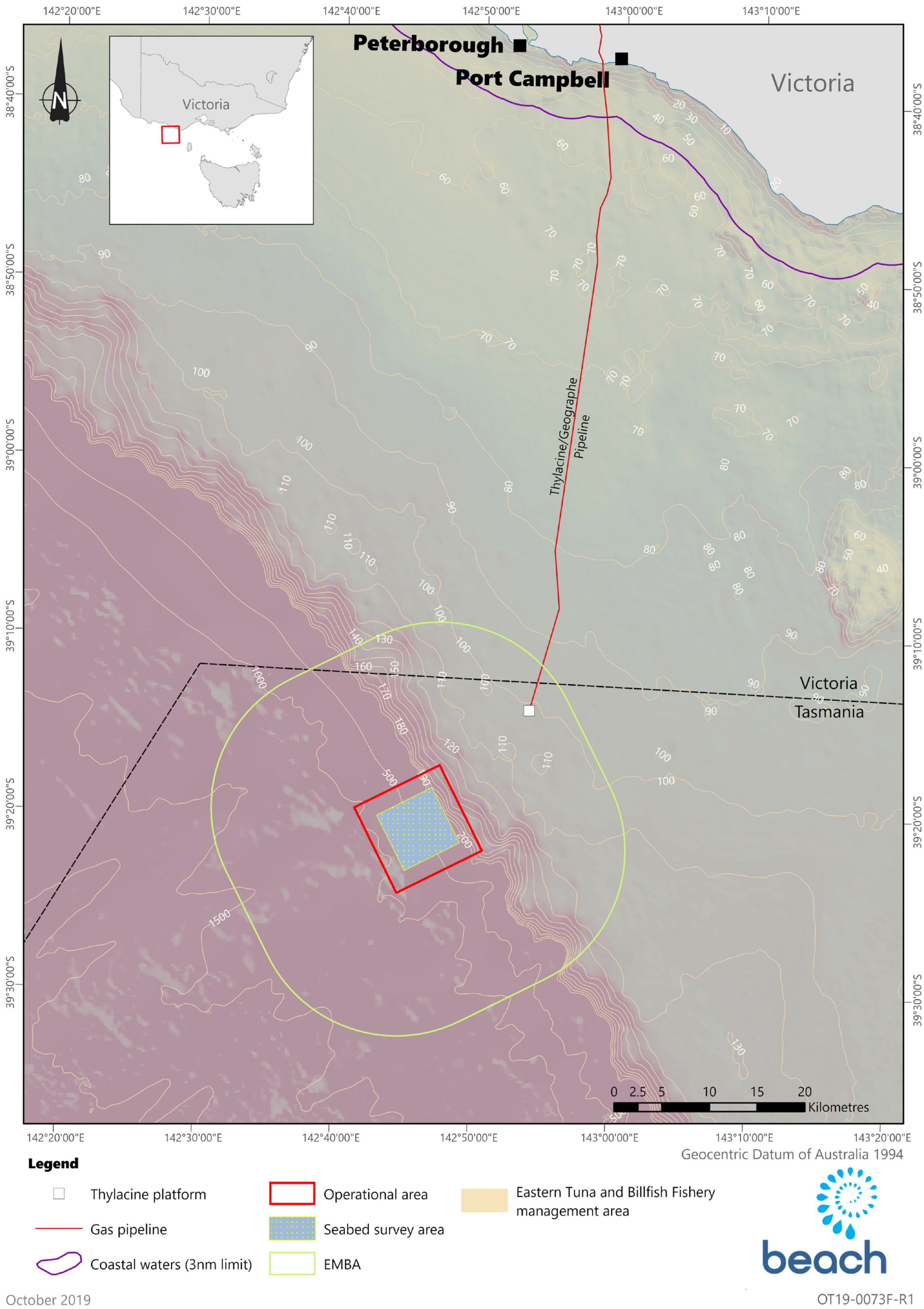


Figure B-9-13: Eastern Tuna and Billfish Fishery management area

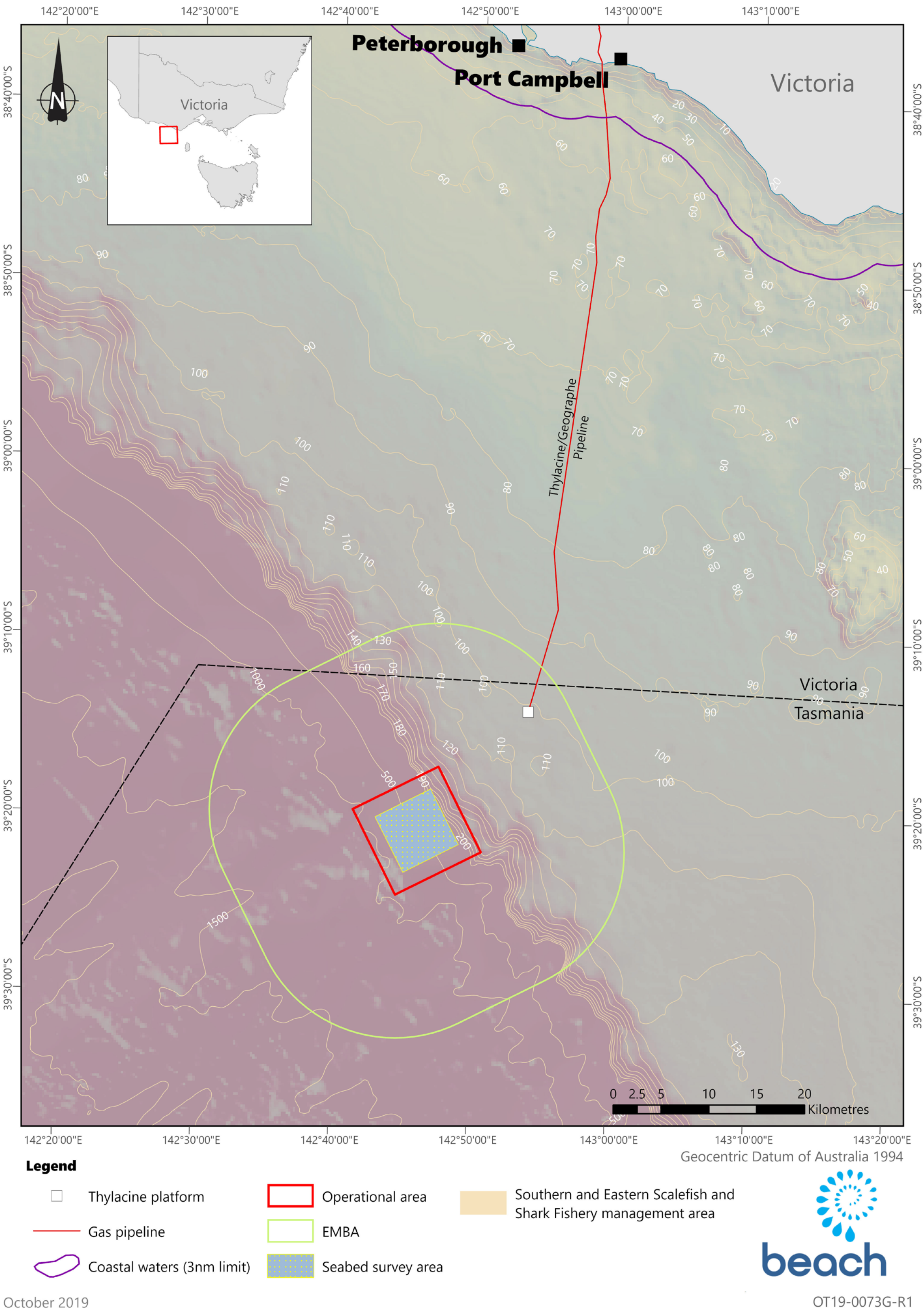


Figure B-9-14: Southern and Eastern Scalefish and Shark Fishery management area

Appendix B.4.2 Victorian managed fisheries

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

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

A description of these fisheries is detailed in (Table B-9-10).

To identify those fisheries that are active within the OA, catch data was requested from the VFA. for the following grids:

- L10, L11, L12
- M10, M11, M12.

For L10 -12 fisheries catch effort data was provided by VFA in the form of monthly catch data per fishery grid area (graticular blocks) for each species with catch (t) and number of fishers for the period of 2014 – 2018 (Stakeholder Record VFA_11). Data for grid rows M10 - M12 was were requested from VFA separately and was not provided in the same format as original the other data. VFA provided the following: “The information you have requested have catch from <5 fishers, so very little data can be provided” (Stakeholder Record VFA_53). Figure B-9-15 details the fishery grid system.

From the data obtained from the VFA it was identified that only the Rock Lobster and Giant Crab fisheries have consistent catch effort within the graticular fishing block grids within the EMBA (Table B-9-11 and Table B-9-12). This aligns with data obtained from Victorian Fisheries Authority (www.vfa.vic.gov.au) as detailed in Table B-9-10.

For the Rock Lobster Fishery, it is unlikely there is catch effort within the OA as southern rock lobsters are found to depths of 150 m, with most of the catch coming from inshore waters less than 100 metres deep (VFA, 2017). The water depth of the OA is 150 – 1,110m.

For the Giant Crab Fishery there is the potential for some overlap with the OA as the giant crabs inhabit the continental slope at approximately 200 m depth and are most abundant along the narrow band of the shelf edge.

The 2014 to 2018 data from the VFA in relation to the Rock Lobster and Giant Crab and Rock Lobster fisheries is shown in Table B-9-11 and Table B-9-12. 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 several grids in a month.

For the Rock Lobster Fishery, the data shows:

- There is a low level of fishing of less than five operators with no consistency of timing.
- No fishing occurred in 2014 or 2018.
- In 2015 fishing only occurred in L12 in one month (April).
- In 2016 fishing occurred in L11 (Jan and Apr), M11 and M12.

- In 2017 fishing occurred in L12 (Aug) and M12.
- In 2019 fishing occurred in M11 and M12.

For the Giant Crab Fishery, the data shows:

- There is a low level of fishing of less than five operators with no consistency of timing.
- Fishing has occurred in L11, M11 and M12 in all years except for M11 in 2017.

Table B-9-10: 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$20 - A$24 million from 2015 to 2018. In 2017-18, annual 230 tonnes and have been fully caught each year. For the subsequent 2018/19 season the quota has been increased to 245t as a result of the introduction of the harvest strategy. 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. It is unlikely there is catch effort within the OA as southern rock lobsters are found to depths of 150 m, with most of the catch coming from inshore waters less than 100 metres deep (VFA, 2017). The water depth of the OA is 150 – 1,110m. Fishing data from VFA for 2014 – 2018 (Figure B-9-15) show that there is fishing effort within the EMBA.	Yes
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 2017- 18 was 10.3 tonnes. Fishing data from VFA for 2014 – 2018 (Figure B-9-16) show that there is fishing effort within the EMBA.	Yes
Abalone Fishery (western zone)	Blacklip abalone Greenlip abalone	A highly valuable fishery (A$20 - $27million from 2015 to 2018) 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

Fishery	Target species	Description	Fishing Effort EMBA
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

Data/information sources: Victorian Fisheries Authority (www.vfa.vic.gov.au), VFA (2017), VFA (2019) DPI (2015),

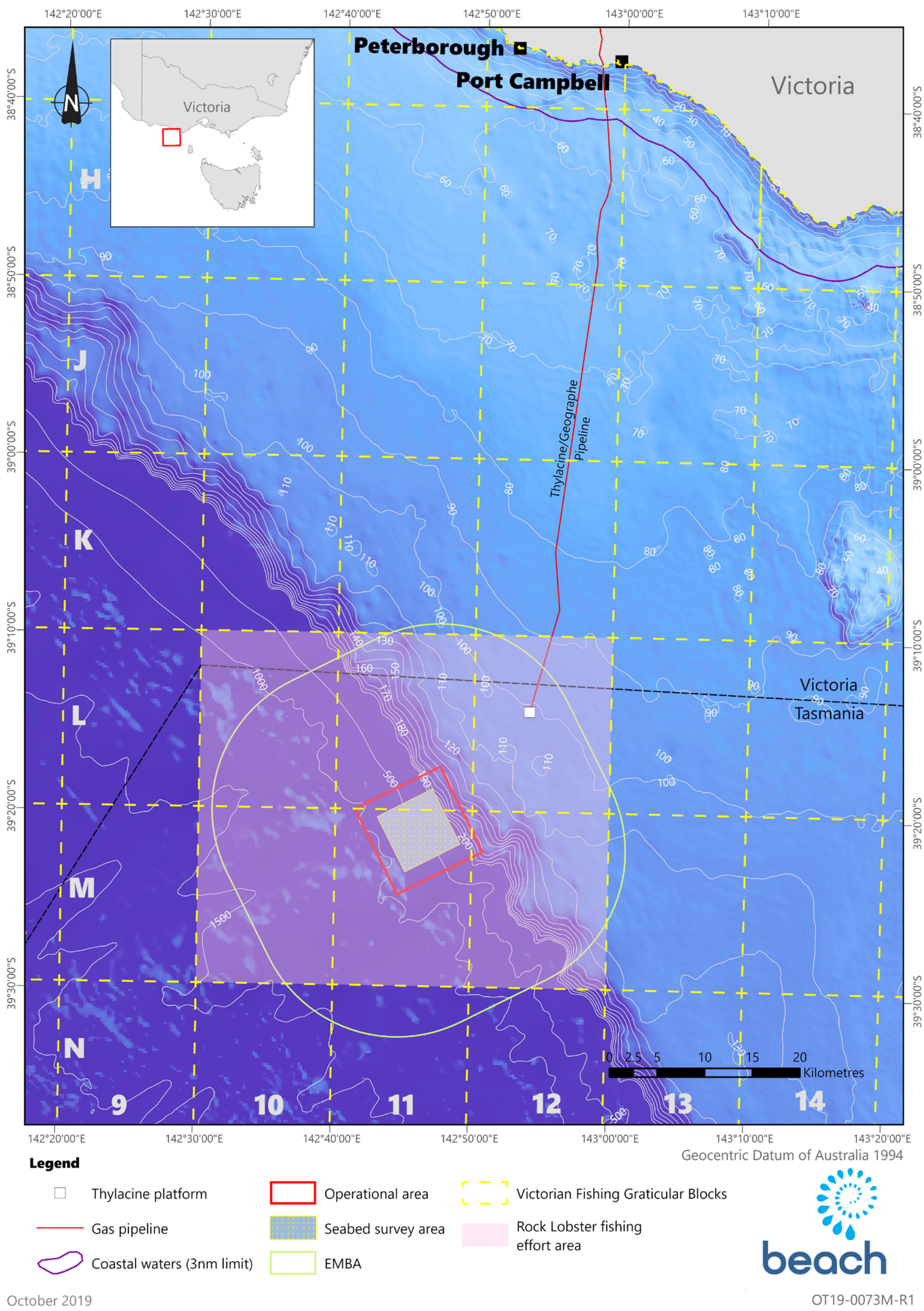


Figure B-9-15: Rock Lobster Fishery catch effort 2014 – 2018.

Table B-9-11: Rock Lobster Fishery fisher effort per grid per month for L10 to L12 for period 2014 to 2019 and presence per year for M10 to M12 for period 2014 to 2019.

Month	L10	L11	L12	Year	M10	M11	M12
Jan 2014				2014			
Feb 2014							
Mar 2014							
Jul 2014							
Sep 2014							
Dec 2014							
Jan 2015				2015			
Feb 2015							
Apr 2015			1				
May 2015							
Jan 2016		1		2016	✓	✓	✓
Feb 2016							
Mar 2016							
Apr 2016		1					
May 2016							
Feb 2017				2017			✓
Mar 2017							
Apr 2017							
May 2017							
Aug 2017			1				
Feb 2018				2018			
Aug 2018							
Sep 2018							
Dec 2018							
[redacted]				2019		✓	✓

Note: Data only shows those time periods where there was fishing effort. VFA data provided for L10 to L12 was in the form of monthly catch data per fishery grid area (graticular blocks) for each species with catch (t) and number of fishers for the period of 2014 to 2018. While for M10 to M12 VFA provided annual presence absence data for fish species caught for period 2014 to 2019.

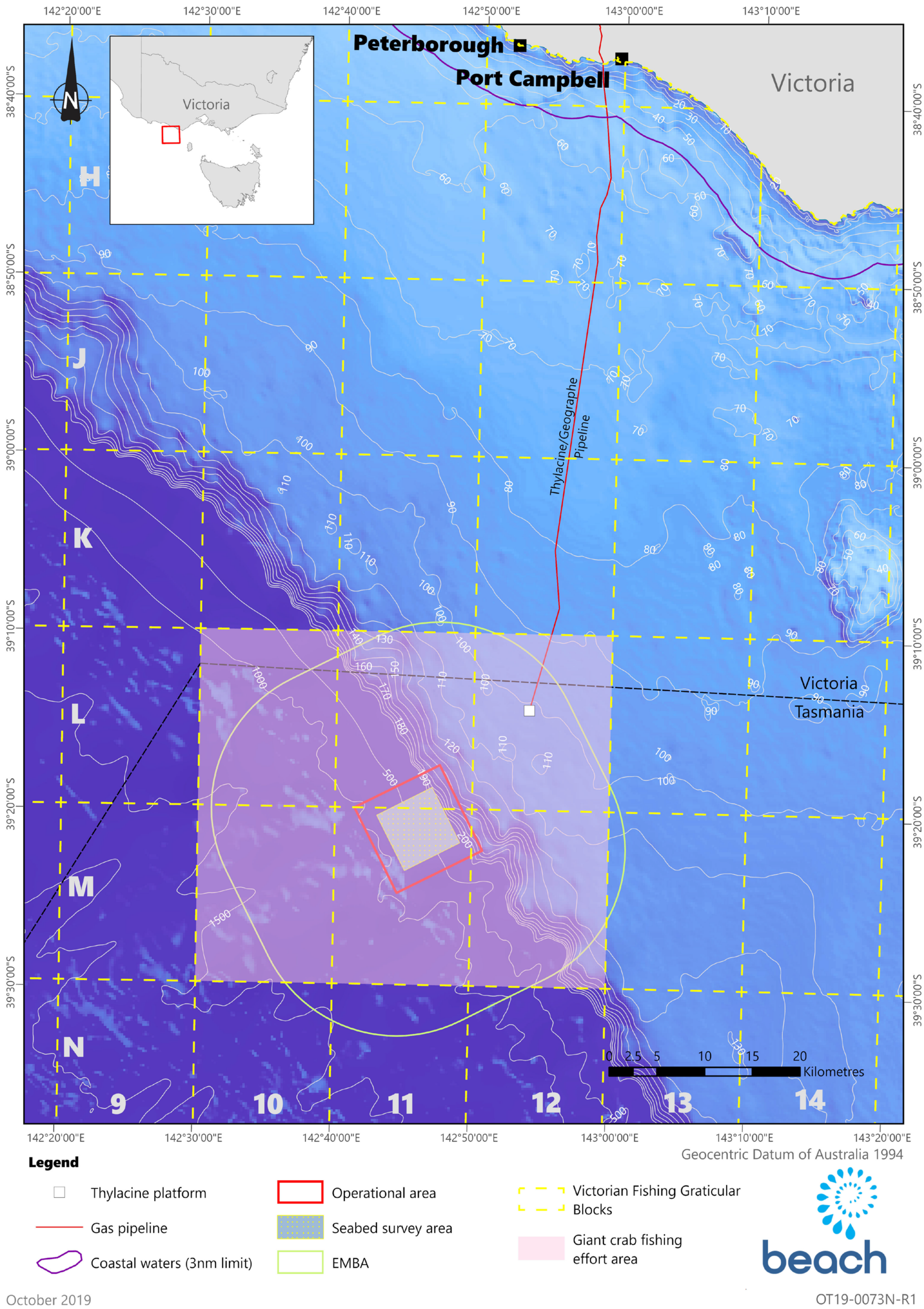


Figure B-9-16: Giant Crab Fishery catch effort 2014 – 2018.

Table B-9-12: Giant Crab Fishery fisher effort per grid per month for L10 to L12 for period 2014 to 2019 and presence per year for M10 to M12 for period 2014 to 2019.

Month	EMBA L10	OA L11	EMBA L12	Year	EMBA M10	OA M11	OA M12
Jan 2014				2014		✓	✓
Feb 2014							
Dec 2014		1					
Jan 2015				2015		✓	✓
Feb 2015							
Nov 2015		1					
Dec 2015		1					
Jan 2016		1		2016	✓	✓	✓
Mar 2016		1					
Apr 2016		1					
May 2016							
Mar 2017		1		2017			✓
Apr 2017		1					
May 2017	1	1					
Jun 2017	1						
Aug 2017		1	1				
Jan 2018		1		2018		✓	✓
May 2018		1	1				
Jun 2018			1				
Aug 2018							
Dec 2018			1				
[redacted]				2019		✓	✓

Note: Data only shows those time periods where there was fishing effort. VFA data provided for L10 to L12 was in the form of monthly catch data per fishery grid area (graticular blocks) for each species with catch (t) and number of fishers for the period 2014 to 2018. While for M10 to M12 VFA provided annual presence absence data for fish species caught for period 2014 to 2019.

Appendix B.4.3 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.

Appendix B.4.4 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.4.5 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.4.6 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-9-17). 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.

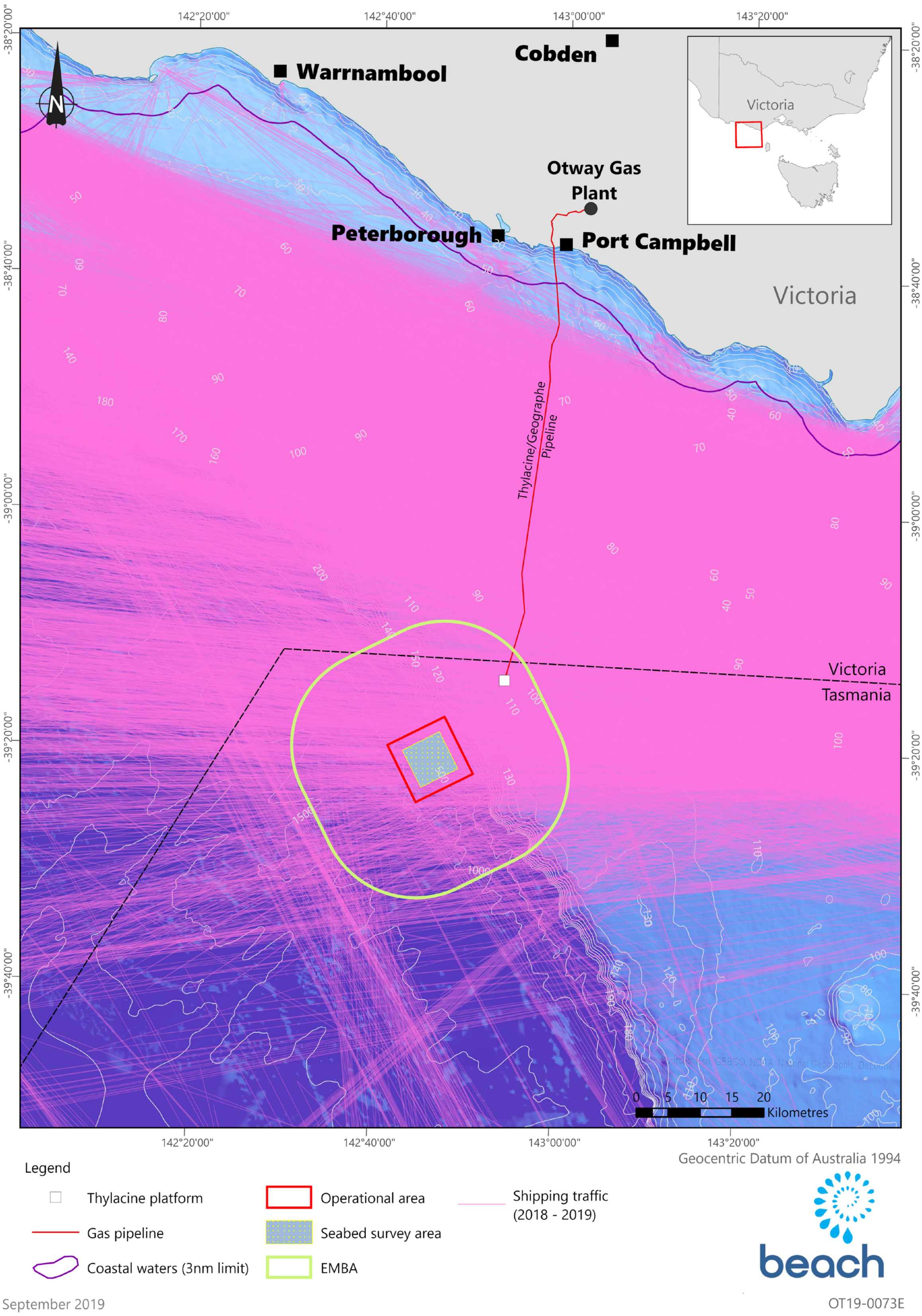


Figure B-9-17: Map of the main shipping lanes in the Bass Strait 2018 to 2019.

Appendix B.4.7 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.

From a review of the NOPSEMA website and engagement with other oil and gas exploration companies a summary of exploration activities that may occur within the OA within the same time period as the site survey are detailed in Table B-9-13. From this review the Spectrum Otway Deep Marine Seismic Survey overlaps the site survey in location and timing.

Table B-9-13: Petroleum exploration potentially within the OA

Titleholder	Activity	Timing and Duration	Area of Overlap
Spectrum Geo Australia Pty Ltd	Otway Deep Marine Seismic Survey	Oct 2019 to end Feb 2020 120 days	Figure B-9-18 shows that the Spectrum acquisition area overlaps a proportion of OA. Based on information on the NOPSEMA website the survey period is for Oct 2019 and 28 Feb 2020 which overlaps the site survey for the month of February. https://info.nopsema.gov.au/activities/336/show_public
Schlumberger Australia Pty Ltd	Otway Basin 2DMC Marine Seismic Survey	Nov 2019 – June 2020 100 days	Figure B-9-19 shows that one 2D seismic line overlaps the OA. Based on information on the NOPSEMA website the survey period is for Nov – June 2020 within no acquisition in the OA between 1 Nov 2019 to 30 April 2020. Thus, there is no overlap with this survey. https://info.nopsema.gov.au/activities/5/show_public
3D Oil T49P Pty Ltd	Dorrigo 3D Marine Seismic Survey	1 Sep - 31 Oct 2019 35 days	Figure B-9-20 shows no overlap with 3D Oil operational area and there is ~ a 40 km separation between the OA and the 3D Oil operational area. Based on information on the NOPSEMA website the survey period is for 1 Sep - 31 Oct 2019 which is outside the period for the site survey. Thus, there is no overlap with this survey. https://info.nopsema.gov.au/activities/344/show_public Feedback from 3D Oil is that the survey may be undertaken within Q3 or Q4 in 2020 (Stakeholder Record 3D_02). Thus, there is not overlap with this survey.

Appendix B.4.8 Petroleum production

There is no non-Beach oil and gas infrastructure within the OA. 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-9-18).

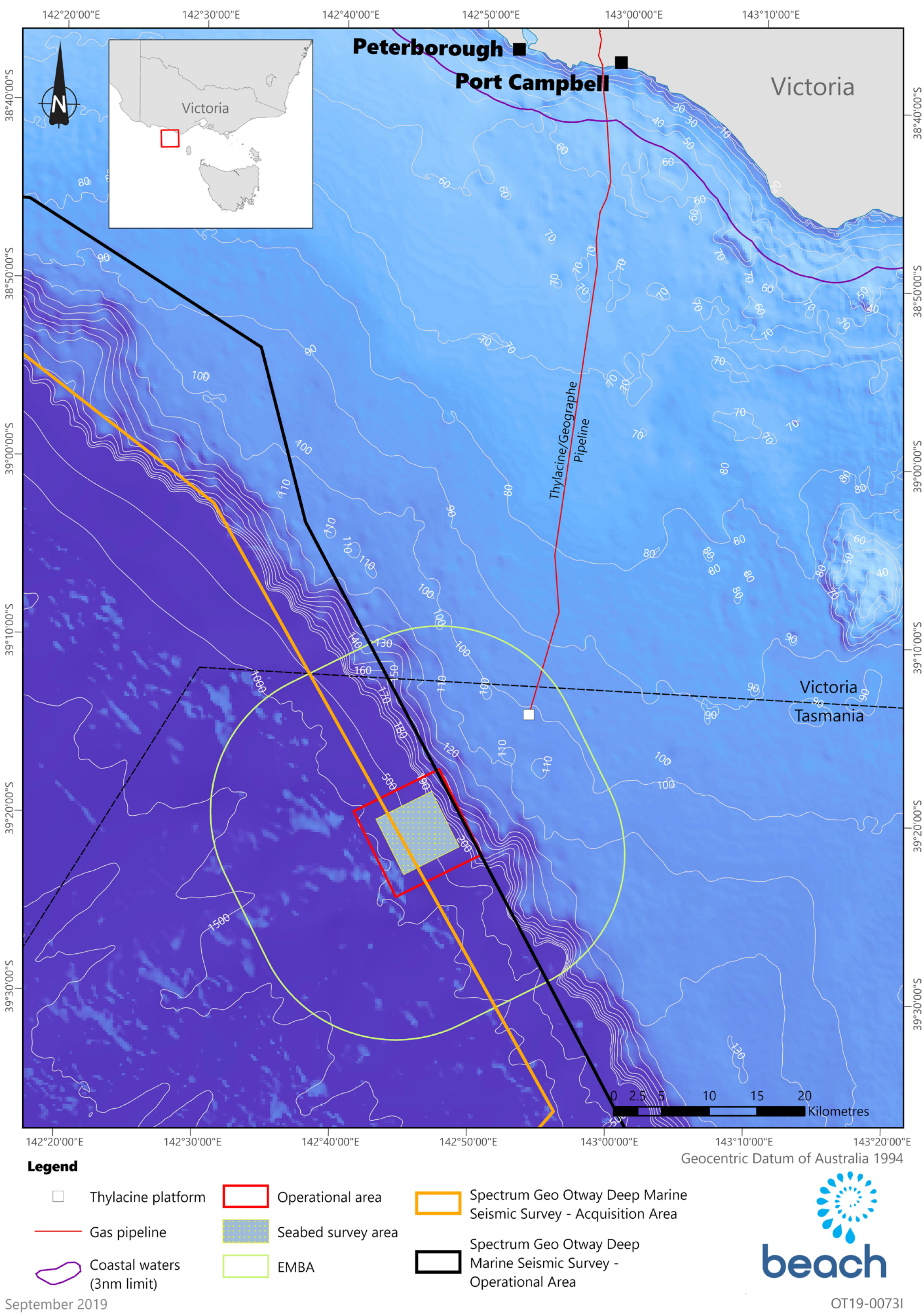


Figure B-9-18: Spectrum Geo Otway Deep Marine Seismic Survey overlap with Operational Area.

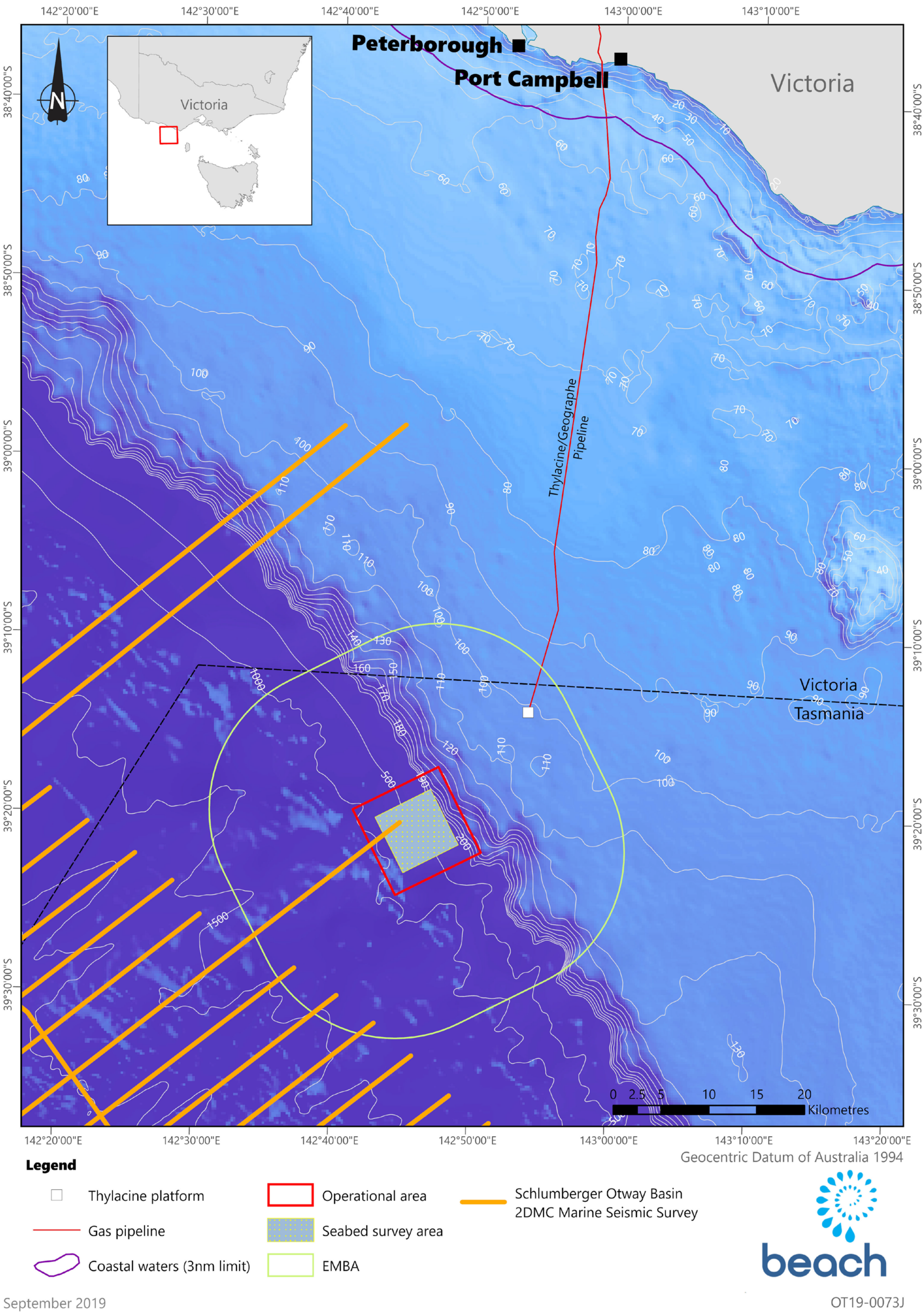


Figure B-9-19: Schlumberger Otway Basin 2D Seismic Survey overlap with Operational Area.

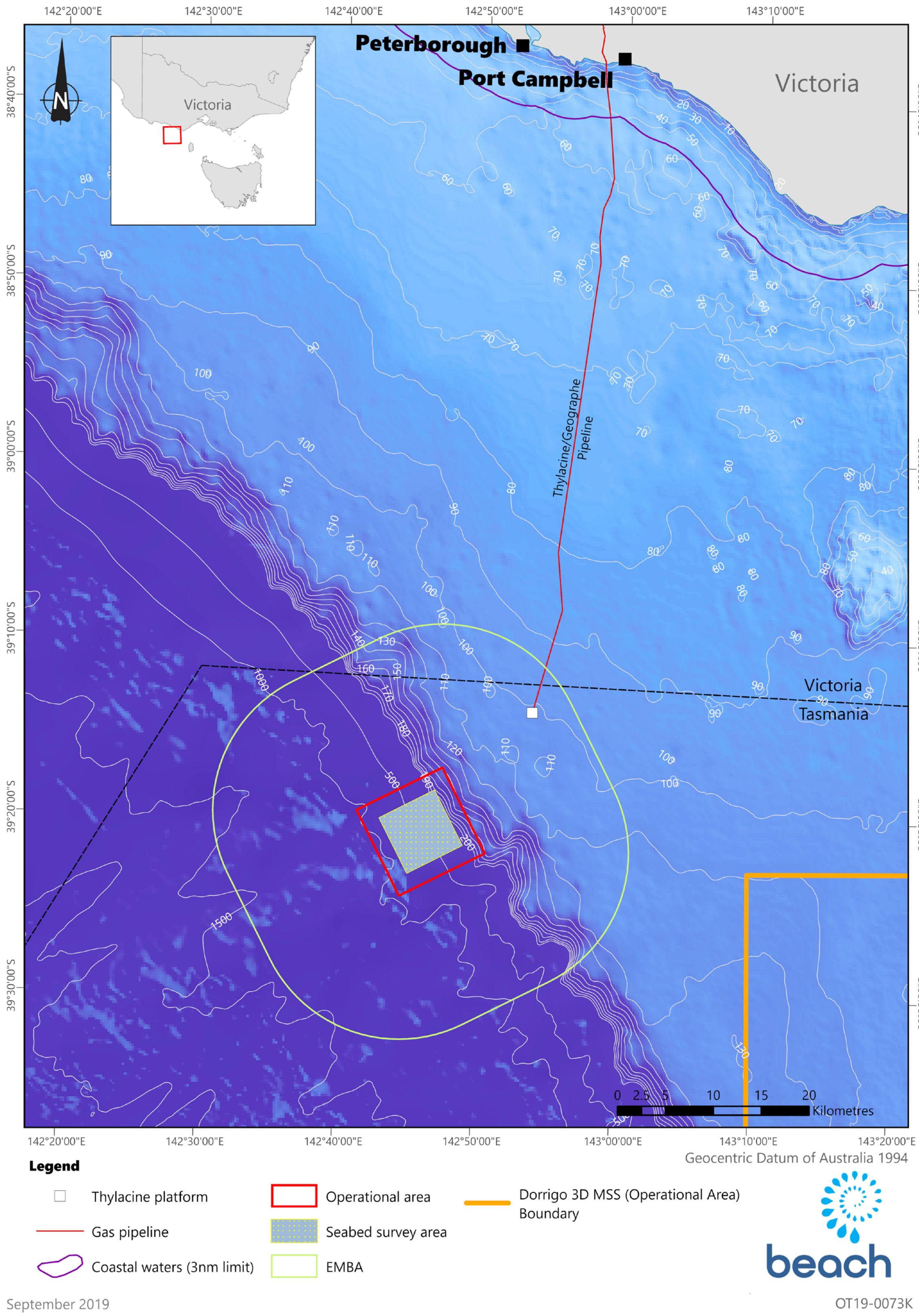


Figure B-9-20: 3D Oil Dorrigo 3D Marine Seismic Survey.

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Appendix C Geophysical Survey JASCO Acoustic Modelling Report

Otway Basin Geophysical Operations Acoustic Modelling

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

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Lattice Energy

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10 May 2019

P001359-001
Document 01473
Version 1.0

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Document Version Control

Version	Date	Name	Change
1.0	2017 November 02	C. McPherson	Final submitted to client

Suggested citation:

McPherson, C., M. Wood. 2017. *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures*. Document 01473, Version 1.0. Technical report by JASCO Applied Sciences for Lattice Energy.

Contents

Figures

Tables

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 µPa^2·s (DEWHA 2008) within 1.03 km of the 450 in^3 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

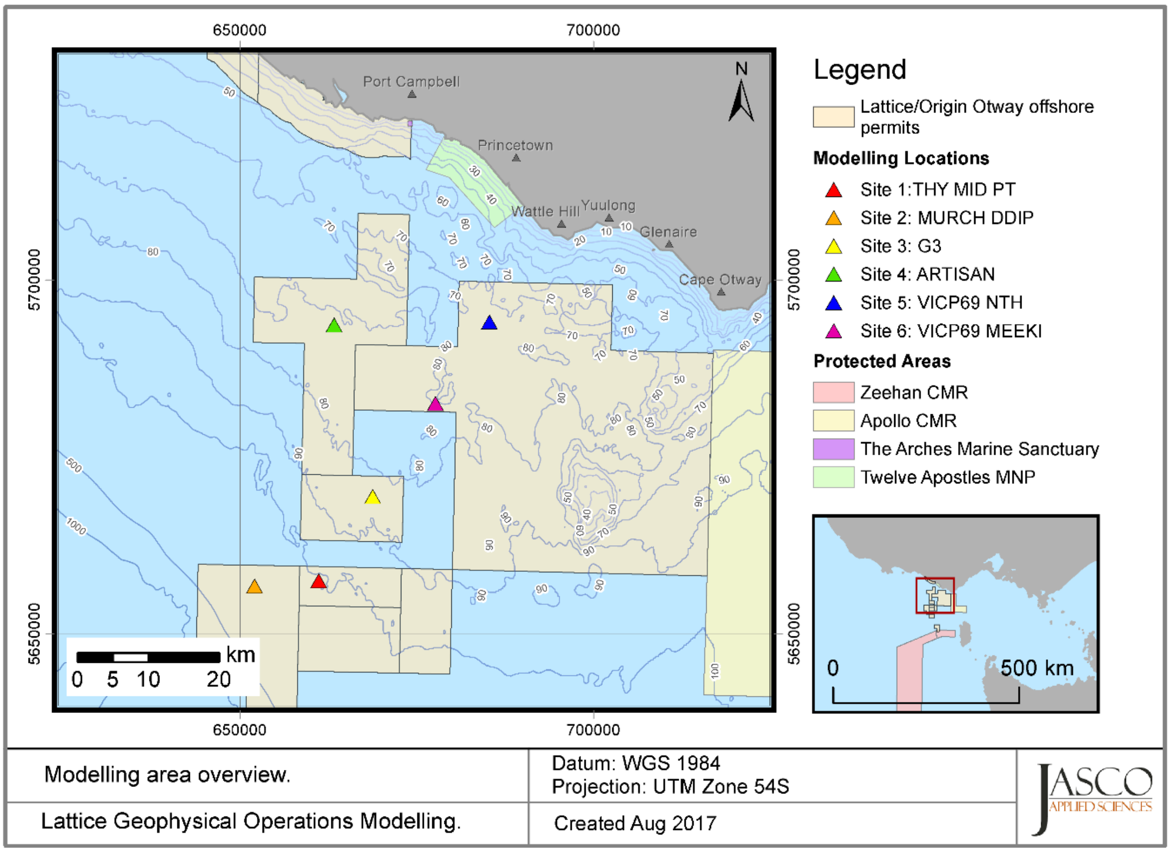

Figure 1. Single pulse modelling site locations and relevant features, including Commonwealth Marine Reserves (CMR), and Marine National Parks (MNP)

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.

<table>
<tr><th rowspan="3">Hearing group</th><th>DEWHA (2008)</th><th>NMFS (2013)</th></tr>
<tr><th rowspan="2">Unweighted per-pulse SEL (dB re 1 µPa²·s)</th><th>Behaviour</th></tr>
<tr><th>SPL (dB re 1 µPa)</th></tr>
<tr><td>Low-frequency cetaceans</td><td rowspan="3">160</td><td rowspan="5">160</td></tr>
<tr><td>Mid-frequency cetaceans</td></tr>
<tr><td>High-frequency cetaceans</td></tr>
<tr><td>Phocid pinnipeds in water</td><td>Not Applicable</td></tr>
<tr><td>Otariid pinnipeds in water</td><td>Not Applicable</td></tr>
</table>

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	

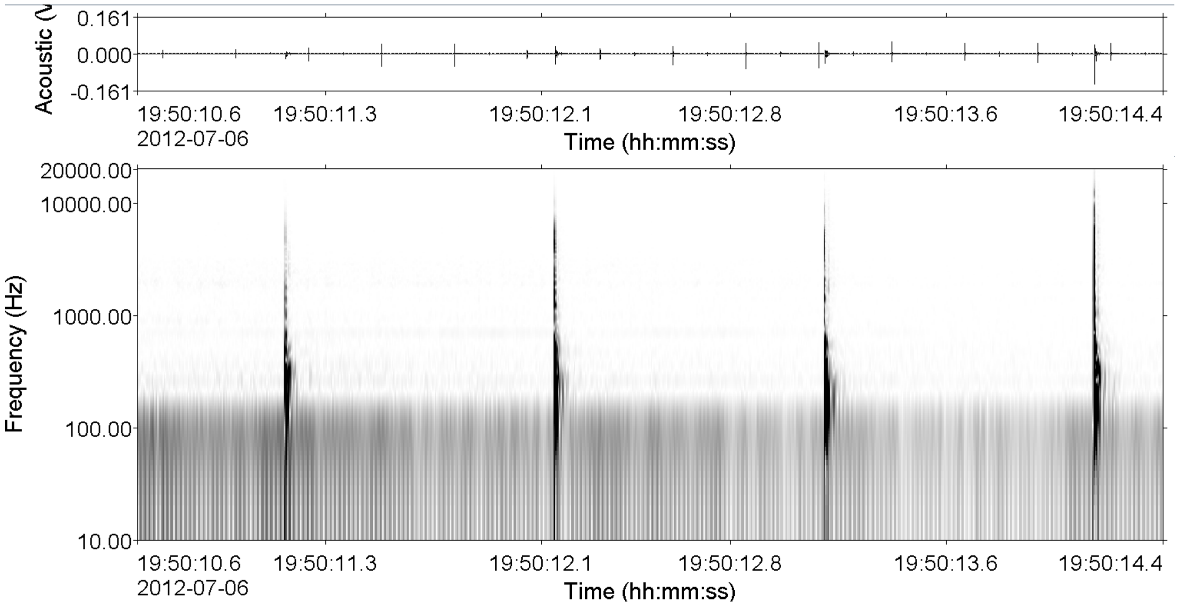

Figure 2. Spectrogram of dual-plate boomer (1000 J) pulses at the closest point of approach. Majority of energy is between 100 and 1000 Hz, with some energy at up to 10 kHz. (131,072 point FFT, 7000 data points, 3500 point overlap, Figure 15 in Martin et al. (2012)).

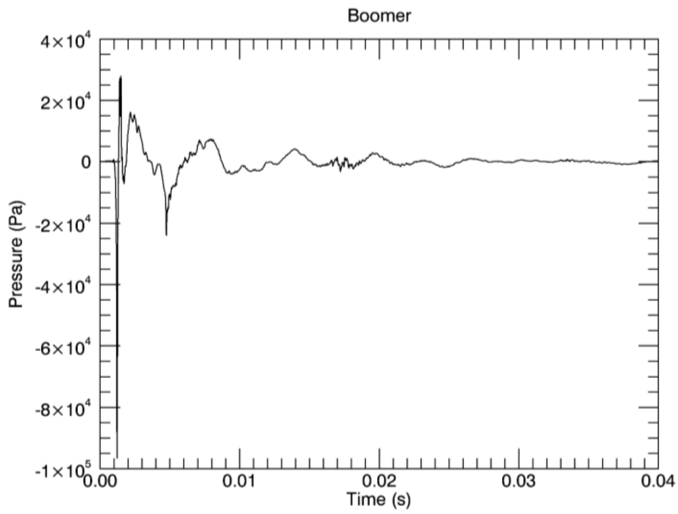

Figure 3. Back-propagated and scaled boomer source signature calculated from measurements (Martin et al. 2012).

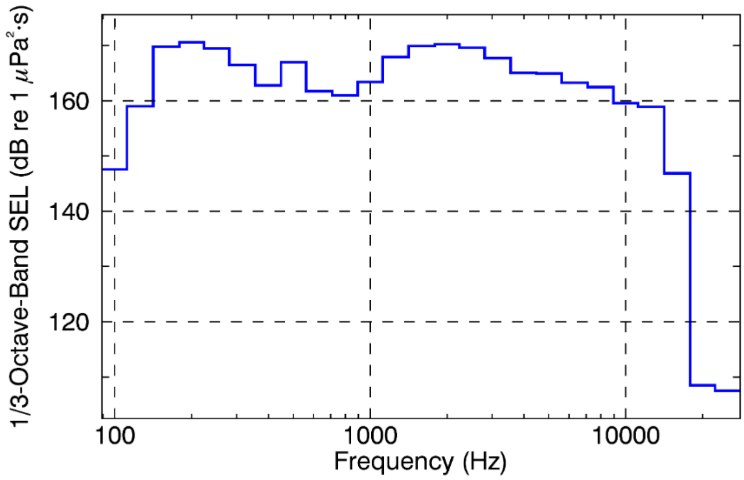

Figure 4. Boomer source spectra calculated from measurements (Martin et al. 2012).

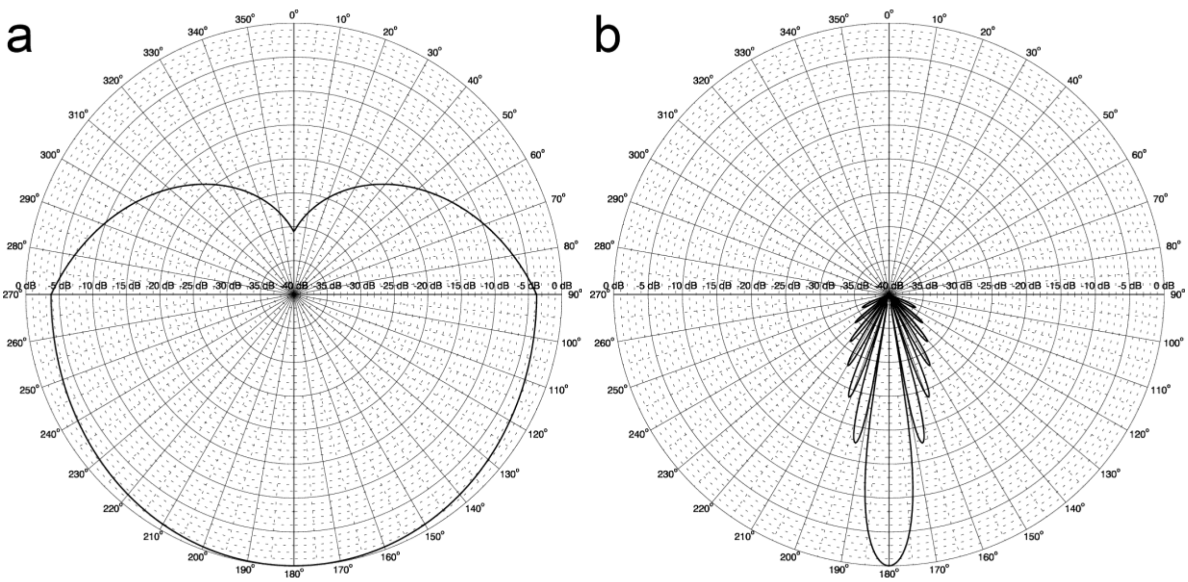

Figure 5. Calculated beam pattern vertical slice for the AA202 boomer plate at (a) 1.25 and (b) 16.0 kHz; across-track direction.

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	

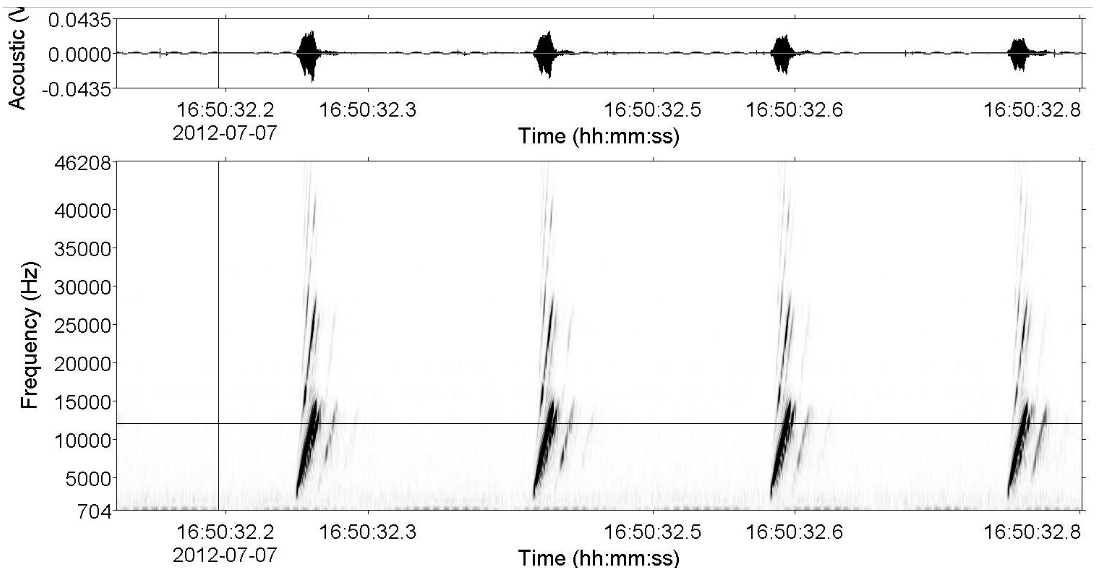

Figure 6. Spectrogram of X-Star SB-216S Sub-Bottom Profiler at closest-point of approach. The centroid frequency of the pulses was approximately 10 kHz, with 90% of the energy between 6 and 13 kHz. Aliased energy is visible above the main pulse. The bottom reflection is visible about 15 ms after the main pulse. (131,072 point FFT, 690 real data points, 345 point overlap.)

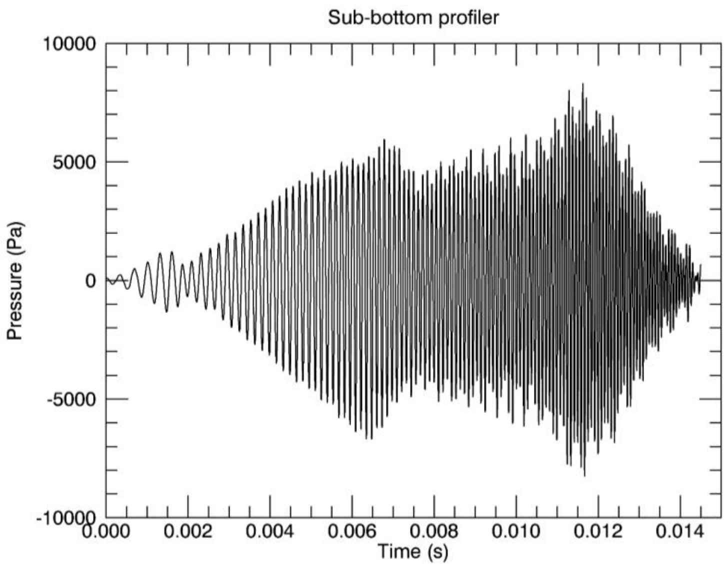

Figure 7. Back-propagated and scaled sub-bottom profiler source signature calculated from measurements (Martin et al. 2012).

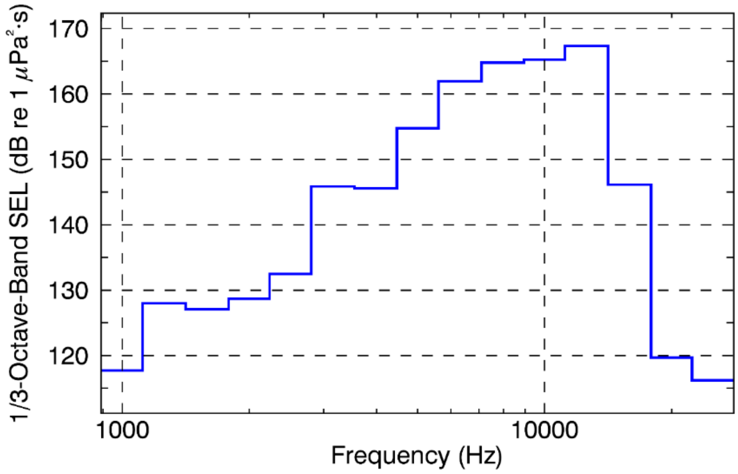

Figure 8. Sub-bottom profiler source spectra calculated from measurements (Martin et al. 2012).

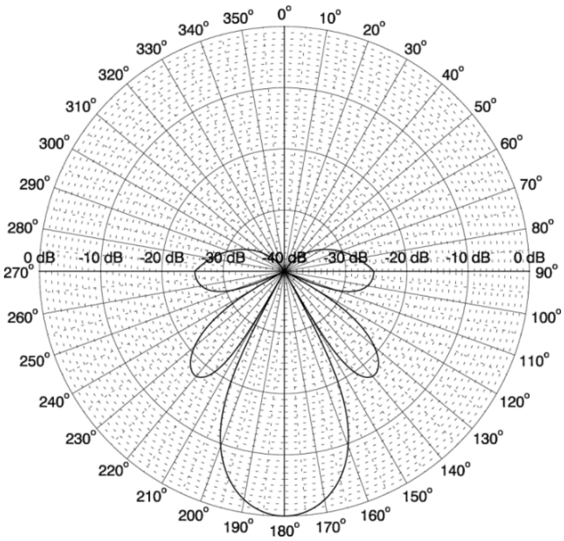

Figure 9. Calculated beam pattern vertical slice for the EdgeTech X-Star sub-bottom profiler at central frequency of 9 kHz.

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.

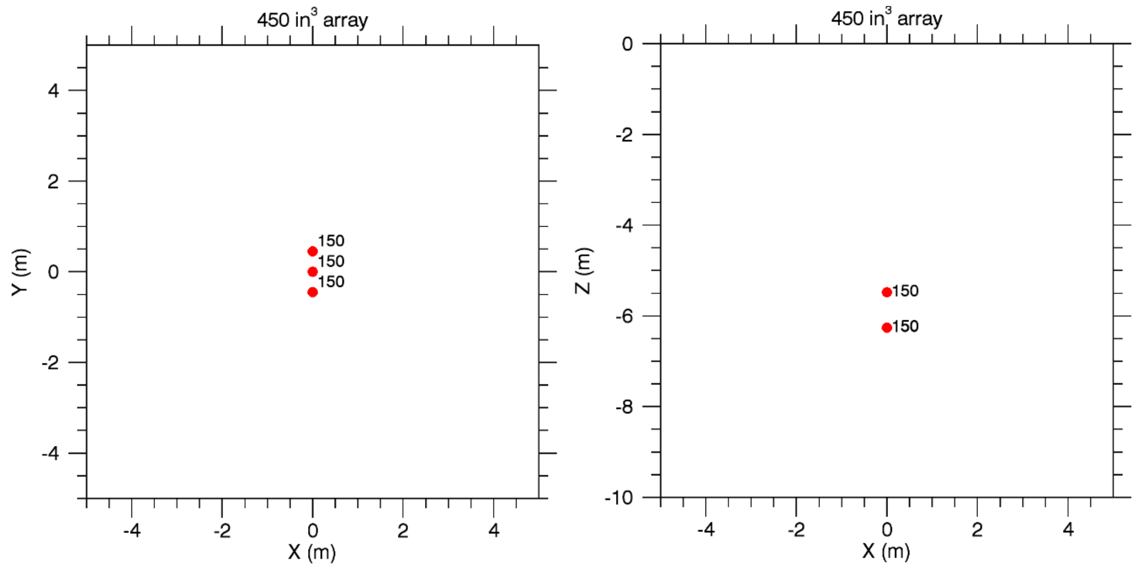

Figure 10. Layout of the modelled 450 in³ VSP array, plan view (left) and side view (right). Centroid operating depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. The convention is that the array is towed in the positive x direction. Also see Table 6.

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.

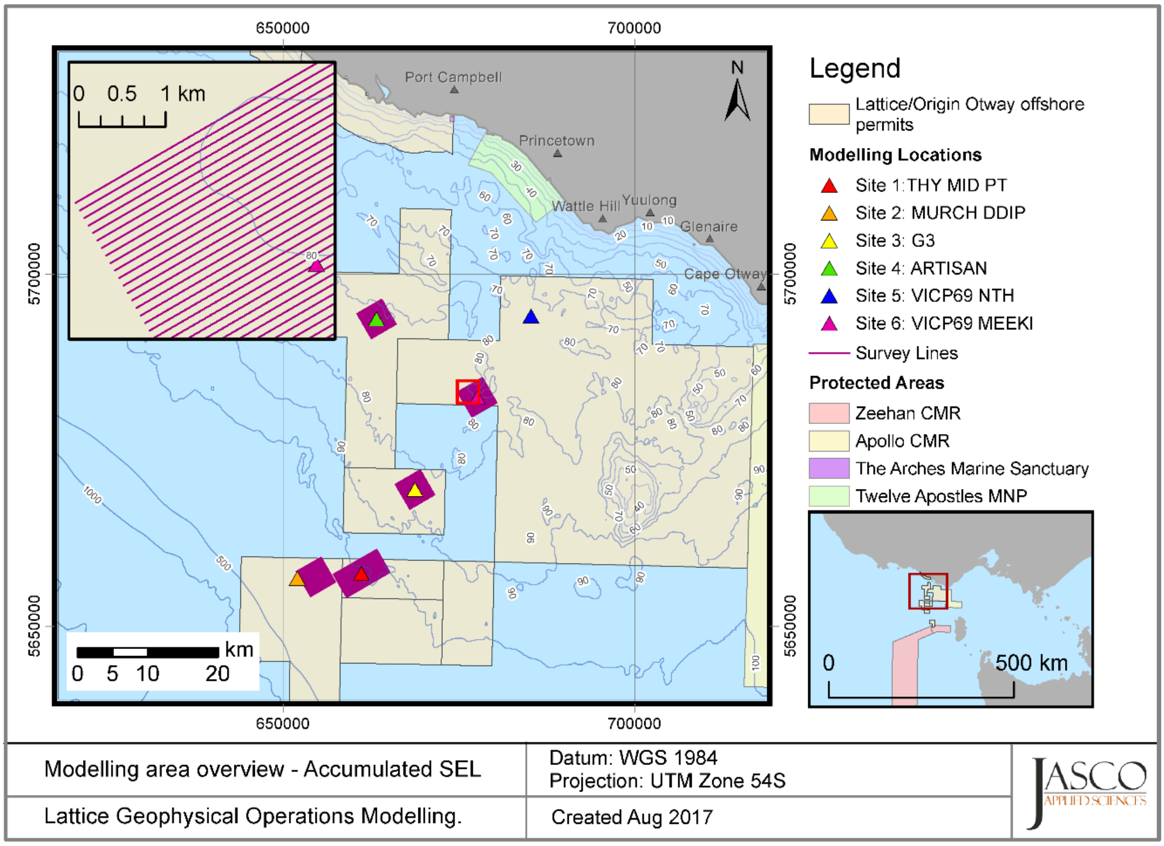

Figure 11. Overview of site surveys (and survey lines) under consideration. The site surveys are referred to by the name of the modelling location located at the same site.

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 in³ 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.

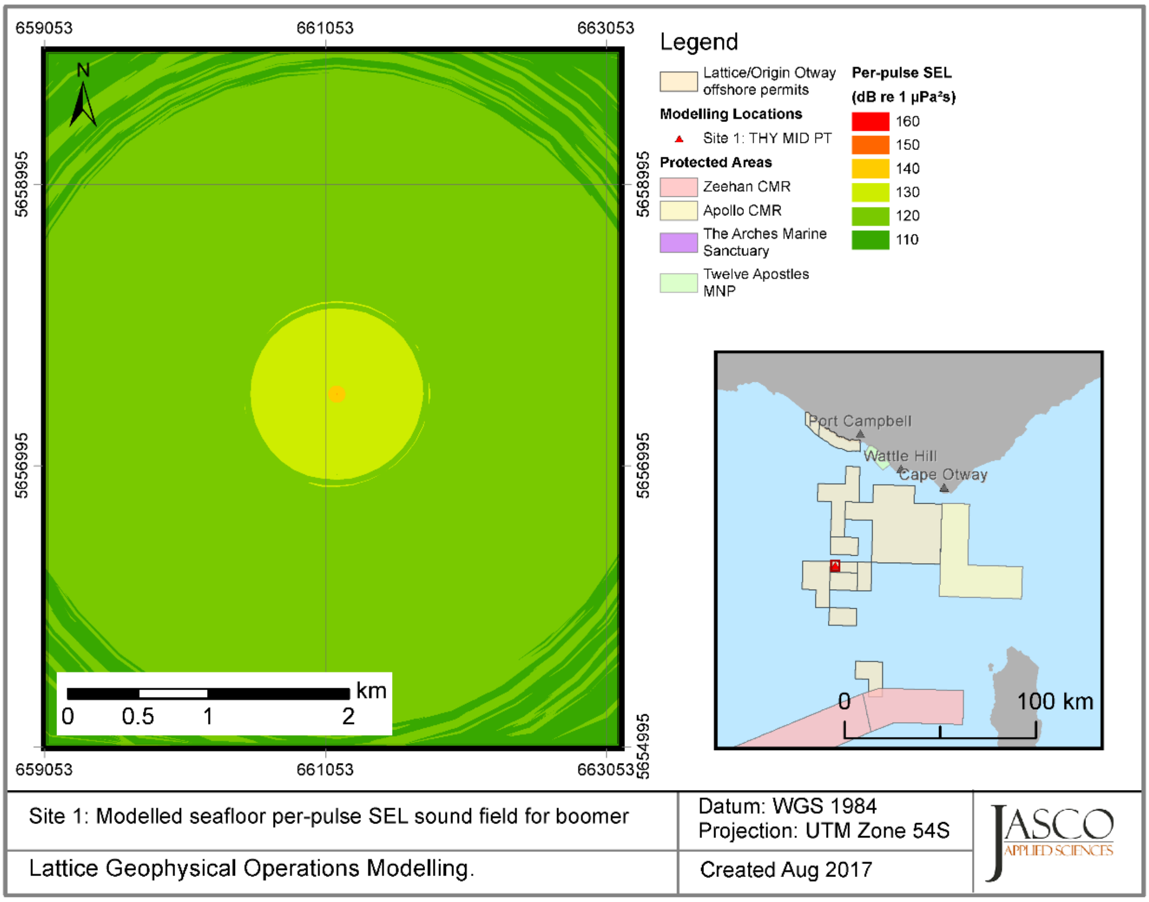

Figure 12. Boomer, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

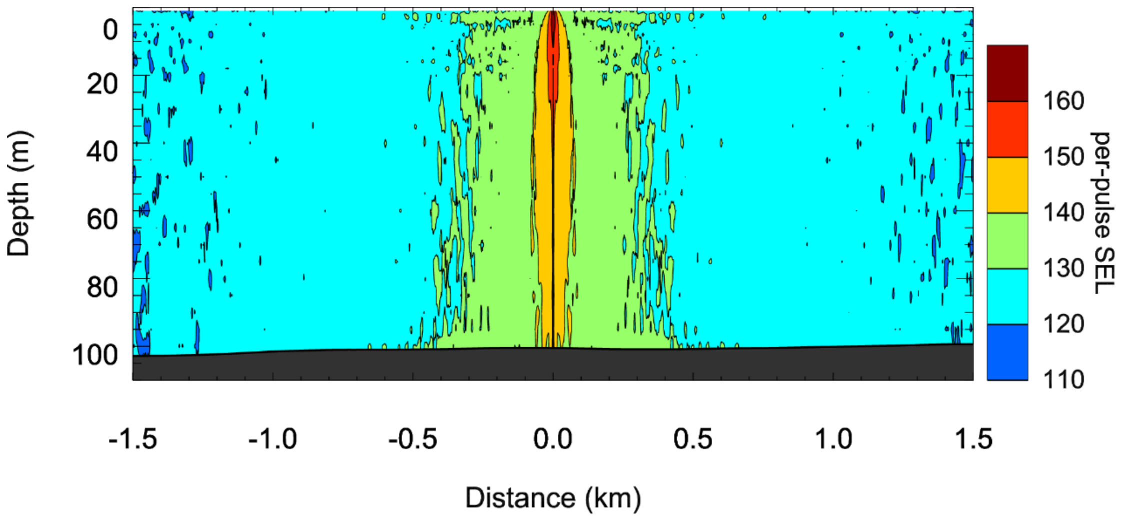

Figure 13. Boomer, Site 1: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

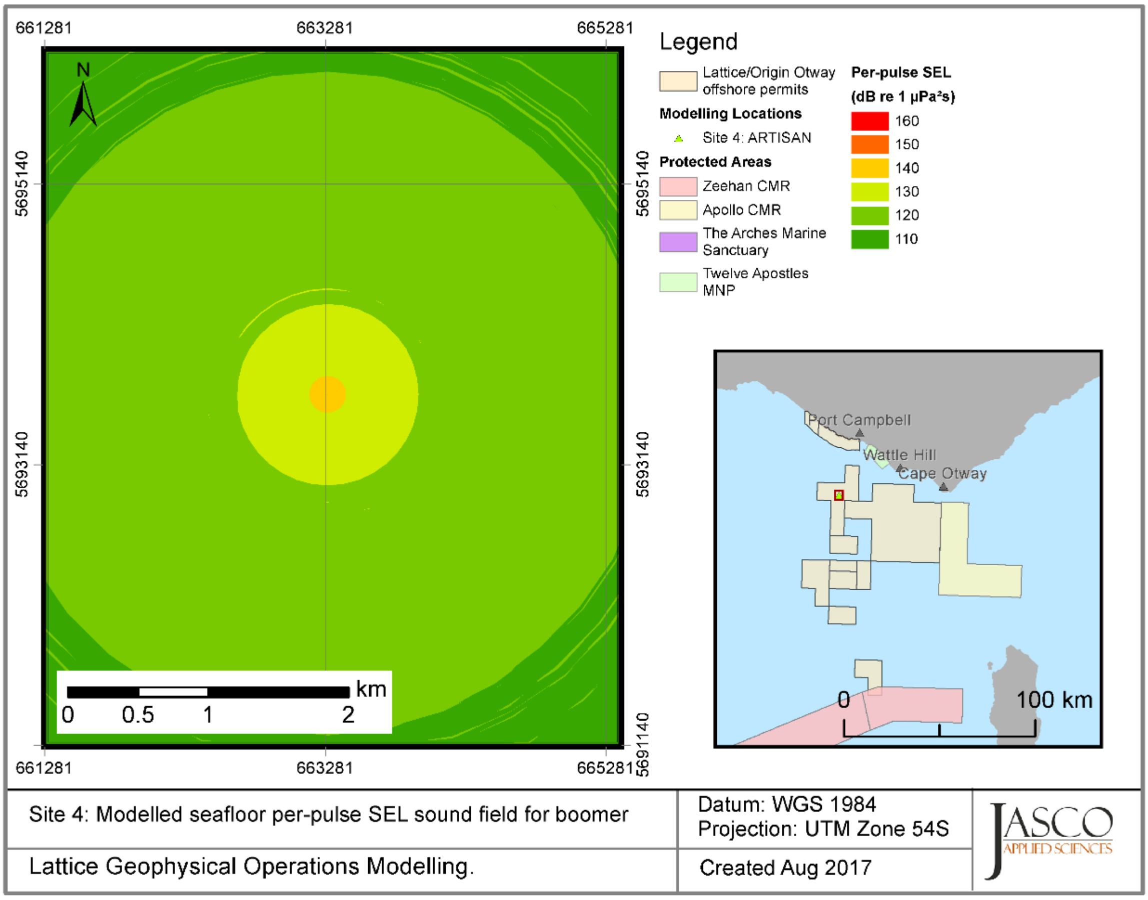

Figure 14. Boomer, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

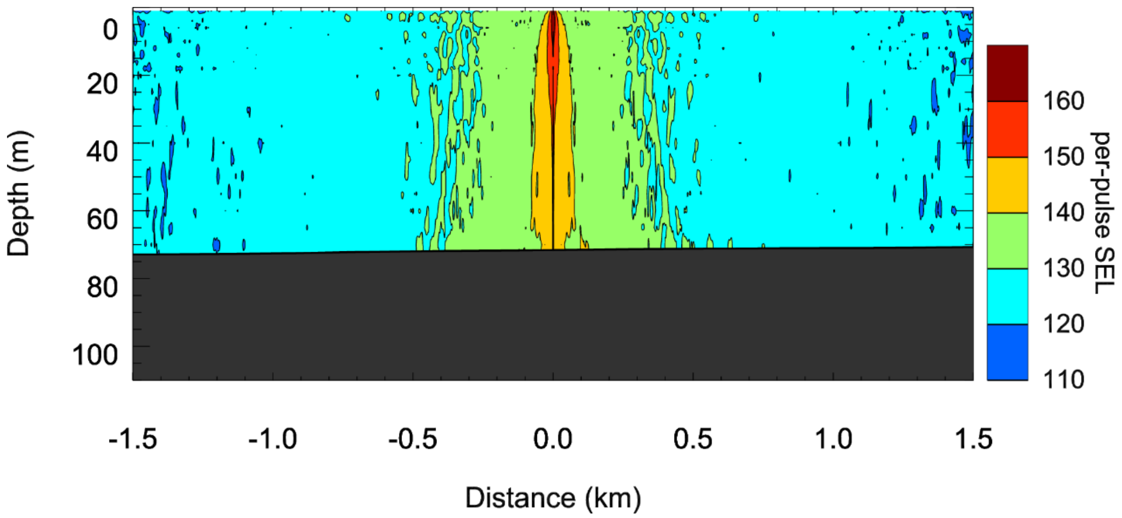

Figure 15. Boomer, Site 4: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

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.

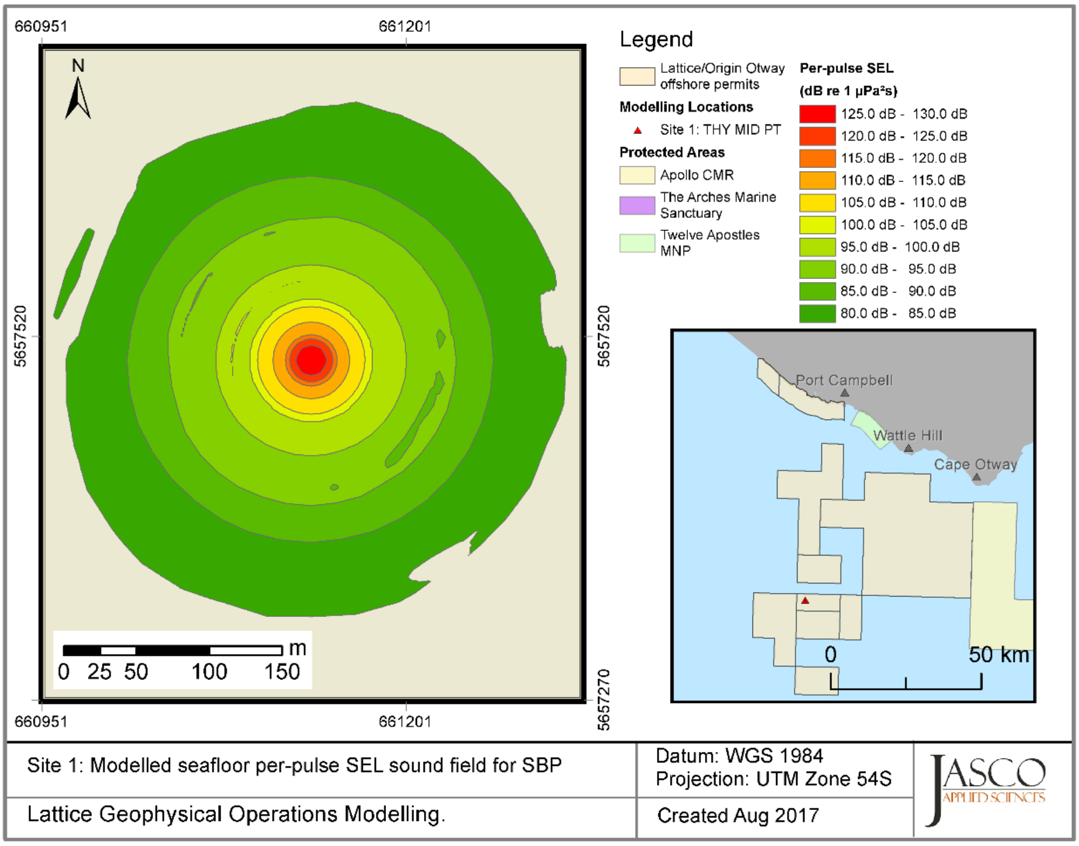

Figure 16. SBP, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

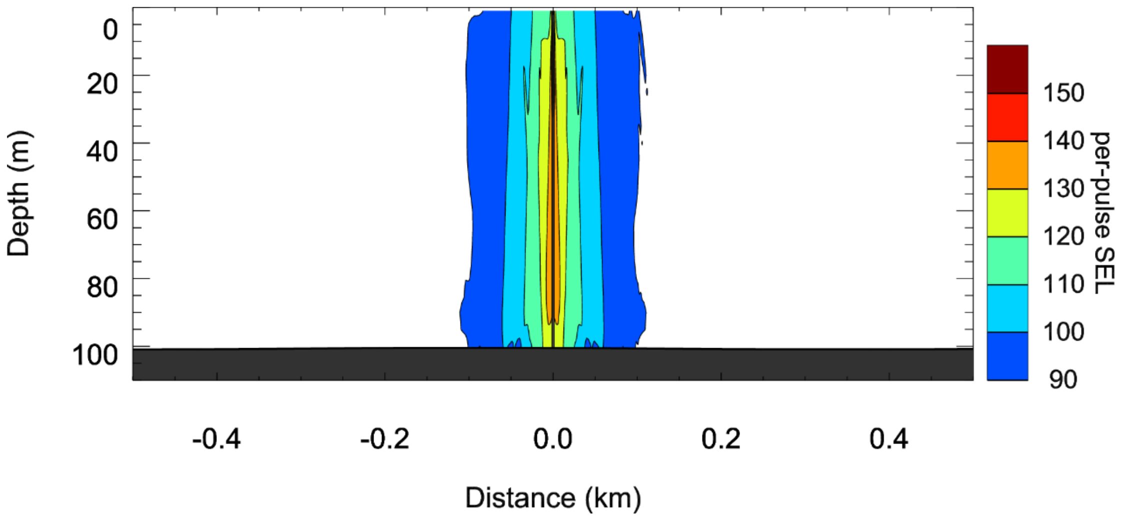

Figure 17. SBP, Site 1: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

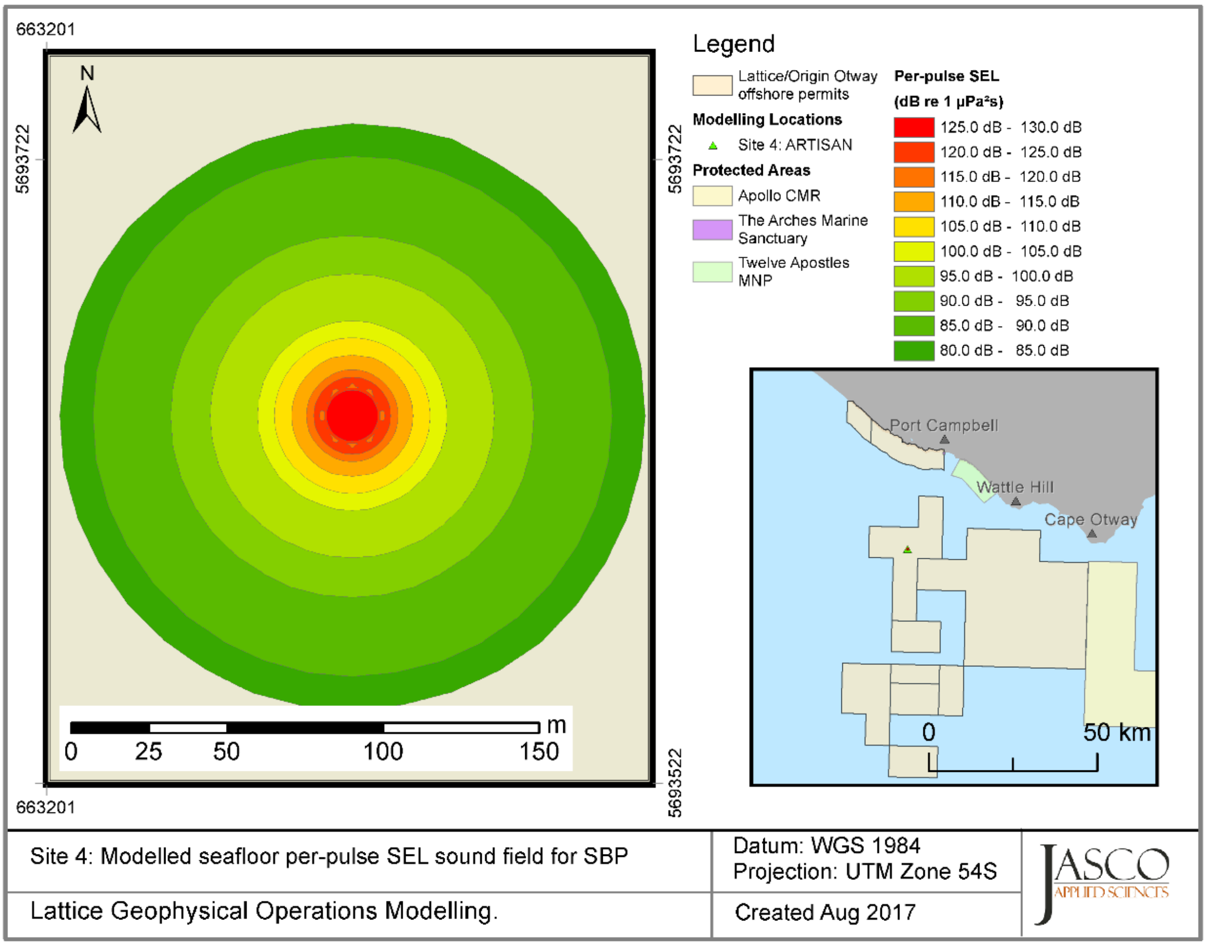

Figure 18. SBP, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

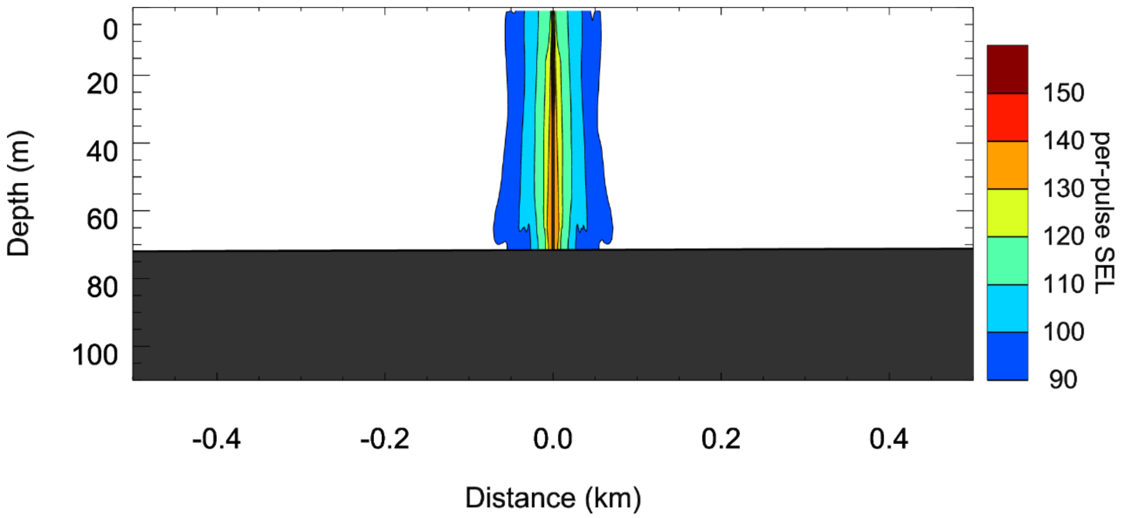

Figure 19. SBP, Site 4: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

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.

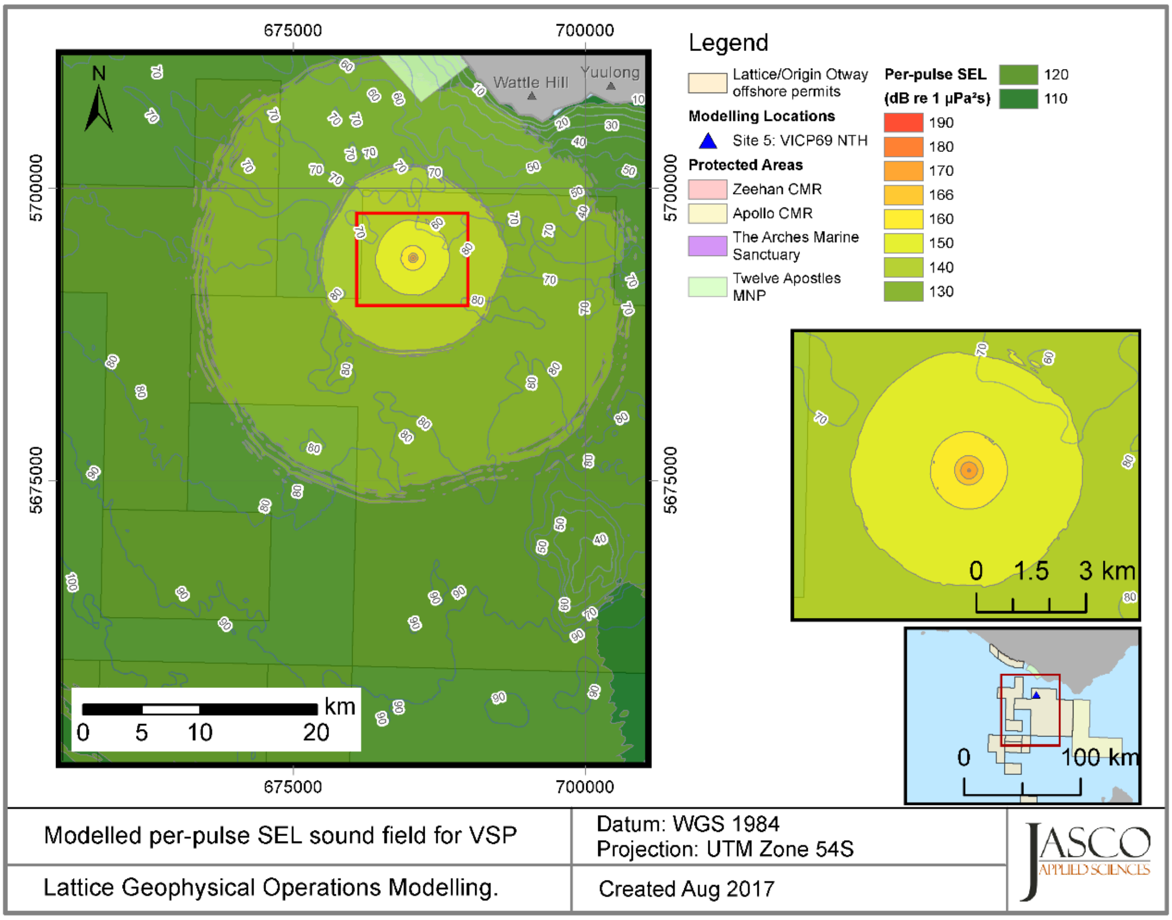

Figure 20. Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 450 in³ VSP array operated at 6 m depth at Site 5.

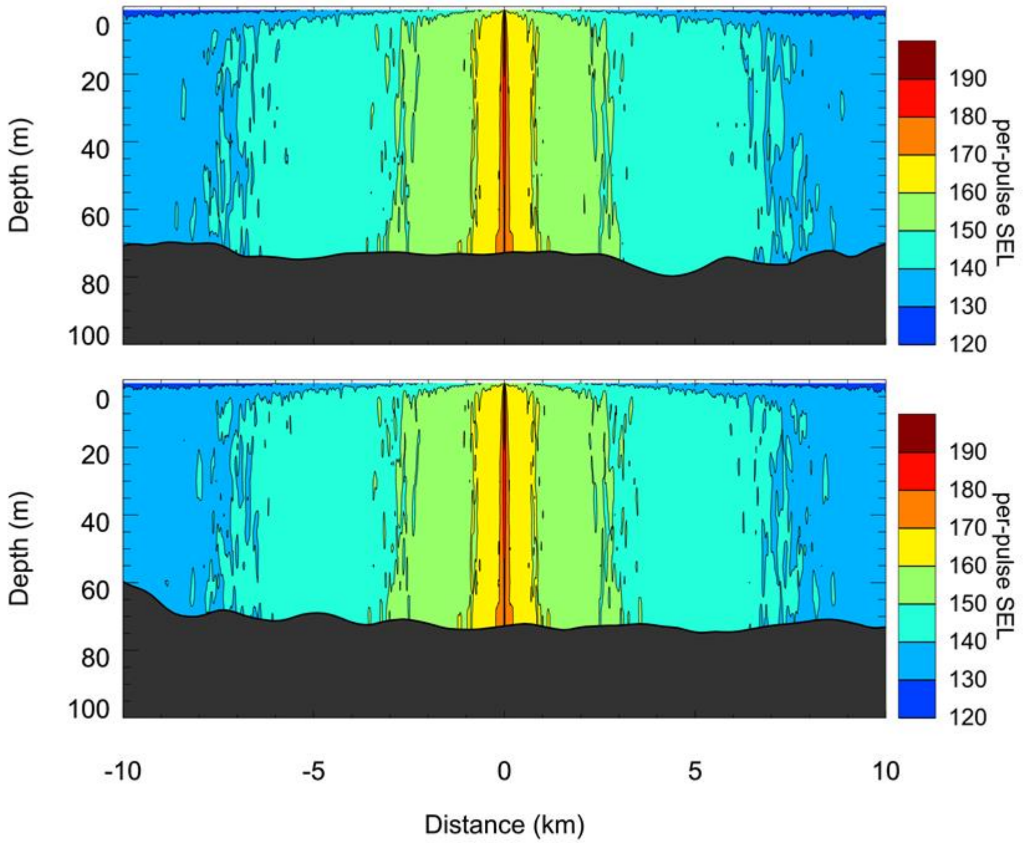

Figure 21. Predicted unweighted per-pulse SEL as vertical slices. Levels are shown in the broadside (top) and endfire directions (bottom). The source depth is 6 m.

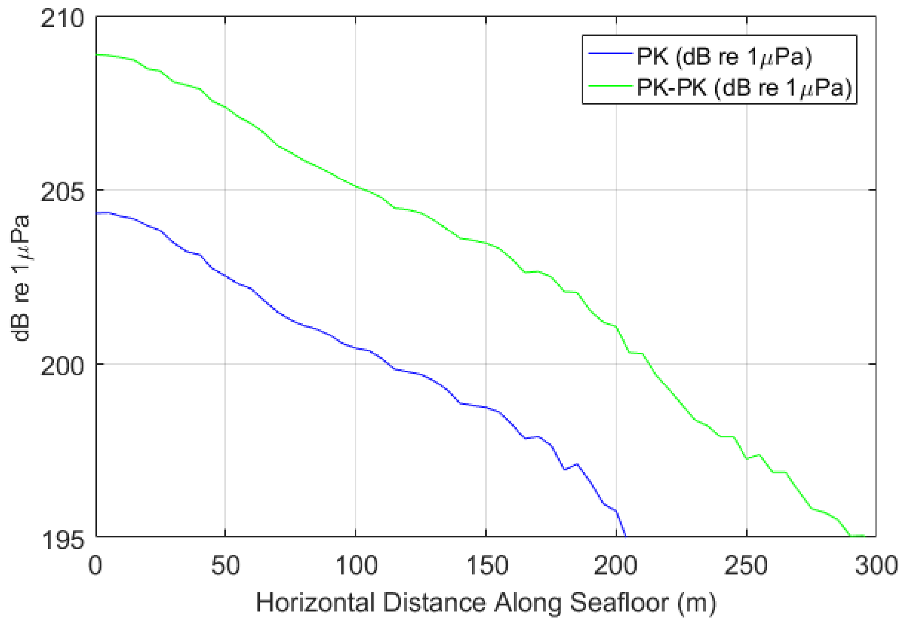

Figure 22. Predicted maximum PK and PK-PK in the endfire direction at the seafloor at Site 5, 72.8 m depth. The source depth is 6 m.

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 µPa²·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.

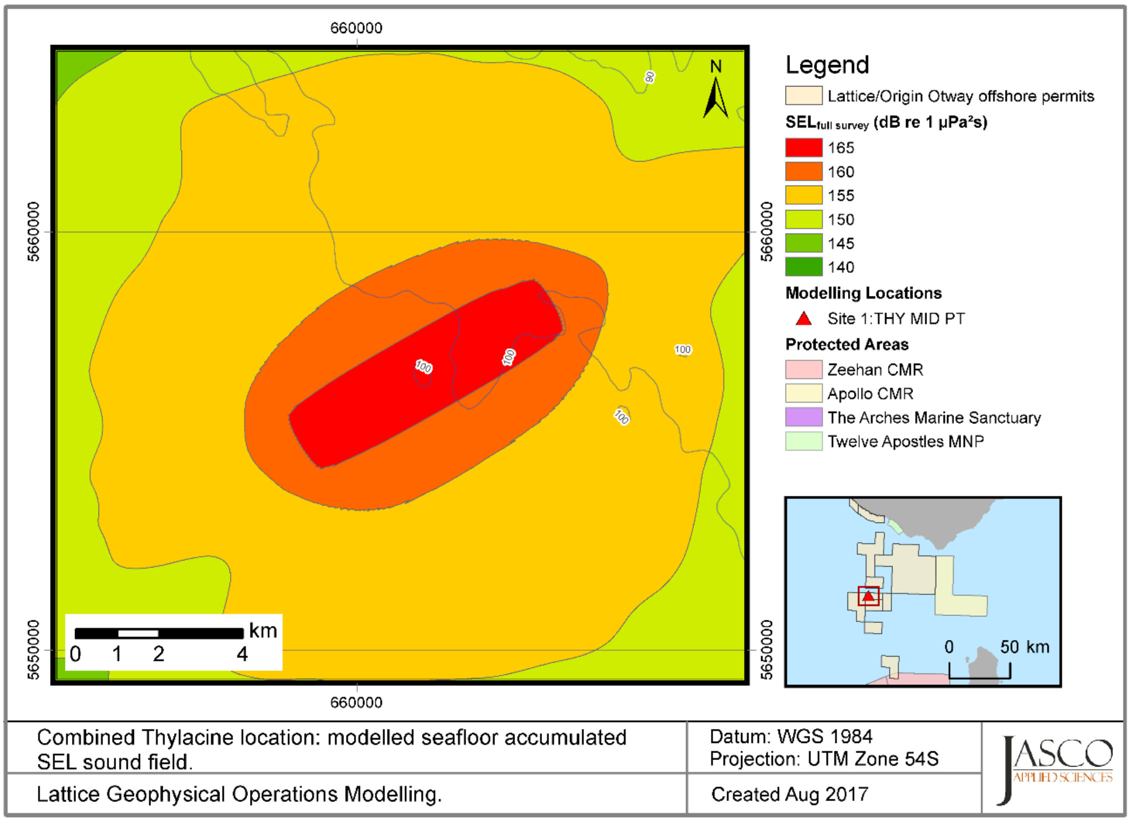

Figure 23. Thylacine Combined location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

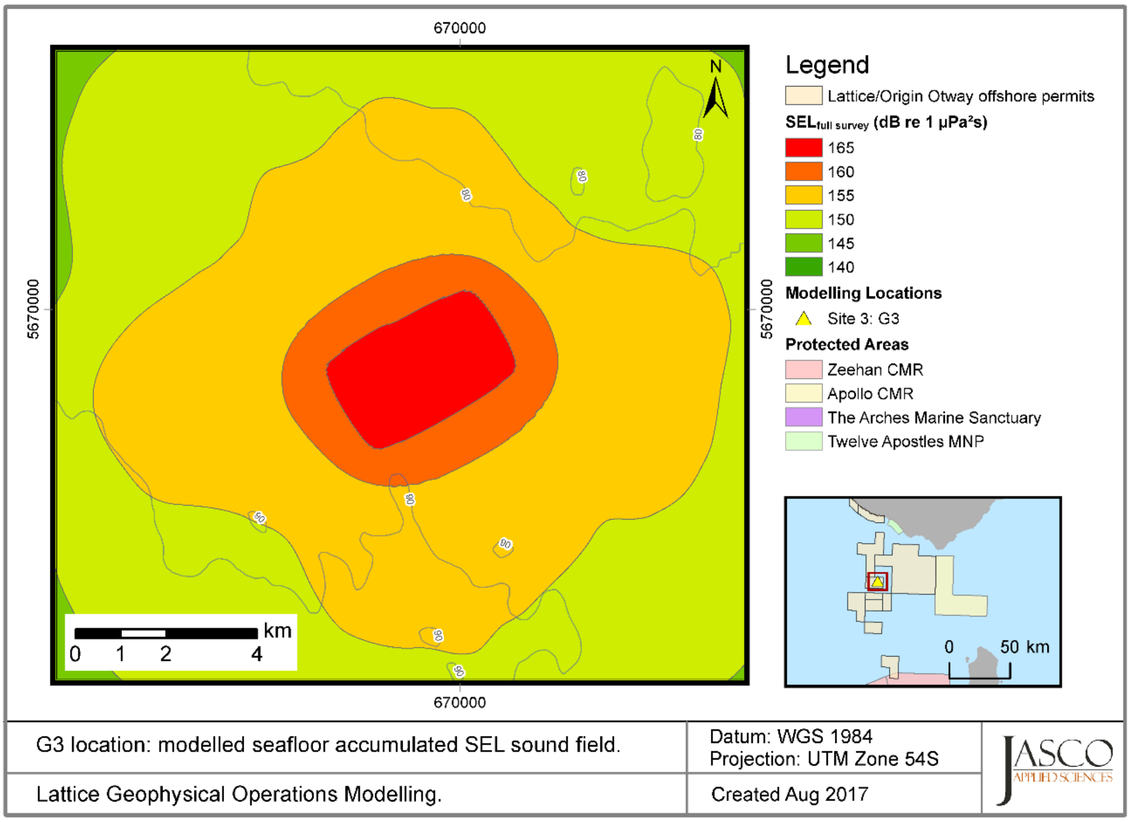

Figure 24. G3 location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

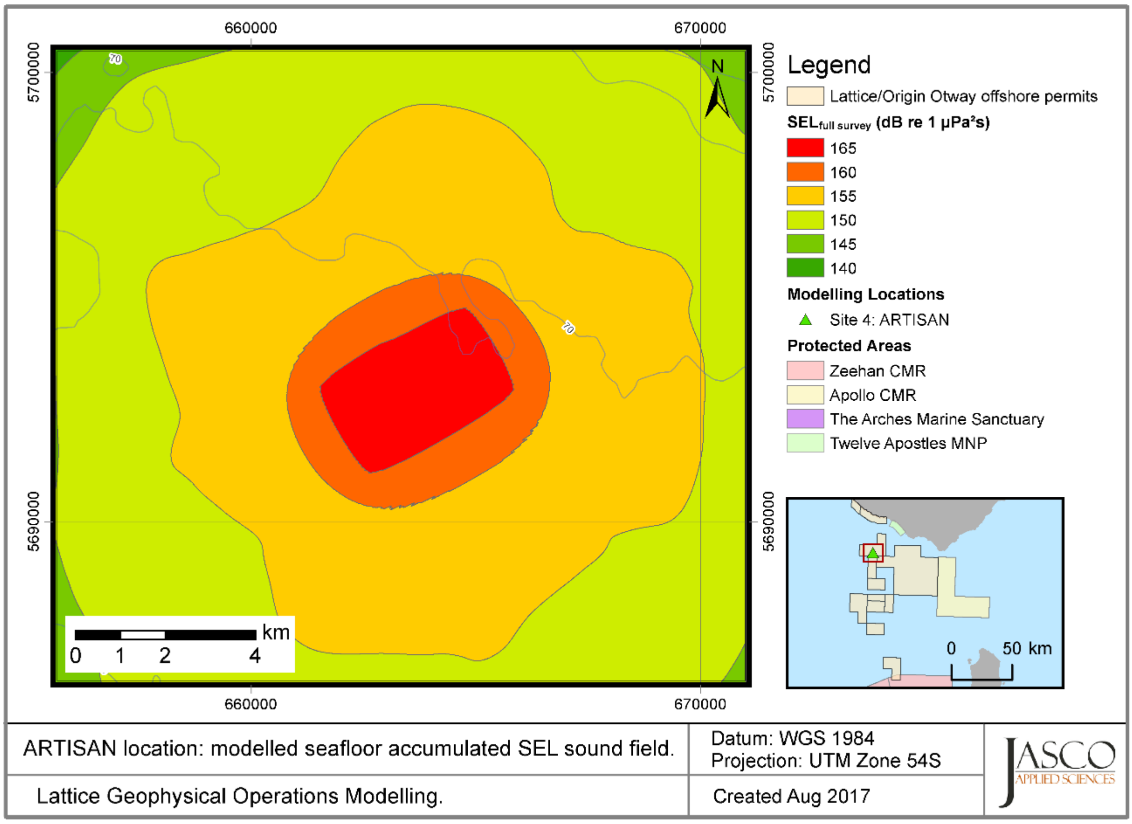

Figure 25. ARTISAN location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

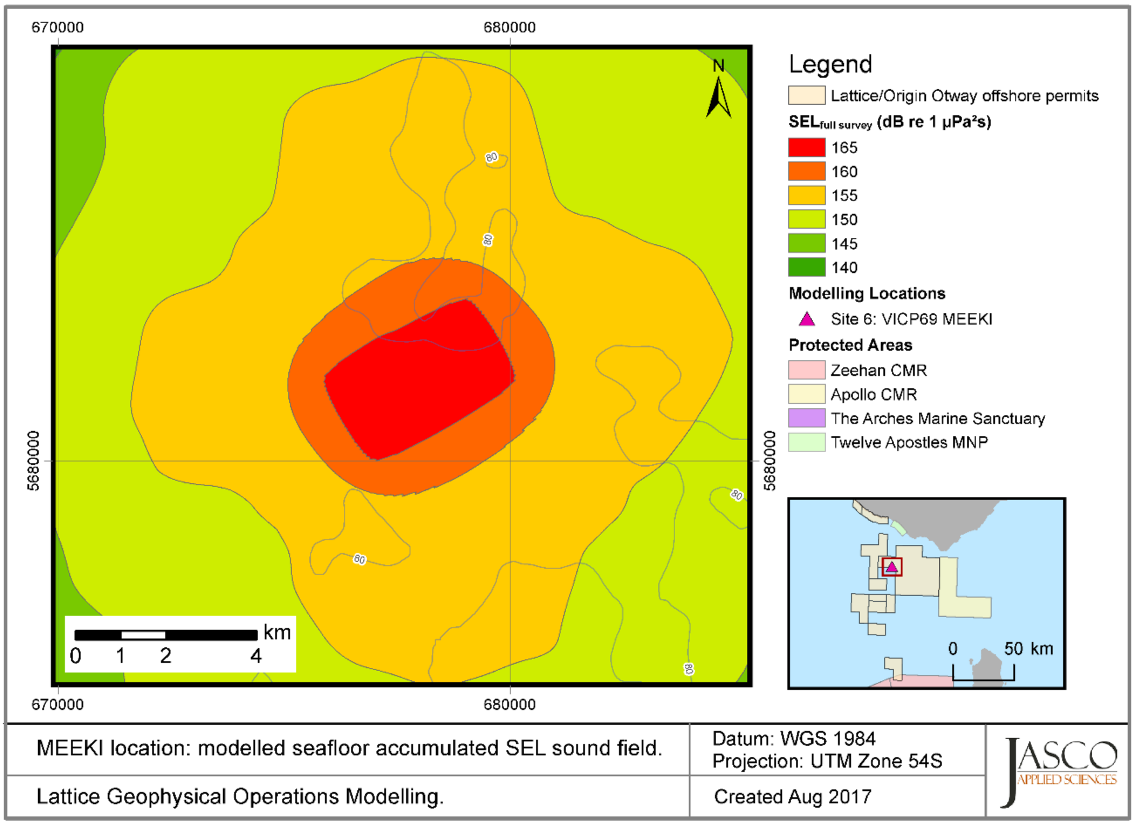

Figure 26. MEEKI location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

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: $\mu Pa^2/Hz$, or $\mu Pa^2 \cdot s$.

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 $\mu Pa^2/Hz$.

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 ($Pa^2 \cdot s$) (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 $\mu Pa^2 \cdot s$.

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:

$$\mathrm{SPL} = 10\log_{10}\left(p^2/p_0^2\right) = 20\log_{10}\left(p/p_0\right)$$

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 µPa^2·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., $\mathrm{SEL}_{LFC,24h}$). 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.

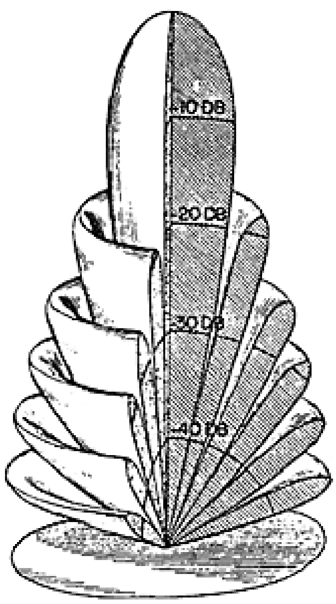

Figure B-1. Typical 3-D beam pattern for a circular transducer (Massa 2003).

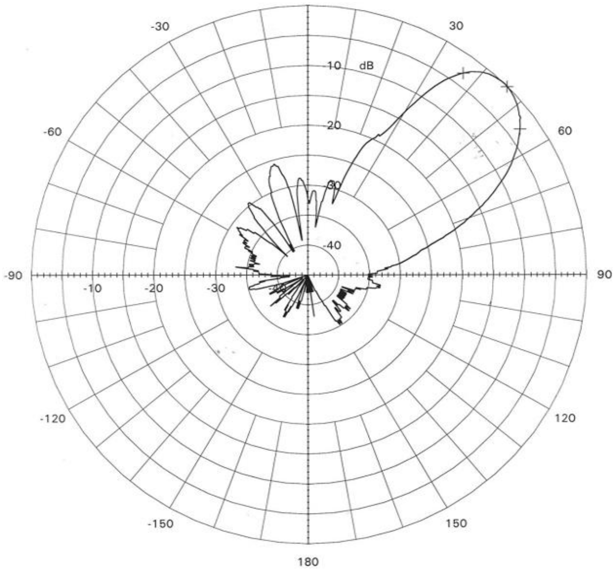

Figure B-2. Vertical cross section of a beam pattern measured in situ from a transducer used by Kongsberg (source: Zykov (2013)).

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:

$$R(\phi) = \frac{2 \cdot J_1(\pi D_\lambda \sin(\phi))}{\pi D_\lambda \sin(\phi)} \text{ and } D_\lambda = \frac{60}{\theta_{bw}}, \quad (1)$$

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 ($\phi < 90°$) 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 $\phi = 90°$ of 30 dB less than that at $\phi = 0°$. This is a conservative estimate of the beam power in the back half-space.

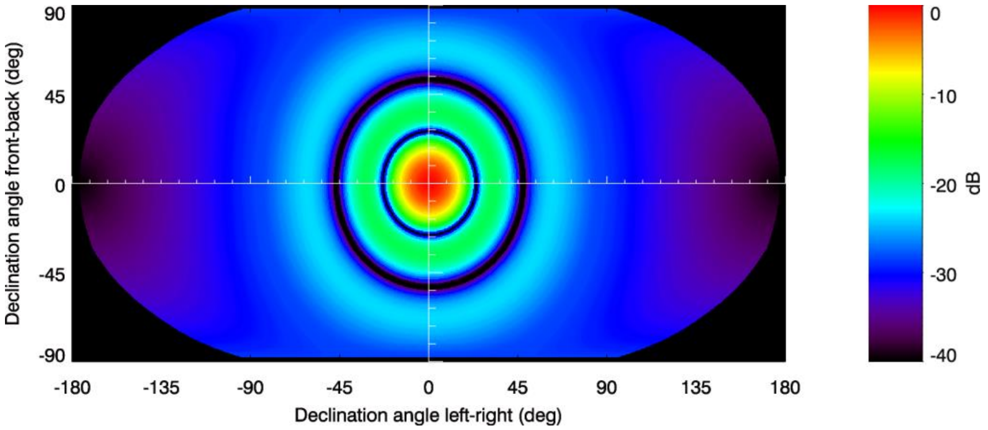

Figure B-3. Calculated beam pattern for a circular transducer with a beamwidth of 20°. The beam power function is shown relative to the on-axis level using the Robinson projection.

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:

$$R_{\text{nf}} < \frac{l^2}{4\lambda} \tag{B-2}$$

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.

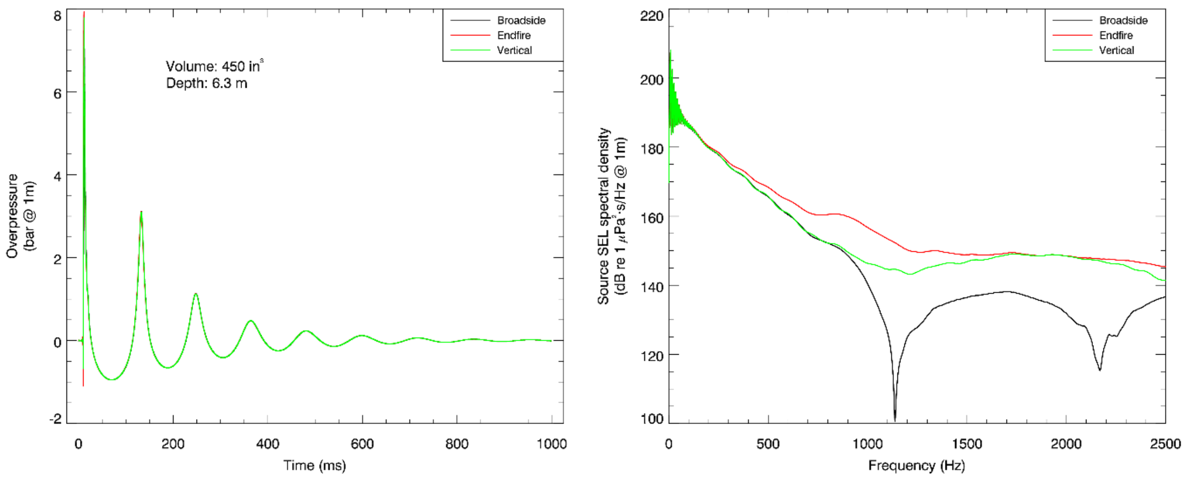

Figure B-4. Predicted source level details for the 450 in^3 VSP array operated at a centroid depth of 6 m. (Left) the overpressure signature and (right) the power spectrum for broadside (perpendicular to tow direction) and endfire (directly aft of the array) directions, and for vertically down.

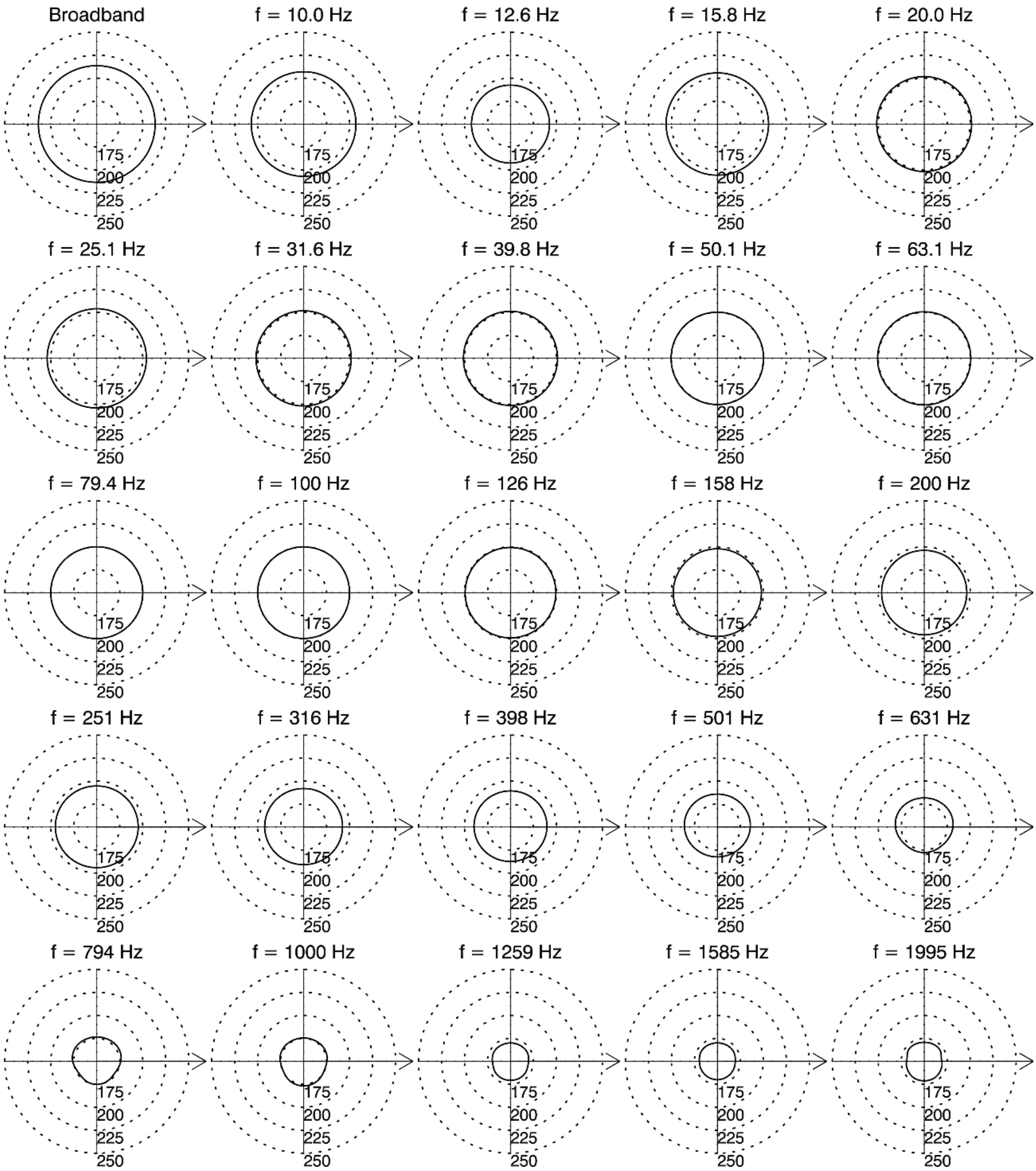

Figure B-5. Directionality of the predicted horizontal source levels for the 450 in³ array, 5–2000 Hz. Source levels (in dB re 1 µPa²·s) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. 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).

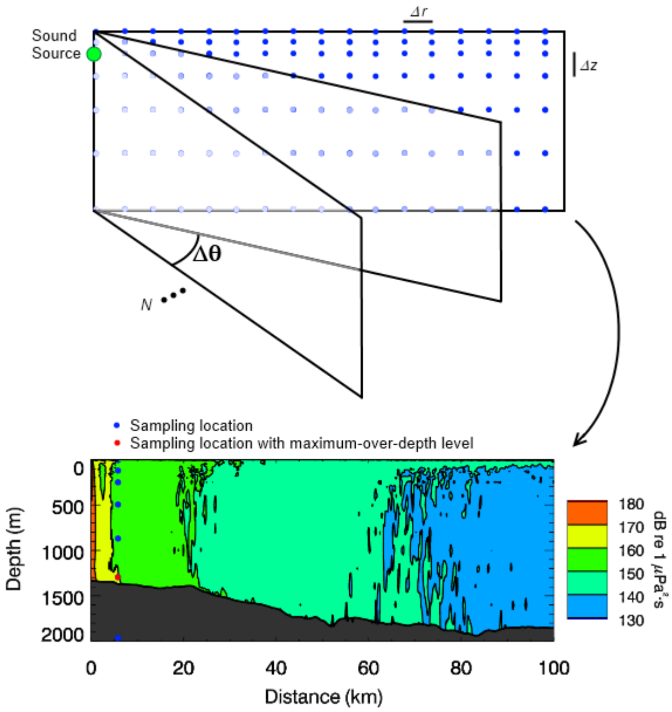

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

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.

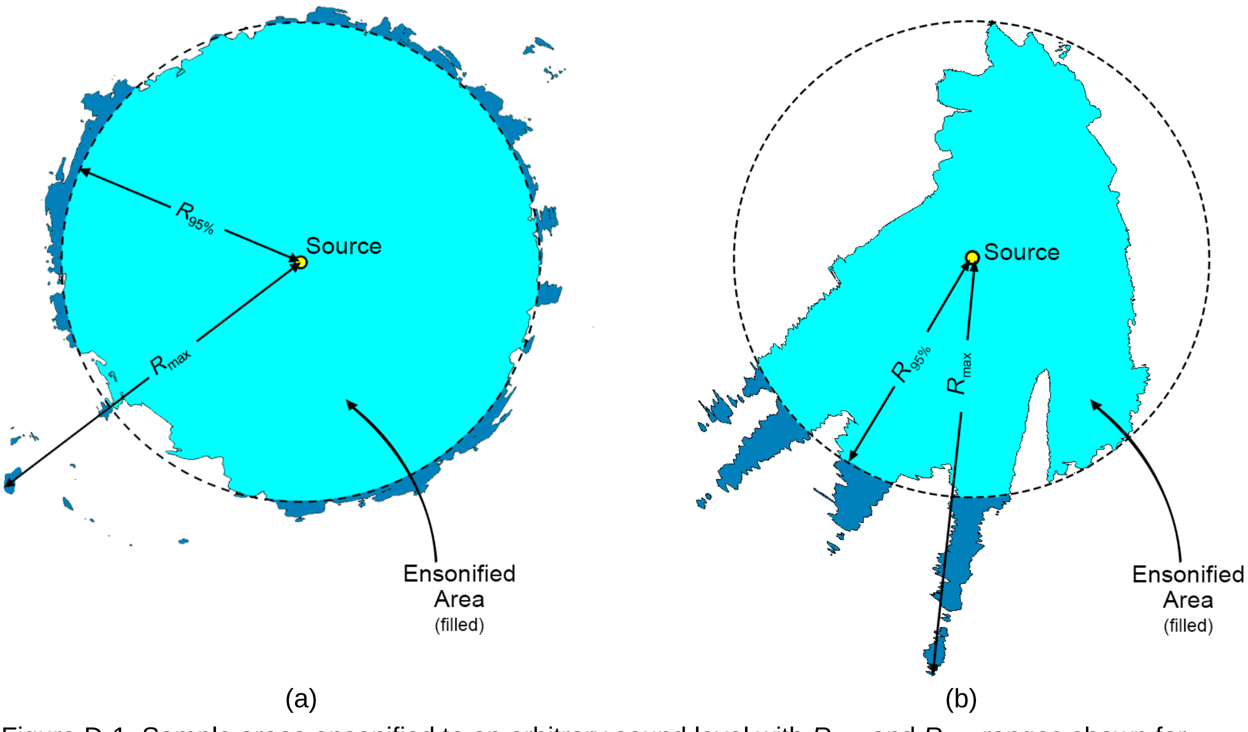

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified 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.

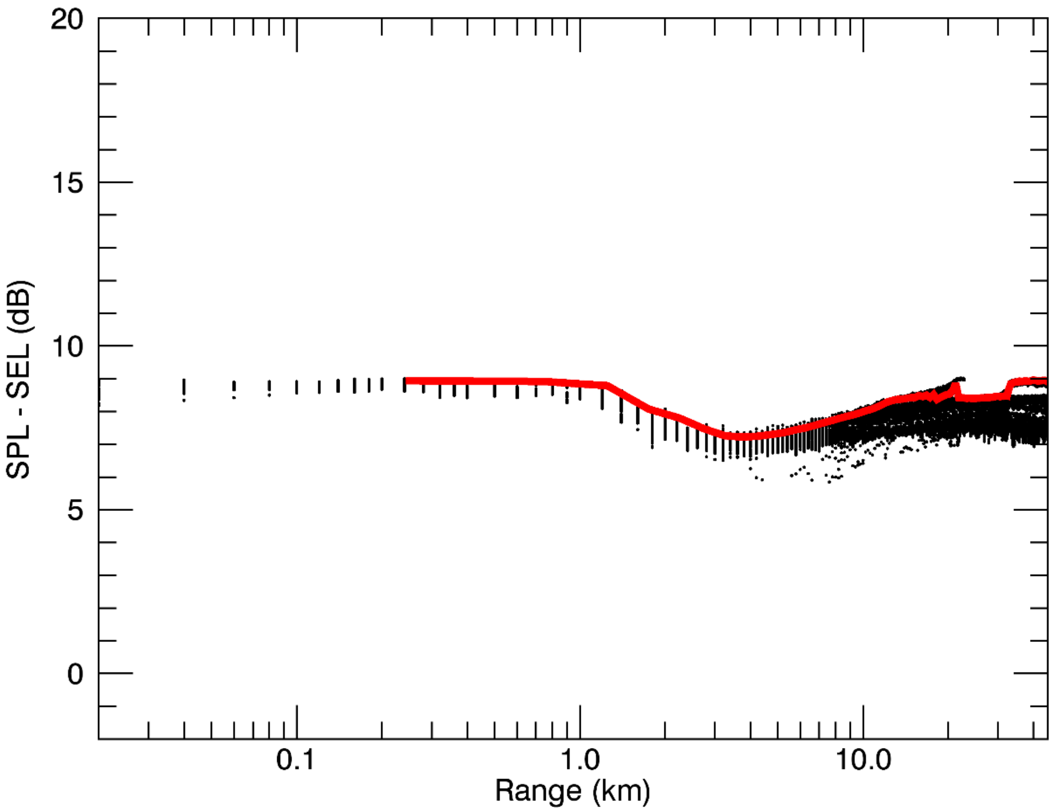

Figure D-2. Conversion Factor applied: Range-dependent conversion function for converting single-pulse SEL to SPL for the 450 in^3 VSP array.

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.

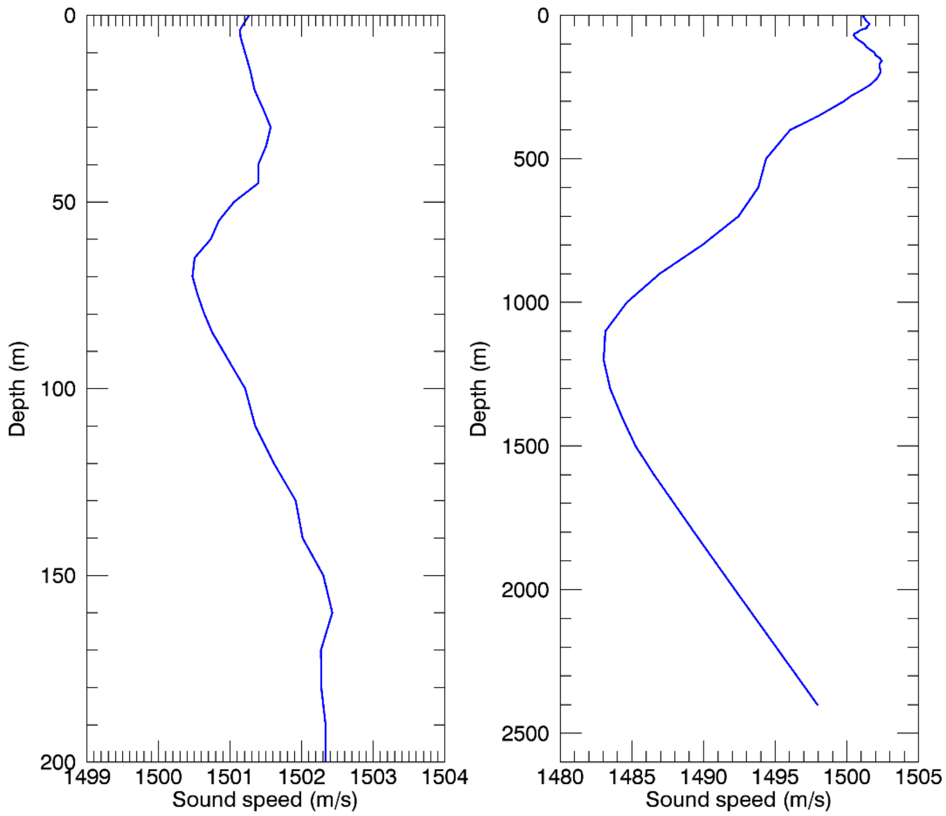

Figure D-3. The sound speed profile for September across the modelling region for the first 200 m (left), and over the entire range of depths (right). The profile was calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

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 2D Survey JASCO Acoustic Modelling Report

Beach Energy T/30P 2-D High-Resolution Reflective Imaging Marine Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Beach Energy
Contract: BE00020370

Authors:

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7 November 2019

P001359-003
Document 01911
Version 1.0

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Suggested citation:

Koessler, M.W. and C.R. McPherson. 2019. *Beach Energy T/30P 2-D High-Resolution Reflective Imaging Marine Survey: Acoustic Modelling for Assessing Marine Fauna Sound Exposures.* Document 01911, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy.

Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

Executive Summary

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned T/30P 2-D High-Resolution Reflective Imaging Marine Survey (2-D Survey) to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates, plankton and corals. Modelling considered a 160 in^3 seismic source, consisting of two 80 in^3 sources, towed at 7 m depth behind a single vessel.

A specialised airgun array source model was used to predict the acoustic signature of the seismic source, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at four defined locations within the Survey Area, with depths between 194 and 995 m, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 hours.

The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_{p}), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{\text{pk-pk}}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_{E}) as appropriate for different noise effect criteria. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which several effects criteria or relevant sound levels were reached. The results are summarised below for the representative single-impulse sites and accumulated SEL scenarios.

Marine mammal injury and behaviour

- The maximum distance where the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded varied between 0.7 and 1.52 km.
- The results for marine mammal injury considered the criteria from the NMFS ([NMFS] National Marine Fisheries Service (U.S.) 2018) technical guidance. NMFS ([NMFS] National Marine Fisheries Service (U.S.) 2018) allows for two metrics in the criteria (PK and SEL_{24h}) for the assessment of marine mammal Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS). The longest distance associated with either metric is required to be applied for assessment. Table 1 summarises the maximum distances for PTS, along with the relevant metric associated with the maximum PTS distance.
- The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that location for 24 hours.

Table 1. Summary of maximum marine mammal PTS onset distances for modelled scenarios.

Hearing Group	Metric associated with longest distance to PTS onset	R_{max} (km)
Low-frequency cetaceans†	SEL_{24h}	0.08
Mid-frequency cetaceans	—	—
High-frequency cetaceans	PK	0.03
Phocid pinnipeds in water	SEL_{24h}	0.02
Otariid pinnipeds in water	—	—

† The model does not account for shutdowns.
A dash indicates the threshold is not reached within the limits of the modelling resolution (20 m).

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m from the acoustic centre of the source.
- The maximum distance to the SEL_{24h} metric for PTS onset was 20 m and 0.05 km for TTS onset (Finneran et al. 2017). As is the case with marine mammals, a reported radius for SEL_{24h} criteria does not mean that turtles travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with either PTS or TTS if it remained in that location for 24 hours.
- The distances to where the NMFS criterion (NSF 2011) for behavioural response of turtles of 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) threshold for behavioural disturbance (McCauley et al. 2000b, McCauley et al. 2000a) could be exceeded are summarised in Table 2.

Table 2. Summary of distances to turtle behavioural response criteria.

SPL (L_p; dB re 1 µPa)	Distance (km)	
	Min	Max
175†	0.12	0.13
166‡	0.36	0.59

† Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000b, McCauley et al. 2000a).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011).

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
    - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
    - Fish with a swim bladder that do not use it for hearing
    - Fish that use their swim bladders for hearing
    - Fish eggs and fish larvae

Table 3 summarises distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 3. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL_{24h} modelled scenarios.

Relevant hearing group	Effect criteria	Water column		Seafloor	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Injury	—	—	*	*
	TTS	SEL_{24h}	0.66	SEL_{24h}	0.66
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	SEL_{24h}	0.03	*	*
	TTS	SEL_{24h}	0.66	SEL_{24h}	0.66
Fish eggs, and larvae	Injury	Both SEL_{24h} & PK	0.02	*	*

A dash indicates not reached within the limits of the modelling resolution (20 m).
An asterisk indicates that the threshold was not reached.

Crustaceans and Bivalves, Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally for context, the PK-PK sound levels assessed in Day et al. (2016) and Day et al. (2019), 209–213 dB re 1 µPa, are also included. None of these sound levels were exceeded at the seafloor.
- Bivalves: PK-PK sound levels of 191, 212 and 213 considered in Day et al. (2017) for scallops were not exceeded at the seafloor.
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated, and compared to the no effect sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not exceeded at the seafloor.
- Plankton: The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017) was estimated at two modelling sites through full-waveform modelling using FWRAM; the maximum distance was 1.52 km.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the planned T/30P 2-D High-Resolution Reflective Imaging Marine Survey (2-D Survey) to assist in understanding the potential acoustic impact on key regional receptors including fish, marine mammals, turtles, benthic invertebrates, plankton and corals. Modelling considered a 160 in^3 seismic source, consisting of two 80 in^3 sources, towed at 7 m depth behind a single vessel.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict the acoustic signature of the array. AASM accounts for individual airgun volumes and array geometry. Complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at four defined locations within the Survey Area, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 h. A conservative sound speed profile that would be most supportive of sound propagation conditions for the potential survey periods was defined and applied at each of the modelling locations.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; L_{pk-pk}), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

2. Modelling Scenarios

Four standalone single impulse sites and one likely scenario for survey operations over 24 hours to assess accumulated SEL were defined. The locations of all modelling sites are provided in Table 4, with all sites and the acquisition lines shown in Figure 1 along with the survey boundaries. The modelling assumed that the survey vessel sailed along the survey lines at ~4.5 knots, with an impulse interval of 12.5 m. For modelling, the considered survey acquisition lines took ~0.84 h (each) to traverse with ~0.82 h of turn time required between the lines. This accounted for 8405 impulses during a 24h period of acquisition; during line turns the seismic source was not in operation. All single impulse sites were modelled with a range dependent modelling method; however, a range independent modelling method was used to determine close range levels and thresholds for seafloor receptors at Site 1. This site was selected as the seafloor sound levels within the Survey Area will be highest for the shallowest depth, and this site is also more relevant to commercial fishery areas of interest on the continental shelf.

Sound levels in the water column were modelled with a full-waveform model (FWRAM, Section 4.2) at Site 2, located in approximately the centre of the Survey Area, providing predictions of SEL, SPL, PK and PK-PK. This site was selected due to the water depth, and that it will provide results applicable to both the shallower and deeper sections of the Survey Area without the bias induced from water depth.

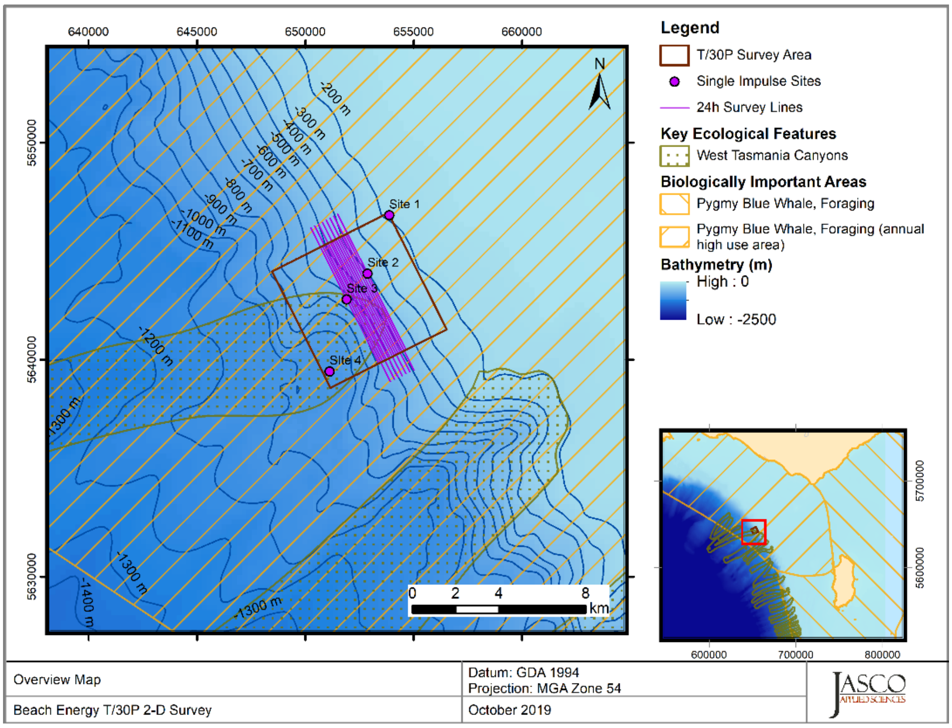

Figure 1. Overview of the modelling sites, acquisition lines, and features for the T/30P 2-D Survey.

Table 4. Location details for the single impulse modelling sites.

Site	Latitude (S)	Longitude (E)	MGA Zone 54		Water depth (m)	Tow direction (°)
			X (m)	Y (m)		
1	39° 18' 56.9770"	142° 47' 5.6362"	653873	5646656	194	152 & 332
2	39° 20' 24.6570"	142° 46' 25.8601"	652867	5643972	405	152 & 332
3	39° 21' 4.0878"	142° 45' 46.5437"	651902	5642774	636	152 & 332
4	39° 22' 52.0590"	142° 45' 16.3962"	651116	5639460	995	152 & 332

3. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a “per pulse” assessment or over 24 h. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405:2017 (2017).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), and United States National Marine Fisheries Service (NMFS 2018). The number of studies that have investigated the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

We chose the following noise criteria and sound levels for this study because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in literature for species with no suggested thresholds (Sections 3.1–3.3 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) in marine mammals.
2. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) (2014) of 160 dB re 1 µPa SPL (L_p) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs and larvae, and turtles (Popper et al. 2014).
4. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in turtles.
5. Turtle behavioural response threshold of 166 dB re 1 µPa SPL (L_p) (NSF 2011), as applied by the US NMFS, along with a sound level associated with behavioural disturbance 175 dB re 1 µPa (SPL) (McCauley et al. 2000b, 2000a).
6. A sound level 178 dB re 1 µPa PK-PK in the water column, reported for comparison to the results in McCauley et al. (2017) for plankton.
7. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) at the seafloor to help assess effects of noise on crustaceans through comparing to results in Day et al. (2016), Day et al. (2019) and Payne et al. (2008).
8. Peak-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$) at the seafloor to help assess effects of noise on bivalves through comparing to results in Day et al. (2017) for scallops.
9. A sound level of 226 dB re 1 µPa PK (L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals.

Additionally, to assess the size of the low-power zone required under the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA 2008), the distance to an unweighted per-pulse SEL of 160 dB re 1 µPa^2·s is reported.

The following section expands on the thresholds and sound levels for marine mammals, fish, turtles, fish eggs, and fish larvae and benthic invertebrates.

3.1. Marine Mammals

The criteria applied in this study to assess possible effects of airgun noise on marine mammals are summarised in Table 5 and detailed in Sections 3.1.1 and 3.1.2, with frequency weighting explained in Appendix A.3.

Table 5. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals.

Hearing group	NMFS (2014)	NMFS (2018)			
	Behaviour	**PTS onset thresholds* (received level)**		**TTS onset thresholds* (received level)**	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196
Phocid pinnipeds in water		185	218	170	212
Otariid pinnipeds in water		203	232	188	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p–denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

3.1.1. 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 marine mammals (NMFS 2014) which has been applied for this report.

3.1.2. Injury and hearing sensitivity changes

There are two categories of auditory threshold shifts or hearing loss: permanent threshold shift (PTS), a physical injury to an animal's hearing organs and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea becoming fatigued.

To assist in assessing the potential for injuries to marine mammals, this report applies the criteria recommended by NMFS (2018), considering both PTS and TTS, to help assess the potential for injuries to marine mammals. Appendix A.2 provides more information about the NMFS (2018) criteria.

3.2. 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 panel convened by NOAA two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

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

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. 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 6 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 single-impulse of a maximum received level of either 231 dB re 1 µPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. Popper et al. (2014) recommend a standard period 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. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 hours has been applied in this study for SEL, which is similar to that applied for marine mammals in NMFS (2016, 2018).

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, 2018).

Table 6. Criteria for seismic noise exposure for fish, adapted from Popper et al. (2014).

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

Notes: Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

3.2.1. Turtles

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. McCauley et al. (2000b) 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 (McCauley et al. 2000b, McCauley et al. 2000a), 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}). 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.

Finneran et al. (2017) presented revised thresholds for turtle injury, considering both PK and frequency weighted SEL, which have been applied in this study, along with the NMFS criterion for behavioural response (SPL of 166 dB re 1 µPa), and a criterion for behavioural disturbance (SPL of 175 dB re 1 µPa) (McCauley et al. 2000b, McCauley et al. 2000a) (Table 7).

Table 7. Acoustic effects of impulsive noise on turtles: Unweighted SPL, SEL_{24h}, and PK thresholds

NSF (2011)	McCauley et al. (2000a)	Finneran et al. (2017)			
Behaviour		PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
SPL (L_p; dB re 1 µPa)		Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 $µPa^2·s$)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 $µPa^2·s$)	PK (L_{pk}; dB re 1 µPa)
160	175	204	232	189	226

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p–denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 $µPa^2s$.

3.3. Benthic Invertebrates (Crustaceans and Bivalves)

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, seabed material and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves.

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

For crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016) and Day et al. (2019) 209–213 dB re 1 µPa, are also included.

For bivalves, PK-PK sound levels of 191, 212 and 213 are presented to allow comparison to the maximum sound levels measured in Day et al. (2017) for scallops.

4. Methods

4.1. Acoustic Source Model

The pressure signature of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels (i.e., source levels) of the 160 in^3 seismic source were modelled with JASCO's Airgun Array Source Model (AASM). Although AASM accounts for notional pressure signatures of each seismic source with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

The 160 in^3 seismic source was modelled over AASM's full frequency range, up to 25 kHz. Appendix B details this model.

4.2. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and Gaussian beam acoustic ray-trace model (MONM-BELLHOP, 10 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 5 Hz to 1024 Hz).
- Wavenumber integration model (VSTACK, 5 Hz to 1024 Hz).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK. Appendix C details each model. MONM-BELLHOP was used to calculate SEL of a 360° area around each source location. FWRAM was used to model synthetic seismic pulses and to generate a generalised range-dependent SEL to SPL conversion function for the considered modelling sites. The range-dependent conversion function was applied to predicted per-pulse SEL results from MONM-BELLHOP to estimate SPL values. FWRAM was also used to calculate water column PK and PK-PK levels.

VSTACK was used to calculate close range PK and PK-PK levels along transects at the seafloor from the loudest broadside direction of the seismic source at the shallowest modelling site (Site 1).

4.3. Parameter Overview

The specifications of the seismic source and the environmental parameters used in the propagation models are described in detail in Appendix D. A single sound speed profile for April was considered in this modelling study; this was identified as the seasonal period that would provide the greatest propagation (Appendix D.3.2) due to the presence of a slight upward refracting sound speed profile. Sediment in the survey area was modelled as layered cemented and semi cemented carbonates for Site 1 (Table D-1) on the continental shelf edge. For deeper modelling sites on the slope sediments were modelled as a succession from soft to hard sediments (silty carbonate sand to cemented limestone) for Sites 2–3 (Table D-2).

4.4. Accumulated SEL

During a seismic survey, new sound energy is introduced into the environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the marine mammal and fish SEL criteria used in this report (Sections 3.1–3.3) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 h. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic pulse impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses.

When there are many seismic pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 20 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields. The single-impulse SEL fields were computed over model grids approximately 200 × 200 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

The unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

4.5. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances of 100 km from the source in each cardinal direction, with a horizontal separation of 20 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta = 2.5°$ for a total of $N = 144$ radial planes. Receiver depths were chosen to span the entire water column over the modelled areas, from 2 m to a maximum of 5000 m, with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using Bellhop for frequencies from 2.5 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency range of interest.

FWRAM was run to 100 km, but along only four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency, from 5 to 1024 Hz in 1 Hz steps. This was done to compute SEL-to-SPL conversions (Appendix D.2) but also to quantify water column PK and PK-PK. The horizontal range step is dependent on frequency and ranges from 50 m at lower frequencies to 10 m above 800 Hz.

The maximum modelled range for VSTACK was 1000 m and a variable receiver range increment that increased away from the source was used, which increased from 10 to 25 m. Received levels were computed for receivers at the seafloor.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section 4.1) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the seismic source, with results provided in Appendix B.2 along with the horizontal directivity plots.

Table 8 shows the PK and per-pulse SEL source levels in the horizontal-plane broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions. The vertical source level that accounts for the “surface ghost” (the out of phase reflected pulse from the water surface) is also presented to make it easier to compare the output of other seismic source models.

Figure B-1 shows the broadside, endfire, and vertical overpressure signature and corresponding power spectrum levels for the source. The signature consists of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy was produced at frequencies below 400 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the source and correspond with the volumes and relative locations of the airguns to each other.

Table 8. Far-field source level specifications for the 160 in^3 source, for a 7 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa m)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa²m²s)	
		10–2000 Hz	2000–25000 Hz
Broadside	233.1	210.1	162.6
Endfire	233.8	210.3	167.0
Vertical	233.8	210.3	167.0
Vertical (surface affected source level)	233.8	211.6	170.0

5.2. Per-pulse Sound Fields

5.2.1. Tabulated results

Per-pulse results for the 160 in³ seismic source towed at 7 m are presented for SPL, SEL, PK, and PK-PK, including seafloor PK and PK-PK in Tables 9–14.

5.2.1.1. Entire water column

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 160 in^3 source to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the four modelled single impulse sites.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	**Site 1 (194 m)**		**Site 2 (405 m)**		**Site 3 (636 m)**		**Site 4 (995 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	$R_{95\%}$	R_{max}		
190	—	—	—	—	—	—	—	—
180	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
170	0.08	0.08	0.07	0.07	0.07	0.07	0.07	0.07
160†	**0.44**	**0.42**	**0.26**	**0.25**	**0.26**	**0.25**	**0.26**	**0.25**
150	1.85	1.62	1.49	1.38	1.51	1.40	0.81	0.77
140	6.87	5.26	8.29	5.76	7.45	6.46	6.87	3.8
130	25.4	21.3	33.1	22.4	30.8	22.9	21.9	17.8
120	141	107	133	105	101	74.7	66.8	56.8

† Low power zone assessment criteria DEWHA (2008).
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Table 10. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 160 in^3 source to modelled maximum-over-depth SPL isopleths from the four modelled single impulse sites.

SPL (L_p; dB re 1 µPa)	**Site 1 (194 m)**		**Site 2 (405 m)**		**Site 3 (636 m)**		**Site 4 (995 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}
200	—	—	—	—	—	—	—	—
190	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
180	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
175#	**0.13**	**0.13**	**0.13**	**0.12**	**0.12**	**0.12**	**0.12**	**0.12**
170	0.40	0.38	0.23	0.22	0.23	0.22	0.23	0.22
166†	**0.59**	**0.54**	**0.37**	**0.36**	**0.36**	**0.34**	**0.36**	**0.34**
160‡	**1.52**	**1.37**	**1.32**	**1.24**	**0.87**	**0.81**	**0.70**	**0.67**
150	5.04	4.37	5.53	4.41	5.66	4.44	4.52	3.3
140	17.2	14.2	23.3	15.0	22.8	15.7	15.6	13.5
130	>100	/	>100	/	>100	/	61.6	48.8

Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000b).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011).
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
A slash indicates that $R_{95\%}$ radius to threshold is not reported when the R_{max} is greater than the maximum modelling extent.

Table 11. Maximum (R_{max}) horizontal distances (km) from the 160 in^3 source to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles, at single-impulse modelling Site 2 (Table 4).

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)
		Site 2 (405 m)
Low-frequency cetaceans (PTS)	219	—
Low-frequency cetaceans (TTS)	213	—
Mid-frequency cetaceans (PTS)	230	—
Mid-frequency cetaceans (TTS)	224	—
High-frequency cetaceans (PTS)	202	0.03
High-frequency cetaceans (TTS)	196	0.07
Phocid pinnipeds in water (PTS)	218	—
Phocid pinnipeds in water (TTS)	212	—
Otariid pinnipeds in water (PTS)	232	—
Otariid pinnipeds in water (TTS)	226	—
Turtles (PTS)	232	—
Turtles (TTS)	226	—
Fish: No swim bladder (also applied to sharks)	213	—
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.02

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

Table 12. Maximum (R_{max}) horizontal distances (in km) from the 160 in^3 source to modelled maximum-over-depth peak-peak pressure level threshold (178 dB re 1µPa, PK-PK), assessed along the four FWRAM modelling transects (maximum presented) at single-impulse modelling Site 2 (Table 4).

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (km)
	Site 2 (405 m)
178	1.52

5.2.1.2. Seafloor

Table 13. Maximum (R_{max}) horizontal distances (in m) from the 160 in^3 source to modelled seafloor peak pressure level thresholds (PK) at the shallowest single-impulse modelling, Site 1 (Table 4).

Hearing group/animal type	**PK threshold (L_{pk}; dB re 1 µPa)**	**Distance R_{max} (m)**
		Site 1 (194 m)
Sound level for sponges and corals†	226	*
Fish: No swim bladder (also applied to sharks)	213	*
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	*

† Heyward et al. (2018)
An asterisk indicates that the sound level/threshold was not reached.

Table 14. Maximum (R_{max}) horizontal distances (in m) from the 160 in^3 source to modelled seafloor peak-peak pressure level thresholds (PK-PK) at single-impulse modelling Site 1 (Table 4). Results included in relation to benthic invertebrates (Section 3.3).

PK-PK (L_{pk-pk}; dB re 1 µPa)	**Distance R_{max} (m)**
	Site 1 (194 m)
213[a,b,c]	*
212[b,c]	*
210[a,b]	*
209[a,b]	*
202[d]	*
191[a,c]	*

[a] Day et al. (2019), lobster
[b] Day et al. (2016), lobster or scallops
[c] Day et al. (2017), scallops.
[d] Payne et al. (2008), lobster
An asterisk indicates that the sound level was not reached.

5.2.2. Sound field maps and graphs

5.2.2.1. Sound level contour maps

Maps of the estimated sound fields, threshold contours, and isopleths of interest for the per-pulse SEL and SPL sound fields have been presented at all modelling sites (Table 4), shown in Figures 2–9.

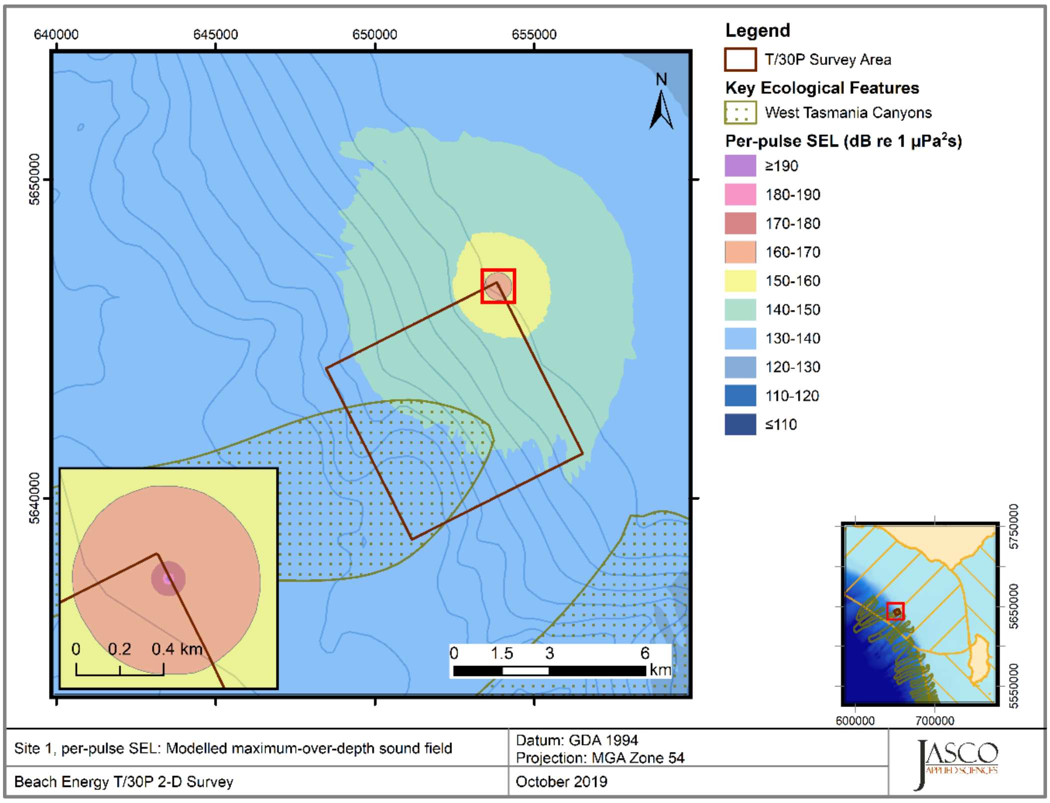

Figure 2. *Site 1, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

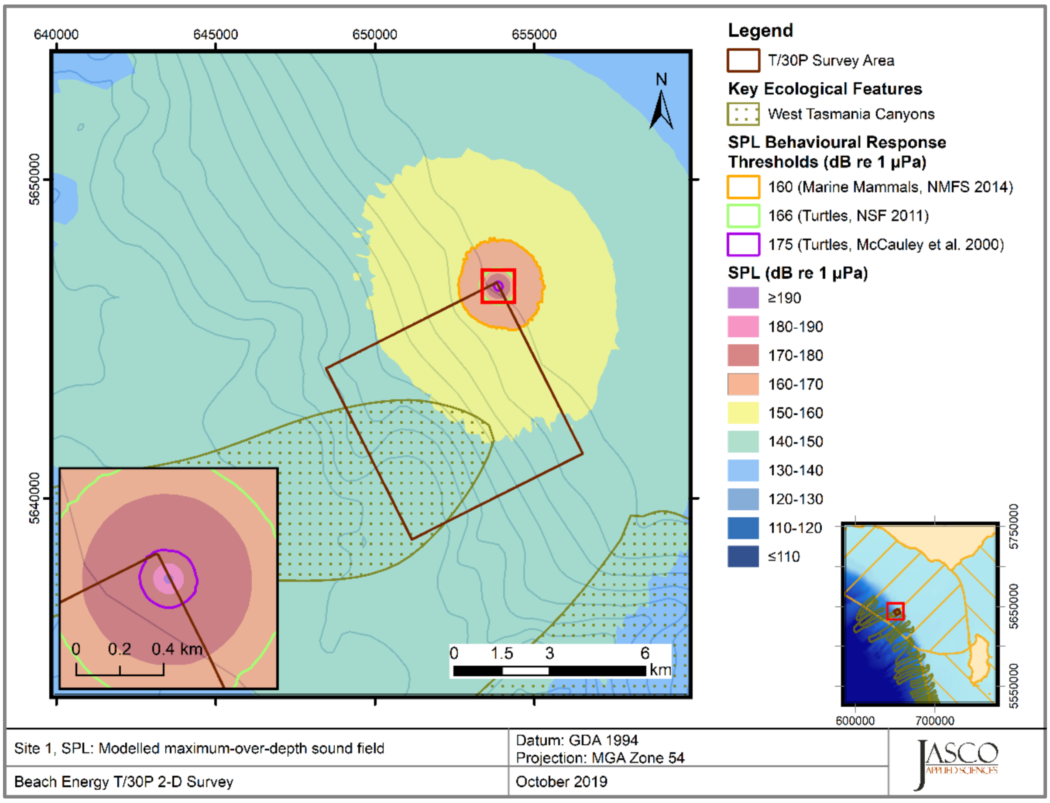

Figure 3. *Site 1, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

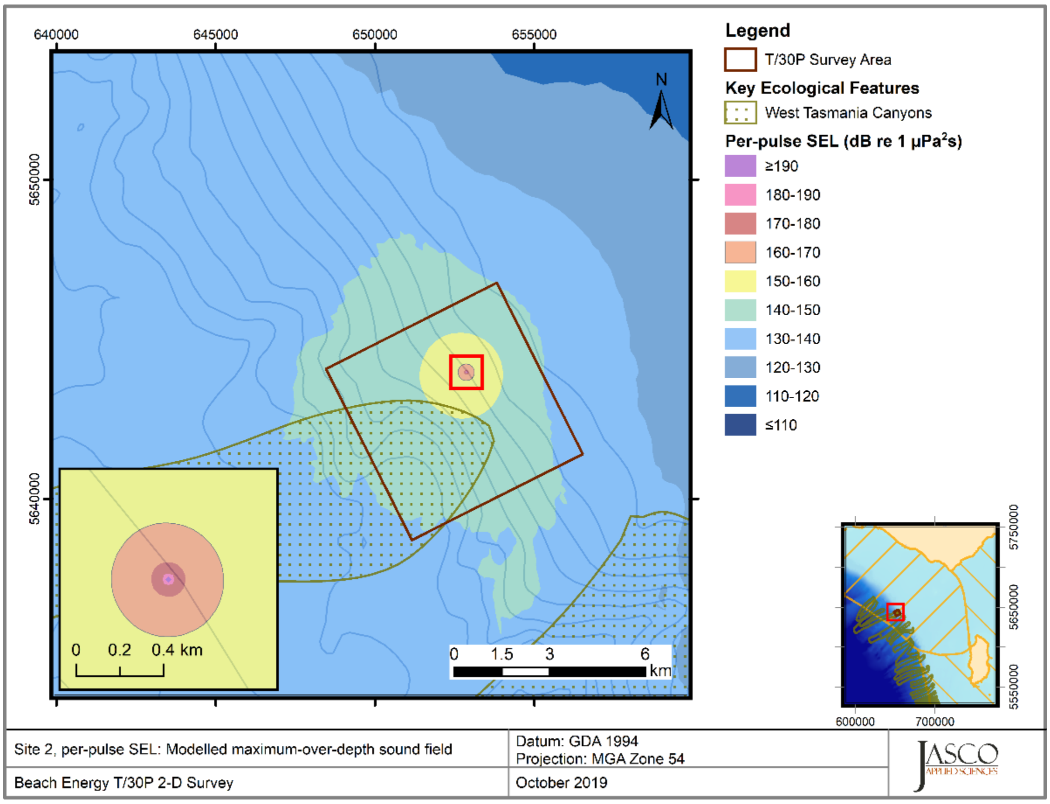

Figure 4. *Site 2, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

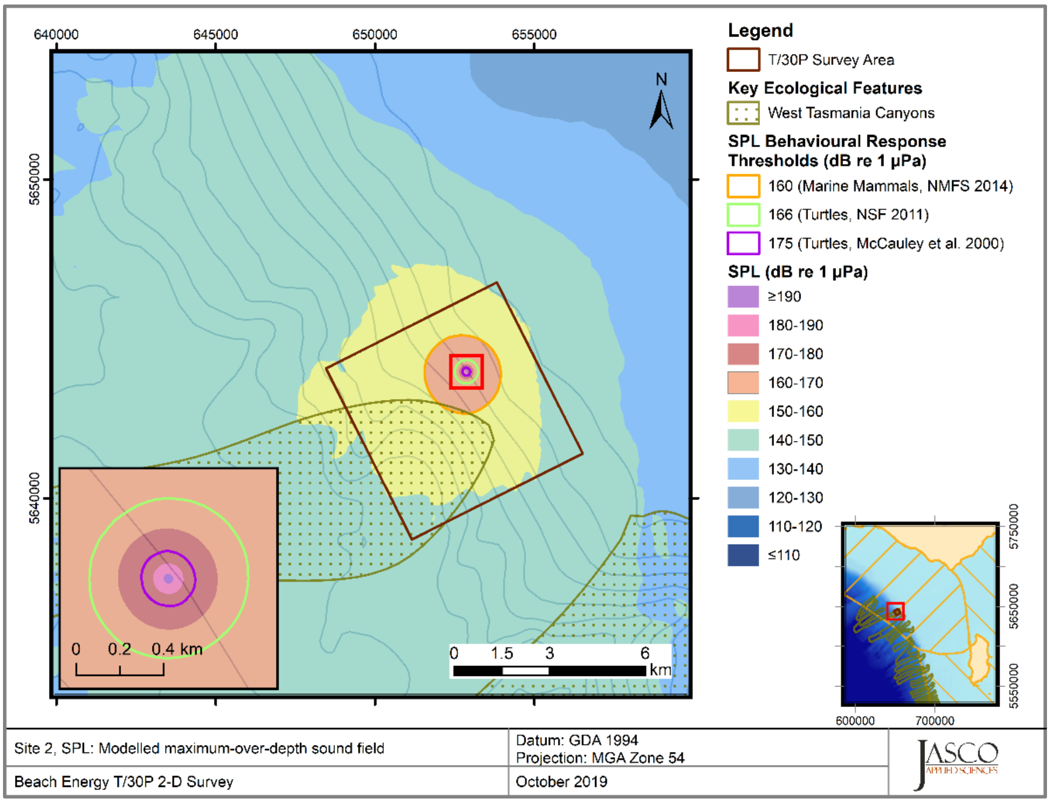

Figure 5. *Site 2, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

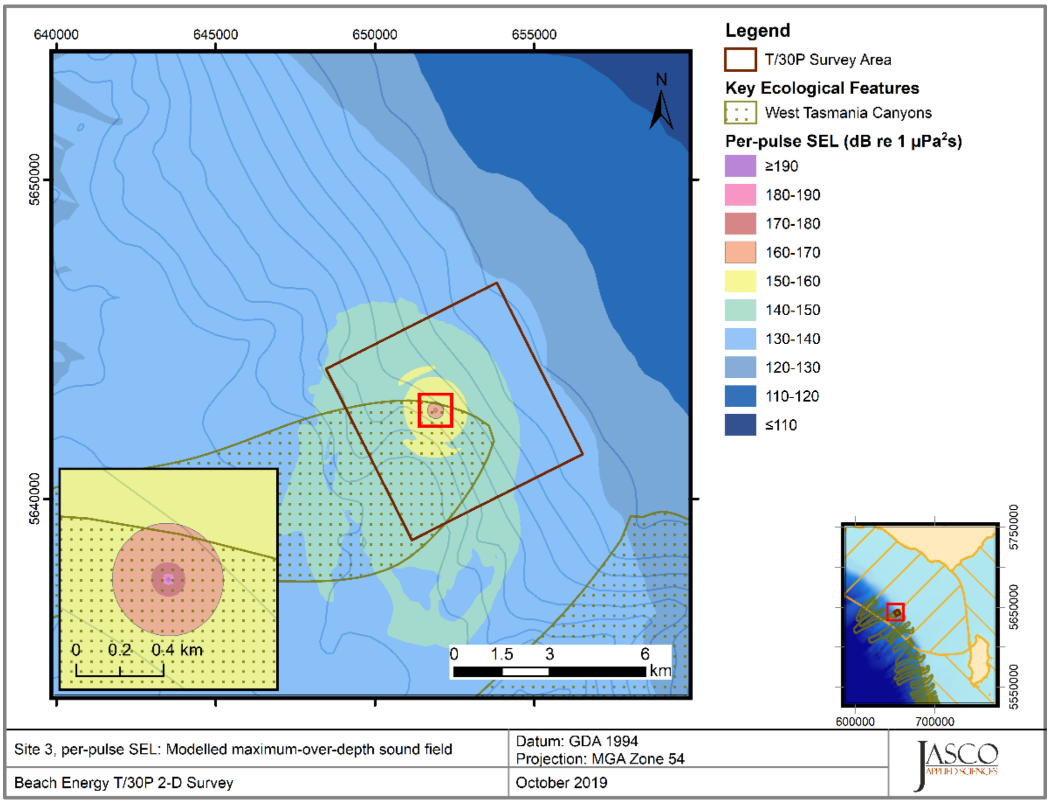

Figure 6. *Site 3, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

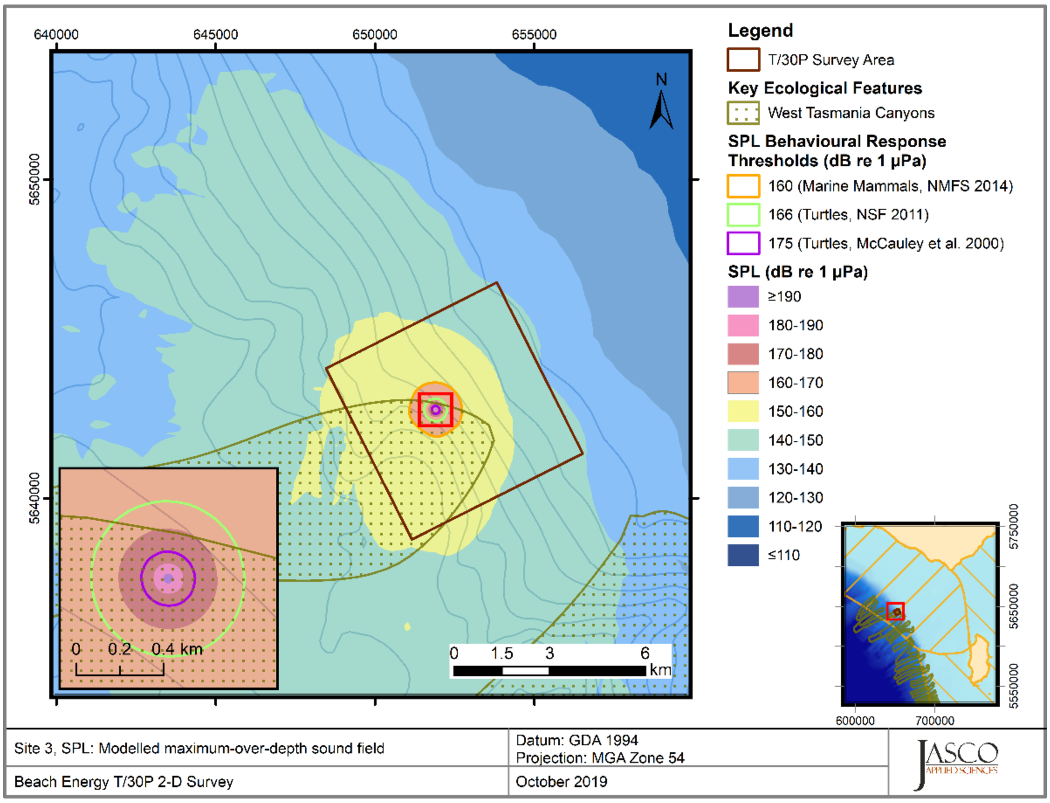

Figure 7. *Site 3, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

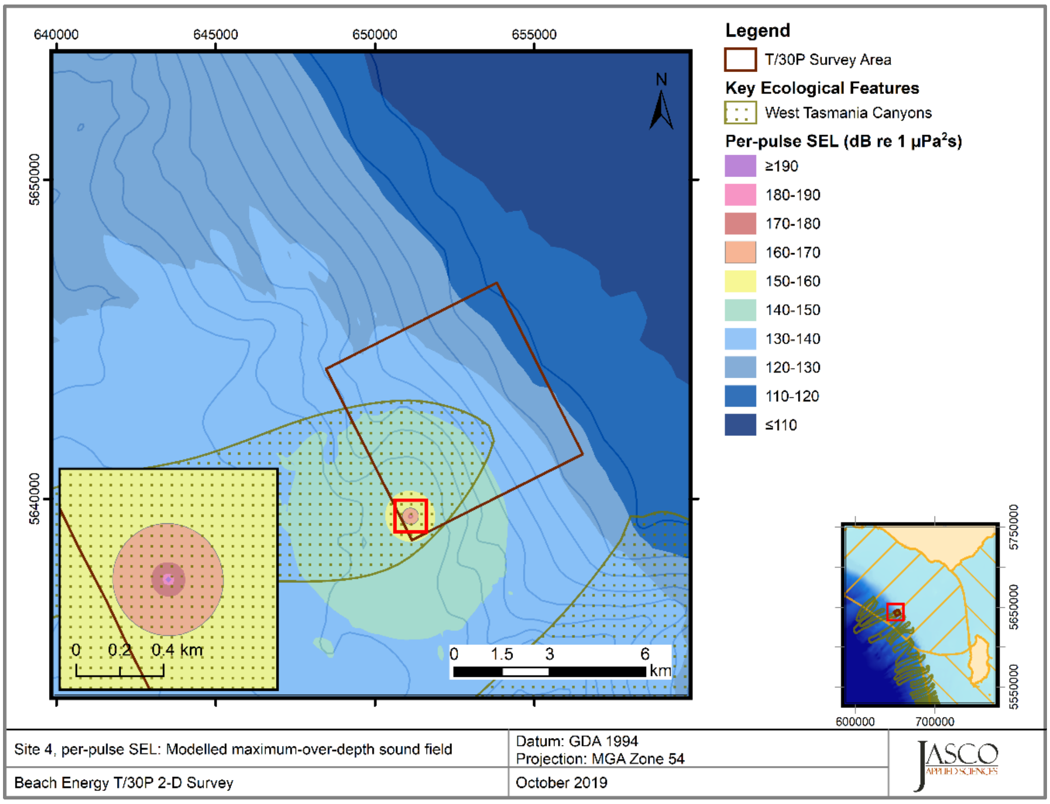

Figure 8. *Site 4, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth results.

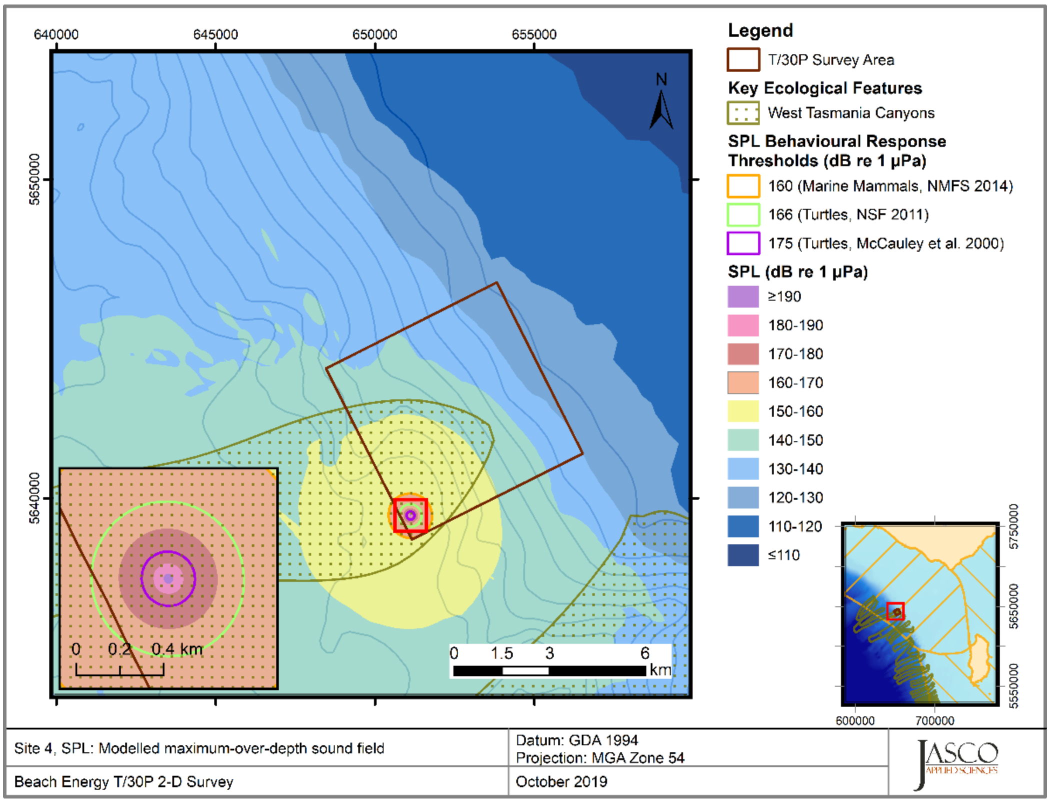

Figure 9. *Site 4, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

5.2.2.2. Vertical slices of modelled sound fields

Vertical slices of the SPL sound fields for the 160 in^3 airgun source are shown in Figures 10–12.

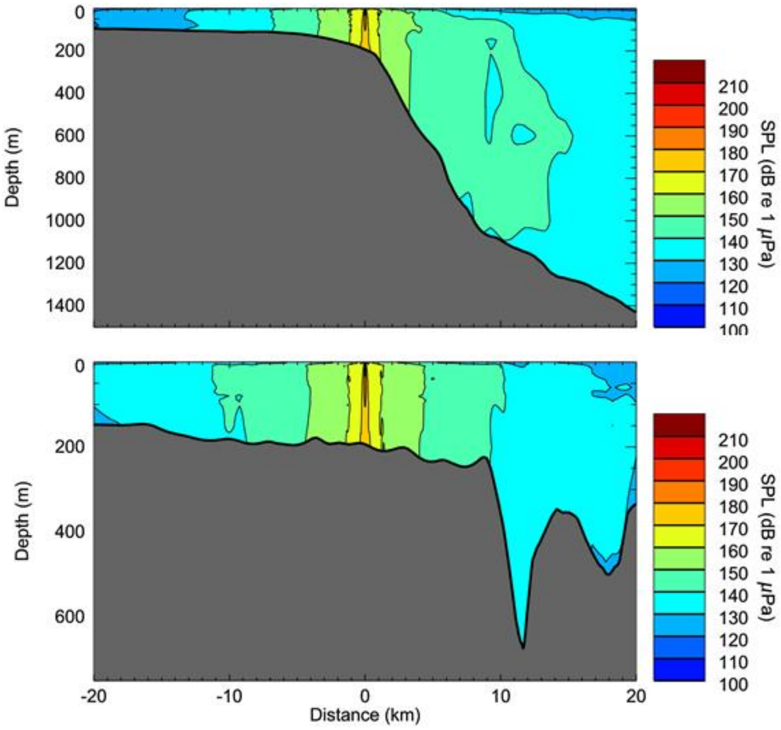

Figure 10. *Site 1, SPL*: Vertical slice of the predicted SPL for the 160 in^3 source. Levels are shown along the broadside (top) and endfire (bottom) directions.

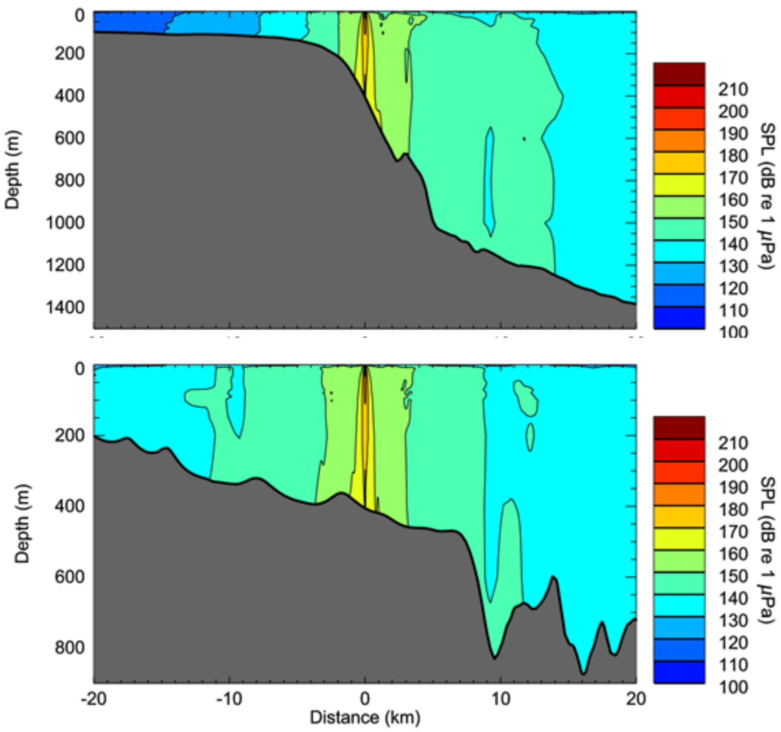

Figure 11. *Site 2, SPL*: Vertical slice of the predicted SPL for the 160 in^3 source. Levels are shown along the broadside (top) and endfire (bottom) directions.

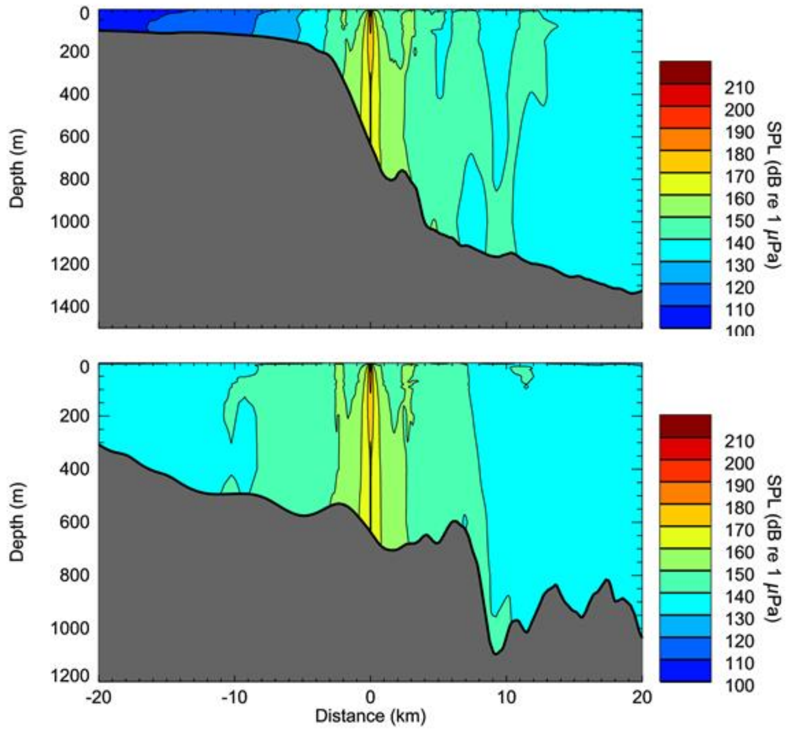

Figure 12. *Site 3, SPL*: Vertical slice of the predicted SPL for the 160 in^3 source. Levels are shown along the broadside (top) and endfire (bottom) directions.

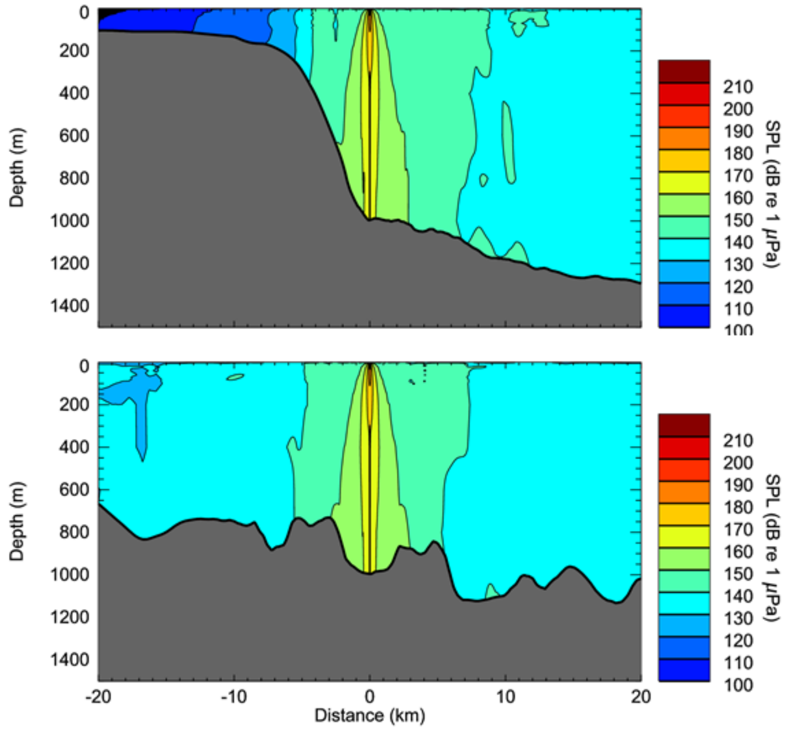

Figure 13. *Site , SPL*: Vertical slice of the predicted SPL for the 160 in^3 source. Levels are shown along the broadside (top) and endfire (bottom) directions.

5.3. Multiple Pulse Sound Fields

The SEL_{24h} results for the proposed survey are presented for one possible operational scenario within the Survey Area. Tables 15 and 16 show the estimated ranges to the appropriate cumulative exposure criterion contour for the various marine fauna groups considered and the corresponding ensonified areas. The ranges in this section are the perpendicular distance from the survey line to the relevant isopleth. Estimates of the maximum-over-depth sound fields, including threshold contours relating to marine mammals and fish, are presented in Figure 14, while estimates of the sound field at the seafloor and threshold contours relevant to fish are presented in Figure 15. Isopleths less than 0.08 km are not shown on the maps.

Table 15. Maximum-over-depth distances (in km) to frequency-weighted SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2018) and turtles (Finneran et al. 2017).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	0.08	10.2
Mid-frequency cetaceans	185	—	—
High-frequency cetaceans	155	—	—
Turtles	204	0.02	0.84
Phocid pinnipeds in water	185	0.02	0.84
Otariid pinnipeds in water	203	—	—
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	9.55	229
Mid-frequency cetaceans	170	—	—
High-frequency cetaceans	140	0.03	2.03
Turtles	189	0.05	7.88
Phocid pinnipeds in water	170	0.05	5.77
Otariid pinnipeds in water	188	—	—

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

Table 16. Distances to SEL_{24h} based fish criteria.

Marine fauna group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Maximum-over-depth		Seafloor	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Mortality and potential mortal injury					
I	219	—	—	*	*
II, fish eggs and fish larvae	210	0.02	1.32	*	*
III	207	0.02	1.67	*	*
Fish recoverable injury					
I	216	—	—	*	*
II, III	203	0.03	2.03	*	*
Fish TTS					
I, II, III	186	0.66	17.2	0.66	15.6

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
An asterisk indicates that the threshold was not reached.

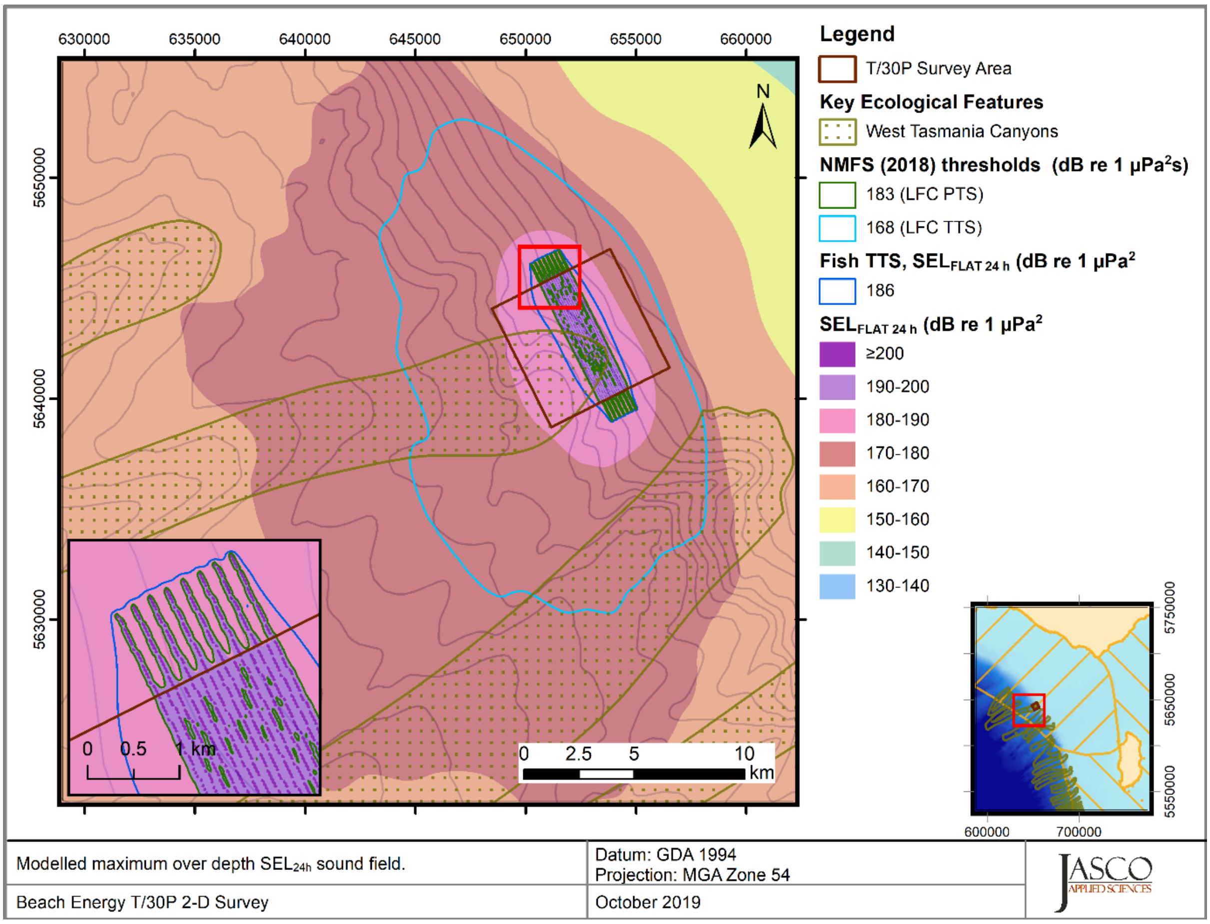

Figure 14. Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for low-frequency cetaceans and fish TTS. Thresholds for mid- and high-frequency cetacean PTS were not reached.

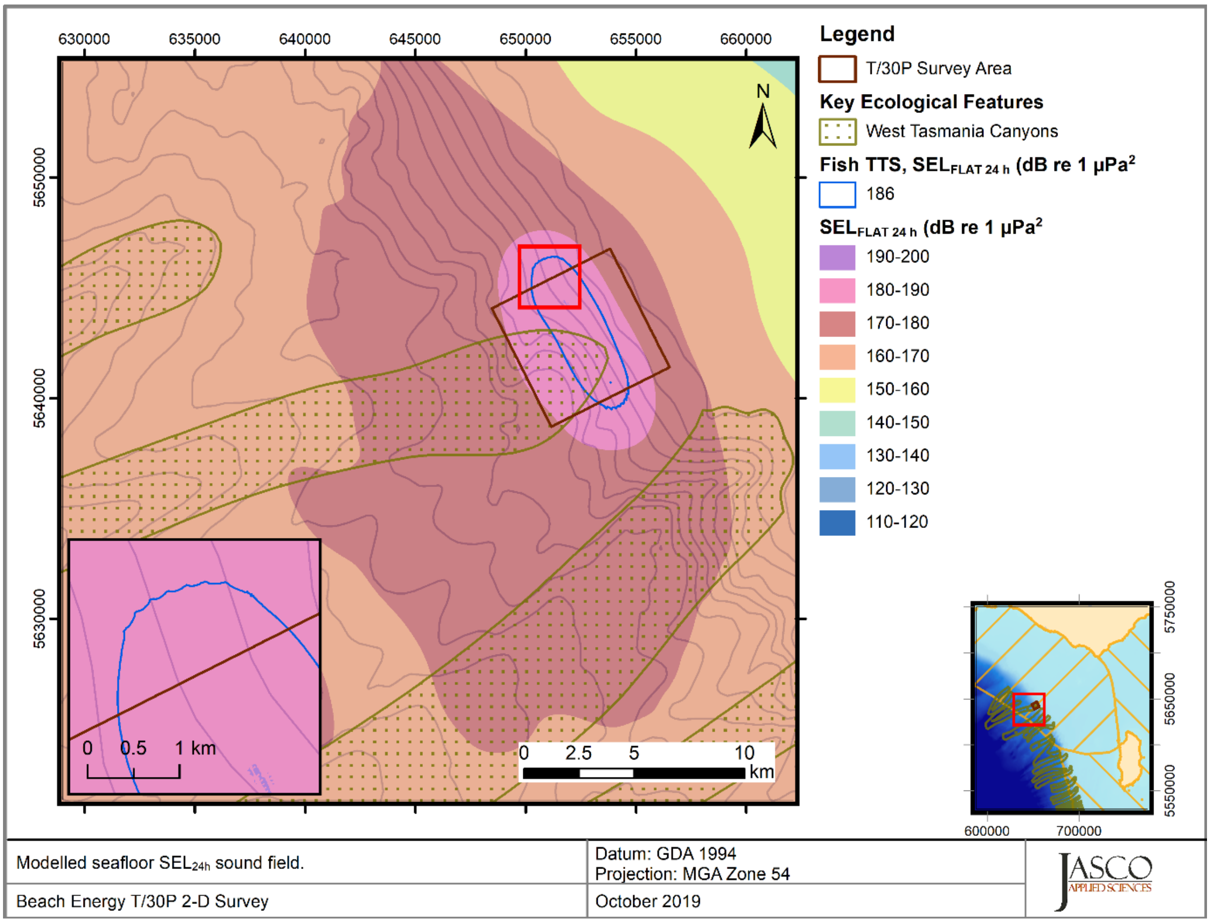

Figure 15. Sound level contour map showing unweighted seafloor SEL_{24h} results, along with the isopleth for fish TTS.

6. Discussion

6.1. Overview and Source Levels

This modelling study predicted underwater sound levels associated with the planned T/30P 2-D Survey. The underwater sound field was modelled for a 160 in^3 seismic source (Appendix B) with a water column sound speed profile for April. An analysis of seasonal sound speed profiles, the results of which are presented in Appendix D.3.2, indicated that the month of April was the most conducive to sound propagation due to the presence of a upward refracting layer; as such it was selected to ensure a conservative estimation of distances to received sound level thresholds over the potential survey periods; modelling also accounted for site-specific bathymetric variations (Appendix D.3.1) and local geoacoustic properties (Appendix D.3.3).

Most acoustic energy from the seismic source is output at lower frequencies, in the tens to hundreds of hertz. The source had a no pronounced broadside directivity (Appendix B.2) and is effectively an omni-directional source.

The overall broadband (10–25000 Hz) unweighted per-pulse SEL source level of the 160 in^3 source operating at 7 m depth was 210.1 dB 1 μPa^{2}m^{2}s in the broadside direction and 210.3 dB 1 μPa^{2}m^{2}s in the endfire direction. The peak pressure level in the same directions was 233.1 and 233.8 dB re 1 μPa m, respectively, these results are presented in Table 8.

6.2. Per-Pulse Sound Fields

The sound speed profile (Figure D-4) was primarily downward refracting apart from a slight upward refracting layer, which extended to approximately 25 m from the sea surface. The sound speed profile had a minimum sound speed at approximately 1100 m that forms the sound channel axis. For source locations near the shelf break, significant amounts of energy can be reflected from the seabed and trapped in the sound channel which can then propagate for large distances within the ocean interior. This phenomenon resulted in large ranges to all isopleths in the offshore directions.

The slight upward refracting layer in the sound speed profile, will only effectively trap frequencies above 1500 Hz (Jensen et al. 2011). The presence of this layer has the potential to trap levels at higher frequencies which would otherwise dissipate more rapidly in range due to propagation, absorption and seabed losses.

The distances to PK and PK-PK based potential injury criteria or sound levels from literature (Sections 3.2 and 3.3) for fish and benthic invertebrates at the seafloor for Site 1 were not reached (Tables 13 and 14). This is a consequence of the deep waters within the survey area and the comparatively small seismic source. The shallowest modelling site provides a good representation of potential impact for seabed receptors, all received levels for impulse locations in deeper waters are expected to be less than the levels predicted at Site 1.

6.3. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic source operation was modelled considering representative scenarios with realistic acquisition patterns for the T/30P 2-D Survey. The modelling predicted the accumulation of sound energy, considering the change in location and the azimuth of the source at each pulse point, which were used to assess possible injury in marine mammals and the SEL_{24h} based fish and marine mammal criteria. The results were presented as maps of the accumulated exposure levels and tabulated values of ranges to threshold levels and exposure areas for the given effects criteria (Section 5.3).

The footprints and range maxima for all accumulated SEL thresholds substantially influenced by the locations of the source near the shelf break. For a survey lines that run parallel to the shelf break energy that is transmitted into the water column in the offshore direction can be trapped in the sound channel and propagate with minimal loss, as discussed above. This effect is manifested in the extended isopleths and R_{max} distances to thresholds in the offshore direction shown Figures 14 and 15. Furthermore, as levels generally decay away from the source the rate of decay decreases with range, propagation effects of this nature can further reduce the decay rate and allow lower levels to persist to longer ranges.

6.4. Summary

The findings of the study pertaining each of the metrics and criteria for various marine species of interest are summarised below with references to the result location.

Marine mammal injury and behaviour

- The maximum distance where the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded varied between 0.7 and 1.52 km (Site 4 and Site 1), provided in Table 10.
- The results for the criteria applied for marine mammal Permanent Threshold Shift (PTS), NMFS (2018), consider both metrics within the criteria (PK and SEL_{24h}). The longest distance associated with either metric is required to be applied. Table 17 summarises the maximum distances for PTS, along with the relevant metric and the location of the results within this report.
- The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that location for 24 hours.

Table 17. Summary of maximum marine mammal PTS onset distances for modelled scenarios (PK values from Table 11 and SEL_{24h} values from Table 15)

Hearing Group	Metric associated with longest distance to PTS onset	R_{max} (km)
Low-frequency cetaceans†	SEL_{24h}	0.08
Mid-frequency cetaceans	—	—
High-frequency cetaceans	PK	0.03
Phocid pinnipeds in water	SEL_{24h}	0.02
Otariid pinnipeds in water	—	—

† The model does not account for shutdowns.
A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m (horizontal modelling resolution for FWRAM) from the acoustic centre of the source.
- The maximum distance to the SEL_{24h} metric for PTS onset was 20 m and 0.05km for TTS onset (Finneran et al. 2017). As is the case with marine mammals, a reported radius for SEL_{24h} criteria does not mean that turtles travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with either PTS or TTS if it remained in that location for 24 hours.
- The distances to where the NMFS criterion (NSF 2011) for behavioural response in turtles of turtles of 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) threshold for behavioural

disturbance (McCauley et al. 2000b, McCauley et al. 2000a) could be exceeded are summarised in Table 18.

Table 18. Summary of distances to turtle behavioural response criteria (from Table 10).

SPL (L_p; dB re 1 µPa)	Distance (km)	
	Min	Max
175†	0.12	0.13
166‡	0.36	0.59

† Threshold for turtle behavioural disturbance from impulsive noise (McCauley et al. 2000b, McCauley et al. 2000a).
‡ Threshold for turtle behavioural response to impulsive noise (NSF 2011).

Fish, fish eggs, and fish larvae

- This modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK (seafloor and water column) and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
    - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
    - Fish with a swim bladder that do not use it for hearing
    - Fish that use their swim bladders for hearing
    - Fish eggs and fish larvae

Table 19 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 19. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and SEL24h modelled scenarios (PK values from Tables 11 and 13, SEL_{24h} values from Table 16).

Relevant hearing group	Effect criteria	Water column		Seafloor	
		Metric associated with longest distance to criteria	R_{max} (km)	Metric associated with longest distance to criteria	R_{max} (km)
Fish: No swim bladder	Injury	—	—	*	*
	TTS	SEL_{24h}	0.66	SEL_{24h}	0.66
Fish: Swim bladder not involved in hearing and Swim bladder involved in hearing	Injury	SEL_{24h}	0.03	*	*
	TTS	SEL_{24h}	0.66	SEL_{24h}	0.66
Fish eggs, and larvae	Injury	Both SEL_{24h} & PK	0.02	*	*

A dash indicates the threshold was not reached within the limits of the modelling resolution (20 m).
An asterisk indicates that the threshold was not reached.

Crustaceans and Bivalves, Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally for context, the

PK-PK sound levels assessed in Day et al. (2016) and Day et al. (2019), 209–213 dB re 1 µPa, are also included. None of these sound levels were exceeded at the seafloor (Table 14).

- Bivalves: PK-PK sound levels of 191, 212 and 213 considered in Day et al. (2017) for scallops were not exceeded at the seafloor (Table 14).
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated, and compared to the no effect sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not exceeded at the seafloor (Table 13).
- Plankton: The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017) was estimated at two modelling sites through full-waveform modelling using FWRAM; the maximum distance was 0.02km (Table 12).

Glossary

1/3-octave
One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017).

1/3-octave-band
Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

90%-energy 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}.

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.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cavitation
A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. See also broadside direction.

ensonified
Exposed to sound.

far-field
The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

hearing group
Groups of marine mammal species with similar hearing ranges. Commonly defined functional hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seabed.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for hearing high frequencies.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic airguns and impact pile driving.

low-frequency (LF) cetacean
The functional cetacean hearing group that represents mysticetes (baleen whales) specialized for hearing low frequencies.

mean-square sound pressure spectral density
Distribution as a function of frequency of the mean-square sound pressure per unit bandwidth (usually 1 Hz) of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2/Hz$.

mid-frequency (MF) cetacean
The functional cetacean hearing group that represents those odontocetes (toothed whales) specialized for mid-frequency hearing.

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.

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 pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

peak-to-peak pressure level (PK-PK)
The difference between the maximum and minimum instantaneous pressure levels. Unit: decibel (dB).

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

received level (RL)
The sound level measured (or that would be measured) at a defined location.

rms
root-mean-square.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for airguns], single-strike SEL [for pile drivers], 24-hour SEL).

sound exposure spectral density
Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ANSI S1.1-1994 R2004). Unit: $\mu Pa^2 \cdot s/Hz$.

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound intensity
Sound energy flowing through a unit area perpendicular to the direction of propagation per unit time.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound level measured in the far-field and scaled back to a standard reference distance of 1 metre from the acoustic centre of the source. Unit: dB re 1 µPa m (pressure level) or dB re 1 $\mu Pa^2 \cdot s \cdot m^2$ (exposure level).

spectral density level
The decibel level ($10 \cdot \log_{10}$) of the spectral density of a given parameter such as SPL or SEL, for which the units are dB re 1 $\mu Pa^2/Hz$ and dB re 1 $\mu Pa^2 \cdot s/Hz$, respectively.

spectrum
An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

surface duct
The upper portion of a water column within which the sound speed profile gradient causes sound to refract upward and therefore reflect off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive noise exposure.

thermocline
The depth interval near the ocean surface that experiences temperature gradients due to warming or cooling by heat conduction from the atmosphere and by warming from solar heating.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also referred to as propagation loss.

wavelength
Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa. Because the perceived loudness of sound, especially 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 (PK; L_{pk}; $L_{p,pk}$; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20\log_{10}\left[\frac{\max\left(\left|p(t)\right|\right)}{p_0}\right] \qquad \text{(A-1)}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure level (PK-PK; $L_{pk\text{-}pk}$; $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure levels in a stated frequency band attained by an impulsive sound, $p(t)$:

$$L_{p,pk-pk} = 10\log_{10}\left\{\frac{\left[\max\left(p(t)\right)-\min\left(p(t)\right)\right]^2}{p_0^2}\right\} \qquad \text{(A-2)}$$

The sound pressure level (SPL; L_p; 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 a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \qquad \text{(A-3)}$$

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 vocalization, 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. A fixed window length of 0.125 s (critical duration defined by Tougaard et al. (2015)) is used in this study for impulsive sounds.

The sound exposure level (SEL; L_E; $L_{E,p}$; dB re 1 µPa^2·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):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \qquad \text{(A-4)}$$

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:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \tag{A-5}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.2. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.2.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 $\mu Pa^2 \cdot s$.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; with the criteria defined in NMFS (2018) applied in this report.

A.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.3.1. Marine mammal frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-6)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36
Phocid seals in water	1.0	2	1,900	30,000	0.75
Otariid seals in water	2.0	2	940	25,000	0.64

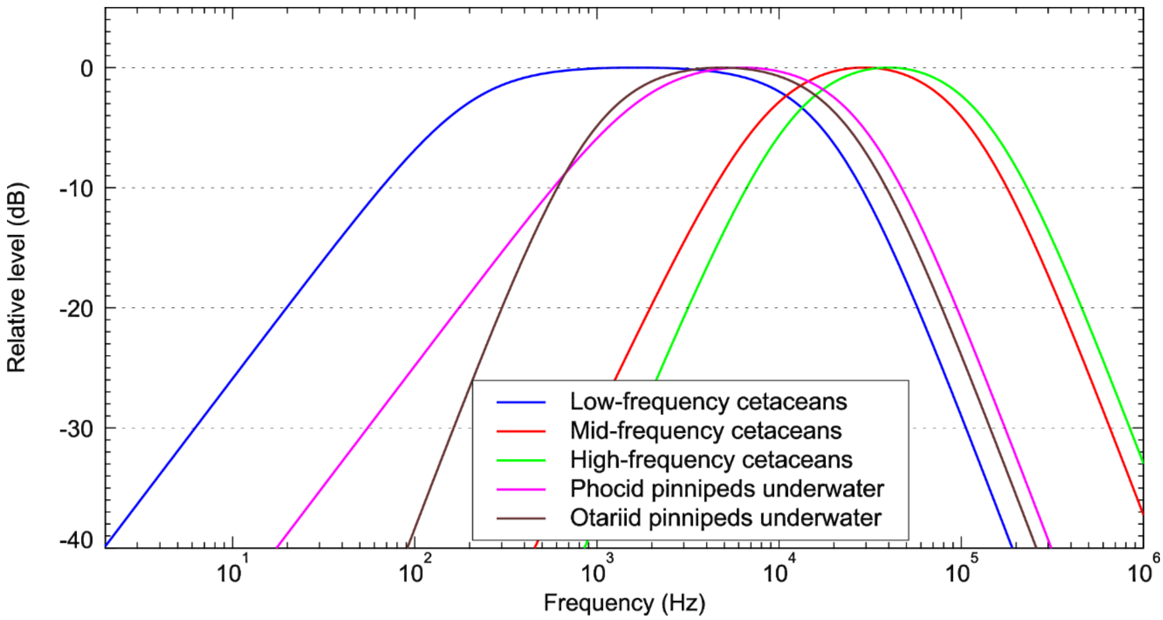


Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed 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.

While airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (800−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 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 a directional point source in the far field.

A seismic array consists of many sources and the point source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Array Source Levels and Directivity

Figure B-1 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signature and corresponding power spectrum levels for the 160 in^3 array (Appendix D.4).

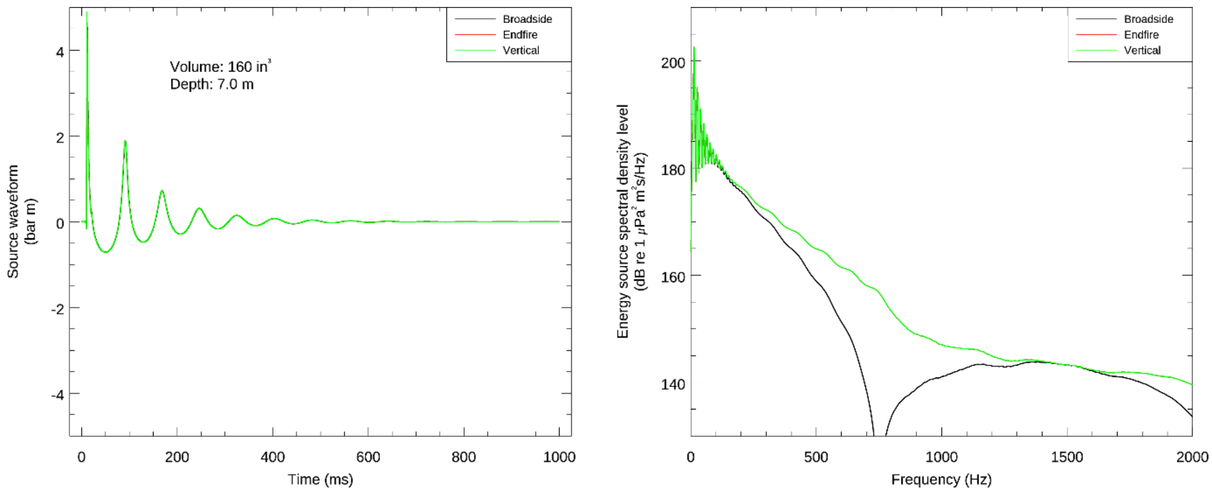


Figure B-1. Predicted source level details for the 160 in^3 array at 7 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane horizontal (broadside), perpendicular (endfire), and vertical directions.

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-2).

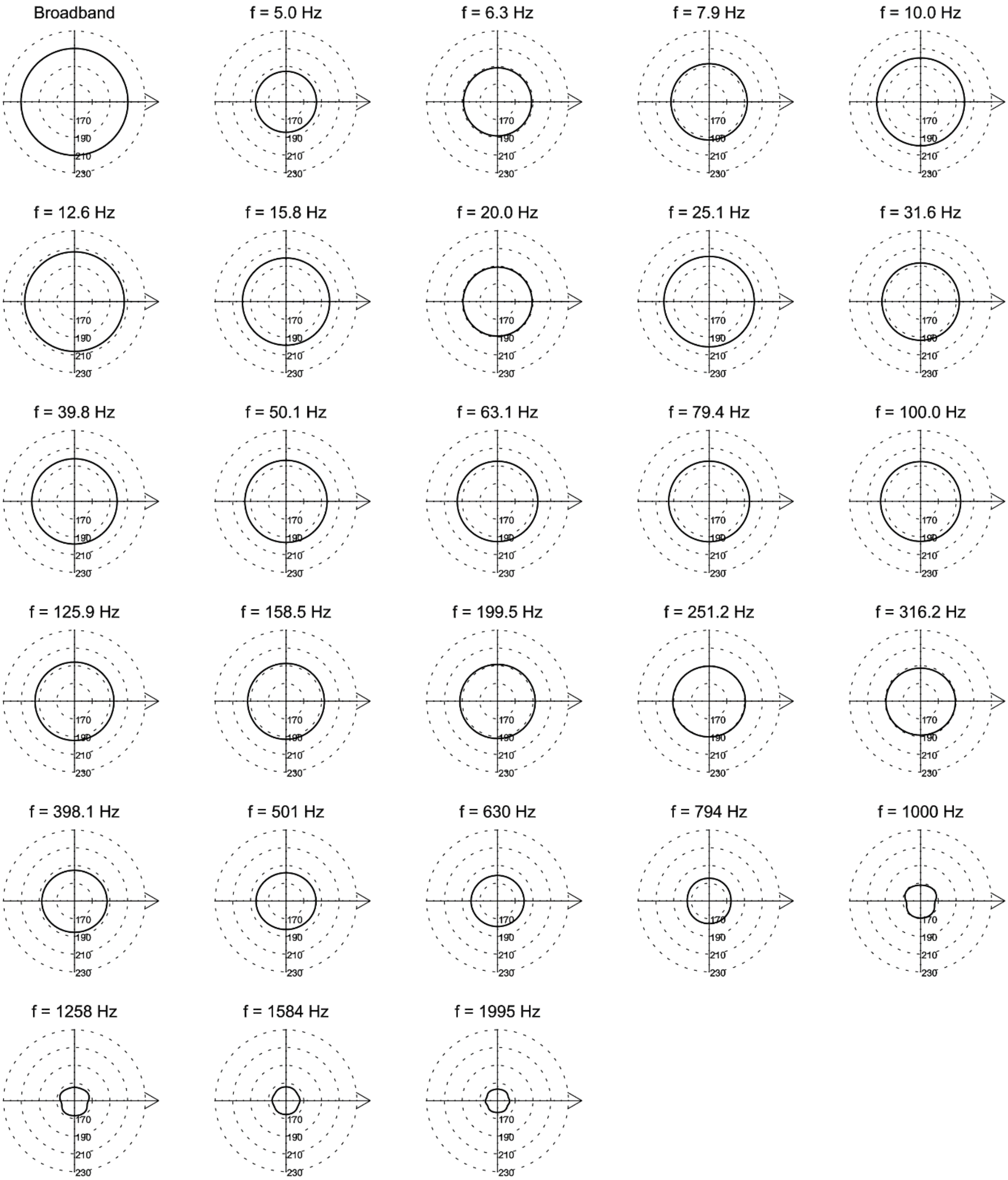


Figure B-2. Directionality of the predicted horizontal source levels for the 160 in^3 seismic source, 10 Hz to 2 kHz. Source levels (in dB re 1 $\mu Pa^2 \cdot s\ m^2$) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. The perpendicular direction to the frame is to the right. Tow depth is 7 m (see Figure B-1).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 10 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).

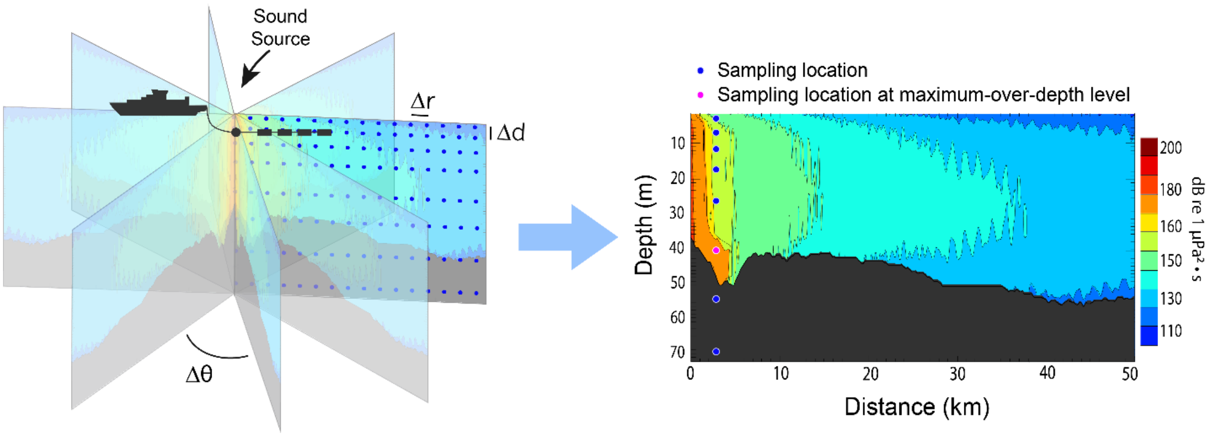


Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

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 of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received 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 location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure C-2). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure C-2) upward so that the trend line encompasses 90% of all the data (dashed line, Figure C-2).

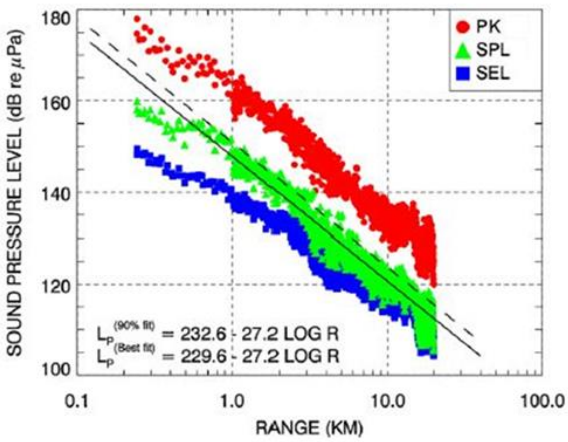


Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

C.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

Appendix D. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

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.

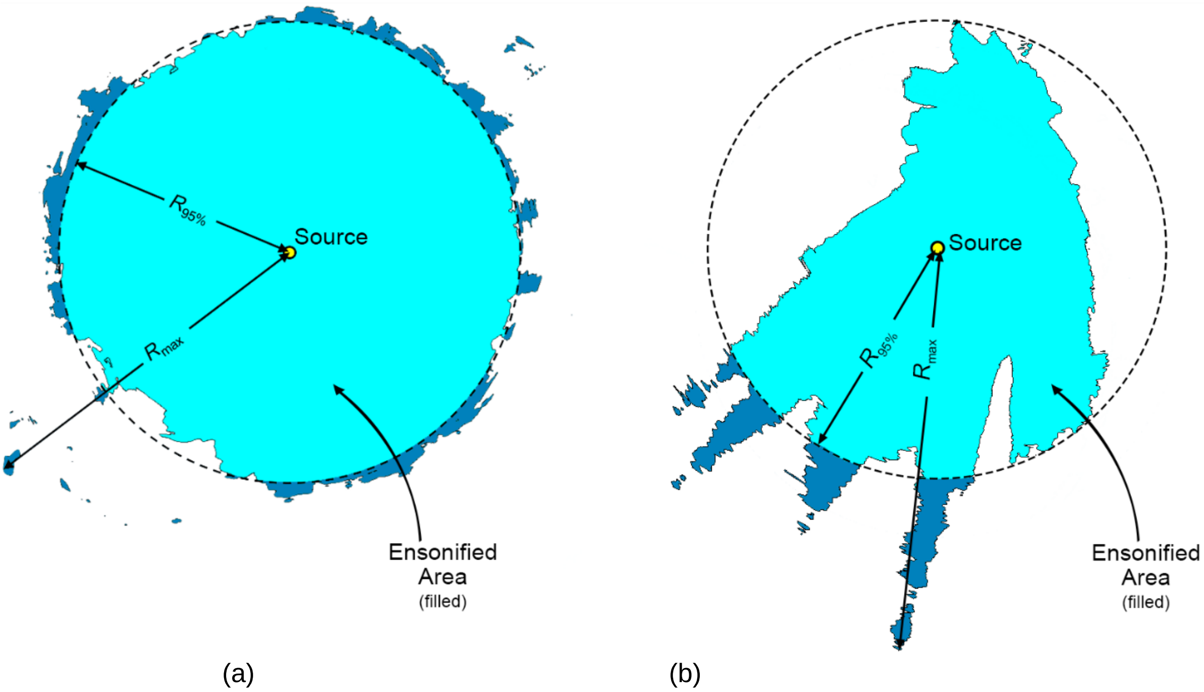


Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified 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 per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017b). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 5–1024 Hz. This was performed along all broadside and endfire radials at two sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL -to-SPL offsets were averaged in 0.3 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range- dependent conversion function was averaged between the two sites and applied to predicted per-pulse SEL results from MONM to model SPL values. Figure D-2 shows the conversion offsets for each site; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source. Modelling was conducted using the average conversion function from all three sites.

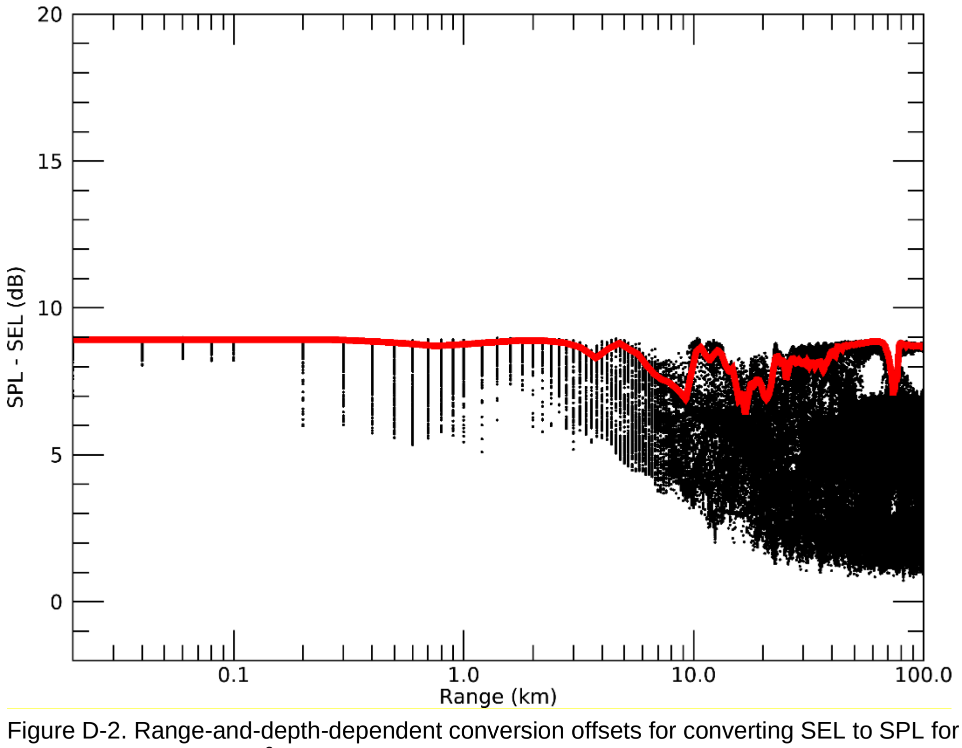


Figure D-2. Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Slices are shown for the 160 in^3 seismic source at Site 2. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009) for the region shown in Figure 1. Bathymetry data were extracted and re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 54) with a regular grid spacing of 200 × 200 m to generate the bathymetry in Figure D-3.

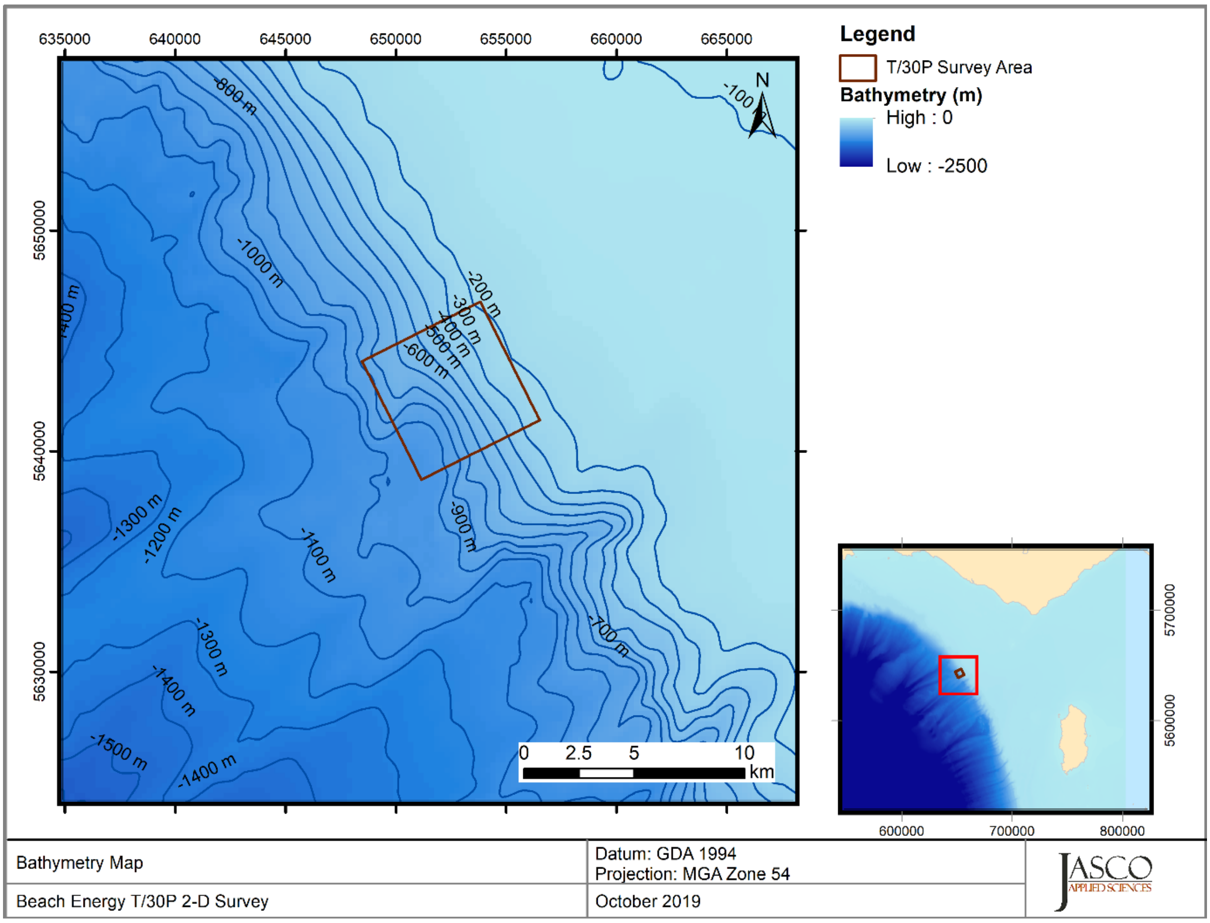


Figure D-3. Bathymetry map of the modelling area.

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 climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles (February to April) were derived from the GDEM profiles within a 100 km box radius encompassing all modelling sites. The April sound speed profile is expected to be most favourable to longer-range sound propagation during the proposed survey time frame. As such, April was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. Figure D-4. shows the resulting profile used as input to the sound propagation modelling.

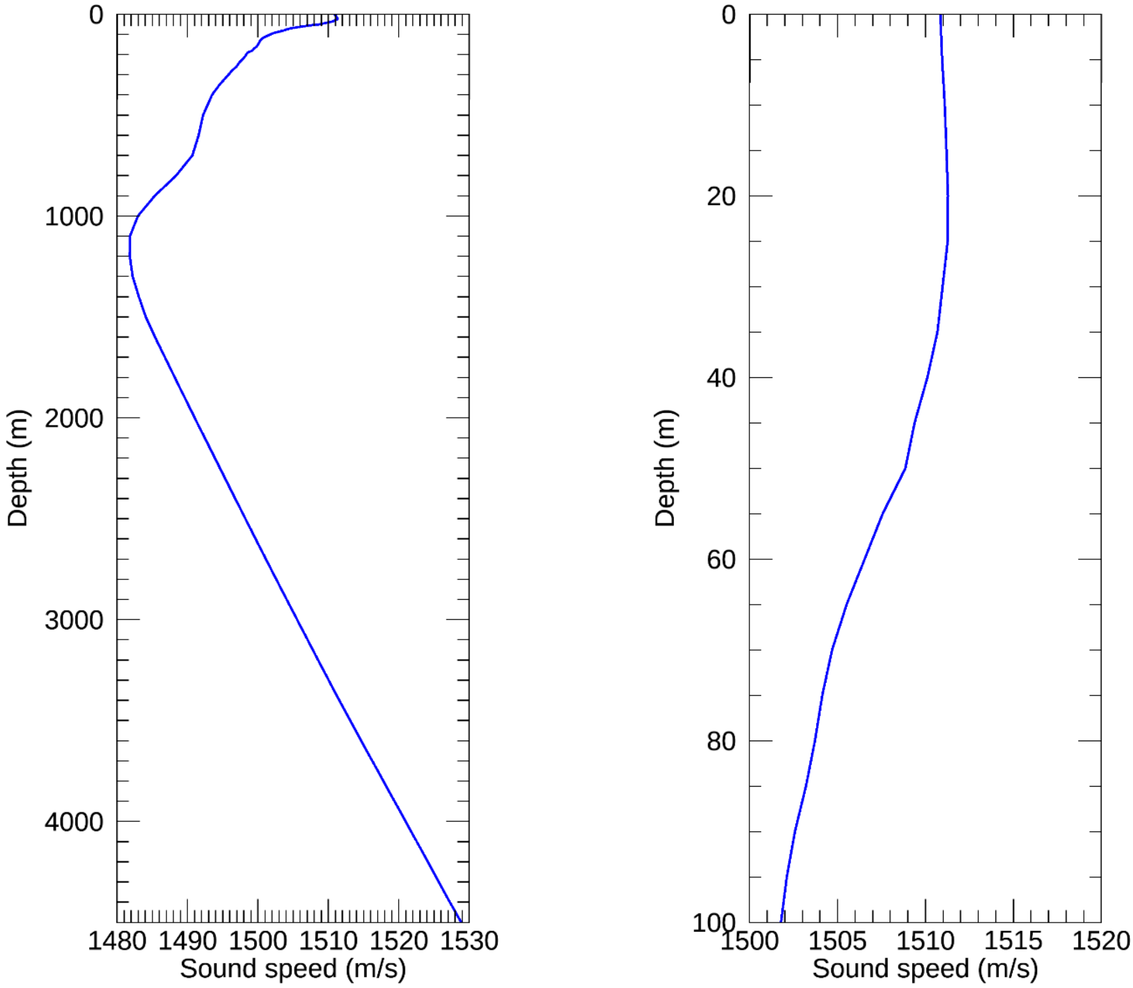


Figure D-4. The final sound speed profile (April) used for the modelling showing the entire water column (left) and the top 100 m within the profile (right). Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Geotechnical data has been acquired from borehole analysis nearby modelling Site 1 at the western edge of the Bass Strait (Duncan et al. 2013). The sediment is typified by a thin layer of well-cemented calcarenite overlying a softer sand/calcarenite layer that extends for a further 100 m below the sea floor. The sound propagation models use a single value shear speed, which has been set at a value representative of the layers beneath the cemented calcarenite layer. Table D-1 lists the geoacoustic properties used for modelling.

Table D-1. Geoacoustic profile used as the input to the models for Site 1.

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 calcarenite	2.20	2600	0.2	500	0.4
1–101	Slightly to semi-cemented sand/calcarenite	1.90	2100	0.12		
101–1000	Semi-cemented sand/calcarenite	1.90	2200	0.12		
>1000	Basement (rock)	3.0	3800	0.1		

Geoacoustic parameters used for modelling at sites in deeper waters (Sites 2–4) were derived from sedimentary grain size measurements from the Australian Government's Marine Sediments (MARS) database (Heap 2009). Most of these samples were taken on or near the seafloor, although some are from sediment at greater depths. On average, the surficial grain size indicates silty sand is present throughout the modelled area. Geotechnical data along the southern Australian shelf typically show sand overlaying calcarenite layers (Bradshaw 2002, Duncan et al. 2013). Representative grain sizes and porosity were used in the grain-shearing model proposed by Buckingham (2005) to estimate the geoacoustic parameters required by the sound propagation models. Table D-2 lists the geoacoustic parameters used for modelling.

Table D-2. Geoacoustic profile used as the input to the models at Site 2 and Site 4.

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)
0–10	Silty carbonate sand to semi-cemented limestone	1.88	1605–1700	0.35–0.70	255	3.65
10–20		1.88–1.89	1700–1755	0.70–0.85		
20–50		1.89–1.90	1755–1850	0.85–1.15		
50–100		1.90–1.92	1850–1950	1.15–1.35		
100–200		1.92–1.96	1950–2100	1.35–1.60		
200–500		1.96–2.05	2100–2355	1.60–1.95		
>500		2.05	2355	1.95		

D.4. Seismic Source

The layout of the seismic sources considered in Appendix B is provided in Figure D-5. Details of the airgun parameters are provided in Table D-3.

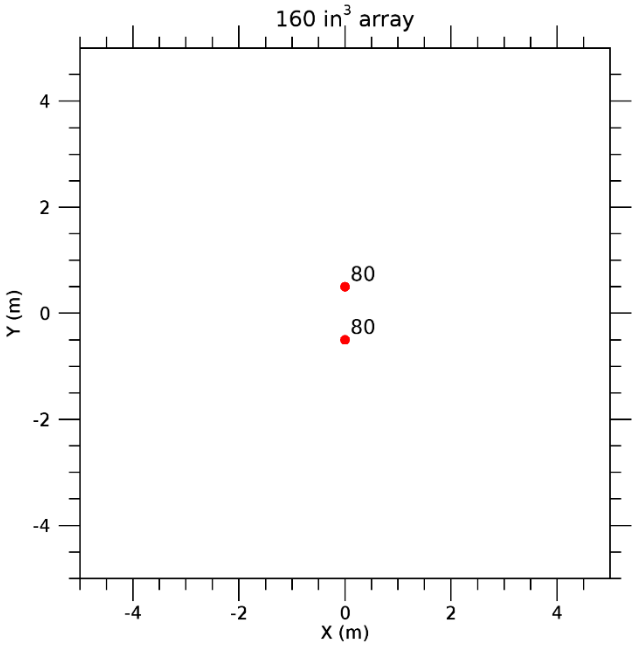


Figure D-5. Layout of the modelled 160 in^3 seismic source array. Tow depth is 7 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-3.

Table D-3. Layout of the modelled 160 in^3 seismic source array. Tow depth is 7 m. Firing pressure for all guns is 2000 psi. Also see Figure D-5.

Gun	x(m)	y(m)	z(m)	Volume (in^3)
1	0	-0.5	7.0	80.0
2	0	0.5	7.0	80.0

D.5. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix E EP Revision Change Register

Any changes to the EP should be assessed against the OPGGS(E)R revision submission criteria detailed in Table 7-9.

Date	EP Revision	Section Revised	Changes	MOC No.	EP Submission Required

Appendix F Stakeholder Information Sheets

Otway Offshore Project
Seabed Assessment T/30P


Otway Gas Plant

Project update | November 2019

Project overview

Beach Energy is planning further development of the Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses in Commonwealth waters 32 to 80km from Port Campbell.

Activities include:

- Seabed assessments to determine the suitability of the seabed for the drilling operations and installation of infrastructure to connect new production wells to the existing platform or pipeline
- Drilling of offshore exploration and production wells, up to 9 in total
- Inspections and modifications to existing seabed infrastructure to prepare for the new activities
- Tie-ins to connect new production wells to the existing platform and pipeline
- Plugging and discontinuing of one or more wells in the Geographe and Thylacine fields

For more information on the Otway Offshore Project, including seabed assessments in other locations and drilling activity, please visit www.beachenergy.com.au/vic-otway-basin/

In addition to the seabed assessments for the Otway Offshore Project, which commenced in October 2019, Beach is also planning a seabed assessment within its T/30P permit.

The objective of the T/30P seabed assessment is to determine a suitable location for anchoring and rig placement for drilling operations within the permit.

Location

The seabed assessment will be undertaken over a portion of the Beach T/30P permit and outside of the permit area, located in Commonwealth waters approximately 75 km from Port Campbell. The map over the page shows the seabed assessment and operational area. The seabed assessment area refers to the area where the data acquisition will occur and is the focus of geotechnical and geophysical investigations. The operational area refers to a broader area around the seabed assessment area which allows for vessel turning and ancillary operations.

The seabed assessment area covers a distance of 6 km x 6 km and sits within the larger operational area which covers a distance of 10 km x 10 km. The coordinates of the operational area are provided in the table below.

Longitude	Latitude
142°41′30.1″E	39°19′55.2″S
142°47′40.9″E	39°17′26.2″S
142°50′53.0″E	39°22′14.1″S
142°44′41.9″E	39°24′43.3″S

Timing

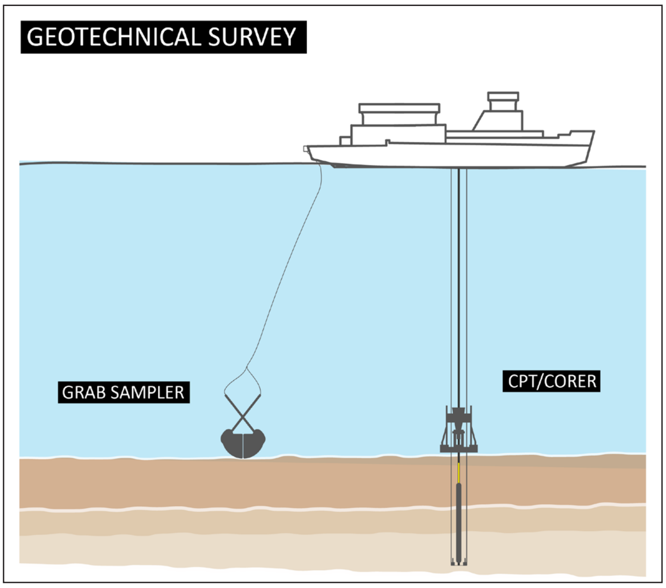
The seabed assessment will take approximately 4 weeks and will be undertaken between February and April 2020.

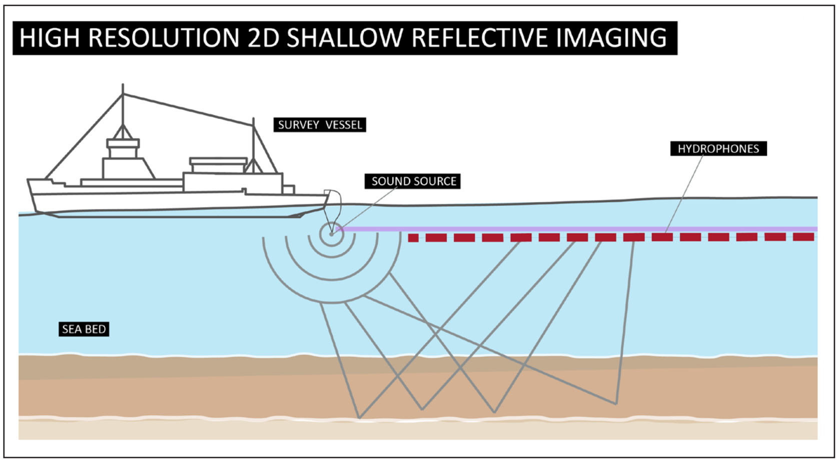
Activities

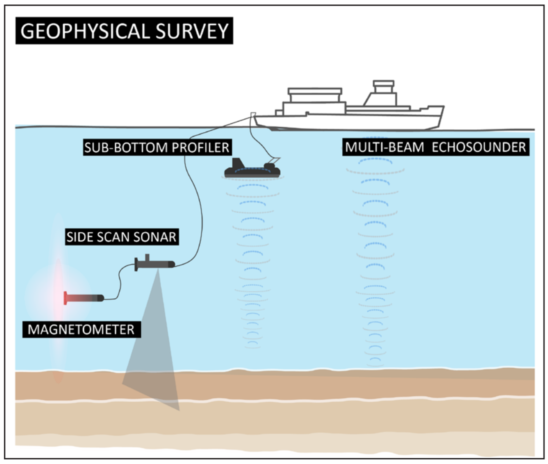
The seabed assessment activities will involve geotechnical and geophysical investigations from a survey vessel as follows:

- Geophysical survey program consisting of multibeam echosounder, side-scan sonar, sub-bottom profiler, magnetometer and 2D high-resolution reflective imaging
- Geotechnical survey program consisting of coring, cone penetration testing (CPT) and sample of seabed sediments using a grab sampler

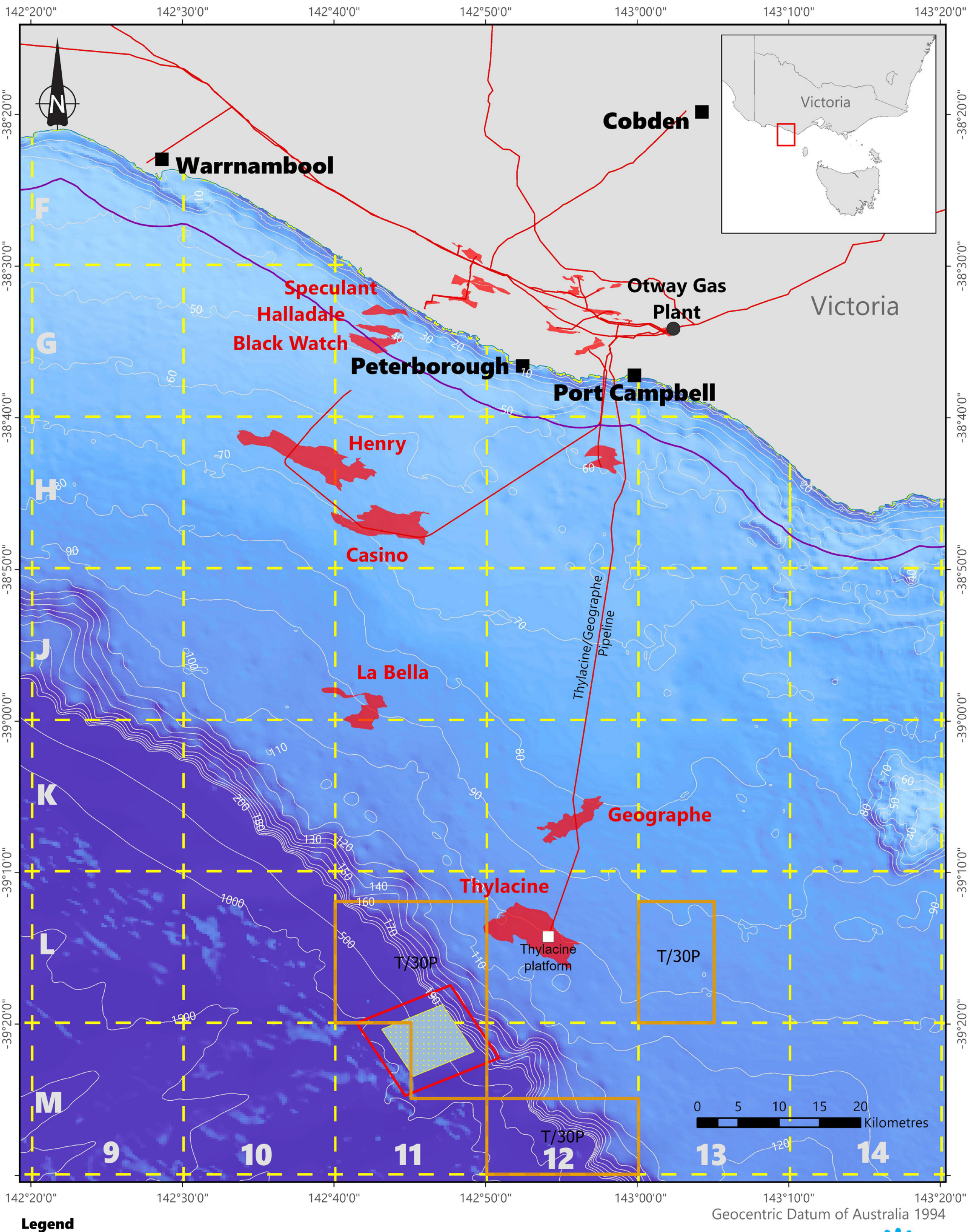
The diagrams below show a common setup for seabed assessments.







T/30P Seabed Assessment Location



Legend

Questions and Answers

Why are you undertaking this seabed assessment?

Beach holds the T/30P exploration permit and is required to complete exploration activities within timeframes set by the Commonwealth National Offshore Permit Titles Administrator (NOPTA). The seabed assessment is required to determine a suitable location for anchoring and rig placement for future drilling operations.

What approvals are required before you can commence the seabed assessment?

An Environment Plan is required to be submitted to the NOPSEMA for approval under the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (the Regulations).

The contents of an Environment Plan are set out in the Regulations and must include a description of the existing environment and the proposed activity, an evaluation of the impacts and risks associated with the activities, environmental performance outcomes and standards, implementation strategy, and reporting requirements.

As the seabed assessment activities include a seismic component, on submission of the Environment Plan to NOPSEMA it will be made available for a public comment period of 30 days. If you would like to be notified of when this public comment period commences you can register your interest on the NOPSEMA website: info.nopsema.gov.au/home/open_for_comment

Why is a seismic survey required?

2D high-resolution reflective imaging which uses a small sound source and streamer, will be undertaken to identify if there is any shallow gas present. If confirmed, this data will enable planning of the appropriate drilling technology to manage that scenario safely. The 2D survey will take up to 7 days and consist of one 160 cubic inch sound source and one 1.2 km streamer towed by a vessel. See figure on page 2 for set-up.

Will the activities affect rock lobsters and scallops?

Sound from the seabed assessment equipment will be a significantly lower intensity than seismic surveys. Modelling identified that sound levels will not reach the impact level at the seafloor, referred to in the Day et al Report[1] and therefore impacts to scallops and rock lobsters are not predicted.

Will the seabed assessment impact upon commercial fishing?

The seabed assessment area is located within existing designated Commonwealth and State fisheries. Engagement with fisheries has identified a low level of activity in the area. Each fishery covers a vast area, whereas the seabed assessment will only require access to a relatively small area of 10 km x 10 km for a period of up to 14 days.

Beach is committed to minimising the impact of its activities and will consult with commercial fishers on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities.

How will you reduce the risk of collision with other vessels?

The survey vessel will operate in accordance with Australian Maritime Standards and ensure safe operations by:

- Having operational and navigation lighting
- Maintaining a 24-hour visual, radio and radar watch for other vessels
- Pre-survey start notifications
- Daily radio message of vessel location

Will an exclusion zone exist?

Exclusion zones will not be in place during the seabed assessment and normal navigational requirements will be required. When undertaking the 2D high-resolution reflective imaging component the vessel will be towing a 1.2 km streamer and thus will have limited manoeuvrability.

To avoid entanglement and safety risks, fishing nets, lines or pots should not be placed in the seabed assessment area for the period of the seabed assessment.

Should the drilling of a well in the T/30P permit area prove successful, Beach may apply to NOPSEMA for a Petroleum Safety Zone (PSZ) to protect any well infrastructure on the seabed. Further consultation on the PSZ will be undertaken closer to the time.

1 Day, R.D., McCauley, R.M. Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M., Institute for Marine and Antarctic Studies, 2016, Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries, University of Tasmania, Hobart, October. CC BY 3.0.

Will the activities affect whales and dolphins?

Based on the noise modelling any impact to whales and dolphins will be low and temporary based on the short duration of the seabed assessment. The Environmental Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1 - Interaction Between Offshore Seismic Exploration and Whales: Industry Guidelines will be implemented when the geophysical survey is undertaken to manage any impacts to whales that may be in the area during the seabed assessment.
At other times, avoidance of whales and dolphins will be undertaken in accordance with the EPBC Regulations (2000) including adherence to distance and speed requirements.

When will drilling occur?

Beach is planning to have drilled the exploration well by early-mid 2021. Beach is required to prepare a drilling Environment Plan and safety case for submission and acceptance by NOPSEMA. Stakeholders will be consulted as part of the development of the environment plan which will be available on the NOPSEMA website for a public comment period of 30 days.

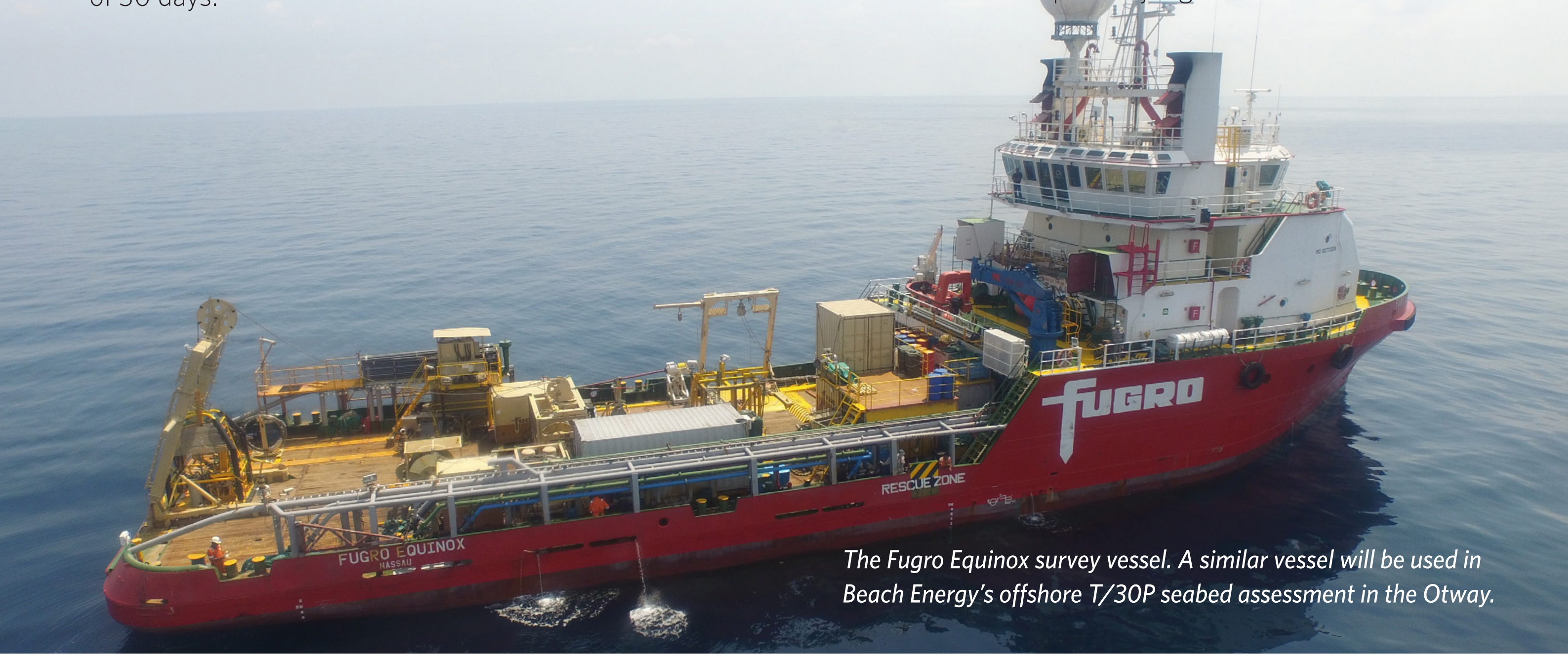
Why are Beach able to conduct seabed assessments outside of the T/30P permit area?

Beach will apply to NOPTA for an access authority to conduct the seabed assessment outside Beach's permit. Beach require this additional data to provide full understanding of the subsurface detail which ensures the safety and positioning of the drill rig.

Consultation

Beach values stakeholder consultation and feedback. The purpose of consultation is to understand how different stakeholders' functions, interests and activities may be affected by the seabed assessments, drilling program and associated activities.

Beach will consider all feedback, including any concerns and objections. Measures will be explored to reduce any impacts and risks, and responses will be provided to stakeholders. All stakeholder feedback, records of consultation, copies of correspondence, including emails will be considered alongside technical and environmental assessments as the Environment Plans are prepared for submission, and will be communicated to NOPSEMA as required by legislation.



The Fugro Equinox survey vessel. A similar vessel will be used in Beach Energy's offshore T/30P seabed assessment in the Otway.

Contact us

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About Beach

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

Appendix G Commercial Fisher Operating Protocol

Beach Energy Otway Development Seabed Survey and Drilling Program
Commercial Fisher Operating Protocol
1 July 2019

This protocol will be undertaken by Beach Energy (Beach) for the Otway Development Seabed Survey and Drilling Programs with Fishers who have identified they fish in the area of the seabed surveys and/or well locations.

The aim of this Commercial Fisher Operating Protocol is to ensure that Beach and Fishers may continue their activities without unduly impacting on each other. These protocols are:

- Beach will notify Fishers a minimum of 4 weeks prior to the commencement of the seabed surveys and drilling program and provide the following information:
  - type of activity;
  - location of activity, coordinates and map;
  - timing of activity: expected start and finish date and duration;
  - sequencing of locations if applicable;
  - vessel or rig details including call sign and contact;
  - requested clearance from other vessels; and
  - Beach contact details.

  Note: coordinates will be provided as degrees and decimal minutes referenced to the WGS 84 datum.
- Beach will consider any reasonable requests to change the sequencing of a survey, however, where a change cannot be accommodated, Beach will inform the Fisher as to the reasons in a timely manner.
- Once the seabed surveys commence, Beach will provide regular (most likely daily) SMS messaging system updates on the locations the vessel will be operating and the expected duration, so Fishers can plan their fishing activities with the least disruption. Beach will request Fishers who wish to receive these SMS updates, to provide their mobile phone number, so they can be included in the distribution list. Beach will also have the vessel master put out daily radio messages on channel 16. The survey vessel will have AIS and so will be able to track any larger fishing vessels in their immediate area.
- The drill rig exclusion zone (500 m) will be communicated via Notice to Mariners. Fishers are to contact channel 16 if they wish to communicate with the rig at any time. The rig will be stationary until it is required to move to the next location. Beach will provide SMS messaging system updates 2 days prior to the rig moving to a new location detailing the new location and the expected duration at the location so Fishers can plan their fishing activities with the least disruption. Beach has undertaken an assessment of the Commonwealth and Victorian fisheries that overlap with the project's operational area and has identified low levels of fishing in this area.

Where Fishers provide Beach with sensitive fishing data, Beach will maintain the confidentiality of that data as per Beach's privacy policy. Given this assessment has identified low levels of fishing and commercial fisheries cover a vast area vs. Beach's seabed surveys and drilling that will only access a relatively small area over a short period of time, Beach's approach is to constructively work with Fishers in order 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, including, past fishing history and the loss incurred. Where the claim is genuine, Beach will provide compensation and will also ensure that the evidence required is not burdensome on the Fisher whilst ensuring genuine claims are processed.