FISHBURN (WA-459-P) 3D SEISMIC SURVEY

ENVIRONMENT PLAN SUMMARY

REVISION 1: Change in survey area shape

TABLE OF CONTENTS

TABLES

FIGURES

UNITS OF MEASUREMENT

‘	Foot (30 cm)
“	Inch (2.54 cm)
bbl	Barrel (159 litres)
°C	Degrees centigrade
g/m^2	Grams per square metre
cP	Centipoise
dB	Decibels
dB(A)	Decibels A-weighting
Hz	Hertz
kl	Kilolitre (1,000 litres)
km	Kilometre (1,000 metres)
km^2	Square kilometres
L	Litre (1,000 ml)
m	Metre (100 cm)
m^2	Square metre
m^3	Cubic metre
mg/L	Milligrams per litre
ml	Millilitre
mm	Millimetre
nm	Nautical mile (1.856 km)
ppb	Parts per billion
ppm	Parts per million
t	Tonne (1,000 kg)
µm	Micrometre (micron)

ABBREVIATIONS and ACRONYMS

3D	3 Dimension
ALARP	As Low As Reasonably Practicable
AMBA	Area that may be affected
AMSA	Australian Maritime Safety Authority
APASA	Asia Pacific - Applied Science Associates
APPEA	Australian Petroleum Production and Exploration Association
AQIS	Australian Quarantine and Inspection Service
BoM	Bureau of Meteorology
CAMBA	China Australia Migratory Birds Agreement
DOEE	Department of Environment and Energy
DoF	Department of Fisheries (WA)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EMBA	Environment the May Be Affected
EHS	Environment, Health and Safety
EHSMS	Environment, Health and Safety Management System
EMS	Environmental Management System
EP	Environment Plan
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
ERP	Emergency Response Plan
GHG	Greenhouse Gas
IAPP	International Air Pollution Prevention
IMS	Incident Management System
JAMBA	Japan Australia Migratory Birds Agreement
KEFs	Key Ecological Features
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships
MDO	Marine Diesel Oil
MNES	Matter of National Environment Significance
MoU	Memorandum of Understanding
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OCNS	Offshore Chemical Notification Scheme
OPEP	Oil Pollution Emergency Plan
OPGGS (E) (Regs)	*Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPEP	Oil Pollution Emergency Plan
PMS	Planned Maintenance System
ROKAMBA	Republic of Korea Australia Migratory Birds Agreement
Santos	Santos Pty Ltd
SOPEP	Shipboard Oil Pollution Emergency Plan
SMS	Santos Management System
STCW	Standards of Training, Certification and Watch keeping

1 INTRODUCTION

Santos Offshore Pty Ltd (Santos) is the operator of exploration permit WA-459-P within Commonwealth waters off northern Western Australia. Santos proposes to undertake the Fishburn 3 dimensional (3D) seismic survey over this permit area.

The Fishburn WA-459-P Seismic Survey Environment Plan was accepted by NOPSEMA on the 23 May 2017. A modification was made to the shape of the survey acquisition area which required Santos to submit a revised environment plan to NOPSEMA. This revised Fishburn WA-459-P Seismic Survey Environment Plan was accepted by NOPSEMA on the 22 June 2017. This environment plan summary is for the revised Fishburn WA-459-P Seismic Survey Environment Plan.

This environment plan summary has been prepared in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regs) following the Environment Plan Summaries Guideline (Rev 1, July 2016) produced by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.1 Nominated Liaison Person Details

The Santos nominated liaison person is:

Tom Baddeley – Manager Public Affairs

Wesfarmers House

40 The Esplanade, Perth, WA, 6000

08 9363 9646

Email: tom.baddeley@santos.com

2 DESCRIPTION OF THE ACTIVITY

2.1 Activity Overview

The Fishburn survey is a typical 3D seismic survey using methods and procedures similar to others conducted in Australian waters. No unique or unusual equipment or operations are proposed.

Water depths in the survey area range from 60 to 100 m.

2.2 Location

The Fishburn survey will take place within Commonwealth waters off the Western Australian coast within the Joseph Bonaparte Gulf. The survey location is approximately 330 km west-south-west from Darwin and approximately 60 km from the closest point to land at Cape Rulhieres in the Kimberley region (Figure 2-1).

Coordinates for the operational area is provided in

Table **2-1**.

For the survey three areas have been defined:

- WA-459-P permit area - which is approximately 2,494 km^2.
- Survey area – this is the area in which the survey vessel will travel along pre-determined lines, towing the streamers and releasing sound waves. Within this area the seismic source will be at full power. This covers an area of approximately 600 km^2.
- Survey operational area – this is outside the survey area and is where activities like set-up, testing of equipment and vessel turn-arounds (to undertake the next line) take place. This covers an area of approximately 3,150 km^2. For the majority of time the seismic source will be at low power while the vessel is in this area. For the reminder of time the vessel will be either powering down to one source (from 3480 in^3 to ~ 40 in^3) as it leaves the acquisition area or powering up as it prepares to re-enter the acquisition area. This is typically with 0.5 – 1 km of the survey area.

Table 2-1: Coordinates for the Fishburn Seismic Survey Areas

Location (GDA 1994 – Degrees Minutes Seconds)					
Permit Area		**Survey Area – See Figure 2-2**		**Operational Area**	
Longitude	**Latitude**			**Longitude**	**Latitude**
127 20 04.41 E	12 49 54.89 S			127 13 36.30 E	12 44 17.11 S
127 50 04.40 E	12 49 54.88 S			127 26 50.50 E	12 36 07.96 S
127 50 04.41 E	13 14 54.88 S			127 45 53.78 E	13 30 37.06 S
127 20 04.42 E	13 14 54.90 S			127 59 55.90 E	13 22 34.15 S

2.3 Timing

The Fishburn survey will take a maximum of 21 days and be undertaken within the period of 15 June and 1 August 2017.

2.4 Seismic Activity

The Fishburn survey is a typical 3D survey using methods and procedures similar to others conducted in Australian waters. No unique or unusual equipment or operations are proposed. Figure 2-4 and Figure 2-5 detail the Fishburn survey equipment and process as described below and a summary of the survey and equipment parameters is provided in Table 2-2.

The survey vessel will travel along a series of pre-determined lines within the survey area at a speed of approximately 4.5 - 5 knots (8-9 km/hour). The vessel will tow two sound wave source units, which operate alternatively with one discharging compressed air as the other recompresses, and cables (known as streamers) which contain microphones (known as hydrophones). As the vessel travels along the lines, sound waves (every 8 seconds) will be directed down through the water and into the geology below the seabed. The sound that reflects back is measured by the hydrophones and is later processed to provide information about the structure and composition of geological formations below the seabed.

There will be up to 12 streamers ~ 6 km long with a tail buoy at the end. The streamers will be towed at a depth of between 15 and 20 m. The distance between each streamer is ~ 100 m. From the bow of the vessel to the tail buoy is ~ 6.5 km long and ~ 1.1 km wide.

Each sail line is approximately 50 km long and will take approximately 10 hrs to acquire and turn around. Time to complete each sail line is dependent on vessel speed and currents. The sails lines are proposed to be in a south-east to north-west direction starting from the western lines moving east.

The survey will be conducted 24 hours a day.

2.5 Survey Vessels

2.5.1 Seismic Vessel

A purpose-built survey vessel will be used and will carry up to 70 people. While the specific vessel for the survey has yet to be determined, the vessel in Figure 2-3 is representative of the type of vessel that will be used.

2.5.2 Support Vessels

There will be up to two support vessels that will undertake activities such as visit Darwin Port for supplies and crew change.

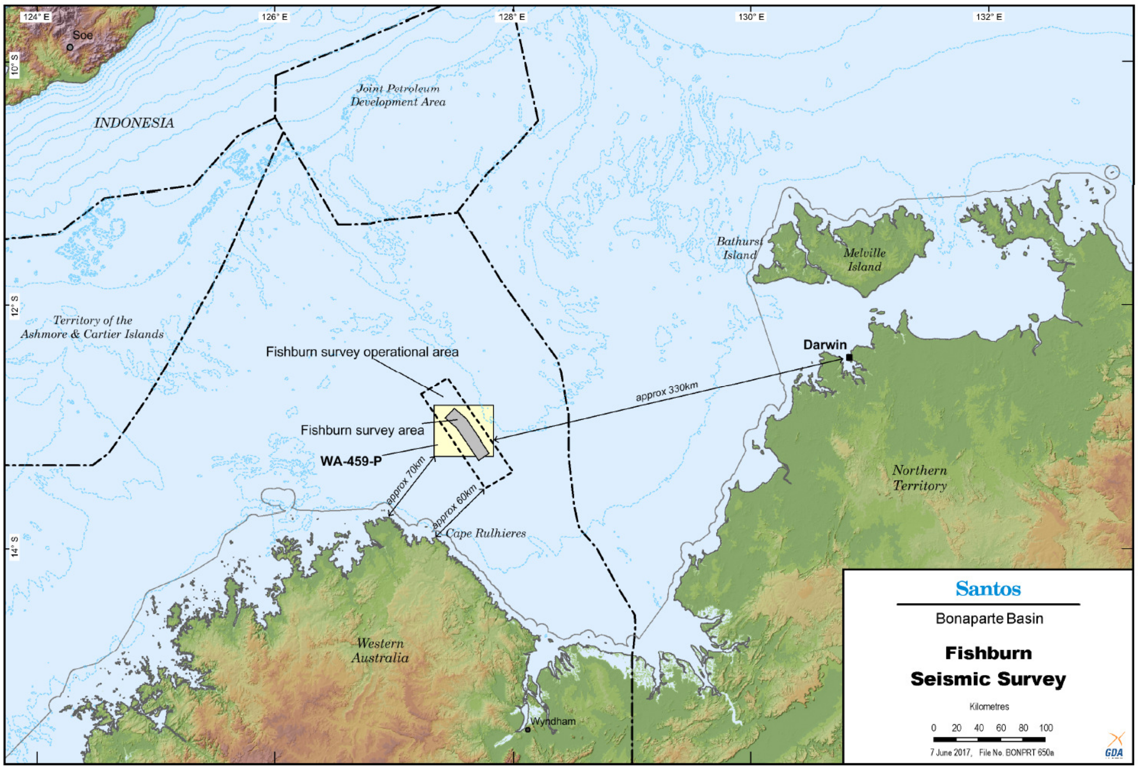


Figure 2-1: Location of Fishburn Seismic Survey

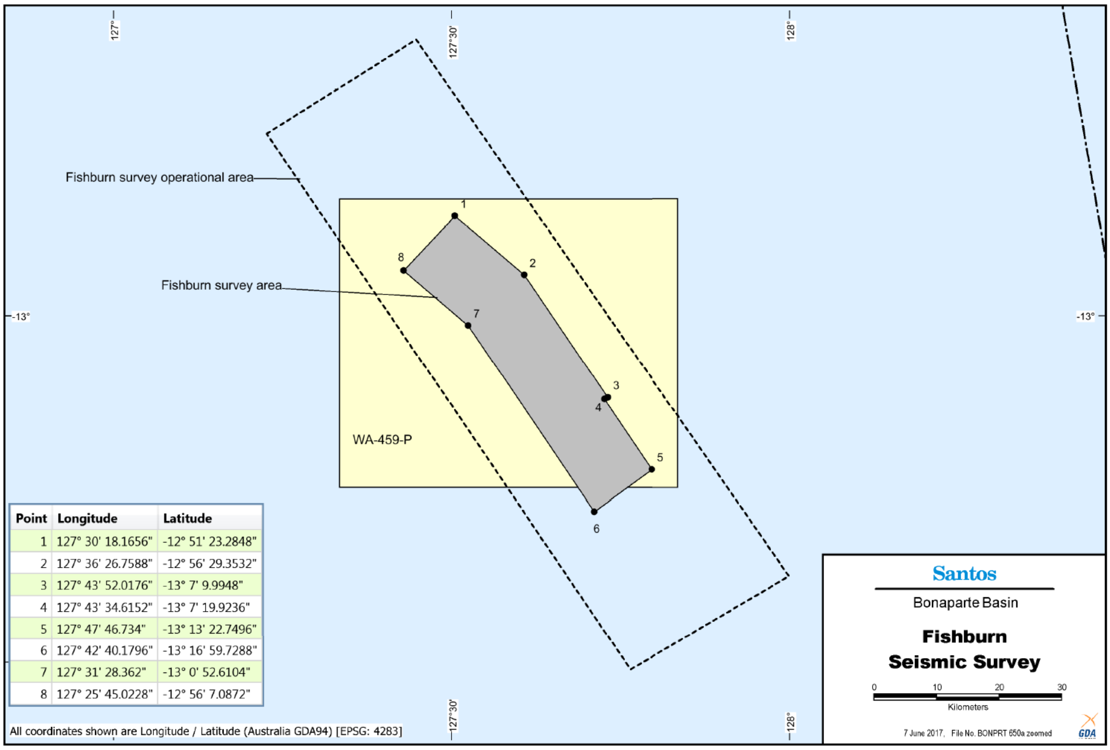


Figure 2-2: Fishburn Seismic Survey Area Coordinates

Table 2-2: Fishburn Seismic Survey Parameters

Parameter	Fishburn Seismic Survey
WA-459-P area	2,494 km^2
Survey area	600 km^2
Operational area	3150 km^2
Survey earliest commencement date	15 June 2017
Survey latest completion date	1 August 2017
Duration of survey	3 weeks (21 days)
Length of sail lines	~ 50 km
Time to traverse a sail line	~ 10 hours
Seismic vessel sail line speed	4.5 - 5 knots (8-9 km/hour)
No. streamers	Up to 12
Distance between streamers	~ 100 m
Streamer length	~ 6 km
Streamer tow depth	Between 15 – 20 m
Distance from seismic vessel bow to tail buoy	~ 6.5 km
Sound source size	3480 cui
Sound source tow depth	~ 6 m

Figure 2-3: Polarcus Asima Seismic Survey Vessel

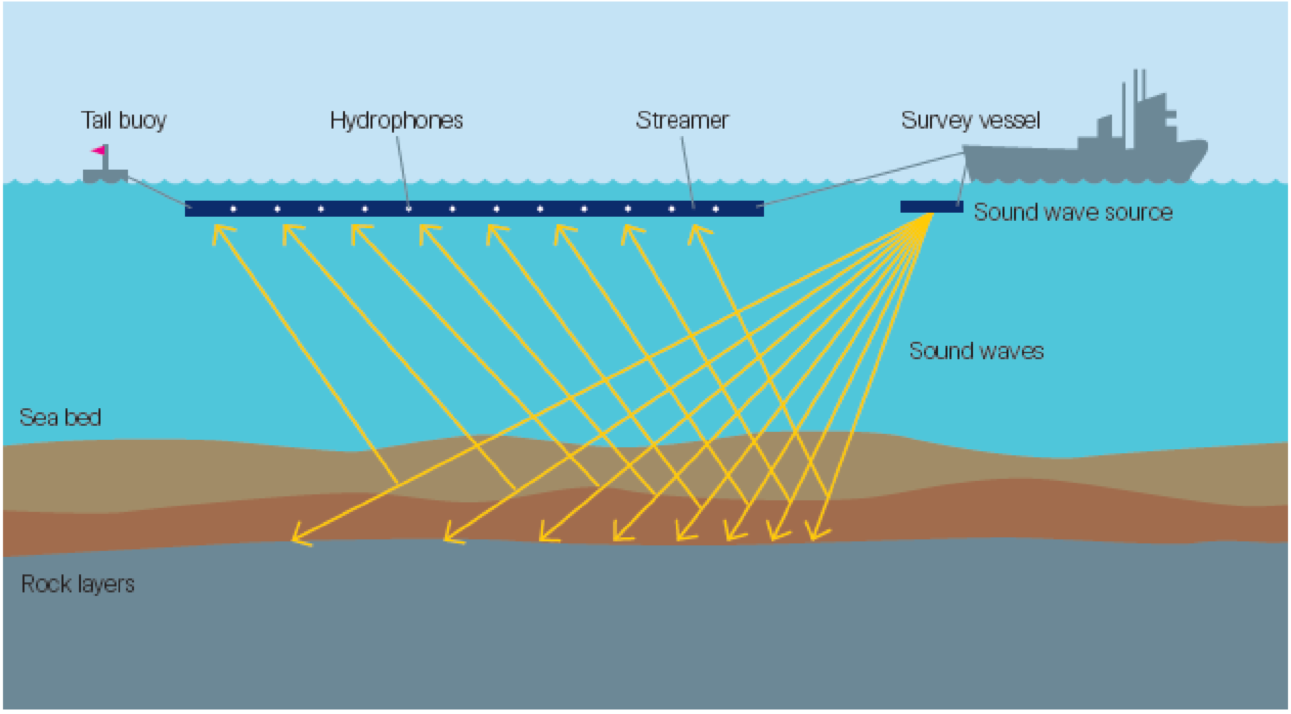


Figure 2-4: Fishburn Survey Equipment and Process Vertical View

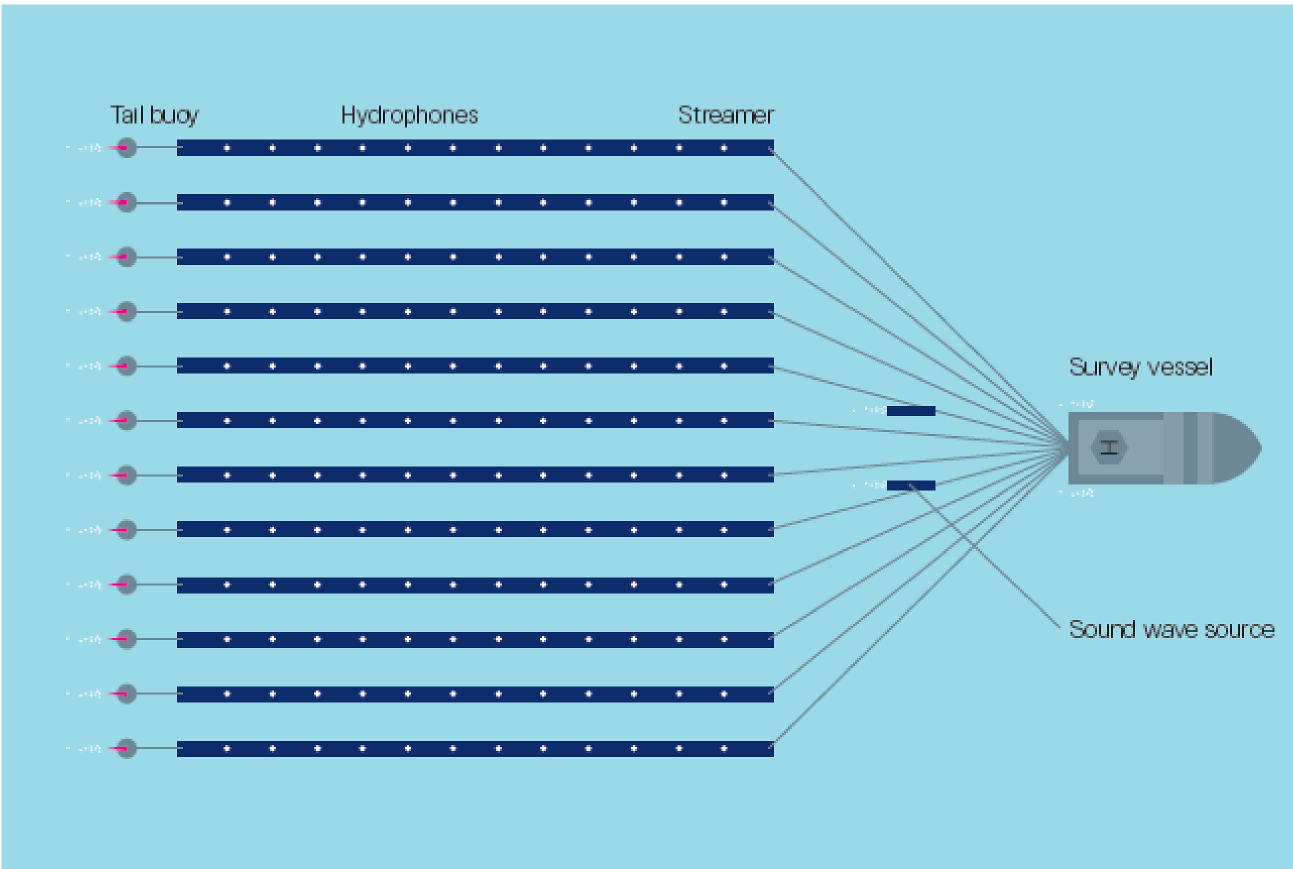


Figure 2-5: Fishburn Survey Equipment and Process Horizontal View

3 CONSULTATION

A summary of the relevant persons consulted in the course of preparing the EP is summarised in Table 3-1.

A summary of the key objections or claims relating to the survey, the merits of these claims and how they were used to inform the Environment Plan is included in Table 3-2.

From the stakeholder consultation undertaken the following notifications and ongoing consultation is required.

- Notify Australian Hydrographic Service a minimum of 3 weeks prior to commencement of activities.
- Notify Department of Defence (offshore.petroleum@defence.gov.au) of any updates and commencement of activity.
- Notify WA Department of Mines and Petroleum of start and cessation of activity. Prestart notification to be undertaken at least 10 days prior to the activity commencing as per regulation 30 of the OPGGS(E)R.
- Notify NPFI of survey commencement and cessation. Keep NPFI informed of NOPSEMA's assessment of the EP. NPFI was notified of the change in the survey area shape and no issues or concerns raised.
- Send AMOSC a copy of the Fishburn OPEP once accepted and notify of when survey starts and finishes.
- Ongoing engagement with Melbana in regards to their WA-488-P Beehive 3D seismic survey.
- Ongoing consultation with Origin in regards to their NT/P84 Gulpener 2D seismic survey.
- Ongoing engagement with TGS in regards to their North West Shelf Renaissance North Multi Client Marine Seismic Surveys which covers the Fishburn survey area. Five year EP. As at Jan 2017 feedback from TGS was that there would be no activity within 100 km of Fishburn survey during June to August 2017. Need to confirm any changes prior to Fishburn survey commencing.
- Ongoing consultation with PGS to determine timings for the Rollo MC3D survey within the area of the Fishburn survey.

Stakeholders were identified based on the EMBA and operational area, thus the change in the shape of the survey area did not trigger a review of stakeholders.

Table 3-1: Fishburn Survey Assessment of Stakeholders

As the assessment of stakeholders was undertaken on those that had functions, interests or activities within the EMBA, the change in the survey shape did not affect that assessment.

Stakeholder	Relevant to Fishburn 3D MSS	Reasoning
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		
Australian Fishing Management Authority (AFMA)	✓	Manage Commonwealth fisheries. Confirmed Northern Prawn Fishery only Commonwealth fishery that operates in the area.
Australian Maritime Safety Authority (AMSA)	✓	AMSA is the statutory and control agency for vessel emergencies in Commonwealth waters. Santos has a signed MoU with AMSA regarding response arrangements. Arrangements are detailed in OPEP Section 7.3.
Australian Hydrographic Service (AHS)	✓	Responsible for Notice to Mariners. Required to notify AHS a minimum of 3 weeks prior to commencement of activities. Detailed in Section 4.1 Ongoing Consultation.
Marine Border Control (MBC)	X	Responsible for coordinating offshore maritime security. MBC confirm they do not need to be notified of survey as receive notifications via AHS Notice to Mariners. Based on this information no further consultation required as not a relevant stakeholder.
Department of Defence (DoD)	✓	Potential for restricted areas and/or activities within survey area. DoD confirmed that no objections to survey but would like to be kept up to date with any developments including commencement of the survey (see consultation records and Section 4.1 Ongoing Consultation).
Department of Environment and Energy (DoEE)	X	As per the Australian Government Agencies' Roles and Relevance under the Offshore Petroleum and Greenhouse Gas Storage Act 2006 Guidance, the DoEE's functions, interests and activities have been incorporated into the requirements of the strategic assessment Program and the DoEE is not considered a relevant agency for consultation purposes under the Program. This does not negate the fact that it may be beneficial for titleholders to contact the DoEE in regard to its other functions, interests and activities that fall outside the Program. The Fishburn survey does not trigger any of the DoEE's other functions, interests and activities, hence, they were assessed as not being a relevant stakeholder.
National Offshore Petroleum Safety Environment Management Authority (NOPSEMA)	✓	Statutory authority for offshore petroleum activities. Consultation prior to EP submission is not required.
Department or agency of the State or the Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant and the Department of the responsible State Minister		
WA Department of Aboriginal Affairs (DAA)	X	Confirmation from DAA that there is no customary fishing in area. Based on this information no further consultation required as not a relevant stakeholder

Stakeholder	Relevant to Fishburn 3D MSS	Reasoning
WA Department of Fisheries (DoF)	✓	Manage State fisheries.
WA Department of Transport (DoT)	X	Control agency for marine pollution emergencies if impact to State waters. DoT Offshore Petroleum Industry Guidance Note Marine Oil Pollution: Response and Consultation Arrangement (Jan 2017) Section 8.1 requires petroleum titleholders to consult with DoT for activities that have the potential to cause a marine pollution emergency in State Waters. As per Section 7.11 (Diesel Refuelling Spill) and Section 7.12 (Diesel Spill from a Vessel Collision), no impacts to State waters were identified. Based on this information no further consultation required as not a relevant stakeholder.
Department of the responsible State Minister, or the responsible Northern Territory Minister		
WA Department of Mines and Petroleum (DMP)	✓	Consultation required as per DMP Consultation Guidance Note (For the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009). Section 4.1 Ongoing Consultation includes activity pre-start and cessation notifications.
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		
Austral Fisheries	✓	Northern Prawn Fishery Licence holder active within and near the WA-459-P permit area. Requested that engagement be undertaken via Northern Prawn Fishery. Based on this information no further direct consultation required.
Beche de mer Fishery – WA	X	Recommended by DoF as potential to operate in area. The WA Beche-de-mer fishery is only permitted to operate in Western Australian waters (See Section 5.6.3 WA Managed Fisheries). Hand harvest fishery unlikely to be in survey area as water depths are over 100 m. Based on this information no consultation required as not a relevant stakeholder.
Charter fishing	X	Confirmation from WA Dept. of Fisheries that no reported charter fishing in area. Based on this information no further consultation required as not a relevant stakeholder.
Customary fishing	X	Confirmation from WA Department of Aboriginal Affairs and Kimberley Land Council that the survey area does not intersect with any Aboriginal heritage places, including customary fishing areas. Based on this information no further consultation required as not a relevant stakeholder.
Northern Prawn Fishery	✓	The Northern Prawn Fishery is active within and near the WA-459-P permit area. Consultation to be undertaken through Northern Prawn Fishery Industry.
North West Slope Trawl Fishery - Cth	X	WAFIC identified that the NWST fishery potentially operates in or near the WA-459-P permit area but AFMA did not. Review of AFMA website, fishery is located in deep water from the coast of the Prince Regent National Park to Exmouth between the 200m depth contour to the outer limit of the Australian Fishing Zone. The NWST fishery area was confirmed with AFMA (Consultation Record AFMA-10) and is not in or near the survey area. Based on this information no consultation required as not a relevant stakeholder.
Pearl Producers Association of WA	X	Pearl Producers Association confirmed proposed activity outside current active pearling activity. Based on this information no further consultation required as not a relevant stakeholder.

Stakeholder	Relevant to Fishburn 3D MSS	Reasoning
Recfishwest	X	Recfishwest confirmed that the area of the proposed seismic program in WA-459-P is highly unlikely to intersect with any recreational fishing activities given its remote location. Based on this information no further consultation required as not a relevant stakeholder.
Western Australian Fishing Industry Council (WAFIC)	✓	Members potentially fish in or near the WA-459-P permit area. Consultation undertaken to identify WA commercial fishers in survey area.
WA - Pearl Oyster Fishery	X	Recommended by DoF. Zone 4 is within permit area and not fished as not commercially viable (See Section 5.6.3 WA Managed Fisheries). Pearl Producers Association confirmed no activity. Based on this information no further consultation required as not a relevant stakeholder.
WA - Joint Authority Northern Shark Fishery	X	Confirmation from DoF that fishery has not operated since 2009 and unlikely to operate in 2017. Based on this information no consultation required as not a relevant stakeholder.
WA - Mackerel Managed Fishery	✓	Recommended by DoF as potential to operate in area. Sent Information Sheet #1 11/10/2016 to all titleholders. Sent follow-up on 18/11/2016 and 16/12/16 all titleholders. No replies and no other points of contact were available. Based on no response from any members, and that fishing tends to be around headlands and reefs and also shoal areas, which are not present in the survey area (see Section 5.6.3 WA Managed Fisheries) it is assessed that the WA Mackerel Managed Fishery is unlikely to fish in the area and no further consultation is required.
WA - Marine Aquarium Fish Managed Fishery	X	Recommended by DoF as potential to operate in area. Sent Information Sheet #1 11/10/2016 to all titleholders. Sent follow-up on 18/11/2016 and 16/12/2016 to all titleholders. No replies. Fishery currently only operates in WA state waters and is active in waters from Esperance to Broome (See Section 5.6.3 WA Managed Fisheries). Based on this information and lack of response from licensees no further consultation required as assessed as not being a relevant stakeholder.
WA - Northern Demersal Scalefish Managed Fishery	X	Recommended by DoF as potential to operate in area. Sent initial information via email 11/1/2016 and again 14/3/2016 to email addresses provided by WAFIC. Two replies advised do not operate in the area. Information Sheet #1 sent 11/10/2016, 18/11/2016 and 16/12/2016 to all licensees that had not already responded. No replies. Based on this information no further consultation required as assessed as not being a relevant stakeholder.
WA - Specimen Shell Managed Fishery	X	Recommended by DoF. Not likely to fish in permit area due to water depth. Sent Information Sheet #1 11/10/2016. Sent follow-up on 18/11/2016 and 16/12/2016. It is unlikely that the fishery is active in the survey area as water depths are 60 - 100 m. Licenced fishers contacted on three occasions. One replied not active in area, one replied does not require further information. Based on this information no further consultation required as assessed as not being a relevant stakeholder.
Western Tuna and Billfish	X	AFMA confirmed that fishery covers the permit area but no active fishers near the WA-459-P permit. Based on this information no consultation required as not a relevant stakeholder.

Stakeholder	Relevant to Fishburn 3D MSS	Reasoning
Any other person or organisation that the titleholder considers relevant.		
Australian Marine Oil Spill Centre (AMOSC)	✓	Santos is a participating member of AMOSC. In an oil spill AMOSC would provide equipment and support. Section 4.1 Ongoing Consultation includes requirement to submit accepted OPEP to AMOSC.
Commonwealth Fishing Association	✓	Initial information and Information Sheet #1 sent to CEO. CEO asked if the Northern Territory Seafood Council (NTSC) (in relation to separate NT survey, not Fishburn), WAFIC and NPFI have been contacted (See individual consultation records). No further consultation required.
Carnarvon Petroleum Limited	X	Hold permit WA-523-P - 180 km north-west of WA-459-P. No activity during timing of survey. As their permit area is greater than 100 km from the Fishburn survey area (distance used to identify any potential simultaneous activities) no further consultation required as not a relevant stakeholder.
ConocoPhillips	X	Not planning to undertake any drilling or seismic activity in the vicinity of WA-459-P during 2017. No further consultation required as not a relevant stakeholder.
Engie Bonaparte Pty Ltd	X	Planning RoV in WA-6-R in September. No further consultation required as activity outside Fishburn survey timing.
Eni Australia	X	Not planning to undertake any drilling or seismic activity in the vicinity of WA-459-P during 2017. No further consultation required as not a relevant stakeholder.
Finniss Offshore Exploration Pty Ltd now Melbana Energy	✓	Planning WA-488-P Beehive 3D seismic survey in 2017. Added to Section 4.1 Ongoing Consultation.
Goldsborough Energy Pty Ltd	X	Not planning to undertake any drilling or seismic activity in the vicinity of WA-459-P during 2017. No further consultation required as not a relevant stakeholder.
Origin	✓	Planning Gulpener 2D Seismic Survey in period of 1st April – 31st July 2017. Added to Section 4.1 Ongoing Consultation.
PGS	✓	Planning Rollo MC3D that has a line that ingresses into WA-459-P. Added to Section 4.1 Ongoing Consultation.
TGS	✓	North West Shelf Renaissance North Multi Client Marine Seismic Surveys covers permit area. Five year EP as at Jan 2017 no activity within 100 km of Fishburn survey during June to August 2017. Added to Section 4.1 Ongoing Consultation to check that program has not changed prior to Fishburn survey commencing.
Woodside Energy Ltd.	X	Not planning to undertake any drilling or seismic activity in the vicinity of WA-459-P during 2017. No further consultation required as not a relevant stakeholder.

Table 3-2: Assessment of Merits for Objections and Claims

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Austral Fisheries	21/06/2014	Santos provided information in regards to survey and to confirm whether to consult directly or via NPF. Response was to consult with Northern Prawn Fishing Industry.	Consultation undertaken directly with NPFI. See NPF records.
Australian Fisheries Management Authority (AFMA)	23/06/2015	Santos initial notification in regards to survey to determine what Commonwealth fisheries in the area. Sent map and coordinates of permit. Requested information on Commonwealth fisheries in area. Followed-up on 5/11/2015	
Australian Fisheries Management Authority (AFMA)	1/12/2015	AFMA replied that the Northern Prawn Fishery (NPF) and Western Tuna and Billfish Fishery (WTBF) appear to overlap the permit area. One operator in WTBF and no industry association associated with the fishery. Unlikely that the fishery will be impacted, but if you would like to make contact you can obtain names and addresses from AFMA Licensing.	Contacted AFMA Licensing (3/12/2015) to obtain information in regards to the NPF and WTBF operator.
Australian Fisheries Management Authority (AFMA)	3/12/2015	Santos contacted AFMA Data and Licence Service who stated that the WTB operator does not fish anywhere near the WA-459-P permit and there are 21 NPF active operators in the area.	EP Section 4 Consultation updated. As the WTBF operator does not fish near the WA-459-P permit they were not seen as being a relevant stakeholder and no further engagement undertaken. Engagement with NPF continued, see NPF records.
Australian Fisheries Management Authority (AFMA)	21/06/2016	Santos asked AFMA if Joint Authority Northern Shark Fishery will reopen in 2017 and if North West Slope Trawl Fishery operate in area.	No response.
Australian Fisheries Management Authority (AFMA)	11/10/2016	Santos sent AFMA Information Sheet #1 relating to the two seismic surveys proposed for the Bonaparte Gulf in 2017. Santos had been advised the Joint Authority Northern Shark Fishery is unlikely to reopen in 2017 and the North West Slope Trawl Fishery does not operate in area. Asked AFMA to confirm.	No response.
Australian Fisheries Management Authority (AFMA)	31/10/2016	Follow up on email sent on 11th October 2016. If no reply will presume that the information that the Joint Authority Northern Shark Fishery is unlikely to reopen in 2017 and that the North West Slope Trawl Fishery does not operate in the area is correct.	No reply from AFMA. Updated EP Section 5.7.2. Commonwealth Managed Fisheries with information in regards to Joint Authority Northern Shark Fishery is unlikely to reopen in 2017 (See WADoF03 record) and that the North West Slope Trawl Fishery does not operate in the area as per AFMA website.
Australian Fisheries Management Authority (AFMA)	15/02/2017	Santos sent AFMA an email in regards to the North West Slope Trawl Fishery boundaries have changed in 2017 and it is unclear if the map on the AFMA website has been updated with these new boundaries.	AFMA confirmed that the North West Slope Trawl Fishery map reflects fishery changes. Based on this map the North West Slope Trawl Fishery is not near the survey area.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
		AFMA confirmed that map on AFMA website reflected the changes.	
Australian Marine Oil Spill Centre (AMOSC)	31/01/2017	Santos sent Fishburn Seismic Survey OPEP for review to asses that response strategy proposed is appropriate and AMOSC can provide support requested. AMOSC provided feedback that may not be able to get trained aerial observer to Darwin within 12 hour timeframe. Suggested wording and controls for aerial surveillance to be undertaken by aircrew until trained observer arrives.	Section 6 of the OPEP updated with AMOSC suggested wording and controls.
Australian Marine Oil Spill Centre (AMOSC)	13/02/2017	Letter from AMOSC that they have reviewed the OPEP in a manner consistent with AMOSC guidelines and our recent correspondence and provide the following observations: – The proposed response strategy is supported and considered appropriate with respect to the two spill events detailed within the plan; – The plan accurately describes the interface between Santos and AMOSC, particularly procedures and notifications for assistance from AMOSC during an incident; and – AMOSC is able to provide technical resource support to Santos, (under the standard terms and conditions of an AMOSC service agreement) as outlined in the plan.	EP Section 4.4 Ongoing Consultation updated to include sending AMOSC accepted OPEP and provide notification of survey start and finish.
Carnarvon Petroleum Limited	11/10/2016	Santos sent introductory email with Information Sheet #1 to determine if the WA-459-P survey will impact functions, interests or activities. Carnarvon Petroleum not planning any activity in WA-523-P.	No action as permit area greater than 100 km area from the survey area.
Commonwealth Fishing Association	2015- 2016	Santos provided information to CFA in regards to two seismic surveys in the Bonaparte Basin in 2016 (NT/P85 and WA-459-P). Updated of delay of surveys until 2017. Provided Information Sheet #1.	See engagement records for NTSC, WAFIC and NPF.
ConocoPhillips (CoP)	6/02/2017	Santos Information Sheet #1 which included WA-459-P permit. CoP advised that they are not planning any undertake any drilling or seismic activity in the vicinity of WA-459-P during 2017.	No action as permit area greater than 100 km area from the survey area.
Department of Defence	21/06/2016	Santos sent introductory email with maps to identify any defence activities in the survey area.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Department of Defence	29/07/2016	Received letter - Defence has no objections to the proposed marine seismic survey. Ensure continued liaison with the AHS - AHS notified a min of 3 weeks prior to commencement of activates.	EP Section 4.4 Ongoing Consultation updated to include requirement to notify AHS a minimum of 3 weeks prior to commencement of activities.
Department of Defence	2/09/2016	Confirmed that the Property Acquisition, Mining and Native Title Property Management Branch which Melissa Felton is the A/Assistant Director is the correct area in the Dept. of Defence for us to provide information in regards to consultation on our activities.	
Department of Defence	11/10/2016	Santos sent Information Sheet #1 relating to two 3D seismic surveys Santos is planning to undertake next year (from mid-June) in the Bonaparte Gulf.	
Department of Defence	21/11/2016	Letter received from DoD. Santos should note that: a. all exploration activities in the area are conducted at its own risk; and b. the Commonwealth of Australia, represented by the Department of Defence, takes no responsibility for: • reporting the location and type of UXO that may be in the areas of interest to Santos; • identifying or removing any UXO; or • any loss or damage suffered or incurred by Santos or any third party arising out of, or directly related to, UXO. Defence takes this opportunity to remind Santos that the Australian Hydrographic Service (AHS) requires advanced notification of any seismic surveys and infrastructure developments within the designated area. Santos is required to provide this information, at minimum, three weeks prior to actual commencement. The Department would like to be kept up to date with any developments including the commencement of survey etc.	Based on other letters Santos has received from the DoD in regards to UXO this is the DoD's general warning as the survey area has not been highlighted by them as an area of concern. There is no action on Santos and hence the risk of UXO is not assessed in the EP. EP Section 4.4 Ongoing Consultation updated to include requirement notify DoD prior to commencement of the survey. EP Section 4.4 Ongoing Consultation updated to include requirement to notify AHS a minimum of 3 weeks prior to commencement of activities.
Engie Bonaparte Pty Ltd	11/10/2016 27/01/2017	Santos sent introductory email with Information Sheet #1 to determine if the WA-459-P survey will impact their functions, interests or activities. Engie confirmed that not currently planning any independent activities, other than routine monitoring at P1 in the Petrel Field, WA-6R. Likely timing of September.	EP Section 5.7.5 Oil and Gas Activities updated to reflect Engie's information.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Eni Australia	11/10/2016 29/12/2016	Santos sent introductory email with Information Sheet #1 to determine if the WA-459-P survey will impact their functions, interests or activities. Eni Exploration advised has no planned survey or drilling activities in the area in 2017. Details about their Blacktip gas production permit in WA-33L (map enclosed). Emergency Response contact details are also enclosed in email.	EP Section 5.7.5 Oil and Gas Activities updated to reflect Eni's information.
Finniss Offshore Exploration Pty Ltd now Melbana Energy	19/10/2016 21/10/2016	Santos sent introductory email with Information Sheet #1 to determine if the WA-459-P survey will impact their functions, interests or activities. Melbana replied there was a potential for them to undertaken a 3D seismic survey in WA-488-P	
Finniss Offshore Exploration Pty Ltd now Melbana Energy	1/02/2017	Santos email to follow up on the outstanding issue of cumulative impacts from multiple seismic surveys. Santos confirms its survey dates of starting 15 June for ~ 21 days. Sent email to confirm WA-488-P activity and timing. Melbana replied that they were unsure when their survey would be and at this stage had not commenced approvals.	EP Section 5.7.5 Oil and Gas Activities updated to reflect Melbana's information. Cumulative impacts from the proposed Melbana survey could not be assessed as they do not have sufficient information in regards to their survey timing and have no information on seismic source noise levels or modelling. EP Section 4.4 Ongoing Consultation updated to capture ongoing engagement with Melbana to ensure any cumulative impacts addressed to ALARP and acceptable levels.
Finniss Offshore Exploration Pty Ltd now Melbana Energy	1/03/2017	Santos notifies Melbana that the Santos Fishburn WA-459-P EP Submitted to NOPSEMA on Monday 27/2/2017. Inform them that the EP contains an assessment of the cumulative impacts of the Fishburn and Gulpener surveys but not the Melbana Beehive survey. Melbana replies 01.03.2017 that it has no further update.	EP Section 4.4 Ongoing Consultation updated to capture ongoing engagement with Melbana to ensure any cumulative impacts addressed to ALARP and acceptable levels.
Finniss Offshore Exploration Pty Ltd now Melbana Energy	8/05/2017	Santos email informing Melbana that Santos now has a contract in place with Polarcus to undertake the Fishburn WA-459-P seismic survey and has a planned start date of 15 June 2017. Was following up in regards to Melbana’s plan for the WA-488-P Beehive seismic survey. Requested could you let us know if this survey is going ahead in 2017 and if so the timing. Melbana replies on 08.05.2017 that no environment plan in yet.	EP Section 4.4 Ongoing Consultation updated to capture ongoing engagement with Melbana to ensure any cumulative impacts addressed to ALARP and acceptable levels.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Goldsborough Energy Pty Ltd / Octanex	19/10/2016	Santos sent introductory email with Information Sheet #1 to determine if the WA-459-P survey will impact their functions, interests or activities. Goldsborough advised that they do not have any seismic or drilling operations planned for either WA-407-P or WA-420-P during 2017. Will notify Santos should this position change.	EP Section 5.7.5 Oil and Gas Activities updated to reflect Goldborough's information.
Kimberley Land Council	24/06/2016	Initial email notifying Kimberley Land Council of proposed 3D seismic survey to take place in WA-459. Also notes the operational area is about 60km from the WA coast, Santos wants to check with KLC on whether the permit or operational area interacts with customary fishing grounds.	
Kimberley Land Council	27/06/2016	Santos sent email notifying Kimberley Land Council of proposed 3D seismic survey to take place in WA-459. Noted that the operational area is about 60km from the WA coast, Santos wants to check with KLC on whether the permit or operational area interacts with customary fishing grounds. KLC confirmed that due to the distance offshore the survey would not impact any customary fishing practices.	EP Section 4 updated. As no customary fishing activity in the area customary fishers are not seen as a relevant stakeholder for ongoing engagement purposes.
Maritime Border Command	5/12/2016 13/02/2017	Santos sent email to ascertain what or if any notifications to MBC are required for seismic surveys, drilling or infrastructure projects. MBC replied that they do not need to receive notifications directly as will see them through the Notice to Mariners that are issued by Australian Hydrographic Service.	
Northern Prawn Fishery	27/10/2015	Initial meeting to introduce Santos and seismic survey in WA-459-P. Outcomes: Permit within Northern Prawn fishery. Advised that wouldn't want seismic to begin in 459 before 15 June. Best time is 15 June to 15 July and Dec to February. Suggested that 459 be shot first, beginning on June 16,	Based on this feedback Santos implemented control measure that survey will be undertaken within 15 June to 1 August. EP Section 7.1 Seismic Underwater Noise.
Northern Prawn Fishery	2/11/2015	Santos provides maps and coordinates of permit and information about seismic survey.	
Northern Prawn Fishery	4/11/2015	NPF email that best timing for the surveys is during our closed seasons, preferably in December.	Further discussion with NPF see records identified that there are two fishing seasons. The first season is from 1 April to 15 June. The second season is from 1 August to 1 December. See EP Section 5.7.2.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Northern Prawn Fishery	13/11/2015	NPF email. Provision of image with fishing activity in the JBG for 2014, which occurred south east of the 459 permit.	
Northern Prawn Fishery	4/12/2015	Santos sent email to NPF asking if Santos should contact the NPF Operators individually or via NPF. NPF replied via them (10/12/2015).	EP Section 4 Consultation updated to document that consultation with NPF to be undertaken through the NPF Industry (NPFI).
Northern Prawn Fishery	21/12/2015	Santos sent email to let NPF know contract for seismic vessel had gone out, and will be in contact in Feb 2016 with more information.	
Northern Prawn Fishery	14/03/2016	Santos sent email to let NPF know survey delayed until 2017 as could not meet NPF preferred timing of mid-June to mid-July. Will be in contact later in year. NPFI reply email acknowledging and appreciating the change in survey timing to suit the fishery.	Survey delayed to 2017 as could not meet NPF closed season timing.
Northern Prawn Fishery	11/10/2016	Letter from VP Exploration informing NPF that planning for Santos' 2017 seismic program has now resumed, attached is an Information Sheet #1 relating to two seismic surveys we are proposing to undertake in the Bonaparte, starting in June next year.	
Northern Prawn Fishery	18/10/2016	NPF email advising best to continue working through NPFI; can distribute the information you provide and work on preparing a combined response on proposals. Santos seeks advice on what the issues and impact would be if the seismic program started in the first half of June or even May? Response: Now this has been rescheduled for June 2017 - should be ok Santos seeks advice on what the issues and impact would be if the seismic program did not finish until into August? Response: That shouldn't be too much of a problem as long as the survey doesn't run over for too long and depending on where the boats are – they will probably start in JBG in late August, early Sep.	Based on this feedback Santos updated EP Section 7.1 Seismic Underwater Noise to included control measure that survey will be undertaken within 15 June to 1 August.
Northern Prawn Fishery	28/11/2016	NPF sent through fishing distribution maps for years 2010-2016.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Northern Prawn Fishery	30/11/2016	Santos sent through example map to try to show the "Extent of Northern Prawn Fishery" boundary (i.e. the area closest to WA-459-P). Outside of this extent boundary there are five fishing activity points from the period 2010 to 2013. These areas not included in the extent boundary as thought the extent area covers 99% of where the fishing takes place. Can't validate that it is 99% as doesn't know how many fishing activity points but is estimated about 500, so that would be 99% covered? Santos wants to confirm okay with the extent boundary.	
Northern Prawn Fishery	14/12/2016	Santos sent follow up email. NPFI replied Yes, all good to represent in the format proposed but just can't use the shot data provided.	EP Section 5.7.2 Commonwealth Managed Fisheries updated to include the NPF fishing distribution information showing an area which encompassed 99% of the NPF fishing effort near the Fishburn survey area. The extent boundary was changed to an area and agreed with NPFI at meeting on 17/1/2017. Meeting records detailed 19/1/2017.
Northern Prawn Fishery	21/12/2016	Santos would like to schedule a meeting in the 2nd half of January to go through modelling and discuss what controls we can use to reduce potential impacts. NPFI replied: Best if your team could present the modelling at our February NPFI meeting so our fishers can see first-hand what is being proposed to minimise impacts.	
Northern Prawn Fishery	19/01/2017	Record of meeting with NPF on 17/1/2017 which involved clarifying information from both Santos and NPFI. Main points were: Agreed on the NPF main activity area map as a way to show where 99% of the NPF fishing activity occurs near the survey area. Discussed noise levels from the survey and recent FRDC studies. NPF requested more information about noise levels compared to the FRDC studies. Discussed level of NPF activity in Joseph Bonaparte Gulf (JBG) and species caught. NPF expect 2017 to be a bigger year in JBG due to more rain and runoff. Discussed spawning. Agreed mitigation against potential impacts was to undertake survey outside of the NPF fishing season unless agreed with NPFI.	Further information provided to NPFI see record 19/1/17, 1/02/2017 and 6/02/2017. EP Section 7.2 Seismic Underwater Noise updated to include control measure - Seismic survey will be undertaken within 15 June – 1 August.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Northern Prawn Fishery	19/01/2017	Santos sent NPF updated NPF information from the environment plan (Rev 2) which included noise propagation information. NPFI going to review and provide feedback. Provided information on the FRDC paper on lobsters received noise level of 209 – 219 dB re 1 μPa from Table 5 on page 46 of the report. Provided report and Appendices as per meeting commitment.	Santos sent NPF updated NPF information and noise impact assessment on invertebrates from the environment plan (Rev 2) which included noise propagation information. NPFI to review and provide feedback. Provided information on the FRDC paper on lobsters received noise level. Provided copy of Carroll et al. 2016 Review if Potential Impacts of Seismic Surveys on Fish and Invertebrates.
Northern Prawn Fishery	30/01/2017	NPF provided comments to Santos on information provided which included adding some information from Days report about potential compromising of the crustacean immune system.	EP Section 7.2 Seismic Underwater Noise - Invertebrates updated to include information provided by NPF. Updated EP section provided to NPF 1/2/2017.
Northern Prawn Fishery	1/02/2017	Santos let NPFI know that the EP has been updated to include NPFI's comments. Will send the updated impact assessment with our proposed survey controls by the end of the week for review.	EP Section 7.2 Seismic Underwater Noise - Invertebrates updated to include information provided by NPF. Updated EP section provided to NPF 1/2/2017.
Northern Prawn Fishery	1/02/2017	NPFI emailed to note that the spawning times for red leg banana prawns mixed up with white banana prawns during the teleconference. Email notes information relating to what is known about the spawning.	Santos provide NPFI updated EP Section 7.2 Seismic Underwater Noise sections (Rev 3) including noise propagation, banana prawn spawning and impacts to plankton. Requested NPFI to review and provide feedback.
Northern Prawn Fishery	1/02/2017	Santos provided NPFI with the information in the EP in regards to banana prawns spawning and asks if should update with NPFI information. Committed to providing the information in the EP in regards to seismic noise impacts on plankton (eggs and larvae). Commented will check that information sent by Patrick at FRDC has been used in the impact assessment, if available.	Santos provide NPFI updated EP Section 7.2 Seismic Underwater Noise sections (Rev 3) including noise propagation, banana prawn spawning and impacts to plankton. Requested NPFI to review and provide feedback.
Northern Prawn Fishery	1/02/2017	NPF replied the white banana prawn vs red leg banana prawn vs tiger prawn patterns are quite different and all driven by different things/ timing. NPF will get back to Santos.	Santos provide NPFI updated EP Section 7.2 Seismic Underwater Noise sections (Rev 3) including noise propagation, banana prawn spawning and impacts to plankton. Requested NPFI to review and provide feedback.
Northern Prawn Fishery	6/02/2017	Santos provide NPFI updated EP sections (Rev 3) including noise propagation, banana prawn spawning and impacts to plankton. Requested NPFI to review and provide feedback.	Santos provide NPFI updated EP Section 7.2 Seismic Underwater Noise sections (Rev 3) including noise propagation, banana prawn spawning and impacts to plankton. Requested NPFI to review and provide feedback.
Northern Prawn Fishery	20/02/2017	Reply from NPFI that EP looks good (noting response re spawning in JBG), very thorough.	
Northern Prawn Fishery	21/02/2017	NPFI provide further information on spawning.	EP Section 5.6.2 Commonwealth Managed Fisheries and Section 5.5.3 updated with information provided by NPFI on spawning.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Northern Prawn Fishery	24/02/2017	Sent email to inform NPFI that spawning information provided had been included in EP and to confirm that: 1. That the control to minimise impacts to the NPF is to undertake the survey outside the NPF fishing season in the period 15 June to 1 August. 2. That from the information we have provided, you are satisfied that your concerns have been adequately addressed.	EP Section 5.6.2 Commonwealth Managed Fisheries and Section 5.5.3 updated with information provided by NPFI on spawning.
Northern Prawn Fishery	27/02/2017	NPFI replied all good - except the times to minimise disruption/impacts to NPF are outside of the fishing seasons being: 15 June – 1 August 1 December – 1 April. Santos replied thanks. Submitting EP today and will keep NPFI informed of NOPSEMA's assessment.	EP activity timing is only for period outside the fishing season 15 June - 1 August so 1 Dec - 1 April period not relevant to the EP. Section 4.1 Ongoing Consultation updated to keep NPFI informed of EP NOPSEMA assessment.
Northern Prawn Fishery	7/06/2017	Santos email to inform NPFI that the survey area had change shape and provide map. Survey area is ~ 0.5 km area from the main NPF fishing area.	No issues or concerns raised.
NT Department of Primary Industry and Fisheries	15/11/2015	Santos provided map and coordinates for permit area to ask if any interest from NT Fisheries. Director Fisheries and Aquaculture did not raise any concerns.	EP Section 4 Consultation updated. No further consultation required.
Origin Energy	31/10/2016	Santos email informing Origin that Santos will be undertaking seismic surveys over WA-459-P and NT/85 in 2017. Sent Information Sheet #1. Santos asked if Origin can advise if planning any drilling seismic activity in the region in 2017.	
Origin Energy	15/12/2016	Origin responded that they intend to undertake the Gulpener 2D Seismic Survey in the Joseph Bonaparte Gulf between the period of 1st April – 31st July 2017. Due to our surveys potentially happening concurrently, please continue to provide updates.	
Origin Energy	1/02/2017	Santos email to Origin - as getting close to submitting Fishburn 3D Seismic EP, would like to follow up on the outstanding issue of cumulative impacts from multiple seismic surveys. Santos confirms its survey dates of starting 15 June for ~ 21 days. Requests Origins planned dates.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Origin Energy	1/02/2017	Origin confirms Gulpener survey dates between 1 Apr and 31 July. The email also notes it has been informed by NPF that their preference is for the survey to commence on or after 15th June.	
Origin Energy	1/02/2017	Santos sent email to set out proposal to get Jasco to look at cumulative impacts from the Origin Gulpener and Santos Fishburn surveys if they were to go ahead at the same time.	EP Section 7.2.8 Seismic Noise Cumulative Impacts details cumulative impact assessment for the Santos Fishburn and Origin Gulpener seismic surveys. Survey acquisition areas, where seismic source is at full power, are 157 km apart. Assessment did not identify any significant increase in noise sound levels within the area between the two surveys.
Origin Energy	1/03/2017	Santos send email to notify Origin of Fishburn EP submission on 27/02/2017. Santos also notes that the EP includes an assessment of the cumulative impacts of the Fishburn and Gulpener surveys but not the Melbana Beehive survey.	Cumulative impacts from the proposed Melbana survey could not be assessed as they do not have sufficient information in regards to their survey timing and have no information on seismic source noise levels or modelling.
Origin Energy	23/03/2017	Santos emails Origin asking if they have any more certainty about when Gulpener will commence and is the area still the same. Origin replies on 23.03.2017 likely we'll commence June.	
Origin Energy	8/05/2017	Santos emails Origin to inform them that Santos now has a contract in place with Polarcus to undertake the Fishburn WA-459-P seismic survey and has a planned start date of 15 June 2017. Was just following up to see if you have a start date for Gulpener? Origin respond on 09.05.2017, we have a signed contract with a vessel and as part of this agreement the works for Gulpener are to be completed by 31 July 2017. At this stage there is still some dependencies for timing around other project commitments of contractors. Best estimate is June with current probability being the last half of June.	
Pearl Producers Association	11/01/2016	Santos introductory email with map and coordinates to establish if activity in the area and/or interested in seismic survey.	
Pearl Producers Association	14/03/2016	Santos email to let know seismic shooting has been delayed for permit WA-459-P - due to contracting issues. Delays mean that we have missed the preferred timeline window so it will be postponed by a year.	
Pearl Producers Association	21/06/2016	Santos email renewing discussion in regards to WA-459-P survey and asking for information as to any pearling activities within area of survey and if so any concerns. Maps attached.	No response.
Pearl Producers Association	11/10/2016	Follow up on email 21/6/16. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, and attached Information Sheet #1.	No response.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Pearl Producers Association	31/10/2016	Follow up on email 11/10/16. Resent Information Sheet #1. Asked could you please advise of any areas of concern you may have and the type of additional information you would like to receive. Hoping you might be able to provide answers to the questions in the email of 21 June. If you would prefer another form of engagement instead of email (over the phone? In person?), please let me know.	
Pearl Producers Association	19/12/2016	PPA replies that the fact sheet has been circulated. Generally agreed the proposed activity is outside the current active pearling activity. It is noted that at the proposed depth there will likely be a variable distribution of *Pinctada maxima*.	EP Section 4 Consultation updated with information that proposed activity is outside the current active pearling activity. No further engagement required. EP Section 5.6.1 Benthic Habitat updated to include information on *Pinctada maxima* (sliver lipped pearl oyster) presence. EP Section 7.2.3 Seismic Underwater Noise Evaluation of Impacts on Invertebrates updated to include information in regards to *Pinctada maxima* (sliver lipped pearl oyster).
PGS	11/10/2016	Santos planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Want to check PGS's activities in the Bonaparte would not be affected by the proposed surveys. Attached Information Sheet #1 with details of our proposed surveys. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	
PGS	13/10/2016	PGS replied: The Fishburn survey sits within our soon to be submitted Rollo MC3D EP. However, this is a strategic EP and no specific surveys are currently planned in that location. PGS will contact Santos should this situation change. PGS does not require any further notification with respect to these proposed surveys unless there is a substantial change in the planned timing.	Section 4.4 Ongoing Consultation was updated to include ongoing consultation with PGS to determine timings for the Rollo MC3D survey within the area of the Fishburn survey.
PGS	9/02/2017	PGS made contact with Santos as the Halvar 2D seismic survey (subset of the Rollo MC3D) includes a line through WA 459 P. Timing for this line is uncertain.	Section 5.7.5 Oil and Gas Activities updated to reflect PGS Halvar 2D seismic survey information that requires access to WA-454-P. EP Section 7.2.8 Seismic Noise Cumulative Impacts updated to include that PGS and Santos Halvar Ingress Agreement will contain a condition that PGS cannot access the WA-459-P while the Fishburn Seismic Survey is being undertaken.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
PGS	1/03/2017	Santos sends notification email informing PGS that they have submitted the Santos Fishburn WA-459-P EP Submitted to NOPSEMA on Monday 27/2/2017. Santos also notes the Performance Outcome Measurement between Santos and PGS which has been included in the EP. PGS replied on 01/03/2017, thanking Santos for the information and stating that they are fine with the PO measurement.	
Recfishwest	11/01/2016	Santos introductory email with map and coordinates to establish if fish in area and/or interested in seismic survey.	
Recfishwest	14/01/2016	Response: Recfishwest confirmed that the area of the proposed seismic program in WA-549-P is highly unlikely to intersect with any recreational fishing activities given its remote location.	EP Section 4 Consultation updated with information that due to remote location recreational fishing activates unlikely.
TGS	11/10/2016	Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Want to check that TGS's activities in the Bonaparte would not be affected by the proposed surveys. Please see attached an Information Sheet with details of our proposed surveys. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	
TGS	31/10/2016	Response: Potential 2D in the Bonaparte Basin with the majority of the data being in the Vulcan Sub Basin. Map of the survey area attached. A small part of 1 line crosses the WA-459-P permit area. If we are acquiring at the same time we will have the flexibility to ensure we will not interfere with your operations as this is a regional 2D. We will ensure we keep in touch as plans progress. EP North presently in with NOPSEMA, under assessment.	
TGS	27/01/2017	Notes timing of WA-459 program will be mid-June to August this year. TGS replies: At this stage we have modified our proposed Q2 acquisition and have no plans to ingress WA-459-P. We will keep you updated if that changes for any reason. Santos clarifies for EP purposes: I need to know if you are planning to be within 100 km of 459 during June and August? TGS replies: No we have nothing planned within 100km of WA-459-P during June and August.	EP Section 4 Consultation updated with TGS information that no activity planned within 100km of WA-459-P for June to August. EP Section 4.4. Ongoing Consultation updated to confirm any changes prior to Fishburn survey commencing. EP Section 5.7.5 Oil and Gas Activities updated within information.
WA Department of Aboriginal Affairs	23/06/2016	Introductory email and seeking to confirm that due to the distance offshore, the survey would not impact any customary fishing practices.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
WA Department of Aboriginal Affairs	23/06/2016	Confirmed survey area too far offshore and no islands nearby where customary fishing activity would occur. Dept. gives details to contact the KLC Broome office.	KLC was contacted, see records. EP Section 4 updated. As no customary fishing activity in the area customary fishers are not seen as a relevant stakeholder for ongoing engagement purposes.
WA Department of Fisheries	16/11/2015	As per the DoF Guidance Statement for Oil and Gas Industry Consultation with the DoF 2013, Santos submitted an online Environment Impact Assessment Form to request advice from the DoF. Submission #107. No record of submission is given.	
WA Department of Fisheries	9/12/2015	Letter received from DoF in reply to Submission #107 outlining DoF advice.	
WA Department of Fisheries	3/03/2016	Email to DoF advising that survey delayed until 2017 and will recommence engagement in Oct/Nov 2016. DoF acknowledged email.	
WA Department of Fisheries	10/10/2016	Contacted DoF to determine if the Joint Authority Northern Shark Fishery will reopen in 2017. Response was unlikely that the JANSF will be operating in 2017, but will keep posted if there is a change to that likelihood. DoF also asked if contacting WA-licensed mackerel fishers who could operate in the area. Santos replied had obtained details from DoF and would be advising those listed of our activities. Also asked in contact with WAFIC. Santos replied had contacted WAFIC but was still following up as no reply.	EP Section 5.7.3 WA Managed Fisheries updated with information in regards to the JANSF. EP Section 4 Consultation and consultation log and records detail consultation with Mackerel Managed Fishery. EP Section 4 Consultation and consultation log and records detail consultation with WAFIC.
WA Department of Fisheries	31/10/2016	Email to DoF relating to Charter Fishing and Fishing Tourism Business that may operate in the survey area. DoF replied: checked the Charter Boat catch data and can confirm, based on historical returns, no Department of Fisheries licensed charter operators have reported activity in WA-459-P.	EP Section 4 Consultation updated with information.
WA Department of Fisheries	2/11/2016	Email to DoF to confirm the statement “no Department of Fisheries licensed charter operators have reported activity in WA-459-P”. Need to clarify for the survey operational area (which extends beyond the permit area). Map and coordinates included. DoF replied they had checked and no reported charter catch data within operational area as too far off shore.	EP Section 4 Consultation updated with information.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
WA Department of Fisheries	15/12/2016	Santos advised survey proposed for Jun - Aug 2017 and provided updated information in regards to: From engagement to date and available information, we have not identified any WA fisheries active within or near the survey area. Have only identified Commonwealth Northern Prawn Fishery active in the area. Could the DoF provide more information on spawning locations and timings? Does the WA Fish Resources Management Act apply for vessels not entering WA waters? Santos assessing potential impacts to fisheries, fish and fish habitats, and as part of our stakeholder engagement and the information obtained to date, we have not identified any WA commercial fisheries, recreational, customary, charter fishing or fish habitat within the Fishburn survey area that could be potentially impacted. In regards to impacts to fish, we will apply applicable mitigation strategies such as soft starts, avoid restricting movement of fish away from the seismic source, minimising the sound intensity and exposure time of the survey as per the Department's Guidance Statement on Undertaking Seismic Surveys in WA Waters.	EP Section 5.7.3 WA Managed Fisheries updated with fisheries information. EP Section 7.2 Seismic Underwater Noise details impact assessment to fish and control measures.
WA Department of Fisheries	16/01/2017	Santos followed up with email sent to DoF 15/12/16. Since email Pearl Producers Association have confirmed their members do not operate in the area. Santos also notes aiming to submit the EP to NOPSEMA week of 1st Feb 2017.	
WA Department of Fisheries	19/01/2017	Response from DoF with responses to email on 15/12/2016 and the following statement. In December 2016, the Department facilitated a risk assessment workshop examining the potential impacts of seismic air gun surveys on marine finfish and invertebrates. The outcomes from this workshop are currently being finalised, and will be published by the end of June 2017. In the interim, and in line with the preliminary assessment undertaken at the workshop, the Department formally objects to any seismic surveys being undertaken in waters less than 50m. This objection is based on scientific outcomes following the recent studies undertaken by FRDC, particularly with regards to mobile and sessile invertebrates.	Santos reviewed survey waters depths (Section 5.5.9 Bathymetry) and identified shallowest waters in the survey area are 60 m. Response to email WADoF-8.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
WA Department of Fisheries	7/02/2017	Santos letter to address information provided by the DoF in the letter dated 19/12/2015, ongoing consultation and email 19/1/2017.	EP Section 5.7.3 WA Managed Fisheries updated with fisheries information. EP Section 5.6.3 Plankton updated with spawning information. EP Section 7.2 Seismic Underwater Noise details impact assessment to fish and control measures. EP Section 7.10 Introduction of Marine Pests updated to include biosecurity commitment to provide DoF information to vessel operators. EP Section 8.7 Incident Reporting updated to include reporting to DoF any suspected or confirmed presence of any marine pest or disease.
WA Department of Fisheries	14/02/2017	Email from DoF - Thank you for the response to the Department of Fisheries, at this stage the Department has no additional comments regarding the proposed Fishburn seismic survey.	
WA Department of Mines & Petroleum	15/12/2016	Notification letter to the WA DMP for Santos's proposed Fishburn Seismic Survey based on the initial notification requirements as per the Department's Consultation Guidance Note for Offshore Petroleum and Greenhouse Storage (Environment) Regulations 2009. Santos' acknowledges that pre-start and cessation notifications are also required to the Department and this requirement will be documented in the Environment Plan required to be accepted by NOPSEMA.	EP Section 4.4 Ongoing Consultation updated to include activity pre-start and cessation notifications.
WA Department of Mines & Petroleum	3/01/2017	DMP acknowledged receipt of information. DMP noted that the proposed activity will be assessed under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 by NOPSEMA. No further information is required at this stage, however please ensure that a pre-start notification is sent through in accordance with regulation 30 of the OPGGS(E)R.	EP Section 4.4 Ongoing Consultation updated to include activity pre-start and cessation notifications.
WA Department of Mines & Petroleum	4/01/2017	Santos acknowledged email and that prestart notification would be undertaken at least 10 days prior to the activity commencing as per regulation 30 of the OPGGS(E)R.	EP Section 4.4 Ongoing Consultation updated to include activity pre-start and cessation notifications. Including prestart notification would be undertaken at least 10 days prior to the activity commencing as per regulation 30 of the OPGGS(E)R.
WA Mackerel Managed Fishery	11/10/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	No response. Noted in letter we will keep on sending information until we hear back from them.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
WA Mackerel Managed Fishery	18/11/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contacted details resent information. No response. Noted in letter we will keep on sending information until we hear back from them.
WA Mackerel Managed Fishery	16/12/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contacted details resent information. No response. Based on no response from any members, and that fishing tends to be around headlands and reefs and also shoal areas, which are not present in the survey area (see Section 5.7.3 WA Managed Fisheries) it is assessed that the WA Mackerel Managed Fishery is unlikely to fish in the area and no further consultation is required. EP Section 4.0 Consultation has been updated with this information.
WA Marine Aquarium Fish Managed Fishery	11/10/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	No response. Noted in letter we will keep on sending information until we hear back from them.
WA Marine Aquarium Fish Managed Fishery	18/11/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contacted details resent information. No response. Noted in letter we will keep on sending information until we hear back from them.
WA Marine Aquarium Fish Managed Fishery	16/12/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contacted details resent information. No response. Based on no response from any members, and that the fishery currently only operates in WA state waters and is active in waters from Esperance to Broome (See Section 5.7.3 WA Managed Fisheries) it is assessed that the WA Fishery Specimen is unlikely to fish in the area and is not a relevant stakeholder. EP Section 4.0 Consultation has been updated with this information.
WA Northern Demersal Scalefish Managed Fishery	11/01/2016	Santos sent introductory email with map and coordinates to 10 licence holders to establish if fish in area and/or interested in seismic survey.	Two responses of no interest.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
WA Northern Demersal Scalefish Managed Fishery	11/10/2016	10 licence holders. 8 licensees sent fact sheet and letter via post as two had already replied not interested. Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	No response. Noted in letter we will keep on sending information until we hear back from them.
WA Northern Demersal Scalefish Managed Fishery	18/11/2016	Follow-up notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contact details resent information. No response. Noted in letter we will keep on sending information until we hear back from them.
WA Northern Demersal Scalefish Managed Fishery	16/12/2016	Follow-up notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contact details resent information. Based on two responses of no interest and lack of response from remaining licensee it is assessed that no further consolation is required. EP Section 4.0 Consultation has been updated with this information.
WA Specimen Shell Managed Fishery	11/10/2016	Notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	No response. Noted in letter we will keep on sending information until we hear back from them.
WA Specimen Shell Managed Fishery	18/11/2016	Follow-up notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contact details resent information. No response. Noted in letter we will keep on sending information until we hear back from them.
WA Specimen Shell Managed Fishery	16/12/2016	Follow-up notification of survey via mail. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	As no other contact details resent information. Two responses that do not require further information. Based on response, and lack of response, from members, and that water depths in the survey area are 60 - 100 m. It is unlikely that the fisheries is active in the survey area (See Section 5.7.3 WA Managed Fisheries). It is assessed that the WA Specimen Shell Managed Fishery is unlikely to fish in the area and is not a relevant stakeholder. EP Section 4.0 Consultation has been updated with this information.
Western Australia Fishing Industry Council (WAFIC)	16/11/2015	Santos initial notification in regards to survey to determine who fishes in the area. Sent map and coordinates. Request information on WA fisheries in area.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Western Australia Fishing Industry Council (WAFIC)	17/11/2015	WAFIC responded that Northern Demersal Scalefish Fishery (State) and the North West Slope Trawl Fishery (Commonwealth) operate in the area indicated in the maps supplied by Santos. Gave contact details for individual fishermen in the NDSF and recommended going through AFMA to get the details for those in the North West Slope Trawl Fishery. Likely that only 2-4 fishers (highlighted) in the NDSF will be affected by your proposed activity. Asked to be kept informed of activity and ongoing consultation.	North West Slope Trawl Fishery is not near the survey area as per map on AFMA website. Notifications sent to all NDSF fishery licence holders – see records. For NDSF based on two responses of no interest and lack of response from remaining licensee it is assessed that no further consolation is required. EP Section 4.0 Consultation has been updated with this information.
Western Australia Fishing Industry Council (WAFIC)	15/12/2015	Santos asked for clarification as AFMA has advised that the only Cth fisheries in the area of WA-459-P are Western Tuna and Billfish and the Northern Prawn Fishery. They also advised that only the NPF actively fish in the area. Asked WAFIC to confirm that North West Slope Trawl Fishery is active in the area as they weren't identified by AFMA.	From a review of the AFMA website the North West Slope Trawl Fishery does not operate in the area of the Fishburn survey.
Western Australia Fishing Industry Council (WAFIC)	16/12/2015	WAFIC advised to go with AFMA's information as WAFIC is not always up to date with fishing activity.	
Western Australia Fishing Industry Council (WAFIC)	15/03/2016	Santos email to inform that the survey will be delayed for permit WA-459-P and that the NDSF licence holders had been contacted. Requested Mackerel Managed Fishery contact details.	
Western Australia Fishing Industry Council (WAFIC)	23/06/2016	Santos provided an update on the survey including maps. Engaging with DoF to obtain licence holder details but did WAFIC have contact of representatives for 1. Joint Authority Northern Shark Fishery 2. Mackerel Managed Fishery 3. Marine Aquarium Fish Managed Fishery 4. Specimen Shell Managed Fishery 5. Charter fishing industry	
Western Australia Fishing Industry Council (WAFIC)	11/10/2016	Santos resuming contact - Provided Information Sheet #1. WA-459-P is relevant to WAFIC. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Western Australia Fishing Industry Council (WAFIC)	25/11/2016	Reply from WAFIC: Would like clearer maps indicating the WA and NT border. Fishburn (WA-459-P) is of interest. State managed fisheries in the Fishburn area - Mackerel & Northern Demersal Scalefish. Kimberley region is their prime catching zone. Noted that via direct engagement with fishers preferred survey to take place between either 15th Jun & 1st Aug or 1st Dec & 1st April - this is when there will be least impact. If outside this timeframe, Santos will potentially incur losses. Following Fisheries have a right to fish in the area, but currently there is no activity in the area - West Coast Deep Sea Crustacean, Marine Aquarium Fish and Specimen Shell. WAFIC raises concerns of the impact these seismic surveys are having on the commercial fishing sector.	Section 5.7.3 WA Managed Fisheries updated with information in regards to fisheries. EP Section 7.2 Seismic Underwater Noise updated to include control measure - Seismic survey will be undertaken within 15 June – 1 August.
Western Australia Fishing Industry Council (WAFIC)	2/12/2016	Santos replied to WAFIC's email 25/11/16 Will ensure WA/NT border on future maps. Attached map of the Fishburn Survey location with WA/NT and State waters boundaries. Acknowledged WAFIC want to receive ongoing communication in regards to the Fishburn survey. Thank you for confirming that mackerel and Northern Demersal Scalefish are potentially activities in the area. Information Sheet #1 sent 11/10/2016 to individual fishers in the Mackerel and Northern Demersal Scalefish fisheries. This was followed up on the 18/11/2016 and to date no replies. Could you confirm the level of activity of these fisheries within the area of the Fishburn survey? As we have not received feedback from any of the fishers, we are assuming that it is not an area where they have a high level of activity. Is this correct? As part of our assessment of noise impacts from the survey, Santos is reviewing applicable studies to identify and understand potential impacts. This will include the recent FRDC studies. We are working with APPEA to look at the research to date in regards to seismic surveys and commercial fishing to identify where there is sufficient data to understand potential impact pathways and where further data is required.	Santos response to email 25/11/2016.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Western Australia Fishing Industry Council (WAFIC)	14/12/2016	Follow up on email 2/12/2016. Trying to understand level of fishing activity within the Fishburn area as WAFIC stated the Kimberley region is prime catching zone for the Mackerel and Northern Demersal Scalefish fisheries. Santos has had no reply from these fisheries based on information sent 11/10/2017 and 18/11/2017. Is this because the operational area of the Fishburn survey not being within the prime catching zone; and/or the proposed timing of the Fishburn survey means it is not an issue for the fishers?	Santos asked WAFIC for more information in regards to level of fishing activity for the Mackerel and Northern Demersal Scalefish fisheries as Santos has had no reply from these fisheries based on information sent 11/10/2017 and 18/11/2017.
Western Australia Fishing Industry Council (WAFIC)	30/01/2017	Santos follows up on email sent on 14th December and restates Santos' proposed timing of least impact (between 15 June and 1 August) is based on feedback from the Northern Prawn Fishery. We have had no other feedback from stakeholders other than that listed below.	
Western Australia Fishing Industry Council (WAFIC)	8/02/2017	Santos follows up on email send on 14th Dec 2016 and 30th January.	
Western Australia Fishing Industry Council (WAFIC)	8/02/2017	WAFIC replies stating there are two potentially impacted state-managed fisheries - the Mackerel fishery and the Northern Demersal Scalefish fishery. It is also noted in the email the different operational areas which might be potentially affected by the survey. WAFIC requests what type of engagement has been has been completed to notify Mackerel fishers and suggest that as per the current draft APPEA Stakeholder Methodology that if they is a lack of response, investigate multiple methods of contact before a "no reply' is registered.	Santos has followed the APPEA engagement methodology but DoF only had one contact detail for each fishing license (mailing address) hence why three repeated attempts to contact with no reply.
Western Australia Fishing Industry Council (WAFIC)	9/02/2017	Santos replied it had tried to follow the APPEA engagement methodology but DoF only had one contact detail for each license (mailing address) hence why three repeated attempts to contact with no reply.	
Western Australia Fishing Industry Council (WAFIC)	10/02/2017	WAFIC replied suggesting to include in the EP consultation the engagement completed (to no avail) whilst also acknowledging the information on Mackerel Zone 3, the fishing water depths and a potential impact.	Section 5.7.3 WA Managed Fisheries updated with information in regards to Mackerel Managed Fisheries. Unlikely to fish in area as mackerel preferred habitat not present.

Stakeholder	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions
Woodside Energy Ltd.	11/10/2016	Santos planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Attached Information Sheet #1 If you require any additional information, have any questions or feedback, please don't hesitate to contact me. Wanted to check that Woodside's interests in the Bonaparte Basin (like WA-522-P and NT/RL2 & NT/RL4) would not be affected by the proposed surveys. Are you also able to advise if Woodside is planning any drilling or seismic activity in the said permits/area? If you are, Santos will need to include this information in the development of its Environment Plan.	
Woodside Energy Ltd.	13/10/2016	Woodside reply: With regards to Woodside's interests in the Bonaparte Basin, specifically WA-522-P and NT/RL2 & NT/RL4, Woodside has no planned seismic or drilling activities in any of these permits next year (2017). If you need to seek ingress permission to enter these blocks then I can send you the contact details for the person in Exploration that manages this area.	EP Section 5.7.5 Oil and Gas Activities updated to reflect Woodside's information as their permit WA-522-P is within 100 km of the survey area, used to identify any potential simultaneous activities.

4 DESCRIPTION OF EXISTING ENVIRONMENT

This section describes the physical, biological, cultural and socio-economic environment and identifies any relevant values and sensitivities of the environment that may be affected by the activity (EMBA). The EMBA is within the area that may be affected (AMBA).

4.1 Regional Environment

The Fishburn Survey and EMBA is within the North-west Marine Bioregion, the Northwest Shelf Transition Bioregion and the Bonaparte Gulf and Oceanic Shoals Mesoscale Bioregions (Figure 4-1). The Bioregional Plan for the North-west Marine Region (DEWHA 2008) has been used in conjunction with other relevant management plans and studies to inform this description of the environment.

The North-west Marine Bioregion comprises Commonwealth waters from the Western Australia–Northern Territory border to Kalbarri, south of Shark Bay. The North-west Marine Bioregion is characterised by the large area of continental shelf and continental slope, highly variable tidal regions and very high cyclone incidence (DEWHA 2008).

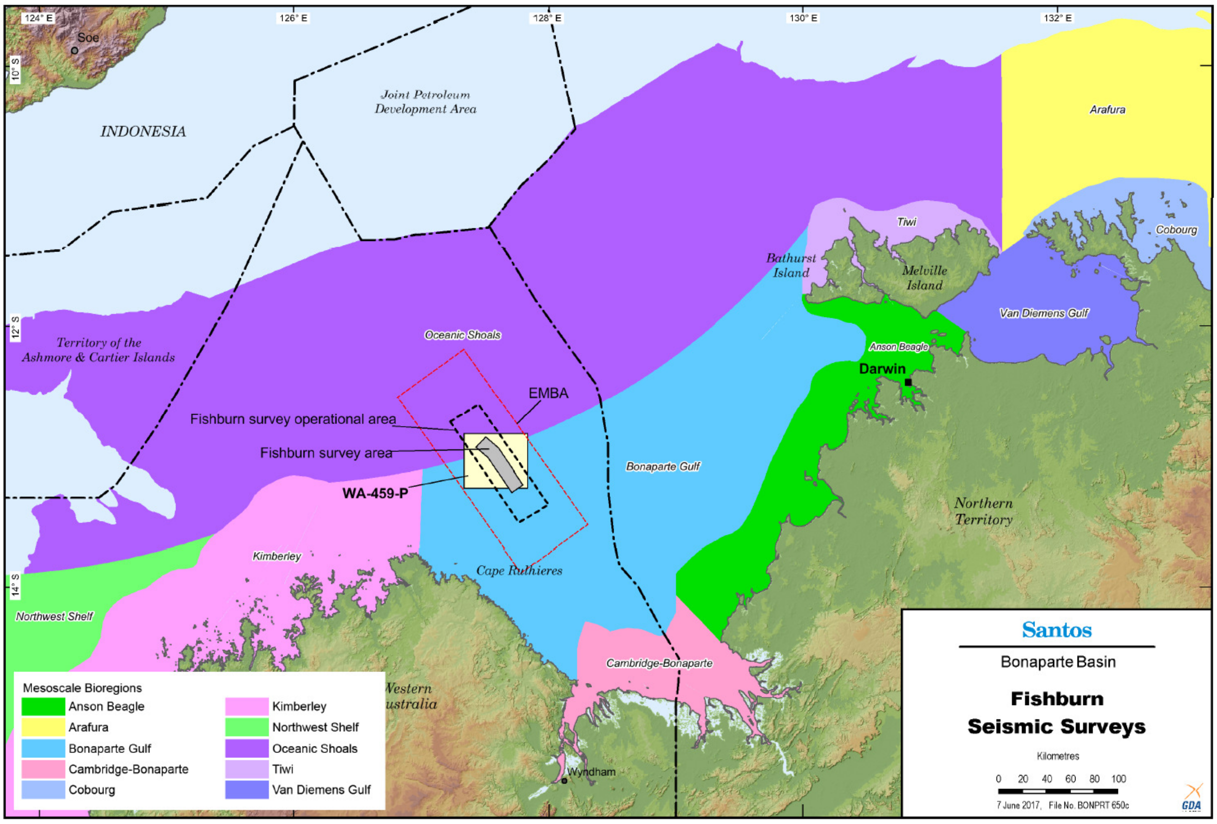


Figure 4-1: Mesoscale Bioregions

4.2 Key Ecological Features

Key ecological features (KEFs) are elements of the Commonwealth marine environment that, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity.

The Fishburn EMBA is within the KEF carbonate bank and terrace system of the Sahul Shelf and potentially two Pinnacles of the Bonaparte Basin are adjacent to the survey operational area and hence within the EMBA (Figure 4-2).

The carbonate bank and terraces of the Sahul Shelf consist of a series of drowned carbonate banks that are generally 10 km^2 in area with flat tops, developed as terraces and benches, and contain step slopes on average ~ 20^o (Baker et al 2008). It is thought that the formation of these banks is associated with hydrocarbon seeps (DEWHA 2008).

The carbonate banks and terrace system of the Sahul Shelf are regionally important because of their role in enhancing biodiversity and local productivity relative to their surrounds. They provide areas of hard substrate in an otherwise soft sediment environment which are important for sessile species. Rising steeply from depths of about 80 m some banks emerge to within 30 m of the water surface, allowing light dependent organisms to thrive. Banks that rise to at least 45 m water depth support more biodiversity such as communities of sessile benthic invertebrates including hard and soft corals, sponges, whips, fans and bryozoans (DoEE 2016a). Brewer et al (2007) also noted that banks within this feature support a high diversity of organisms including reef fish.

The banks and channels between them are also known foraging area for flatback, olive ridley and loggerhead turtles (DEWHA 2008).

The Bonaparte Basin contains 60% of the pinnacles in the North-west Marine Region. The limestone pinnacles can be up to 50 m high and 50–100 km long and are thought to be remnants of calcareous shelf and coastal features from previous low sea-level stands (DoEE 2016b). Surveys of the pinnacles within the Oceanic Shoals Commonwealth Marine Reserve suggest the area supports a wide range of high-order pelagic animals with 32 species observed, including 11 shark species, black marlin, barracuda, olive ridley turtle, sea snakes and orcas (Nichol et al 2013). Marine turtles including flatback, loggerhead and olive ridley are known to forage around the pinnacles and they are considered a general use area for green and freshwater sawfish (DoEE 2016b).

From Figure 4-2 and the bathymetry map in Figure 4-3 it seems that there are two pinnacles adjacent to the survey operational area that are at 50 m water depths. These pinnacles are isolated and a significant distance from the main area of pinnacles within the Bonaparte Basin.

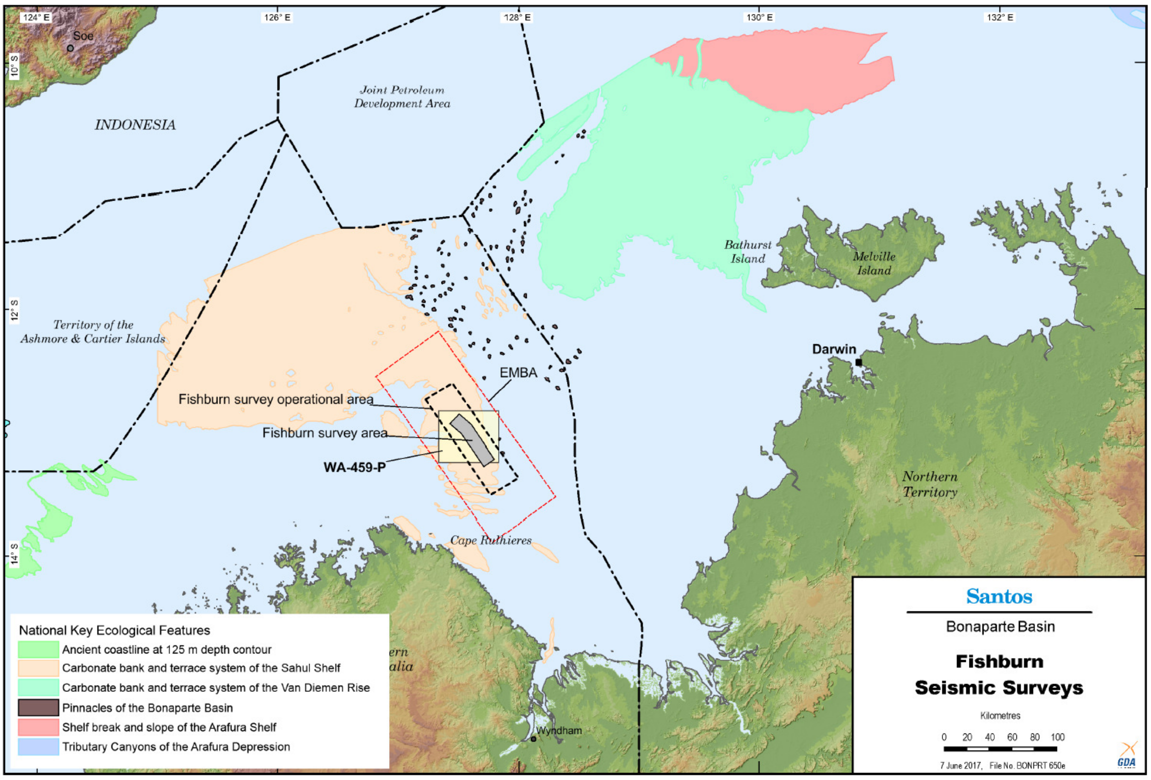


Figure 4-2: Key Ecological Features within the North-west Marine Region Profile (DSEWPaC 2012a)

4.3 Physical Environment

4.3.1 Climate

The region has a tropical monsoonal climate with two distinct seasons known as the North-west Monsoon or "wet season" (late October to mid-March) and the South-east Monsoon or "dry season" (May to mid-October). Regular rainfall and high rainfall are characteristics of the North-west Monsoon, particularly over coastal areas and during cyclones. This is due to large amounts of moisture being gathered as the monsoon crosses the sea from the Asian high-pressure belt on its way to the intertropical convergence zone which migrates southward close to or over northern Australia (Ding et al. 2013). Conversely, the South-east Monsoon originates from the Southern Hemisphere high-pressure belt and is relatively dry and cool (Ding et al. 2013).

Cyclones are common in the region, occurring between December and April (BOM 2016). These phenomena result in severe storms with gale force winds and a rapid rise in water levels.

4.3.2 Air Temperatures

Wyndham, located on Western Australia mainland, is the nearest meteorological station to the Fishburn survey area. Data collected from 1968 to 2016 shows that the highest maximum temperature (mean of 39.4℃) occurs in November whilst the lowest maximum temperature (mean of 16.9℃) occurs in July (BoM 2016).

4.3.3 Rainfall

Data collected from 1968 to 2017 at the Wyndham weather station show that the mean annual rainfall is 826 mm, with the highest rainfall in February (204 mm) and the least in August (0 mm) (BoM 2015). Typically the majority of the rain occurs from December to April (mean of 704.5 mm).

4.3.4 Winds

Wind patterns in the region are controlled by the seasonal migration of high-pressure cells from latitudes 25-30°S in winter to 35-40°S in summer (Pearce et al. 2003). Wind data from the National Centre for Environmental Prediction Climate Forecast System Reanalysis demonstrated two predominant directions; westerly winds during the months September to March and east-south-easterly winds during April to August. Monthly average wind speeds range from 8.6–14.6 knots and the monthly maximum wind speeds range from 23.0–47.8 knots (RPS APASA 2016). For the period of the survey (June to August inclusive) average wind speeds range from 10.6 to 14.6 knots from the east-southeast.

4.3.5 Sea Temperature

Surface water temperatures vary seasonally and are influenced by the Indonesian Throughflow. During the Northwest Monsoon, a thermocline flow of relatively cool water dominates resulting in the tropical Indian Ocean being cooled rather than warmed (Ding et al. 2013). The region typically has water surface temperatures of 26-30℃ (RPS APASA 2016).

4.3.6 Waves

Short period waves, within the northwest shelf region are generated by local synoptic winds and are typically the largest during winter months when the south-easterly trade winds dominate (Maxwell 2004).

Long period waves are influenced by swells generated in the Southern Ocean. In the Bonaparte Basin, the Southern Ocean swell is slightly higher during winter than in summer due to the northerly migration of swell-generating storms. The wave period and significant wave height generated by this swell is highly dependent on the exact location within the basin. For example, the Joseph Bonaparte Gulf is protected from the Southern Ocean swell and therefore swells affecting the area are limited to those generated by cyclones or prolonged storm winds (Maxwell 2004).

The region is a moderate-energy environment except when influenced by tropical cyclones which generate short-term major fluctuations in sea levels. Depending on the size, intensity, speed and relative location of the cyclone, swells generated may have periods of 6-18 s and wave heights of 0.5-9 m.

4.3.7 Tides

The Bonaparte Basin is subject to a semi-diurnal tides with two high and low tides per day and has the highest tidal range in northern Australia (> 4 m) (DEWHA 2007a). Within the Bonaparte Gulf Bioregion, tides range from 2-3 m offshore (microtidal) rising to 3-4 m inshore (mesotidal).

4.3.8 Currents

Broad-scale ocean circulation of the North Australian Shelf is dominated by the Indonesian Throughflow current system. In the area there are two predominant directions; east-northeast or west-northwest.

For the period of the survey (June to August inclusive) average current speeds range from 0.11 to 0.16 m/s to the west-northwest in June and July and east-northeast in August (RPS APASA 2016).

4.4 Bathymetry

Water depths of the EMBA range from 100 m to approximately 60 m (Figure 4-3).

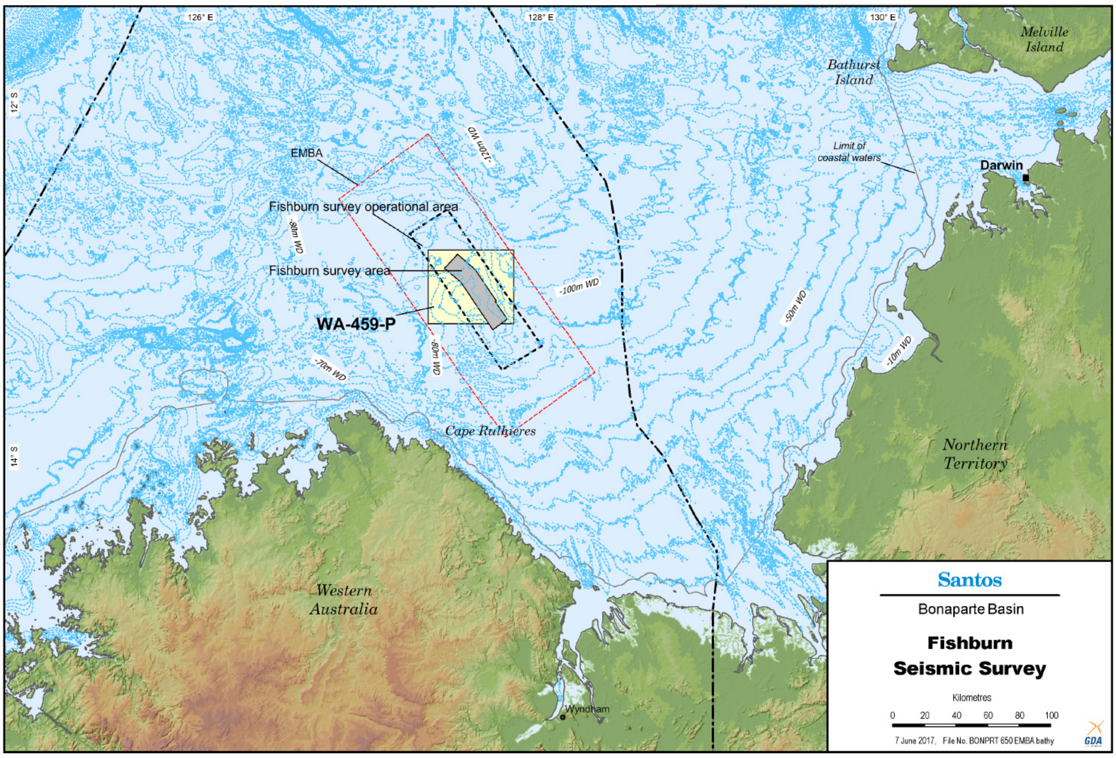


Figure 4-3: Bathymetry of the Survey Area and EMBA

4.5 Geomorphic Features

The Joseph Bonaparte Gulf includes ten geomorphic features, with the inner area comprising mostly shelf, the outer area comprising basin, and the outer Joseph Bonaparte Gulf – Timor Sea comprising banks and terraces separated by deep/hole/valley features (Przeslawski et al. 2011). The Fishburn EMBA is within the inner area of the Joseph Bonaparte Gulf and as shown in Figure 4-4 geomorphic features within the survey EMBA consist of:

- Shelf – low-relief expanses of unconsolidated sediment.
- Banks/shoals – local or regional areas of elevated seafloor with one or more steep sides.
- Basin – low-relief expanses of unconsolidated sediment.
- Ridges - long, narrow elevation with steep sides.

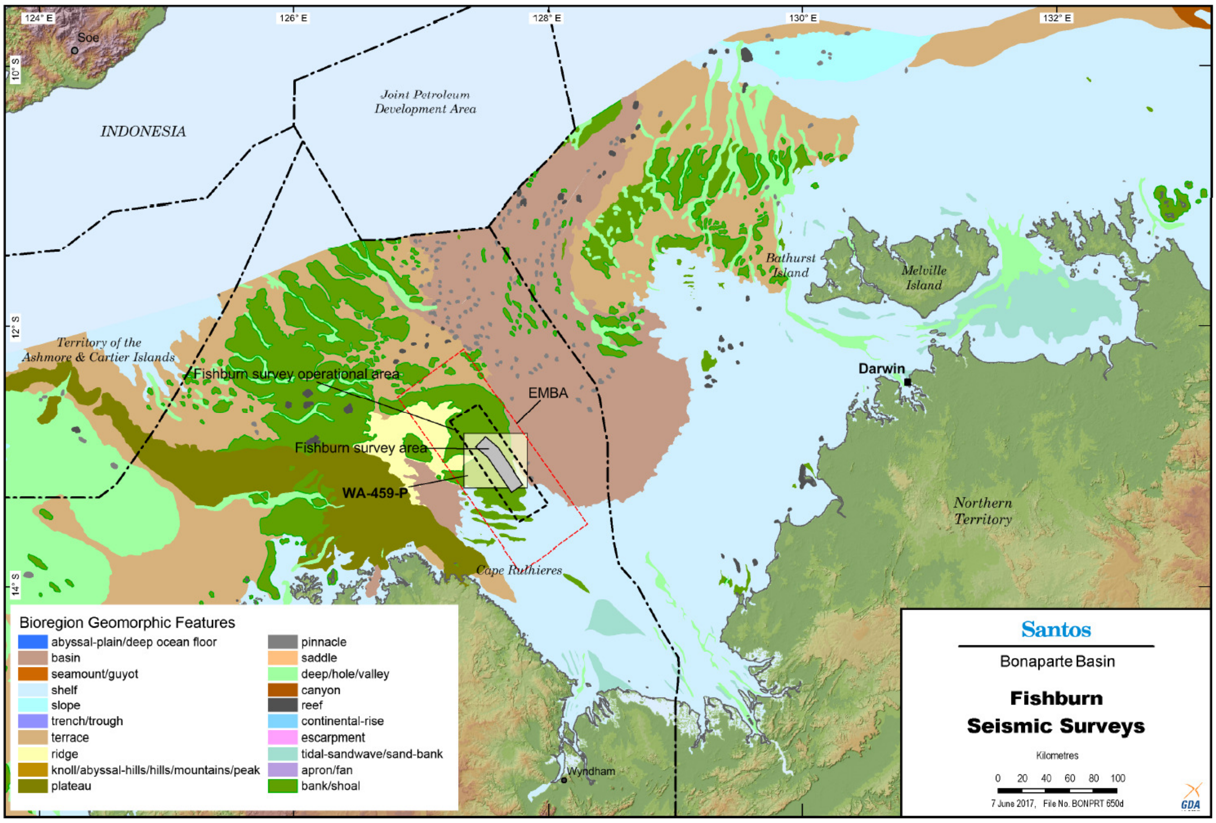


Figure 4-4: Geomorphic Features of the Fishburn Seismic Area

4.6 Benthic Environment

The benthic environment of the Joseph Bonaparte Gulf is linked to its geomorphic features, with the majority of the area characterized by infaunal plains, with some localised reefs and outcrops supporting sponge gardens. Przeslawski et al (2011) provides an overview of the benthic environment associated with the different geomorphic features within the EMBA (Figure 4-5).

- Shelf – sediment plains that are swept by strong tidal currents and are subject to large influxes of suspended sediment and freshwater, particularly during the wet season. Support diverse infaunal communities that play a key ecological role by contributing to nutrient cycling and sediment turnover (bioturbation) at the local scale. Low abundance of crustaceans, echinoderms and sessile epifauna.
- Banks/shoals - elevated features with a relatively high proportion of hard substrate that support patches of moderately dense octocoral and sponge gardens which in turn provide habitat for other epifauna and cryptofauna. Banks support high numbers of epifaunal species. Infaunal species richness is moderately high in bank sediments. Very few macroalgae (including Halimeda) or reef-forming hard corals were recorded.
- Ridges/sills - characterised by soft sediments with high variation among epifaunal species richness. Sponge and octocoral gardens may be present though infaunal species are low.
- Basin - low-relief expanses of unconsolidated sediment, and the available biological data suggests that these habitats are dominated by infauna with limited epifauna.

Though the main geomorphic feature within the survey area is bank/shoal, the bathymetry within the survey area (60 – 100 m) is on the lower limited of water depths where banks typically occur (20 – 60 m) (Przeslawski et al. 2011).

Inpex undertook benthic habitat surveys using drop cameras for the Inpex Ichthys pipeline at locations within and to the east and west of the EMBA (Inpex 2010). Figure 4-6 shows the five survey locations of which four are located in the geomorphic (bank/shoal) and habitat (sponge garden) communities identified by (Przeslawski et al. 2011) to occur in the survey area. Results identified:

- Site 4: Within the geomorphic feature of basin. Clay/silty substrate with high density of burrows. Low abundance of feather stars and basket stars.
- Site 5: Within the geomorphic feature of bank/shoal. Bioturbate sandy substrate. Low abundance of sea fans, feather stars, basket stars, tree soft coral, sea whips and sponges.
- Site 6: Within the geomorphic feature of bank/shoal. Sandy substrate. High abundance of sea fans, sea pens, bryozoans, sea whips, feather stars and sponges.
- Site 7: Within the geomorphic feature of bank/shoal. Low abundance of sea whips, tree soft coral and hydroids.
- Site 8: Within the geomorphic feature of bank/shoal. Feather stars common with tree soft coral and a ball sponge noted.

Based on this information it would be expected that the benthic habitat within the survey area and the broader EMBA would consist of sandy substrate that supports patches of low abundance of epifauna such as feather stars, sea pens, sea fans, sea whips, soft corals, bryozoans, hydroids and sponges ranging from low to high abundance. It is unlikely that the EMBA contains hard or reef forming corals.

The Pearl Producers Association noted that at the proposed depths where the Fishburn survey is to take place, there will most likely be a variable distribution of *Pinctada maxima* (sliver lipped pearl oyster) which are known to be present to less dense quantities in the Joseph Bonaparte Basin out to the 100 m isobath. *P. maxima* have a wide distribution throughout northern Australia and into Asia.

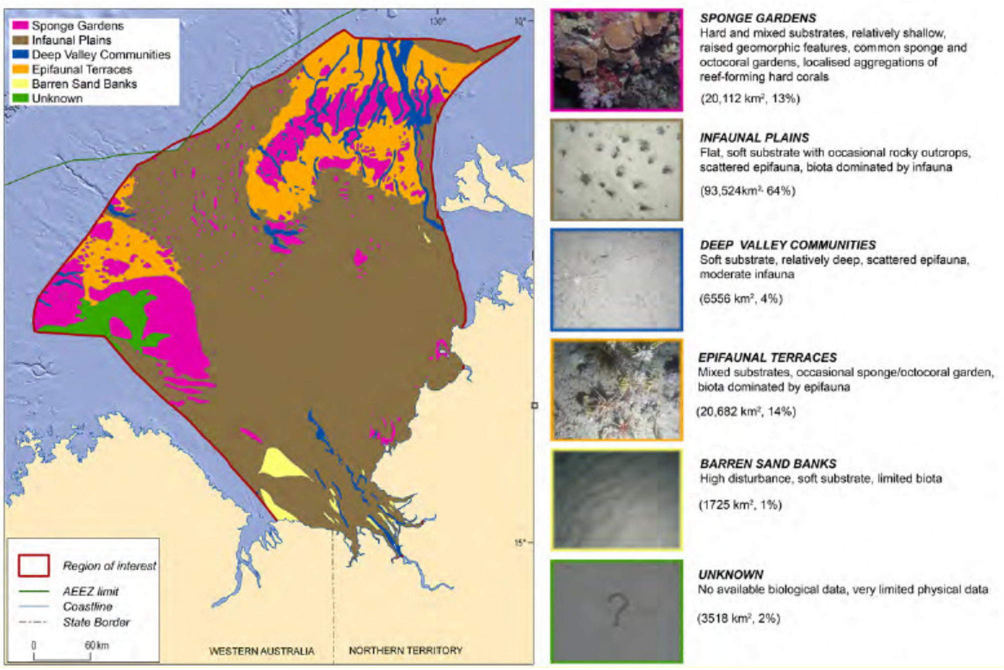


Figure 4-5: Generalised Habitat Map showing the Potential Distribution of Habitats and Biological Communities in the Joseph Bonaparte Gulf (Przeslawski et al. 2011).

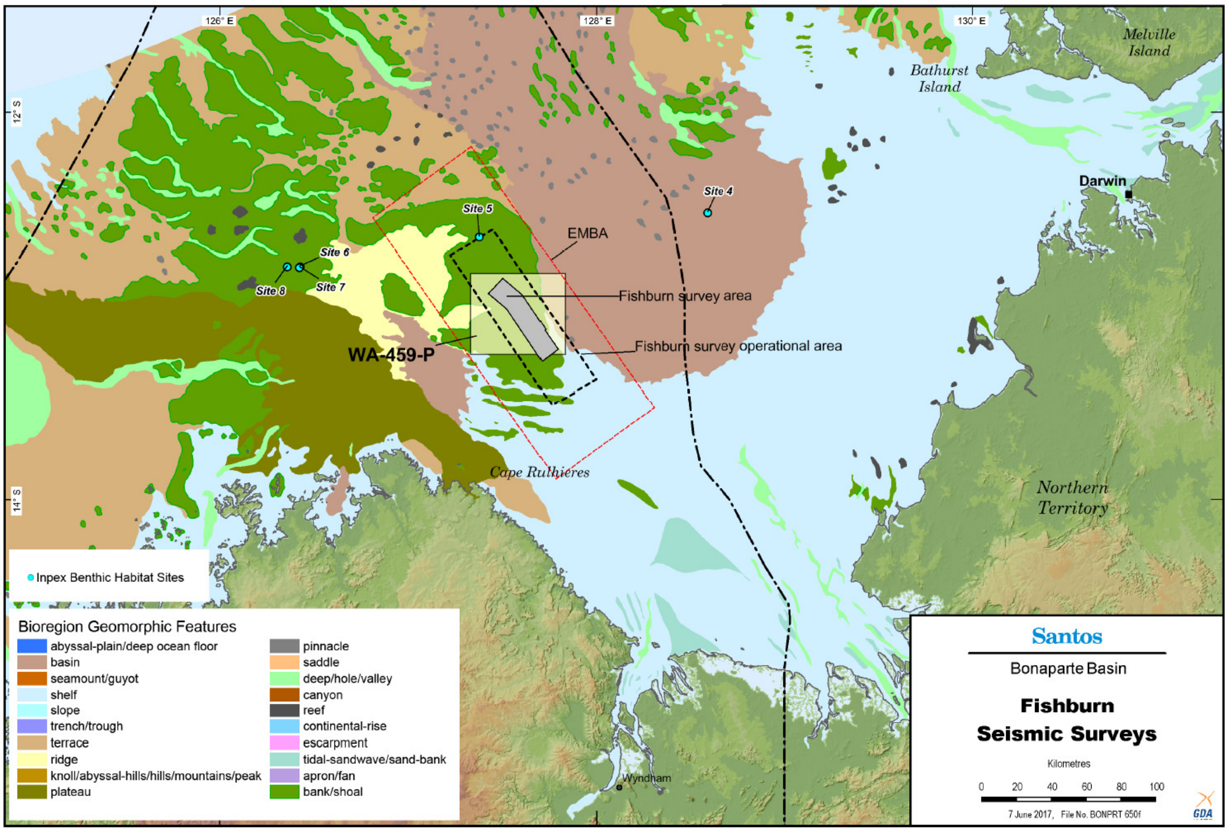


Figure 4-6: Location of the Inpex Drop Camera Locations Relative to the Fishburn EMBA

4.7 Biological Environment (Protected Species)

A search of the DoEE Protected Matters Database was undertaken for the Fishburn EMBA. Table 4-1 details fauna identified by the Protected Matters Search and any applicable management plans. The majority of species identified are likely to transit through the area with the exception of loggerhead, green, olive ridley and flatback turtle as the survey area overlaps foraging biologically important areas for these species (Figure 4-7).

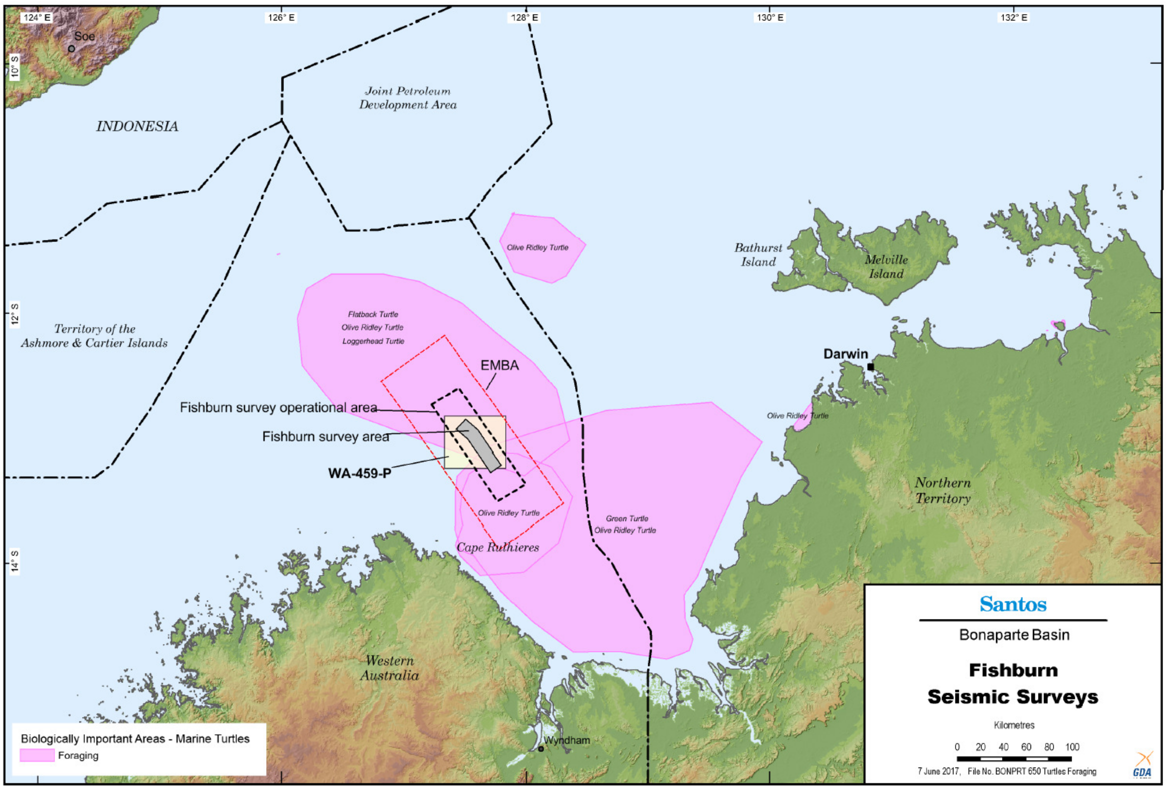


Figure 4-7: Biologically Important Area for Foraging Turtles overlapping the EMBA

Table 4-1: Threatened and Migratory Species that May Occur within EMBA

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery Plan and Approved Conservation Advice	Presence of Biologically Important Area	Relevant Management Actions
Sharks					
White shark	*Carcharodon carcharias*	Vulnerable, Migratory	Recovery Plan for the White Shark (*Carcharodon carcharias)*	No	None identified
Northern river shark	*Glyphis garricki*	Endangered	Sawfish and River Sharks Multispecies Recovery Plan	No	None identified
Dwarf sawfish	*Pristis clavata*	Vulnerable, Migratory	Sawfish and River Sharks Multispecies Recovery Plan Approved Conservation Advice for *Pristis clavata* (Dwarf Sawfish)	No	None identified
Largetooth (Freshwater) sawfish	*Pristis*	Vulnerable, Migratory	Sawfish and River Sharks Multispecies Recovery Plan	No	None identified
Green sawfish	*Pristis zijsron*	Vulnerable, Migratory	Sawfish and River Sharks Multispecies Recovery Plan Approved Conservation Advice for Green Sawfish	No	None identified
Whale shark	*Rhincodon typus*	Vulnerable, Migratory	Whale Shark (*Rhinocodon typus)* Recovery Plan 2005-2010 *expired recovery plan	No	Evaluate risk of vessel strike Evaluate risk from noise emissions
Narrow sawfish	*Anoxypristis cuspidate*	Migratory	__	No	__
Shortfin mako	*Isurus oxyrinchus*	Migratory	__	No	__
Longfin mako	*Isurus paucus*	Migratory	__	No	__
Rays					
Reef manta ray	*Manta alfredi*	Migratory	__	No	__
Giant manta ray	*Manta birostris*	Migratory	__	No	__

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery Plan and Approved Conservation Advice	Presence of Biologically Important Area	Relevant Management Actions
Reptiles					
Loggerhead turtle	*Caretta caretta*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	Yes – Foraging (Figure 4-7)	Evaluate risk of vessel strike Section 6.8) Management of marine debri (Section 6.6) Soft start procedures to be implemented for seismic surveys that occur within the distribution of marine turtles (Section 6.1) Spill risk strategies and response programs include management for marine turtles and their habitats (Section 6.11 and 6.12) Management of light pollution (Section 6.3) Management of vessel/fauna interactions (Section 6.8).
Green turtle	*Chelonia mydas*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	Yes – Foraging (Figure 4-7)	
Leatherback turtle	*Dermochelys coriacea*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	No	
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	No	
Olive Ridley Turtle	*Lepidochelys olivacea*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	Yes – Foraging (Figure 4-7)	
Flatback Turtle	*Natator depressus*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	Yes – Foraging (Figure 4-7)	
Salt-water Crocodile	*Crocodylus prosus*	Migratory	__	No	__
Birds					
Curlew sandpiper	*Calidris ferruginea*	Critically Endangered, Migratory	Approved Conservation Advice for *Calidris ferruginea* (Curlew Sandpiper).	No	None identified

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery Plan and Approved Conservation Advice	Presence of Biologically Important Area	Relevant Management Actions
Eastern curlew, Far eastern curlew	*Numenius madagascariensis*	Critically Endangered, Migratory	__	No	__
Common noddy	*Anous stolidus*	Migratory	__	No	__
Streaked shearwater	*Calonectris leucomelas*	Migratory	__	No	__
Lesser frigatebird	*Fregata ariel*	Migratory	__	No	__
Great frigatebird	*Fregata minor*	Migratory	__	No	__
Osprey	*Pandion haliaetus*	Migratory	__	No	__
Mammals					
Sei whale	*Balaenoptera borealis*	Vulnerable, Migratory	Conservation Advice *Balaenoptera borealis* (sei whale) *not a recovery plan	No	Minimise vessel collisions
Blue whale	*Balaenoptera musculus*	Endangered, Migratory	Conservation Management Plan for the Blue Whale 2015-2025	No	Minimise vessel collisions
Fin whale	*Balaenoptera physalus*	Vulnerable, Migratory	Conservation Advice *Balaenoptera physalus* (fin whale) *not a recovery plan	No	Minimise vessel collisions
Humpback whale	*Megaptera novaeangliae*	Vulnerable, Migratory	Conservation Advice for *Megaptera novaeangliae* (humpback whale) *not a recovery plan	No	Assess and address anthropogenic noise Minimise vessel collisions Report all fauna strike events
Bryde's whale	*Balaenoptera edeni*	Migratory	__	No	__
Spotted Bottlenose Dolphin	*Tursiops aduncus*	Migratory	__	No	__
Killer Whale	*Orcinus orca*	Migratory	__	No	__

4.8 Socio-economic Environment

4.8.1 Commonwealth Managed Fisheries

Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA) under the *Fisheries Management Act* 1991 (Cth). Commonwealth fisheries with jurisdictions to fish within the permit area are given in Table 4-2. Based on discussions with AFMA and information from the ABARES Fishery Status Report (Paterson et al. 2016) it was identified that only the Northern Prawn Fishery (NPF) actively fishes in the area.

Table 4-2: Commonwealth Managed Fisheries within the Environment that May Be Affected

Fishery	Actual Catch Effort within Permit Area/s	Comments
Western Tuna and Billfish Fishery	No	Efforts have been concentrated off south-west Western Australia over recent years.
Western Skipjack Fishery	No	No fishing effort since 2008-2009.
Southern Bluefin Tuna Fishery	No	Since 1992 juvenile Southern Bluefin Tuna have been targeted in the Great Australian Bight and waters off South Australia. Spawning area is off the north-west of WA outside of Joseph Bonaparte Gulf.
Northern Prawn Fishery	Yes	Known to fish at a low (<0.1 days/km^2) to medium (0.1-0.25 days/km^2) intensity within the Joseph Bonaparte Gulf (DAWR 2015). DoF confirmed that there are 21 active operators who may fish within the EMBA.
North West Slope Trawl Fishery	No	Advised by WA DoF that may fish in the area. Fishery is located in deep water from the coast of the Prince Regent National Park to Exmouth between the 200m depth contour to the outer limit of the Australian Fishing Zone. This area is not near the survey area.

4.8.2 Western Australian Managed Fisheries

Western Australian fisheries are managed by the Western Australian Department of Fisheries (DoF) under the *Fish Resources Management Act 1994* (WA). Although Western Australian state waters extend from the coastal baseline (generally the high water mark) out to 3 nm, Western Australia's fisheries extend into Commonwealth waters.

The DoF advised that the fisheries in Table 4-3 exist in, or are in close proximity to, the areas associated with the proposed survey. A review of data from the 2014/15 Fisheries Status Report as well as consultation with the DoF and licenced fishes did not identify any WA commercial fisheries that operate within the EMBA.

The Pearl Producers Association noted that at the proposed depths where the survey is to take place, there will most likely be a variable distribution of *Pinctada maxima* (sliver lipped pearl oyster) which are known to be present to less dense quantities in the Joseph Bonaparte Basin out to the 100 m isobath. There are no current or future fisheries of *Pinctada maxima* in or near the EMBA and *Pinctada maxima* have a wide distribution throughout northern Australia and into Asia.

Table 4-3: State Managed Fisheries within the EMBA

Fishery	Actual Catch Effort within Survey Area	Comments
Beche de mer Fishery	No	The WA beche-de-mer fishery is only permitted to operate in Western Australian waters (Hart et al. 2015). It is a hand harvest fishery unlikely to be in EMBA due to water depths of 60 - 100 m.
Joint Authority Northern Shark Fishery	No	Confirmation from DoF that fishery has not operated since 2009 and unlikely to operate in 2017.
Mackerel Managed Fishery	Unlikely	Targets Spanish mackerel using near-shore trolling gear around reefs, shoals and headlands. The fishery is divided into three zones, Area 1 - Kimberley (121°E to WA/NT border), Area 2 -Pilbara (114°E to 121°E) and Area -3 Gascoyne (27°S to 114°E) (Fletcher & Santoro 2015). The Kimberley area is the prime catching area and accounts for 50% of the allowable quota. A total of 11 vessels operated during 2014 with three within the Kimberley area (Fletcher & Santoro 2015). Feedback from WAFIC (See Section 4 Consultation) is that Mackerel licence holders fishing water depth range is under 100 m correlating directly with the survey scope. Fishing tends to be around headlands and reefs and also shoal areas (which are not necessarily close to the coast). Unlikely to fish in the EMBA as mackerel preferred habitat not present. Licenced fishers have been contacted on two occasions with no response.
Marine Aquarium Fish Managed Fishery	No	The fishery currently only operates in WA state waters and is active in waters from Esperance to Broome (Fletcher & Santoro 2015). In 2014, 10 licences operated in the fishery (Fletcher & Santoro 2015). The fishery targets more than 250 species of finfish and also takes coral, live rock, invertebrates, seagrass and algae (DoF 2010). It does so using divers and hand held nets. This limits the fishery's area and the number of catches. EMBA is not within area of known operation.
Northern Demersal Scalefish Managed Fishery	Unlikely	Operates off the north-west coast of WA in the waters east of 120°E and targets predominately red emperor and goldband snapper. Although permitted to use handlines, droplines and traplines, since 2002 the fishery has been essentially trap based (Fletcher & Santoro 2015). This has allowed fishing to occur in depths greater than 200 m. In 2014 eight vessels operated using between 18-36 fish traps per day and resulting in a catch of 1,111 tonnes (Fletcher & Santoro 2015). Licenced fishers have been contacted on two occasions. Two operators replied that they do not operate in the area.
Pearl Oyster Fishery	No	Dive fishery operated in shallow coastal waters along the North-West Shelf. The fishery is separated into four zones: NW Cape to longitude 119°30'E (Zone 1), east of Cape Thouin (118°20'E) and south of latitude 18°14' (Zone 2), west of longitude 125°20'E and north of latitude of 18°14'S (Zone 3) and east of longitude 125°20'E to the Western Australian/Northern Territory border (Zone 4) (Fletcher & Santoro 2015). EMBA is situated in Zone 4 and though all licences can access this zone, stocks in the area are not currently economically viable (Fletcher & Santoro 2015). Pearl Producers Association have confirmed no activity in the area.
Specimen Shell Managed Fishery	No	Fishery covers entire WA coastline, however, concentrates its efforts in areas adjacent to population centres (Fletcher & Santoro 2015). In 2014, over 200 different specimen shell species were collected using methods ranging from diving to wading to remote controlled underwater vehicles (Fletcher & Santoro 2015) Although there are 32 licences in the fishery, only 11 are regularly active (Fletcher & Santoro 2015). Unlikely to be in EMBA as water depths of 60 - 100 m. Licenced fishers have been contacted on three occasions. One reply not active in area, One reply did not require further information.

4.8.3 Other socio-economic activities within the area

A summary of other socio-economic activities that occur within the area are presented in Table 4-4.

Table 4-4: Summary of other Socio-economic activities

Socio-economic activities	Summary
Recreational Activities	Based on stakeholder consultation with WA Department of Fisheries, WA Department of Aboriginal Affairs, Kimberley Land Council, Recfishwest and Amateur Fishermen's Association of NT, no recreational activities or customary fishing was identified to occur within the EMBA. See Section 4 for stakeholder engagement records.
Oil and Gas Activities	The Bonaparte Basin is an established hydrocarbon province with a number of commercial operations such as the Bayu-Undan gas and condensate field, which is operated by ConocoPhillips and processed at their Darwin LNG plant, and the Blacktip Field operated by Eni Australia B.V. Consultation identified two activities that may occur around the same time as this survey: • Origin NT/P84 Gulpener 2D seismic survey currently planned for between 1 April – 31 July 2017. • Melbana WA-488-P Beehive 3D seismic survey potentially occurring in 2017. • PGS Rollo Multi-client 3D seismic survey. One line ingresses into the Fishburn survey area. Current start date for survey is July 1 2017 and unlikely to commence in area of Fishburn survey.
Shipping	Darwin's close proximity to South-east Asia makes the surrounding area a key shipping region. AMSA has identified high traffic shipping volumes in close proximity to the Darwin Harbour, around operating petroleum fields and along key shipping routes to and from South-East Asia and to and from petroleum fields.
Defence Activities	The Royal Australian Navy undertakes frequent patrols of fishing areas within northern Australia and operates from their HMAS Coonawarra base stationed in Darwin. According to the National Oceans Office no defence training areas are within the EMBA.

4.9 Indigenous Heritage

A search of the Department of Aboriginal Affairs' (WA) Aboriginal Heritage Inquiry System did not identify any registered Aboriginal heritage sites, other heritage sites or Aboriginal heritage survey areas within the EMBA.

A search of the Australian Heritage Database did not identify and indigenous heritage areas within the EMBA.

4.10 Maritime Heritage

Historic shipwrecks are recognised and protected under the *Historic Shipwrecks Act* 1976 that protects historic wrecks and associated relics. Under the Act, all wrecks more than 75 years old are protected, together with their associated relics regardless of whether their actual locations are known. The Commonwealth minister responsible for the environment can also make a declaration to protect any historically significant wrecks or articles and relics that are less than 75 years old.

A search of the National Shipwreck and Relic database did not identify any shipwrecks or relics within the EMBA.

4.11 Commonwealth Protected Areas

As per Section 5.2 a search of the DoEE Protected Matters Database identified that the EMBA is within the Oceanic Shoals Marine Reserve Multiple Use Zone (Figure 4-8) The Oceanic Shoals Marine Reserve Multiple Use Zone allows commercial activities such as fishing, tourism, and oil and gas exploration.

Figure 4-8 shows that the EMBA is 75 km from the Kimberley Marine Reserve and 60 km from the Joseph Bonaparte Marine Reserve.

A review of the Commonwealth Marine Reserves Review did not identify any changes to these marine reserve boundaries or any changes to the Oceanic Shoals Marine Reserve Multiple Use Zone that overlaps the EMBA (Buxton and Cochrane 2015).

The Oceanic Shoals Marine Reserves major conservation values are:

- Important internesting area for flatback and olive ridley turtles.
- Important foraging area for loggerhead and olive ridley turtle.
- Examples of the ecosystems of two provincial bioregions: the Northwest Shelf Transition Province (which includes the Bonaparte, Oceanic Shoals, and Tiwi meso-scale bioregions) and the Timor Transition Province.
- Four key ecological features are represented in the reserve:
  - carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature).
  - carbonate banks of the Joseph Bonaparte Gulf (enhanced productivity, high biodiversity, unique sea-floor feature).
  - pinnacles of the Bonaparte Basin (enhanced productivity, unique sea-floor feature).

4.12 State Protected Areas

A review of the WA Marine Parks and Reserve did not identify any current or proposed marine parks or reserves within the EMBA (Figure 4-9).

The proposed North Kimberley Marine Park is located within State waters and is approximately 30 km from the EMBA. The proposed Cape Londonderry Sanctuary Zone is the closest area (~ 30 km from the EMBA) and is proposed as it contains a section of the Sahul Shelf that provides critical habitat for green turtles, snubfin dolphins, seabirds and dugongs (DPaW 2016).

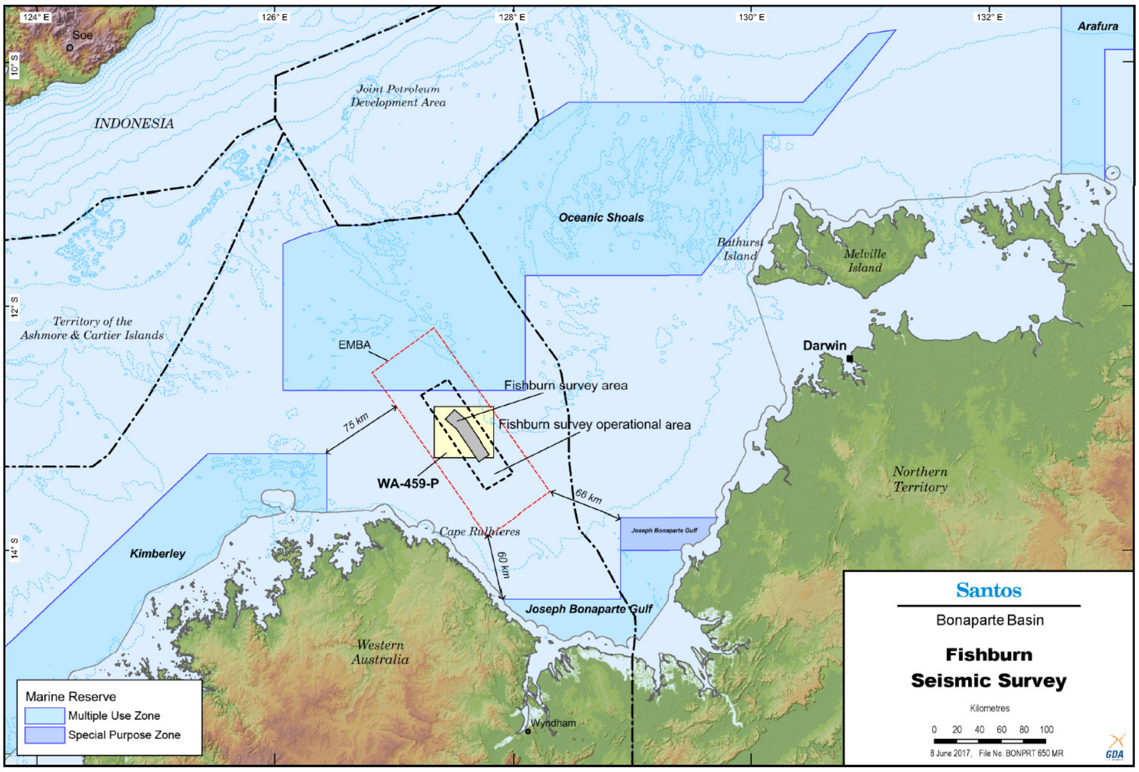


Figure 4-8: Commonwealth Marine Reserves

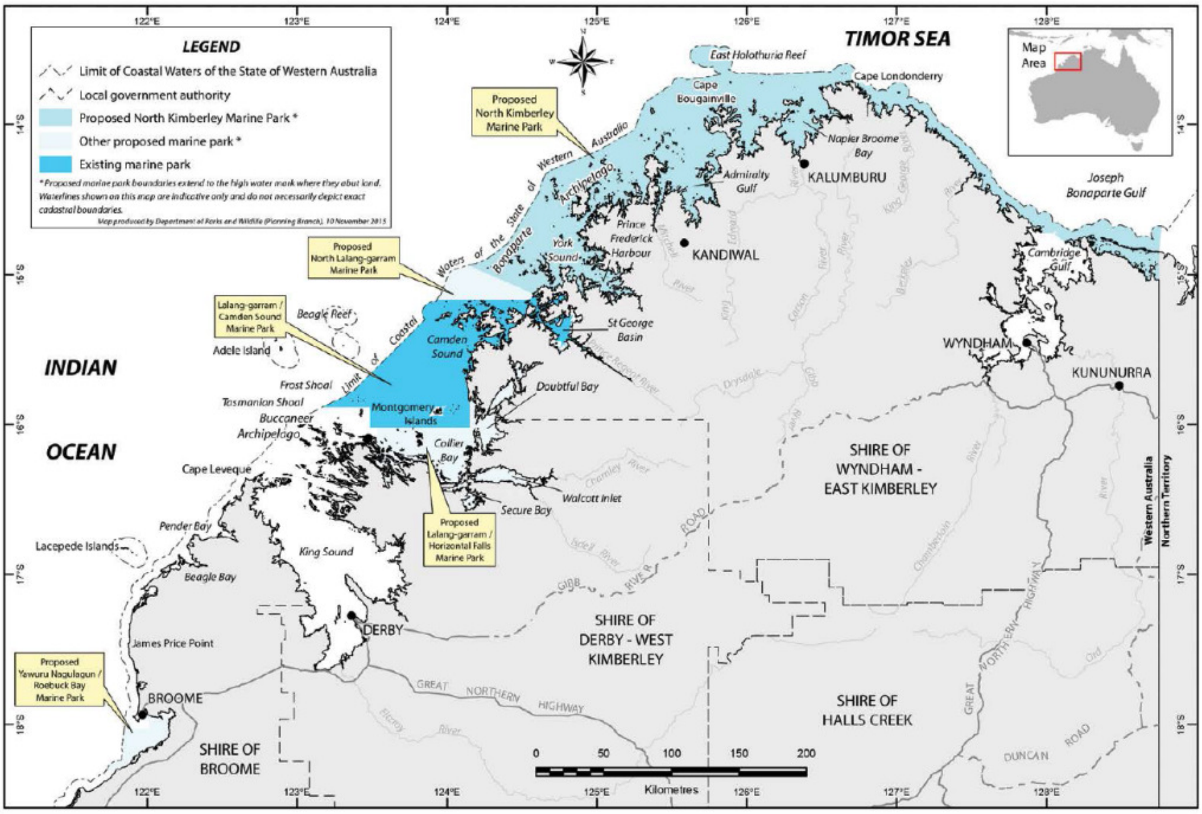


Figure 4-9: Location of Proposed North Kimberley Marine Park

5 ENVIRONMENTAL RISK ASSESMENT METHODOLOGY

The environmental risk assessment process undertaken for the seismic survey comprised of the following components that are discussed further in the following sections:

1. Identification of environmental hazards
2. Identification of the area that may be effected
3. Description of the environment that may be affected
4. Identification of the particular values and sensitivities
5. Identification and evaluation of potential environmental impacts
6. Control measure identification and ALARP decision framework
7. Determine severity of consequence
8. Determine likelihood
9. Determine residual risk ranking
10. Determination of Acceptability

5.1 Identification of Environmental Hazards (Aspects)

Environmental hazards or aspects are those elements of the activity that can interact with the environment. Environmental hazards were identified for operations and emergency conditions. An assessment of each component of the activity was undertaken and the environmental hazards (aspects) identified.

5.2 Identification of the Area that may be Affected

Following the identification of environmental hazards, the likely extent of each hazard, the area that may be affected (AMBA) was determined. Based on the risk assessment outcomes, the AMBA by a diesel spill resulting from a vessel collision was identified as the largest for the survey.

5.3 Description of Environment that may be Affected

The environment that may be affected (EMBA) for the AMBA was then described. A summary of The EMBA is provided in Section 4.

5.4 Identification of Particular Values and Sensitivities

Based on Santos' and publicly available information a review of the existing environment was undertaken to identify the environmental values and / or sensitivities with the potential to occur within the AMBA. These were used to inform the risk assessment as they provide the potential worst case consequence.

5.5 Identification and Evaluation of Potential Environmental Impacts

Based on Santos' and publicly available information, the known and potential impacts to the identified receptors were identified. These were then evaluated and specifically considered:

- receptor sensitivity to identified hazard
- extent and duration of the potential impact

5.6 Control Measure Identification and ALARP Decision Framework

Based upon the identified assessment technique used to demonstrate ALARP, control measures were identified in accordance with the defined environmental performance outcomes, to eliminate, prevent, reduce or mitigate consequences associated with each of the identified environmental impacts.

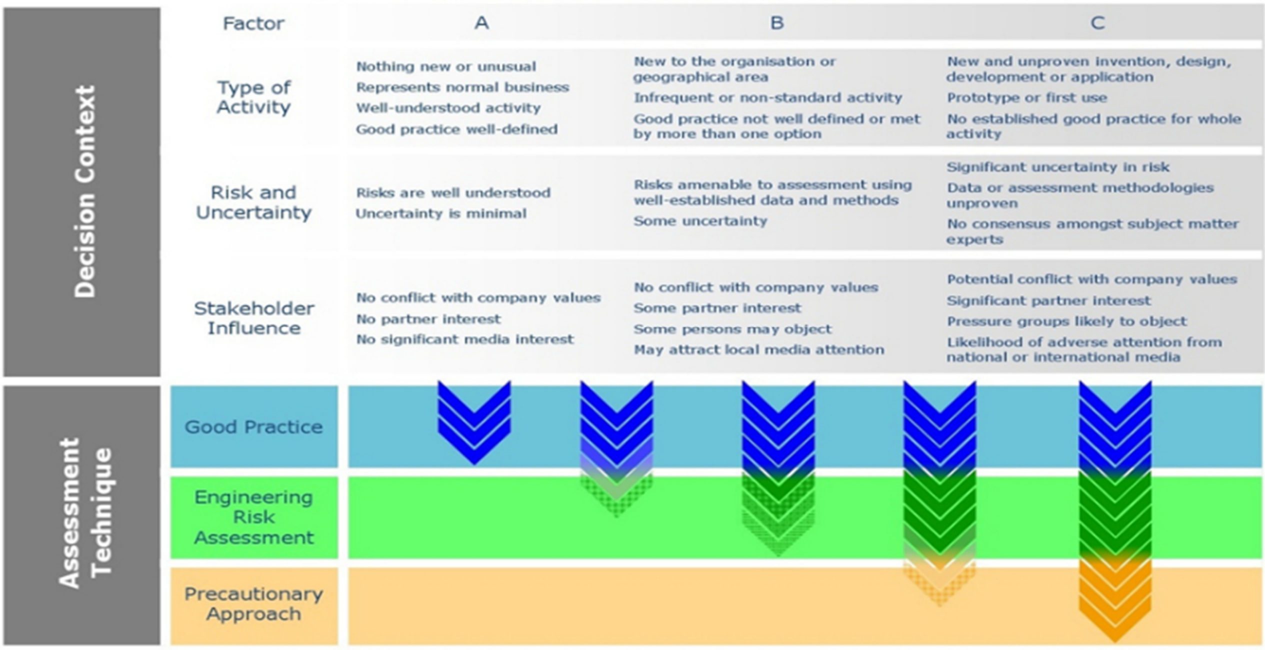
5.6.1 ALARP Decision Framework

In alignment with NOPSEMA's ALARP Guidance Note (GN0166), Santos have adapted the approach developed by Oil and Gas UK (OGUK) (formerly UKOOA) for use in an environmental context to determine the assessment technique required to demonstrate that potential impacts and risks are ALARP (Figure 6 1). Specifically, the framework considers impact severity and several guiding factors:

- Activity type;
- Risk and uncertainty; and
- Stakeholder influence.

This framework provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the impact or risk (referred to as the Decision Type A, B or C).

Figure 5-1: Impact and Risk 'Uncertainty' Decision Making Framework



5.6.2 Control Measure identification

Control measures were identified for each hazard with the aim of eliminating the hazard, or if this is not reasonably practicable, to minimise the risk to as low as reasonably practicable (ALARP). The process of identifying control measures is an iterative process of:

- Identifying a risk control
- Assessing the risk control
- Deciding whether residual risk levels are tolerable
- If not tolerable, identifying a new risk control
- Assessing the effectiveness of that control

Santos uses a hierarchy of control (Table 5-1) where you start at the top of the list and ask "Is there any reasonably practicable way that we can eliminate the hazard?" If the answer is yes then this is the most effective way of managing the hazard. If the answer is no then you move down to the next option in the list. This process of working down the list is repeated until a control measure/s can be found.

Once the control measures were determined performance outcomes, performance standards and measurement criteria were established. Terms used for measuring the environmental performance for each hazard are defined as:

- *Control measure* – a system, an item of equipment, a person or a procedure that is used as a basis for managing environmental impacts and risks.
- *Performance outcome* – a statement of the measurable level of performance required for the management if environmental aspects of an activity to ensure that the environmental impacts and risks will be of an acceptable level.
- *Performance standard* – performance required of a control measure.
- *Measurement criteria* – defines how environmental performance will be measured and determine whether the outcomes and standards have been met.

Table 5-1: Santos Hierarchy of Control

Control	Effectiveness	Example
Eliminate		*Removal of the risk.* Refueling of vessels at port eliminates the risks of an offshore refueling.
Substitute		*Change the risk for a lower one.* The use of low-toxicity chemicals that perform the same task as a more toxic additive.
Engineering		*Engineer out the risk.* The use of oil-in-water separator to minimise the volume of oil discharged.
Isolation		*Isolate people or the environment from the risk.* The use of bunding for containment of bulk liquid materials.
Administrative		*Provide instructions or training to people to lower the risk.* The use of Job Hazard Analysis to assess and minimise the environmental risks of an activity.
Protective		*Use of protective equipment.* Containment and recovery of spilt hydrocarbons.

5.7 Determination of Severity of Consequence

Once the potential hazards and receptors were identified the potential level of impact (consequence) was assessed and assigned. Consequence is defined using the Santos Environmental Consequence Classification (Table 5-2) from the Santos Operational Risk Matrix. The consequence level for each hazard is documented in the risk assessment tables in Section 7.

Table 5-2: Santos Environmental Consequence Classification

Level	Environment
VI	Regional and long term impact on an area of significant environmental value. Destruction of an important population of plants and animals with recognised conservation value. Complete remediation impossible.
V	Destruction of an important population of plants or animals or of an area of significant environmental value. Complete remediation not practical or possible.
IV	Extensive and medium term or localised and long term impact to an area, plants or animals of recognised environmental value. Remediation possible but may be difficult or expensive.
III	Localised and medium term or extensive and short term impact to areas, plants or animals of significant environmental value. Remediation may be difficult or expensive.
II	Localised and short term impact to an area, plants or animals of environmental value. Readily treated.
I	Localised and short term environmental or community impact – readily dealt with.

Definitions

Duration of potential impact	Extent of impact
Short term: Days or weeks	**Localised**: Within the Operational Area
Medium Term: Less than 12 months	**Extensive**: Within the EMBA
Long Term: Greater than 12 months	**Regional**: Outside of the EMBA

5.8 Determination of Likelihood

Likelihood is defined as the likelihood of the consequence occurring, this includes the likelihood of the event occurring and the subsequent likelihood of the consequence occurring. Likelihood is defined using the Santos Likelihood Descriptors (Table 5-3) from the Santos Operational Risk Matrix.

Table 5-3: Santos Likelihood Descriptors

Level		Criteria
Almost Certain	**f**	Occurs in almost all circumstances or could occur within days to weeks
Likely	**e**	Occurs in most circumstances or could occur within weeks to months
Occasional	**d**	Has occurred before in Santos or could occur within months to years
Possible	**c**	Has occurred before in the industry or could occur within the next few years
Unlikely	**b**	Has occurred elsewhere or could occur within decades
Remote	**a**	Requires exceptional circumstances and is unlikely even in the long term or only occurs as a “100 year event”

5.9 Residual Risk Ranking

Risk is expressed in terms of a combination of the consequence of an impact and the likelihood of the impact occurring. Santos uses a Corporate Risk Matrix (Table 5-4) to plot the consequence and likelihood to determine the level of risk.

Once the level of risk is determined Santos uses a Risk Significance Rating (Table 5-5) to determine the magnitude of the risk and if further action is required to reduce the level of risk using the process described in Section 6.6.

Table 5-4: Santos Risk Matrix

	I	II	III	IV	V	VI
f	2	3	4	5	5	5
e	2	3	4	4	5	5
d	2	2	3	4	4	5
c	1	2	2	3	4	5
b	1	1	2	2	3	4
a	1	1	1	2	3	3

Table 5-5: Santos Risk Significance Rating

RISK LEVEL	MITIGATION / INVESTIGATION FOCUS (ADD ADDITIONAL BUSINESS UNIT SPECIFIC REQUIREMENTS WHERE REQUIRED)
5	- Intolerable risk level - Following verification of the residual risk at level 5, activity must stop - Activity cannot recommence until controls implemented to reduce residual risk to level 4 or lower - Dedicated multi-disciplinary incident investigation team - Management involvement in the investigation
4	- Assess risk to determine if ALARP - If ALARP, activities related to maintenance of controls/ barriers prioritised & managed - If not ALARP, improve existing controls and/or implement new control/s - Dedicated multi-disciplinary incident investigation team
3	- Assess risk to determine if ALARP - If ALARP, activities related to maintenance of controls/ barriers prioritised & managed - If not ALARP, improve existing controls and/or implement new control/s - Full incident investigation
2	- Assess risk to determine if ALARP - If ALARP, activities related to maintenance of controls/ barriers prioritised & managed - If not ALARP, improve existing controls and/or implement new control/s - Incident investigations using simple tools
1	- Managed as stipulated by the related work processes - No incident investigation required

5.10 Determination of Impact and Risk Acceptability

The model Santos used for determining acceptance of residual risk is detailed in Figure 5-2. In summary:

A Level 5 residual risk is intolerable and must not be accepted or approved by Management.

A Level 2 – 4 residual risk is acceptable provided that ALARP has been achieved and demonstrated.

A level 1 residual risk is acceptable and it is assumed that ALARP has been achieved.

In addition to the requirements detailed above, for the purposes of offshore petroleum activities, impacts and risk to the environment are considered broadly acceptable if:

- The residual risk is determined to be 1 (and ALARP Decision Type A selected and good practice control measures applied), or
- The residual risk is determined between 2 and 4 and ALARP can be demonstrated; and
- The following have been met:
  - Principles of ecologically sustainable development (See Section 2)
  - Legal and other requirements (See Section 2)
  - Santos policies and standards (See Section 8.1)
  - Stakeholder expectations (See Section 4)

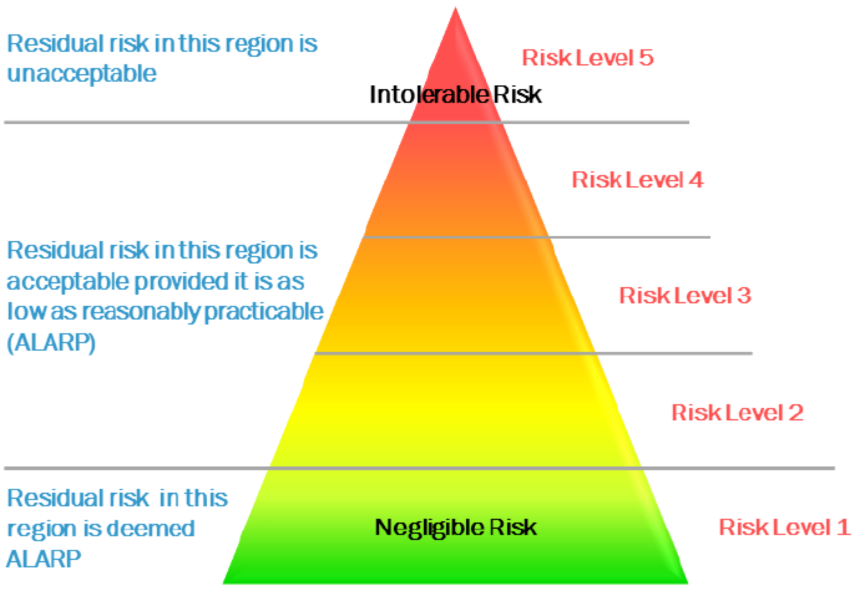


Figure 5-2: Santos Residual Risk Acceptance Model

6 ENVIRONMENTAL RISK ASSESSMENT

A summary of the risk assessment outcomes for the Fishburn seismic survey are detailed in Table 6-1. Residual risk is determined based on the control measures that will be implemented as detailed in each hazard section.

Table 6-1: Summary of Risk Assessment Outcomes

Hazard	Residual Risk	Acceptable
Seismic Underwater Noise	Low	Acceptable if ALARP
Vessel and Helicopter Noise	Low	Acceptable if ALARP
Light Emissions	Very Low	Broadly Acceptable
Atmospheric Emissions	Very Low	Broadly Acceptable
Waste Water Discharges	Very Low	Broadly Acceptable
Waste	Very Low	Broadly Acceptable
Seabed Disturbance	Very Low	Broadly Acceptable
Fauna Interactions	Very Low	Broadly Acceptable
Marine User Interactions	Very Low	Broadly Acceptable
Introduction of Marine Pests	Very Low	Broadly Acceptable
Diesel Spill	Very Low	Broadly Acceptable

6.1 Seismic Underwater Noise

6.1.1 Hazard

When the seismic source is operating sound pulses will be generated from the source array.

6.1.2 Area that Might be Affected by the Hazard

JASCO Applied Sciences conducted an assessment of underwater noise levels for the Fishburn survey. The study used three sound propagation models to predict the acoustic field around the airgun array for frequencies of 10 Hz to 2 kHz.

The modelling approach accounted for the acoustic emission characteristics of a 3480 in^3 seismic source array and considered source directivity and the range-dependent environmental properties in the area. The sound level results are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), single shot (i.e., per-pulse) sound exposure levels (SEL) as appropriate.

The underwater acoustic signature of the array was predicted with JASCO's Airgun Array Source Model (AASM) that accounts for individual airgun volumes and array geometry. Predicated source sound levels are shown in Table 6-2**.**

For the Fishburn survey a single shot site approximately in the centre of the operational area was assessed. This site in 63 m water depth, was selected as it was representative of the survey area which is relative flat. Table 6-3 details the estimated distances to the SEL and SPL isopleths.

SEL modelling was conducted to assess the sound field at receiver depths spanning the entire water column over the modelled areas, from 1 m to a maximum of 600 m, along radials separated by 2.5. The vertical slice plots (Figure 6-1 and Figure 6-2) demonstrate that close to the source (SEL > 170 dB), the maximum horizontal distance from the seismic array to a specific sound level typically occurs at the seafloor. The maximum-over-depth location of the sound level in the water column for the 150, 160, 170 and 180 dB re 1µPa^2·s isopleths is highlighted in the rear endfire direction. As can be seen, this location often occurs close to or at the seafloor. Therefore it can be said that the horizontal distance from the airgun array to a specific sound level is almost same regardless of considering maximum-over-depth or seafloor methods of calculation. This is due to the way the sound field propagates in these shallow water depths and the sound speed profile for the region. The same relationship will be true for assessing PK levels.

The modelling results for the Fishburn survey indicate strongest sound propagation in the broadside directions, south-east and north-west.

Table 6-2: Source Level Specifications for 3480 in3 Array at 6 m Tow Depth

Direction	Peak pressure level (dB re 1 µPa @ 1 m)	SPL (dB re 1 µPa @ 1 m)	SEL (dB re 1 µPa2·s @ 1 m)	
			10–2000 Hz	2000–25000 Hz
Broadside Perpendicular to the travel direction of a source	248.0	230.8	225.1	186.2
Endfire Parallel to the travel direction of a source.	247.0	230.9	225.1	189.0

Table 6-3: Distances from the Fishburn Source to Modelled SEL and SPL Isopleths

Isopleth	SPL (dB re 1 µPa)		SEL (dB re 1 µPa^2·s)	
	Rmax (km)	R95% (km)	Rmax (km)	R95% (km)
200	0.06	0.06	-	-
190	0.29	0.26	0.06	0.06
180	1.3	1.1	0.29	0.26
170	4.7	3.3	1.6	1.2
160	13.7	9.1	4.8	3.7
150	39.2	30.1	14.9	10.3
140	121.3	86.5	43.3	33.1

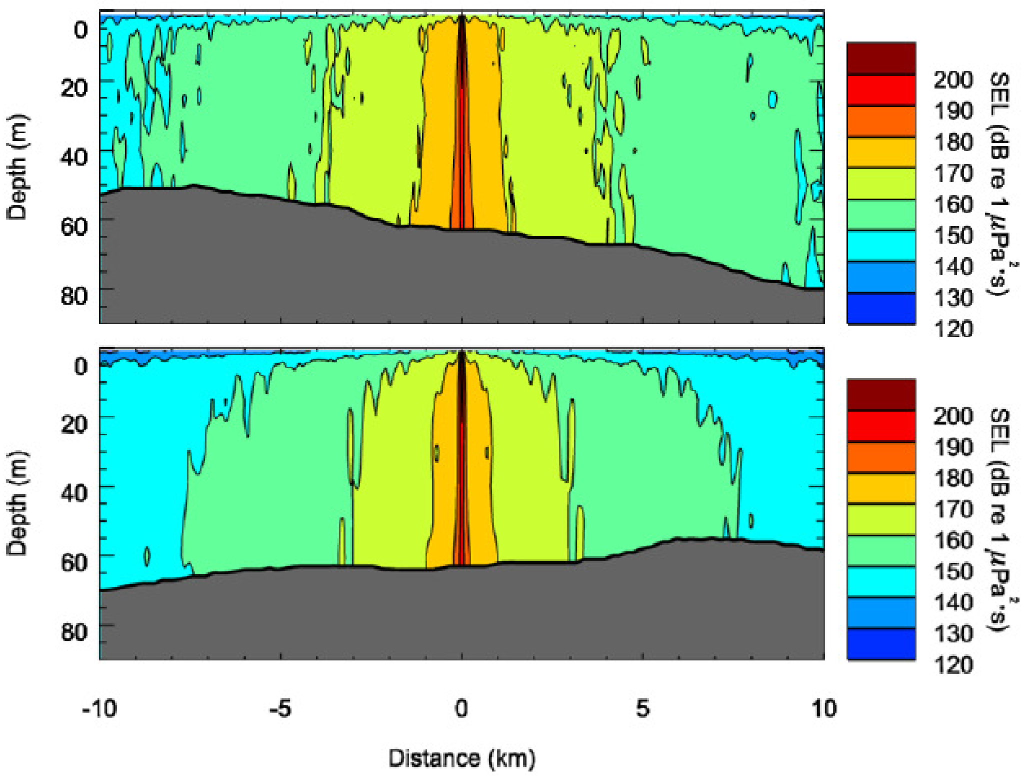


Figure 6-1: Predicted unweighted per-pulse SEL for the 3480 in^3 array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

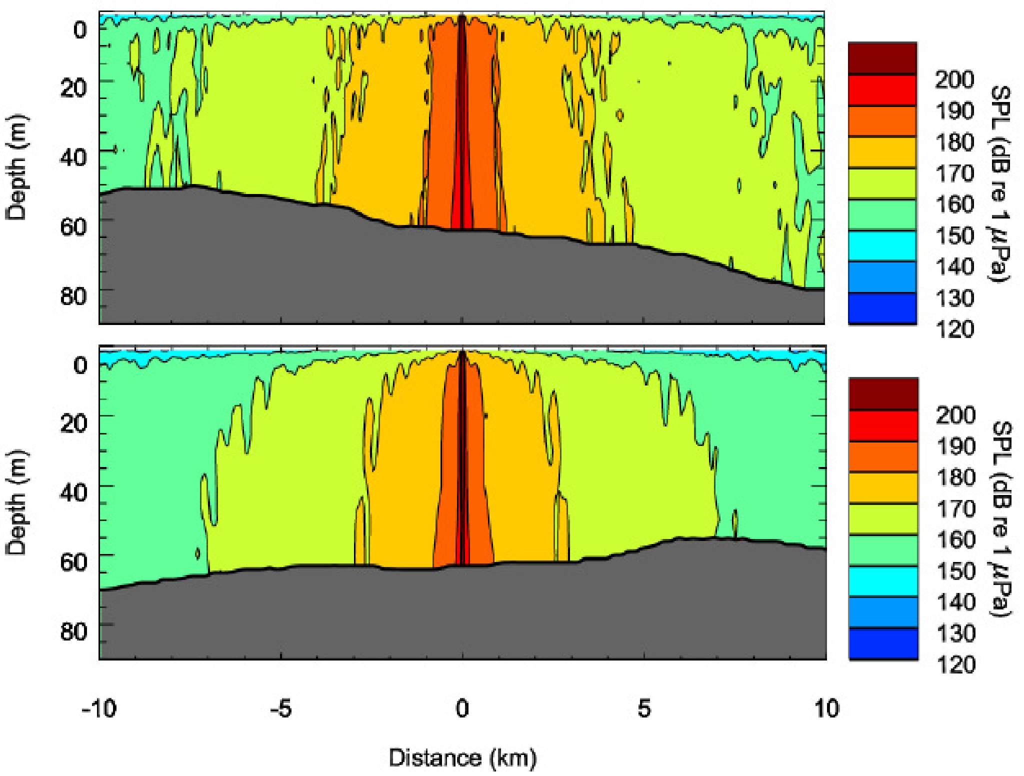


Figure 6-2: Unweighted SPL for the 3480 in3 array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

6.1.3 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Receptors that could potentially be impacted by seismic sound pulses are:

- Plankton including commercially important fish larvae/eggs
- Invertebrates including commercial species
- Fish
- Sharks and rays
- Turtles
- Marine mammals – whales and dolphins (cetaceans)

6.1.4 Known and Potential Environmental Impacts

Potential biological and ecological impacts from seismic sound pulses are:

- Physical such as mortality or injury including temporary or permanent hearing loss
- Physiological such as changes in metabolic rate or biochemical stress indicators
- Behavioural such as disturbance or displacement or impairment/mask the ability to navigate, find food or communicate
- Local abundance and catch which may occur from physical, physiological and/or behavioural changes

6.1.5 Evaluation of Environmental Impacts

6.1.5.1 Plankton

Receptor Sensitivity

Plankton includes fish eggs and larvae which are transported by currents and winds and hence cannot take evasive behaviour to avoid seismic sources. Larval fish species studied appear to have hearing frequency ranges similar to those of adults and similar acoustic startle thresholds (Popper et al. 2014). Swim bladders may develop during the larval stage and may render larvae susceptible to pressure-related injuries such as barotrauma. Effects of sound upon eggs, and larvae containing gas bubbles, is focused on barotrauma rather than hearing (Popper et al. 2014).

Larval stages are often considered more sensitive to stressors than adult stages, but exposure to seismic sound reveals no differences in larval mortality or abundance for fish, crabs or scallops (Carroll et al. 2016).

The effects of an operating 3D seismic array on plankton was investigated by Parry et al. (2002), alongside their work on scallops. Vertical plankton tows (0 – 20 m depth) were taken along transects running parallel and adjacent to seismic survey lines. A last-minute change to the seismic vessel track meant the initial balanced sampling design became five control transects (5 net tows ~500 m apart along each transect) and one impact transect (10 net tows). Plankton tows along the impact transect were made within 30–60 min of the seismic pass. Parry et al. (2002) found no detectable impacts on plankton based on their species composition and live/dead state but did concede that their statistical power to detect any impacts was low, requiring decreases in abundance of >30–40% for copepods and >80–90% for most other taxa.

Day et al. (2016a) found no effects on the mortality, abnormality, competency, or energy content of lobster larvae (*Jasus edwardsii*) after exposure of early embryonic stages to SELs of 190 – 197 dB re μPa^2.s. Pearson et al. (1994) exposed larvae of the Dungeness crab (*Cancer magister*) to single discharges from a seven-airgun array. For immediate and long-term survival and time to moult, this study did not reveal any statistically significant differences between the exposed and unexposed larvae, even those exposed within 1 m of the seismic source.

Impacts to larvae have been identified at intense and lengthy periods of exposure to low-frequency sound. Tank experiments by Aguilar de Soto et al. (2013) showed evidence of morphological abnormalities in early stage scallop larvae from simulated airgun signals. The lengthy exposure period of 3 s shot intervals for an exposure duration of 90 h, 1 m distance from sound source is not realistic in an actual survey. Christian et al. (2003) found major developmental differences between control and treatment groups of snow crab eggs exposed to peak sound level of 216 dB re 1 μPa every 10 s for 33 min. Again, the exposure period of a consistent peak sound level is not realistic of an actual survey.

Popper et al. (2014) identified a fish eggs and larvae mortality and potential mortality injury peak pressure level threshold of 207 dB re 1 µPa (PK) (Table 6-4). Based on the modelling this threshold would be within 240 m (R_{max} distance) of the sound source (Table 6-4).

Table 6-4: Fish Eggs and Larvae Mortality and Potential Mortal Injury Peak Pressure Threshold

Receptor	Mortality and Potential Mortal Injury Peak pressure level threshold (dB re 1 µPa)	Distance Rmax (metres)
Fish eggs and larvae	207	240

<u>Extent and Duration of Exposure and Identified Potential Impact</u>

Based on information from the Northern Prawn Fishery commercial prawn species such as banana, tiger and endeavour prawns may spawn within the survey area. These species spawn throughout the year with their peak spawning season outside the timing of the survey, with the exception of brown tiger prawns whose peak spawning period is between July and October. However, the survey area was not identified by the NPFI as a significant area of spawning. No other spawning areas were identified within the EMBA.

Based on the noise modelling, the area where the sound source levels exceed the mortality or mortal injury threshold for fish eggs and larvae is restricted to a distance of <240 m from the seismic source at full power (Table 6-4). The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2.

Thus, the area where the sound source levels are above the mortality or mortal injury threshold for fish eggs and larvae would equate to 678 km^2.

However, this has to be viewed in the context of:

- The broader area in which the survey is being undertaken. For plankton the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km^2 (2017r), the area of potential impact of 678 km^2 represents 1.2% of this region.
- There is no indication that the area of potential impact includes any locations where significant fish or invertebrate aggregations / spawning occurs, thus it is unlikely that large numbers of fish eggs and larvae will be present in the survey area during acquisition.
- Any plankton, including fish eggs and larvae, present in the water column within the area of potential impact will not be evenly distributed, and are likely to exhibit substantial spatial patchiness.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- Any mortality or mortal injury effects to fish eggs and larvae resulting from seismic noise emissions are likely to 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 & 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.

Thus, based on this analysis, though mortality or mortal injury may occur to plankton, including fish eggs and larvae, potential impacts are localised (1.2% of the Bonaparte Gulf Meso-scale Bioregion) and short term. These potential impacts are not significant when compared to rates of natural mortality in planktonic populations (on average 10 - 20% per day).

6.1.5.2 Invertebrates

Marine invertebrates lack a gas-filled bladder and are thus unable to detect the pressure component of sound waves. However, all cephalopods as well as some bivalves, echinoderms and crustaceans have a sac-like structure called a statocyst which includes a mineralised mass (statolith) and associated sensory hairs (Carroll et al. 2016). Cephalopods have epidermal hair cells which help them to detect particle motion in their immediate vicinity (Kaifu et al. 2008). Decapods have similar sensory setae on their body (Popper et al. 2001) and antennae which may be used to detect low-frequency vibrations (Montgomery et al. 2006).

The statocyst organs, found in a wide range of invertebrates, are utilised by animals to maintain their equilibrium and orientation and to direct their movements through the water. Their functions include the detection of gravitational forces and linear accelerations. Although there is little information available on the functioning of these sensory organs, it has been suggested that marine invertebrates are sensitive to low-frequency sounds and that this sensitivity is not directly linked to sound pressure but to particle motion detection (André et al., 2016; Roberts et al., 2016; Edmonds et al., 2016). The statocysts may play a key role in controlling the behavior responses of invertebrates to a wide range of stimuli.

Prawns

Receptor Sensitivity

There has recently been a number of comprehensive reviews of seismic noise impacts to invertebrates; Carroll et al. (2016), Edmunds et al. (2016) and DoF (2016 in draft). Studies specific to prawn species are limited, however, a number of studies have been undertaken on decapods with a range of effects to no effects identified. As such studies of species in the same scientific order (Decapoda) have been used to provide an indication of how sensitive prawns are when exposed to sound waves

Edmonds et al. (2016) undertook a review and critical evaluation of crustacean sensitivity to loud impulsive, low frequency underwater noise typically produced by seismic surveys. They identified that sensitivity to underwater noise is shown by the Norway lobster and closely related crustacean species, including juvenile stages. They concluded that current evidence supports physiological sensitivity to local, particle motion effects of sound production. The DoF review (2016 in draft) also supported that there was no evidence in the current literature of direct mortality of crustaceans from seismic exposure. A range of physiological responses have been identified in some studies, however, the received sound levels are typically at levels that would be received within a few hundred metres from the sound source or have been from repeated exposure at the same sound levels which is not realistic in an actual survey.

Day et al. (2016b) found airgun exposure caused damaged statocysts in rock lobsters (*Jasus edwardsii*) up to a year later. However, no such effects were detected in snow crabs after exposure to 200 shots at 10 s intervals and 17–31 Hz) (Christian et al. 2003). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 197-237 dB re 1 µPa (PK-PK), respectively.

Day et al. (2016b) also found that the rock lobster showed delayed time to right itself after exposure to airguns and that 2 out of 3 experiments found no difference in tail extension reflex, while one showed exposed lobsters had a 23% decrease 14 days after exposure. In contrast, no differences in righting time were detected in the American lobster (*Homarus americanus*) 9, 65, or 142 days after exposure to airgun noise (Payne et al., 2007). For these studies, measured received noise levels were 209-212 dB re 1 µPa (PK-PK) and 202 dB re 1 µPa (PK-PK), respectively.

Day et al. (2016b) also identified no changes to haemolymph biochemistry in rock lobsters up to 120 days post exposure, though a reduction in haemocyte cell numbers was identified. Seismic exposure also had a consistent and prolonged negative effect on lobster total haemocyte count (THC) for up to 120 days post-exposure, with decreases in THC ranging from 23% to 60% in the four experiments potentially compromising their immune system. THC is commonly used as an assessment of stress and is suggested to be related to immune competency and health status of crustaceans. Payne et al (2007) found no effects of seismic surveys on American lobster haemolymph biochemistry but possible reduction in calcium. In contrast, Christian et al (2003, 2004) found no chronic or long-term effects on stress bioindicators in haemolymph. Andriguetto-Filho et al (2005) also carried out histopathological studies on gonadal and hepatopancreatic tissue and reported that there was no damage that could be associated with exposure to a four airgun array with a source peak pressure of 196 dB re 1 µPa at 1 m within shallow waters (2-15 m).

Extent and Duration of Exposure and Identified Potential Impact

It is likely that the mechanism of impacts for invertebrates, such as prawns, are not from sound pressure, but rather from particle motion. However, what is unknown is what particle motion levels lead to a behavioural response, as described in Day et al. (2016), or mortality. Water depth and seismic source array size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher levels, which can then be related to effects on prawns. Despite the results presented in Day et al. (2016), the science around which metrics relate to an effect, and the relationship therefore to impact, is still an area of ongoing research. While the pressure related metrics identified in Day et al. (2016) have been used to estimate the area of potential impact from seismic surveys in some impact assessments, the literature available does not clearly define either the metric which should be used, or any associated level to use while conducting an assessment.

In lieu of a suitable proxy, and because prawns have the potential to be in either the water column or on the substrate, an understanding of level for pressure related metrics at which impacts were identified gives some mechanism for being able to understand the area of potential impact from the Fishburn survey. As Payne et al. (2007) identified no effects on righting time in lobster at 202 dB re 1 μPa (PK-PK), and Day et al. (2016) found effects at 209 dB re 1 μPa (PK-PK), the level of 202 dB re 1 μPa (PK-PK) has been applied in this assessment as a precautionary threshold to determine potential impacts. While the modelling limits for PK and PK-PK were 500 m, extrapolation of the levels beyond the modelling limits estimates that received levels will be below 202 dB re 1 μPa (PK-PK) at approximately 575 m from the Fishburn noise source. The higher sound pressure level, 209 dB re 1 μPa (PK-PK), where physiological impacts have been identified would be within ~ 60 m of the Fishburn noise source.

Based on NPF data from 2010 to 2016, 95% of the NPF fishing activity, within the southern portion of the Joseph Bonaparte Gulf, is ~ 35 km from the survey acquisition area, where the seismic source is constantly at full power, and ~ 9.5 km from the survey operational area, where the seismic source is predominately at low power (Section 3.2). Considering that the survey area is at the closest point > 9 km from the main area in the southern portion of the Joseph Bonaparte Gulf where the NPF fish, mortality or physiological impacts to prawns within the fishing area is highly unlikely based on the predict sound levels.

Though the survey and operational area are not within the main NPF fishing area, there could potentially be prawns within these areas as they are within the broader NPF fishing area. It is assumed that prawn distribution and abundance within the survey area would be equivalent to the broader NPF fishing area, which covers an area of 880,000 km^2 (NPFI 2017).

Based on the noise modelling, the area where the conservative threshold, where physiological impacts have not been identified, is within a distance of < 575 m from the seismic source at full power. The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2.

Thus, the area in which prawns could experience noise levels above threshold levels would equate to 723 km^2.

However, this has to be viewed in the context of:

- The area of potential impacts is very small in context of the NPF fishing area where prawns could be present.
- Based on a spatial extent of 880,000 km^2 for the NPF, the area of potential impact 723 km^2 represents only 0.08% of the total NPF area.
- Any prawns present within the area of potential impact will not be evenly distributed, and are likely to exhibit substantial spatial patchiness.
- The survey period does not overlap the main migration of juvenile prawns in the Joseph Bonaparte Gulf, with the migration of the main cohort occurring between November and March, with a possible second cohort migrating from April to June.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- Physiological impacts identified are unlikely to result in significant impacts to prawns or prawn populations in light of the small area of impact (0.08% of the total NPF area) and prawns typically become sexually mature at six months and spawn more than once a year which would negate any impacts on such a small scale.

Thus, based on this analysis, physiological impacts are unlikely to result in significant impacts to prawns or prawn populations as impacts would be localised (0.08% of the total NPF area) and medium term (6 months) based on the prawns sexual maturity.

Molluscs

Receptor Sensitivity

Other invertebrate species that may potentially occur in the area are molluscs (cephalopods and bivalves) including the silver lipped pearl oyster (*Pinctada maxima*). As detailed in Section 5.6.3 there are no current or future fisheries of *Pinctada maxima* in or near the EMBA and they have a wide distribution throughout northern Australia and into Asia.

Cephalopods have been found to respond to sound between 30 and 600 Hz, being most sensitive between 100 and 200 Hz, suggesting that they detect sound similarly to most fish, with the statocyst acting as an accelerometer through which they detect the particle motion component of a sound field (Kaifu et al. 2008, Mooney et al. 2010).

There have been no observed cephalopod mortalities directly associated with seismic survey exposure in the field (DoF 2016). Though there is anecdotal data from the strandings of giant squid *(Architeuthidae spp.)* that showed tissue, statolith and organ damage after seismic surveys (Guerra et al. 2004), there was no direct evidence to link the suggested cause and effect (CMST 2016). Laboratory studies that exposed two species of squid to seismic noise showed that *Alloteuthis sublata* was tolerant to a sound level up to 260 dB, *Loglio vulgaris* was fatally injured at levels of 246 – 252 dB within 3 – 11 minutes of exposure (Norris and Mohl 1983 in DoF 2016). André et al. (2011) demonstrated that they can be injured by sweeping waves 50-400 Hz at levels of 157 dB SPL produced continuously for up to two hours. However, the exposure experiments in both of these studies are complicated to relate to commercial seismic surveys due to either the exposure levels or the duration of the exposure event.

Studies have shown that seismic sounds can elicit a behavioral response in cephalopods. McCauley et al. (2003) and Fewtrell and McCauley (2012) described behavioural responses of squid (*Sepioteuthis australis*) such as squid inking at a sound exposure level of 163 dB re 1μPa^2.s and an increase in movement away from the seismic source at a sound exposure level of 140 – 150 dB re 1μPa^2.s. They also noted that the squid showed fewer alarm response with subsequent exposure to the seismic source.

The potential effects on catch rates or abundances have been tested on cephalopods with no significant differences detected between sites exposed to seismic operations and those not exposed (Carroll et al. 2016). Thus it is likely that cephalopods in the area of the survey may show a behavioral response to the seismic noise and move away from the source. There is not enough information to gauge the scale of this movement, and the displacement distance, however, it is likely that they would move back to the area once the seismic source has passed.

The majority of studies undertaken on seismic impacts to molluscs have been on commercial scallops. As for other invertebrate studies results show mixed results of impacts and no impacts. Typically impacts are seen in laboratory studies or in field studies where there has been repeated exposure.

Harrington et al. (2010) conducted a scallop (*Pecten fumatus*) dredge before and two months after exposure to a 2000 psi air gun array. No evidence of short or long term impacts on the survival or health of adult specimens was detected. This study was undertaken following a die-off of scallops that fisherman claimed was the result of a seismic survey but neither the fisherman nor the study could definitively attribute the scallop die-off to the survey (CMST 2016). Przeslawski et al. (2016) also recorded no impact of seismic exposure on adult scallop mortality rates or a range of physiological attributes two months after exposure to maximum sound exposure levels of 146 dB re 1μPa^2.s. Day et al. (2016) found that exposure to a seismic source (191 – 213 dB re 1μPa) did not cause any incidence of immediately mass mortality, however, repeated exposure (54 – 393 shots) significantly increased mortality, and the risk of mortality significantly increased with time as the majority of mortality was recorded at the day 120 sample point. Day et al. (2016) also found that exposed scallops has faster recessing times, elicited a novel velar flinch and had substantial disruptions in the biochemistry of the hemolymph. In one experiment there was some indication that righting time might be slowed.

Although studies have not necessarily looked at the effects of seismic sources on the pearl oyster directly, it is apparent that several species of bivalve, including two oyster species, are remarkably resilient to the shock waves created by the detonation of high explosives underwater. The one study that examined the effects of underwater explosions on the pearl oyster (LeProvost et al. 1986) found that no mortality occurred in the exposed animals over a 13-week period and at a minimum exposure range of 1 m from the blast centre.

As previously outlined, seismic sources cause less impacts on benthic invertebrates than explosives, hence it is likely that bivalves, such as *P. maxima*, would have to be within a very close range of a seismic source to experience pathological damage or mortality: available evidence would suggest ~ 1–2 m. It is more difficult to determine the distances at which sub-lethal effects (such as morphological, biochemical and physiological changes being indicators of some level of stress in an animal) could occur. Again, there are limited studies done specifically on the pearl oyster, and so conclusions must be drawn from studies done on similar bivalve species.

La Bella et al. (1996) examined biochemical indicators of stress in bivalves exposed to seismic noise and found that hydrocortisone, glucose and lactate levels between test and control animals were significantly different (P >0.05) in the venerid clam *Paphia aurea*, showing evidence of stress caused by acoustic noise. This was at a minimum exposure range of 7.5 m.

Extent and Duration of Exposure and Identified Potential Impact

As detailed in Section 5.6.3 there are no current or future fisheries of *P. maxima* in or near the EMBA and they have a wide distribution throughout northern Australia and into Asia. There is no indication that the survey area includes any locations where molluscs would be in greater numbers than the surrounding areas.

Based on the research to date, mortality and mortal injury effects in molluscs that have been reported to occur in experiments relating to seismic surveys are only likely to occur at very close ranges to the source (< 10 m). Physiological impacts identified may affect individuals but are unlikely to have long term or population effects based on the small area of impact and that molluscs are likely to be widely distributed throughout the broader Joseph Bonaparte Gulf.

Commercial Catch Rate

Receptor Sensitivity

Potential effects of seismic signals on catch rates and abundance have been tested on decapods with no significant differences detected in any of these studies between sites exposed to seismic operations and those not exposed (Carroll et al 2016).

Parry and Gason (2006) detected no change in catch per unit effort in a Victorian Southern rock lobster (*Jasus edwardsii*) fishery before, during and after intensive seismic exploration projects. Steffe and Murphy (1992) observed a declining trend in catch rate in a king prawn (*Penaeus plebejus*) fishery in the period after a seismic survey, however, the authors could not attribute this trend directly to the survey. Andriguetto-Filho et al. (2005) examined bottom trawl yields of a non-selective Brazilian shrimp fishery before and after exposure to seismic sources (196 dB) and did not identify any statistically significant changes to the catch yield after exposure to seismic survey activity. It was stated that the limited dispersal capacities of shrimp (compared to migratory fish species) suggested any attempted movement out of the survey area was not detectable (DoF 2016). Christian et al. (2003) identified that post-seismic snow crab catches were higher than pre-seismic catches but this was likely due to physical, biological or behavioral factors unrelated to the seismic source. They concluded that there was no significant relationship between catch and distance from the seismic source (received levels 197-237 dB re 1 µPa (PK-PK)).

It should be noted that a number of researchers (Edmonds et al. 2016 and Christian et al. 2003) have commented that current stock assessment methodologies do not have the resolution to show statistically significant changes in distribution or abundance from the seismic survey operations above that of natural variation.

In the past, commercial scallop fishermen expressed concerns about the potential impacts of seismic surveys on their catch levels. In a study off the Isle of Man, Brand and Wilson (1996) assessed the effect of seismic surveys in the field by comparing long-term catch-per-unit-effort (CPUE) of commercial scallops with CPUE following a seismic survey. They found no evidence that seismic surveys affected CPUE of scallops and instead attributed a decline (coincident with a 3D seismic survey) to two years of poor recruitment prior to the seismic survey.

Similarly in the Bass Strait, scallop fishermen expressed concern that seismic acquisition might kill scallops (*Pecten fumatus*), weaken their adductor muscles (indicator of sub-lethal effects) or increase the mortality of larval scallops. In a study conducted by the Victorian Marine and Freshwater Research Institute (MAFRI), the effects of seismic airgun noise were measured by comparing the mortality and adductor muscle strength of scallops deployed in an area exposed to passes of a survey vessel towing an operating 24-airgun array, with those in a control area 20 km away from the test area (Parry et al. 2002). This study found that mortality rate and adductor muscle strength of scallops suspended in the water column and exposed to the operating airgun array (at a minimum distance of 11.7 m) was not significantly different from the controls.

A recent critical review of the potential impacts of marine seismic surveys on fish and invertebrates (Carroll et al. 2017) concluded that"

> *"For marine invertebrates, the potential effects of seismic signals on catch rates or abundances have been tested on cephalopods, bivalves, gastropods, decapods, stomatopods, and ophiuroids with no significant differences detected in any of these studies between sites exposed to seismic operations and those not exposed".*

Extent and Duration of Exposure and Identified Potential Impact

Based on the research to date, that has not identified any changes to invertebrate catch rates from seismic surveys, and that the Fishburn seismic survey is at the closest point > 9 km from the main area of the Northern Prawn Fishery, it is highly unlikely that catch rates and abundance of prawns will be impacted. The survey area has not been identified by the NPFI as a recruitment area for prawns and impacts to prawns that may be within the survey area is detailed in the section on prawns. The NPF area covers 880,000 km^2 (NPFI 2017) and the area where the seismic source will be a full power is 646 km^2 which equates to an overlap of 0.075%. Any potential impacts would be localised (0.075% of the NPI area) and short term (for the period of the survey up to 21 days). The survey will also be undertaken outside the NPF season as a precautionary measure further reducing the likelihood of any impacts.

6.1.5.3 Fish

Receptor Sensitivity

Fish have a range of sensory mechanisms that can detect sound and vibration, including free-standing neuromasts, lateral line systems, and otoliths. Neuromasts are sense organs that respond to water movement and are typically found in fish below the skin of their heads and in fluid filled canals (lateral lines) running along their sides. Neuromasts and lateral line systems detect particle motion.

Sound detection in fish is via ears consisting of hardened, calcareous otoliths overlying epithelia with sensory cilia. Some fish species also have swim bladders that are physically coupled to the ears, allowing them greater hearing sensitivity and frequency range. There are substantial differences in auditory capabilities from one fish species to another, hence the use of anatomy to distinguish fish groups, as done by Popper et al. (2014) (Table 6-5). Within these categories, two groups have an increased ability to hear. The first of those are fish with swim bladders close, but not intimately connected to the ear, can hear up to about 500 Hz, and are sensitive to both particle motion and sound pressure. Fish with swim bladders mechanically liked to the ear are primarily sensitive to pressure, although they can still detect particle motion. These fishes have the widest hearing range, extending to several kilohertz, are generally more sensitive to sound pressure than any of the other groups of fish (Hawkins and Popper 2016). The predominant frequency range of seismic survey sound emissions, which for the Fishburn seismic source is below 650 Hz, is within the detectable hearing range of most fishes.

A review of research of seismic impacts on fish by the WA DoF (2016), detailed that observations from the literature indicate underwater noise produced by seismic air guns is generally not lethal to adult teleosts unless they are within a few metres of an air gun source, however sub lethal physical damage to structures such as the inner ear, lateral line or internal organs (e.g. swim bladder) may occur in fish up to 100 metres from a high energy sound source.

The Working Group on the Effects of Sound on Fish and Turtles undertook a review of experimental findings of sound on fishes. In their American National Standards Institute (ANSI) accredited report (Popper et al. 2014) they presented sound exposure criteria for different levels of effects for different groups of species, Table 6-5, 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.
- Temporary threshold shift.

Masking and behavioral effects are assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. 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 are proposed for fish without a swim bladder, fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing.

A recent study by Popper et al. (2016) found that the two fish species (pallid sturgeon and paddlefish), with body masses in the range 200–400 g, exposed to a single shot 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. They also found no difference in injuries between fish exposed closest to the source compared with those exposed furthest.

Based on these studies and the sound exposure thresholds for fish proposed by Popper et al. (2014) (Table 6-5) the fish mortality, potential mortality injury and recoverable injury peak pressure level threshold of > 207 dB re 1 µPa (PK) is used for this assessment. Based on the modelling this threshold would be within 240 m (R_{max} distance) of the sound source (Table 6-6). It is possible that fish would move away from the sound source (Streever et al. 2016) and hence not be exposed to these levels.

Table 6-5: Sound Exposure Thresholds for Fish

Receptor	Mortality and Potential Mortal Injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB 24 h SEL or > 213 dB peak	> 216 dB 24 h SEL or > 213 dB peak	>> 186 dB 24 h SEL	N) Low (I) Low (F) Low	N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection	210 dB 24 h SEL or > 207 dB peak	203 dB 24 h SEL or > 207 dB peak	>> 186 dB 24 h SEL	N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB 24 h SEL or > 207 dB peak	203 dB 24 h SEL or > 207 dB peak	186 dB 24 h SEL	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate

Note: 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).

Table 6-6: Fish Mortality, Potential Mortal Injury and Recoverable Injury Peak Pressure Threshold

Receptor	Mortality and Potential Mortal Injury Recoverable Injury Peak pressure level threshold (dB re 1 µPa)	Distance Rmax (metres)
Fish – no swim bladder	213	75
Fish Swim bladder not involved in hearing Swim bladder involved in hearing	207	240

<u>Extent and Duration of Exposure and Identified Potential Impact</u>

No commercial fishing areas or spawning areas were identified to occur within or near the survey area or alternatively during the survey timing period. It is likely that a range of fish species including reef fish and syngnathids (pipefish, seahorse or pipehorse species) may be present in the EMBA with more abundance of species expected associated with the two pinnacles identified just outside of the operational area.

Impacts to commercial fish catch rates were not assessed as no commercial fishing was identified within or near the survey area.

Mortality, potential mortality injury and recoverable injury

Based on the noise modelling, the area where the sound source levels exceed the fish mortality, potential mortality injury and recoverable injury threshold is restricted to a distance of <240 m from the seismic source at full power (Table 6-6). The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2.

Thus, the area where the sound source levels are above the fish mortality, potential mortality injury and recoverable injury threshold would equate to 678 km^2.

However, this has to be viewed in the context of:

- The broader area in which the survey is being undertaken. For fish the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km^2 (2017r), the area of potential impact of 678 km^2 represents 1.2% of this region.
- The area of impact does not include any locations where significant fish numbers occur. Two pinnacles that have the potential for site attached or reef fish are located outside the operational area and therefore outside the area of impact. Thus, it is unlikely that large numbers of fish will be present in the area of impact during acquisition.
- Fish within the area of impact will not be evenly distributed and likely to moving within and in and out of the area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days;
- Potential fish mortality, potential mortality injury and recoverable injury to fish are unlikely with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey.

Thus, based on this analysis, mortality, potential mortality injury and recoverable injury to fish is unlikely based on the localised area of impact (1.2% of the Bonaparte Gulf Meso-scale Bioregion) and short term that fish would be exposed to noise levels above threshold levels as the vessel moves through the survey area for the duration of the survey (up to 21 days).

Temporary threshold shift

TTS exposure criteria are based on an accumulative sound exposure level (SEL) over 24 h and the assumption of a stationary receptor underpins the calculations. Accumulative SEL over 24 h, was not assessed for the Fishburn survey based on the assumption that site attached fish, though may be present within some habitat areas within the area of impact, abundance would not be high. There is the potential of site attached fish to be more abundant in association with the two pinnacles outside the operational area, the closest being 8.2 km from the survey area where the seismic source is at full power.

Typically, the maximum range at which the TTS exposure criteria for fish with a swim bladder (>> 186 dB 24 h SEL) is predicted to occur is within 3 – 5 km radius of each seismic line (Jasco personal communication).

This potential area of impact for fish TTS is assessed as being acceptable based on:

- Any hearing loss and subsequent decrease in fitness (if it were to occur in the first place) would be temporary and recovery would take place over a relatively short time frame after the seismic vessel has moved away from the exposed fish, and the sound levels are reduced. The period over which fish would regain normal hearing ability is dependent upon several factors including the intensity and duration of sound exposure. Popper et al. (2005) reported that for fish that showed TTS, recovery to normal hearing levels occurred within 18–24 hours.
- The only study carried out to date on exposure of tropical reef fishes to airgun noise found that no TTS occurred in either hearing specialists or generalists (Hastings et al. 2008; Hastings and Miksis-Olds 2012) at exposure levels 4 dB higher than the sound exposure threshold for TTS provided in Popper et al. (2014).

- The small size of the Fishburn full power zone (646 km^2) and additional 5 km radius of each line where the TTS exposure criteria is potentially exceeded, within the broader area in which the survey is being undertaken. For fish the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km^2 (2017r), the area of the full power zone is 646 km^2 represents ~ 1.12% of this region and an area of impact of 5 km would equate to 1,389 km^2 which represents 2.4% of this region.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- It is unlikely that listed fish species identified in the protected matters search are found within the survey area due to waters depths and habitat type. No commercial fishing areas were identified to occur within or near the survey area, a range of fish species including reef fish may be present within the potential area of TTS impact with more abundance of species expected associated with the two pinnacles identified outside of the potential are of TTS impact.
- The two pinnacles where more abundance of fish species including reef fish may occur is 8.2 km from the survey area (where the seismic source is a full power) providing a 3 km buffer on the estimated TTS exposure criteria of 5 km radius of each line.
- Impacts at a population level are unlikely as the survey is not being undertaken during any fish spawning seasons and the area is not identified as signification aggregation area.

Fish behavioural changes

There are no recommended exposure criteria for fish behaviour or masking. Based on the risk criteria proposed by Popper et al. (2014) behavioural responses are more likely to occur near the seismic source (tens of metres) with diminishing responses further from the seismic source (source hundreds to thousands of metres). The subjective relative risk criteria from Popper et al. (2014) at intermediate to far ranges indicated that fish with no swim bladder or swim bladders not involved in hearing may experience a low to moderate behavioral impact, while fish that have swim bladders involved in hearing may experience a moderate to high behavioral impact. The risk criteria proposed by Popper et al. (2014) for masking is low at all distances from the seismic source for fish with no swim bladder or swim bladders not involved in hearing, while fish that have swim bladders involved in hearing may experience a low masking impacts at the close to the source increasing to moderate impact as they move away from the source and the noise becomes more or less continuous.

In terms of behavioural responses, there is the possibility that seismic survey noise could cause fish to move away from the survey area. Should this occur during spawning or other ecologically significant life history events, population level effects may occur.

To be considered a significant impact, any masking effects or behavioural changes would result in reduction of fish abundance due to health effects or increased aversion, which could reduce catchability by predators and thus affect other species of concern.

Potential behavioural and/or masking impacts to fish from the Fishburn survey are assessed as being acceptable based on:

- Any behavioural and/or masking impacts to fish (if it were to occur in the first place) would be temporary and recovery would take place over a relatively short time frame after the seismic vessel has moved away from the exposed fish, and the sound levels are reduced.
- The small size of the Fishburn full power zone (646 km^2), within the broader area in which the survey is being undertaken though noise levels. For fish the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- It is unlikely that listed fish species identified in the protected matters search are found within the survey area due to waters depths and habitat type. No commercial fishing areas were identified to

occur within or near the survey area, a range of fish species including reef fish may be present within the potential area of impact with more abundance of species expected associated with the two pinnacles identified outside of the potential are of TTS impact.

- The two pinnacles where more abundance of fish species, including reef fish may occur, is 8.2 km from the survey area (where the seismic source is a full power) and based criteria of Popper et al. (2014) would be within the intermediate to far distances from the source. Potential behavioral impacts at these distances are likely to be:
  - Low for fish with no swim bladder or swim bladders not involved in hearing.
  - Moderate for fish with swim bladders involved in hearing.

  Potential masking impacts at these distances are likely to be:

  - Low for fish with no swim bladder or swim bladders not involved in hearing.
  - Low to moderate for fish with swim bladders involved in hearing.
- Impacts are short term based on the survey period of 21 days and therefore unlikely to have result in reduction of fish abundance due to health effects or increased aversion.
- Impacts at a population level are unlikely as the survey is not being undertaken during any fish spawning seasons and the area is not identified as signification aggregation area.

6.1.5.4 Sharks and Rays

Receptor Sensitivity

Elasmobranchs sense sound via the inner ear end organs and as they lack a swim bladder it is thought that they are only capable of detecting the particle motion component of acoustic stimuli, unlike the more highly sensitive teleosts which can also detect sound pressure (Myrberg 2001).

Extent and Duration of Exposure and Identified Potential Impact

There are no migratory, feeding or aggregation areas within or near the EMBA for sharks, including whale sharks or rays

To date there are no studies on seismic sound impacts on elasmobranchs. Popper et. al. (2014) proposed that the sound exposure criteria for fish without a swim bladder are appropriate for sharks in the absence of other information.

The sound exposure thresholds proposed by Popper et al. (2014) (Table 6-5) for fish without a swim bladder mortality, potential mortality injury and recoverable injury peak pressure level threshold of > 213 dB re 1 µPa (PK) is used for this assessment. Based on the modelling this threshold would be within 75 m (R_{max} distance) of the sound source at full power (Table 6-6). The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2.

Thus, the area where the sound source levels are above the mortality, potential mortality injury and recoverable injury threshold applicable to sharks and rays would equate to 656 km^2.

However, this has to be viewed in the context of:

- The broader area in which the survey is being undertaken. For shark and rays the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km^2 (2017r), the area of potential impact of 576 km^2 represents 1.14% of this region.
- There is no indication that the area of potential impact includes any locations where significant shark or ray numbers occur, thus it is unlikely that large numbers of sharks or rays will be present in the survey area during acquisition.
- Sharks or rays will not be evenly distributed within the area of potential impact and likely to moving within and in and out of the area.

- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- Mortality, potential mortality injury and recoverable injury to sharks or rays are unlikely with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey.

Thus, based on this analysis, mortality, potential mortality injury and recoverable injury to sharks or rays is unlikely based on the localised area of impact (1.14 % of the Bonaparte Gulf Meso-scale Bioregion) and short term that sharks or rays would be exposed to noise levels above threshold levels as the vessel moves through the survey area for the duration of the survey (up to 21 days).

6.1.5.5 Turtles

<u>Receptor Sensitivity</u>

There is limited information on sea turtle hearing. Morphological studies of green and loggerhead turtles (Ridgway et al. 1969, Wever 1978, Lenhardt et al. 1985) found that the sea turtle ear is similar to other reptile ears, but has some adaptations for underwater listening. A thick layer of fat may conduct sound to the ear in a similar manner as the fat in jawbones of odontocetes (Ketten et al. 1999), but sea turtles also retain an air cavity that presumably increases sensitivity to sound pressure. Sea turtles have lower underwater hearing thresholds than those in air, owing to resonance of the aforementioned middle ear cavity, and hence they hear best underwater (Willis 2016).

Electrophysiological and behavioural studies on green and loggerhead sea turtles found their hearing frequency range to be approximately 50–2000 Hz, with highest sensitivity to sounds between 200 and 400 Hz (Ridgway et al. 1969, Bartol et al. 1999, Ketten and Bartol 2005, Bartol and Ketten 2006, Yudhana et al. 2010, Piniak et al. 2011, Lavender et al. 2012, Lavender et al. 2014), although these studies were all conducted in-air. Underwater audiograms are only available for three species. Two of these species, the red-eared slider (Christensen-Dalsgaard et al. 2012), the loggerhead turtle (Martin et al. 2012), both demonstrated higher sensitivity at around 500 Hz (Willis 2016). Recent work on green turtles has refined their maximum underwater sensitivity to be between 200 and 400 Hz (Piniak et al. 2016). Yudhana et al. (2010) measured auditory brainstem responses from two hawksbill turtles in Malaysia and found that peak frequency sensitivity occurred at 457 Hz in one turtle and at 508 Hz in the other.

Nelms et al. (2016) conducted a review of seismic surveys and turtles which considers the studies detailed below. A common theme is the complex nature of the studies, from the interpretation of behavioural responses, determining responses due to airguns or vessel noise/presence, through to difficulties in visually detecting animals. Most studies looking at the effect of seismic noise on marine turtles have focused on behavioural responses as physiological impacts are more difficult to observe in living animals.

Sea turtles have been shown to avoid low-frequency sounds (Lenhardt 1994) and sounds from an airgun (O'Hara and Wilcox 1990), but these reports did not note received sound levels. Moein et al. (1994) found that penned loggerhead sea turtles initially reacted to a single airgun but then showed low or no response to the sound (habituated to it). Caged green (*Chelonia mydas*) and loggerhead (*Caretta carett*a) turtles increased their swimming activity in response to an approaching airgun when the received SPL was above 166 dB re 1 μPa and they behaved erratically when the received SPL was approximately 175 dB re 1 μPa (McCauley et al. 2000). This study was conducted in cold water, and might not represent typical responses.

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.

Weir (2007) carried out observations from on-board a seismic survey vessel during a 10-month 3D survey offshore from West Africa, concluding that:

> *"..There was indication that turtles occurred closer to the source during guns-off than full-array, with double the sighting rate during guns-off in all distance bands within 1000 m of the array."*

The reduction in number of turtles observed within 1,000 m during operation of a full airgun array (Weir 2007) is therefore reasonably consistent with the observations of McCauley et al. (2003), which indicated an avoidance response threshold of approximately 175 dB re 1 μPa (SPL_{rms}).

In the absence of definitive data which could be used to determine the sound levels that could injure a turtle, temporary threshold shift (TTS) or permanent threshold shift (PTS) onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011). Since this time, Popper et al. (2014) suggested mortality and potential mortal injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa²·s (SEL_{24h}). The Popper et al (2014) > 207 dB re 1 µPa (PK) threshold is used in this assessment as it is based on the latest information to date. Based on the modelling this threshold would be within 240 m (R_{max} distance) of the sound source where it is expected that turtles would move away from the sound source and hence not be exposed to these levels.

Based on the limited data in regards to noise levels that illicit a behavioral response in turtles, the lower level of 166 dB re 1 µPa level drawn from NSF (2011) is typically applied, both in Australia and by NMFS, as the threshold level at which behavioural disturbance could occur. Based on the modelling this threshold would be within 6.3 km (R_{max} distance) of the sound source. The R_{max} distance is used for this receptor based on that the survey and operational area overlap foraging BIAs for a number of turtle species.

Extent and Duration of Exposure and Identified Potential Impact

Foraging flatback, loggerhead, green and olive ridley turtles may be encountered during the survey based on the survey area overlaps foraging biologically important areas for these species.

Research findings indicate that impacts on marine turtles from seismic survey noise are likely to be restricted to:

- short ranges and high sound intensities (perhaps less than few hundred metres range from source) on individuals;
- surveys that take place over protracted periods close to areas that constitute narrow, restricted migratory paths; or
- surveys that take place over protracted periods close to areas important for feeding, breeding and nesting.

Marine turtles may possibly be exposed to noise levels sufficient to cause physical damage if airgun arrays start suddenly with turtles nearby. In circumstances where arrays are already operating, (i.e., as a vessel moves along an acquisition line) individuals would be expected to implement avoidance measures before entering ranges at which physical damage might take place. With soft start procedures, it is extremely unlikely that an individual will be exposed to levels that may result in physical damage.

The Fishburn 3D survey and operational areas do not overlap any identified narrow or restricted migratory paths, and so impacts on an individual or at a population level are not anticipated.

Mortality, potential mortality injury and recoverable injury

Based on the noise modelling, the area where the sound source levels exceed the turtle mortality or mortal injury threshold (207 dB re 1 µPa (PK)) is restricted to a distance of <240 m (R_{max} distance) from the seismic source at full power. The area where the seismic source will be at full power is within the survey area (600 km²) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km².

Thus, the area where the sound source levels are above the turtle mortality or mortal injury threshold would equate to 678 km².

However, this has to be viewed in the context of:

- The area of potential impacts is small in context of the turtle foraging areas within which turtles likely to be present in the survey area would be likely to occur within.
- Based on the turtle foraging areas the area of potential impact ranges from 0.6% to 2.2% (Table 6-7).
- Turtles within the area of potential impact will not be evenly distributed and likely to moving within and in and out of the area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- Potential mortality or mortal injury to turtles are unlikely with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey.

Thus, based on this analysis, mortality or mortal injury to turtles is unlikely based on the localised area of impact, with up to 2.2% of the available foraging area impacted, and short term that turtles would be exposed to noise levels above threshold levels as the vessel moves through the survey area for the duration of the survey (up to 21 days).

Behavioral disturbance

Based on the noise modelling, the area where the sound source levels exceed the turtle behavioral disturbance threshold (SPL 166 dB re 1 µPa) is restricted to a distance of 6.3 km (R_{max} distance) of the sound source at full power. The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2

Thus, the area where the sound source levels are above the turtle behavioral disturbance threshold would equate to 1,607 km^2.

However, this has to be viewed in the context of:

- The area of potential impacts is small in context of the turtle foraging areas within which turtles likely to be present in the survey area would be likely to occur within.

Based on the turtle foraging areas the area of potential impact ranges from 1.6% to 4.8% (

- Table 6-8).
- Turtles within the area of potential impact will not be evenly distributed and likely to moving within and in and out of the area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- There is no peak season identified for turtles to be present in significant numbers within the foraging areas.

Based on this assessment it is possible that foraging turtles may receive noise levels above the behavioural disturbance threshold criteria and this could lead to them moving area from the area. Thus, it is possible that turtles could be disturbed and move away from a localised area between 1.6% to 4.8% of their foraging areas for the duration of the survey (21 days – short term).

Table 6-7: Area of Overlap for Turtle Foraging Areas and Full Power Area with 240 m mortality, potential mortal injury and recoverable injury threshold area

Turtle	Foraging Area km2	Area Intersecting Full Power Area inc. 240 m threshold. km2	Area Intersecting Full Power Area inc. 240 m threshold %
Flatback	27401	598	2.2
Loggerhead	27401	598	2.2
Green	42391	272	0.65
Olive Ridley	78027	999	1.3

Table 6-8: Area of Overlap for Turtle Foraging Areas and Full Power Area with 6.3 km behavioural threshold area

Turtle	Foraging Area km^2	Area Intersecting Full Power Area inc. 6.3 km behavioural threshold area km^2	Area Intersecting Full Power Area inc. 6.3 km behavioural threshold area %
Flatback	27401	1308	4.8
Loggerhead	27401	1308	4.8
Green	42391	658	1.6
Olive Ridley	78027	2351	3.0

6.1.5.6 Marine Mammals

Marine mammal species evolved from terrestrial mammals and share basic hearing anatomy and physiology with their terrestrial ancestors. Marine mammals, however, have broader hearing frequency ranges due to the much higher sound speed underwater compared to in air. The functional hearing of cetaceans is characterised by a shift of the area of best hearing to higher frequencies for odontocetes (toothed whales and dolphins) and lower frequencies for mysticetes (baleen whales) (Wartzok and Ketten 1999, Mooney et al. 2012). Mysticetes and potentially odontocetes increased their ability to receive sound through the skull and both modified their middle ear structures to increase the amplitude of low-frequency sounds in particular (Ketten 1992, Cranford and Krysl 2015).

Because sounds can propagate well underwater and over large distances, many marine species use underwater acoustic signals as their principal mode of information transmission and situation awareness. Listening to the environment or active signalling requires well-developed hearing abilities. Cetaceans, in particular, depend heavily on hearing and sound to communicate, avoid predators, and forage.

The type and scale of the effect on cetaceans to seismic sounds will depend on a number of factors including the level of exposure, the physical environment, the location of the animal in relation to the sound source, how long the animal is exposed to the sound, the exposure history, how often the sound repeats (repetition period) and the ambient sound level. The context of the exposure plays a critical and complex role in the way an animal might respond (Gomez et al. 2016, Southall et al. 2016).

High levels of anthropogenic underwater noise can have potential effects on cetaceans ranging from changes in their acoustic communication, behavioural disturbances and in more severe cases physical injury or mortality (Richardson et al. 1999).

Temporary and Permanent Hearing Loss

<u>Receptor Sensitivity</u>

Physiological impacts such as physical damage to the auditory apparatus, e.g., loss of hair cells or permanently fatigued hair cell receptors, can occur in marine mammals when they are exposed to intense or moderately intense sound levels and could cause permanent or temporary loss of hearing sensitivity. While the loss of hearing sensitivity is usually strongest in the frequency range of the emitted noise, it is not limited to the frequency bands where the noise occurs but can affect a broader hearing range. This is because animals perceive sound structured by a set of auditory bandwidth filters that proportionately increase in width with frequency.

A temporary threshold shift (TTS) is hearing loss from which an animal recovers, usually within a day at most, whereas permanent threshold shift (PTS) is hearing loss from which an animal does not recover (permanent hair cell or receptor damage). The severity of TTS is expressed as the duration of hearing impairment and the magnitude of the shift in hearing sensitivity relative to pre-exposure sensitivity, in dB. TTS occurs at lower exposure levels than PTS. The cumulative effects of repeated TTS, especially if the animal receives another sound exposure near or above the TTS threshold before recovering from the previous sensitivity shift, could cause PTS. If the sound is intense enough, an animal could succumb to PTS without first experiencing TTS (Weilgart 2007). Though the relationship between the onset of TTS and the onset of PTS is not fully understood, a specific amount of TTS can be used to predict sound levels that are likely to result in PTS. For example, in establishing PTS thresholds, Southall et al. (2007) assume that PTS occurs with 40 decibels of

TTS. While there are results from TTS and PTS studies on odontocetes exposed to impulsive sounds (Finneran 2016), there is no data for mysticetes.

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 µPa²·s (DEWHA 2008). This threshold minimises the likelihood of TTS in mysticetes and large odontocetes according to the background paper. Policy Statement 2.1 does not apply to smaller dolphins and porpoises, as DEWHA assessed these cetaceans as having peak hearing sensitivities occurring at higher frequency ranges than those that seismic arrays typically produce.

Extent and Duration of Exposure and Identified Potential Impact

As the Fishburn EMBA is not within or near a biologically important area for cetaceans or any migratory routes, there is a low likelihood of encountering cetaceans and those in the area would be transiting.

Based on the noise modelling, the area where the sound source levels exceeds the cetacean TTS threshold (SEL 160 dB re 1 µPa²·s) is within 4.8 km (R_{max} distance) from the seismic source at full power. The area where the seismic source will be at full power is within the survey area (600 km²) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km².

Thus, the area in which cetaceans could experience noise levels above threshold levels would equate to 1,356 km².

However, this has to be viewed in the context of:

- The broader area in which the survey is being undertaken. For cetaceans the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km² (2017r), the area of potential impact of 1,356 km² represents 2.4% of this region.
- There is no indication that the area of potential impact includes any biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition.
- Cetaceans within the area of potential impact will not be evenly distributed and likely to moving within and in and out of the area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.
- TTS and PTS to cetaceans is unlikely as they are likely to move away from the survey area when noise levels are above behavioural thresholds.

Thus, based on this analysis, TTS and PTS to cetaceans is unlikely based on the implementation of a low power and shut down zones, with potential impact to be within a localised area (2.4% of the Bonaparte Gulf Meso-scale Bioregion) and short term in that cetaceans would be exposed to noise levels above threshold levels as the vessel moves through the survey area for the duration of the survey (up to 21 days).

Behavioural Disturbance

Receptor Sensitivity

Behavioural responses to underwater sound are difficult to determine because animals vary widely in their response type and strength, and the same species exposed to the same sound may react differently (Nowacek et al. 2004, Gomez et al. 2016, Southall et al. 2016). An individual's response to a stimulus is influenced by the context in which the animal receives the stimulus and how relevant the individual perceives the stimulus to be. A number of biological and environmental factors can affect an animal's response—behavioural state (e.g. foraging, travelling or socialising), reproductive state (e.g., female with or without calf, or single male), age (juvenile, sub-adult, adult), and motivational state (e.g., hunger, fear of predation, courtship) at the time of exposure as well as perceived proximity, motion, and biological meaning of the sound and nature of the sound source.

Animals might temporarily avoid anthropogenic sounds, but could display other behaviours such as approaching novel sound sources, increasing vigilance, hiding and/or retreating, that might decrease their foraging time (Purser and Radford 2011). Some cetaceans might also respond acoustically to seismic survey noise in a range of ways, including by increasing the amplitude of their calls (Lombard effect) , changing their spectral (frequency content) or temporal vocalisation properties, and in some cases, cease vocalising (IWC McDonald et al. 1995, 2007, Parks et al. 2007, Di Iorio and Clark 2010, Castellote et al. 2012, Hotchkin and Parks 2013, Blackwell et al. 2015).

The BRAHSS (Behavioural Response of Australian Humpback whales to Seismic Surveys) project conducted studies at Peregian Beach, Qld, and Dongara, WA, to better understand the behavioural responses of humpback whales to noise from the operation of seismic air gun arrays (Cato et al. 2013). Results from the first sets of experiments have recently been published (Dunlop et al. 2015, Dunlop et al. 2016, Godwin et al. 2016), together with concurrent studies of the effects of vessel noise on humpback whale communications (Dunlop 2016). In most exposure scenarios a distance increase from the sound source was observed and interpreted as potential avoidance. The study, however, found no difference in the 'avoidance' response to either ‘ramp-up’ or the constant source producing sounds at a higher level than early ramp-up stages. In fact, a small number of groups showed inspection behaviour of the source during both treatment scenarios. ‘Control’ groups also responded, which suggested that the presence of the source vessel alone had some effect on the behaviour of the whales. Despite this, the majority of groups appeared to avoid the source vessel at distances greater than the radius of most injury based mitigation zones.

Small odontocetes responded to airgun sounds by moving laterally away from the sound, showing the strongest lateral spatial avoidance, compared to mysticetes and killer whales which showed more localised spatial avoidance. Other larger odontocetes studied included long-finned pilot whales (*Globicephala melas*) which only changed their orientation in response to sound exposure, while sperm whales did not significantly avoid the sound (Stone and Tasker 2006).

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds as documented in the literature. Their review found that most marine mammals exhibit varying responses between an SPL of 140 and 180 dB re 1 µPa, but a lack of convergence in the data from multiple studies prevented them from suggesting explicit criteria. The causes for variation between studies included lack of control groups, imprecise measurements, inconsistent metrics, and context dependency of responses including the animal’s activity state.

The National Marine Fisheries Service (NMFS) in the U.S use a threshold SPL 160 dB re 1 µPa for potential behavioural disturbance to marine mammals (NMFS 2013). From the modelling for the survey this noise threshold level could be expected to occur within 9.1 km $R_{95\%}$ and 13.7 km R_{max} of the seismic source. Avoidance, however, is not directly related to sound level thresholds but also influenced by the state of the animals (e.g. their reproductive, health, and foraging condition) and the context of exposure.

Extent and Duration of Exposure and Identified Potential Impact

As the Fishburn EMBA is not within or near a biologically important area for cetaceans or any migratory routes, there is a low likelihood of encountering cetaceans and those in the area would be transiting.

Based on the noise modelling, the area where the sound source levels exceeds the behavioural disturbance to marine mammals threshold (SPL 160 dB re 1 µPa) is within 13.7 km (R_{max} distance) from the seismic source at full power. The area where the seismic source will be at full power is within the survey area (600 km^2) and a kilometer at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. To be conservative an additional 2 km, either end of the survey area, is applied to the survey area giving a total area of 646 km^2.

Thus, the area in which cetaceans could experience noise levels above threshold levels would equate to 3,055 km^2.

However, this has to be viewed in the context of:

- The broader area in which the survey is being undertaken. For cetaceans the Bonaparte Gulf Meso-scale Bioregion would be representative of the broader area in which the survey is being undertaken as it is representative of water depths, habitats and hydrodynamics within the survey area.
- Based on the area for the Bonaparte Gulf Meso-scale Bioregion is 57,589 km^2 (2017r), the area of potential impact of 3,055 km^2 represents 5.3% of this region. This is a conservative assessment as marine mammals identified to be within the survey area would be transiting through a much greater area.

- There is no indication that the area of potential impact includes any biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition.
- Cetaceans within the area of potential impact will not be evenly distributed and likely to moving within and in and out of the area.
- The area of potential impact assumes that the area will receive the same sound levels at the same time, which is not the case, sound levels will change as the seismic vessel moves through the area during the survey for up to 21 days.

Thus, based on this analysis, behavioural disturbance to cetaceans could occur within a localised area (5.3% of the Bonaparte Gulf Meso-scale Bioregion) and be short term in that cetaceans would be exposed to noise levels above threshold levels as the vessel moves through the survey area for the duration of the survey (up to 21 days).

As the Fishburn EMBA is not within or near a biologically important area for cetaceans or any migratory routes, there is a low likelihood of encountering cetaceans and those in the area would be transiting so behavioural disturbances would be likely to consist of avoiding the area of the survey.

Acoustic Masking

Receptor Sensitivity

Acoustic masking occurs when sounds interfere with an animal's ability to perceive biologically relevant sounds. It can be defined as a reduction in communication and listening space (active acoustic space) that an individual experiences due to an increase in background noise (natural and anthropogenic) in the frequency bands relevant for communicating and listening. Acoustic masking can decrease the range over which an animal might communicate with its peers or detect predators or prey (Clark et al. 2009). Masking can occur naturally from wind, precipitation (Au et al. 2004), wave action, seismic activity (Nowacek et al. 2015), other natural phenomena and biological sounds (Zelick et al. 1999, Erbe et al. 2015).

Marine wildlife almost certainly has adapted to naturally occurring signal masking, yet the reduced active acoustic space under noisy natural conditions is a physical constraint that cannot be overcome completely. Anthropogenic sounds contribute to the ambient soundscape, and can mask biologically important sounds, potentially reducing the active (perception) space to levels that can't support active foraging and socialising. The amount of masking an animal experiences is determined by the amplitude, timing, and frequency content of the interfering sounds, as well as how sounds are spatially distributed.

Studies in regards to acoustic masking in the ocean have traditionally focused on mysticetes and shipping sounds (Clark et al. 2009). Mysticetes communicate using calls with energy primarily in low-frequency bands that overlap completely with the bands carrying the main energy of shipping sounds (Arveson and Vendittis 2000, Allen et al. 2012, Bassett et al. 2012). Sound output from ships can also extend to relatively high frequencies (e.g., up to 30 kHz, Arveson and Vendittis 2000, and up to 44.8 kHz, Aguilar Soto et al. 2006) and can affect odontocetes (toothed whales) especially at shorter ranges.

Sound from seismic surveys contribute to ocean-wide acoustic masking (Hildebrand 2009), and are considered to have the potential to displace some species and populations from their habitats (Erbe et al. 2015, Nowacek et al. 2015). Little is known, however, about the masking effects of seismic sounds other than aggregate noise from multiple seismic surveys and shipping can lead to higher sound levels, resulting in increased masking (Nowacek et al. 2015).

In order to estimate impact of masking through considering the reduction in active acoustic space quantitatively, it is necessary to take into account parameters such as call source levels and their adaptive compensation (Lombard response), detection thresholds based on the receiver perception capabilities, signal directivity, band specific (spectral) noise levels, and noise and signal duration. Instead, a qualitative assessment of masking has been undertaken for this risk assessment, and only mysticetes and killer whales have been considered due to the overlap between the frequency content of the seismic pulses and their hearing capabilities. Comparisons to ambient measurements made in deeper water to the north-east can be made (McPherson et al. 2016a, McPherson et al. 2016c), as this is the closest available monitoring location for which results are available, although it is deeper and likely quieter. The length of time a seismic pulse will have an SPL higher than the ambient maximum from the monitoring program (146 dB re 1 µPa) is no longer than approximately one second. However, even distant seismic impulses can take 2 seconds to fall below average ambient levels in the Timor Sea (McPherson et al. 2016b), when considering 0.125 s windowed data. A worst case assessment could assume that in the area ensonified above 140 dB re 1 µPa, masking or reduction of active acoustic space is significant for the duration of a seismic pulse, and could occur for up to four seconds. Depending upon the propagation environment, inter-pulse noise levels can be higher than average ambient noise levels for the entire period between seismic impulses (Guan et al. 2015, McPherson et al. 2016b).

Masking effects on killer whales would only occur close to the seismic source, due to the limited transmission range of biologically relevant frequencies. The seismic vessel itself will likely contribute equally to the masking experienced by killer whales as the seismic source, and the ranges that this masking could occur at would be small given the propagation environment.

Calls from mysticetes, which might transit through the EMBA, are typically longer than the period of time the sound levels are above the upper ambient levels, and thus a portion of calls may experience masking beyond what could naturally occur. However, the negative effect on communication efficiency of prolonged periods of time during which seismic pulses compete with calls may be more pronounced than this argument for a single pulse would indicate and cannot be readily estimated.

Extent and Duration of Exposure and Identified Potential Impact

As the Fishburn EMBA is not within or near a biologically important area for cetaceans or any migratory routes, there is a low likelihood of encountering cetaceans and those in the area would be transiting so though masking may occur it could range from localised to within an extensive area (maximum of ~ 120 km) and would be for a short duration (4 seconds per pulse until the cetacean move away from the survey area and hence unlikely to have a significant impact.

6.1.5.7 Cumulative Impacts

Cumulative impacts can occur from multiple surveys occurring at the same time leading to an increase in predicted noise levels on receptors. It can also occur from repeated surveys within the same area over time. A review of the NOPSEMA website and via stakeholder consultation the surveys detailed in Table 6-9 have identified as completed or planned in the area of Fishburn survey.

This section assess the potential for cumulative impacts associated with:

- The Fishburn survey being undertaken within an area where previous seismic surveys have occurred.
- The Fishburn survey being undertaken at the same time as another seismic survey within the area.

This section does not assess cumulative impacts from seismic surveys within the area that occur after the Fishburn survey as that should be the responsibility of that titleholder as part of their cumulative impact assessment.

Previous Seismic Surveys

Cumulative impacts can occur when the timing between surveys is less than the recovery rate of any potential impacts to receptors.

A review of the receptors within the Fishburn survey area identified the following:

- With the exception of biologically important areas for foraging loggerhead, green, olive ridley and flatback turtles, no biological important habitats were identified for other species.
- No benthic habitats were identified that are not likely to be widespread within the Joseph Bonaparte Gulf.
- No protected or commercial species habitats were identified to occur in the area.
- No commercial fishing activities occur in the survey area and the nearest, the NPF, is ~ 35 km from the survey acquisition area and ~ 9.5 km from the survey operational area.
- The Key Ecological Feature carbonate banks and terrace systems of the Sahul Shelf is within the survey area.
- The Key Ecological Feature, Pinnacles of the Bonaparte Basin are located outside the survey operational area.

Based on the seismic noise impact assessment undertaken for the Fishburn survey, impacts were identified to be short term (days/weeks) within the period of the seismic survey (21 days) with the exception of physiological impacts to invertebrates which was assessed as medium term (6 months).

As the last survey undertaken within the Fishburn survey area was in 2012 cumulative impacts to receptors from the Fishburn survey are not likely.

Table 6-9: Completed or Planned Surveys within or near the Fishburn Survey Area

Year	Company	Permit	Name	Comment
2012	Santos	WA-459-P	Fishburn 2D Seismic Survey	Within the WA-459-P permit
2012	MEO Australia	WA-454-P	Floyd 3D Seismic Survey	Approximately 27 km between the Floyd and Fishburn acquisition areas. Figure 6-3.
2013	GX Technology Australia Pty Ltd		Westralia 2D SPAN Marine Seismic Survey	2 lines (AUI-5700 and AUI-5000) outside of the WA-459-P permit. Figure 6-3.
2017	Origin	NT/P84	Gulpener 2D Seismic Survey	Currently planned between 1 April – 31 July 2017.
2017	PGS	WA-459-P	Rollo Multi-client 3D Seismic	One line ingresses into the Fishburn survey area. Current start date for survey is July 1 2017 and will not be in the Fishburn survey area. The Santos/PGS WA-459-P Ingress Agreement will include a condition that PGS cannot ingress the WA-459-P permit while the Fishburn survey is being undertaken. See Performance Outcome.
2017	TGS	WA-459-P	North West Shelf Renaissance North Seismic Survey	Strategy survey not planned within 100 km of the permit area in June to August.
2017	Melbana	WA-488-P	Beehive 3D Seismic Survey	Survey not being undertaken during period of Fishburn survey.

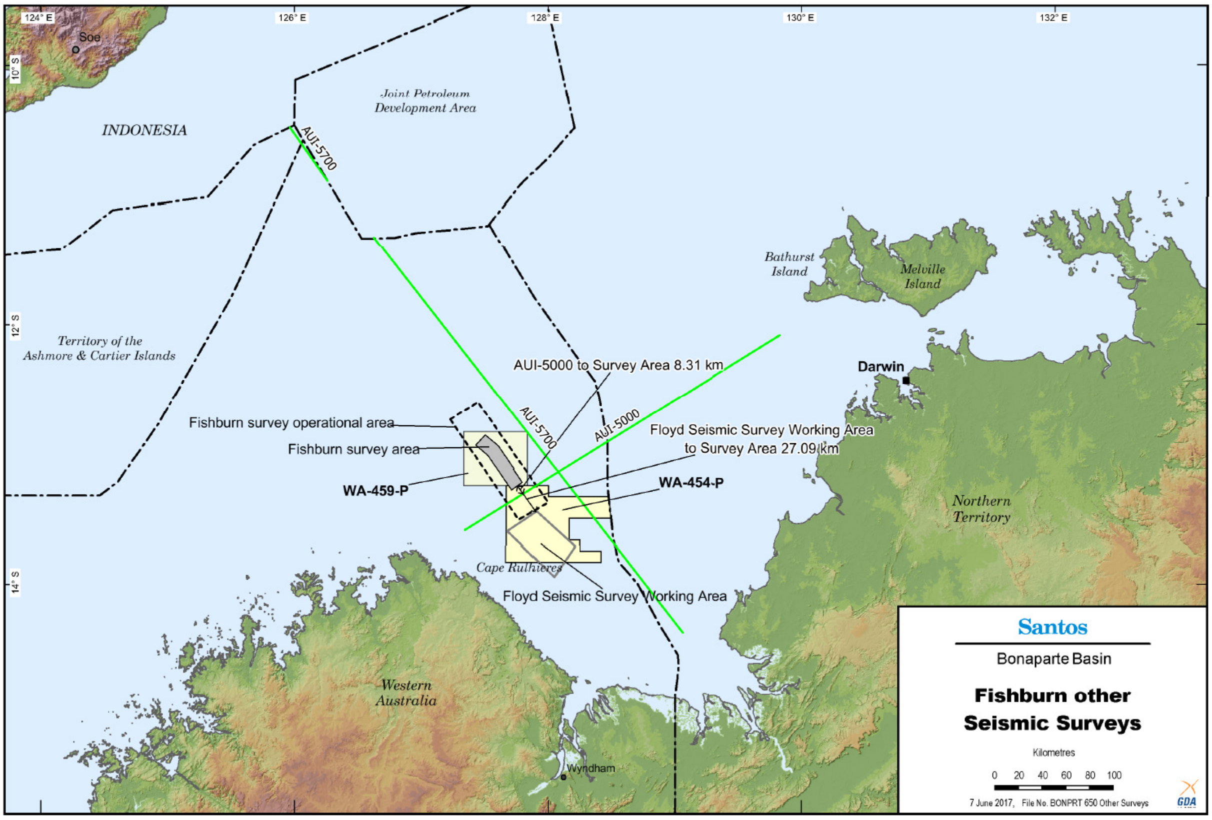


Figure 6-3: Fishburn Survey with Previous Seismic Surveys

Seismic Surveys within Same Time Period

For the Fishburn survey two main receptors have been identified, the NPF and foraging turtles. Based on the location of the survey areas for the Fishburn and Gulpener surveys and the WA-488-P permit (at the date the location of the Beehive surveys within this permit is not known) there is the potential for cumulative noise impact to the NPF and foraging turtles.

The activities which have been included in the cumulative impact assessment were defined according to the following criteria:

- Activities that have a high degree of certainty of being undertaken at the same time as the Fishburn survey.
- Activities for which there is sufficient information available to conduct the assessment.

Based on these criteria the assessment looked at the cumulative impacts from the Fishburn and Gulpener surveys as the Beehive survey timing is still uncertain and they do not have sufficient information on the seismic acquisition area or noise exposure levels.

The Fishburn and Gulpener survey are a significant distance from each other (Figure 6-4). The acquisition areas, where the seismic source is constantly at full power, are 157 km apart and the operational areas, where the seismic source is not constantly at full power, are 122 km apart.

JASCO Applied Sciences conducted an assessment of the cumulative noise impacts from the Fishburn and Gulpener surveys. The full report is in Addendum 2. Though the assessment look at the NPF the results can also be applied to the turtle foraging BIA as it is in the same location as the NPF area between the Fishburn and Gulpener survey areas.

In summary the assessment determined:

- The most conservative cumulative operations exposure scenario accounting for a single impulse from both the Fishburn and Gulpener surveys is to consider two simultaneous impulses at the two closest acquisition area corners.
- The received per-pulse SEL from the Gulpener survey at the edge of the NPF area closest to the Fishburn survey are predicted to be below ambient levels. Therefore, the cumulative per-pulse SEL from both surveys at this point will be equal to the per-pulse SEL from the Fishburn survey, or 130 – 140 re 1 $\mu Pa^2 \cdot s$.
- The highest received levels from Gulpener survey within the NFP area are expected to occur at the closest edge of the NPF area to the Gulpener survey, and are expected to be approximately 125 dB re 1 $\mu Pa^2 \cdot s$. At this same location, the levels from the Fishburn survey are expected to be approximately 110 – 120 dB re 1 $\mu Pa^2 \cdot s$. The worst case combined levels are therefore likely to be approximately 125 – 126 re 1 $\mu Pa^2 \cdot s$.
- Within the NPF area, the per-pulse SEL from the Fishburn survey will contribute more to the cumulative SEL, due to the predicted lower transmission loss. Therefore, for the majority of the NPF, the cumulative per-pulse SEL is expected to increase slightly beyond the levels expected from the Fishburn survey alone.
- The combined per-pulse SELs will therefore only increase slightly beyond the levels expected from the Fishburn survey alone, approximately 100 – 130 re 1 $\mu Pa^2 \cdot s$, and the cumulative daily SEL within the NPF area is expected to remain within estimated daily ambient SEL bounds of 150 – 171 dB re 1 $\mu Pa^2 \cdot s$.

The combined per-pulse SELs will therefore only increase slightly beyond the levels expected from the Fishburn survey alone, and the cumulative daily SEL within the NPF area is expected to remain within daily ambient SEL bounds.

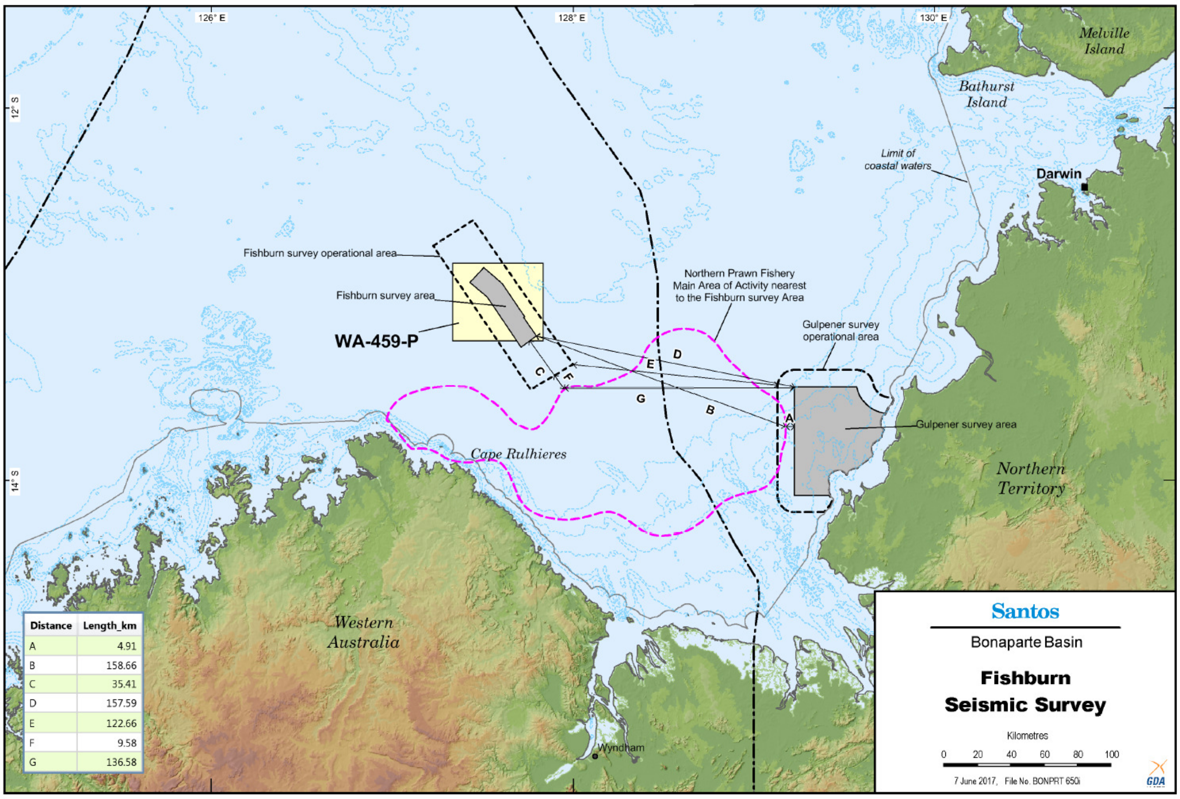


Figure 6-4: Location and Distances for the Fishburn and Gulpener Seismic Surveys

6.1.6 Control measures

Control measures to be implemented are:

- *Survey Timing* - Survey undertaken within 15 June – 1 August to avoid Northern Prawn Fishery fishing season.
- *EPBC Act Policy Statement* 2.1 - Interaction between Offshore seismic exploration: Part A will be implemented for the survey with the following precaution zones for cetaceans and turtles.
  - Observation zone: 3+ km horizontal radius from the acoustic source.
  - Low power zone: 2 km horizontal radius from the acoustic source.
  - Shut-down zone: 500m horizontal radius from the acoustic source.
- *EPBC Act Policy Statement* 2.1 - Interaction between Offshore seismic exploration: Part B. B.1.Marine Mammal Observers will be implemented for the survey with a trained MFO to undertake observations for fauna.
- *Santos/PGS Ingress Agreement* - Ingress Agreement with PGS includes a condition that PGS cannot ingress the WA-459-P permit while the Fishburn survey is being undertaken.
- *DoF Guidance Statement on Undertaking Seismic Surveys* - The following will be implemented as per the WA DoF Guidance Statement on Undertaking Seismic Surveys:
  - Soft Starts" for every event.
  - Avoid restricting movement of fish away from the source of seismic sounds.
  - Minimise seismic source sound intensity and exposure.

6.2 Vessel and Helicopter Noise

6.2.1 Hazard

Noise emission subsea will occur from:

- Vessel engines and thrusters
- Helicopter rotors

6.2.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Based upon the receptors identified in Section 4, those known to be sensitive to vessel and/or helicopter underwater sound include:

- Fish
- Sharks and rays
- Turtles
- Marine mammals - whales and dolphins (cetaceans)

6.2.3 Known and Potential Environmental Impacts

Given the levels of noise predicted potential impacts to fauna would be limited to non-physiological effects such as

- Behavioural changes.
- Localised avoidance.

6.2.4 Evaluation of Environmental Impacts

Receptor Sensitivity

Activities that generate underwater noise can affect marine fauna by interfering with aural communication, eliciting changes in behaviour or, in extreme cases, by causing physiological damage to auditory organs. The potential for noise from anthropogenic sources to impact fauna depends on a range of factors, including the intensity and frequencies of the noise, prevailing ambient noise levels and the proximity of noise sensitive species.

Hearing damage in marine mammals from shipping noise has not been widely reported (OSPAR 2009) and there is no direct evidence of mortality or potential mortal injury to fish or sea turtles from ship noise (Popper et al. 2014).

There are no noise thresholds for continuous noise sources such as vessels for fauna such as fish without a swim bladder (sharks, rays), fish with a swim bladder but nor used in hearing or turtles (Popper et al. 1994). Popper et al. (1994) does proposed thresholds for recoverable injury and TTS based on exposure of white noise on goldfish. Popper et al. did identify that responses from fauna to vessel noise are likely to be low for mortality, mortal injury and recoverable injury and moderate to low for TTS near the vessel (tens of metres) and at intermediate (hundreds of metres) to far distances (thousands of meters), respectively. Masking and behavioural changes are more likely near the vessel (tens of metres) and at intermediate distances (hundreds of metres).

Sound traveling from a source in the air such as a helicopter, to a receiver underwater is affected by both in-air and underwater propagation processes, which are further complicated by processes occurring at the air-seawater surface interface. The received level underwater depends in a complex way on source altitude and lateral distance, receiver depth, water depth, and other variables.

Extent and Duration of Exposure and Identified Potential Impact

For the majority of the time that the seismic vessel is in the area the seismic source will be the dominate noise source.

Underwater noise generated by the presence of the survey vessels may result in changes in behaviour of marine fauna such as disturbance, avoidance or attraction. Underwater noise from the survey vessels is transient and is typical of other underwater noise emitted by commercial shipping or fishing vessels.

There are no breeding, feeding or resting area for cetaceans, sharks or rays in or near the survey area, hence, impacts would be to transiting cetaceans, sharks or rays and would be limited to local avoidance of the area.

There are also no commercial fishing or habitats within the operational area likely to support reef or site attached fish. Two pinnacles outside the operational area may potentially support reef or site attached fish.

The operational area, where the supports vessels will operate, overlaps fforaging BIAs for flatback, loggerhead, green and olive ridley turtles and hence, turtles may move away from areas where the vessels are operating.

Based on the noise levels likely from the support vessels and that they will be moving throughout the operational area, it is possible impacts would be localised, based on a smaller area than from the seismic source noise levels, and short term (survey duration of 21 days) to fauna of environmental value.

Based on the extremely short duration that helicopter noise is likely to be heard underwater (seconds to minutes) and the low frequency of helicopter flights to the seismic vessel during the survey (once a fortnight for crew change) it is unlikely that fauna of environmental value in the area will be impacted by localised and short term noise from a helicopter.

6.2.5 Control measures

Control measures to be implemented are:

- *EPBC Regulations Part 8* - Vessels will meet the requirements of Part 8 of the EPBC Regulations specifically:
  - Travel at less than 6 knots within the caution zone of a cetacean (150 m radius for dolphins, 300 m for whales and turtles).
  - Do not approach closer than the caution zones for whales, turtles and dolphins.
  - If cetacean or turtle shows signs of disturbance move away at a constant speed less than 6 knots.
- *EPBC Regulation Part 8* - Helicopters will meet the requirements of Part 8 of the EPBC Regulations specifically:
  - Must not operate at a height lower than 1,650 feet or within a horizontal radius of 500 m of a cetacean or turtle.

6.3 Light Emissions

6.3.1 Hazard

The seismic and support vessels will operate day and night and are required to be lit for navigational purposes and for safe deck operations when working at night.

6.3.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Based upon the receptors identified in Section 4, those known to be sensitive to light emissions include:

- Turtles
- Marine Birds

There is no evidence to suggest that artificial light sources adversely affect the migratory, feeding or breeding behaviours of cetaceans. Cetaceans predominantly utilise acoustic senses to monitor their environment rather than visual sources (Simmonds et al. 2004).

6.3.3 Known and Potential Environmental Impacts

Given the temporary nature of vessel lighting predicted potential impacts to fauna would be limited to:

- Localised attraction

6.3.4 Evaluation of Environmental Impacts

Turtles

The survey and operational area is within a biological important area for foraging turtles. Lighting from moving vessels has not been identified as a risk to foraging turtles in the EPA Environmental Assessment Guideline No. 5 Protecting Marine Turtles from Light Impacts (EPA 2010), the DoEE Species Profile and Threats Database or the Recovery Plan for Marine Turtles in Australia 2017 – 2027 (DoEE 2017s).

<u>Extent and duration of exposure and identified potential impact</u>

Lighting from seismic and support vessels will be localised to a small radius of light glow around the vessels and temporary in nature as the vessel transits through the survey and operational area over the short duration of the survey (21 days). The survey and operational areas overlap a foraging BIA for four turtle species and consequently here is the potential for a larger number of individuals to be present in these areas. Lighting from moving vessels has not been identified as a risk to foraging turtles and consequently, as light emissions would be localised, within metres of the vessel, and short term as the vessel moves through the area and for a duration of up to 21 days, impacts to fauna of an environmental value are remote.

Marine Birds

Seabirds may be attracted to vessels at night due to light glow. Bright lighting can disorientate birds, thereby increasing the likelihood of seabird injury or mortality through collision with infrastructure, or mortality from starvation due to disrupted foraging at sea (Wiese et al. 2001 in DSEWPaC 2012e). Nesting birds may be disorientated where lighting is adjacent to rookeries, however, this is not identified as a potential impact as the nearest rookeries are on land 60 km from the operational area.

<u>Extent and duration of exposure and identified potential impact</u>

Lighting from the seismic and support vessels will be localised to a small radius of light glow around the vessels and temporary in nature as the vessel transits through the survey and operational area over the short duration of the survey (21 days). No biologically important areas or specific aggregation areas have been identified as potentially occurring within the EMBA. As such, it is only expected that transient individuals will be exposed to changes in ambient light levels. Consequently, as light emissions would be localised, within metres of the vessel, and short term as the vessel moves through the area and for a duration of up to 21 days, impacts to fauna are remote.

6.3.5 Control measures

Control measures to be implemented are:

- *Vessel lighting requirements* - Vessel external lights will be directed onto deck, except where required for navigational purposes or safe operations.

6.4 Atmospheric Emissions

6.4.1 Hazard

The following vessel activities will generate atmospheric emissions:

- Combustion of marine diesel from vessel engines and deck equipment.
- Incineration of wastes.

6.4.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

No receptors identified in Section 4 are expected to be exposed to atmospheric emissions.

6.4.3 Known and Potential Environmental Impacts

The known and potential environmental impacts of atmospheric emissions are:

- Localised and temporary decrease in air quality
- Contribution to global greenhouse gas effect

6.4.4 Evaluation of Environmental Impacts

The combustion of diesel in vessels may result in a localised reduction in air quality. Greenhouse gases will be produced via the combustion of diesel in vessel engines, generators and deck equipment. Infrequent, incineration of a small volume of solid waste may also occur.

Due to the short duration of the survey (21 days) and proximity to settlements (180 km from the survey area), air emissions are not expected to result in a detectable impact to sensitive receptors. In addition to this, total air emissions generated from the survey would represent an insignificant contribution to overall greenhouse gas emissions. Consequently, air emissions would be localised and short term and potential impacts are unlikely.

6.4.5 Control measures

Control measures to be implemented are:

- *Marine diesel quality* - Low-sulphur marine diesel (where sulphur content of fuel oil does not exceed 3.5%) will be used as the primary fuel.
- *Equipment maintenance* - Vessel engines will be maintained in accordance with Planned Maintenance System.
- *Air Pollution Certificate* - Vessels with gross tonnage > 400 t will have International Air Pollution Certificate (IAPP).
- *MARPOL Annex VI; Control of Emissions from Ships – Shipboard Incineration* - If incineration is undertaken, incinerator has IMO certificate.
- *Training* - Personnel responsible for operation of the incinerator are trained.

6.5 Waste Water Discharges

6.5.1 Hazard

The following waste water discharges will be generated from the survey vessels:

- Sewage and grey water
- Deck drainage
- Bilge water
- Cooling water
- Brine

6.5.2 Sensitive environmental receptors with the potential to occur within the AMBA

The following could be exposed to planned waste water discharges:

- Plankton including commercially important fish larvae/eggs
- Invertebrates including commercial species
- Fish
- Sharks and rays
- Turtles
- Marine mammals – whales and dolphins (cetaceans)

6.5.3 Known and Potential Environmental Impacts

The known and potential environmental impact of waste water discharges is:

- Localised impact on water quality from increased temperature, salinity, nutrients and hydrocarbons.

6.5.4 Evaluation of Environmental Impacts

Sewage and greywater

Sewage and greywater discharges can cause temporary and localised turbidity and nutrient enrichment. Sewage is treated in a sewage treatment plant prior to discharge reducing solid levels and hence turbidity and nutrient content. Grey waters include shower, hand basin and sink discharges and are not treated prior to discharge.

<u>Extent and duration of exposure and identified potential impact</u>

No sensitive receptors to turbidity and nutrient enrichment such as seagrass and coral reefs where identified within the EMBA.

As the vessels will be moving whilst discharging sewage and greywater, any changes to water quality will be limited to surface waters with these wastes rapidly diluted in the surface layers of the water column and dispersed by currents.

Given the high dilution and dispersal, low volumes and short discharge period, discharge of these wastes is expected to result in localised changes to water quality periodically around the vessels over the short duration of discharge for the short duration of the survey (up to 21 days). Consequently, sewage and greywater discharges will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, impacts to fauna including fauna of an environmental value are unlikely.

Deck drainage

Decks are maintained clean and free from oil and grease, with all hazardous materials stored in bunded areas and drip trays under any potential leakage points. Uncontaminated deck drainage from rain, sea splash and wash down water is channeled via scuppers directly into the sea. Impacts from desk drainage can only occur from minor spills that are not appropriately responded to and clean-up. These spills can potentially be discharged into the marine environment via deck drainage.

Extent and duration of exposure and identified potential impact

Given the small volumes of deck drainage and the low concentration of chemicals or hydrocarbons that it could contain, any release to the sea would be expected to result in a change to water quality that is highly localised and temporary in nature.

Given the high dilution and dispersal, low volumes and short discharge period, discharge of contaminated deck drainage is expected to result in localised changes to water quality periodically around the vessels over the short duration of the survey (21 days). Consequently, deck drainage discharges will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

Bilge water

Bilge water is the mixture of water, oily fluids, lubricants, cleaning fluids, and other similar wastes that accumulate in the lowest part of a vessel typically from engines and machinery. It is managed by either being retained in a holding tank and discharged to a facility on-shore, or treated onboard with an oily water separator (OWS) after which the treated bilge water can be discharged overboard if the oil-in-water concentration is below 15 ppm. Discharge can only be undertaken while the vessel is moving.

Extent and duration of exposure and identified potential impact

As the vessels will be moving whilst discharging bilge waters that are treated to reduce hydrocarbon content to below 15 ppm, any changes to water quality will be limited to surface waters with these discharges rapidly diluted in the surface layers of the water column and dispersed by currents. Given the high dilution and dispersal, low volumes and short discharge period, discharge of these wastes is expected to result in localised changes to water quality periodically around the vessels over the short duration of the survey (21 days). Consequently, deck drainage discharges will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

Cooling water

Vessels will either use seawater as a heat exchange medium for cooling engines or have box coolers that have no discharge. Were seawater is used as a cooling medium discharge temperatures are typically 5 to 10 °C higher then inlet temperature.

Extent and duration of exposure and identified potential impact

As the vessels will be moving whilst discharging cooling waters any increases in water temperature will be limited to surface waters with these discharges rapidly diluted in the surface layers of the water column and dispersed by currents. Given the high dilution and dispersal, low volumes and short discharge period, discharge of these cooling water is expected to result in localised changes to water quality periodically around the vessels over the short duration of the survey (21 days). Consequently, cooling water discharges will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

Brine

Vessels will have fresh water generators to make freshwater for drinking, showers and cooking. Fresh water generators use either reverse osmosis or distillation. Both processes result in the discharge of seawater with a slightly elevated salinity (~ 10% higher).

Extent and duration of exposure and identified potential impact

As the vessels will be moving whilst discharging brine any increases in salinity will be limited to surface waters with these discharges rapidly diluted in the surface layers of the water column and dispersed by currents. Given the high dilution and dispersal, low volumes and short discharge period, discharge of brine is expected to result in localised changes to water quality periodically around the vessels over the short duration of the survey (21 days). Consequently, brine discharges will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

6.5.5 Control measures

Control measures to be implemented are:

- *Sewage treatment plant* - Sewage will be treated prior to discharge via a MARPOL approved sewage system.
- *Preventative Maintenance System* - The MARPOL approved sewage system will be maintained in accordance with the PMS.
- *Oil-water separator* - Bilge water will pass through a MARPOL approved oil-water separator to reduce OIW content to 15ppm prior to discharge. Treated bilge will only be discharged while en-route.
- *Preventative Maintenance System* - The MARPOL approved oil-water separator will be calibrated and maintained in accordance with the PMS.
- *Operating Parameters* - Cooling water systems and fresh water generators operated within operating parameters.
- *Chemical Assessment* - Santos Offshore Chemical Assessment Process used to assess and approve fluids with potential to be discharged to marine environment.
- *Containment* - Equipment, chemicals and hydrocarbons with the potential for spillage will be contained in appropriately bunded areas.
- *Vessel Shipboard Oil Pollution Emergency Plan* (*SOPEP)* - Vessel SOPEP implemented.
- *Vessel SOPEP* – Vessel SOPEP kits available and stocked.

6.6 Waste

6.6.1 Hazard

Both non-hazardous and hazardous wastes will be generated on the vessels during the survey. With the exception of food scraps and wastes that can be incinerated all wastes will be sent to shore for recycling or disposal.

6.6.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Receptors known to be sensitive to food scrap discharges are:

- Fish

Those that maybe impacted by windblown waste are:

- Fish
- Rays and sharks
- Turtles
- Cetaceans

6.6.3 Known and Potential Environmental Impacts

Potential impacts from the discharge of food scraps and waste accidentally going overboard are:

- Marine and onshore litter
- Injury to marine fauna and seabirds
- Changes to fauna behaviour
- Localised and temporary increase in nutrient matter

Atmospheric emissions from incineration of waste on-board vessels are covered in Section 7.4.

6.6.4 Evaluation of Environmental Impacts

Putrescible waste

Under the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Section 26F), food/galley wastes of <25 mm size are permitted to be discharged overboard when a vessel is en-route, and is located greater than 3 nm from land.

<u>Extent and duration of exposure and identified potential impact</u>

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 over the short duration of the survey (up to 21 days). As the vessel is not stationary, it is expected that any impacts to fauna associated with an increased food source would be temporary and not lead to changes of behaviour due to the short periods of time the vessels would be in one area. Consequently, given the high dilution and dispersal, low volumes and short discharge period, discharge of macerated food scraps will be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 21 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

Windblown wastes

Windblown wastes not recovered from the marine environment may impact fauna if it is eaten or via entanglement.

<u>Extent and duration of exposure and identified potential impact</u>

Ingestion or entanglement in windblown waste has the potential to result in fauna mortality. Windblown wastes would be rare as wastes with the potential to be windblown will be stored in closed containers and in the event of waste being blown overboard attempts would be made to recover it.

Consequently, potential impacts to marine fauna as a result of windblown waste is unlikely and would be limited to individual occurrences not expected to affect populations, thus are considered as localised and short term.

6.6.5 Control measures

Control measures to be implemented are:

- *Waste Management Plan* - Waste will be handled according to the vessel waste management plan.
- *Waste Management Plan* - Waste with potential to be windblown will be stored in covered containers.
- *Waste Management Plan* - Waste blown overboard will be recovered if possible.
- *Marpol Annex V* - Food scraps will be macerated to ≤25 mm size, and are only discharged overboard when vessel is greater than 3 nm from land.

6.7 Seabed Disturbance

6.7.1 Hazard

The following may result in seabed disturbance from the survey activities:

- Anchoring in the event of an emergency
- Streamer loss
- Dropped objects

Vessel grounding was not identified as feasible risks due to there being no emergent features within the survey area.

6.7.2 Sensitive environmental receptors with the potential to occur within the AMBA

Based upon the receptors identified in Table 5 1, those known to be sensitive to seabed disturbance include:

- Key Ecological Features
- Commercial fisheries

6.7.3 Known and Potential Environmental Impacts

Predicted potential impacts of seabed disturbance are:

- Disturbance to and/or loss of benthic habitat
- Damage to commercial trawling or fishing equipment

6.7.4 Evaluation of Environmental Impacts

Disturbance to benthic habitat

Though the survey area is within two key ecological features as detailed in Section 5.3, no sensitive benthic habitats were identified within the survey area.

<u>Extent and duration of exposure and identified potential impact</u>

Seabed disturbance is not planned to occur during this survey as per:

- Anchoring will only occur in an emergency situation.
- Streamer drag is not expected given water depths > 60 m and the streamers are fitted with pressure activated, self-inflating buoys that are designed to bring the equipment to surface if accidently lost.
- All lifting over water will be undertaken within the safe work load. Any dropped objects will be recovered if possible.

In the unlikely event that one of the events detailed occurred, and the object was not recoverable, impacts to benthic habitats would be localised due to the size of the object interacting with the seabed. In addition, any impacts would be expected to recover and thus are considered short term.

Damage to commercial trawling or fishing equipment

There is limited commercial trawling or fishing in the survey area. The Northern Prawn Fishery is the only commercial fishing identified in the area and there has been no activity recorded in the survey area since 2013.

<u>Extent and duration of exposure and identified potential impact</u>

Damage to commercial trawling or fishing equipment can potentially occur if an object is not recoverable from the sea floor. In these circumstances the location of the object will be recorded and communicated to fishing groups and the Department of Fisheries.

In the unlikely event that a dropped object occurred, and the object was not recoverable, commercial fishers would be required to avoid a highly localised area. Interaction with the dropped object would potentially result in damage to equipment that is readily treated / repaired.

6.7.5 Control measures

Control measures to be implemented are:

- *Lifting procedures* - Lifts across water will be undertaken within safe work loads.
- *Vessel anchoring requirements* - Vessel anchoring will only occur in emergency situations
- *Streamer equipment - S*treamers will be fitted with pressure activated, self-inflating buoys.
- *Dropped object management* - Dropped objects will be recovered where feasible.
- *Dropped object reporting* - If recovery of a dropped objects is not feasible its location will be recorded and communicated to fishing groups and Department of Fisheries.

6.8 Fauna Interactions

6.8.1 Hazard

Vessels undertaking the seismic survey have the potential to interact with fauna.

6.8.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Receptors known to be sensitive to fauna interaction include:

- Turtles
- Sharks and rays
- Cetaceans

6.8.3 Known and Potential Environmental Impacts

The known and potential environmental impacts from vessels interactions with fauna are:

- Injury and/or death from vessel strike.

6.8.4 Evaluation of Environmental Impacts

Receptor Sensitivity Fauna Strike

Marine fauna such as cetaceans, sharks, rays and turtles that are likely to be in surface waters are potentially at risk from being struck by a vessel.

Cetaceans are naturally inquisitive marine mammals that are often attracted to vessels with dolphins commonly seen 'bow riding'. The reaction of cetaceans to the approach of a ship is quite variable. Some species remain motionless when in the vicinity of a ship while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving ships (Richardson et al., 1995).

Collisions between vessels and cetaceans occur more frequently where high vessel traffic and cetacean habitat occurs (WDCS, 2006). A recent review of vessel whale strike data identified up to 109 potential strikes in Australian waters from 1840 to 2015 (Peel et al. 2016a). Typically more strikes occur in areas where there are higher vessel and fauna numbers such as off the east coast of Australia (Figure 6-5).

There is limited data on other potential fauna such as turtles, sharks and rays potentially due to lack of collisions being noticed and lack of reporting, however, there is evidence of strikes occurring via marks observed on animals (Peel et al. 2016b).

Receptor Sensitivity - Fauna Entanglement

Potential impacts to fauna can occur from entanglement in streamers. Turtles are seen as potentially at risk as they can become caught and drown. Nelms et al. (2016) undertook a literature review of impacts of seismic surveys on turtles and commented that no peer-reviewed literature documented any turtle entrapments in tail buoys, but the authors had received anecdotal reports (unpublished) of turtle entrapments in tail buoys.

No data or anecdotal evidence could be found in regards to entanglement of other fauna in seismic streamers.

Extent and Duration of Exposure and Identified Potential Impact

The risk of vessel strike and entanglement is limited to the footprint of the vessels, which is temporary in nature as the vessel transits through the survey and operational area over the short duration of the survey (up to 21 days). Within these areas, it is expected that numbers of cetaceans, sharks or rays present will be low as there are no identified feeding, breeding, aggregation or migration areas are present. The survey and operational areas overlap a foraging BIA for four turtle species and consequently there is the potential for a larger number of individuals to be present in these areas.

Though fauna will the potential to be struck or become entangled in equipment may be present in the area, events are unlikely and impacts are assessed as localised and short-term to fauna of environment value as:

- Vessels will be slow moving (4.5 – 5 knots).
- A Marine Fauna Observer will be engaged on the seismic vessel.
- Fauna will the potential to be struck or become entangled are expected to move away from vessels based on predicted noise levels.

- Streamers will have turtle excluders to minimise potential for entanglement.

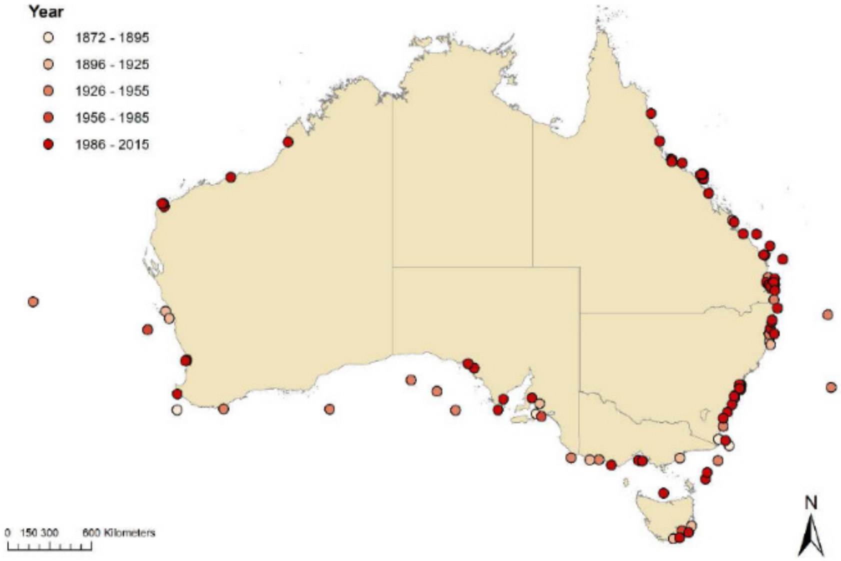


Figure 6-5: Approximate Locations of Fauna Vessel Strikes Causing Death (Peel et al. 2016)

6.8.5 Control measures

Control measures to be implemented are:

- *EPBC Regulations Part 8* - Vessels will meet the requirements of Part 8 of the EPBC Regulations specifically:
  - Travel at less than 6 knots within the caution zone of a cetacean (150 m radius for dolphins, 300 m for whales and turtles).
  - Do not approach closer than the caution zones for whales, turtles and dolphins.
  - If cetacean or turtle shows signs of disturbance move away at a constant speed less than 6 knots..
- *EPBC Act Policy Statement Part B1: MMO* - A trained MFO will undertake observations for fauna.
- *Vessel/Fauna Requirements – streamers deployed* - Turtle guards fitted to tail and head buoys
- *Fauna Strike Reporting Requirements* - Collisions with fauna will be reported via the online National Ship Strike Database.

6.9 Marine Users Interactions

6.9.1 Hazard

The seismic and support vessels have the potential to interact with other marine users in the area.

6.9.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Based upon the receptors identified in Table 5 1, the only marine users identified is minor shipping.

6.9.3 Known and Potential Environmental Impacts

The known and potential environmental impacts of interactions with shipping vessels are:

- Vessel collision

Note: Vessel collisions resulting in a diesel spill are addressed in Section 7.12.

6.9.4 Evaluation of Environmental Impacts

Interactions with other marine users is limited to the footprint of the seismic and support vessels within the operational area. Any interactions will be temporary in nature as the vessel transits through the survey and operational area over the short duration of the survey (21 days). A review of receptors within the Fishburn seismic survey area did not identify any commercial or recreational fishing activity and limited shipping activity. Although the Northern Prawn Fishery operates near the survey area, the survey is being undertaken outside of it operating season.

For the majority of time that the seismic and support vessels will be within the survey acquisition and operational area they will be moving at a rate of 4.5 – 5. Knots (8-9 km/hr) along the sail lines. The distance from the vessel bow to the streamer tail buoy is 6.5 km and the long operational area around the survey acquisition area is required to allow the seismic vessel to turnaround without entanglement of the streamers.

For vessels transiting through the area normal navigation at sea processes are undertaken whereby vessels are not restricted but move through the area using navigational aids to avoid each other. Thus any potential impacts will be within a localised area that needs to be avoided (vessel/streamers) ~ 6.5 km) and short term (~ 1 hr from vessel/streamer to pass).

Based on the limited vessel activity in the area and the survey being outside the Northern Prawn Fishery it is unlikely that that the survey will impact on other marine users.

6.9.5 Control measures

Control measures to be implemented are:

- *Navigational requirements* - Class certificate demonstrates vessel complies with the Navigation Act 2012 and applicable Marine Orders.
- *Navigational requirements* - Tail buoys clearly marked / lighted to identify streamer ends to other users.
- *Notifications* - Notice to Mariners via notifications to Australian Hydrographic Service a minimum of 3 weeks prior to commencement of activities.

6.10 Introduction of Marine Pests

6.10.1 Hazard

The following activities have the potential to result in the introduction of marine pests to the project area:

- Vessel ballast water discharge containing foreign species.
- Biofouling of vessel hull or in-water equipment.

6.10.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Based upon the receptors identified in Table 5 1, those expected to be sensitive to the introduction of a marine pest include:

- Key Ecological Feature
- Northern Prawn Fishery

6.10.3 Known and Potential Environmental Impacts

The known and potential environmental impacts of marine pest introduction are:

- The survival, colonisation and spread of foreign species that may compete with native species for resources, reducing species diversity and abundance.

6.10.4 Evaluation of Environmental Impacts

Vessels have the potential to transport and introduce marine pests from ballast water or biofouling. Successful marine pest invasion requires the following three steps:

1. Colonisation and establishment of the marine pest on a vector (e.g. vessel hull) in a donor region (e.g. home port).
2. Survival of the settled marine species on the vector during the voyage from the donor to the recipient region (e.g. project area).
3. Colonisation (e.g. dislodgement or reproduction) of the marine species in the recipient region, followed by successful establishment of a viable new local population.

Marine pests are likely to have little or no natural competition or predation, thus potentially outcompeting native species for food or space, preying on native species or changing the nature of the environment. It is estimated that Australia has over 250 established marine pests, and it is estimated that approximately one in six introduced marine species becomes pests (DoE 2015l).

Contracted vessels for the survey are likely to be sourced from within Australia but if vessels from overseas are contracted they will be required to be compliant with Australian quarantine requirements.

<u>Extent and duration of exposure and identified potential impact</u>

In the event that a marine pest is introduced into the survey or operational areas, there is the potential for this pest to become established within a Key Ecological Feature. Although the carbonate banks and terrace system of the Sahul Shelf are regionally important and as they provide areas of hard substrate in an otherwise soft sediment environment. In the event that a marine pest was introduced and became established in this area, it is expected that this would result in a localised but medium term impact to an area of significant environmental value.

The vessels will be required to meet all quarantine requirements in regards to biofouling and ballast management, and the survey area is in water depths greater than 60 m reducing the likelihood of establishment. As such there is a low likelihood that if a marine pest was on a vessel it would be able to establish.

6.10.5 Control measures

Control measures to be implemented are:

- *AQIS requirements* - Overseas vessels contracted will receive AQIS clearance to enter Australian water
- *Ballast Water requirements* - Vessels will meet the DAWR Australian Ballast Water Management Requirements.
- *Biofouling Requirements* - Vessels will meet the requirements of the IMO Guidelines for the Control and Management of Ship's Biofouling to Minimise the Transfer of Invasive Aquatic Species.
- *In-water equipment inspection* - In-water equipment will be inspected for biofouling and cleaned prior to deployment.
- *Reporting* - Suspected or confirmed marine pests or diseases will be reported to the WA DoF.

6.11 Diesel Refuelling Spill

6.11.1 Hazard

Bunkering of diesel is unlikely given the short time period of the survey, but has been included in case it is required. Bunkering is undertaken at sea so that the survey can continue as quickly as possible rather than take time out to return to port.

The following have the potential to result in a marine diesel oil (MDO) spill to the marine environment whilst refuelling:

- Refuelling hose leak or connection failure

Spills resulting from overfilling or from an on board coupling or connection failure will be contained within the vessels drains and slops system and hence will not reach the marine environment.

6.11.2 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

Based upon the receptors identified in Table 5 1, those with the potential to be exposed to a diesel spills include:

- Plankton including commercially important fish larvae/eggs
- Invertebrates including commercial species
- Fish
- Sharks and rays including whale sharks
- Turtles
- Marine birds
- Marine mammals – whales and dolphins (cetaceans)

6.11.3 Known and Potential Environmental Impacts

The potential environmental impacts of a MDO spill are:

- Toxic effects to the marine environment including marine fauna

6.11.4 Evaluation of Environmental Impacts

A refuelling hose leak or dry-break connection failure could result in MDO being discharged to the marine environment as the refuelling hose is in direct contact with the water. AMSA's guideline for indicative maximum credible spill volumes (AMSA 2015) recommends that the maximum credible spill volume during refuelling with continuous supervision is calculated as: transfer rate x 15 minutes flow. The shut in time of 15 minutes for refuelling with continuous supervision is very conservative and would typically be undertaken within minutes.

Based on an expected transfer rate of 150 m^3/hr an MDO spill of 37.5 m^3 was calculated. This volume is lower than the MDO spill volume for a vessel collision (280 m^3) and hence the evaluation of impacts to receptors is discussed in Section 6.12 rather than repeated here. Based on the modelling undertaken for the larger 280 m^3 spill, a smaller refuelling spill would be likely to spread and dissipate more quickly (i.e. within days) and be more localised.

In the unlikely event of a refuelling incident impacts to fauna of environmental value would be localised and short term (days) as the diesel would rapidly dissipate.

6.11.5 Control measures

Control measures to be implemented are:

- *Vessel Bunkering Procedure* - Bunkering undertaken as per vessel bunkering procedure which includes:
  - Bunkering during daylight hours only.
  - Continuous monitoring of bunker hose and receiving tank.
  - Bunker hose is certified to maximum transfer pressures and is visually inspected prior to use.
- *Bunkering Equipment* - At a minimum bunkering hose will have floats and dry-break couplings.
- *SOPEP Response* - Vessel SOPEP implemented for spills on-board vessel.
- *OPEP implementation* - Fishburn Oil Pollution Emergency Plan implemented for spills to water.

6.12 Diesel Spill from Vessel Collision

6.12.1 Hazard

A review of receptors within the Fishburn seismic survey area did not identify any commercial or recreational fishing activity and limited shipping activity thus a vessel collision is unlikely but is classified as a credible scenario.

A MDO tank rupture resulting from vessel grounding is not seen as a credible scenario as there are no emergent features within the seismic survey area.

6.12.2 Area that Might be Affected by the Hazard

To understand the potential consequences of a MDO spill and the response preparedness required, stochastic modelling was undertaken (RPS-APASA 2016). The following modelling inputs were used.

Spill Volume

AMSA's guideline for indicative maximum credible spill volumes for other, non-oil tanker, vessel collision (AMSA 2015) is the volume of the largest fuel tank. The loss of a full tank is most likely an overestimate as hydrostatic pressure would limit the release and pumping of material to another tank could also restrict the amount lost.

Based on the type of seismic and survey vessel that may be used, the largest MDO tank volume of 280 m^3 has been used to undertake the impact assessment.

Location

The spill location selected for modelling was chosen based on the closet point that the survey vessel would be to shore (Figure 6-6).

Marine Diesel Oil Properties

Marine diesel oil (MDO) is the common marine fuel used in vessel engines and is a mixture of both volatile (95%) and persistent (5%) hydrocarbons and is classified as a Group III hydrocarbon (Table 6-10). The general behaviour of MDO at sea includes the following aspects:

- Spreads very rapidly with the slick elongated in the direction of prevailing wind and current.
- Evaporation is the dominant process contributing to the removal of spilled MDO from the sea surface and can account for 60-70% loss (depending on wind conditions and sea temperature).
- Residues usually consist of heavy compounds which may persist longer and will tend to disperse as oil droplets into the upper layers of the water column.

Table 6-10: Marine Diesel Oil Properties

		Marine Diesel Oil
API Gravity		37.6
Density @ 25°C g/mL		0.83
Viscosity @ 20 °C (cSt)		4.0@25^{0}C
Pour Point °C		-14
Distillation % mass	Volatiles (<180°C)	6
	Semi-Volatile (180°C -265°C)	34.6
	Low Volatility (265°C -380°C)	54.4
	Residual (>380°C)	5
Group		**Group III**

Modelling Overview

The spill modelling was performed using an advanced three-dimensional trajectory and fates model, SIMAP (Spill Impact Mapping Analysis Program). The SIMAP model calculates the transport, spreading, entrainment and evaporation of spilled hydrocarbons over time, based on the prevailing wind and current conditions and the physical and chemical properties.

The SIMAP system, the methods and analysis presented herein use modelling algorithms which have been anonymously peer reviewed and published in international journals. Further, RPS APASA warrants that this work meets and exceeds the ASTM Standard F2067-13 "*Standard Practice for Development and Use of Oil Spill Models*".

The modelling study was carried out in several stages. Firstly, a five year current dataset (2008–2012) that includes the combined influence of ocean and tidal currents was developed. Secondly, the currents, local winds and detailed hydrocarbon characteristics were used as inputs in the three-dimensional oil spill model (SIMAP) to simulate the drift, spread, weathering and fate of the spilled oil.

As spills can occur during any set of wind and current conditions, modelling was conducted using a stochastic (random or non-deterministic) approach, which involved running 100 randomly selected single trajectory simulations during the period 1 May to 31 August, with each simulation having the same spill information (spill volume, duration and composition of hydrocarbons) but varying start time. This ensured that each spill trajectory was subjected to varying wind and current conditions.

The SIMAP model is able to track hydrocarbons to levels lower than biologically significant or visible to the naked eye. Therefore, reporting thresholds have been specified (based on the scientific literature) to account for "exposure" on the sea surface and "contact" to shorelines at meaningful levels. Table 6-11 details the threshold levels and the information used to determine the thresholds.

Modelling Results

The modelling predicated:

- Oil was more likely to travel north-west of the release site, which aligns with the predominant wind direction (south-east) for the May to August (inclusive) period.
- No shoreline contact.
- No contact to State or Territory waters.
- Low oil exposure (99%) on the sea surface was observed up 117 km from the release site and moderate oil exposure (99%) was observed up to 33 km from the release site. There was an isolated patch of oil at the moderate threshold that travelled up to 203 km from the release site. The high oil exposure was limited to 24 km from the release site.
- The relatively small spill volume and evaporative nature of MDO indicated that surface oil did not persist beyond 22 days (post release) above visible levels (0.5 g/m^2).
- Entrained and aromatic concentrations did not persist in the water column long enough to trigger the relevant lowest exposure thresholds.

The area of potential surface oil exposure from the modelling location is shown in Figure 6-7. This area was then applied to the boundary of the survey operational area to determine the potential surface oil exposure from a MDO spill anywhere within the survey operational area (Figure 6-8). This method was applied, rather than modelling at numerous locations, as the survey operational area is small and there are no significant features within the area or nearby that would create a significant difference in the model inputs such as tides, currents, winds, sea surface temperature and salinity.

To determine the area that might be affected by a vessel collision MDO spill as review of receptors in Table 5.1 was undertaken to identify those sensitive to surface oil exposure. It was identified that there were no social receptors that could be affect by the low exposure threshold where oil is potentially visible on the sea surface. Thus, the moderate exposure threshold at which ecological impacts may occur was used to determine the area that might be affected. This area is detailed in Figure 6-9.

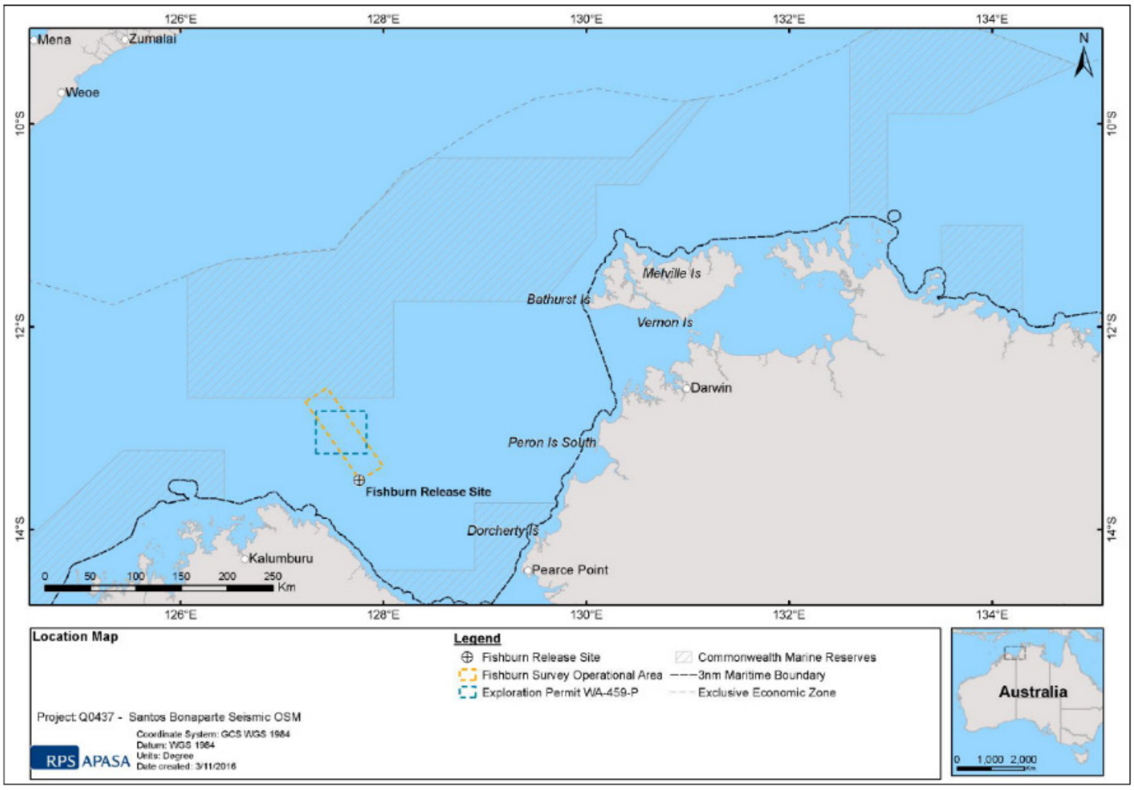


Figure 6-6: Diesel Spill Modelling Location

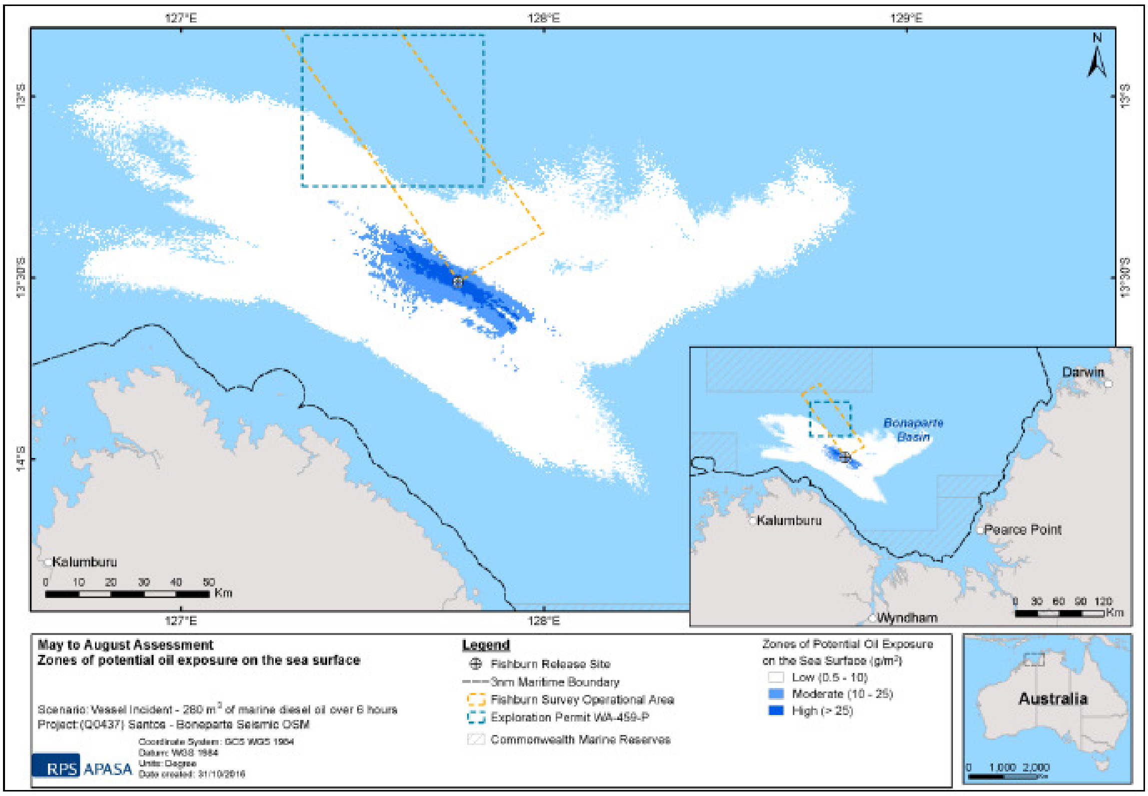


Figure 6-7: Area of Potential Surface Oil Exposure for Modelling Location Release

.

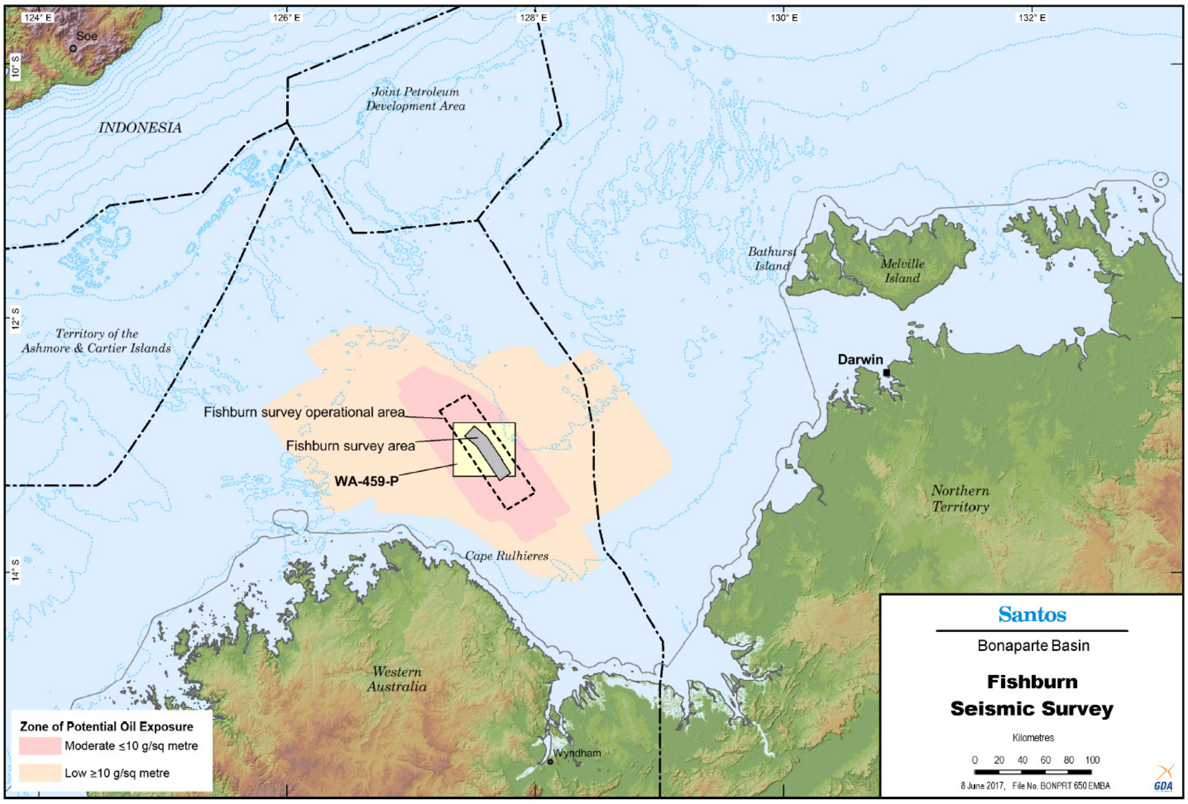


Figure 6-8: Area of Potential Surface Oil Exposure from a 280 m³ MDO Spill within the Survey Operational Area

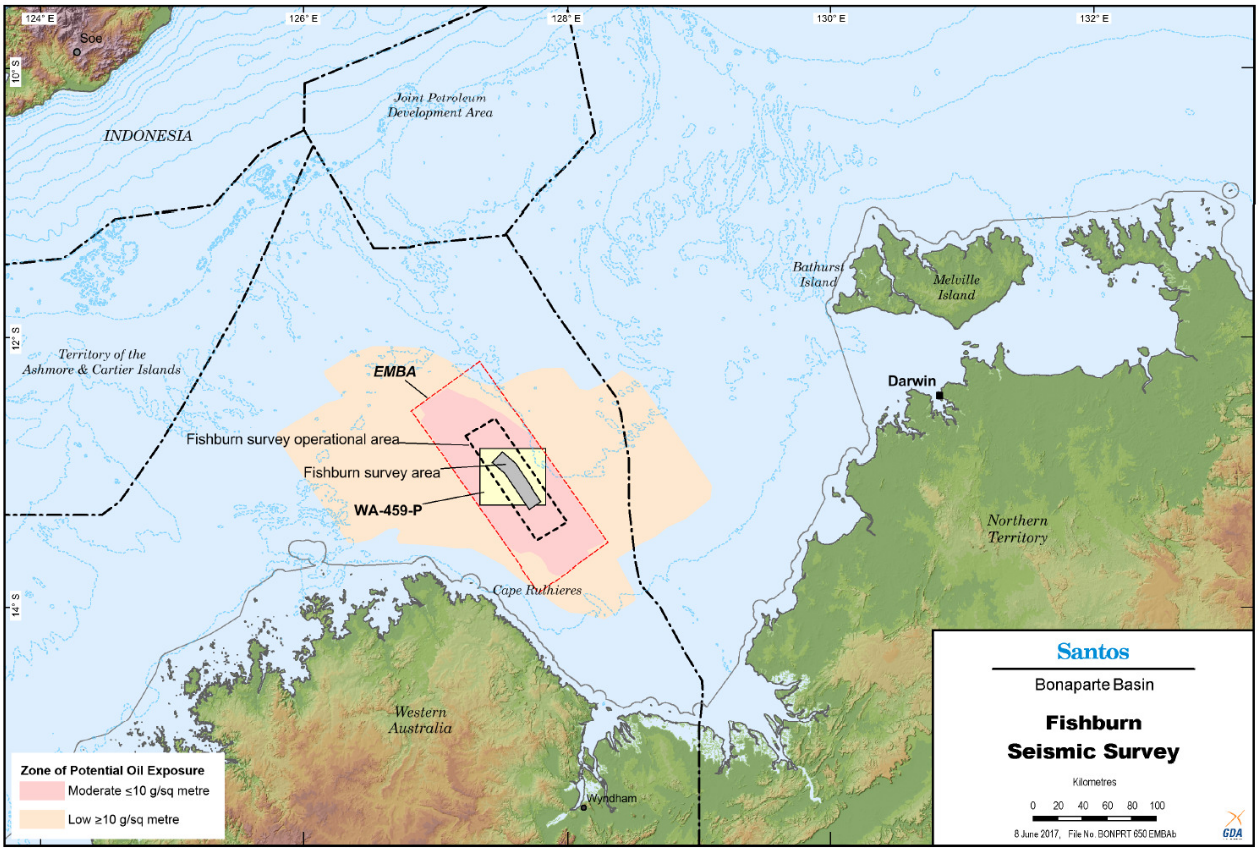


Figure 6-9: Vessel Collision MDO Spill Area that May Be Affected

Table 6-11: Oil Spill Modelling Tresholds

Threshold Value	Description of Potential Effect
Surface hydrocarbons	
Low exposure: 0.5 – 10 g/m²	The 0.5 g/ m² threshold equates approximately to an average thickness of ~0.5 µm. Oil of this thickness is described as a silvery to rainbow sheen in appearance, according to the Bonn Agreement Oil Appearance Code (Bonn Agreement 2009) and is also considered the practical limit of observing oil in the marine environment (AMSA, 2012). This threshold is considered below levels which would cause environmental harm and it is more indicative of the areas perceived to be affected due to its visibility on the sea surface.
Moderate exposure: 10 - 25 g/ m²	Ecological impact has been estimated to occur at 10 g/ m² as this level of oiling has been observed to mortally impact birds and other wildlife (French et al. 1996, French-McCay 2009.
High exposure: > 25 g/ m² or µm	Studies have indicated that a concentration of surface oil above 25 g/ m² or greater would be harmful to marine birds that come in contact with the oil (Scholten et al. 1996, Koops et al. 2004).
Shoreline Accumulated Hydrocarbons	
Low exposure: 100 g/ m²	French et al. (1996) and French-McCay (2009) have defined an oil exposure threshold for shorebirds and wildlife (furbearing aquatic mammals and marine reptiles) on or along the shore at 100 g/ m², which is based on studies for sub-lethal and lethal impacts. These thresholds have been used in previous environmental risk assessment studies (French-McCay 2003, French-McCay et al. 2004, French-McCay et al. 2011, NOAA 2013). Observations by Lin and Mendelssohn (1996), demonstrated that more than 1,000 g/ m² of oil during the growing season would be required to impact marsh or mangrove plants significantly.
Moderate exposure: 100 - 1,000 g m²	
High exposure: > 1,000 g/ m²	
Dissolved Aromatic Hydrocarbons	
Low: 576 ppb.hrs (6 ppb for 96 hrs)	Studies indicate that the dissolved aromatic compounds (typically the mono-aromatic hydrocarbons and the two and three ring poly-aromatic hydrocarbons) are commonly the largest contributor to the toxicity of solutions generated by mixing oil into water (Di Toro et al. 2007). The threshold value for species toxicity in the water column is based on global data from French et al. 1999 and French-McCay, 2002, 2003, which showed that species sensitivity (fish and invertebrates) to dissolved aromatics exposure > 4 days (96-hour LC50) under different environmental conditions varied from 6 to 400 µg/l (ppb) with an average of 50 ppb. This range covered 95% of aquatic organisms tested, which included species during sensitive life stages (eggs and larvae). Based on scientific literature, a minimum threshold of 6 parts per billion (ppb) over 96-hours or equivalent was used to assess in-water low exposure zones (Engelhardt, 1983; Clark, 1984; Geraci & St. Aubin, 1988; Jenssen, 1994; Tsvetnenko, 1998. French-McCay, 2002 indicates that an average 96 hour LC50 of 50 ppb and 400 ppb could serve as an acute lethal threshold to 5% and 50% to biota, respectively. Hence, the thresholds were used to represent the moderate and high exposure zones, respectively.
Moderate: 4,800 ppb.hrs (50 ppb for 96 hrs)	
High: 38,500 ppb.hrs (400 ppb for 96 hrs)	
Entrained Hydrocarbon Droplet	
Low Exposure: 960 ppb.hrs (10 ppb for 96 hrs)	Considering that entrained oil has undergone processes analogous to weathering and/or water-washing (i.e., many of the toxic soluble hydrocarbons have been removed through evaporation and/or dissolution), its toxicity is representative of true 'dispersed oil' phase impacts. OSPAR (2012) has published predicted no effect concentrations (PNEC) for 'dispersed oil' in produced formation water (PFW) discharges. Dispersed oil in PFW discharges are small, discrete droplets suspended in the discharged water which are very similar to insoluble dispersed oil droplets formed from subsea blowouts. In essence the oil has been
Moderate Exposure: 9,600 ppb.hrs (100 ppb for 96 hrs)	

Threshold Value	Description of Potential Effect
High Exposure 48,000 ppb.hrs (500 ppb for 96 hrs)	partitioned (naturally separated) from gas/oil/water mixture by solubility (water washing) and vapour pressure (evaporation) based on the individual hydrocarbon chemical properties. Appropriate threshold values were extrapolated from the No effect concentrations examined in Smit et al., 2009 based on effects ranging from oxidative stress to impacts on growth, reproduction and survival and are represented by: 7 µg/l (7ppb) (for 1% affected fraction of species), 70.5µg/l (70ppb) (for 5% affected fraction of species) and 804 µg/l (804 ppb) (for 50% affected fraction of species). Utilising methodologies contained in ANZECC (2000), PNECs can be back-calculated to determine LC50 values by applying a factor of 100 to the PNEC values. This approach is supported by assessment factor criteria contained within the European Chemicals Agency (2008) and the OECD Existing Chemicals Programme 2002 (OECD, 2002). Employing these criteria, the following conservative threshold values for entrained hydrocarbons are applied: LC50 (99% species protection): 700 µg/l (ppb) LC50 (95% species protection): 7,050 µg/l (ppb); and LC50 (50% species protection): 80,400 µg/l (ppb).

6.12.3 Sensitive Environmental Receptors with the Potential to Occur within the AMBA

A review of receptors in Section 4 identified those receptors within the AMBA sensitive to surface oil exposure. These are detailed in Table 6-12.

6.12.4 Known and Potential Environmental Impacts

The potential environmental impacts of a MDO spill are:

- Toxic effects to the marine environment including marine fauna

6.12.5 Evaluation of Environmental Impacts

Potential receptors and an assessment of impacts from a MDO spill are detailed in Table 6-12. As detailed in Section 7.12.2 modelling predicted that entrained and aromatic concentrations would not trigger the lowest exposure thresholds. Thus the impact assessment was undertaken on surface oil exposure. For this assessment the moderate surface oil threshold was used as this is the threshold at ecological impact has been estimated to occur as no social receptors were identified that could be affected by surface oil exposure.

Potential impacts are only likely to occur to fauna present on the ocean surface or when air breathing fauna, such as turtles and cetaceans, surface to breathe. In these situations, fauna may come into contact directly with the MDO or indirectly via vapours as the MDO breaks down. Most evaporation of MDO is within the first 48 hours (RPS-APASA 2016) hence, fauna would be exposed to vapours for a short time frame.

Due to the weathering nature of MDO a spill spreads rapidly and thinly and hence is not expected to result in fauna ingesting significant volumes or result in persistent oiling.

Based on the threshold levels, impacts to fauna would be limited to within the EMBA and would be short term, hydrocarbons are predicted not persist beyond 22 days.

Thus, though a vessel collision would be remote, impacts would be extensive (within the EMBA) and short term (up to 22 days) to fauna of environmental value.

Table 6-12: Impact Assessment of MDO Spill on Receptors

Environment Receptor	Potential Impact to Receptor	Summary of Potential Impacts
Shoreline	No	No shoreline contact.
Benthic Habitat	No	No impact as entrained and aromatic concentrations did not trigger the lowest exposure thresholds.
Sharks and rays	No	No impact as entrained and aromatic concentrations did not trigger the lowest exposure thresholds.
Turtles	Yes	May encounter surface hydrocarbons. The survey and operational areas overlap a foraging BIA for four turtle species and consequently here is the potential for a larger number of individuals to be present in these areas. As such, turtles may encounter surface hydrocarbons given their presence in the BIA. Sea turtles can be affected by oil spills via oiling, direct ingestion of oil and prolonged exposure to oil vapours (NOOA 2010). Contact with spilt hydrocarbons can result in coating of body surfaces causing irritation of mucous membranes in the nose, throat and eyes which can result in inflammation and infection. Potential impacts to the respiratory system may also result from inhalation of oil vapours when they come to the surface to breathe. Due to the weathering nature of MDO a spill spreads rapidly and thinly and consequently, turtles are not expected to ingest significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS-APASA 2016) hence, turtles would be exposed to vapours for a short time frame. Thus, impacts to turtles that may foraging in the area are likely to be localised and short term in nature.
Marine Birds	Yes	May encounter surface hydrocarbons. No biological important areas within moderate threshold surface exposure area, consequently it is only expected that transient individuals could be exposed to surface hydrocarbons above thresholds that could result in an impact. Marine birds may become exposed to oil from diving to obtain food or resting on the sea surface. They can be affect by oiling, exposure to oil vapours and direct and indirect ingestion of oil. Oiling of feathers can impact on the bird's ability to thermo-regulate (IPECA 2017). Due to the weathering nature of MDO a spill spreads rapidly and thinly and hence marine birds are not expected to ingest significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS-APASA 2016) hence, marine birds would be exposed to vapours for a short time frame. Thus, impacts to marine birds that may feeding or resting in the area are likely to be localised and short term in nature.
Cetaceans	Yes	May encounter surface hydrocarbons. No biological important areas within moderate threshold surface exposure area, consequently it is only expected that transient individuals could be exposed to surface hydrocarbons above thresholds that could result in an impact. Cetaceans may become exposed to oil on surfacing to breathe where they can be affect by oiling, exposure to oil vapours and ingestion of oil. There is little documented evidence of effects of oiling on whales (IPECA 2017). Due to the weathering nature of MDO a spill spreads rapidly and thinly and hence cetaceans are not expected to ingest significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS-APASA 2016) hence, cetaceans would be exposed to vapours for a short time frame. Thus, impacts to cetaceans that may present in the area are likely to be localised and short term in nature.
Commercial fishing	No	Northern Prawn Fishery is outside the moderate threshold surface exposure area and entrained and aromatic concentrations did not trigger the lowest exposure thresholds and consequently, this fishery is not expected to be impacted by this type of event.
Recreational activities	No	No recreational activities identified.
Maritime Heritage	No	No recreational activities identified.

Environment Receptor	Potential Impact to Receptor	Summary of Potential Impacts
State Protected Areas	No	No recreational activities identified.
Commonwealth Protected Areas	Yes	Oceanic Shoals Marine Reserve may encounter surface hydrocarbons. Impacts to Key Ecological Features within the Oceanic Shoals Marine Reserve and fauna that maybe present are discussed within relevant sections in this table.
Key Ecological Features	No	Carbonate banks and terrace systems of the Sahul Shelf and Pinnacles of the Bonaparte Basin are submerged features and entrained and aromatic concentrations did not persist in the water column long enough to trigger the lowest exposure thresholds.

6.12.6 Control measures

Control measures to be implemented are:

- *Navigational requirements* - Class certificate demonstrates vessel complies with the Navigation Act 2012 and applicable Marine Orders.
- *Notifications* - Notice to Mariners via notifications to Australian Hydrographic Service a minimum of 3 weeks prior to commencement of activities.
- *OPEP implementation* - Fishburn Oil Pollution Emergency Plan implemented for spills to water.

7 IMPLEMENTATION STRATEGY

Santos manages the environmental impacts and risks of its activities through the implementation of the Santos Management System (SMS). The SMS provides a formal and consistent framework for all activities of Santos employees and contractors. The framework for the SMS is provided in Figure 7-1 and includes:

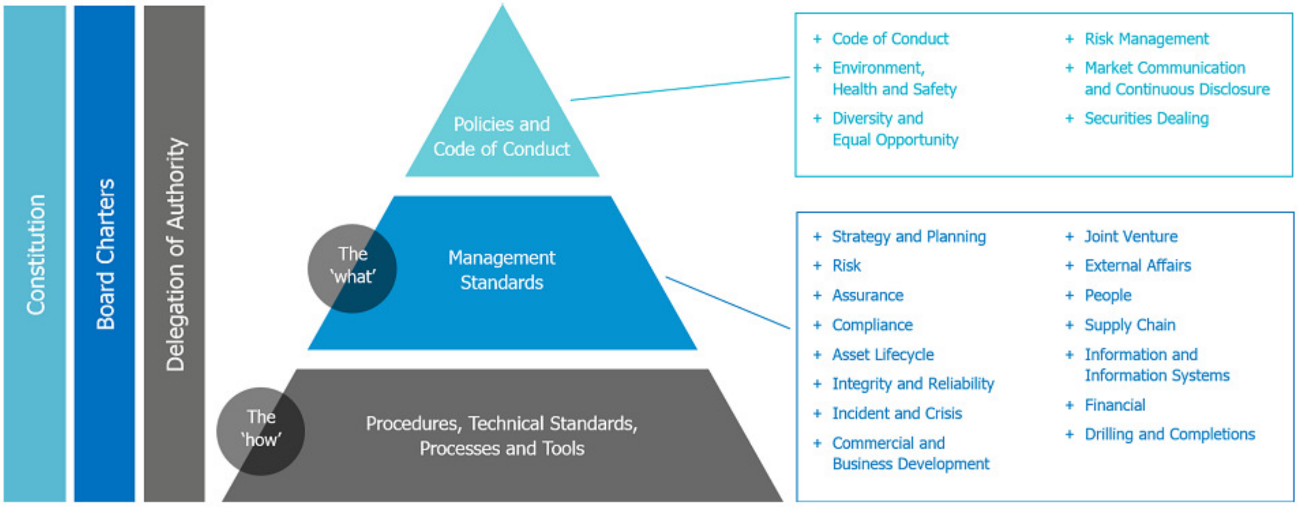


Figure 7-1: Santos Management System Framework

The Environment plan sets a range of Environmental Performance Outcomes and Environmental Performance Standards for the activity which are guided by the Implementation strategy to ensure they are met. Specifically, the implementation strategy within the EP details:

- Roles and Responsibilities
- Training and Competencies
- Management of Change
- Emergency Response
- Chemical Assessment Process
- Incident Reporting
- Environmental Performance Monitoring and Reporting

Specifically, the implementation strategy provides for inducting offshore personnel to ensure they understand the environmental requirements as developed under the EP, and ensure personnel with specific accountabilities in the plan are aware of their responsibilities.

Compliance and environmental performance is monitored via a range of measures including audits and inspections. Where a non-conformance or improvement is identified, actions are implemented to correct the non-conformance and prevent reoccurrence. Reportable and recordable incidents resulting from the survey will be reported to NOPSEMA in accordance with the OPGGS(E) Regulations. A report summarising the final environmental performance will be provided to NOPSEMA upon completion of the survey.

The environment plan will be reviewed in accordance with any changes that are identified throughout the survey. In the event that the proposed change is a significant modification or new stage of activity, introduces a significant new environmental impact or risk, results in a significant increase to an existing environmental impact or risk, or, as a cumulative effect results in an increase in environmental impact or risk, the EP will be revised and submitted for re-assessment and acceptance by NOPSEMA.

8 OIL POLLUTION EMERGENCY RESPONSE PLAN

The Fishburn Oil Pollution Emergency Plan (OPEP) describes the offshore spill response arrangements to be undertaken by Santos Ltd (Santos) for an oil spill from the activities associated with the Fishburn Seismic Survey. The objectives of the OPEP are to ensure:

- Santos has timely access to appropriately trained people and resources in order to effectively respond to and manage an oil spill response.
- The timely implementation of pre-determined response strategies as outlined in this OPEP.
- That the procedures used by Santos are consistent with those used by the applicable plans including the National Plan to Combat Pollution of the Sea by Oil and Other Noxious and Hazardous Substances (NatPlan) and Australian Industry Cooperative Oil Spill Response Arrangements (AMOSPlan).
- Effective integration and use of industry/government response efforts and resources.

8.1 Oil Spill Response Arrangements

The National Plan for Maritime Environmental Emergencies is a national integrated Government and industry organisational framework enabling effective response to marine pollution incidents and maritime casualties. The Australian Maritime Safety Authority (AMSA) manages the National Plan, working with State/Northern Territory governments, the shipping, ports, oil, salvage, exploration and chemical industries, and emergency services to maximise Australia's marine pollution response capability.

Based upon the oil spill events identified in the EP, it is determined that the events would occur in Commonwealth waters with no impact to State or Territory waters. Consequently, AMSA is the identified control Agency for these events. The Control Agency is the agency or company assigned by legislation, administrative arrangement, or within the relevant contingency plan, to control response activities to a maritime environmental emergency. The jurisdiction governments will ensure that there is an appointed Control Agency for each of the hazards identified within their overall emergency management arrangements.

The Control Agency will have responsibility for appointing the Incident Controller to control the operational response to an incident.

Santos has signed a MoU with AMSA regarding response arrangements. The MoU is the result of consultation between Santos and AMSA, and sets out their understanding of their respective roles and responsibilities when responding to ship-sourced marine pollution incidents and non-ship sourced marine pollution incidents.

8.2 Preparedness Training

Key Santos and Vessel Contractor roles are identified in the OPEP. These positions have position descriptions for both operational and emergency roles that outline the competency requirements including experience, training and qualifications.

For the key roles identified in the OPEP, the requirements in this OPEP will be communicated prior to the survey commencing. All offshore personnel will be required to complete an induction that will cover the requirements in the Fishburn EP and this OPEP.

8.3 Testing of Response Arrangements

The response arrangements in this OPEP will be tested prior to commencing the survey.

The arrangements for testing the response arrangements will include:

- a statement of the objectives of testing;
- mechanisms to examine the effectiveness of response arrangements against the objectives of testing; and
- mechanisms to address recommendations arising from tests.

The OPEP response arrangement testing and any actions will be recorded in EHS Toolbox – Emergency Response Exercise

9 REFERENCES

Austin, D., and Pollom, R. 2016. The IUCN Red List of Threatened Species 2016. http://www.iucnredlist.org/ viewed 16 May 2017.

Australian Maritime Safety Authority. 2015 Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities.

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

André, M., Kaifu, K., Solé, M., van der Schaar, M., Akamatsu, T., Balastegui, A., Sánchez, A.M., Castell, J.V., 2016. Contribution to the understanding of particle motion perception in marine invertebrates. In: Popper, N.A., Hawkins, A. (Eds.), The Effects of Noise on Aquatic Life II. Springer, New York, pp. 47–55.

Andriguetto-Filho, JM, Ostrensky, A, Pie, MR, Silva, UA, and Boeger, WA (2005). Evaluating the impact of seismic prospecting on artisanal shrimp fisheries. Continental Shelf Research, 25(14):1720-1727.

Australian Fisheries Management Authority 2017. Northern Prawn Fishery. Available from: http://www.afma.gov.au/fisheries/northern-prawn-fishery/ Viewed 11/1/2017.

Australian and New Zealand Environment and Conservation Council (ANZECC) 2000. Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines (National water quality management strategy; no.4). Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Baker, C., Potter, A., Tran, M. and Heap, A.D. 2008. Geomorphology and Sedimentology of the Northwest Marine Region of Australia. Geoscience Australia, Record 2008/07. Geoscience Australia, Canberra. 220pp.

Bamford M, Watkins D, Bancroft W, Tischler G and J Wahl. 2008. Migratory Shorebirds of the East Asian - Australasian Flyway; Population Estimates and Internationally Important Sites. Wetlands International - Oceania. Canberra, Australia.

Bannister, J.L., Kemper, C.M. and Warnecke R.M. 1996. The Action Plan for Australian Cetaceans. The Director of National Parks and Wildlife Biodiversity Group, Environment Australia, September 1996 ISBN 0 642 21388 7.

Bartol, S.M., J.A. Musick, and M.L. Lenhardt. 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). *Copeia*: 836-840.

Bartol, S.M. and D.R. Ketten. 2006. *Turtle and tuna hearing*. *In*: Swimmer, Y. and R. Brill. Volume December 2006. NOAA Technical Memorandum NMFS-PIFSC-7. 98-103 pp. http://www.sefsc.noaa.gov/turtles/TM_NMFS_PIFSC_7_Swimmer_Brill.pdf#page=108.

Bonn Agreement. 2009. Bonn Agreement aerial operations handbook, 2009 - Publication of the Bonn Agreement, London.

Brand, AR, Wilson, UAW 1996. Seismic Surveys and Scallop Fisheries. Unpublished Report on the Impact of a Seismic Survey on the 1994 Isle of Man Queen Scallop Fishery. Port Erin Marine Laboratory, University of Liverpool, Port Erin, Isle of Man.

Bray, D.J., and Thompson, V.J. 2017. Fishes of Australia. http://fishesofaustralia.net.au/home/species/ viewed 16 May 2017.

Brewer, D.T., Lyne, V., Skewes, T.D., and Rothlisberg, P. (2007) Trophic Systems of the North West Marine Region. Report to The Department of the Environment and Water Resources. CSIRO Cleveland. 156 pp.

Buxton, C. D. and Cochrane, P. (2015). Commonwealth Marine Reserves Review: Report of the Bioregional Advisory Panel. Department of the Environment, Canberra. 341pp.

G.M., Cavanagh R.D., Kulka D.W., Stevens J.D., Soldo A., Clo S., Macias D., Baum J., Kohin S., Duarte A., Holtzhausen J.A., Acuña E., Amorim A. & Domingo A. 2009. *Isurus oxyrinchus*. The IUCN Red List of Threatened Species 2009.

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

Christian, J.R., Mathieu, A., Buchanan, R.A., 2004. Chronic Effects of Seismic Energy on Snow Crab (Chionoecetes opilio). Environmental Funds Project No. 158. Fisheries and Oceans Canada. Calgary (25pp).

Christian, J.R., Mathieu, A., Thompson, D.H.,White, D., Buchanan, R.A., 2003. Effect of Seismic Energy on SnowCrab (Chionoecetes opilio). Environmental Funds Project No. 144. Fisheries and Oceans Canada. Calgary (106p).

Christensen-Dalsgaard, J., C. Brandt, K.L. Willis, C.B. Christensen, D. Ketten, P. Edds-Walton, R.R. Fay, P.T. Madsen, and C.E. Carr. 2012. Specialization for underwater hearing by the tympanic middle ear of the turtle, *Trachemys scripta elegans*. *Proceedings of the Royal Society of London B: Biological Sciences* 279(1739): 2816-2824.

Clark, RB. 1984. 'Impact of oil pollution on seabirds', *Environmental Pollution*, vol. 33, no.1, pp. 1–22.

Commonwealth of Australia. 2002. Species group report card – seabirds. Supporting the marine bioregional plan for the North Marine Region.

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

Day, R.D., McCauley, R.M., Fitzgibbon, Q.P., Semmens, J.M., Institute for Marine and Antarctic Studies. 2016b. Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries, University of Tasmania. Hobart. October CC BY 4.0

D'Anastasi B., Simpfendorfer C. & van Herwerden L. 2013. *Anoxypristis cuspidata*. The IUCN Red List of Threatened Species 2013.

Department of the Environment. 2015a. Sawfish and River Sharks Multispecies Recovery Plan. Commonwealth of Australia 2015.

Department of the Environment. 2015b. Conservation Management Plan for the Blue Whale 2015-2025. Commonwealth of Australia.

Department of Environment and Energy. 2015. Conservation Advice *Numenius madagascariensis* eastern curlew.

Department of Environment and Energy. 2016a. SPRAT Database Carbonate bank and terrace system of the Sahul Shelf. Viewed 16 Dec 2016. https://environment.gov.au/sprat-public/action/kef/view/3

Department of Environment and Energy. 2016b. SPRAT Database Pinnacles of the Bonaparte Basin. Viewed 16 Dec 2016. https://environment.gov.au/sprat-public/action/kef/view/62

Department of Environment and Energy. 2017. SPRAT (Species Profile and Threats) Database. http://www.environment.gov.au/sprat viewed 16 May 2017.

Department of Environment and Energy. 2017a. SPRAT Profile *Carcharodon carcharias* — White Shark, Great White Shark. http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64470 viewed 4/1/2017.

Department of Environment and Energy. 2017b. SPRAT Profile *Pristis clavata* — Dwarf Sawfish, Queensland Sawfish http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68447 viewed 4/1/2017.

Department of Environment and Energy. 2017c. SPRAT Profile *Rhincodon typus* — Whale Shark http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66680 viewed 4/1/2017.

Department of Environment and Energy. 2017d. SPRAT Profile *Caretta caretta* — Loggerhead Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1763 viewed 4/1/2017.

Department of Environment and Energy. 2017e. SPRAT Profile *Dermochelys coriacea* — Leatherback Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768 viewed 4/1/2017.

Department of Environment and Energy. 2017f. SPRAT Profile *Eretmochelys imbricata* — Hawksbill Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1766 viewed 4/1/2017.

Department of Environment and Energy. 2017g. SPRAT Profile *Chelonia mydas* — Green Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765 viewed 4/1/2017.

Department of Environment and Energy. 2017h. SPRAT Profile *Lepidochelys olivacea* — Olive Ridley Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1767 viewed 5/1/2017.

Department of Environment and Energy. 2017i. SPRAT Profile *Natator depressus* — Flatback Turtle http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59257 viewed 5/1/2017.

Department of Environment and Energy. 2017j. SPRAT Profile *Crocodylus porosus* — Salt-water Crocodile http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1774 viewed 5/1/2017.

Department of Environment and Energy. 2017k. SPRAT Profile *Calidris ferruginea* — Curlew Sandpiper http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=856 viewed 5/1/2017.

Department of Environment and Energy. 2017l. SPRAT Profile *Pandion cristatus* — Eastern Osprey http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82411 viewed 5/1/2017.

Department of Environment and Energy. 2017m. SPRAT Profile *Anous stolidus* — Common Noddy http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=825 viewed 5/1/2017.

Department of Environment and Energy. 2017n. SPRAT Profile *Balaenoptera borealis* — Sei Whale http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=34 viewed 6/1/2017.

Department of Environment and Energy. 2017o. SPRAT Profile *Balaenoptera physalus* — Fin Whale http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=37 viewed 6/1/2017.

Department of Environment and Energy. 2017p. SPRAT Profile *Megaptera novaeangliae* — Humpback Whale http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=38 viewed 6/1/2017.

Department of Environment and Energy. 2017q. SPRAT Profile *Balaenoptera edeni* — Bryde's Whale http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=35 viewed 6/1/2017.

Department of Environment and Energy. 2017r. Integrated Marine and Coastal Regionalisation of Australia (IMCRA) v4.0 - Meso-scale Bioregions Metadata http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BE6EED98E-2800-424F-A1E9-D489E71E99BB%7D Accessed 11/4/2017

Department of Environment and Energy 2017s Recovery Plan for Marine Turtles in Australia, Commonwealth of Australia 2017.

Department of the Environment and Heritage. 2005a. Whale Shark (*Rhinocodon typus)* Recovery Plan 2005-2010. Commonwealth of Australia.

Department of the Environment and Heritage. 2005b. Blue, Fin and Sei Whale Recovery Plan 2005 – 2010. Canberra, Commonwealth of Australia.

Department of the Environment and Heritage. 2005c. Humpback Whale Recovery Plan 2005 - 2010. Department of the Environment and Heritage. Canberra, Commonwealth of Australia

Department of Environment, Water, Heritage and the Arts. 2005. Australian National Guidelines for Whale and Dolphin Watching. Commonwealth of Australia.

Department of Environment, Water, Heritage and the Arts. 2008. The North-west Marine Region Bioregional Plan Bioregional Profile. Commonwealth of Australia.

Department of Fisheries. 2016 (in draft). Literature Review of the Potential Effects of Seismic Air Gun Surveys on Marine Finfish and Invertebrates in Western Australia. Draft Prepared for Seismic Survey Ecological Risk Assessment.

Department of Fisheries. 2017a. Pink Snapper. http://www.fish.wa.gov.au/Species/Pink-Snapper/Pages/default.aspx

Department of Fisheries. 2017b. Spanish Mackerel. http://www.fish.wa.gov.au/Species/Spanish-Mackerel/Pages/default.aspx

Department of Fisheries. 2013. Guidance Statement on Undertaking Seismic Surveys in Western Australian Waters. Fisheries Occasional Publication No. 112, 2013. Government of Western Australia. Department of Fisheries.

Department of Parks and Wildlife 2016, Proposed North Kimberley Marine Park indicative joint management plan 2016, Department of Parks and Wildlife, Perth.

Department of Sustainability, Environment, Water, Heritage and the Arts. 2013. Recovery Plan for the White Shark (*Carcharodon carcharias).* Commonwealth of Australia.

Department of Sustainability, Environment, Water, Population and Communities 2012a. Marine Bioregional Plan for the North-west Marine Region.

Department of Sustainability, Environment, Water, Population and Communities 2012b. Marine Bioregional Plan for the South-west Marine Region.

Department of Sustainability, Environment, Water, Population and Communities 2012c. Marine Bioregional Plan for the North Marine Region.

Department of Sustainability, Environment, Water, Population and Communities. 2012d. Species Group Report Card – Bony Fishes. Supporting the Marine Bioregional Plan for the North-west Marine Region. Australian Government.

Department of Sustainability, Environment, Water, Population and Communities. 2012e. Species Group Report Card – Seabirds and Migratory Shorebirds. Supporting the Marine Bioregional Plan for the North-west Marine Region. Australian Government.

DFO 2004. Potential impacts of seismic energy on snow crab. DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/003.

Di Toro, D.M., McGrath, J.A., Stubblefield, W.A. 2007. 'Predicting the toxicity of neat and weathered crude oil: Toxic potential and the toxicity of saturated mixtures', *Environmental Toxicology and Chemistry*, vol. 26, no. 1, pp. 24–36.

Double MC, Andrews-Goff V, Jenner KCS, Jenner M-N, Laverick SM, Branch TA, et al. (2014) Migratory Movements of Pygmy Blue Whales (*Balaenoptera musculus brevicauda*) between Australia and Indonesia as Revealed by Satellite Telemetry. PLoS ONE 9(4): e93578. doi:10.1371/journal.pone.0093578.

Edmonds, N.J., Firmin, C.J., Goldsmith, D., Faulkner, R.C., Wood, D.T., 2016. A review of crustacean sensitivity to high amplitude underwater noise: data needs for effective risk assessment in relation to UK commercial species. Mar. Pollut. Bull. 108, 5–11.

Engelhardt, FR 1983. 'Petroleum effects on marine mammals', *Aquatic Toxicology, vol.* 4, no.3, pp. 199–217.

Environmental Protection Authority. 2010. Environmental Assessment Guideline for Protecting Marine Turtles from Light. No. 5.

European Chemicals Agency. 2008. Chapter R.10 - Characterisation of dose [concentration] -response for environment. In Guidance on information requirements and chemical safety assessment (pp. 26-29). ECHA.

Fletcher, W.J. and Santoro, K. 2015. Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: The State of the Fisheries. Department of Fisheries, Western Australia.

French, D, Reed, M, Jayko, K, Feng, S, Rines, H, Pavignano, S, Isaji, T, Puckett, S, Keller, A, French III, FW, Gifford, D, McCue, J, Brown, G, MacDonald, E, Quirk, J, Natzke, S, Bishop, R, Welsh, M, Phillips, M, Ingram, BS 1996, *The CERCLA Type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Volume I - Model Description, Final Report*, Office of Environmental Policy and Compliance, U.S. Department of the Interior, Washington DC.

French-McCay, DP. 2002. 'Development and application of an oil toxicity and exposure model, OilToxEx', Environmental Toxicology and Chemistry, vol. 21, no. 10, pp. 2080-2094.

French-McCay, DP. 2003. 'Development and application of damage assessment modelling: example assessment for the North Cape oil spill', Marine Pollution Bulletin, vol. 47, no. 9, pp. 9–12.

French-McCay, DP. 2004. 'Spill impact modelling: development and validation', Environmental Toxicology and Chemistry, vol. 23, no.10, pp. 2441–2456.

French-McCay, DP. 2009. 'State-of-the-art and research needs for oil spill impact assessment modelling', *Proceedings of the 32nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, pp. 601–653.

French, D, Reed, M, Jayko, K, Feng, S, Rines, H, Pavignano, S, Isaji, T, Puckett, S, Keller, A, French III, FW, Gifford, D, McCue, J, Brown, G, MacDonald, E, Quirk, J, Natzke, S, Bishop, R, Welsh, M, Phillips, M, Ingram, BS 1996 The CERCLA Type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Volume I - Model Description, Final Report, Office of Environmental Policy and Compliance, U.S. Department of the Interior, Washington DC.

French, D, Schuttenberg, H & Isaji, T 1999. 'Probabilities of oil exceeding thresholds of concern: examples from an evaluation for Florida Power and Light', Proceedings of the 22nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Alberta, pp. 243–270.

French-McCay, D, Rowe, JJ, Whittier, N, Sankaranarayanan, S, & Etkin, DS 2004, 'Estimate of potential impacts and natural resource damages of oil', *Journal of Hazardous Materials*, vol. 107, no. 1, pp. 11–25.

French-McCay, D, Reich, D, Rowe, J, Schroeder, M & Graham, E 2011. 'Oil spill modeling input to the offshore environmental cost model (OECM) for US-BOEMRE's spill risk and costs evaluations', *Proceedings of the 34th Arctic and Marine Oil Spill Program (AMOP) Technical Siminar, Environment Canada,* Ottawa.

Froese, R., and Pauly. D (eds.) 2017. FishBase. http://www.fishbase.org/ viewed 16 May 2017

Geraci, JR., & St. Aubin, DJ 1988. *Synthesis of effects of oil on marine mammals*. 292. Ventura, CA, USA: US Department of the Interior, Minerals Management Service, Atlantic OCS Region, OCS Study, MMS 880049.

Guan, S., J. Vignola, J. Judge, and D. Turo. 2015. Airgun inter-pulse noise field during a seismic survey in an Arctic ultra shallow marine environment. *Journal of the Acoustical Society of America* 138(6): 3447-3457.

GHD 2014 Santos Limited Mutineer-Exeter Development FPSO Water and Sediment Monitoring Survey.

Hart, A., Murphy, D. and Green, K. 2015. Beche-de-mer Fishery Status Report in Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15: The State of the Fisheries eds. W.J. Fletcher and K. Santoro, Department of Fisheries, Western Australia, pp. 39-48.

Hart, A., Travaille, K.L., Jones, R., Brand-Gardner, S., Webster, F., Irving, A. and Harry, A.V. 2016. Western Australian Marine Stewardship Council Report Series No. 5: Western Australian Silver-lipped Pearl Oyster (Pinctada maxima) Industry. Department of Fisheries, Western Australia. 316pp.

Hawkins, A. D. and Popper, A. N. 2016. A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates. – ICES Journal of Marine Science, doi:10.1093/icesjms/fsw205.

Houde ED & Zastrow CE 1993. Ecosystem- and taxon-specific dynamic and energetics properties of larval fish assemblages. Bulletin of Marine Science 53 (2): 290-335.

Inpex 2010 Ichthys Gas Field Development Project Draft Environmental Impact Statement.

IPIECA 2017. A Guide to Oiled Wildlife Response Planning. IPIECA Report series Volume 13. International Petroleum Industry Environmental Conservation Association.

Jenner, K.C.S., M.N. Jenner & K.A. McCabe (2001). Geographical and temporal movements of humpback whales in Western Australian waters. *APPEA journal*. Page(s) 749-765.

Jenssen, BM 1994, 'Review article: Effects of Oil Pollution, Chemically Treated Oil, and Cleaning on the Thermal Balance of Birds', *Environmental Pollution*, vol.86, no. 2, pp. 207–215.

Kaifu, K., T. Akamatsu, and S. Segawa. 2008. Underwater sound detection by cephalopod statocyst. *Fisheries Science* 74(4): 781-786.

Kent, C.S., McCauley, R.D., Duncan, A., Erbe, C. Gavrilov, A. Lucke, K. and Parnum, I. 2016. Underwater Sound and Vibration from Offshore Petroleum Activities and their Potential Effects on Marine Fauna: An Australian Perspective. Centre for Marine Science and Techniology (CMST) Curtin University.

Ketten, D.R., C. Merigo, E. Chiddick, H. Krum, and E.F. Melvin. 1999. Acoustic fatheads: parallel evolution of underwater sound reception mechanisms in dolphins, turtles, and sea birds. *Journal of the Acoustical Society of America* 105(2): 1110.

Ketten, D.R. and S.M. Bartol. 2005. *Functional measures of sea turtle hearing*. ONR project final report. Document Number ONR Award Number N00014-02-1-0510. Office of Naval Research (US).

Klimey, A.P. and Anderson, S.D. 1996. Residency patterns of White Sharks at the South Farrallone Islands, California. In: Great White Sharks: The biology of *Carcharodon carcharias*. A.P. Klimley & D.G. Ainley eds. Academic Press, New York USA. Pp 365 - 373.

Koops, W, Jak, RG & van der Veen, DPC 2004, 'Use of dispersants in oil spill response to minimise environmental damage to birds and aquatic organisms', *Proceedings of the Interspill 2004: Conference and Exhibition on Oil Spill Technology,* Trondheim, presentation 429.

La Bella G, Cannata S, Froglia C, Modica A, Ratti S and Rivas G 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Society of Petroleum Engineers. International Conference on Health, Safety and Environment, New Orleans, Louisiana, 9-12 June, pp. 227-238.

Last P.R., and Stevens J.D. 1994. Sharks and Rays of Australia. CSIRO. Pp. 513.

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2012. Hearing capabilities of loggerhead sea turtles (*Caretta caretta*) throughout ontogeny. *In The Effects of Noise on Aquatic Life*. Springer. 89-92. http://www.soundandmarinelife.org/research-categories/physical-and-physiological-effects-and-hearing/modelling-mysticete-baleen-whale-hearing.aspx.

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2014. Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. *Journal of Experimental Biology* 217(14): 2580-2589. http://jeb.biologists.org/content/217/14/2580.abstract.

LeProvost, Semeniuk and Chalmers 1986. Harriet Field - The Effect of Underwater Seismic Explosions on Pearl Oysters. Report to Apache Energy Ltd; ref: no. H62; document no. EAA-60-RU-002.

Lin, Q & Mendelssohn, IA 1996, 'A comparative investigation of the effects of south Louisiana crude oil on the vegetation of fresh, brackish and Salt Marshes', *Marine Pollution Bulletin*, vol. 32, no. 2, pp. 202–209.

Marchant S., & Higgins PJ. 1990. Handbook of Australian, New Zealand and Antarctic birds, vol. 1, part A: ratites to petrels. Oxford University Press, Melbourne.

Marshall A., Kashiwagi T., Bennett M.B., Deakos M., Stevens G., McGregor F., Clark T., Ishihara H. & Sato K. 2011a. *Manta alfredi*. The IUCN Red List of Threatened Species 2011.

Marshall A., Bennett M.B., Kodja G., Hinojosa-Alvarez S., Galvan-Magana F., Harding M., Stevens G. & Kashiwagi T. 2011b. *Manta birostris*. The IUCN Red List of Threatened Species 2011.

Martin, K.J., S.C. Alessi, J.C. Gaspard, A.D. Tucker, G.B. Bauer, and D.A. Mann. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): A comparison of behavioral and auditory evoked potential audiograms. *Journal of Experimental Biology* 215(17): 3001-3009. http://jeb.biologists.org/content/jexbio/215/17/3001.full.pdf.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adihyta, J. Murdoch, et al. 2000. Marine seismic surveys: A study of environmental implications. *Australian Petroleum Production Exploration Association (APPEA) Journal* 40: 692-708.

McPherson, C., K. Kowarski, J. Delarue, C. Whitt, J. MacDonnell, and B. Martin. 2016a. *Passive Acoustic Monitoring of Ambient Noise and Marine Mammals—Barossa Field: July 2014 to July 2015*. Document Number 00997, Version 1.0. Technical report by JASCO Applied Sciences for ANZ Infrastructure & Environment, Jacobs.

McPherson, C., B. Martin, M. Wood, and A. MacGillivray. 2016b. Long range airgun inter-pulse noise field in offshore northern Australian waters. *The Journal of the Acoustical Society of America* 140(4): 3021-3021. http://asa.scitation.org/doi/abs/10.1121/1.4969370.

McPherson, C.R., M. Wood, and H. Yurk. 2016c. *Effects of Seismic Survey Noise on Marine Fauna, ConocoPhillips Barossa MSS*. Document Number 01104, Version 1.0. Technical report by JASCO Applied Sciences for Jacobs.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M.L. Lenhardt, and R. George. 1994. *Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges, in Sea Turtle Research Program: Summary Report*. *In*: Hales, L.Z. (ed.). Report from U.S. Army Engineer Division, South Atlantic, Atlanta GA, and U.S. Naval Submarine Base, Kings Bay GA. Technical Report CERC-95. 90 pp.

Mollet, H.F., Cliff, G., Pratt Jr, H.L. and Stevens, J.D. 2000. Reproductive Biology of the female shortfin mako, *Isurus oxyrinchus* Rafinesque, 1820, with comments on the embryonic development of lamnoids. Fish. Bull. 98: 299-318.

Mooney, T.A., Hanlon, R.T., Christensen-Dalsgaard, J.,Madsen, P.T., Ketten, D.R., Nachtigall, P.E., 2010. Sound detection by the longfin squid (Loligo pealeii) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure. J. Exp. Biol. 213, 3748–3759.

Montgomery, J.C., A. Jeffs, S.D. Simpson, M. Meekan, and C. Tindle. 2006. Sound as an orientation cue for the pelagic larvae of reef fishes and decapod crustaceans. *Advances in Marine Biology* 51: 143-196.

Myrberg, A.A. 2001. The Acoustical Biology of Elasmobranchs. *Environmental Biology of Fishes* 60(1): 31-46. http://dx.doi.org/10.1023/A:1007647021634.

National Oceanic and Atmospheric Administration. 2010. Oil and Sea Turtles. Biology, Planning and Repsonse. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Ocean Service. Office of Response and Restoration.

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

Nelms, S.E., W.E. Piniak, C.R. Weir, and B.J. Godley. 2016. Seismic surveys and marine turtles: An underestimated global threat? *Biological Conservation* 193: 49-65.

Nichol, S.L., Howard, F.J.F., Kool, J., Stowar, M., Bouchet, P., Radke, L., Siwabessy, J., Przeslawski, R., Picard, K., Alvarez de Glasby, B., Colquhoun, J., Letessier, T. & Heyward, A. 2013. *Oceanic Shoals Commonwealth Marine Reserve (Timor Sea) Biodiversity Survey: GA0339/SOL5650 – Post Survey Report*. Record 2013/38. Geoscience Australia: Canberra.

Northern Prawn Fishery 2017 About our fishery. http://npfindustry.com.au/the-northern-prawn-fishery/ Viewed 9/4/17.

Organisation for Economic Co-operation and Development (OECD) 2002. Chapter 4: Initial Assessment of Data. In OECD, Manual for Investigation of HPV Chemicals, pp. 1-11.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia* 2: 564-567. http://www.jstor.org/discover/10.2307/1446362.

OSPAR Commission. 2009. Overview of Impacts of Anthropogenic Underwater Sound in the Marine Envirnment. London. UK: OSPAR Commission.

OSPAR Commission 2012. OSPAR guidelines in support of recommendation 2012/5 for risk-based approach to the management of produced water discharges from offshore installations. OSPAR Commission, p. 21.

Parry, GD, Heislers, S, Werner, GF, Asplin, MD, Gason, A 2002. Assessment of Environmental Effects of Seismic Testing on Scallop Fisheries in Bass Strait. Marine and Freshwater Resources Institute Report No. 50. Marine and Freshwater Resources Institute, Queenscliff, Victoria.

Parry, G.D. and Gason, A., 2006. The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. Fish. Res. 79, 272–284.

Patterson, H, Noriega, R, Georgeson, L, Stobutzki, I & Curtotti, R 2016, Fishery Status Reports 2016, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 3.0.

Payne, J.F., Andrews, C.A., Fancey, L.L., Cook, A.L., Christian, J.R., 2007. Pilot study on the effects of seismic air gun noise on lobster (Homarus americanus). Can. Tech. Rep. Fish. Aquat. Sci. (No. 2712).

Pearson, W.H., Skalski, J.R., Sulkin, S.D. and Malme, C.I. (1994). Effects of Seismic Energy Releases on the Survival and Development of Zoel Larvae of Dungeness Crab (Cancer magister). Marine Environmental Research 38, 93-113.

Peel, D., Smith, J.N. and Childerhouse, S. 2016a. Historical Data on Australian Whale Vessel Strikes. International Whaling Commission. SC/66b/HIM/05 Rev1.

Peel, D., Kelly, N. Smith, J.N. and Childerhouse, S. 2016b. Marine Biodiversity Hub Project C5 – Scoping of Potential Speicies for Ship Stirke Risk Analysis. Pressures and Impacts. National Envirnmental Science Programme.

Piniak, W.E., D.A. Mann, S.A. Eckert, and C.A. Harms. 2011. Amphibious hearing in sea turtles. *In*: Hawkins, T. and A.N. Popper (eds.). *Proceedings of the 2nd International Conference on the Effects of Noise on Aquatic Life*. August 15-20, 2010. Springer-Verlag. (In Press).

Piniak, W.E.D., D.A. Mann, C.A. Harms, T.T. Jones, and S.A. Eckert. 2016. Hearing in the Juvenile Green Sea Turtle (Chelonia mydas): A Comparison of Underwater and Aerial Hearing Using Auditory Evoked Potentials. *PLOS ONE* 11(10): e0159711. http://dx.doi.org/10.1371%2Fjournal.pone.0159711.

Poiner, I.R. and Harris, A.N.M. 1995. Incidental cpature, direct mortality and delayed mortlaity of sea turtles in Australi's Northern Prawn Fishery. Marine Biology 125:8013.

Popper, A.N., M. Salmon, and K.W. Horch. 2001. Acoustic detection and communication by decapod crustaceans. *Journal of Comparative Physiology A: Neuroethology, Sensory, Neural, and Behavioral Physiology* 187(2): 83-89. http://dx.doi.org/10.1007/s003590100184.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. SpringerBriefs in Oceanography, Volume ASA S3/SC1.4 TR-2014. ASA Press. 87 pp.

Popper, A.N., Gross, J.A., Carlson, T.J., Skalski, J., Young, J.V., Hawkins, A.D., Zeddies, D., 2016. Effects of exposure to the sound from seismic airguns on pallid sturgeon and paddlefish. PLoS One 11, e0159486.

Przeslawski, R., Daniell, J., Nichol, S., Anderson, T. & Barrie, J.V., 2011. Seabed Habitats and Hazards of the Joseph Bonaparte Gulf and Timor Sea, Northern Australia. Record 2011/040. Geoscience Australia, Canberra.

Przeslawski, R., Hurt, L., Forrest, A., Carrol, A. Geoscience Australia. 2016. Potential short-term impacts of marine seismic surveys on scallops in the Gippsland Basin. Canberra. April. CC BY 3.0

Reardon M.B., Gerber L. & Cavanagh R.D. 2006. *Isurus paucus*. The IUCN Red List of Threatened Species 2006.

Reilly S.B., Bannister J.L., Best P.B., Brown M., Brownell Jr. R.L., Butterworth D.S., Clapham P.J., Cooke J., Donovan G.P., Urbán J. & Zerbini A.N. 2008. *Balaenoptera edeni*. The IUCN Red List of Threatened Species 2008.

Richardson, W.J., Greene, C.R., Malme,C.I and Thomson, D.H. 1995. Marine Mammals and Noise. Academic Press. San Diego. 576 p.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences* 64(3): 884-890.

Roberts, L., Cheesman, S., Elliott,M., Breithaupt, T., 2016. Sensitivity of Pagurus bernhardus (L.) to substrate-borne vibration and anthropogenic noise. J. Exp. Mar. Biol. Ecol. 474, 185–194.

Scholten, MCTh, Kaag, NHBM, Dokkum, HP van, Jak, R.G., Schobben, HPM & Slob, W 1996, *Toxische effecten van olie in het aquatische milieu*, TNO report TNO-MEP – R96/230, Den Helder.

Smit, MG, Bechmann, RK, Hendriks, AJ, Skadsheim, A, Larsen, BK, Baussant, T, Shaw, B & Sanni, S 2009, 'Relating biomarkers to whole-organism effects using species sensitivity distributions: A pilot study for marine species exposed to oil', *Environmental Toxicology and Chemistry*, vol. 28, no. 5, pp. 1104-1109.

Simmonds, M.P., Dolman, S.D., Weilgart, L. 2004. Oceans of Noise 2004. Whale and Dolphin Conservation Society, Chippenham, UK.

Steffe, A. and Murphy, J. 1992. The commercial fisheries and oyster cultivation industry of Botany Bay. Report prepared for FAC. Fisheries Research Institute, NSW Fisheries, Sydney, NSW.

Streever, B., S.W. Raborn, K.H. Kim, A.D. Hawkins, and A.N. Popper. 2016. Changes in fish catch rates in the presence of air gun sounds in Prudhoe Bay, Alaska. *Arctic* 69(4): 346-358. http://dx.doi.org/10.14430/arctic4596.

Tsvetnenko, Y 1998, 'Derivation of Australian tropical marine water quality criteria for protection of aquatic life from adverse effects of petroleum hydrocarbons', *Environmental Toxicology and Water Quality*, vol.13, no. 4, pp. 273–284.

Threatened Species Scientific Committee 2014a. Approved Conservation Advice for *Glyphis garricki* (northern river shark).

Threatened Species Scientific Committee 2014b. Approved Conservation Advice for *Pristis pristis* (largetooth sawfish).

Threatened Species Scientific Committee 2014c. Listing Advice Isurus oxyrinchus *shortfin mako shark.*

Wever, E.G. 1978. *The reptile ear: Its structure and function*. Princeton University Press, Princeton, N.J.

Weir, C. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. *Marine Turtle Newsletter*, 116: 17-20.

WDCS. 2006. Vessel Collisions and Cetaceans: What happens when they don't miss the boat. Whale and Dolphin Society. United Kingdon.

Whiting, A.U., Thomson, A., Chaloupka, M. and Limpus, C.J. 2008. Seasonality, abundance and breeding biology of one of the largest populations of nesting flatback turtles, *Nator depressus*: Cape Domett, Western Australia. Australian Journal of Zoology. 56: 297 – 303.

Willis, K.L. 2016. Underwater Hearing in Turtles. *In* Popper, N.A. and A. Hawkins (eds.). *The Effects of Noise on Aquatic Life II*. Springer New York, New York, NY. 1229-1235. http://dx.doi.org/10.1007/978-1-4939-2981-8_154.

Yudhana, A., J.D. Sunardi, S. Abdullah, and R.B.R. Hassan. 2010. Turtle hearing capability based on ABR signal assessment. *Telkomnika* 8: 187-194.