BETHANY 3D SEISMIC SURVEY

ENVIRONMENT PLAN SUMMARY

TABLE OF CONTENTS

APPENDICES

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 Dimensional
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
BIA	Biologically Important Area
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 former
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
FPZ	Full Power Zone
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
MP	Marine Park
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NST	Northwest Shelf Transition
NT DPIR	Northern Territory Department of Primary Industry and Resources
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*
OSMP	Oceanic Shoals Marine Park
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
WA	Western Australia

1 INTRODUCTION

1.1 Scope of this EP

Santos Offshore Pty Ltd (Santos) is planning to undertake the Bethany 3 dimensional (3D) Seismic Survey over the NT/P85 and NT/P82 exploration permits. Both permits are within Commonwealth waters within the Joseph Bonaparte Gulf off Northern Territory waters.

Santos will undertake the Bethany survey for and on behalf of the:

- titleholders of NT/P85 - being Santos and Origin Energy Resources Limited (Origin); and
- titleholder of NT/P82 - being Magellan Petroleum (Offshore) Pty Ltd (Magellan).

The above titleholders' details are listed in Table 1-1 below.

This environment plan has been prepared in accordance with the requirements of the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and associated Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regs). It has also been prepared with reference to the Environment Plan Content Requirements Guidance Note (Rev 3, April 2016) produced by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.2 Titleholder

Table 1-1 provides details of the Bethany survey titleholders and the titleholders' nominated liaison person.

Santos has entered into an Operations Services Agreement with Magellan (the titleholder of NT/P82) under which Magellan authorises the carrying out of the Bethany survey over NT/P82 on Magellan's behalf, and access to NT/P82 for that purpose.

Santos will undertake the Bethany survey on behalf of the titleholders of NT/P85 and NT/P82, it will be Santos' management systems and processes that will apply during the course of the Bethany survey. These systems and processes are detailed in Section 8 Implementation Strategy.

As per Section 8.4, in the event that there is a change in the titleholders, the titleholder's nominated liaison person or a change in the contact details for the titleholder or liaison person, Santos will notify NOPSEMA and provide the updated details.

Table 1-1: Titleholder and Nominated Liaison Person

Titleholder Details	Liaison Person Details
NT/P85 Name: Santos Offshore Pty Ltd 60 Flinders Street, Adelaide, SA 5000 Telephone number: 08 8116 5000 ACN: 005 475 589 Name: Origin Energy Resources Limited Level 3, 135 Coronation Drive, Milton Queensland 4064 Telephone number:07 3858 0202 ACN: 007 845 338 **NT/P82** Name: Magellan Petroleum (Offshore) Pty Ltd Level 5, 9 Sherwood Road, Toowong, Queensland 4066 Telephone number: 0458 333 307 ACN: 105 292 644	Michael Giles Manager, Operations Geophysics Santos Offshore Pty Ltd 60 Flinders St, Adelaide, SA, 5000 08 9363 9113 Email: michael.giles@santos.com

2 ENVIRONMENT REQUIREMENTS

This section provides information on the requirements that apply to the activity and how they apply to the activity. Requirements include relevant laws, codes, other approvals and conditions, standards, agreements, treaties, conventions or practices (in whole or part) that apply to jurisdiction that the activity takes place in.

The Bethany Seismic Survey will take place within Commonwealth waters. The impact assessment undertaken and documented in Section 7 did not identify any impacts or risks to State or Territory waters.

There are no other approvals and conditions that apply to the survey.

Relevant requirements associated with the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), related policies, guidelines, plans of management, recovery plans, threat abatement plans and other relevant advice issued by the Department of Environment and Energy (DoEE) are detailed in the applicable sections within Section 5 as part of the description of the existing environment.

Table 2-1 provides a summary of requirements that apply to the activity and are relevant to the activity's environmental management.

Table 2-1: Summary of Requirements Relevant to the Activity and its Environmental Management

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
Australian Maritime Safety Authority Act 1990	Facilitates international cooperation and mutual assistance in preparing and responding to major oil spill incidents, and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies.	In Commonwealth waters AMSA is the Statutory Agencies for vessels and must be notified of all incidents involving a vessel. *Section 8.7 details this requirement.* In Commonwealth waters AMSA is the Control Agency for all ship-sourced marine pollution incidents and will respond in accordance with its Marine Pollution Response Plan. Santos has a MoU with AMSA on Support for Oil Spill Preparedness and Response. *These arrangements are detailed in Section 7.3 of the OPEP.*	Australian Maritime Safety Authority (AMSA)
Biosecurity Act 2015 Biosecurity Regulations 2016	The objects of this Act are: (a) to provide for managing the following: (i) biosecurity risks; (ii) the risk of contagion of a listed human disease; (iii) the risk of listed human diseases entering Australian territory or a part of Australian territory, or emerging, establishing themselves or spreading in Australian territory or a part of Australian territory; (iv) risks related to ballast water; (v) biosecurity emergencies and human biosecurity emergencies; (b) to give effect to Australia's international rights and obligations, including under the International Health Regulations, the SPS Agreement and the Biodiversity Convention.	The Biosecurity Act and regulations apply to 'Australian territory' which is the airspace over and the coastal seas out to 12 nm from the coast line. *Biosecurity risks associated with the survey are detailed in Section 7.10*	Department of Agriculture and Water Resources (DAWR)
Biosecurity Act 2015, as amended by the Biosecurity Amendment (Ballast Water and	Australian Ballast Water Management Requirements (DAWR 2016)	The Australian Ballast Water Management Requirements set out the obligations on vessel operators with regards to the management of ballast water and ballast tank sediment when operating within Australian seas. These requirements include legislative obligations under the: • Biosecurity Act 2015 (Biosecurity Act), and	DAWR

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
Other Measures) Act 2017.		• International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention). The Australian Ballast Water Management Requirements also provide guidance for vessel operators on best practice policies while in Australia. The requirements apply to all vessels operating internationally and domestically in Australia. *Section 7.10* details these requirements.	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act aims to protect the environment, particularly matters of national environmental significance for which Australia has made international agreements. The Act streamlines national environmental assessment and approval processes, and promotes ecologically sustainable development and conservation of biodiversity. It also provides for a cooperative approach to the management of natural, cultural, social and economic aspects of ecosystems, communities and resources.	Petroleum activities are excluded from within the boundaries of a World Heritage Area (Sub regulation 10A(f). *Section 5.2 details that the survey is not within the boundaries of a World Heritage Area.* The EP must describe matters protected under Part 3 of the EPBC Act and assess any impacts and risks to these. *Section 5 describes matters protected under Part 3 of the EPBC Act.* *Section 7 provide an assessment of any impacts and risks to matters protected under Part 3 of the EPBC Act.*	Department Environment and Energy (DoEE)
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Section 3A of the Act defines the principles of ecological sustainable development. The following principles are principles of ecologically sustainable development : (a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations; (b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation; (c) the principle of inter-generational equity--that the present generation should ensure that the health, diversity and productivity of	Petroleum activities must be carried out in a manner consistent with the principles of ecological sustainable development set out in Section 3A of the EPBC Act. *Section 6.10 Determination of Impact and Risk Acceptability details that residual risks between 2 and 4 need to show that ALARP is demonstrated and the principles of ecologically sustainable development have been met.*	Department Environment and Energy (DoEE)

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
	the environment is maintained or enhanced for the benefit of future generations; (d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; (e) improved valuation, pricing and incentive mechanisms should be promoted.		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Policy Statement 2.1 Interaction between offshore seismic exploration and whales	The aim of this Policy Statement is to: 1. provide practical standards to minimise the risk of acoustic injury to whales in the vicinity of seismic survey operations; 2. provide a framework that minimises the risk of biological consequences from acoustic disturbance from seismic survey sources to whales in biologically important habitat areas or during critical behaviours; and 3. provide guidance to both proponents of seismic surveys and operators conducting seismic surveys about their legal responsibilities under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)1.	The policy statement provides guidance on undertaking seismic activities in Australian waters to limit potential impacts to whales. *Section 7.1 details how the policy statement has been applied to this survey.*	Department Environment and Energy (DoEE)
Environment Protection and Biodiversity Conservation Regulations 2000	Provides additional regulations in regards to Matters of National Environmental Significance.	Part 8 of the Regulations details requirements for operating vessels and aircraft in relation to cetaceans. The requirements are detailed in the Australian National Guidelines for Whale and Dolphin Watching (DEWHA, 2005) *Section 7.2 and 7.8 detail these requirements.*	Department Environment and Energy (DoEE)
Historic Shipwrecks Act 1976	Protects the heritage values of shipwrecks and relics (older than 75 years) below the low water mark.	Anyone who finds the remains of a ship, or an article associated with a ship, needs to notify the relevant authorities, as soon as possible but ideally no later than after one week, and to give them information about what has been found and its location. *Section 5.8 details that there are no historic shipwrecks near or within the permit areas.*	Department Environment and Energy (DoEE)

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
Navigation Act 2012	Regulates international ship and seafarer safety, shipping aspects of protecting the marine environment and the actions of seafarers in Australian waters. It gives effect to the relevant international conventions (MARPOL 73/78, COLREGS 1972) relating to maritime issues to which Australia is a signatory. The Act also has subordinate legislation contained in Regulations and Marine Orders.	COLREGS - International Regulations for Preventing Collisions at Sea - Rule 27 covers light requirements for vessels not under command or restricted in their ability to manoeuvre. Several Marine Orders (MO) are enacted under this Act relating to offshore petroleum activities, including: MO Part 21: Safety of navigation and emergency procedures MO Part 27: Radio equipment MO Part 30: Prevention of collisions MO Part 31: Vessel; Surveys and Certification MO Part 32: Cargo handling equipment MO Part 59: Offshore Support Vessel Operations *Section 7 detail were the applicable requirements apply to the survey.*	AMSA
Offshore Petroleum and Greenhouse Gas Storage Act 2006 Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009	Addresses all licensing, health, safety, environmental and royalty issues for offshore petroleum exploration and development operations extending beyond the three nautical mile limit. Ensures that petroleum activities are undertaken in an ecologically sustainable manner and in accordance with an approved EP.	A titleholder must have an in force EP prior to the commencement of any petroleum activity. *This requirement is met by submission and acceptance of this EP.* A significant modification, change or new stage of an existing activity that is not included in an in force EP requires a revision of the EP to be submitted to NOPSEMA for acceptance. *Section 8.4 details this requirement.* Titleholders are required to maintain financial assurance sufficient to give the titleholder carrying out the petroleum activity, the capacity to meet the costs, expenses and liabilities that may result in connection with carrying out the petroleum activity; doing any other thing for the purpose of the petroleum activity; or complying (or failing to comply) with a requirement under the OPGGS Act in relation to the petroleum activity. *This requirement is required to be met by the titleholder before NOPSEMA can accept the EP.*	NOPSEMA
NOPSEMA Guidance Note: Activities within Commonwealth Marine Reserves (2015)	Outlines the management status of Australian Marine Parks (AMP) and the implications of this for the management of petroleum activities in and around AMPs.	The activity is within the Oceanic Shoals MP which is classed as a "Type B" MP where general approvals have been issued by the DNP allowing mining activities in these reserves until management plans come into effect. Titleholders preparing EPs that involve planned or emergency response activities within, or with potential to impact on, this MP type should have regard to the Australian IUCN reserve management principles relevant to each zone within the MP.	NOPSEMA

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
		Section 5.9 describes the Oceanic Shoals Marine Park, the zoning and given the absence of a management plan, includes an evaluation against the ICUN reserve management principles.	
Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Act 2003 Offshore Petroleum and Greenhouse Gas Storage (Regulatory Levies) Regulations 2004	An Act to impose levies relating to the regulation of offshore petroleum activities and greenhouse gas storage activities.	Requires that EP levies are imposed on EP submissions, including revisions, where the activities to which the EP relates are authorised by one or more Commonwealth titles. *This requirements applies once the EP is accepted.*	NOPSEMA
Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area	Under the OPGGS (Environment) Regulations, a titleholder is required to consult with each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan may be relevant. The Australian Government has developed guidance for titleholders to assist in determining which agencies may be relevant for consultation purposes in developing or revising environment submissions.	Provides guidance as to which Commonwealth Departments or agencies are potentially relevant stakeholders and how to consult with. The guidance document also details reporting requirements to Commonwealth Departments or agencies. *Section 4 describes the Commonwealth Departments or agencies identified as potential relevant stakeholders using this guidance.* *Section 8 details any reporting requirements identified.*	DIIS
Protection of the Sea (Prevention of Pollution from Ships) Act 1983	Regulates ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc.	Provides exemptions for the discharge of materials in response to marine pollution incidents. Requires ships greater than 400 gross tonnes to have pollution emergency plans. Provides for discharges and emissions from ships as per MARPOL Annex I, II, III, IV, V and VI. Several Marine Orders are enacted under this Act relevant to the activity, including: MO Part 91: Marine Pollution Prevention - Oil MO Part 93: Marine Pollution Prevention – Noxious Liquid Substances MO Part 94: Marine Pollution Prevention – Harmful Substances in Packaged Forms	AMSA

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
		MO Part 95: Marine Pollution Prevention - Garbage MO Part 96: Marine Pollution Prevention – Sewage (MARPOL Annex IV) MO Part 97: Marine Pollution Prevention – Air Pollution MO Part 98: Marine Pollution Prevention – Anti-fouling Systems. *Section 7 detail were the applicable requirements apply to the survey.*	
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Is an offence to engage in negligent conduct that results in a harmful anti-fouling compound being applied to a ship. Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria.	If required a ship must have a current anti-fouling certificate and must not use harmful antifouling compounds. The Marine Order MO Part 98: Marine Pollution Prevention – Anti-fouling Systems is enacted under this Act. *Section 7.10 detail these requirements.*	AMSA
International Association of Geophysical Contractors (IAGC) Environment Manual for Worldwide Geophysical Operations (2013)	Provides the industry with useful information for conducting geophysical field operations in an environmentally sensitive manner.	Provide guidelines for best practice operations of seismic surveys to minimise environment impacts. *Section 7 details applicable guidance.*	IAGC
International Maritime Organisation (IMO) Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) 2011	Provide a globally consistent approach to the management of biofouling. They were adopted by the Marine Environment Protection Committee (MEPC) in July 2011 and were the result of three years of consultation between IMO Member States	Specific requirements are that vessels have a biofouling management plan and biofouling record book. *Section 7.10 detail these requirements.*	International Maritime Organisation (IMO)
Draft National Strategy for Mitigating Vessel	The overarching goal of the Strategy is to provide guidance on understanding and reducing the risk of vessel collisions and the	Though in draft the strategy provides information and guidance on reducing vessel collisions with marine mega-fauna. *Section 7.8 detail applicable information and requirements.*	DoEE

Requirements	Scope	How it Applies to the Activity or Activity's Environmental Management	Administering Authority
Strike of Marine Mega-fauna	impacts they may have on marine mega-fauna.		

3 DESCRIPTION OF THE ACTIVITY

3.1 Activity Overview

Santos Offshore Pty Ltd (Santos) proposes to undertake the Bethany 3 dimensional (3D) seismic survey over the NT/P85 and NT/P82 permits in Commonwealth waters off Northern Territory.

The Bethany 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.

The full power zone (FPZ), where the survey acquisition will take place, is approximately 4,565 km^2 with a larger operational area (12,610 km^2) around it to allow for vessel turn-arounds and testing of equipment.

Water depths in the operational area range from 20 to 202 m.

The survey will take a maximum of 75 days and will be undertaken within the period of 1 May to 30 September 2018 or 2019.

3.2 Location

The Bethany survey will take place within Commonwealth waters off the Northern Territory coast within the Joseph Bonaparte Gulf (Figure 3-1). The survey area is located approximately 250 km north-west from Darwin, and approximately 70 km from Melville Island (closest emergent feature).

3.3 Survey Area

The the following areas have been defined for the survey:

- NT/P82 and NT/P85 permit areas - which are approximately 13,287 km^2.
- Full power zone (FPZ) – this is the area in which the survey vessel will travel along pre-determined lines, towing the streamers and releasing sound waves with the seismic source at full power. Outside this area the seismic source will be either powering down to one source (from ~ 2,380 in^3 to ~ 40 in^3) as it leaves the full power zone or powering up as it prepares to re-enter the full power zone. This area is approximately 4,565 km^2.
- Survey operational area – this is outside the full power zone and is where activities like set-up, testing of equipment and vessel turn-arounds (to undertake the next line) take place. This area is approximately 12,610 km^2.

Coordinates for the full power zone and operational area are in Figure 3-2.

3.4 Timing

The Bethany survey will take a maximum of 75 days and be undertaken within the period of 1 May to 30 September 2018 or 2019.

3.5 Seismic Activity

The Bethany 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 3-3 and Figure 3-4 detail the Bethany survey equipment and process as described below and a summary of the survey and equipment parameters is provided in Table 3-1. The survey will be conducted 24 hours a day.

The survey vessel will travel along a series of pre-determined lines within the survey area (Figure 3-1) at a speed of approximately 4.5 - 5 knots (8-9 km/hour). The vessel will tow two or three sound wave source units, and cables (known as streamers) containing microphones (known as hydrophones). The sound source units operate alternately, with one discharging compressed air as the other recompresses. As the vessel travels along the lines, sound waves will be directed down through the water and into the geology below the seabed at 12.5 m intervals (approximately every 5.4 seconds).

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 200 km long and will take approximately 27 hours to acquire and turn around. The time required to complete each sail line is dependent on vessel speed and currents. The sail lines are proposed to be in an east-west direction starting from the northern lines moving south.

3.5.1 Infill

When acquiring 3D marine seismic data, surface currents may shift the streamers away from their nominal positions. This shift, called feathering, can lead to holes in the data coverage. Holes in data coverage can also occur when the airgun array is turned off due to technical or logistical reasons (e.g. technical problems or marine fauna interactions). These holes are typically filled in by steering the vessel closer to the previous sail-line or by acquiring additional sail-lines along the coverage holes. These extra sail-lines are commonly known as infill. Infill can be a large part of the time and cost for a marine seismic survey—infill acquisition on a typical 3D survey can account for up to 25% or more of the total time on prospect. Without infill activity, seismic surveys would be incomplete, the data compromised and client contract requirements not fulfilled.

It is not possible to estimate what the amount of feather (and resulting coverage) will be. Initially, the pre-plot lines are acquired, with the vessel returning later to acquire adjacent to the existing coverage. Typically, pre-plot sail lines will be completed and the infills are left to the end of a survey, once the seismic data have been partially processed and all infill locations identified.

With proper infill management, unnecessary infill lines may be reduced or avoided. The on-board navigator steers the seismic vessel for coverage to minimise the amount of infill. Additionally, steerable streamers and fan-mode technique for the streamer spread are used to minimise infill requirements.

3.6 Seismic Source Justification

The seismic source is comprised of a number of airguns of varying volumes, distributed in an array such that the primary energy is directed downwards into the subsurface (not horizontally away from the source). The total volume size of the airgun array has been chosen based on the range of water depths within the survey area, and depth of the target within the subsurface to ensure adequate seismic imaging.

The initial design for the survey was to use a 3,480 in^3 with an operating pressure of 2000 psi. Discussions with seismic operators identified that a smaller source array of ~ 2,380 in^3 was available that would still achieve the technical objectives for the desired range of target depths. Thus, the smaller ~ 2,380 in^3 will be used for the Bethany survey.

3.7 Survey Vessels

3.7.1 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 3-5 is representative of the type of vessel that will be used.

3.7.2 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 3-6 and Figure 3-7 show representative support vessels.

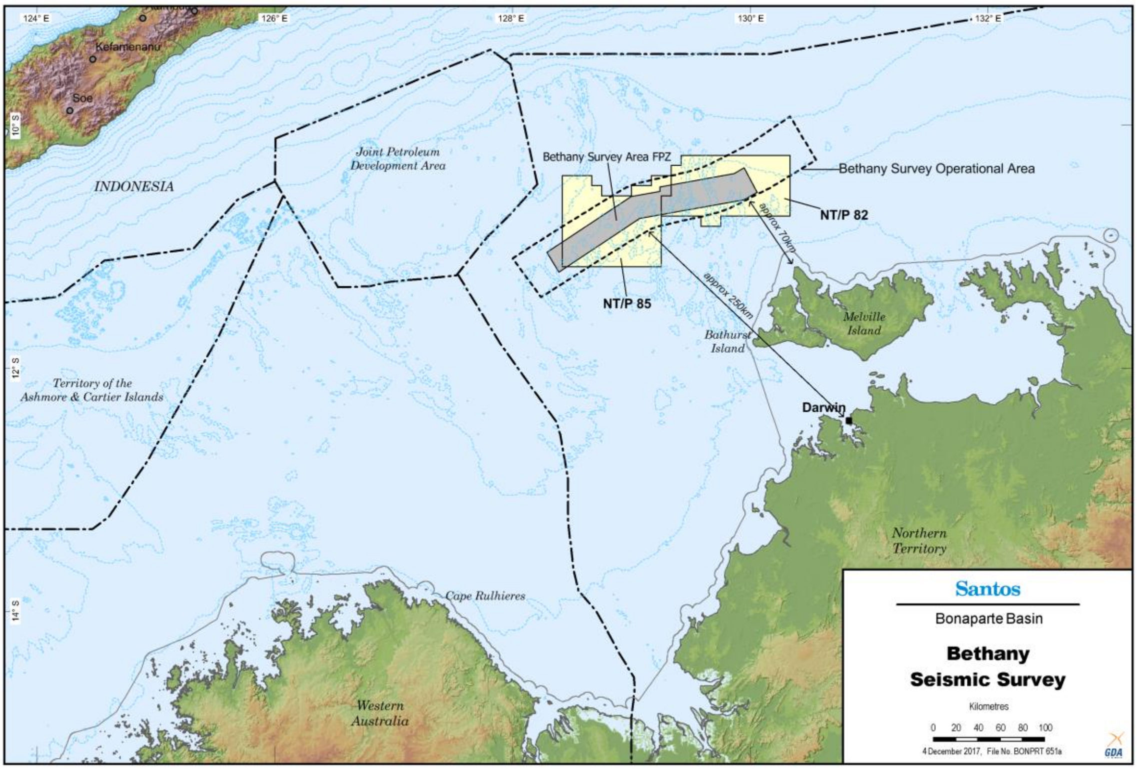


Figure 3-1: Location of Bethany Seismic Survey Areas

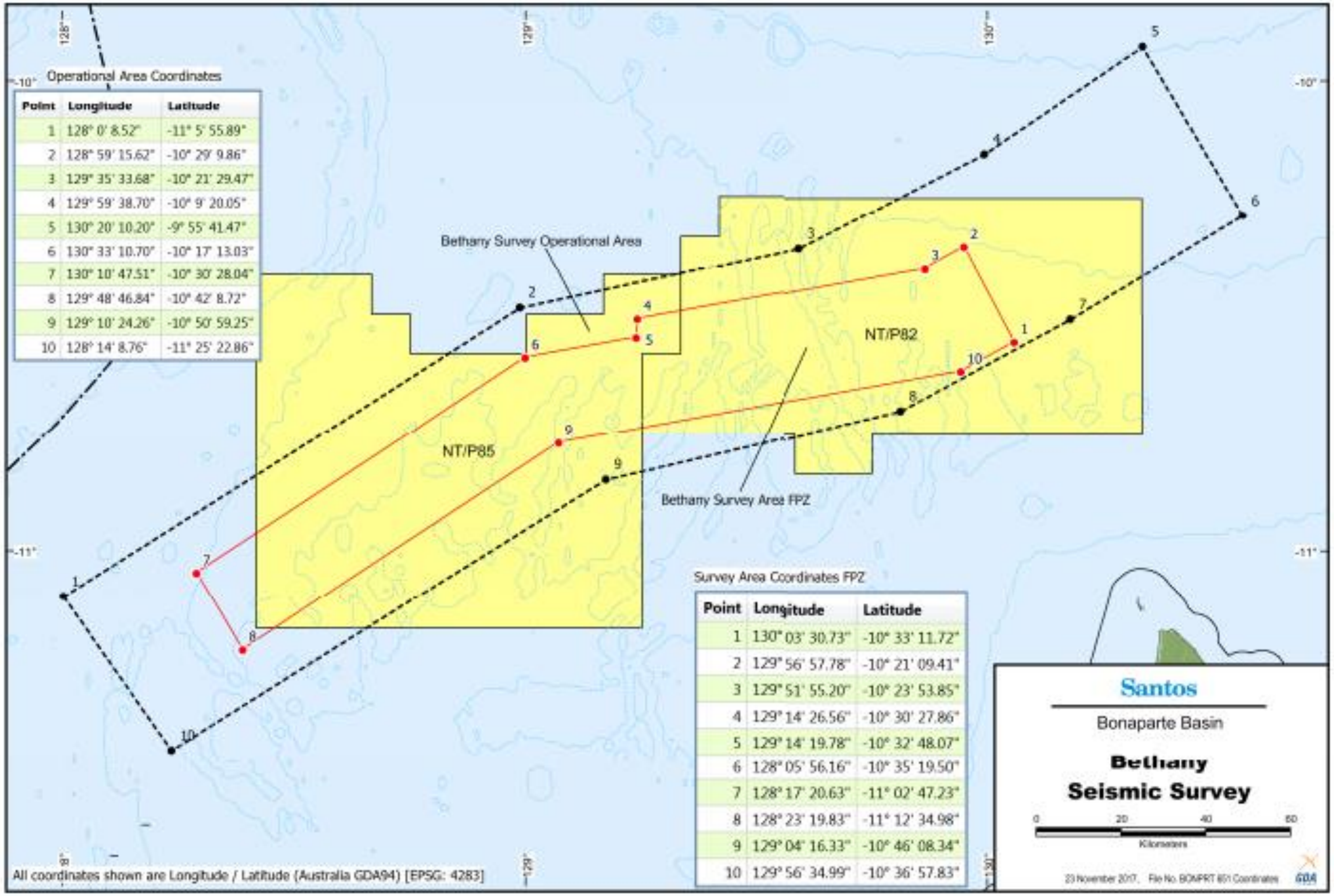


Figure 3-2: Bethany Operational Area and Full Power Zone Coordinates

Table 3-1: Bethany Seismic Survey Parameters

Parameter	Bethany Seismic Survey
NT/P85 and NT/P82 area	13,287 km^2
Full power zone	4565 km^2
Operational area	12,610 km^2
Survey earliest commencement date	1 May 2018 or 2019
Survey latest completion date	30 September 2018 or 2019
Duration of survey	75 days
Length of sail lines	200 km
Time to traverse a sail line	~ 27 hours
Distance between acquisition lines	600 m
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	~ 2,380 in^3
Sound source tow depth	~ 6 m

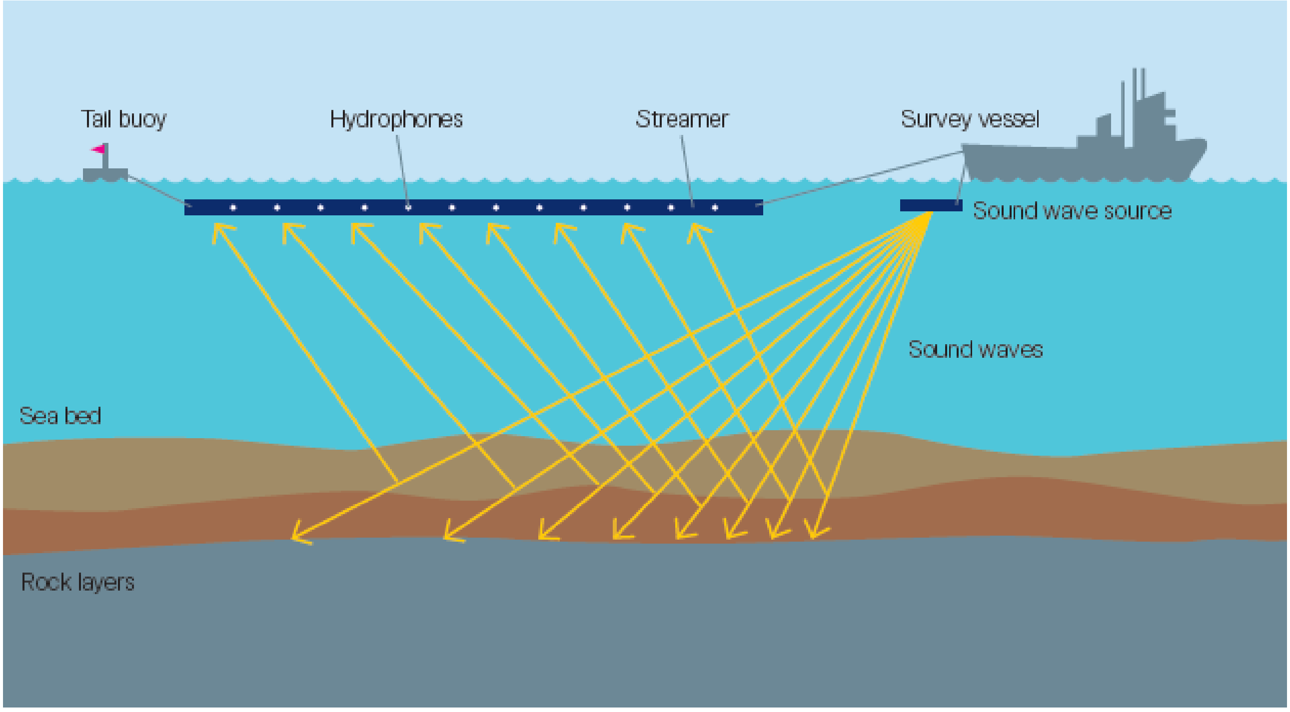


Figure 3-3: Bethany Survey Equipment and Process Vertical View

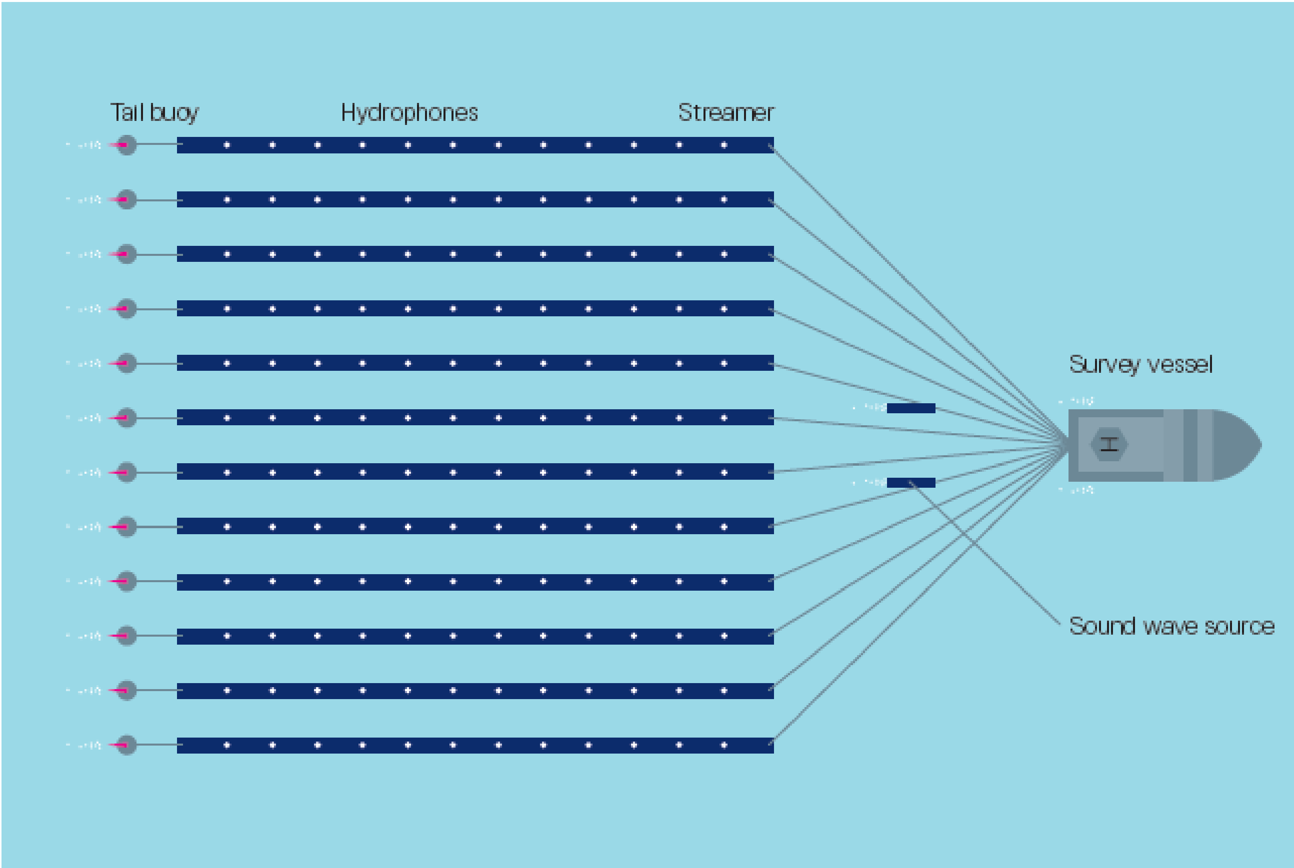


Figure 3-4: Bethany Survey Equipment and Process Horizontal View

Figure 3-5: Polarcus Asima Seismic Survey Vessel

Figure 3-6: Crest Voyager Support Vessel

Figure 3-7: Empress Marine Support Vessel

4 CONSULTATION

The principal objectives of consultation undertaken for the Bethany survey is:

- Identify relevant stakeholders.
- Initiate and maintain open communications between relevant stakeholders and Santos.
- Identify, establish and implement stakeholder engagement tools for initial and on-going communications.
- Establish an open and transparent process for input.
- Proactively seek agreement with relevant stakeholders on recommended strategies to minimise negative impacts and maximise positive impacts of the activity.
- Provide a means for recording initiatives in which communication and/or consultation is undertaken, issues raised and responses recorded.

Stakeholder consultation has been guided by the following:

- NOPSEMA Decision-Making Guideline – Criterion-10A(g) Consultation Requirements
- APPEA Stakeholder Consultation and Engagement Principles and Methodology - Draft

The consultation process undertaken by Santos for the Bethany survey is detailed in Table 4-1 with a summary of the consultation in Table 4-2. The Stakeholder Consultation Records (Appendix 2) contain the detailed records of correspondence. Section 4.1 details the ongoing consultation required.

For the consultation process Santos has used the requirements in the OPGGS (Env) Regulations in regards to a relevant person:

- Each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;
- Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant;
- The Department of the responsible State Minister, or the responsible Northern Territory Minister;
- 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;
- Any other person or organisation that the titleholder considers relevant.

4.1 Ongoing Consultation

4.1.1 Notifications

From the stakeholder consultation undertaken, and documented in Table 4-2 and Appendix 2 Stakeholder Consultation Records, the following notifications and ongoing consultation is required.

- Notify Australian Hydrographic Service (datacentre@hydro.gov.au), AMSA (rccaus@amsa.gov.au) and ADF Airspace (ADF.Airspace@defence.gov.au) 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 the survey.
- Notify Defence upon cessation of acquisition and completion of survey.
- Notify NT Department of Primary Industry and Resources 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.
- Send AMOSC a copy of the Bethany OPEP once accepted and notify of when survey starts and finishes.

- Provide the following stakeholders with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
  - Amateur Fishermen's Association of the NT Executive Officer
  - Aquarium Fishery Chair of the Licensee Committee
  - ConocoPhillips
  - Director of National Parks
  - Northern Prawn Fishery
  - Northern Territory Seafood Council
  - PGS
  - Pearl Producers Association
  - Spanish Mackerel Licensee Committee Chair
  - Spanish Mackerel Licensee (one licensee asked to be kept informed)
  - TGS
  - Timor Reef and Demersal Fishery Licensees – relevant to area
  - Tiwi Land Council

At a minimum the daily report will include:

- Current survey vessel position
- 72 hour look ahead for survey activities and location
- Support vessel activities and location
- Contact details for the survey and support vessel

When stakeholders are notified of the survey start date (2 weeks before starting) they will be asked if they require a daily report (or another time period), how they want to receive the report and what information they require.

Note: the 2 weeks' notice is a pre-start notification, not a consultation period for provision of information to new relevant persons.

4.1.2 Ongoing Identification of Relevant Persons

Santos will continue to identify new relevant persons, prior to the Bethany survey commencing and during the life of the EP.

Should new relevant persons be identified prior to, or during the survey, these stakeholders will be contacted, provided information about the survey and invited to make comment.

New relevant persons may be identified during the course of ongoing consultation with existing relevant persons, or if new relevant persons makes themselves known to Santos and express an interest in the survey.

In addition, Santos will:

- Review relevant stakeholders during the EP review and verification process outlined in Section 8.4.2 (4 weeks prior to commencement of the survey and annually from the date of acceptance of the EP), including contacting the NT Department of Primary Industry and Resources to confirm if there are any new fishery licence holders; and
- Ask stakeholders to advise Santos of any changes in their contact person or contact details or any known new relevant persons when providing the 2 weeks' pre-start notification identified in Section 4.1.1 above.

If new relevant persons are identified, Table 4-2 will be updated to include any new relevant persons and the revised table will be incorporated into the latest revision of the EP.

If any new relevant persons are identified Santos will provide them with:

- the EP Public Summary;
- the latest revision of the complete EP, if requested;
- any additional information required by the stakeholder.

This information is considered sufficient for any new relevant persons to allow them to make an informed assessment of the possible consequences of the activity on their functions, interests or activities.

If any new objections or claims are raised following provision of this information, Santos will consider the merits of these objections and claims and provide a response to the stakeholder. All objections/claims received from stakeholders, and the assessments of the merits of these objections/claims, will be recorded in the Stakeholder Consultation Records (Appendix 2).

In accordance with the Santos Offshore Environment Management of Change (MoC) Process described in Section 8.4, if any new objection or claim is deemed to be valid it will be identified as an environmentally relevant change (see Section 8.4.2). If this new environmentally relevant change 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, this EP will be revised and submitted for re-assessment and acceptance by NOPSEMA, in accordance with the MoC Process described in Section 8.4.

4.1.3 Ongoing Provisions of Additional Information

Section 8.4.1 describes the process that Santos will implement for periodic evaluation of this EP. If this review process identifies an environmentally relevant change that may have an influence on a relevant person's assessment of the possible consequences of the activity on their functions, interests or activities, then Santos will inform them of the change as soon as is practicable. In accordance with the process described in Section 4.1.2 above, if any new objections or claims are raised following provision of this information, Santos will consider the merits of these objections and claims and provide a response to the stakeholder.

Table 4-1: Bethany Survey Consultation Process

Stage	Timing	Santos	Information	Stakeholder	Details
Early Notification	2015/ 2016	Identified potentially affected stakeholders via: • Existing relationship • Peak bodies • Govt departments • NOPSEMA EP Summary website	Information provided to potentially affected stakeholders via email and meetings, such as: • Map and coordinates of survey area • Area of survey • Timing • Water depth	Advised Santos if operate in area and whether any issues	Stakeholders were identified by • Engagement with other oil and gas operators as part of the Bonaparte Operators Group whose participants include Santos, Origin, ConocoPhillips, Melbana and Magellan. • Review of petroleum activity Environment Plan Summaries available on the NOPSEMA website. • Participation in the Bonaparte Fishing Group Roundtable whose participants include Shell, ENI, Origin, ConocoPhillips, NT Seafood Council, Charles Darwin University, Australian Institute of Marine Science, CSIRO, AFMA, NT Department of Primary Industry and Fisheries (now Primary Industry and Resources). • Participation in the APPEA Oil & Gas – Commercial Fishing Industries' Associations Cross Industry Roundtable whose participants include APPEA, Inpex, Exxon, ConocoPhillips, Seafood Industry Vic, Commonwealth Fishing Association, WA Fishing Industry Council, Pearl Producers Association, International Association of Geophysical Contractors and Wildcatch SA. • Engagement with government departments and fishing associations. During this phase stakeholders were given general information about the survey such as location map and coordinates to determine if they operated in the area, had any issues or if they wanted further information when available. From this identification process a list of potential relevant stakeholders was developed (Table 4-2). At this stage, based on the information provided from stakeholders, some stakeholders were assessed as not being relevant and no further consultation with those stakeholders was required.
Commencement of Environment	Oct 2016	Notification of commencement of EP	Sent Information Sheet #1 to stakeholders detailing:	Advise Santos:	Information Sheet #1 sent to potential relevant stakeholders identified during the early notification

Stage	Timing	Santos	Information	Stakeholder	Details
Plan (EP) Preparation and Related Consultation		preparation and consultation	• Activity description • Timing • Location • Contact person	• If further consultation is required • Areas of concern • Preferred method of consultation going forward • Type of information desired	phase, excluding those stakeholders that had already been identified as not relevant.
	Nov 2016	Follow-up with stakeholders that have not provided feedback in regards to sending Information Sheet #1.		Provide feedback to Santos as per above.	Information Sheet #1 was resent to potential relevant stakeholders who had not already replied. Where available an alternative method of contact was used.
	Dec 2016	Follow-up with stakeholders that have not provided feedback in regards to sending Information Sheet #1.		Provide feedback to Santos as per above	Information Sheet #1 was resent to potential relevant stakeholders who had not already replied. Where available an alternative method of contact was used.
Provide relevant information due to change	Jan 2017	Provide information to relevant person so they can determine how their functions, interests and activities may be affected. Due to a change to the Bethany survey area Information Sheet #2 was sent to all stakeholders who received Information Sheet #1.	Information Sheet #2 was sent to all stakeholders detailing: • Change to Bethany survey as will cover NT/P85 and NT/P82 • Description of activity • Timing • Location • Description of environment • Potential risks and impacts Proposed controls and management strategies • Stakeholder engagement process	Advise Santos of impacts on functions/interest/ activities, and any claims or objections. Request further information as required	Due to a change to the Bethany survey area Information Sheet #2 was sent to all stakeholders who received Information Sheet #1. This reinitiated the process to identify any relevant stakeholders and if the new survey area had an impact on their functions/interest/ activities, and if they had any claims or objections.
	Mar 17	Follow-up with stakeholders that have not provided feedback in regards to sending Information Sheet #2.		Provide feedback to Santos as per above.	Information Sheet #2 was resent to potential relevant stakeholders who had not already replied. Where available an alternative method of contact was used.

Stage	Timing	Santos	Information	Stakeholder	Details
Identification of relevant persons	Nov 16 – Mar 17	Identify relevant persons based on the feedback from stakeholders during early, commencement of EP and provide relevant information due to change notifications phases.	Stakeholder Engagement Plan detailing for each relevant person: • Relevant functions, interest or activities • Area of interest or concern • Ongoing form of engagement		Based on the information provided from stakeholders or if there had been no reply to the three attempts to elicit a response, some stakeholders were assessed as not being relevant and no further consultation with those stakeholders was required. Other stakeholders were identified as relevant and more detailed information was made available. As there was only a small number of relevant stakeholders requiring different information, tailored information for each stakeholder was provided rather than a generic information sheet as provided in Information Sheet #2.
Provide relevant information	Nov 16 – Jan18	Provide information to relevant person so they can determine how their functions, interests and activities may be affected.	Tailored to each stakeholder.	Advise Santos of impacts on functions/interest/ activities, and any claims or objections. Request further information as required	Tailored information provided to each relevant stakeholder
Collate, assess and address issues raised and provide response to Stakeholders	Nov 16 – Mar 18	Assess stakeholder's claims or objections	Provide information as to how stakeholder's claims or objections addressed and documented in the EP	Advise Santos if claims or objections adequately addressed or further engagement required	Engagement with some relevant stakeholders was ongoing to further understand any objections or claims. The EP was updated where relevant and consultation records collated.
Submission of EP	Jan 18	Submission of EP to NOPSEMA	Email notification from Santos to relevant persons. Email notification from NOPSEMA portal if registered.	For information	Consultation with those relevant stakeholders who want to be informed of when the EP submitted.
Provide relevant information due to change	Sept 17 - Mar 18	Provide information to relevant person so they can determine how their functions, interests and activities may be affected.	Email notification from Santos to relevant persons.	Advise Santos of impacts on functions/interest/activities, and any claims or objections. Request further information as required.	Email notification from Santos to AMSA and AHS informing them of a change to the proposed timing of acquisition of the survey.
EP Acceptance	2018	NOPSEMA review and acceptance	Email notifications when NOPSEMA provides feedback, and if accepted, EP Summary	For information	Consultation and notifications to relevant stakeholders prior, during and at the cessation of the survey.

Stage	Timing	Santos	Information	Stakeholder	Details
			once published on NOPSEMA website.		

Table 4-2: Bethany Survey Assessment of Stakeholders

The Stakeholder Consultation Records (Appendix 2) contains the detailed records of correspondence.

Stakeholder	Relevant to Bethany Survey	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 Stakeholders in this section were identified using the Australian Government Guidance Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area.		
Australian Fishing Management Authority (AFMA)	✓	Manage Commonwealth fisheries.
Australian Maritime Safety Authority (AMSA)	✓	AMSA is the statutory and control agency for vessels 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)	✓	AMBA is adjacent to two Military Prohibited, Restricted and Danger (PRD) Areas.
Department of Environment and Energy (DoEE)	X	As the DoEE's functions, interests and activities have been incorporated in the requirements of the Program, the DoEE is not considered a relevant agency for consultation purposes under the OPGGS(E) Regulations. 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 (as described above). The Bethany survey does not trigger any of the DoEE's other functions, interests and activities hence, they were assessed as not being a relevant stakeholder.
Director of National Parks (DNP)	✓	The DNP is a relevant person as the activity is within the boundaries of a proclaimed marine park.

Stakeholder	Relevant to Bethany Survey	Reasoning
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		
NT Department of Aboriginal Affairs	✓	Consultation undertaken to determine if any customary fishing or heritage area.
NT Department of Primary Industry and Resources - Fisheries	✓	Manage NT fisheries.
Department of the responsible State Minister, or the responsible Northern Territory Minister		
NT Department of Primary Industry and Resources	✓	Under the OPGGS Env Regulations the Department of the relevant Minister is a relevant person
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		
Amateur Fishermen's Association of the NT (AFANT)	✓	Represent recreational and charter fishing off NT. Due to distances from Darwin and Melville Island recreational activities limited.
Aquarium Fishery	✓	Chair of Aquarium Fishery confirmed that Monsoon Aquatics only Aquarium Fishery licence holder to operate in or near survey area.
Arafura Bluewater Charters	✓	Charters to Tassie, Evans or Flinders shoals. Tassie Shoal is within the AMBA.
Charter fishing	✓	One charter fishery may operate in area (Arafura Bluewater Charters)..
Customary fishing	X	Confirmed with NTPIR-Fisheries and NT Department of Aboriginal Affairs no customary fishing due to distance from shore.
Demersal Fishery - NT Fishery Joint Authority	✓	Operational and survey area overlaps fishery. From consultation one licence holder was identified as potentially operating in the area.
Monsoon Aquatics	✓	Aquarium Fishery licence holder that ppotentially operate in or near survey area.
Northern Prawn Fishery	✓	Operational area overlaps fishery area.
Northern Territory Seafood Council	✓	Represent Demersal, Timor Reef, Spanish Mackerel, Offshore Net and Line and Aquarium Fisheries. Ongoing consultation.

Stakeholder	Relevant to Bethany Survey	Reasoning
NT Guided Fishing Association (NTGFA).	✓	Potentially operate in or near survey area. Asked that engagement be via AFANT.
Offshore Net and Line Fishery - NT Fishery Joint Authority	X	Operational and survey area overlaps fishery area. NT DPIR data shows no activity for this fishery in the operational area. Contact with licence holders elicited one response who confirmed he does not fish in area.
Pearl Producers Association	✓	Operational and survey area overlaps Pearl Oyster Shell fishery.
Spanish Mackerel Fishery	✓	Operational and survey area overlaps fishery. From consultation two licence holders asked to be kept up to date on the survey.
Timor Reef Fishery - NT Fishery Joint Authority	✓	Operational and survey area overlaps fishery. From consultation two licence holders were identified as operating in the area. One licence holder sold their licence in November 2017 and consultation has been undertaken with new licence holder.
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	✓	Peak body for Commonwealth fisheries.
ConocoPhillips Australia Exploration Pty Ltd	✓	Hold permit NT/RL6 (intersects survey area) and NT/RL5 (~1km from survey area).
Eni Australia Limited	✓	Hold permit NT/RL8 ~ 20 km from survey area.
Inpex	✓	Hold Masela permit ~ 60 km from survey area.
Shell Australia Pty Ltd	✓	Hold permit NT/RL7 ~ 13 km from survey area.
PGS	✓	Rollo Multi Client Seismic Survey ~ 35 km from survey area.
Tiwi Island Council	✓	Tiwi Island 120 km SW of survey area. Santos has ongoing engagement.
TGS	✓	North West Shelf Renaissance North Multi Client Marine Seismic Surveys intersect survey area.

5 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). The AMBA for the survey has been developed by combining of two different aspect exposures; noise emissions from the seismic array and a diesel spill resulting from a vessel collision. The reason for using two different aspects is that exposures from a hydrocarbon spill are limited to the north-west of the operational area due to oceanic currents in the region, whilst modelled noise emissions were identified to exceed hydrocarbon impact exposures to the south-east. Figure 5-1 shows the AMBA for the survey. For more information on the aspect exposures for noise and spills, see Section 7.1 and 7.12 respectively.

Using Santos' and publicly available information and the results from the Protected Matters Search a review of biological, cultural and socio-economic environment was undertaken to identify the environmental values and / or sensitivities that can reasonably be expected to occur within the AMBA. Table 5-1 provides a summary of these values and sensitivities.

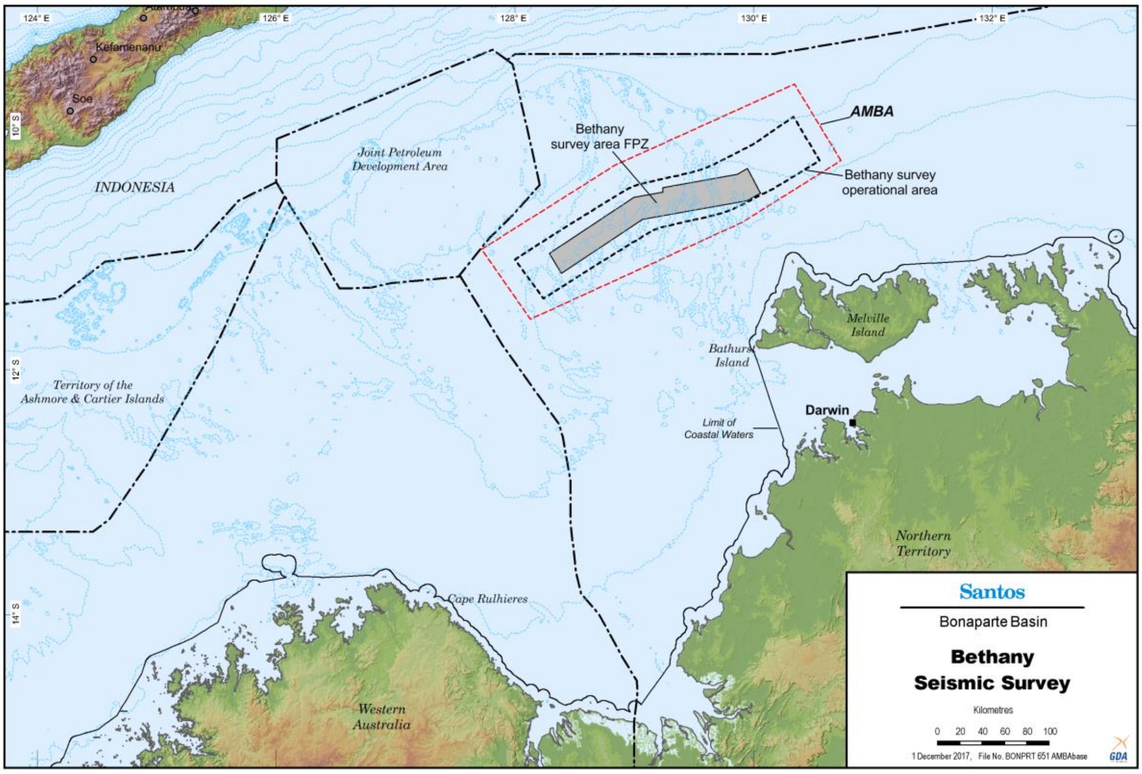


Figure 5-1: Bethany Survey Area that May Be Affected (AMBA)

Table 5-1: Environmental Values and/or Sensitivities with the Potential to Occur within the AMBA

Environment Receptor	Summary
Benthic	Benthic habitat is mainly comprised of abiotic substrate, such as sand interspersed with rocky subtances, supporting communities of invertebrate filter feeders, such as hydroids, soft corals, gorgonians, and sponges. These benthic communities are likely to support epibenthic faunal communities that may include molluscs, crustaceans, echinoderms and fishes. Water depths within the AMBA restricts the ability for photosynthetic reliant biotic communities, such as hard corals and macro algae, if present they are at the limits of their preferred habitat (water depths <35m) and subsequently are not expected to be abundant. Filter feeding organisms found on sandy substrates, supports patches of low abundance epifauna such as feather stars, sea pens, sea fans, sea whips, soft corals, bryozoans, hydroids and sponges are expected to be present in deeper waters. The geomorphology of the survey area is complex covering an area consisting of banks, terraces, valleys, plains and pinnacles. However, the complexity of the benthic habitats overlaying these features is limited by the depth of the water and the associated lack of benthic light availability, as well as the dominance of sandy substrates restricting the establishment of more complex reef ecosystems. The survey area can be described as a deep-water environment consisting mainly of sand with rocky outcrops supporting small discreet communities of predominantly filter feeding benthic communities. The lack of habitat complexity within the survey area is likely to restrict the diversity of fish communities in this area. Tassie Shoal is identified within the AMBA but not the operational or survey area.
Plankton	Phytoplankton (alga) and zooplankton (fauna including larvae) likely to be present. However, given the oligotrophic nature of the North Marine Region waters, production in the AMBA is expected to be sparse and patchy.
Fish	Protected fish species such as pipefish, seahorse and pipehorse species are likely to occur in the AMBA. The main commercial species expected to be found in the AMBA are goldband snapper (*Pristipomoides spp*.), saddletail snapper (*Lutjanus malabaricus*), crimson snapper (*L. erythropterus*) and Spanish mackerel (*Scomberomorus commerson*). Given the potential for habitat supporting hard corals (within the AMBA) and pinnacles (within the AMBA and operational area), reef fish may be present. However, due to the absence of more structurally complex habitats such as banks and absence of pinnacles the diversity of fish families present within the survey area is likely to be low due to the low complexity of the benthic habitat in this area. Therefore, fish species richness in the survey area is predicted to be relatively low due (water depths over 85% of the survey area >40 m) and unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages. Additionally, substrate type (over 65% of abiotic benthic habitat) is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages.
Sharks	No feeding, breeding or aggregation areas for sharks near the AMBA and consequently if present would only be transient. Those species identified as having the potential to transit through the AMBA include: • Speartooth shark and northern river sharks • Largetooth sawfish and the green sawfish • Whale shark • Shortfin and longfin mako

Environment Receptor	Summary
Rays	No feeding, breeding or aggregation areas for rays near the AMBA and consequently if present would only be transient. Those species identified as having the potential to transit through the AMBA include: • Reef manta ray and giant manta ray
Turtles	All six species of marine turtles have the potential to transit through the AMBA. In addition to this, olive ridley and flatback turtles are likely to be present as the AMBA and the operational area overlaps an olive ridley foraging biologically important area (BIA) and the AMBA overlaps a habitat critical to the survival of the species for flatback turtles. The AMBA overlaps three KEFs that are known to provide habitat for the green, flatback, loggerhead and olive ridley turtles.
Marine Birds	No marine birds are expected to be present in significant numbers given the AMBA does not overlap any known BIAs.
Cetaceans	No migratory, resting, feeding or calving BIAs for cetaceans within or near the AMBA and consequently if present would only be transient. Five species of cetaceans may transit through the AMBA: • Sei whale • Blue whale • Bryde's whale • Killer whale • Spotted bottlenose dolphin Omura's whales may also be present in the AMBA.
Commercial fishing	Commonwealth Fishery: • Northern Prawn Fishery - Bethany AMBA and operational area overlap. NT Fishery: • Aquarium Fishery – Bethany AMBA, no overlap with operational or survey area • Timor Reef Fishery - Bethany AMBA, operational area and survey area overlap. • Demersal Fishery - Bethany AMBA, operational area and survey area overlap. • Pearl Oyster Fishery – Bethany AMBA operational area and survey area overlap.
Recreational activities	Recreational game-fishing concentrated around the oceanic shoals. Only a single shoal is located within the AMBA.
Petroleum Activities	Two activities were identified: • TGS North West Shelf Renaissance North Multi Client Marine Seismic Survey. Survey restricted to WA waters ~ 55 km from survey area. • PGS Rollo Multi Client 3D Seismic Survey. Survey restricted to WA waters ~ 55 km from survey area.
Shipping	Low levels of vessel activity.
Defence	Defence areas adjacent to the AMBA.
Commonwealth Protected Areas	Within the Oceanic Shoals Marine Park Multiple Use Zone IUCN VI
Key Ecological Features	Carbonate bank and terrace system of the Van Diemen Rise Pinnacles of the Bonaparte Basin Shelf Break of the Arafura Shelf

5.1 Regional Environment

The Bethany Survey AMBA is within the North Marine Region (NMR) and the Oceanic Shoals Mesoscale Bioregion (Figure 5-2). The Marine Bioregional Plan for the North Marine Region (DSEWPaC 2012c) has been used in conjunction with other relevant management plans and studies to inform this description of the environment.

The NMR comprises Commonwealth waters from west Cape York Peninsula to the Western Australian-Northern Territory (WA-NT) border. The marine environment of the NMR is known for its high diversity of tropical species but relatively low endemism, in contrast to other bioregions. This region is highly influenced by tidal flows and less by ocean currents (DSEWPaC 2012c).

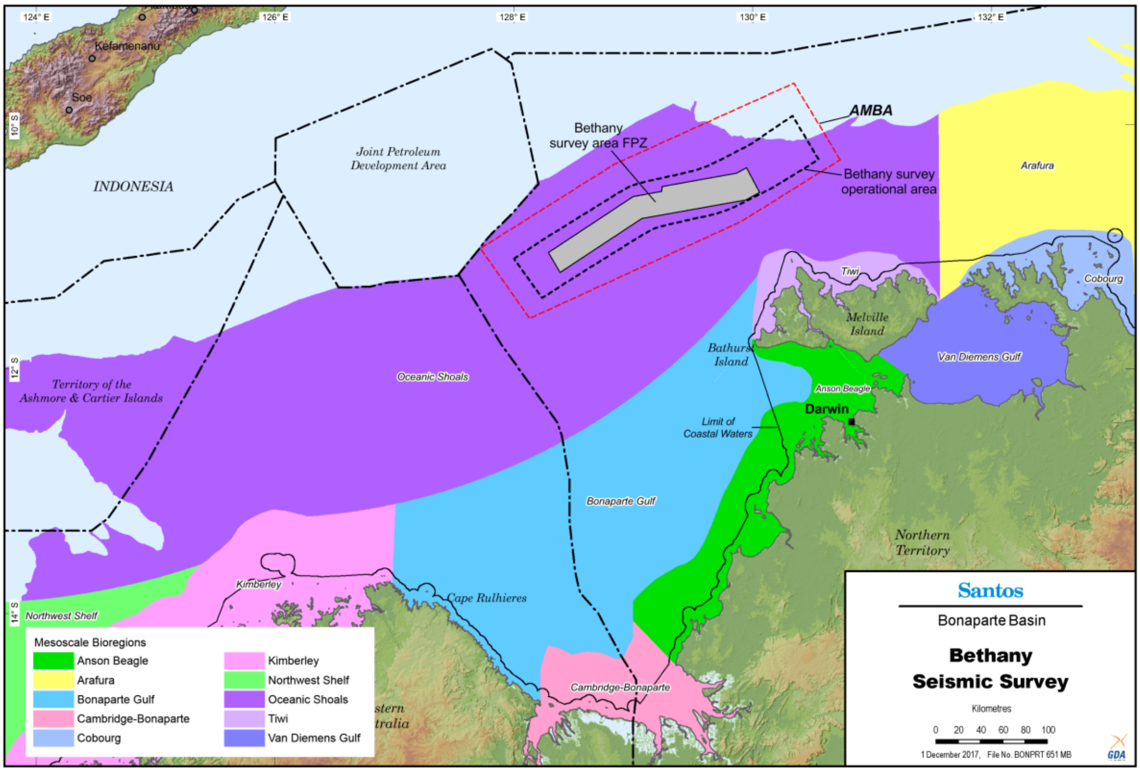


Figure 5-2: Mesoscale Bioregions

5.1.1 IMCRA Regions

The physical, biological and social environments within the AMBA is discussed (where relevant), with reference to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0 (IMCRA v. 4.0) Mesoscale and Provincial Bioregions. Based on IMCRA, which is based on fish, benthic habitat and oceanographic data, the Bethany AMBA, Operational Area and FPZ are within the Northwest Shelf Transition bioregion, and the AMBA and Operational also have a small area within the Timor Transition bioregion (Commonwealth of Australia [CoA] 2006) (Figure 5-3, Table 5-2).

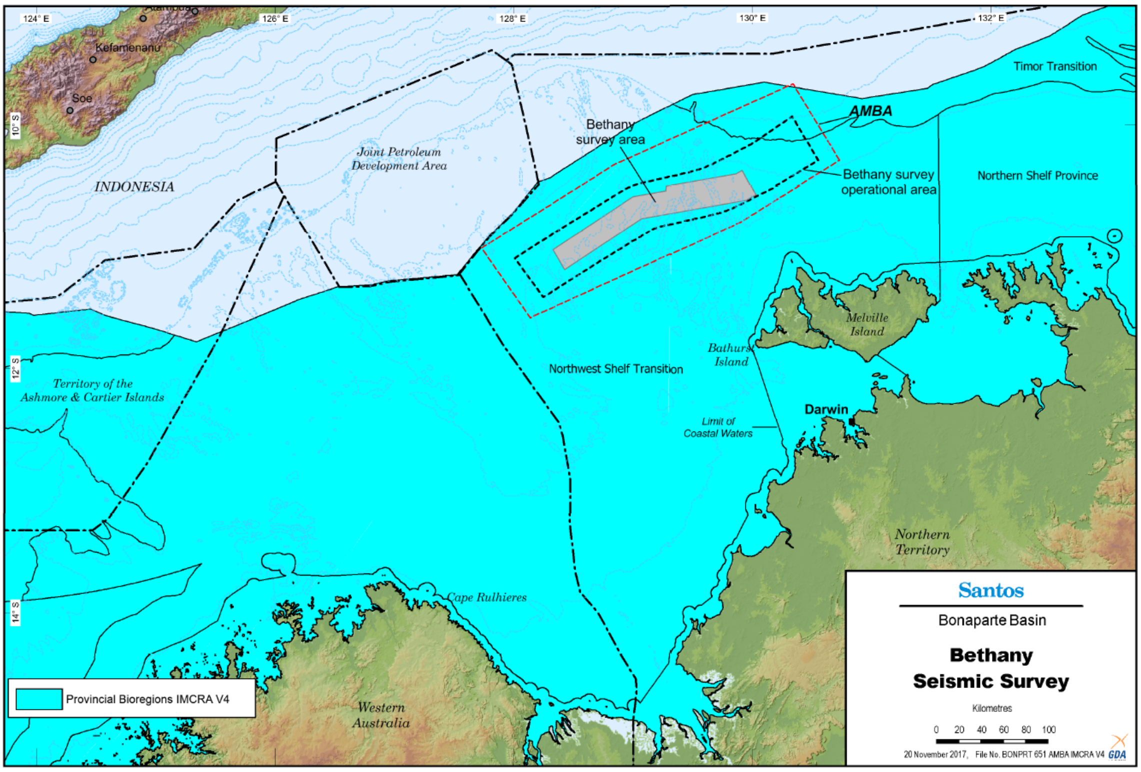


Figure 5-3: Provincial Bioregions IMCRA V4

Table 5-2: IMCRA Regions within the AMBA, Operational Area and FPZ

IMCRA Region	Occurrence			~% FPZ overlap with IMCRA Region	Distance from FPZ to IMCRA Region
	AMBA	Operational Area	Full Power Zone		
Northwest Shelf Transition	✓	✓	✓	1.48%	-
Timor Transition	✓	✓	-	-	26 km

5.1.1.1 Northwest Shelf Transition

The Northwest shelf transition (NST) overlaps the North and Northwest Marine Regions from Tiwi Island (NT) to Cape Leveque (WA). It is a transitional zone between the east and west of Australia, however, marine plant and animal groups are more like those of west coast than the east coast. The NST contains complex geomorphology and is characterised by coastal areas, the shelf and basins in the Joseph Bonaparte Gulf, and by banks, shoals, terraces and reefs dissected by valleys on the Van Diemen Rise The majority of the NST is located on the continental shelf, and only a small area extends on to the continental slope. (DEWHA 2008b).

The Indonesian Throughflow has an influence on the provincial bioregion, bringing warmer oligotrophic water of lower salinity and nutrient-levels from the tropical western Pacific. The banks are a hotspot for biodiversity, providing a vast substrate that supports diverse tropical reef ecosystems (DEWHA 2008b).

The NST is characterised by complex geomorphology. Geomorphic features include shelves (e.g. Sahul Shelf and Arafura Shelf), shoals (e.g. Flinders–Evans Shoals), banks (e.g. Van Diemen Rise), terraces, basins (e.g. Bonaparte Basin) and valleys (see Table 5.7).

The Van Diemen Rise is a significant feature of the ocean floor in the provincial bioregion and part of a unique system of carbonate banks that are shared with the adjacent North-west Marine Region (see Section 5.3.1). The carbonate banks from the Van Diemen Rise are thought to be directly related to hydrocarbon seepage from the Bonaparte Basin. Palaeo-river channels up to 150 km long, 5 km wide and 240 m deep between the carbonate banks form pathways for ocean currents and tidal flows that funnel cooler oceanic waters up onto the Van Diemen Rise (DEWHA 2008b).

The carbonate pinnacles in this provincial bioregion include complex hard substrate environments and provide a very different habitat to adjacent muddy basin sediments. The Van Diemen Rise is distinctly different in morphology and character from other parts of the Region and provides habitats for a wide range of marine communities (DEWHA 2008b).

Cetaceans are not frequently sighted in this provincial bioregion. Benthic algae and seagrass communities are confined to the intertidal area adjacent to the provincial bioregion, with high turbidity restricting light penetration in the coastal shelf areas to waters up to depths of 20 m. Healthy offshore populations of crustaceans (including prawns) are indicators of inshore biological productivity, but the direct linkages between these species and marine systems are poorly understood. Fifteen species of seasnake are also known to occur in the provincial bioregion, including the elegant seasnake, olive-headed seasnake, Stokes' seasnake and Dubois' seasnake (DEWHA 2008b).

Halimeda species are likely to be a dominant biological component of the banks, similar to banks found in the North-west Marine Region. The Halimeda banks sustain a range of invertebrate communities including sponges, soft corals, hard corals, bryozoans, ascidians and other sessile filter feeders. Foraminifera (single-celled planktonic animals with a perforated chalky shell) are a common component of the benthic fauna. Pelagic line fisheries (mackerel) are linked to localised planktonic food webs at upwelling sites at the heads of channels and indicate important trophic linkages with nutrients from localised upwellings. Red snapper (*Lutjanus erythropterus*) are likely to be associated with complex habitats amongst banks and channels. Hard substrate sediments associated with deep channels are likely to support sponges, soft corals and other sessile filter feeders similar to those species found beyond the Region. The Van Diemen Rise is also considered to be an important shark habitat and foraging olive ridley turtles have been observed at the banks and shoals (DEWHA 2008b).

Adjacent to the Northwest Shelf Transition (within the North-west Marine Region), the shoals contain species such as polychaete worms, crustaceans, brittle stars, gobiid fish, bivalves and sipunculans. It is likely that similar species would be found in the Region around the banks and shoals of the eastern areas of the Northwest Shelf Transition (DEWHA 2008b).

The abundance and biomass of primary consumers (e.g. crustaceans and molluscs) in the Northwest Shelf Transition is very high compared with the rest of the North Marine Region and terrestrial inputs of freshwater, sediments and nutrients from neighbouring catchments adjacent to the provincial bioregion contribute to biological productivity in coastal waters. However, there is little transfer of nutrients from coastal waters to oceanic waters, and the basin and deeper shelf productivity are likely to be more dependent on internal nutrient cycling and upwellings of productive oceanic waters (DEWHA 2008b).

In offshore parts of the Northwest Shelf Transition light penetration through relatively clear, shallow waters stimulates high levels of benthic primary production (macroalgae). Unique benthic microbial communities associated with hydrocarbon seeps, where gases including methane are release from the seabed below the surface sediments, are also found in the deeper waters (see Figure 5-4). Epibenthic communities such as sponges found in channels are likely to support first order (plankton) and second order consumers (juvenile small fish, crustaceans and sea stars; DEWHA 2008b).

5.1.1.2 Timor Transition

The Timor transition provincial bioregion is characterised by continental slope, canyons, ridges, terraces and the Arafura Depression. It is the only bioregion in the Region that does not lie on the continental shelf (DEWHA 2008b). The Timor Transition shelf extends into waters 200–300 m deep in the Arafura Depression. The provincial bioregion is extensively dissected into a series of canyons around 80–100 m deep and 20 km wide, and represent a drowned river system that existed during the Pleistocene era. Sediments within the Timor Transition are mainly calcium carbonate rich, although sediment type varies from sandy substrate, to soft muddy sediments and hard rocky substrate (DEWHA 2008b).

Pelagic species are the prominent biological community in the open water environment of the Timor Transition. Many of the pelagic fish species that inhabit the provincial bioregion also have pelagic larval stages. Pelagic species found within the troughs of this provincial bioregion include snaggle-teeth fish, hatchet fish and lantern fish (DEWHA 2008b). The shelf-edge/slope is believed to support distinct benthic communities associated with cooler water upwellings, as well as whale sharks and an unusual array of threadfin fish species (Polynemidae). Distinct genetic stocks of red snapper (*Lutjanus erythropterus*) are also found in the canyons and channels of the provincial bioregion, and unique fish assemblages have been found on the Lynedoch Bank which lies on the western boundary of the Timor Transition and outside of the scope of this EP (DEWHA 2008b).

Marine turtles have been reported to feed in the deeper canyon waters and solitary, cold water corals have been located in canyons and troughs at depths of around 200 m. Relict reefs occur next to drainage channels of the outer slope, probably at sites of local upwellings of cooler, nutrient rich water from the Timor Sea (DEWHA 2008b). Records show that at least 284 demersal fish species (those living on or near the seabed) are found in this provincial bioregion. However, few data are available for the continental slope in the Timor Transition (DEWHA 2008b).

The Indonesian Throughflow brings warm waters from the western Pacific Ocean through the Indonesian Seas into the Timor and Arafura Seas. This current influences pelagic dispersal of nutrients and species, and biological productivity, which drives long-term patterns of transport and dispersal of larvae, juvenile and migrating adult organisms across the Region (DEWHA 2008b).

5.2 Matters of National Environment Significance

A search of the DoEE Protected Matters Database was undertaken covering a 1 km buffer around the Bethany AMBA. The matters of national environmental significance identified by the search are summarised in Table 5-3.

Table 5-3: Department of the Environment Protected Matters Database Search Summary

Matter of National Environmental Significance	Search Findings	Comment
World Heritage Property	None	
National Heritage Place	None	
Wetlands of Importance	None	
Great Barrier Reef Marine Park	None	
Commonwealth Marine Area	2	EEZ and Territorial Sea Extended Continental Shelf
Listed Threatened Ecological Communities	None	
Listed Threatened Species	18	See Sections 5.5.2 – 5.5.9
Listed Migratory Species	32	See Sections 5.5.2 – 5.5.9
Other Matters Protected by the EPBC Act	**Search Findings**	**Comment**
Commonwealth Land	None	
Commonwealth Heritage Places	None	
Listed Marine Species	63	See Sections 5.5.2 – 5.5.9
Whales and Other Cetaceans	24	See Section 5.5.9
Critical Habitats	None	
Commonwealth Reserves Terrestrial	None	
Commonwealth Reserves Marine	1	The AMBA is within the Oceanic Shoals Marine Park multiple use zone. See Section 5.9.

Extra Information	Search Findings	Comment
State and Territory Reserves	None	
Regional Forest Agreements	None	
Invasive Species	None	
Nationally Important Wetlands	None	
Key Ecological Features (Marine)	3	Carbonate bank and terrace system of the Van North Pinnacles of the Bonaparte Basin North Shelf break and slope of the Arafura Shelf See Section 5.3

5.3 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. During the development of marine bioregional plans, a regional pressure analysis broadly defined human-driven processes, was conducted to assess present and emerging pressures affecting conservation values in the Marine Regions and the effectiveness of mitigation and management arrangements that are currently in place to address these pressures, the result of this pressure analysis is summarised for relevant KEF (DoEE 2017u).

The Bethany AMBA and operational area overlaps three KEFs; Carbonate bank and terrace system of the Van Diemen Rise, Pinnacles of the Bonaparte Basin and the Shelf Break of the Arafura Shelf (Figure 5-5, Table 5-4). The FPZ only overlaps the Carbonate bank and terrace system of the Van Diemen Rise.

Table 5-4: Key Ecological Features within the AMBA, Operational Area and Full Power Zone

KEF	Occurrence			~% FPZ overlap with KEF	~ Distance of FPZ to KEF
	AMBA	Operational Area	Full Power Zone		
Carbonate bank and terrace system of the Van Diemen Rise	✓	✓	✓	14%	-
Pinnacles of the Bonaparte Basin	✓	✓	-	-	20 km
Shelf Break and slope of the Arafura Shelf	✓	✓	-	-	4 km

5.3.1 Carbonate bank and terrace system of the Van Diemen Rise

The bank and terrace system of the Van Diemen Rise is part of the larger system associated with the Sahul Banks to the north and Londonderry Rise to the east; it is characterised by terrace, banks, channels and valleys, with relatively high proportions of hard substrate which support sponge gardens and octocorals, identified in the eastern Joseph Bonaparte Gulf along the banks, ridges and terraces (DoEE 2017u; Heap *et al. 2010*). A seabed mapping survey of eastern Joseph Bonaparte Gulf was undertaken by Geoscience Australia and AIMS (Anderson *et al*. 2011) to map and sample seabed environments on the Van Diemen Rise. Towed video transects were undertaken to describe and quantify the benthic habitats and epibenthos present in four geomorphic environments (banks, terraces, valleys and plains) found on the Van Diemen Rise.

Banks are the shallowest and most complex benthic environment with diverse and often dense epibenthic assemblages. Banks were characterised by mostly low-lying rock outcrops, which supported dense and diverse habitat-forming assemblages such as hard corals (18% occurrence), sponges (86% occurrence) and octocorals (99% occurrence) along with smaller colonies of bryozoan and ascidians. These complex benthic habitats also supported a range of other taxa, including molluscs, crustaceans, echinoderms and fishes. Rocky outcrops were interspersed with small areas of coarse-grained soft sediments (7.4%) that were either relatively barren or supported few organisms (Anderson *et al*. 2011).

Terraces occurred at intermediate depths and had less benthic topographical complexity than the banks. However, where rocky outcrops were present these areas supported moderate to high densities of sessile epifauna, dominated by sponges and octocorals. These areas were devoid of hard corals due to the depth and subsequent lack of benthic light availability. Rock outcrops were smaller and patchier in distribution on terraces relative to banks, and were interspersed by large expanses of coarse-grained sediments that supported few epibenthic organisms. Biota samples from terraces were dominated by sponges and supported black corals typically associated with deeper hard substrate and a range of other taxa including gastropods, crabs, bryozoan, ascidians, urchins, brittlestars, crinoids, seastars, holuthurians, nudibranchs, worms and small fishes (Anderson *et al*. 2011).

Valleys were the deepest of the four geomorphic environments, comprising flat, bioturbated muddy sand that supported significantly fewer epibenthic organisms than terraces or banks. Octocorals and sponges were the most common taxa recorded and were mostly found as 1 – 2 individuals or in small aggregations. Biomass of taxa was markedly lower than on banks and terraces (Anderson *et al*. 2011).

Plains and deep holes/valleys were the least complex of the four geomorphic environments, characterised by flat, bioturbated muddy sand and supported the fewest epibenthic organisms. These included mostly solitary or small clumps of octocorals and sponges and urchins (Anderson *et al*. 2011). Epibenthic communities such as the sponges found in the channels support first and second-order consumers (Section 5.5.1) (DoEE 2017u) (DoEE 2016a). The variability in water depth and substrate composition may contribute to the presence of unique ecosystems in the channels. Species present include sponges, soft corals and other sessile filter feeders associated with hard substrate sediments of the deep channels; epifauna and infauna include polychaetes and ascidians. Olive ridley turtles, sea snakes, pelagic fish such as mackerel, red snapper, a distinct gene pool of goldband snapper and sharks are also found associated within this feature (Figure 5-4) (DSEWPaC 2012c; DoEE 2017t).

No pressures were assessed as “of concern” for the Carbonate bank and terrace system of the Van Diemen rise. Pressures assessed as “of potential concern” are changes in sea temperature and ocean acidification, as a result of climate change, and extraction of living resources. Therefore, no pressures from the proposed activity have been identified for this KEF (DoEE 2017u).

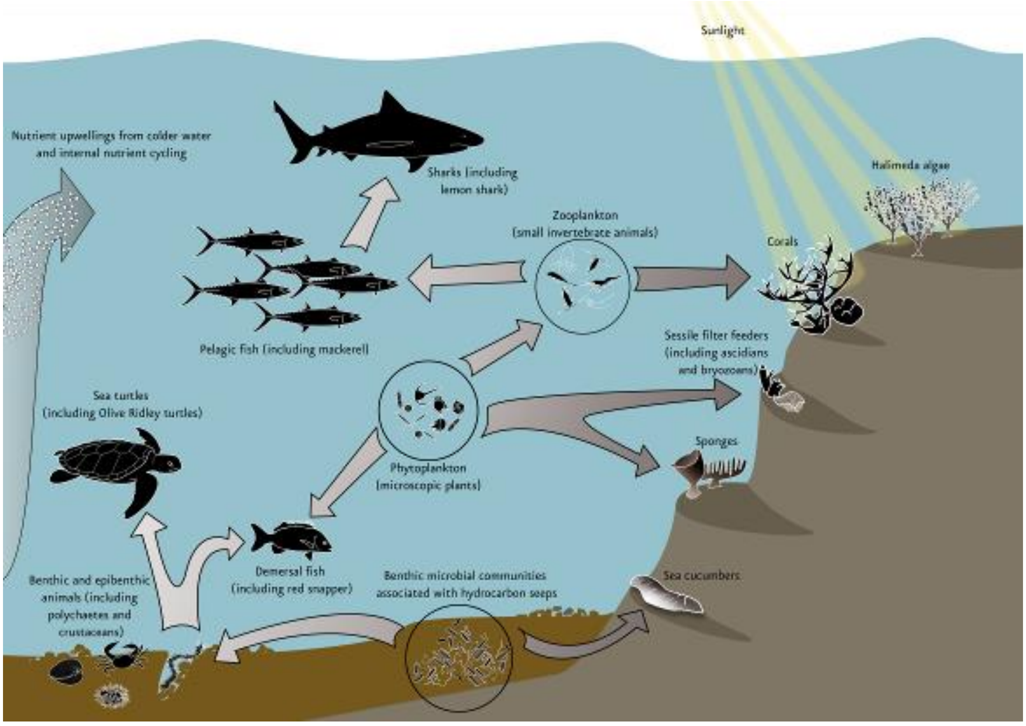


Figure 5-4: Simplified diagram of trophic relationships of the Van Diemen Rise

5.3.2 Pinnacles of the Bonaparte Basin

Covering more than 520 km^2 within the Bonaparte Basin, this feature contains the largest concentration of pinnacles along the Australian margin, and provide a hard substrate in an otherwise soft sediment environment and therefore important for sessile species (DoEE 2017u). Rising from depths of 80 m some pinnacles rise to 30 m below the sea surface, and can be up to 50 m high and 50–100 km long. 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 Marine Park 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). Other communities such as sessile benthic invertebrates including hard and soft corals, sponges, whips, fans, bryozoans and aggregations of demersal fish species such as snappers, emperors and groupers DoEE 2017t). The pinnacles are subject to frequent disturbances from tropical cyclones and tidal currents driven by the large tidal fluctuations of the region (DoEE 2017u). This mobilises mud sediments which creates high levels of turbidity in the water column. The reason this feature attracts a wide range of high-order pelagic animals is likely because the vertical walls generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish (DSEWPaC 2012c).

As shown in Figure 5-5 a small number (~3) pinnacles are within the survey operational area with the closest pinnacle being ~20 km from the FPZ. A larger number of pinnacles (~17) are outside the operational area but within the AMBA.

No pressures were assessed as “of concern” for the Pinnacles of the Bonaparte Basin. Pressures assessed as “of potential concern” are changes in sea temperature and ocean acidification as a result of climate change; and extraction of living resources. Therefore, no pressures from the proposed activity have been identified for this KEF (DoEE 2017u).

5.3.3 Shelf Break and slope of the Arafura Shelf

The shelf break and slope of the Arafura Shelf is characterised by continental slope, patch reefs, and hard substrate pinnacles. The biota is largely affiliated with the Timor-Indonesian-Malay region, is within the AMBA and is >4 km from the FPZ (DoEE 2017u). The ecosystem processes of the feature are largely unknown in the region; however, the Indonesian Throughflow and surface wind‐driven circulation are likely to influence nutrients, pelagic dispersal and species and biological productivity in the region. The shelf edge occurs at water depths of 120-180m. The enhance biological productivity of the upwellings and are believed to attract feeding aggregations of pelagic marine organisms into the vicinity of the shelf break, e.g. planktivorous and predatory fish, marine turtles, sharks, and seabirds. Fish communities that occur in this key ecological feature represent the break between the Timor Province provincial bioregion and the Timor Transition provincial bioregion. Demersal fish species, including commercially fished red snapper species (*Lutjanus erythropterus*) are found in the area, which is also likely to support whale sharks, sharks and marine turtles (DoEE 2017u). Although little is known of the biology of the shelf slope benthos, the deeper (100–300 m in depth), cooler waters provide a different environment to the remainder of the Region. Several submerged living coral/Halimeda reefs extend up into the euphotic zone from the shelf slope, providing structural habitat and focal points for diversity. Biota associated with the feature is largely of Timor–Indonesian Malay affinity (DEWHA 2008b) (DSEWPaC 2012c).

No pressures were assessed as “of concern” for the Shelf break and slope of the Arafura Shelf. Pressures assessed as “of potential concern” are changes in sea temperature and ocean acidification as a result of climate change; extraction of living resources and oil pollution. Therefore, no pressures from the proposed activity have been identified for this KEF (DoEE 2017u).

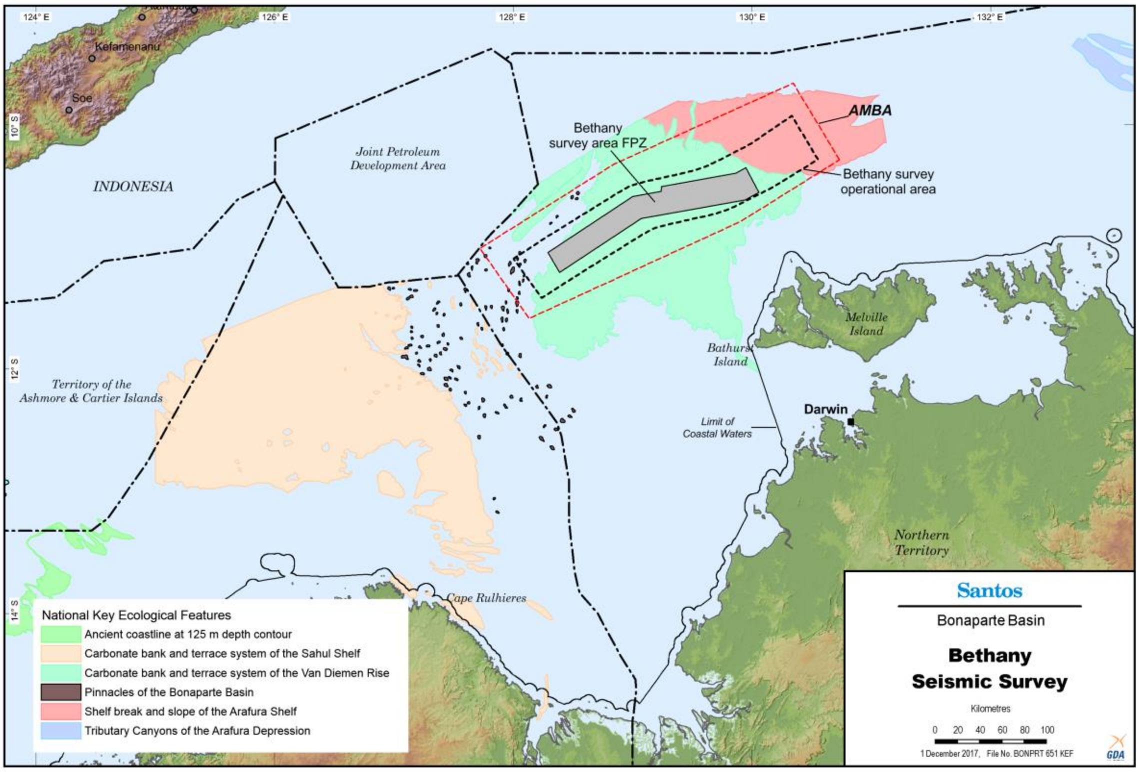


Figure 5-5: Key Ecological Features within the North-west Marine Region Profile (DSEWPaC 2012c)

5.4 Physical Environment

5.4.1 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. Conversely, the South-east Monsoon originates from the Southern Hemisphere high-pressure belt and is relatively dry and cool.

Cyclones are common in the region, occurring between December and April (BoM 2017). These phenomena result in severe storms with gale force winds and a rapid rise in water levels.

5.4.2 Air Temperatures

Pirlangimpi, located on the Tiwi Islands in Northern Territory, is the nearest meteorological station to the Bethany survey area. Data collected from 1963 to 2017 shows that the highest maximum temperature (mean of 38.6°C) occurs in November whilst the lowest maximum temperature (mean of 24.2°C) occurs in July (BoM 2017).

5.4.3 Rainfall

Data collected from 1963 to 2017 at the Pirlangimpi weather station show that the mean annual rainfall is 1993 mm, with the highest rainfall in January (412 mm) and the least in July (2 mm) (BoM 2017). Typically, the majority of the rain occurs from December to April.

5.4.4 Winds

The survey area is situated in the tropical region and experiences a monsoonal climate with two predominant seasons: a summer wet season, October to April and a winter dry season, May to September. These are referred to as the northwest and southeast monsoons respectively. During the northwest monsoon or wet season, prevailing winds are typically from the west and north-west and during the southeast monsoon or dry season prevailing winds are from the east and south-east.

An analysis of high resolution wind data for the years 2008-2012 from the National Centre for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (Figure 5-6) by RPS APASA (2017) identified three general trends:

- westerly winds during the months December to March
- east-south-easterly winds during the months April to July
- easterly winds during the September to October.

Monthly average wind speeds range from 5.9–13.3 knots and the monthly maximum wind speeds range from 21.6–40.8 knots (Table 5-5).

Table 5-5: Predicted Average and Maximum Winds Speed for the Bethany Location

Month	Average wind (knots)	Maximum wind (knots)	General Direction (From)
January	12.7	37.4	West
February	11.9	40.8	West
March	8.1	28.0	West
April	8.8	22.9	East-Southeast
May	13.0	24.8	East-Southeast
June	12.8	24.4	East-Southeast
July	13.3	26.6	East-Southeast
September	11.8	26.6	East
September	8.5	23.2	East
October	7.7	21.6	East
November	5.9	22.2	Variable
December	8.1	23.6	West
Minimum	**5.9**	**21.6**	
Maximum	**13.3**	**40.8**	

5.4.5 Sea Temperature

Surface water temperatures vary seasonally and are influenced by the Indonesian Throughflow. Monthly sea temperature and salinity profiles of the water column near the survey area were obtained from the World Ocean Atlas 2013 (RPS APASA 2017). The monthly average sea surface temperatures ranged between 26.7°C and 30.8°C (Table 5-6) (RPS APASA 2017). Monthly average sea surface temperatures were shown to be lower between June to October, ranging between 26.7°C and 27.8°C, which occurs during the months of May to September (inclusive) (RPS APASA 2017).

The monthly average salinity values remain relatively stable ranging between 33.0 and 34.7 psu (Table 5-6) (RPS APASA 2017).

Table 5-6: Monthly Average Sea Surface Temperatures for the Bonaparte Gulf

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	29.6	28.3	29.9	29.2	29.1	27.4	26.8	26.7	27.0	27.8	29.9	30.8
Salinity (psu)	34.3	34.4	34.2	34.3	34.3	34.2	33.7	33.0	34.4	34.4	34.7	34.7

5.4.6 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.

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.

The region is a moderate-energy environment except when influenced by tropical cyclones which generate short-term major fluctuations in sea levels. The highest waves occur in January and July; however, wave heights can reach up to 8 m during cyclone season (Dec - March) (Przeslawski et al. 2011).

5.4.7 Tides

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

5.4.8 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 (Table 5-7 and Figure 5-7).

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 2017).

Broad-scale ocean circulation of North Australian is dominated by the Indonesian Throughflow current system and the Holloway current which flows south-west and close to the coastline, intensifying during April to July due to increased wind forcing. Data describing the flow of ocean currents indicates that waters drifted predominantly northward (north, north-northeast or north-northwest) (RPS APASA 2017) (Figure 5-7).

RPS APASA (2017) also indicate minimum and maximum average current speeds around 0.25 m/s and 0.34 m/s, respectively (Table 5-7). For the period of the survey (May to September inclusive) average current speeds range from 0.30 m/s to the north- northwest in May-July and 0.29 m/s to the north-northwest and southwest in September (RPS APASA 2017).

Table 5-7: Current Data for the Bethany Survey Area

Month	Average current speed (m/s)	Maximum current speed (m/s)	General Direction (Towards)
January	0.34	0.90	Northeast
February	0.31	0.81	Northeast
March	0.26	0.73	North-Northeast
April	0.27	0.73	North
May	0.30	1.01	North-Northwest
June	0.28	0.81	North-Northwest
July	0.31	0.81	North-Northwest
September	0.29	0.77	North-Northwest and Southwest
September	0.28	0.68	North-Northwest and Southwest
October	0.27	0.72	North-Northwest and Southwest
November	0.25	0.78	North
December	0.28	0.77	North-Northeast
Minimum	**0.25**	**0.68**	
Maximum	**0.34**	**1.01**	

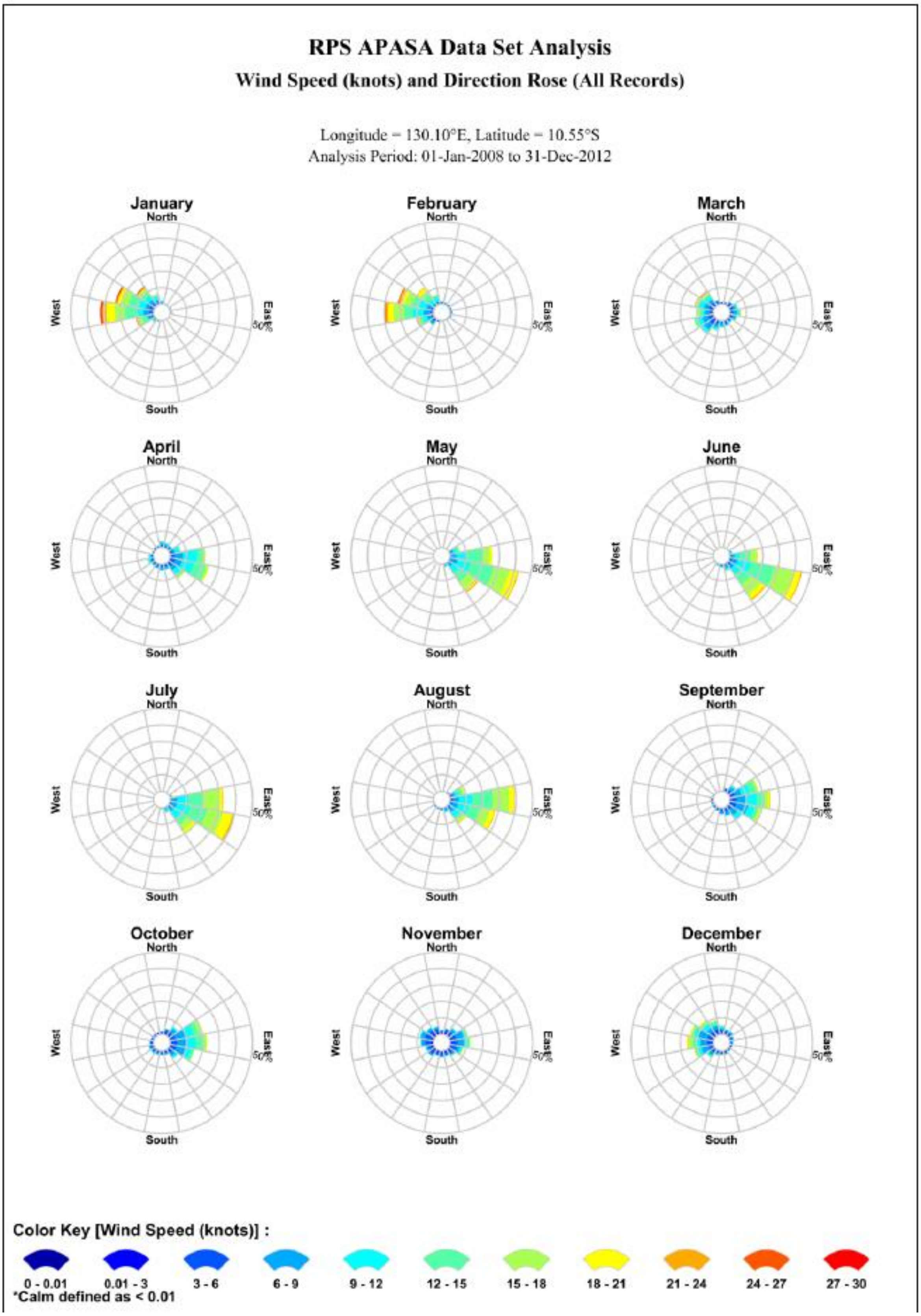


Figure 5-6: Modelled Monthly Wind Roses (2008 - 2012)

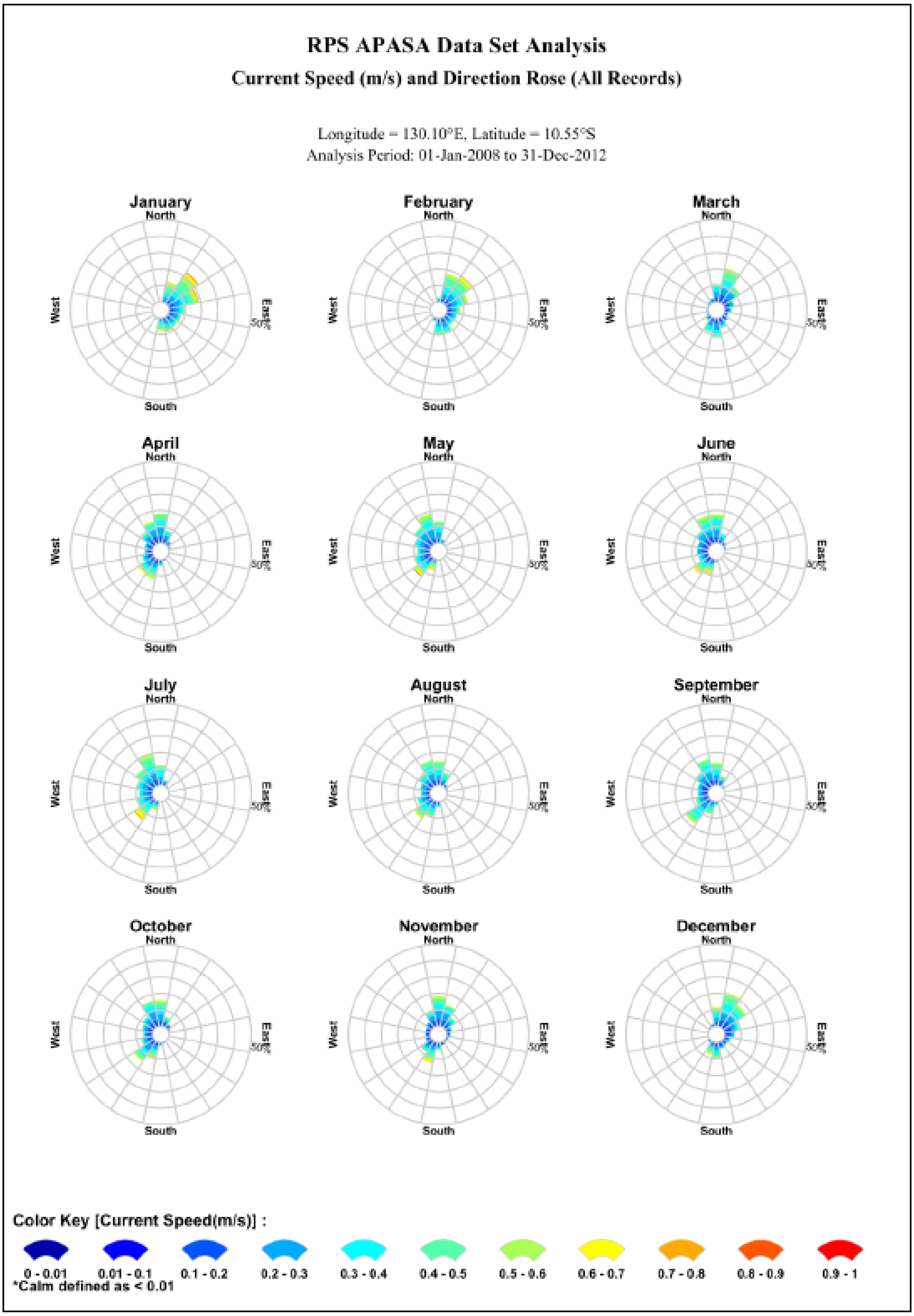


Figure 5-7: Current Speed and Direction

5.4.9 Bathymetry

The bathymetry of the AMBA is representative of the geomorphic features of the area (Figure 5-8). Water depths of the AMBA range from approximately 20 - 376 m with the majority of the AMBA within 40 – 202 m water depth (Table 5-8). Water depths of the operational area range from ~ 20 - 202 m with the majority > 40 m. Water depths in the FPZ range from 20 - 157 m with the majority > 40 m.

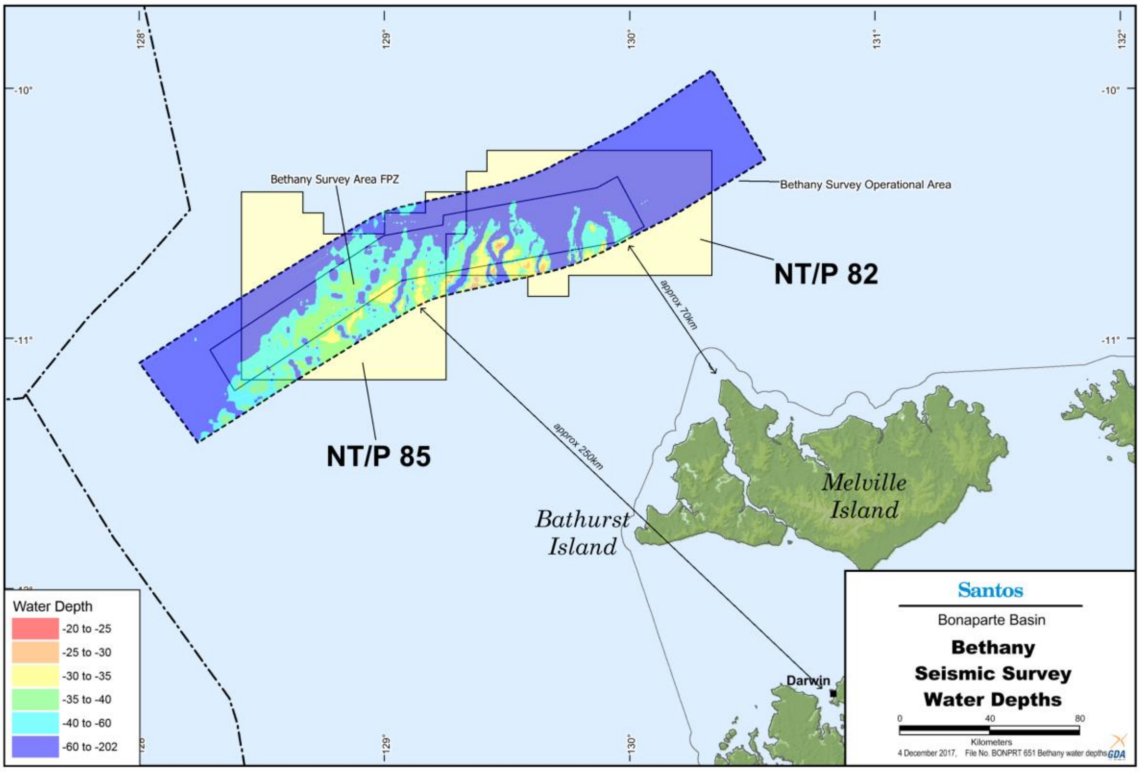


Figure 5-8: Bathymetry of the Survey Area and Operational Area

Table 5-8: Water Depths within the AMBA, Operational Area and Full Power Zone

Depth Range (m)	AMBA		Operational Area		Full Power Zone	
	Km^2	%	Km^2	%	Km^2	%
0 to -20	4.64	0.02%	0.076	0.001%	0	0.00%
20 to -25	70.14	0.24%	1.75	0.014%	0.9	0.02%
25 to -30	627.65	2.19%	95.44	0.76%	11.1	0.24%
30 to -35	1006.37	3.51%	558.7	4.43%	152.4	3.34%
35 to -40	1480.89	5.17%	937.19	7.43%	493.8	10.82%
40 to -60	4470.56	15.59%	2646.64	20.99%	1675.7	36.7%
60 to -202	19641.53	68.51%	8373.36	66.40%	2230.9	48.87%
202 to -376	1358.91	4.74%	0	0%	0	0%

5.4.10 Geomorphic Features

An understanding of the seabed bathymetry and the type of seabed forms (geomorphic features) can be an important determinant of the diversity and dynamics of marine biological communities, especially in areas where there are limited biological studies. Geoscience Australia utilised bathymetry and published geological studies to identify and classify geomorphic features of the seabed (Harris et al. 2005). The geomorphic features from this study are shown in (Figure 5-9).

Based on this information the following geomorphic features are identified to be present within the survey AMBA:

- Bank/Shoal – Bank: elevation over which the depth of water is relatively shallow but normally sufficient for safe surface navigation. Shoal: offshore hazard to surface navigation that is composed of unconsolidated material. Based on water depths within the AMBA (> 20 m) shoals are not present.
- Basin - depression, characteristically in the deep-sea floor, more or less equidimensional in plan and of variable extent.
- Deep/ Hole/Valley – Deep: restricted to depths greater than 6,000 m. Hole: local depression, often steep sided, of the sea floor. Valley: relatively shallow, wide depression, the bottom of which usually has a continuous gradient. Based on water depths within the AMBA (< 376 m) deeps are not present.
- Pinnacles - High tower or spire-shaped pillar of rock or coral, alone or cresting a summit. It may extend above the surface of the water. It may or may not be a hazard to surface navigation.
- Slope - Slope seaward from the shelf edge to the upper edge of a continental rise or the point where there is a general reduction in slope.
- Terrace - relatively flat horizontal or gently inclined surface, sometimes long and narrow, which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

Table 5-9 details which geomorphic features are overlapped by the AMBA, Operational Area and FPZ.

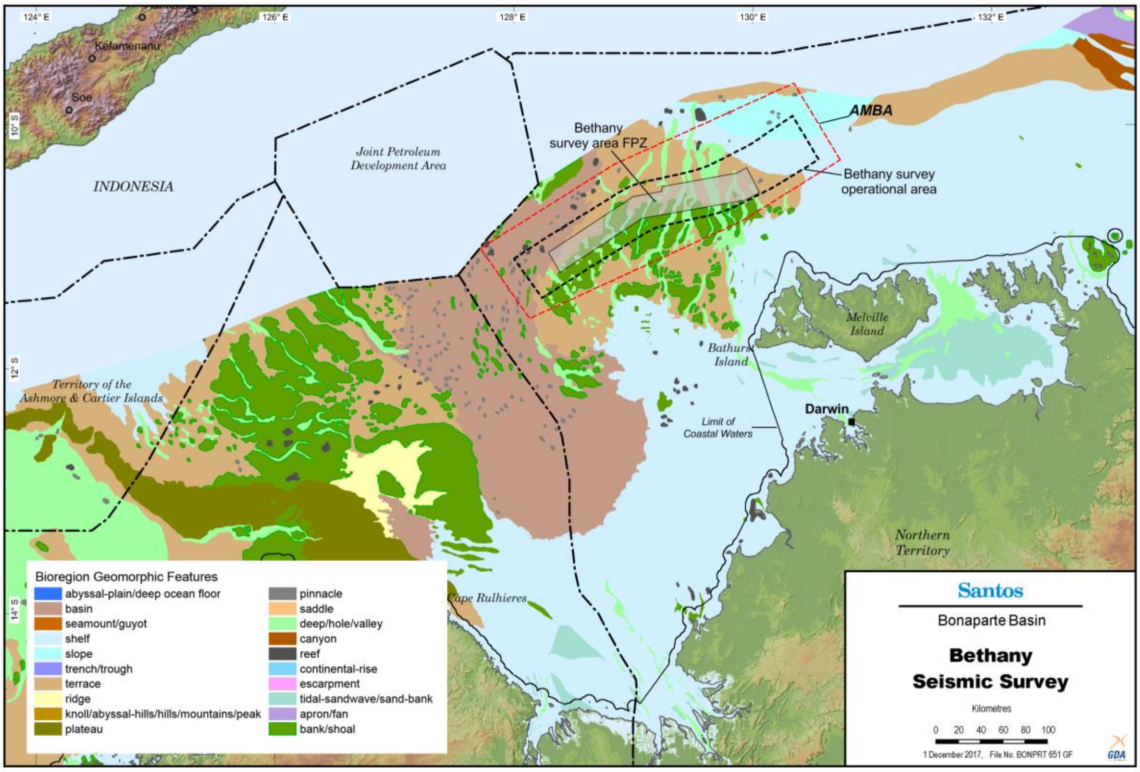


Figure 5-9: Geomorphic Features of the Bethany Seismic Area

5.5 Biological Environment

5.5.1 Benthic Environment

Benthic habitat is the seabed substrates that benthic communities grow on or in, and range from unconsolidated sand to hard substrates such as limestone or igneous rock, and can occur singly or in combination (EPA 2017). Benthic communities are the biological communities that live on or in the seabed, contain light-dependant taxa such as algae, seagrass, corals, which obtain energy through photosynthesis and or marine fauna such as molluscs, sponges and worms, which obtain their energy by consuming other organisms or organic matter.

5.5.1.1 Comparison of Benthic Habitat and Geomorphic Features

The findings from two benthic surveys undertaken by Geoscience Australia (GA) Heap et al (2010) and Anderson et al (2011) have been used to provide a description and verify the benthic environment based upon the geomorphic features expected to be present within the OSMP and FPZ (Table 5-9).

Two surveys of benthic habitats within the eastern sector of the Oceanic Shoals Marine Park (OSMP) have been previously undertaken. The first survey in 2009, focused on four areas in the eastern sector of the OSMP to obtain detailed geological (sedimentological, geochemical, geophysical) and biological data (macro-benthic and infaunal diversity, community structure) for the banks, channels and plains (Heap et al 2010). The purpose of the survey in 2010 was to build on the 2009 survey to extend the biophysical maps and information of the complex seabed environment of the Van Diemen Rise and identify potential geo-hazards and unique, sensitive environments that relate to offshore infrastructure (Anderson et al 2011). These studies were summarised in the regional overview of seabed habitats and geo-hazards by Przeslawski et al. (2011) who concludes that the benthic environment of the outer Joseph Bonaparte Gulf – Timor Sea is linked to its geomorphic features.

Figure 5-10 shows the location of the four study areas (A, B, C and D) from the two surveys in 2009 and 2010, in relation to the Bethany AMBA, with Area A overlapping the survey area. As such, this information is expected to provide a suitable understanding regarding the benthic environment within the AMBA.

The latest Oceanic Shoals Marine Park (OSMP) publication states (NERP Marine Biodiversity Hub 2015):

> "The three surveys of the Oceanic Shoals CMR (2009, 2010, 2012) targeted discrete areas of the banks, pinnacles and terraces, covering a combined area of almost 2,200 km^2. While these samples represent only 3% of the ~73,000 km^2 of KEFs included in the Oceanic Shoals CMR, the knowledge of these KEFs gained from these surveys is likely to be typical for these features within and adjacent to the reserve. In particular, because these seabed features provide hard substrata for sponge and coral communities, similar patterns at the spatial scale of these features can be expected to occur across the reserve wherever hard raised substrata exists."

Additionally, Figure 5-12 shows examples of the benthic habitat types reported in the Anderson et al. (2011) survey and therefore likely to occur within the FPZ. The georeferenced still images were captured over geomorphic features with the highest % coverage identified in Table 5-9, terrace (49%), bank (28%), valley / hole (21%) (GA 2017).

The terrace geomorphic feature in Figure 5-12 shows a range of benthic habitats such as, sponges, octocorals and small fishes and the bank feature is predominately comprised of hard corals, sponges and octocorals. Whereas, the hole / deep valley feature is comprised of mostly fine sand sediment, and the frequent bioturbation (burrows, mounds and tracks) observed is an indication that burrowers and crinoids may be present.

The benthic habitat characteristics within the OSMP and the Bethany FPZ are broadly consistent with the results of other similar surveys in the offshore waters of the Northwest Shelf Transition provincial bioregion. For example:

- Barossa offshore development area located on a plain comprised of soft sediments, frequent bioturbations (burrowers), octocorals (particularly sea pens) and some mobile crustaceans (ConocoPhillips 2017).
- Sunrise Gas Project found epifauna were sparse and were predominately comprised of hyoids, sponges and crinoids (SKM 2001).

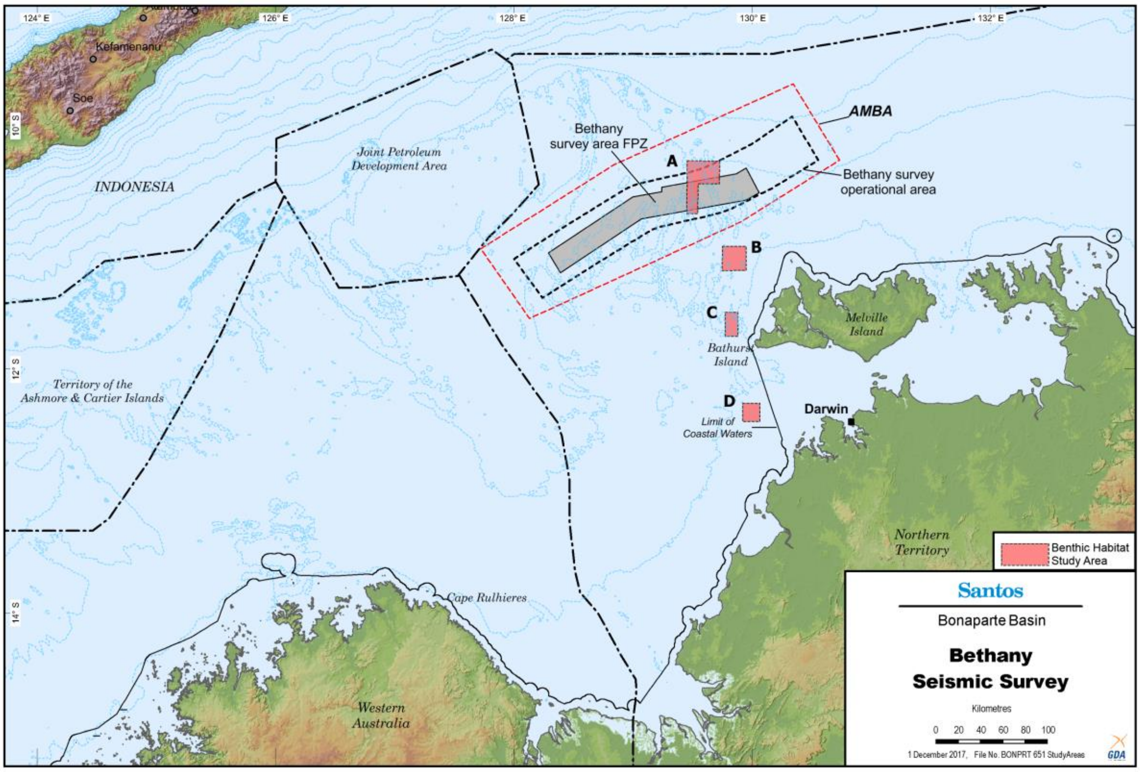


Figure 5-10: Bethany AMBA and Proximity to Previous Benthic Surveys

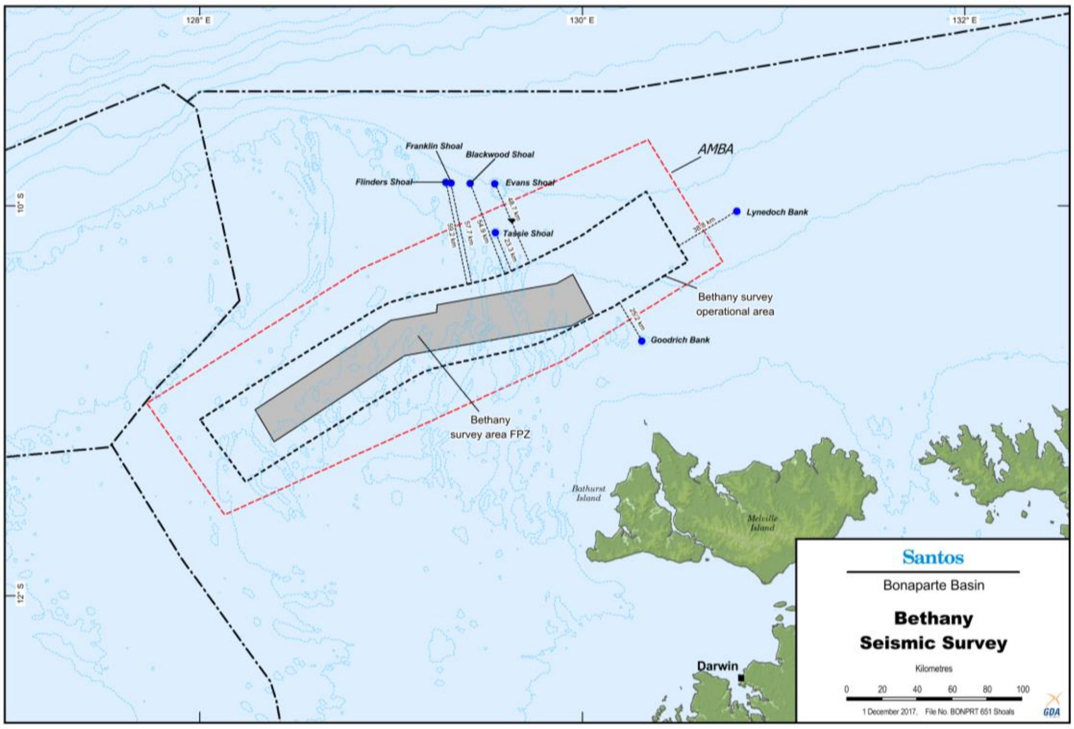
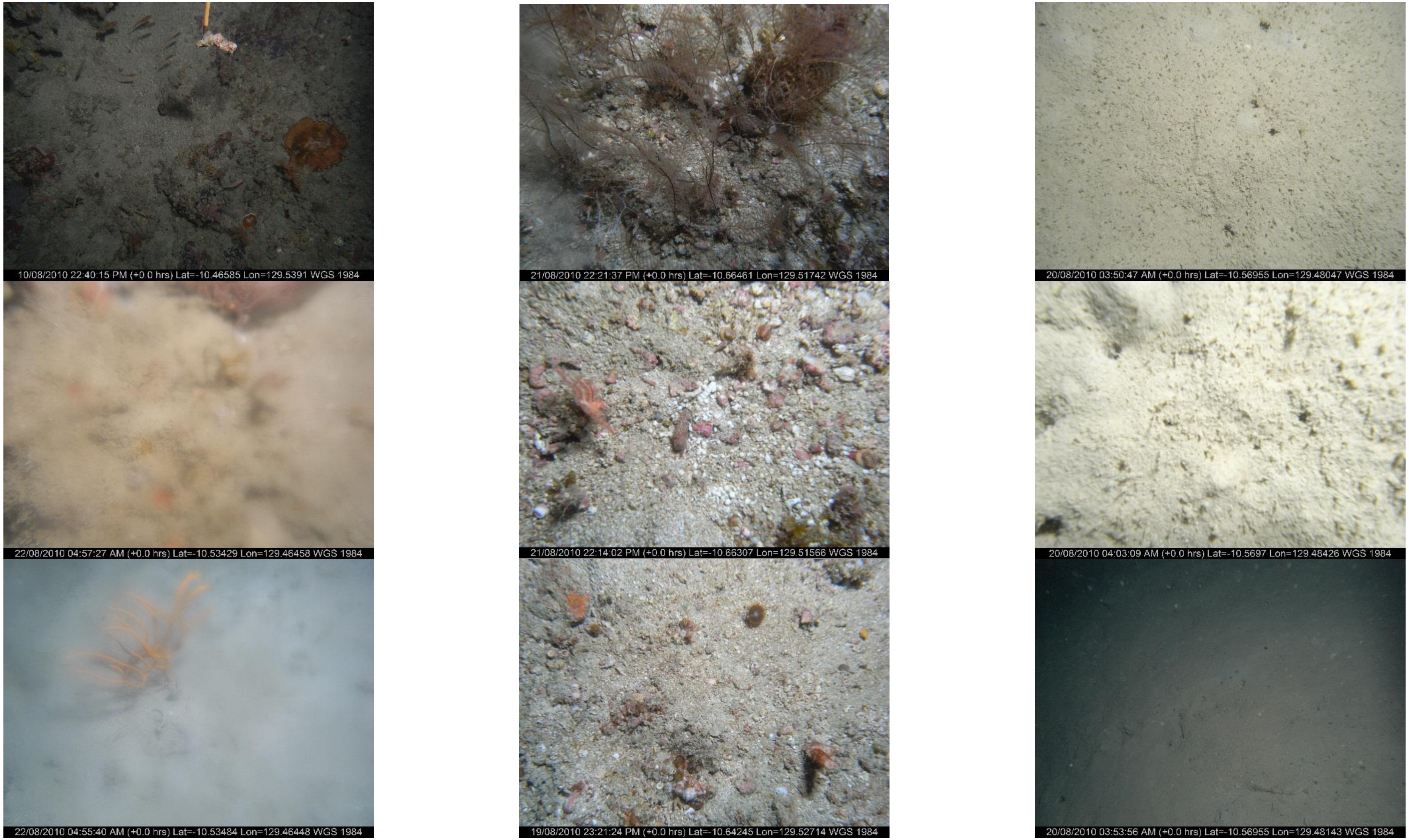


Figure 5-11: Proximity of Shoals to the AMBA

Table 5-9: Benthic Environment Summary for the Bethany Survey

Geomorphic Feature	Occurrence			Benthic Environment Summary	~% within FPZ	~% of FPZ within OSMP Geo. Feature
	Full Power Zone	Operational	AMBA			
Bank	✓	✓	✓	Banks, which are located in shallower waters (~ 20 - 60m), were found to comprise complex benthic environments with diverse and often dense epibenthic assemblages (Figure 5-12–b). Przeslawski et al (2011) noted that banks were more likely than plains or terraces to have moderate to dense biological coverage and the only geomorphic feature to support reef-forming corals. These features were found to support a range of epibenthic fauna, including molluscs, crustaceans, echinoderms and fishes (Anderson et al 2011). Benthic habitats were comprised of hard corals, sponges and octocorals (Anderson et al. 2011). Although hard corals were present within bank features, these were only discovered in shallow water depths (<35 m) and terraces in deeper waters (48 - 101 m) were devoid of hard coral (Anderson et al. 2011).	28	7
Hole/valley	✓	✓	✓	Valleys where identified within deeper areas of 40 – 200 m (Przeslawski et al. 2011). Valley features were also identified to comprise octocorals and sponges, however these were mostly found as 1-2 individuals or in small aggregations (Anderson et al. 2011). Przeslawski et al. (2011) indicates that low relief features (basin), include plains and channel floors characterised by sediments that support rich infaunal communities but sparse epifaunal abundances ((Figure 5-12– c).	21	18
Terrace	✓	✓	✓	Terraces occur at intermediate depths (~ 48 – 101 m) and are benthically less complex than banks, but where rocky outcrops were present they supported moderate to high densities of sessile epifauna, dominated by sponges and octocorals ((Figure 5-12 – a) (Anderson et al. 2011). Terrace features also supported a range of epibenthic fauna including gastropods, crabs, bryozoa, ascidians, heart urchins, brittlestars, crinoids, sea stars, holothurians, nudibranchs, worms and small fishes (Anderson et al. 2011). Although present, the occurrence of octocorals associated with terrace features were markedly lower than those assemblages associated with banks.	49	10
Basin	✓	✓	✓	Basin features comprise low-relief expanses of unconsolidated sediment, with Przeslawski et al (2011) indicating that these habitats are dominated by infauna with limited epifauna.	2	0.5

Geomorphic Feature	Occurrence			Benthic Environment Summary	~% within FPZ	~% of FPZ within OSMP Geo. Feature
	Full Power Zone	Operational	AMBA			
Shelf	-	✓	✓	The Arafura shelf is the northern extension of the Australian continental platform. It is a gently seaward sloping plain with subdued topography (Harris et al. 2005).	-	-
Pinnacle	-	✓	✓	The Pinnacles of the Bonaparte Basin are a Key Ecological Feature. As shown in Figure 5-5 a small number (~3) pinnacles are within the operational area. Pinnacles of the Bonaparte Basin are comprised of limestone and it is thought that the vertical walls generate local upwelling of nutrient-rich water, leading to phytoplankton productivity that attracts aggregations of planktivorous and predatory fish, seabirds and foraging turtles (DSEWPaC 2012c). As the pinnacles provide areas of hard substrate in an otherwise relatively featureless environment they are presumed to support a high number of species; however, the species richness and diversity of these structures is generally poorly understood (Brewer et al. 2007). Communities associated with the pinnacles are thought to include sessile benthic invertebrates such as hard and soft corals and sponges, and aggregations of demersal fish species such as snapper, emperor and grouper (DSEWPaC 2012c).	-	-
Slope	-	✓	✓	The slope feature within the operational area is associated with the slope of the Arafura Shelf, which is known to support a large number of 284 demersal fish species (Last et al. 2005). The Shelf Break and Slope of the Arafura Shelf is characterised by continental slope, patch reefs and hard substrate pinnacles (Harris et al. 2005).	-	-
Shoals	-	-	✓	The AMBA overlaps a single shoal. Tassie Shoal is located approximately 23 km from the operational area (Figure 5-11). No information could be found regarding Tassie Shoal. It is expected that the benthic environment of this feature would be similar to the description provided for banks in the Survey Area subsection above.	-	-



a) Terrace (49% FPZ; 10% OSMP) **b) Bank (28% FPZ; 7% OSMP)** **c) Hole / Deep Valley (21% FPZ; 18% OSMP)**

Figure 5-12: Geomorphic features and benthic habitats within the OSMP and FPZ (GA 2017)

5.5.1.2 Benthic Environment Predictive Modelling

Where there is limited information, environmental features are used as indicators for the types of species and habitats likely to occur. These include bioregions, water depth, seafloor features and key ecological features (DNP 2017). Another way to 'fill in the gaps' between field observations is to build spatial predictive habitat models. For the marine environment, such modelling involves collecting and integrating spatial datasets to build realistic representations of both the topography and composition of the seafloor and major biotic groups (Radford and Puotinen 2016).

Spatial predictive modelling has been utilised for the Oceanic Shoals Marine Park (OSMP). Multiple field campaigns have collected high resolution survey data in seven study areas within or near the Oceanic Shoals, however these studies collectively cover only a small fraction of the total area of the Marine Park, however by using spatial predictive modelling a benthic habitat map was produced for the entire OSMP. The predictive model uses high resolution bathymetric data or hydro-acoustic data inputs, and verified field data. For the OSMP, AIMS underwater towed video was used to document where biota of various types actually exists, the field data is then used to build and test the predictive model (Radford and Puotinen 2016).

A separate model for each class of benthos was then developed by exploring the statistical relationship between the predictors and field data presence or absence across the area, the resulting model predicts the likelihood that the class actually exists ranging from 0 (no chance) to 1 (100% certainty it exists). Data is then combined to produce mixed category maps compilation to find out where different classes may co-exist together (Radford and Puotinen 2016). However, it is important to note there were some inaccuracies in the model. For example, the model predicted hard coral but the benthic class was actually something else (giving false hits). Most commonly this was Alcyon. The relative proportion of false positives and misses given the sample size was then used to estimate overall accuracy of the classification. However, across all classes the model accuracy was high (82.97% total accuracy) (Radford and Puotinen 2016).

The classes with a 'poor' accuracy results are as follows: abiotic, filter feeders, macroalgae and seagrasses.

Data points that were:

- Abiotic were most often mistakenly predicted to be whips.
- Filter feeders were most often mistakenly predicted to be sponges.
- Macroalgae were most often mistakenly predicted to be Halimeda.
- Seagrass were most often mistakenly predicted to be filter feeders.

In order to use this model in identifying habitat types likely to support site-attached species within the Bethany FPZ and to reduce inaccuracies in the prediction, classes have been grouped into two broad categories based on the likelihood of supporting site attached species:

1. Abiotic and Burrowers/Crinoids – unlikely to support site attached species.
2. Alcyon, Filterers, Gorgonians, Halimeda, Hard Coral, Macroalgae, Seagrass, Soft Coral and Unknown – likely to support site attached species.

For the Bethany habitat assessment three 'poorly' modelled habitat types, filter feeders, macroalgae and seagrasses are grouped with habitat classes they were mistaken for, and therefore reducing inaccuracy of the model. Whereas, the abiotic class mistakenly predicted to be whips has been underestimated, and therefore habitat coverage predictions for this class is considered to be conservative.

Bethany Habitat Modelling

To further investigate the likelihood of the types of benthic habitat within the FPZ, Santos contracted Jacobs to conduct a desktop assessment of the habitat features present in the survey area. This was undertaken by reviewing the benthic habitat data for the OSMP collected by the Australian Institute of Marine Science (AIMS). Jacobs prepared a map (Figure 5-13) that overlaid the habitat data with the survey area to gain an understanding of the benthic habitat categories present. The habitat categories (classified by AIMS and confirmed Ben Radford pers. comm. 2017) and their relative percentage coverage in the survey area are detailed in Table 5-10.

Figure 5-13 and Table 5-10 shows that the overall coverage of epibenthos habitats is low for all three areas, and much of the benthic habitat within the OSMP, KEF (FPZ coverage) and FPZ is classified as abiotic (sand and rock), and covers a large percentage of the area; 70.52%, 53.67% and 66.76%, respectively. Of the biotic habitat categories within the FPZ and the KEF, filter feeders had the highest coverage (19.16% and 16.10%, respectively). Sessile invertebrate filter feeders (e.g. sponges, bryozoans and hydroids) are heterotrophic, extracting their food from the surrounding waters. In the FPZ and KEF, burrowers and crinoids had the second highest coverage (10.01%, 9.30 %respectively) and may include groups such as polychaetes, crabs, starfish, feather stars and brittle stars. Whereas, in the OSMP, burrowers and crinoids dominated (17.59%) and the filter feeders were second highest % coverage (9.68%).

The habitat categories present are likely related to the water depth of the survey area (between 45-100 m). Filter feeders are generally the most common epibenthic fauna within deep-water (light-limited) environments, as they don’t rely on light to produce energy, instead filtering plankton from the water column (Heyward et al. 1997). In contrast, photosynthetic dependent organisms, such as hard corals and macroalgae are likely to be less prevalent at these depths.

Another study which examined seabed biodiversity within mid-shelf areas adjacent to the Goodrich Bank and Cape Helvetius found these areas had a similar benthic habitat to that of the FPZ. The mid-shelf sites were generally turbid with large areas of bare seabed which supported patchy sponge dominated filter feeder communities, associated with limited areas of consolidated substrates (Heywood et al. 2017).

The most distinguishing feature of the analysis for the three areas is that the % coverage of benthic habitat categories are similar and appear uniform in occurrence. For example, the highest biotic benthic habitat categories for the three areas are invertebrate filter feeders and burrowers and crinoids. The least % all with a level of coverage <2% are hard corals, gorgonians (which include sea fans and sea whips), soft corals and Halimeda (a calcareous macroalgae). Additionally, the area of the OSMP and therefore within the FPZ, is identified as a representative habitat, and supports tropical benthic habitat that is typical throughout the region (ConocoPhillips 2017).

Figure 5-13: Benthic habitat categories present within the seismic survey area

Table 5-10 summarises the benthic habitat categories identified within the Oceanic Shoal Marine Park (AMBA is located entirely within the OSMP), the KEF - Carbonate banks of the Van Diemen Rise, and FPZ. A comparison of these areas by habitat is shown in Figure 5-14.

Table 5-10: Benthic Habitat Categories within the OSMP

Benthic Habitat Categories	Description	OSMP % coverage	KEF* % coverage	FPZ % coverage
Abiotic	Sand interspersed with rocky substrates.	70.52	53.70	66.76
Alcyon	Soft corals that can cement sclerites and consolidate them at their base into alcyonarian spiculite, thus making them reef builders (Jenssen et al 2011).	0.28	0.40	0.42
Burrowers/Crinoids	Soft sediment communities such as polychaetes, crabs, starfish, feather stars and brittle stars, which in their adult form are attached to the sea bottom by a stalk, some are attached only as juveniles and become free-swimming as adults.	17.59	9.30	10.01
Filterers	Sessile invertebrate filter feeders (e.g. sponges, bryozoans and hydroids) are heterotrophic, extracting their food from the surrounding waters. Filter feeders that dominate in the deep water, light-limited habitats as they don't rely on light to produce energy, instead filtering plankton from the water column (Heyward et al. 1997).	9.68	16.10	19.16
Gorgonians	Soft sediment communities that tend to anchor themselves in mud or sand.	0.40	0.50	0.68
Halimeda	Calcareous macroalgae and photosynthetic dependent organism.	0.07	0.10	0.10
Hard Coral	Photosynthetic dependent organisms.	0.71	1.10	1.69
Macroalgae	Photosynthetic dependent organisms.	0.10	0.20	0.06
Seagrass	Marine flowering plants, photosynthetic dependent organisms.	-	-	0.01
Soft Coral	Primarily colonial sessile animals – not light dependant.	0.34	0.40	0.42
Unknown	n/a	0.31	0.50	0.70
Not Classified	n/a	n/a	17.80	-

Source: Jacobs Report – Bethany Seismic Survey, Site Attached Fish Assemblages (2017).
*KEF - Carbonate banks of the Van Diemen Rise

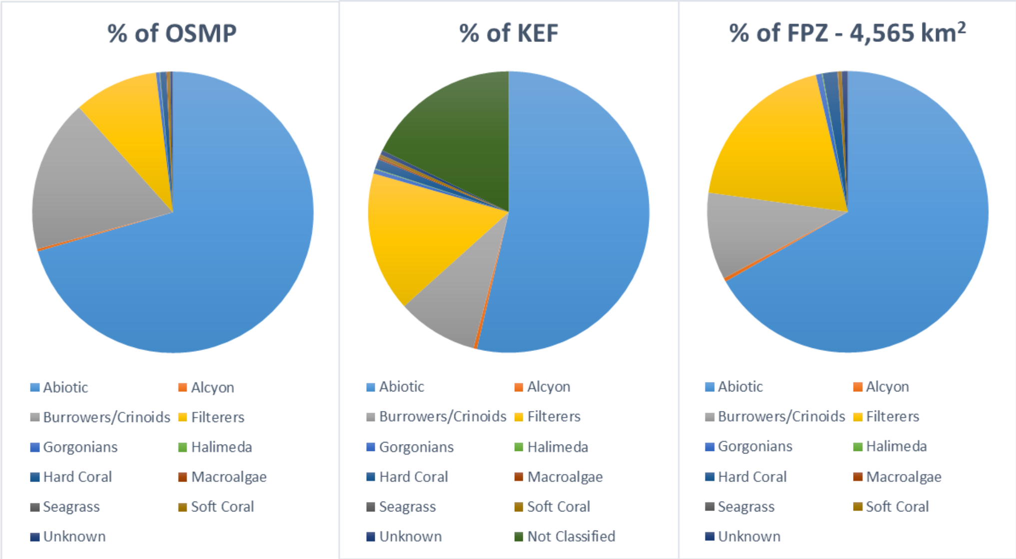


Figure 5-14: Comparison of the % cover of the benthic habitats for the OSMP, FPZ and KEF – carbonate banks of the Van Diemen Rise

Source: Jacobs Report – Bethany Seismic Survey, Site Attached Fish Assemblages (2017)
*KEF - Carbonate banks of the Van Diemen Rise

5.5.1.3 Comparison with benthic surveys in the vicinity of the Bethany FPZ

Additional information on the benthic habitat types present within the OSMP was obtained from the Barossa Environmental Studies Benthic Habitat Report prepared for ConocoPhillips (Jacobs 2016). Sites sampled as part of this study that were in the vicinity of the survey area have been overlaid on Figure 5-13 and a summary of the habitat features for each are described below.

Based on the information summarised below, the benthic habitat within the FPZ consists mainly of abiotic substrate such as sand interspersed with rocky substrates supporting communities of invertebrate filter feeders (i.e. hydroids, soft corals, gorgonians and sponges). The water depth within the survey area (between 45-100 m) restricts the ability for photosynthetic reliant biotic communities such as hard corals and macroalgae to survive; however, filter feeding organisms that rely on plankton for food thrive in this environment (Jacobs 2017).

The geomorphology of the survey area is complex covering an area consisting of banks, terraces, valleys, plains and pinnacles. However, the complexity of the benthic habitats overlaying these features is limited by the depth of the water and the associated lack of benthic light availability, as well as the dominance of sandy substrates restricting the establishment of more complex reef ecosystems.

The survey area can be described as a deep-water environment consisting mainly of sand with rocky outcrops supporting small discreet communities of predominantly filter feeding benthic communities. The lack of habitat complexity within the survey area is likely to restrict the diversity of fish communities in this area (Jacobs 2017).

Scarps (Sites HM014 and HM019)

These sites were located in water of approximately 185m. The higher side of the scarp profile consisted of rock boulders and consolidated shell grit, sediment and hydroid/bryozoan turf. This habitat supported invertebrate filter feeders, including gorgonians, sea whips, featherstars and sponges. The lower side of the scarp was predominantly sand (Jacobs 2017).

Seamounts (Sites HM010B, HM011 and HM029)

The top of the seamounts were between 50 m and 80 m in depth, with the primary habitat consisting of sand and algae-covered rubble, with soft corals, sponges, sea whips and sea cucumbers noted. Trigger fish nests were prevalent at HM011, located reasonably close together and covering a large area. The slope of HM029 had a rocky face with coarse sand deposits supporting sea whips, gorgonians, other soft corals and sponges (Jacobs 2017).

Barossa Permit Area (Sites HM013, HM016, HM017, HM018, HM021, HM022, HM023)

These sites ranged in depth from 211 m to 309m. The substrate in these areas was predominantly silty sand and slightly undulating (<25 cm in height) with widespread bioturbation (i.e. burrows, mounds and tracks). Observed biota included sea pens, anemones, decapod crustaceans, starfish, soft corals and some demersal fish.

While the sampling sites from the Jacobs study lie outside of the survey area, the water depths and habitat categories present are similar to what was observed for the AIMS data, especially at sites HM010B, HM011 and HM029 (Jacobs 2017).

5.5.2 Pelagic Environment

A search of the DoEE Protected Matters Database was undertaken for the Bethany AMBA. Table 5-11 details fauna identified by the Protected Matters Search and any applicable management plans.

Table 5-11: Threatened and Migratory Species that May Occur within AMBA

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery plan / Approved Conservation Advice	Relevant Management Actions
Sharks				
White shark	*Carcharodon carcharias*	Vulnerable, Migratory	Recovery Plan for the White Shark (*Carcharodon carcharias)*	None identified
Northern river shark	*Glyphis garricki*	Endangered	Sawfish and River Sharks Multispecies Recovery Plan Approved Conservation Advice for Glyphis garricki (Northern River Shark).	None identified
Speartooth Shark	Glyphis glyphis	Critically Endangered	Sawfish and River Sharks Multispecies Recovery Plan Approved Conservation Advice for *Glyphis glyphis* (Speartooth shark)	None identified
Largetooth (Freshwater) sawfish	*Pristis*	Vulnerable, Migratory	Sawfish and River Sharks Multispecies Recovery Plan	None identified
Green sawfish	*Pristis zijsron*	Vulnerable, Migratory	Sawfish and River Sharks Multispecies Recovery Plan Approved Conservation Advice for Green Sawfish	None identified
Whale shark	*Rhincodon typus*	Vulnerable, Migratory	Whale Shark (*Rhinocodon typus)* Recovery Plan 2005-2010 *expired recovery plan Approved Conservation Advice *Rhincodon typus* whale Shark	Evaluate risk of vessel strike (Section 7.8) Evaluate risk from noise emissions (Section 7.1 and 7.2)
Narrow sawfish	*Anoxypristis cuspidate*	Migratory	—	—
Shortfin mako	*Isurus oxyrinchus*	Migratory	—	—
Longfin mako	*Isurus paucus*	Migratory	—	—
Rays				
Reef manta ray	*Manta alfredi*	Migratory	—	—
Giant manta ray	*Manta birostris*	Migratory	—	—
Reptiles				
Loggerhead turtle	*Caretta caretta*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery plan / Approved Conservation Advice	Relevant Management Actions
Green turtle	*Chelonia mydas*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	Evaluate risk of vessel strike (Section 7.8) Management of marine debris (Section 7.6) Soft start procedures to be implemented for seismic surveys that occur within the distribution of marine turtles (Section 7.1). Spill risk strategies and response programs include management for marine turtles and their habitats (Section 7.11 and 7.12), Management of light pollution (Section 7.3) Management of vessel/fauna interactions (Section 7.8).
Leatherback turtle	*Dermochelys coriacea*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 – 2027 Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle)	
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	
Olive Ridley Turtle	*Lepidochelys olivacea*	Endangered, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	
Flatback Turtle	*Natator depressus*	Vulnerable, Migratory	Recovery Plan for Marine Turtles in Australia 2017 - 2027	
Salt-water Crocodile	*Crocodylus prosus*	Migratory	—	—
Birds				
Curlew sandpiper	*Calidris ferruginea*	Critically Endangered, Migratory	Approved Conservation Advice for *Calidris ferruginea* (Curlew Sandpiper).	None identified
Eastern curlew, Far eastern curlew	*Numenius madagascariensis*	Critically Endangered, Migratory	—	—
Common noddy	*Anous stolidus*	Migratory	—	—
Streaked shearwater	*Calonectris leucomelas*	Migratory	—	—
Lesser frigatebird	*Fregata ariel*	Migratory	—	—
Great frigatebird	*Fregata minor*	Migratory	—	—
Osprey	*Pandion haliaetus*	Migratory	—	—
Mammals				
Sei whale	*Balaenoptera borealis*	Vulnerable, Migratory	Conservation Advice *Balaenoptera borealis* (sei whale) *not a recovery plan	Minimise vessel collisions (Section 7.8)

Common Name	Scientific Name	EPBC Act Status	Management Plan / Recovery plan / Approved Conservation Advice	Relevant Management Actions
Blue whale	*Balaenoptera musculus*	Endangered, Migratory	Conservation Management Plan for the Blue Whale 2015-2025	Minimise vessel collisions (Section 7.8)
Fin whale	*Balaenoptera physalus*	Vulnerable, Migratory	Conservation Advice *Balaenoptera physalus* (fin whale) *not a recovery plan	Minimise vessel collisions (Section 7.8)
Humpback whale	*Megaptera novaeangliae*	Vulnerable, Migratory	Conservation Advice for *Megaptera novaeangliae* (humpback whale) *not a recovery plan	Assess and address anthropogenic noise (Section 7.1 and 7.2) Minimise vessel collisions (Section 7.8) Report all fauna strike events (Section 7.8)
Antarctic Minke Whale	Balaenoptera bonaerensis	Migratory	—	—
Bryde's whale	*Balaenoptera edeni*	Migratory	—	—
Spotted Bottlenose Dolphin	*Tursiops aduncus*	Migratory	—	—
Killer Whale	*Orcinus orca*	Migratory	—	—
Sperm Whale	*Physeter macrocephalus*	Migratory	—	—

5.5.3 Plankton

Plankton consists of microscopic organisms typically divided into phytoplankton (alga) and zooplankton (fauna including larvae. Plankton play a major role in the trophic system with phytoplankton being a primary producer and zooplankton a primary consumer. Phytoplankton rapidly multiply in response to bursts of nutrient availability and are subsequently consumed by zooplankton that in turn are consumed by other fauna species.

The composition of phytoplankton in the North Marine region is highly diverse; about 200 species are known to occur in the area. The predominant phytoplankton species are the large, tropical diatom flora (single-celled algae) on the continental shelf (DSEWPaC 2012c). Copepod animals (zooplankton) found in the region comprise a diverse group of small crustaceans. They are characteristic of warm shallow coastal waters, with around 88 of the 102 species identified in the region common to South-East Asia (Othman et al. 1990).

Phytoplankton have marked seasonal cycles in tropical regions with higher productivity occurring during the cooler months and lower productivity in the warmer months (Blondeau-Patisser et al 2011, Schroeder et al 2009).

In the north marine region, there is very little mixing between turbid coastal boundary layer waters and clear (oligotrophic) offshore waters, and hence there is little transfer of nutrients, freshwater or sediments into offshore waters (Schroeder et al 2009). Consequently, the main source of nutrients is expected to be from the Indonesian Throughflow which transports warm, low-salinity water into the Bonaparte Basin during storm and cyclone events (Brewer et al. 2007), and upwelling's from high density and nutrient rich deep ocean waters. Consequently, plankton productivity in the AMBA is expected to be sparse and patchy. Zooplankton that rely on phytoplankton for food are then subject to similar constraints and seasonality in the area.

Furthermore, a bio-regional scale, modelling pf potential connectivity between NMR and North-West Marine Region (NWMR) Marine Parks suggests (Figure 5-15):

- 77% larvae chance of larvae being retained within its area of origin.
- OSMP receives and contributes larvae to Marine Parks within the NMR and NWMR, with the furthest connectivity occurring with West Cape York Marine Park to the east and the Montebello Islands Marine Park to the southwest.
- OSMP links the NMR eastern Marine Parks and the NWMR western Marine Parks.

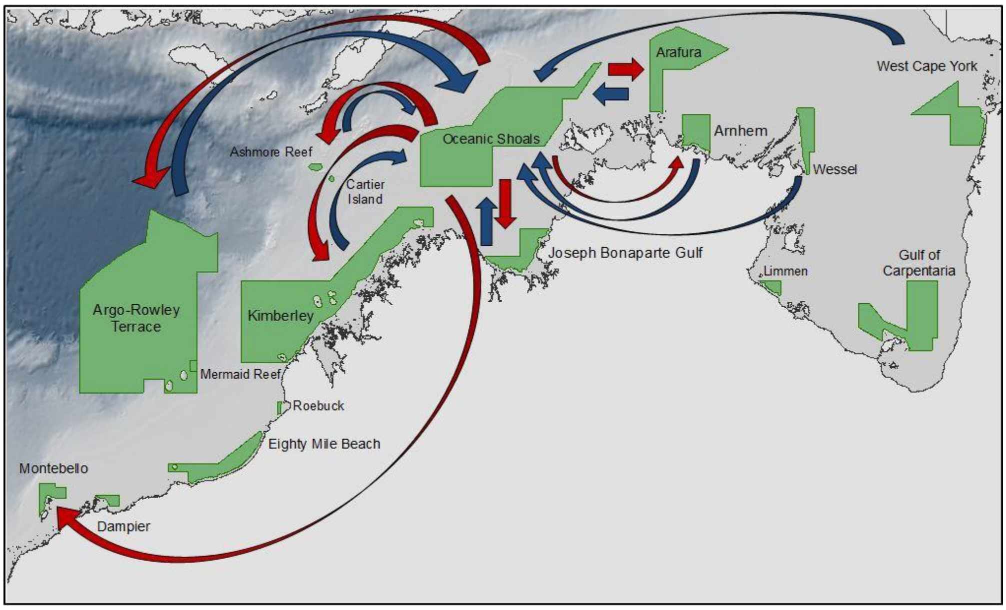


Figure 5-15: Modelled connectivity to and from the Oceanic Shoals CMR*

Source: modified from NERP Marine Biodiversity Hub (2015)

**Red arrows indicate export of larvae from the Oceanic Shoals to other CMRs, blue arrows indicate import of larvae to the Oceanic Shoals from other CMRs.*

It should also be noted, that although oligotrophic, unlike more temperate waters, plankton productivity in this area is also limited by light attenuation (Burford and Rothlisberg 1999). Schroeder et al (2009) suggests however that light attenuation in offshore waters (due to turbidity) is lowest in the cooler months due to trade winds-induced mixing and algal bloom occurrences.

Based on information from the Northern Prawn Fishery Industry (NPFI) commercial prawn species such as banana and tiger and endeavour prawns are known to spawn in areas closer to the coast and as such are considered to be outside of the AMBA.

Consultation with the NT DPIF identified that the peak spawning period for commercial fish in the area such as snapper is within October and May and hence outside the survey timing. Since this consultation the TRF have stated that peak spawning is from Sept to May.

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 *P. maxima* which spawn in the spring months of September or October with primary spawning from the middle of October to December. A smaller secondary spawning occurs in February and March (Hart et al. 2016). Hence, spawning of this species may occur during the survey timing.

5.5.4 Fish

The proposed Bethany survey area likely supports offshore pelagic and demersal fish assemblages which are typical of those found in the North Marine Region and are not unique or endemic.

To evaluate the likely fish (to taxonomic family level) associated with the benthic habitat and geomorphological features (Section 5.5.1.2), Santos contracted Jacobs to conduct a desktop assessment of the fish families likely to occur in the FPZ. The aim of the study was to identify benthic habitats likely to support site attached fish, fish families likely to occur, hearing sensitivity, identification of protection listing, uniqueness, and degree of site attachment (Jacobs 2017).

From Section 5.5.1.2 the FPZ can be described as representing deep undulating habitat with banks and troughs, predominantly composed of sand and rock. These substrates primarily support filter feeding communities which don't rely on photosynthesis for survival. The absence of more structurally complex habitats consisting of hard and soft corals influences the diversity and abundance of fish families within the area (Jacobs 2017). These findings are similar to the biodiversity patterns identified from the key findings of the three recent surveys of the OSMP surveys, where pelagic species were preferentially associated with raised geomorphic features (NERP Marine Biodiversity Hub 2015).

A list of potential fish families within the survey area, based on the habitat categories present, was compiled by reviewing the findings from other studies on the North West shelf of Western Australia that had examined fish diversity in similar habitats (Jacobs 2017).

- The following published papers and reports were utilised in the study:
    - A study undertaken by Moore et al. 2017 provided an assessment of the fish communities associated with the submerged oceanic banks and shoals in north-west Australia (Moore *et al.* 2017).
    - The Barossa Benthic Habitat Report (Jacobs 2016) detailed the fish families observed during the habitat assessment undertaken.
    - Barossa marine studies program, a regional shoals and shelf assessment was conducted to assess the benthic habitat of Evans, Tassie, Blackwood Shoals as well as at two mid-shelf locations (Heyward et al. 2017).
- To further support findings from the literature review, additional data sources for potential fish families and species were reviewed. These included the following datasets:
    - Bycatch data from the Timor Reef Fishery; and
    - Images from AIMS/Geoscience Australia research trips of the Eastern Joseph Bonaparte Gulf (GA 2017).

The review found that the diversity of fish families present within the survey area is likely to be low due to the low complexity of the benthic habitat in this area. Moore et al (2017) found that the major drivers of species richness and abundance were the percentage cover of calcareous reef (i.e. reef substrata), depth and to a lesser extent aspect. Therefore, it can be expected that fish species richness in the survey area will be relatively low due to the water depths (over 85% of the survey area is in water depths greater than 40 m) and substrate type (over 65% of abiotic benthic habitat).

Although the KEFs that overlap the operational area (Carbonate banks and terraces of the Van Diemen Rise and the Sahul Shelf, and pinnacles of the Bonaparte Basin) represent a range of substrates, aspects and depths, demersal fish communities appear to correlate with the spatial patterns observed for the benthic biodiversity occurring in larger and more diverse communities on the offshore, shallower, less turbid banks/shoals (Anderson *et al*. 2011). Recent studies of the North West oceanic shoals (e.g. Tassie Shoals and Echuca Shoals) found that they support some of the highest fish species richness reported to date for mesophotic reefs (20-80 m) (Moore et al 2017; Heyward et al 2017). Therefore, the species identified for the survey area are well represented throughout the North West Marine Region and are not considered endemic or unique.

Table 5-12: Fish families identified that may occur within the survey area based on literature, trawl bycatch data and additional information from research trips

Fish Family	Common Name	Identified in Moore et al 2017	Identified in Jacobs 2016	Identified in Heyward et al 2017	Identified in Fishermen trawl catch data	Identified in AIMS images captured during research trips*
Acanthuridae	Surgeonfishes, tangs, and unicornfishes	Yes	-	Yes	No	-
Balistidae	Triggerfishes	Yes	Yes	Yes	Yes	-
Carangidae	Jacks, pompanos, jack mackerels, runners, and scads.	Yes	Yes	Yes	Yes	Yes
Gobiidae	Gobies	-	Yes	-	-	Yes
Indostomidae	Armored sticklebacks	-	Yes	-	-	-
Labridae	Wrasses	Yes	Yes	Yes	Yes	-
Lethrinidae	Emperors, emperor breams, and pigface breams	-	Yes	Yes	Yes	-
Lutjanidae	Snappers	Yes	Yes	Yes	Yes	Yes
Malacanthidae	Tilefishes, Amadais, Blanquillos, Burrowfishes, Horseheads, Moonfishes, Quakerfish, Sand Tilefishes, Tile-fish	-	-	Yes	-	-
Monacanthidae	Leatherjackets	-	-	Yes	Yes	-
Mullidae	Goatfishes	-	-	Yes	Yes	-
Paralichthyidae	Sand flounders	-	Yes	-	Yes	-
Platycephalidae	Flatheads	-	Yes	-	-	Yes
Pomacentridae	Damselfishes	-	Yes	-	-	-
Serranidae	Groupers, rockcods and their allies	-	-	Yes	Yes	-
Sygnathidae	Seahorses, pipefishes, seadragons, pipehorses	-	-	-	-	-
Tetradontidae	Pufferfishes, toadfishes	Yes	-	Yes	Yes	-
Triglidae	Searobins, Armour gurnards	-	Yes	-	Yes	-
Zanclidae	Moorish Idol	-	Yes	-	-	-
Branchiostomidae	Lancelet	-	-	-	-	-
Holocentrinae	Squirrelfish	-	-	-	-	Yes

Source: modified from Jacobs (2017)

Without specific studies of each family determining their hearing sensitivity and associated behavioural response, it is difficult to assess their response to seismic noise. In the absence of this experimental data, the fish families identified in Table 5-12 were classified further depending on their degree of site attachment assessed against the following criteria:

- Reef associated – generally reliant on reef structures (hard substrate with epibenthos communities) and are unlikely to move away from isolated reef habitats;
- Limited mobility – locomotion generally limited to crawling over the seabed so unlikely to be able to quickly move >200 m from the seismic source;
- Retreat response – Responds to threats by retreating into habitat (hiding in reef structure or burrowing into seabed) so may not move away from the seismic source.

5.5.4.1 Pelagic and Demersal

The fish family assessment identified pelagic and demersal species including Carangidae (snapper species) and Lutjanidae (Trevallies and Jacks) (Table 5-13). These species rely less on the benthic habitat, have increased swimming ability and would be more likely to flee a seismic sound source. These findings are consistent with the main demersal and pelagic commercial fisheries operating within the survey area and target a range of tropical snappers (Section 5.6.3) (Jacobs 2017).Based on information from the NT DPIR (Section 5.6.3) the main commercial species likely to be found in the AMBA are goldband snapper (*Pristipomoides* spp.), saddletail sea perch (alternatively called saddletail snapper) (*Lutjanus malabaricus*) and red snapper (alternatively called crimson snapper) (*L. erythropterus*).Goldband snapper is widely distributed throughout northern Australia and the tropical Indo-West Pacific. Analysis of otolith stable isotopes indicates that the Northern Territory has a separate biological stock within this distribution. The species occurs over a wide depth range, but is commercially fished from 80 to 150 m in depth (NT Government 2016).

A review of bycatch data from the Timor Reef Fishery in 2015, in the vicinity of the Bethany survey confirmed the presence of pelagic demersal fish families Carangidae and Lutjanidae (Table 5-12). Trawling in 2015 occurred directly within the survey area on the northern edge; however, the majority of the trawling occurred just north and north east outside of the survey area. The trawl net panels are 23 cm and 15 cm at the cod end, therefore fish smaller than 23 cm may escape which may bias the data towards fish larger than 23 cm. i.e. the trawl fishery is not targeting smaller site-attached species.

Saddletail sea perch is a widespread Indo-Pacific species found throughout tropical Australian waters. Genetic studies indicate that within Northern Territory waters (including the Timor Sea, Arafura Sea and the Gulf of Carpentaria) the species is comprised of one biological stock. The species occurs over a wide depth range, from coastal to offshore areas and is fished in waters up to 150 m in depth (NT Government 2016). Red snapper is a widespread Indo-Pacific species found throughout tropical Australian waters. Genetic studies indicate that within Northern Territory waters (including the Timor Sea, Arafura Sea and the Gulf of Carpentaria) the species is comprised of one biological stock. The species occurs over a wide depth range, from coastal to offshore areas and is fished in waters up to 150 m in depth (NT Government 2016).

Surveys of the benthic environment by Heap et al. (2010), Anderson et al. (2011) and Przeslawski et al. (2011) indicate that epibenthic fish can be expected within the AMBA, however these surveys did not specify if those observed were reef or site attached fish (see Section 5.5.1). However, they noted that fish were present where dense epibenthic communities existed, and given the potential for these to be present within the AMBA (Section 5.4.10) it is conservatively assumed that dense aggregations of reef or site attached species may be present where pinnacles or shallow banks occur within the AMBA. The analysis of the AIMS images captured during these research trips confirmed the presence of pelagic demersal fish families Carangidae and Lutjanidae over sediment flats and deep hole valleys (Table 5-12; Table 5-13, and Figure 5-16).

Figure 5-12

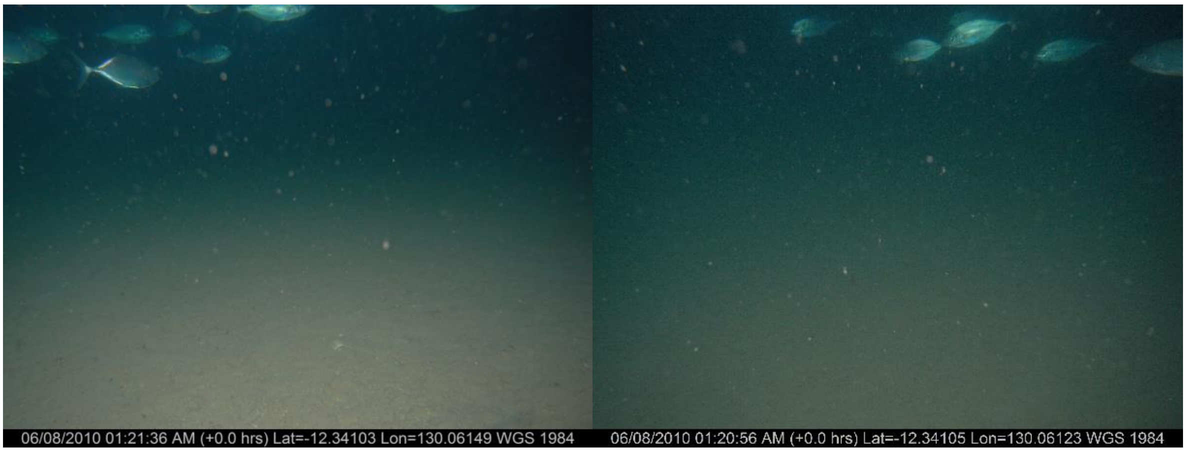


Figure 5-16: Fish family Carangidae within the OSMP and FPZ

Table 5-13: Fish families likely to occur in the Bethany survey area and their associated hearing sensitivity, protection listing, uniqueness and predicted flee response

Fish Family	Hearing Sensitivity	Protection Listing	Uniqueness	Characteristics	Basis for Site Attachment	Maxima Seismic Survey Predictions (Woodside 2007)
Acanthuridae	Swim bladder present Hearing sensitivity unknown	Not listed	Can slash other fishes with their sharp caudal spines	Most surgeon fishes graze on benthic algae, while some feed on zooplankton or detritus (Fishbase database. Accessed 25/10/2017). Some species (*Acanthurus lineatus*) are strongly site attached and remain within and actively defend specific areas of reef substratum against feeding activities of other herbivores (Choat and Bellwood 1985).	Reef associated.	Non-fleeing
Balistidae	Hearing specialist (Sand and Enger 1973)	Not listed	Lay demersal eggs in nest guarded by female (Fishbase database. Accessed 25/10/2017)	Balistids characteristically have omnivorous diets and access a wide range of plant and invertebrate food sources (Kuwamura 1991). Acquire food resources by foraging in specialised habitats with the family including both planktivorous and benthic feeding species (Randall *et al*. 1997).	Reef associated	Likely to flee (mostly)
Carangidae	Swim bladder present Hearing sensitivity unknown	Not listed		Fast swimming predators of the waters above the reef (Fishbase database. Accessed 25/10/2017). Some root in the sand for invertebrates and fishes. Usually in small schools over sand bottoms near reefs.	Not considered site attached due to good swimming ability and minimal reliance on reef structures for shelter.	Likely to flee
Gobiidae	Hearing generalist (Ladich 2002)	Not listed	The smallest fishes belong to this family. Some species have symbiotic relationships with invertebrates (shrimps).	Most are cryptic bottom dwelling carnivores while others are planktivorous. They are associated with shallow coastal waters and coral reefs. Typically nest spawners that are guarded by the male (Fishbase database. Accessed 25/10/2017).	Reef associated Limited mobility Retreat response	Non-fleeing
Indostomidae	Swim bladder present Hearing sensitivity unknown	Not listed		Swim bladder physoclistic (no connection between swim bladder and intestinal tract, pressure of swim bladder is regulated by special tissues or glands) (Fishbase database. Accessed 25/10/2017).	Reef associated	N/A

Fish Family	Hearing Sensitivity	Protection Listing	Uniqueness	Characteristics	Basis for Site Attachment	Maxima Seismic Survey Predictions (Woodside 2007)
Labridae	Swim bladder present Hearing sensitivity unknown	Not listed	Most species change colour and sex with growth. Males dominate several females.	Most species are sand burrowers and are carnivores on benthic invertebrates or planktivores. Many of the species in this family are less than 15 cm (Fishbase database. Accessed 25/10/2017).	Reef associated Retreat response	Non-fleeing (mostly)
Lethrinidae	Swim bladder present Hearing sensitivity unknown	Not listed	Highly commercial	Bottom feeding, carnivorous fishes, ranging primarily on or near reefs. Can be solitary or schooling and do not appear territorial (Fishbase database. Accessed 25/10/2017).	Reef associated	Likely to flee (mostly)
Lutjanidae	Swim bladder present Hearing sensitivity unknown	Not listed		Most species are predators of crustaceans and fishes but several are planktivorous. Generally demersal down to depths of 450 m (Fishbase database. Accessed 25/10/2017).	Not considered site attached due to good swimming ability and minimal reliance on reef structures for shelter.	Likely to flee (mostly)
Malacanthidae	Swim bladder present Hearing sensitivity unknown	Not listed	All species live in burrows.	Feed on benthic invertebrates or zooplankton (Fishbase database. Accessed 25/10/2017).	Retreat response	Likely to flee
Monacanthidae	Swim bladder present Hearing sensitivity unknown	Not listed	Lay demersal eggs in a site prepared and guarded by the male or both parents.	Commonly known as file fishes. Most species feed on benthic invertebrates (Fishbase database. Accessed 25/10/2017).	Reef associated	Non fleeing
Mullidae	Swim bladder present Hearing sensitivity unknown	Not listed		Chin with 2 long barbels, which contain chemosensory organs for probing the sand or holes in the reef for benthic invertebrates or small fish (Fishbase database. Accessed 25/10/2017).	Reef associated	Likely to flee
Paralichthyidae	No swim bladder	Not listed	Distinct pairing in some species.	This family is characterised by the flounders. Species have no spines in pectoral and pelvic fins (Fishbase database. Accessed 25/10/2017).	Limited mobility Retreat response	N/A
Platycephalidae	Swim bladder present Hearing sensitivity unknown	Not listed		This family is characterised by the flatheads. Demersal, burying in the sediments, feeding mainly on crustaceans and small fishes (Fishbase database. Accessed 25/10/2017).	Limited mobility Retreat response	Likely to flee

Fish Family	Hearing Sensitivity	Protection Listing	Uniqueness	Characteristics	Basis for Site Attachment	Maxima Seismic Survey Predictions (Woodside 2007)
Pomacentridae	Hearing generalist (Ladich 2002)	Not listed	Males guard and aerate the eggs	Many species are highly territorial herbivores, omnivores and planktivores. Eggs are demersal and adhere to the substrate. Anemonefishes are included in this family and live in close association with sea anemones (Fishbase database. Accessed 25/10/2017).	Reef associated Limited mobility (due to small size) Retreat response	Non-fleeing
Serranidae	Swim bladder present Hearing sensitivity unknown	Not listed	Groupers are protogynous hermaphrodites	Large and diverse group of predatory marine fish ranging in size from 4 cm to 3 m in length (Fishes of Australia database. Accessed 25/10/2017)	Reef associated	Non-fleeing (mostly)
Sygnathidae	Swim bladder present Hearing sensitivity unknown	Listed marine species	Males have a brood pouch in which eggs are laid, fertilized and incubated.	This family includes the pipefishes and seahorses. (Fishes of Australia database. Accessed 25/10/2017)	Partially reef associated[1] Limited mobility	Non fleeing
Tetradontidae	Swim bladder present Hearing sensitivity unknown	Not listed	Capable of greatly inflating themselves with water.	Demersal eggs are laid in a nest and presumably defended. Some species are feeding generalists while others have a preference for certain invertebrates or algae (Fishbase database. Accessed 25/10/2017).	Reef associated	Non-fleeing
Triglidae	Swim bladder present Non-specialist (Ladich 2002)	Not listed	Good sound producers.	Commonly known as gurnard. Bottom dwellers typically found in deeper water (>380 m) (Fishes of Australia database. Accessed 25/10/2017)	Limited mobility	N/A
Zanclidae	Unknown	Not listed	Pelagic spawners whose larvae drift for a long time before settlement.	Feed mainly on sponges and benthic invertebrates (Fishbase database. Accessed 25/10/2017). The Moorish idol (*Zanclus cornutus*) is the only species in this family. They inhabitat turbid inner lagoons, reef flats and clear seaward rocky and coral reefs (Myers 1999).	Reef associated	Non-fleeing

[1] Some species associated with inshore shallow habitats, seagrass beds, sheltered bays and estuaries with sandy or muddy bottoms.

5.5.4.2 Site-attached

Site attached fish are generally small to medium sized that rely on the benthic habitat, have decreased swimming ability, and are less likely or unable to flee a seismic sound source due to their swimming ability. Jacobs fish family assessment identified one family as a ‘Listed Marine Species”, Sygnathida (pipefish and seahorses) (Section 5.5.4.3).

Without specific studies of each family determining their hearing sensitivity and associated behavioural response, it is difficult to assess their response to seismic noise. In the absence of this experimental data, an insight into their response to seismic noise is be best determined based on their degree of site attachment assessed against the following criteria (Jacobs 2017):

- Lay demersal eggs and build nests (Balistidae, Pomacentridae, Tetradontidae, Monacanthidae)
- Live in burrows or under the sand (Gobiidae, Platycephalidae, Malacanthidae)
- Feed on benthic organisms like algae, sponges or invertebrates (Acanthuridae, Zanclidae, Mullidae).

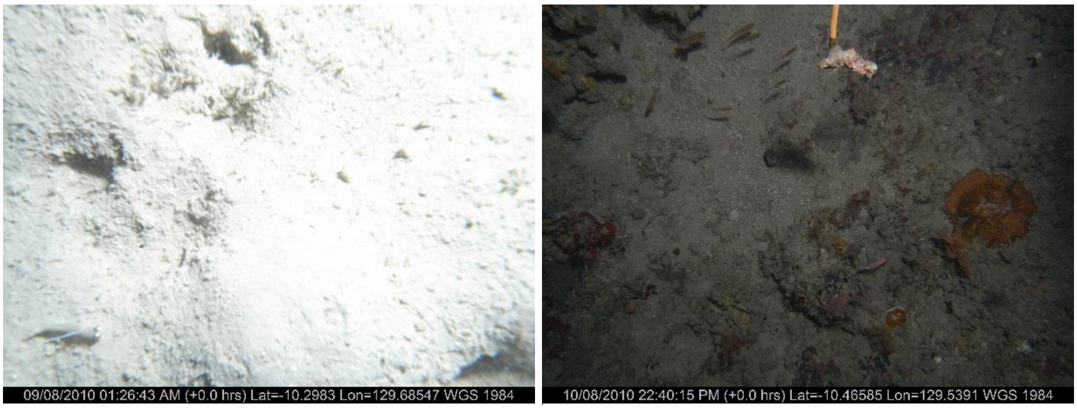


Figure 5-17: Fish family Gobiidae (left) and Holocentrinae (right) within the OSMP and FPZ

However, it should be noted Jacobs identified uncertainties associated with these methods as it is based on an assessment at the family level and there may be temporal aspects to life history traits (e.g. trigger fish (Balistidae) may only be site attached while guarding their nest/territory). These uncertainties were noted when comparing these results to a similar review, for the Maxima 3D Marine Seismic Survey at Scott Reef, conducted by AIMS for Woodside Energy Ltd. (Woodside 2007). AIMS reviewed the fish families known to occur at Scott Reef to determine which families would be expected to remain and/or seek refuge within the reef structures rather than temporarily vacate their home range or particular territory from an approaching air gun array (Table 5-13). AIMS identified some fish families, e.g. Balistidae, Malacanthidae, as likely to flee where as they had previously been identified as site-attached based on their life history traits. Without any empirical evidence recorded during a seismic survey or experimental observations, it should be noted that these assessments are somewhat subjective with the potential for different conclusions (Jacobs 2017). Nevertheless, the assessment considers multiple sources of data (government surveys, peer-review research papers, and fisheries trawl by-catch data) for the region to determine fish families likely to be present.

Surveys of the benthic environment by Heap et al. (2010), Anderson et al. (2011) and Przeslawski et al. (2011) indicate that epibenthic fish can be expected within the AMBA. The analysis of the AIMS images captured during these research trips confirmed the presence of two site attached fish families Gobiidae and Holocentrinae (Squirrelfish) over terrace features, which the FPZ which constitute 10% of the feature within the OSMP (Table 5-12; Table 5-13, and Figure 5-17). Additionally, fishermen trawl catch data confirmed the presence of Balistidae and Labridae, potential site attached species identified in the fish assessment, Moore et al (2017) and Heyward et al. (2017) (Table 5-13; Table 5-12). It is important to note that the size of the fishermen trawl nets do not permit the take of the smaller site attached species for example, Gobiidae and Holocentrinae (Jacobs 2017). The trawl net panels are 23 cm and 15 cm at the cod end, therefore fish smaller than 23 cm may escape which may bias the data towards fish larger than 23 cm.

Furthermore, as described in Section 5.5.4.1, shallow waters <35 m depth constitutes only 3.6 % of the FPZ, whereas water depths >35 m to the maximum depth of ~157 m constitutes the remaining 96.4% of the FPZ. Banks within the FPZ, which are located in water depths of ~20 – 60 m comprise of only ~7% of the banks within the entire Oceanic Shoals Marine Park (Table 5-9), were found to comprise of complex benthic environments with diverse and often dense epibenthic assemblages. Przeslawski et al. (2011) noted that banks were more likely than plains or terraces to have moderate to dense biological coverage and the only geomorphic feature to support reef-forming corals. These features were found to support a range of epibenthic fauna, including molluscs, crustaceans, echinoderms and fishes (Anderson et al. 2011). Whilst the Bethany operational area overlaps three pinnacle features (Table 5-9), none occur within the FPZ.

Given the very low proportion of shallow waters (<35 m depth) overlapped by the FPZ, and the limited presence of bank features and absence of pinnacles in the FPZ, it is reasonable to conclude that the survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages. These fish communities are more likely to be associated with shallow areas of the banks (<35 m depth) with high coverage of hard corals, with pinnacle features, or with shallow shoals such as Tassie Shoal and Evans Shoal. Additionally, the area of the OSMP and therefore the FPZ, is identified as a representative habitat, and supports tropical biota that is typical throughout the region (ConocoPhillips 2017).

5.5.4.3 Listed Marine Species

5.5.4.3.1 Syngnathids

The Protected Matters Database search identified 23 pipefish species, four seahorse species and four pipehorse species that may potentially occur in the AMBA. Seahorses (*Hippocampus* spp.) and pipehorses (*Solegnathus spp*.) are among the site-associated fish genera (DSEWPAC 2012a). The fish family assessment also identified Syngnathids as the only Listed Marine Species within the AMBA (Jacobs 2017).

Species within the Family Syngnathid (pipefishes, seahorses and pipehorses) have distinct characteristics, with differing habitats, distribution and relative abundance patterns across the region. Some species are apparently rare and localised; other species are widely distributed and very common, such as the Pacific short-bodied pipefish (*Choeroichthys brachysoma*) (DSEWPAC 2012d).

As described in the species group report card – bony fishes (DSEWPAC 2012d), which supplements and supports the NMR bioregional plan, seahorses and pipefishes are a diverse group and occupy a wide range of habitats, with these species generally displaying a preference for seagrass and macroalgal beds, coral reefs, mangroves and sponge gardens (DSEWPAC 2012d). Most seahorses are found in coastal areas, typically at depths of 1-15 m, occurring in relatively protected environments among sea-grasses, kelp beds, algal and rocky reefs, mangrove prop roots and coral reefs (CITES 2001). A few species prefer open sand or muddy bottoms, as well as areas influenced by strong currents and tidal flow, and deeper reef environments (15-60 m depth) (CITES 2001). Seahorses tend to be patchily distributed at low densities (Lourie et al. 2004).

The NMR bioregional plan (DSEWPAC 2012c) indicates a “general occurrence in waters >20 m deep” for seahorses and pipefishes. A review of information on habitat preference and water depth range has been conducted for the 31 syngnathid species identified in the Protected Matters Database search.

A spatial analysis of detailed bathymetry data has been undertaken for the Bethany survey full power zone (FPZ; the area within which the airgun array will be discharged at full power). This analysis shows that shallow waters <35 m depth constitute only 3.6 % of the FPZ, whereas water depths >35 m to the maximum depth of ~157 m constitute the remaining 96.4 % of the FPZ. Of the 31 syngnathid species listed in Table 5-15 only 12 species (seven pipefishes; two pipehorses; and three seahorses) have been recorded in water depths >35 m. It is important to note that the maximum water depths shown in Table 5-15 are just that—i.e. the greatest depths at which that species has been recorded worldwide and therefore not necessarily representative of the normal depth range over which most populations would generally occur. The remaining 19 species can be regarded as shallow water species, with depth ranges <35 m.

Of the 12 species that may occur in depths >35 m, only eight have been recorded in the NMR: *Doryrhamphus dactyliophorus*; *Halicampus brocki*; *H. grayi*; *Hippocampus histrix*; *Solegnathus hardwickii*; *S. lettiensis*; *Trachyrhamphus bicoarctatus*; and *T. longirostris*. Of these eight species, only two have been recorded in the deeper offshore waters of the Arafura Sea—*Solegnathus hardwickii* (two records in 97 m and 105 m); and *S. lettiensis* (one record in 184 m) (Atlas of Living Australia; NCRIS/GBIF 2017). The distribution for the remaining species of pipefishes, seahorses and pipehorses recorded in the NMR is limited to nearshore waters of the Joseph Bonaparte Gulf, Darwin Harbour, Tiwi Islands, Cobourg Peninsula, eastern Arnhem Land, the Gulf of Carpentaria, the western and northern coastlines of the Cape York Peninsula and islands in the Torres Strait.

The background information and analysis of information for the NMR regional profile (Rochester et al. 2007) was based on the collation of five datasets held by CSIRO Marine and Atmospheric Research (CMAR), including one for syngnathids. This CMAR syngnathid dataset (DEW 2007) contained only 18 records of three of the syngnathid species (*Haliichthys taeniophorus*; *Trachyrhamphus bicoarctatus*; and *T. longirostris*) listed in Table 5-15. Again, all of these records are from shallow, nearshore waters of eastern Arnhem Land, the Gulf of Carpentaria, the western and northern coastlines of the Cape York Peninsula and islands in the Torres Strait (Rochester et al. 2007; DEW 2007) – see Figure 5-19. Other syngnathid species recorded in trawl bycatch (from both prawn and fish trawl fisheries) in the NMR are *Hippocampus hystrix*, *H. kuda*, *Solegnathus hardwickii*, *S. lettiensis*, *Eurypegasus draconis* and *Pegasus volitans* (NOO 2004).

The species group report card – bony fishes (DSEWPAC 2012d) for the NMR bioregional plan indicated that biologically important areas have not yet been identified for seahorse and pipefish species in the NMR. Additionally, a pressure analysis process described report card identified that there were two threats that were of 'potential concern' for seahorse and pipefish species in the NMR—physical habitat modification (dredging; fishing gear [active and derelict]); and bycatch from commercial fishing.

The 2009 and 2010 surveys of the eastern part of the Joseph Bonaparte Gulf, which included two areas within the OSMP (Areas A and B; see Section 5.5.1 and Figure 5-10), included sampling of the epifauna using a benthic sled. Epibenthic sleds/sledges are an effective sampling tool for invertebrate macrofauna and hyperbenthos (animals living just above the seabed), including small, site attached fishes. Table 5-10 provides details of the benthic sled samples taken during the 2009 and 2010 surveys in Areas A, B, C and D. During the 2009 survey a total of 44 benthic sled samples were collected in water depths of 20 – 180 m, including two sled samples in the Bethany survey area, and a further five in the operational area (Figure 5-18). From these 44 samples there was only a single record of a syngnathid—a pipefish from station 041 in Area C, in a water depth of 26 m (Heap et al. 2010). Indeed, this was clearly a rare and unusual discovery, as it merits specific mention in the post-survey report: "*Of interest was the recovery of a pipefish*" (Heap et al. 2010; page 78).

During the 2010 survey a total of 41 benthic sled samples were collected in water depths of 22 – 115 m, including seven sled samples in the Bethany survey area, and a further eight in the operational area (Table 5-14 From these 41 samples there were two records of syngnathids—a seahorse from station 64 in Area B, in a water depth of 51 m, and another seahorse from station 10 in Area D, in a water depth of 45 m (Anderson et al. 2011). Again, these records are clearly out of the ordinary, as they merit specific mention in the post-survey report.

Table 5-14: Benthic Sled Samples Collected During 2009 and 2010 Surveys

Area	Water Depth Range (m)	No. of Samples	In Survey Area	In Operational Area
2009 Survey				
A	78 - 107	10	2	5
B	24 - 82	5	-	-
C	20 - 180	13	-	-
D	40 - 52	16	-	-
2010 Survey				
A & A1	54 - 115	17	7	8
B	28 - 103	5	-	-
C	22 - 79	2	-	-
D	31 - 49	17	-	-
	Total	**85**	**9**	**13**

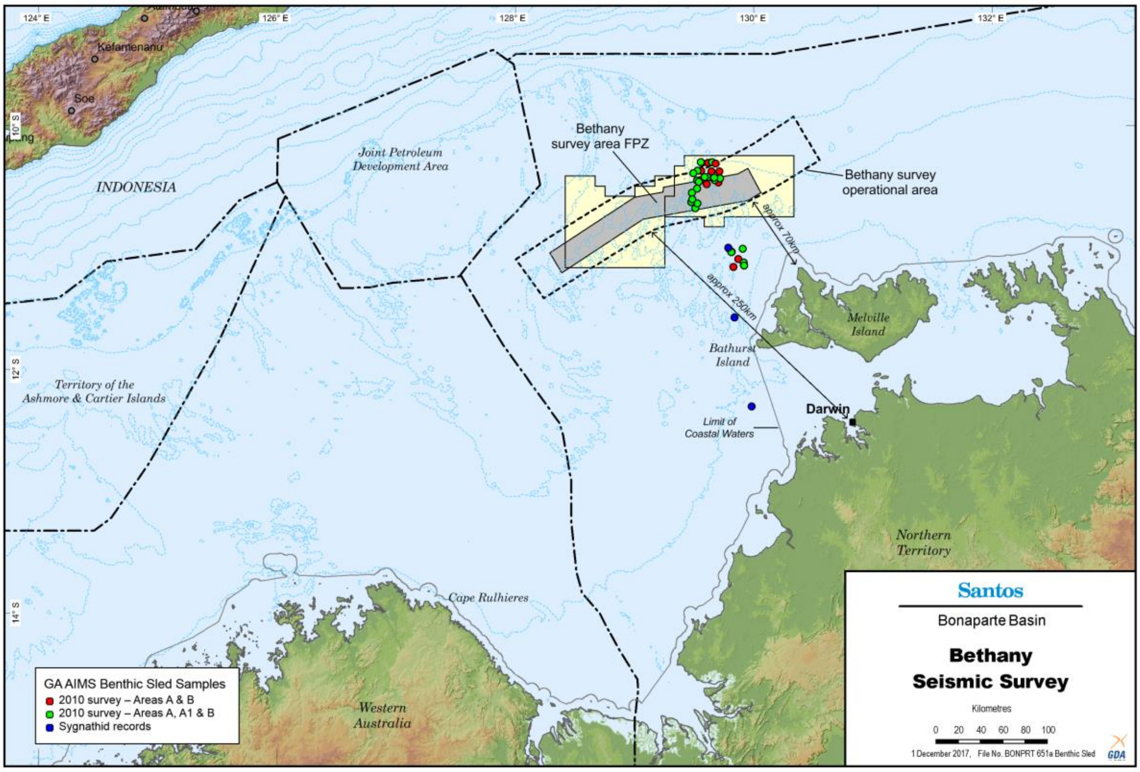


Figure 5-18: Benthic Sled Samples Collected in Areas A and B during 2009 and 2010 Surveys, and Syngnathid Records

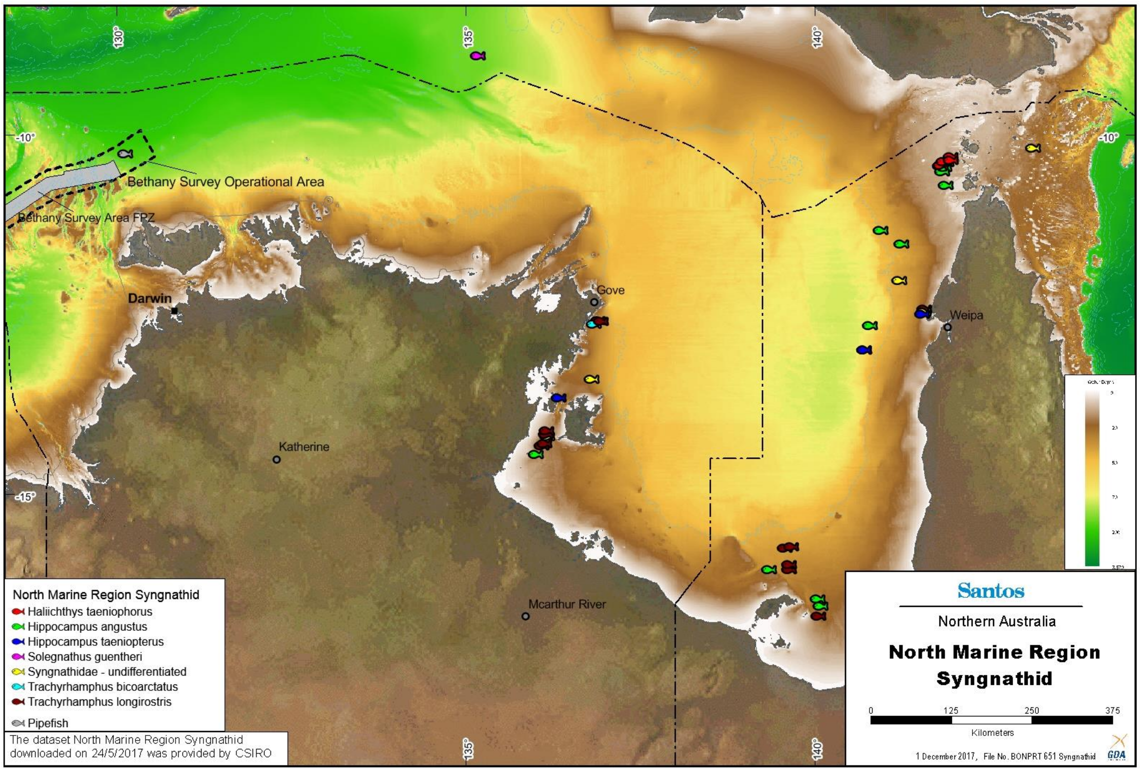


Figure 5-19: CMAR Syngnathid Records in the NMR, and Single Pipefish Record for Bethany Survey Area

From a total of 85 benthic sled samples collected during the 2009 and 2010 surveys there were just three captures of individual syngnathids: a seahorse in Area B, a pipefish in Area C, and a seahorse in Area D. There were no syngnathids in the 27 sled samples taken in Areas A and A1, of which nine samples were in the Bethany survey area, and a further 13 in the operational area (Table 5-14). The benthic sled samples taken during both surveys covered the full range of geomorphic features and benthic habitat types that occur within the OSMP (Heap et al. 2010; Anderson et al. 2011).

A post-survey report for the 2012 survey of four areas of the western part of the OSMP (Nichol et al. 2013), which included 22 benthic sled samples in water depths of 35 – 91 m, makes no mention of the capture of any syngnathids.

During stakeholder consultation by Santos for the Bethany survey, the NT Department of Primary Industry and Resources (DPIR) identified that there had been a single pipefish caught in the Timor Reef Fishery (TRF) trawl trial at a location in the north-eastern extent of the survey FPZ in 121 m water depth (Figure 5-18). The NT DPIR noted that this low frequency of capture maybe due to the trawl net size.

No pipefish, seahorse or pipehorse species were identified in a study of species composition of prawn trawl bycatch undertaken in the Joseph Bonaparte Gulf to the south of the AMBA (Tonks et al. 2008). Similarly, several bycatch studies of the Northern Prawn Fishery (NPF) in areas of the Arafura Sea and the Gulf of Carpentaria do not include any records of species from the Family Syngnathidae (Ramm et al. 1990; Pender et al. 1992). The straightstick pipefish (*Trachyrhamphus longirostris*) has been recorded in bycatch from the NPF in two detailed reviews of the ecological sustainability of bycatch and biodiversity in prawn trawl fisheries (Stobutzki et al. 2000; Griffiths et al. 2007).

Based on the data provided in Table 5-15 and the additional information discussed above, it is reasonable to conclude that the presence of syngnathid species in the Bethany survey and operational areas is likely to limited to isolated occurrences of a very small number of species (primarily pipefishes) in deeper waters. No syngnathids were recorded during extensive sampling of the epifauna and hyperbenthos in parts of the survey and operational area, across a water depth range of 54 – 115 m. Of the eight syngnathid species that may occur in water depths >35 m and have been recorded in the NMR, only two species have been recorded in the deeper offshore waters of the Arafura Sea. Therefore, pipefishes, seahorses and pipehorses are extremely unlikely to constitute an important component of any site-attached fish assemblages that may occur in the Bethany survey and operational areas.

Table 5-15: Summary of Habitat Preference and Depth Range for Syngnathid Species that May Occur within AMBA

Species	Habitat[1,2,3,4,8,9,10]	Depth Range (m)	ALA Records in North Marine Region[5]	CMAR Records[6,7]
Maximum Recorded Depth <35 m				
Bhanotia fasciolata	Collected in depths of 5-7 m. Demersal individuals are most common in reef and tidepool habitats, but they occur to depths of at least 14-17 m. Lives openly on muddy or silty substrates in depths of 3-25 m.	3-25	No records in NMR	-
Campichthys tricarinatus	Sand, coral rubble, algae (including *Sargassum*), isolated coral knolls, soft corals, small sponges, low coral outcrops, sheltered reef and rocky islets in depths of 3-11 m.	2-11	Yes - 4 records	-
Choeroichthys brachysoma	Has been recorded in depths of up to 27.4 m it most commonly occurs in seagrass, reef and coral habitats in depths of less than 5 m. Reefs (fringing, exposed, sheltered and limestone), live corals (including *Porites*, *Acropora*, *Millepora* and *Synarea*), soft corals, dead corals, algae (including *Sargassum* and filamentous algae), seagrass, sponges, hydroids, coral and shell rubble, coral rock, beach rock, sandstone terraces, isolated rock pools, caves, lagoons, mud, sand, and silt.	1-27	Yes – numerous records	-
Choeroichthys suillus	Occurs in inshore reef habitats. Coral knolls, live corals, coral rubble, shell rubble, coral rock, ledges, sand, seagrass and algae in depths of 1-14 m.	1-15	Yes - 1 record	-
Corythoichthys amplexus	Most commonly found in depths greater than 9 m. Outer reefs, reef edges, coral gutters, bomboras, caves, isolated coral knolls, reef walls and slopes, against drop-offs, ledges, live corals (including *Acropora*, alcyonarians and gorgonians), soft corals, sand rubble, lagoons, sand and fine silt, in depths of 0-35 m.	0-35	No records in NMR	-
Corythoichthys flavofasciatus	Fringing coral reefs, coral reef crests, reef flats, live corals (including *Acropora*), gorgonians, limestone rock platforms, soft corals, dead corals, algae, encrusting organisms, rubble, rocky shores, gutters, drop-offs, bomboras, pools, caves and sand, in depths of 0.1-30 m	<1-30	No records in NMR	-
Corythoichthys intestinalis	Inhabits sheltered sponge and coral reefs in shallow lagoons and harbours at 3-12 m. Most commonly taken within the 0-3 m depth range from sand, coral or 'grass' bottoms. Coral slopes, reef flats, reef edges, bomboras, live corals (including *Acropora*), soft corals, dead corals, rocky shore, mangroves, seagrass, sand rubble, rock rubble, caves, lagoons, mud, sand and silt.	3-12	No records in NMR	-
Corythoichthys schultzi	Coral reefs and outer reef edges, wrecks, bomboras, coral knolls, channels, live corals (including *Acropora* and alcyonarians), mangroves, weed beds, coral rubble, sand rubble, vertical walls, caves, lagoons, sand and silt, in depths of 1-30 m.	1-30	No records in NMR	-
Cosmocampus banneri	Coral reefs (including outer reefs), ledges, lagoons, live corals, rock, sponges, sand and rubble in depths of 2-30 m.	2-30	No records in NMR	-
Filicampus tigris	Inhabits areas near channels in inshore sheltered bays and estuaries with sandy or muddy bottoms, or along seagrass bed edges at 2-30 m.	2-30	No records in NMR	-
Halicampus dunckeri	Widespread tropical species that prefers sandy and algal-rubble habitats near coral reefs.	5-25	Yes - 1 record	-
Halicampus spinirostris	Inhabits shallow coral rubble areas in lagoons and intertidal zones of inshore coral reefs in 5-10 m.	5-10	No records in NMR	-

Species	Habitat[1,2,3,4,8,9,10]	Depth Range (m)	ALA Records in North Marine Region[5]	CMAR Records[6,7]
Haliichthys taeniophorus	Inhabits a variety of inshore shallow water areas including weedy regions bordering open substrates, coral reefs, rocky, gravel, sandy and muddy substrates; also associated with sponges, algae, hydroids, shells and seagrass usually from 1-18 m.	0-18	Yes – 18 records	All CMAR records were from eastern Torres Strait bioregion, in water depths of 11-13 m.
Hippichthys penicillus	Found in lower reaches of streams and rivers, seagrass beds in estuaries and other shallow inshore habitats.	0-5	Yes – 22 records	-
Hippocampus planifrons	Inhabits algal and rubble reefs in shallow bays from the intertidal to depths of 20 m.	0-20	No records in NMR Endemic to tropical WA	-
Micrognathus micronotopterus	Usually inhabits shallow inshore reefs and tidepools, amongst sparse seagrasses and algae-rubble, in depths from 1-5 m, although individuals have been collected from depths to 10 m.	1-10	Yes – 10 records	-
Solenostomus cyanopterus	Inhabit protected coastal and lagoon reefs, deeper coastal reefs and deep, clear estuaries with seagrass or macro-algae in 4-21 m.	4-21	No records in NMR	-
Solenostomus paegnius	Reef associated. Depth range 0-10 m.	0-10	No records in NMR	-
Syngnathoides biaculeatus	Inhabits shallow, protected waters of bays, lagoons and estuaries including mangrove areas, in association with seagrass beds and macroalgae in depths at 0-10 m.	0-10	Yes – 3 records	-
Maximum Recorded Depth >35 m				
Doryrhamphus dactyliophorus	Inhabits protected reefs and lagoons, usually in caves and crevices to 10 m. "*This species is rarely found in depths over 20 m.*"[8] *"A shallow water species, commonly found inshore and outer reef lagoons…" "Adults to about 10 m depth. Reports from deep water are based on other banded species. They are often seen in large caves…"*[9]	5-56	Yes - 1 record	-
Doryrhamphus excisus	Inhabits coastal to outer reefs, in a variety of habitats including lagoons, reef flats, reef slopes and walls, channels, coral gutters, usually in or near crevices and caves, in depths between 5 and about 45 m.	5-45	No records in NMR	-
Doryrhamphus janssi	Inhabits sheltered inshore coral reefs where pairs usually maintain cleaning stations in caves and crevices with sponges, and below large plate corals. *"Sheltered inner reefs, usually in caves with sponges and below large plate corals."*[9]	14-44	No records in NMR	-
Halicampus brocki	Occurs on coral and rocky reefs with algae. Inhabits patches of coral and macro-algae on coastal reefs at 3-45 m. *"Inner reefs, coral and algae-rich habitats, usually at moderate depths. Flores specimen was photographed at 35 m depth."*[9]	3-45	Yes - 1 record	-
Halicampus grayi	Inhabits silty and muddy soft bottoms on the continental shelf from inshore bays to deep offshore areas to 100 m. *"Mainly lives in muddy habitats…" "Shallow inshore muddy bays to deep offshore, reported to 100 m depth."*[9]	0-100	Yes – 5 records	-
Hippocampus histrix	Inhabits areas with both hard and soft bottoms, often attached to soft corals or sponges at 10-95 m, usually 15-40 m. Also found on shallower algae-rubble or rocky reef areas in about 10 m depth. *"Typically, at moderate depths of about 15 m or deeper, on soft bottom with soft corals and sponges, but occasionally found in algae-rubble reef zones at about 10 m depth."*[9]	5-95	Yes – 7 records	-

Species	Habitat[1,2,3,4,8,9,10]	Depth Range (m)	ALA Records in North Marine Region[5]	CMAR Records[6,7]
	"Typically found >6 m depth; maximum reported depth 20 m; seagrass bed, weedy rocky reefs, sponges; soft bottom with soft corals and sponges."[10]			
Hippocampus kuda	Found in shallow inshore waters normally between 0-8 m depth with a maximum recorded depth of up to 55 m. Inhabits coastal bays, harbours and lagoons, sandy sediments in rocky littoral zones, macroalgae and seagrass beds, mangroves, muddy bottoms, and shallow reef flats. *"Occurs in estuaries, harbours and lower reaches of rivers, may tolerate brackish water for a short time. Shallow water and intertidal, sometimes stranded in rock pools during spring-tides."*[9] *"Typically found at 0–8 m depth; maximum reported depth 55 m; coastal bays and lagoons, in seagrass and in floating weeds; sandy sediments in rocky littoral zone; macroalgae and seagrass beds; branches, muddy bottoms; mangroves…"*[10]	0-55	No records in NMR	-
Hippocampus spinosissimus	Benthic in inner reef waters on rubble substrates and in sponge and seagrass habitats near coral reefs at 20-63 m; often attached to corals in deep current-prone channels between reefs or islands. *"Known only from the 2 types trawled at 70 m depth…" "Its habitat was described as sand and scallops." "It seems that it may be a small, deep water species that is occasionally brought up by strong upwellings to the shallower depths."*[9] *"Typically found at >8 m depth; maximum reported depth 70 m; octocorals, macro algae, not hard corals, sand but not mud; near coral reefs on sandy bottoms."*[10]	20-70	No records in NMR	-
Solegnathus hardwickii	Mostly known from trawled specimens captured from 12 m to 100 m depth, though it has been collected in depths of up to 180 m. *"Reported from trawls in less than 100 m, but enters relatively shallow depths of about 40 m."*[9]	12-180	Yes – 1 record	-
Solegnathus lettiensis	Benthic inhabitant of outer continental shelf waters and has been captured from depths of 42-180 m. Trawl bycatch records in 150-180 m water depths in Australia.	42-180	Yes – 1 record	-
Trachyrhamphus bicoarctatus	Inhabits sheltered coastal lagoon and reef areas on sandy and rubble habitats amongst seagrasses and macroalgae at 1–30 m. Has been recorded to 42 m. *"Some populations inhabit seagrass beds and others only rubble sand areas. Most are seen on sand and mud areas, prone to strong currents. Red Sea population occurs in sheltered bays with seagrasses at few metres depth. Elsewhere usually soft bottom to about 25 m."*[9]	1-42	Yes – 7 records	Only one CMAR record from the northern part of the Groote bioregion in the Gulf of Carpentaria, in water depth of 28 m.
Trachyrhamphus longirostris	Most specimens have been trawled or dredged from muddy to sandy-bottom habitats in depths of 16-91 m, in association with sand, rubble, seagrasses, algae, sponges, sea pens and hydroids. *"It is less common and is mainly known from deep trawls over muddy substrates, but enters sheltered muddy estuaries where, out in the open, it lays on the bottom."*[9]	16-91	Yes – 16 records	Caught in widely separated regions of the Gulf of Carpentaria in depths of 17–45 m, and are likely to be near rocky reefs and other hard, vertically-structured substrates

Sources: [1] DoEE (2017); [2] Bray and Thompson (2017); [3] Austin and Pollom (2016); [4] Froese and Pauly (2017); [5] NCRIS/GBIF (2017); [6] DEW (2007); [7] Rochester et al. (2007); [8] Kuiter (1998); [9] Kuiter (2009); [10] Lourie et al. (2004).

5.5.5 Sharks

The Protected Matters Database search identified six species of threatened sharks: white shark, northern river shark, largetooth sawfish, green sawfish and whale shark. Of those identified, the white shark, whale shark, freshwater sawfish and green sawfish are also migratory. The Protected Matters Database search also identified three additional migratory sharks: narrow sawfish, shortfin mako and longfin mako.

White Shark

The white shark is widely distributed, and located throughout temperate and sub-tropical waters with their known range in Australian waters including all coastal areas except the Northern Territory (DoEE 2017a). Studies of white sharks indicate that they appear to be largely transient, with a few longer-term residents; however, individuals are known to return to feeding grounds on a seasonal basis (Klimey & Anderson 1996). Observations of adult white sharks are more frequent around fur seal and sea lion colonies whilst juveniles are known to congregate in certain key areas. According to the National Conservation Values Atlas there are no biologically important aggregation, breeding or foraging areas near the AMBA and given that the AMBA is at the extreme end of the white shark’s distribution, it is unlikely that white sharks will be encountered.

The Recovery Plan for the White Shark (*Carcharodon carcharias)* (DSEWPaC 2013) does not identify any threats or objectives that are relevant to the activity.

Sawfish and River Sharks

The northern river shark is listed as endangered under the EPBC Act based partly on its limited geographic distribution (TSSC 2014a). Within Australia, the northern river shark is known to occur in Western Australia and the Northern Territory, occupying both marine and freshwater environments including the Joseph Bonaparte Gulf, Daly River, Adelaide River and the South and East Alligator Rivers (TSSC 2014a). Whilst northern river sharks have been observed well offshore, the extent to which this occurs is unknown (TSSC 2014a). Figure 5-20 shows the distribution of the northern river shark. Given that this species has been observed offshore, the AMBA is within the area that northern river shark may occur.

The speartooth shark is listed as critically endangered under the EPBC Act based on its limited geographic distribution and the estimated total number of mature individuals being extremely low and likely to continue to decline partly on its limited geographic distribution (TSSC 2014a). Within the Northern Territory, the speartooth shark is known to occupying the Van Diemen Gulf drainage area (TSSC 2014a). Although unconfirmed, it is thought that adults use deep-water habitat, however, juvenile and sub-adult speartooth sharks are known to utilise large tropical river systems as their primary habitat (TSSC 2014a). The AMBA is within the area where adult speartooth sharks may occur (Figure 5-21).

Largetooth sawfish (formerly known as the freshwater sawfish) utilise both freshwater (juvenile) and marine (adult) environments during the different stages of its lifecycle (TSSC 2014b) Within Australia, largetooth sawfish have been recorded in numerous drainage systems across northern Western Australia, Northern Territory and northern Queensland (TSSC 2014b). The AMBA is within the area where adult largetooth sawfish are known to occur (Figure 5-22). In addition, the largetooth sawfish is also likely to be present within the pinnacles of the Bonaparte Basin (DSEWPaC 2012a).

The green sawfish occurs in both inshore and offshore marine coastal waters of northern Australia. Its current known distribution stretches from Broome in Western Australia around northern Australia and down the east coast as far as Jervis Bay, NSW (DoEE 2017c). The AMBA is within the area where adult green sawfish are known to occur (Figure 5-23).

The narrow sawfish lives in coastal and estuarine habitats across northern Australia and is generally restricted to shallow waters (less than 40 m) (D'Anastasi et al. 2013). The species is known to occur in the Gulf of Carpentaria, but its distribution and migration is largely unknown. Given the distance from shallow coastal waters, it is unlikely that this species would be encountered in the AMBA.

A review of the National Conservation Values Atlas did not identify any biologically important aggregation, breeding or foraging areas for river sharks or sawfish near the AMBA.

Due to their slow growth and maturation rates, longevity, low fecundity and low rates of natural mortality, sawfish are particularly vulnerable to human-induced pressures (DSEWPaC 2012a). The Sawfish and River Sharks Multispecies Recover Plan (DoE 2015a) covers largetooth sawfish, green sawfish, speartooth shark and the northern river shark. The primary objective of this recovery plan is to:

- Improve the population status leading to the removal of the sawfish and river shark species from the threatened species list of the EPBC Act.
- Ensure that anthropogenic activities do not hinder recovery in the near future, or impact on the conservation status of the species in the future.

The recovery plan and specific conservation advises identifies the principal threats to these sawfish and river shark species from: commercial fishing activities; recreational fishing, Indigenous fishing, illegal, unreported and unregulated fishing, and habitat degradation and modification. Other potential threats to the species include the collection of animals for display in public aquaria and marine debris. Habitat degradation and marine debris are threats that are relevant to the Bethany survey and are detailed in Table 5-16.

Currently, there are no adopted recovery plans or conservation advice documents for the narrow sawfish. The IUCN however identifies entanglement due to marine debris as a relevant key threat (D'Anastasi et al. 2013).

Table 5-16: Sawfish and River Sharks Multispecies Recover Plan Threats Relevant to the Activity

Relevant Threats	Objective	Relevant Actions to Activity
Marine debris	Reduce and, where possible, eliminate any adverse impacts of marine debris on sawfish and river shark species noting the linkages with the Threat Abatement Plan for the Impact of Marine Debris on Vertebrate Marine Life.	Management of marine debris is detailed in Section 7.6 Waste.
Habitat Degradation	Implement measures to reduce adverse impacts of habitat degradation and/or modification.	The activity and any potential risks or impacts to sawfish and river shark habitat are assessed in Section 7. No impacts or risks to sawfish and river shark habitat were identified.

Whale Shark

The whale shark is a filter feeding shark and is the largest known species of fish in the world (DoEE 2017c). It is considered to be an oceanic and coastal species, commonly seen far offshore but also closer inshore near coral atolls (DoEE 2017c). Whale sharks generally prefers tropical to warm temperate waters where surface sea temperature ranges from 21° to 25 ºC (DoEE 2017c). In Australian waters the whale shark is commonly seen in waters off northern Western Australia, Northern Territory and Queensland with only very occasional sightings off Victoria and South Australia (Last & Stevens 1994). The movements of whale sharks are not well documented; however, they are known to seasonally aggregate (March / April) in shallow tropical waters off the North West Cape in Western Australia (DoEE 2017c). According to the National Conservation Values Atlas there is a biologically important foraging area >200 km to the south-west of the AMBA (Figure 5-24). Based on their widespread distribution and highly migratory nature, individuals may transit through the AMBA.

The Whale Shark (*Rhinocodon typus*) Recovery Plan 2005-2010 (DEH 2005a) ceased to be in effect from 2015. The DoEE SPRAT profile (DoEE 2017d) identifies increased noise from boats and boat strike as threats that are relevant to the activity (Table 5-17).

Table 5-17: Whale Shark Threats Relevant to the Activity

Objective	Relevant Threats	Relevant Actions
To maintain existing levels of protection for the whale shark in Australia while working to increase the level of protection afforded to the whale share within the Indian Ocean and Southeast Asian region to enable population growth in order to remove the Whale Shark from the EPBC Act.	Increased levels of noise resulting from an increase in boat traffic may have a negative impact on the migration patterns	Management of noise impacts are detailed in Section 7.1 and 7.2.
	Boat strike	Management of fauna interaction is detailed in Section 7.8

Makos

The shortfin mako is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al. 2000). It is widespread in Australian waters having been recorded in offshore waters all around the continent's coastline with exception of the Arafura Sea, the Gulf of Carpentaria and Torres Strait (TSSC 2014c). Shortfin makos are also highly migratory and travel large distances. Due to their widespread distribution in Australian waters, their presence in the AMBA is likely to be limited to transiting individuals.

Currently there are no adopted recovery plans or conservation advice documents given for the shortfin mako. Though the IUCN does not identify any relevant threats (Cailliet et al. 2009) the listing advice for the shortfin mako identified fishing as a threat (TSSC 2014c).

Longfin makos habitat oceanic and pelagic habits typically in tropical regions (DSEWPaC 2012b). They are highly mobile species and have a wide-ranging distribution (DSEWPaC 2012b). Whilst assumed to be a deep-dwelling shark, sightings on the ocean surface and the species' diet suggest a greater depth range (Reardon et al. 2006). Though there is limited information about the longfin mako their presence in the AMBA is likely to be limited to transiting individuals.

Currently there are no adopted recovery plans or conservation advice documents given for the longfin mako. In addition, the IUCN does not identify any relevant threats (Reardon et al. 2006).

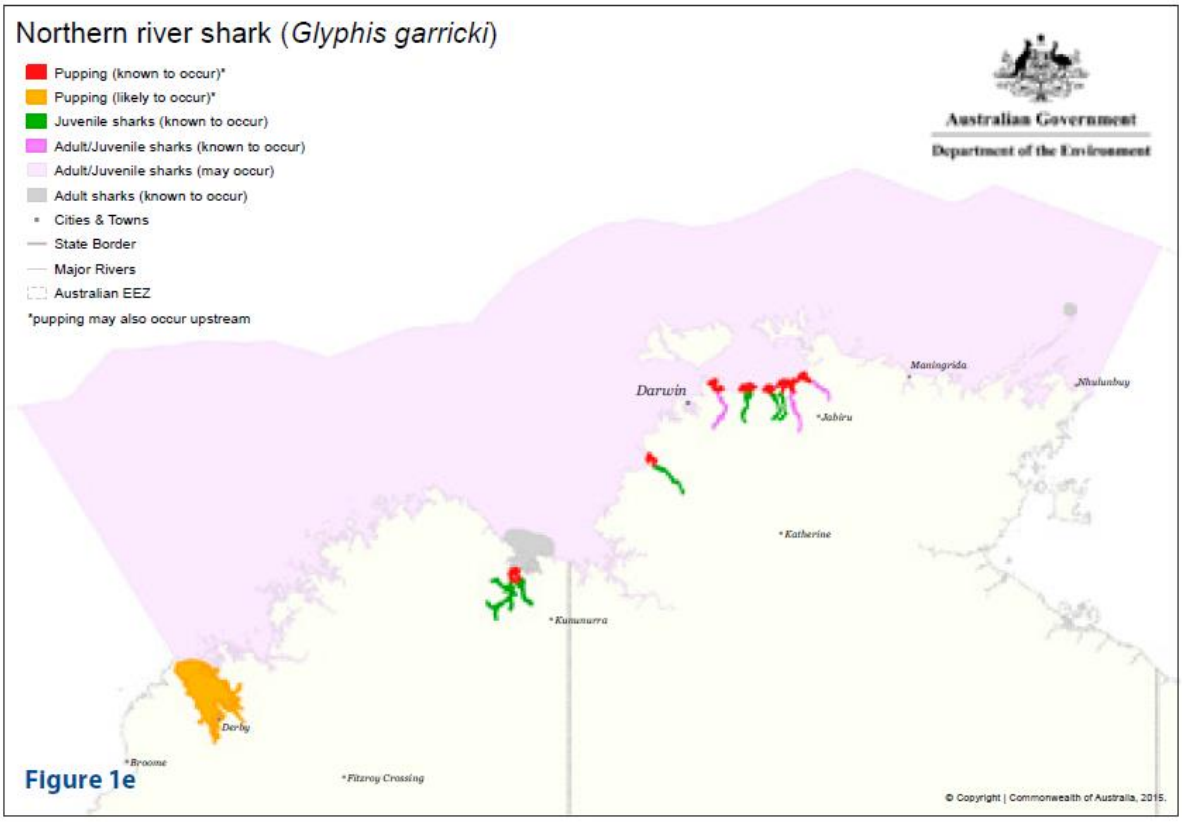


Figure 5-20: Distribution of Northern River Shark (DoE 2015a)

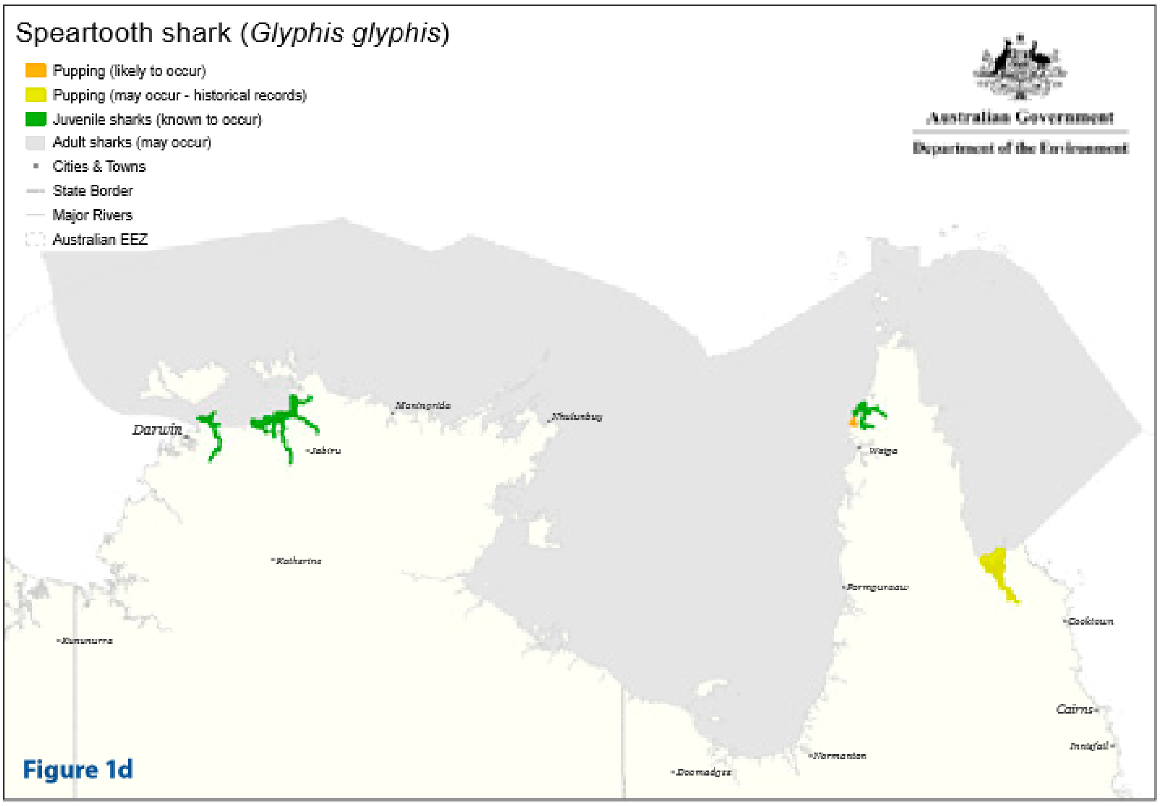


Figure 5-21: Distribution of Speartooth Shark (DoE 2015a)

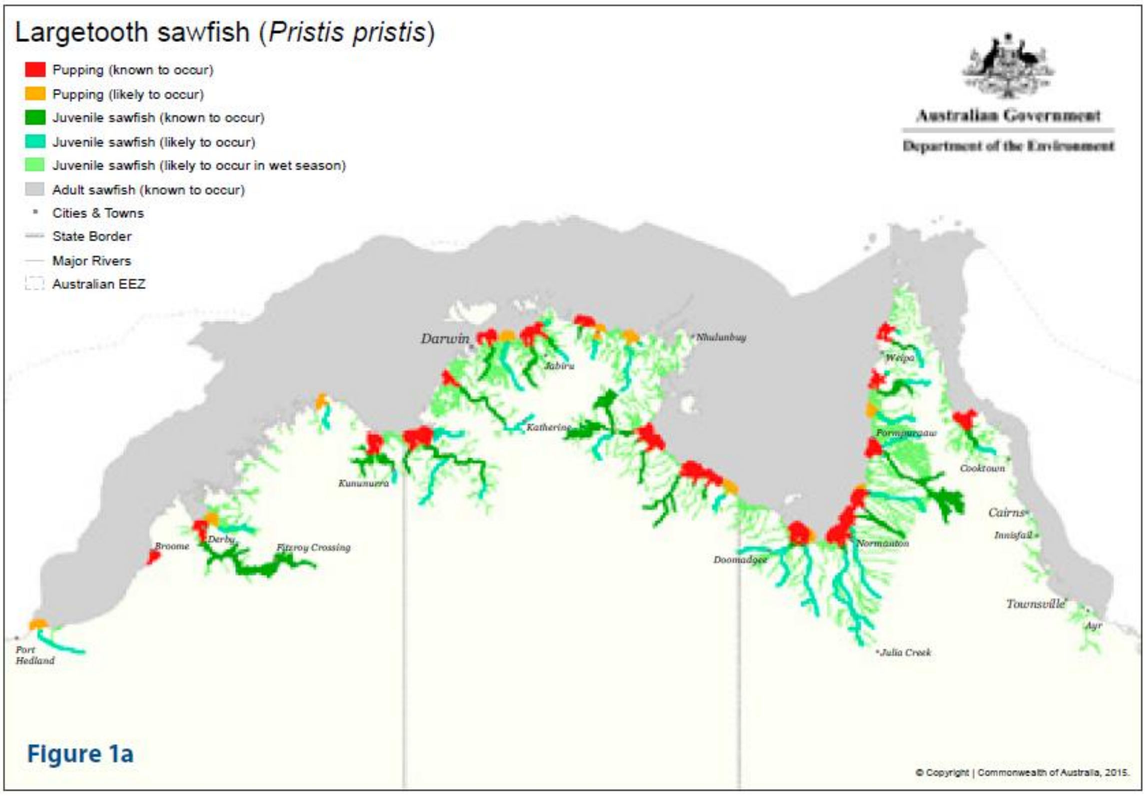


Figure 5-22: Distribution of Largetooth Sawfish (DoE 2015a)

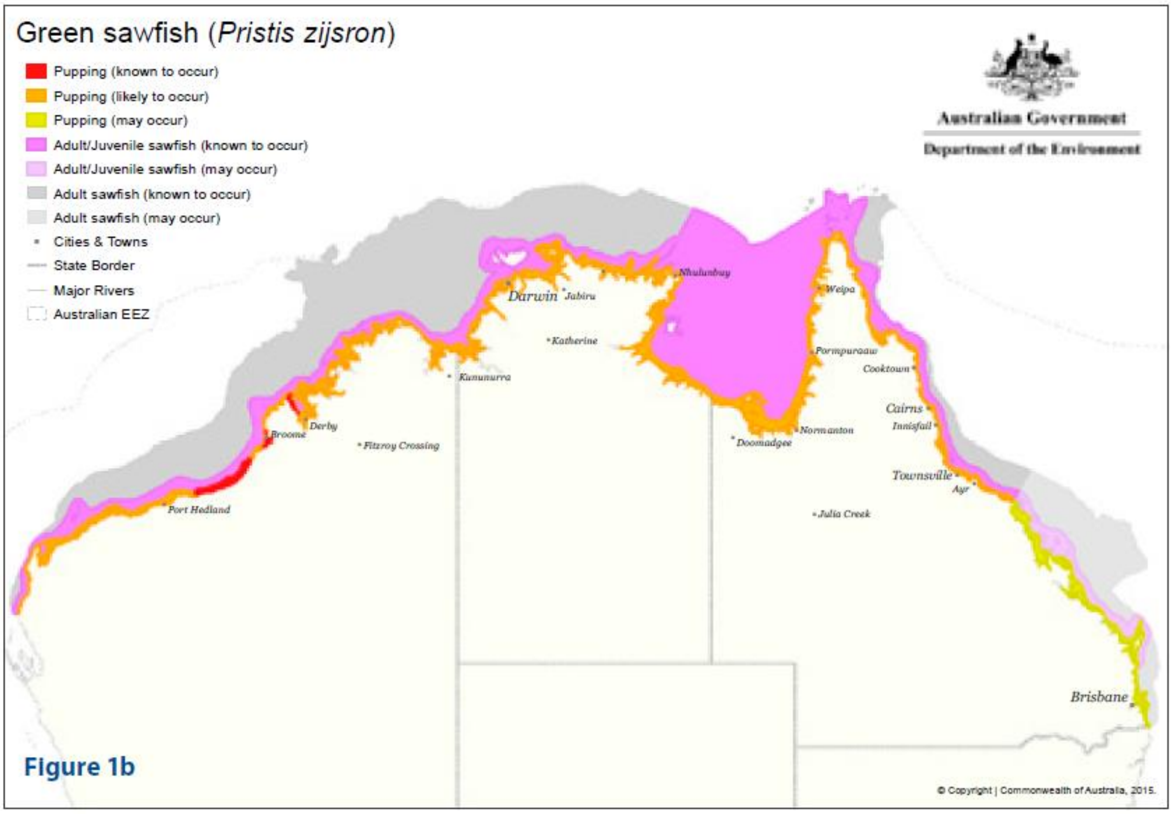


Figure 5-23: Distribution of Green Sawfish (DoE 2015a)

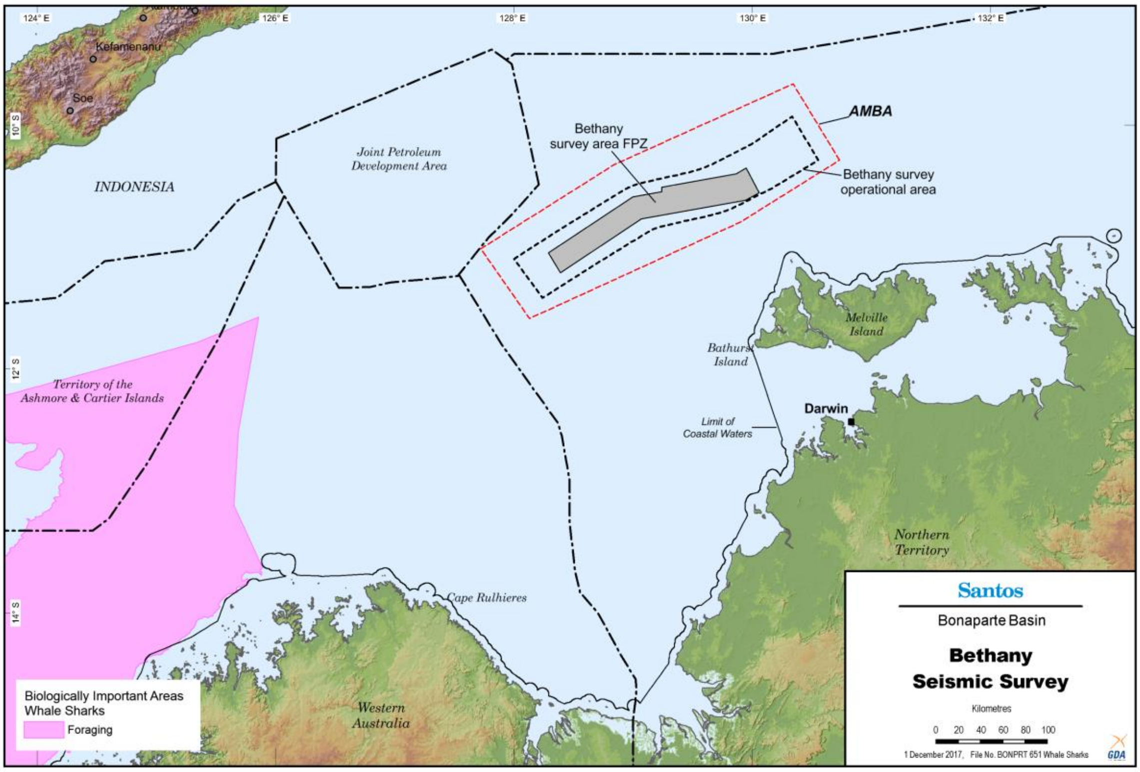


Figure 5-24: Biologically Important Area for Whales Sharks

5.5.6 Rays

The Protected Matters Database searches identified two migratory ray species, the reef manta ray and the giant manta ray.

The reef manta ray has a circumglobal range in tropical and sub-tropical waters with sightings between waters off Perth in Western Australia, all along the northern coastal line of Australia, and to the waters off the Solitary Islands in New South Wales (Marshall et al. 2011a). Whilst this species tends to inhabit near-shore environment, it is known to have a lower depth limit of 300 m and has been sighted around offshore coral reefs, rocky reefs and seamounts (Marshall et al. 2011a). In addition, it makes seasonal migrations of several hundred kilometres (Marshall et al. 2011a). Despite there being no known aggregation sites within close proximity to the AMBA reef manta rays maybe present in the AMBA as transiting individuals.

Similar to the reef manta ray, the giant manta ray has a widespread distribution along the coast of Australia and is also known to seasonally migrate between aggregation sites (Marshall et al. 2011b). The giant manta ray is commonly sighted along productive coastlines with regular upwelling, oceanic island groups and particularly offshore pinnacles and seamounts (Marshall et al. 2011b). This species has been recorded within the OSMP (Nichol et al. 2013). Despite there being no known aggregation sites within close proximity to the AMBA giant manta rays maybe present in the AMBA as transiting individuals.

Currently there are no adopted recovery plans or conservation advice documents given for the reef or giant manta ray. The IUCN identifies entanglement due to marine debris and boat strike as relevant key threats (Marshall et al. 2011a and b). These threats are discussed in Section 7.6 and 7.8, respectively.

5.5.7 Reptiles

The Protected Matters Database search identified six species of threatened and migratory marine turtle species. The loggerhead, leatherback and olive ridley turtles are listed as endangered whilst the green, hawksbill and flatback turtles are listed as vulnerable. The salt-water crocodile was also identified as a migratory reptile species.

The AMBA is within a biologically important foraging area for the olive ridley turtle (Figure 5-25), and a habitat critical for the survival of the species for internesting flatback turtles (Figure 5-26).

The loggerhead turtle has a global distribution throughout tropical, subtropical and temperate waters. In Australia, the loggerhead turtle occurs in waters of coral and rocky reefs, seagrass beds, and muddy bays throughout eastern, northern and western Australia (DoEE 2017d). Whilst nesting is mainly concentrated on sub-tropical beaches in southern Queensland and from Shark Bay to the North West Cape in Western Australia between November to March, foraging is more widespread. Loggerhead turtles show fidelity to both their foraging and breeding areas and can migrate over 2,600 km between the two (DoEE 2017d). The Western Australian stock forage from Shark Bay in Western Australia through to Arnhem Land in the Northern Territory (DoEE 2017d). As a juvenile, the turtle feeds on algae, pelagic crustaceans, molluscs and flotsam whilst as an adult it feeds on gastropod molluscs, clams, jellyfish, starfish, coral, crabs and fish (DoEE 2017d). Loggerhead turtles are known to forage around the pinnacles of the Bonaparte Basin (DSEWPaC 2012a, DSEWPaC 2012c) consequently, it may be encountered within the AMBA.

The leatherback turtle is a pelagic feeder found in tropical, subtropical, and temperate waters throughout the world. Whilst it is less abundant off the northern Australian continental shelf, it is occasionally sighted in the Gulf of Carpentaria and near Cobourg Peninsula (DSEWPaC 2012c). No major nesting has been recorded in Australia, with isolated nesting recorded in Queensland and the Northern Territory (DSEWPaC 2012c). The closest confirmed internesting site for the leatherback turtle is at Cobourg Peninsula (DoEE 2017e) over 170 km south-east of the AMBA. Leatherback turtle forage on pelagic soft-bodied creatures (such as jellyfish, squid, salps, siphonophores and tunicates) all year round in Australian waters (DoEE 2017e), thus it is possible that this species may be present within the AMBA.

Hawksbill turtles are found in tropical, subtropical and temperate waters in all the oceans of the world (DoEE 2017f). As a juvenile, the hawksbill turtle feeds on plankton in the open ocean and then feeds on sponges, hydroids, cephalopods, gastropods, jellyfish, seagrass and algae as an adult (DoEE 2017f). The species is also highly migratory, moving up to 2400 km between foraging and breeding areas (DSEWPaC 2012c). Due to genetic variability, Australia's population is considered to comprise of two distinct stokes; one in Western Australia and the other in the north-east of Australia (DSEWPaC 2012c). These distinct populations are also known to have significantly different breeding seasons. The north-east subpopulation breeds throughout the year with a peak nesting period during July to October (DSEWPaC 2012c), whilst the Western Australian population peaks around October to January. Although there were no BIAs associated with this species in or near the AMBA, as hawksbill turtles are oceanic it is possible that it may be present within the AMBA.

Green turtles nest, forage and migrate across tropical northern Australia (DoEE 2017g) and are commonly found foraging and nesting in the Gulf of Carpentaria (DSEWPaC 2012c). Green turtles have been recorded nesting on the Tiwi Islands, albeit in low numbers occurring between October to April (DoEE 2017t). The Recovery Plan for Marine Turtles in Australia 2017 -2027 (DoEE 2017t) specifies a 20 km internesting buffer for green turtles. The AMBA is ~ 70 km from the Tiwi Islands so is outside of this internesting buffer. The pinnacles of the Bonaparte Basin are thought to be a key ecological feature where green turtle's transverse between foraging and nesting grounds (DSEWPaC 2012a). Within such foraging areas, adult green turtles feed on seagrass, sponges and algae (DoEE 2017g), consequently, they may be encountered within the AMBA.

The olive ridley turtle has a worldwide tropical and subtropical distribution and is known to occur in both Western Australia and Northern Territory (DSEWPaC 2012c). Major nesting habitat critical to the survival of olive ridley turtles have been identified at Melville and Bathurst Islands approximately ~ 70 km from the AMBA (DoEE 2017t), with nesting occurring all year round and peak nesting occurring between April and June. The Recovery Plan for Marine Turtles in Australia 2017 -2027 (DoEE 2017t) specifies a 20 km internesting buffer for olive ridley turtles. The AMBA is ~ 70 km from Bathurst Island, the closest to the AMBA, so is outside of this internesting buffer. After nesting, olive ridley turtles are known to migrate up to 1,050 km to various foraging areas (DoEE 2017h) including the pinnacles of the Bonaparte Basin and the carbonate banks and terrace system of the Sahul Shelf (DSEWPaC 2012a). Adult turtles forage for crabs, shrimp, tunicates, jellyfish, salps and algae in depths ranging from several meters to over 100 m (DoEE 2017h). The National Conservation Values Atlas identifies that the AMBA overlaps with a biologically important foraging area for this turtle species, and hence it is likely to be encountered.

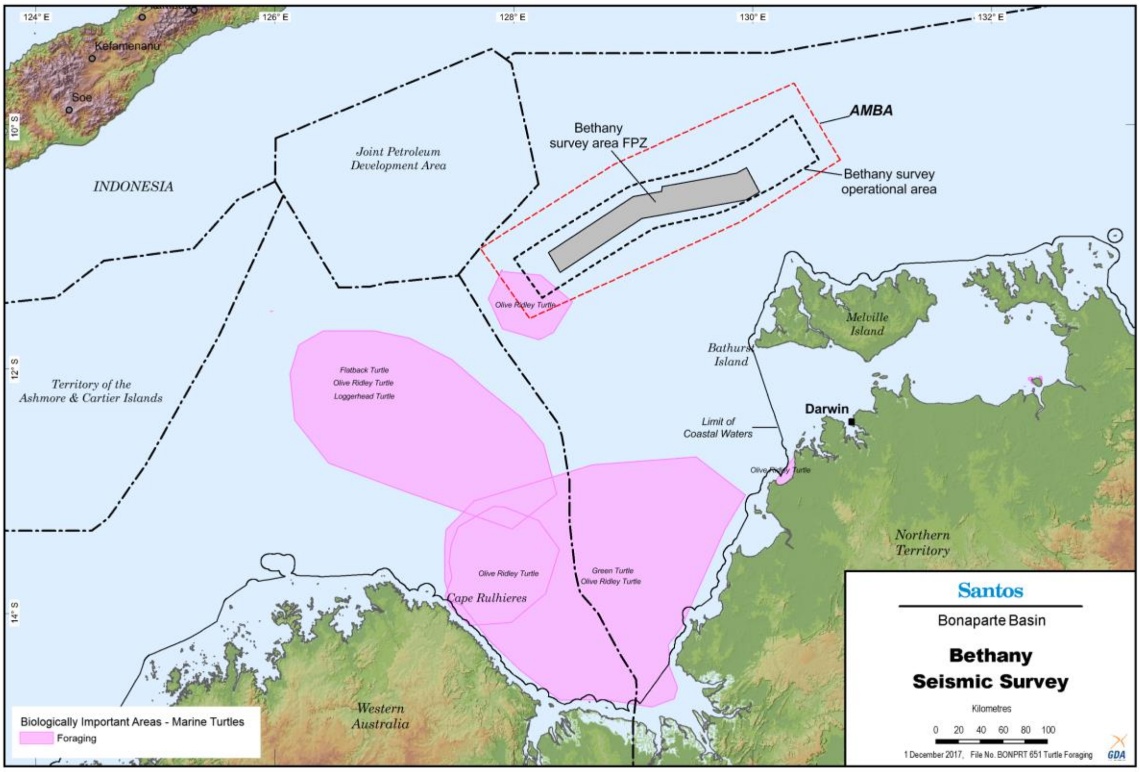


Figure 5-25: Biologically Important Area for Foraging Turtles overlapping the AMBA

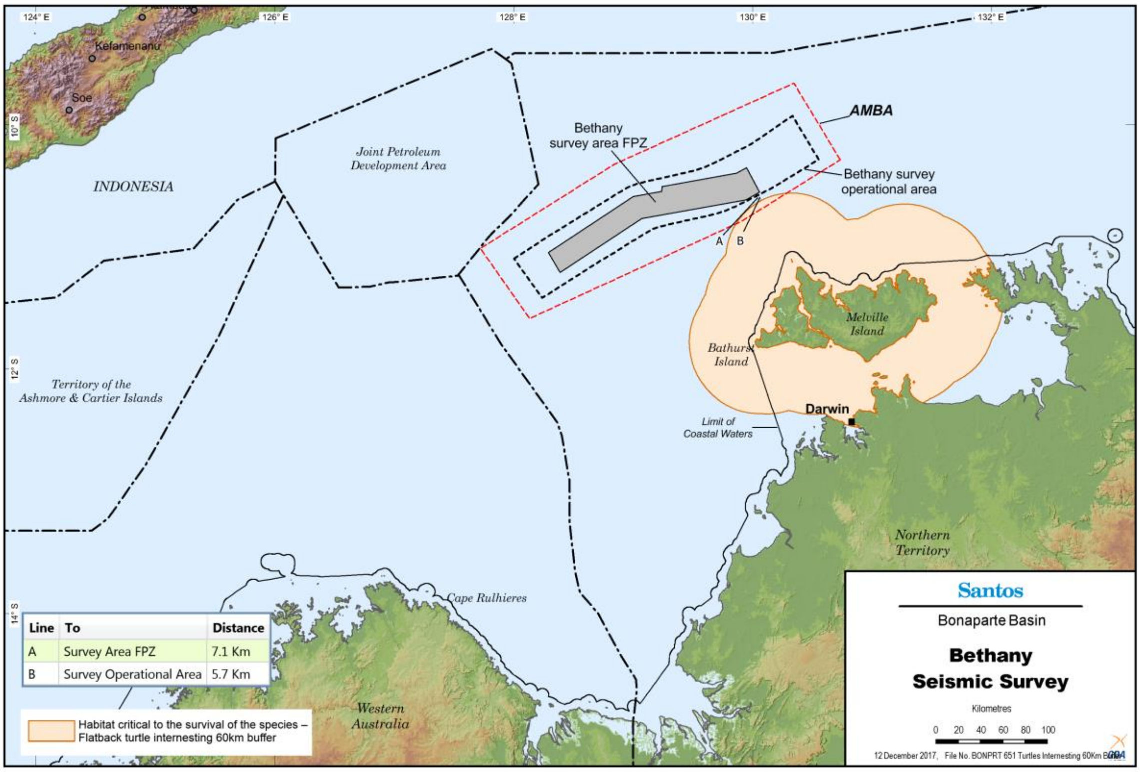


Figure 5-26: Biologically Important Area for Turtle Internesting near AMBA

The flatback turtle is only found in Australian waters and some nearby waters in Indonesia and Papua New Guinea. It is commonly found in the North Marine Region, nesting in northern Australia and foraging in the region. Flatback turtles lack an oceanic phase and remain in the surface waters of the continental shelf and once the pelagic stage of its life is completed, they move to sub-tidal soft bottomed habitats inshore, feeding on benthic organisms. Flatback turtles have a wide foraging range with individuals which nest on the Pilbara coast dispersing to feeding areas extending from Exmouth Gulf to the Tiwi Islands (DSEWPaC 2012a). Adults are omnivorous, feeding on sponges, hydroids, cephalopods, gastropods, cnidarians, seagrass and algae. The species has been recorded foraging in depths less than 10 m to over 40 m around the pinnacles of the Bonaparte Basin.

Flatback turtle nesting areas have been identified at the Tiwi Islands, however, they have not been identified as major or minor important nesting areas (DoEE 2017t). Nesting occurs on the Tiwi Islands all year with peak nesting between June to September (DoEE 2017t. The Recovery Plan for Marine Turtles in Australia 2017 - 2027 (DoEE 2017t) has recently been released and this internesting area is classed as a habitat critical for survival of the species. The current recovery plan specifies a 60 km internesting buffer for flatback turtles. Figure 5-26 shows that the internesting buffer is within the AMBA but is outside of the Operational Area (~5.7 km).

Previously, flatbacks have been recorded internesting in water depths of 40 m (M. Guinea (personal communication, March 16, 2017). Studies indicate flatback turtles cover large distances during internesting (Waayers et al 2011), but also recorded that they tend to travel within 5 km of the nesting coastline. Internesting behaviours are linked to benthic habitat with preferred habitat being coastal waters over soft-bottomed sea beds (DoEE 2017i). As the AMBA overlaps a habitat critical for survival of the species and the KEF (pinnacles of the Bonaparte Basin) in which this species is known to frequent, this species is likely to be encountered within the AMBA.

A study of turtle bycatch of the Northern Prawn Fishery to the south of the AMBA, recorded five species: flatback, 59% of the total), loggerhead (10%), olive ridley (12%), green (8%) and hawksbill (5%). They identified that turtle catches varied with water depth: the highest catch rates were from trawls in water between 20 and 30 m deep, relatively few turtles (10%) were captured in water deeper than 40 m (Poiner & Harris 1995) indicating that preferred habitat is within shallow waters.

The Recovery Plan for Marine Turtles in Australia 2017 – 2027 (DoEE 2017t) covers the six marine turtles identified from the protected matters search as potentially occurring within the AMBA. Table 5-18 identifies the recovery plan objectives and actions relevant to the activity.

The Protected Matters Database search identified five species of seasnake that may potentially occur in the AMBA: *Acalyptophis peronii*; *Aipysurus duboisii*; *A. eydouxii*; *A. laevis*; and *Astrotia stokesii*. Seasnakes are widespread through the waters of the NMR in offshore and near-shore habitats. They can be highly mobile and cover large distances or they may be restricted to relatively shallow waters. Most seasnakes have shallow benthic feeding patterns and live in shallow, coastal tropical waters; rarely found in water depths exceeding 30 m (Cogger 1975; Guinea 2013). Seasnakes are frequently observed in and around offshore islands and the waters of the shelf. However, there is no information on their frequency of occurrence in deeper offshore waters although individuals are often observed at the surface.

Nineteen species of seasnake from the Families Hydrophiidae and Laticaudae are known to occur in the NMR. Beyond data obtained from commercial prawn trawling, little is understood about distribution, abundance or diversity of seasnakes in the region, but they may be found in shallower waters usually less than 50 m.

The salt-water crocodile is distributed from King Sound in Western Australia throughout coastal Northern Territory to Rockhampton in Queensland, where it can be found in coastal waters, estuaries, lakes, inland swamps and marshes up to 150 km inland from the coast (DoEE 2017j). Whilst sightings of salt-water crocodiles far out to sea have been recorded it is very unlikely that it would be encountered within the AMBA.

Table 5-18: Recovery Plan for Marine Turtles in Australia 2017 – 2027 Objectives and Actions Relevant to the Activity.

Recovery Objective	Relevant Key Threats	Action Area	Relevant Actions to the Activity
Long Term Recovery Objective. Minimise anthropogenic threats to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list.	4B Marine debris	Reduce the impacts from marine debris	Management of marine debris is detailed in Section 7.6 Waste.
	4C Chemical and terrestrial discharge	Minimise chemical and terrestrial discharge	Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs. Management of oil spills is detailed in Section 7.11 and 7.12.
Interim Recovery Objectives relevant to the activity. Interim Objective 3: Anthropogenic threats are demonstrably minimised. Target 3.1: Robust and adaptive management regimes that lead to a reduction in anthropogenic threats to marine turtles and their habitats are in place. Target 3.2: Threat mitigation strategies are supported by high quality information	4G Light pollution	Minimise light pollution	Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats. Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution. Management of light pollution is detailed in Section 7.3. Section 7.1.5.8 Cumulative Impacts from Seismic Noise did not identify any activities within 100 km of the operational area thus cumulative light impacts would not occur from the activity.
	4J Vessel disturbance	No specific action	Management of vessel/fauna interactions is detailed in Section 7.8.
	4K Noise interference	Understand the impacts of anthropogenic noise on marine turtle behaviour and biology.	Implementation of EPBC Act Policy Statement 2.1 – Interactions between Offshore Seismic Exploration soft start procedures to afford protection for marine turtles. Management of noise is detailed in Section 7.1 and 7.2.

5.5.8 Marine Birds

At least 43 seabird species listed under the EPBC Act are known to occur in the North Marine Region (DSEWPaC 2012c). The Protected Matters Database search identified two listed threatened and migratory marine bird species, the curlew sandpiper and the eastern curlew as potential occurring within the AMBA. It also identified the osprey as a migratory wetland and listed marine species and the common noddy, streaked shearwater, lesser frigatebird and great frigatebird as marine listed species.

In Australia, curlew sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. They are rarely recorded in the north-west Kimberley, around Wyndham and Lake Argyle (DoEE 2017k). No sites of international importance were identified within or near the AMBA

(Bamford 2008) and no biologically important areas were identified for these species. It is unlikely that this species would be present in the AMBA (Figure 5-27).

Within Australia, the eastern curlew has a primarily coastal distribution. It does not breed in Australia and is found foraging on soft sheltered intertidal sandflats or mudflats, open and without vegetation or covered with seagrass, often near mangroves, on salt flats and in saltmarsh, rockpools and among rubble on coral reefs, and on ocean beaches near the tideline (DoEE 2015). No sites of international importance were identified within or near the AMBA (Bamford 2008). It is unlikely that this species would be present in the AMBA.

Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands (DoEE 2017l). Ospreys are not known as an offshore bird as prefer coastal areas to feed and breed. Due to the distance offshore, it is unlikely that this species would be present in the AMBA.

In Australia, the common noddy occurs mainly in ocean off the Queensland coast, but the species also occurs off the north-west and central Western Australia coast (DoEE 2017m). During the breeding season, it usually occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand. When not at the nest, individuals will remain close to the nest, foraging in the surrounding waters (DoEE 2017m). It is unlikely that this species would be present in the AMBA.

Following its winter migration from the northern hemisphere, the streaked shearwater occurs frequently in northern Australia from October to March, with some records as early as August and as late as May (Marchant & Higgins 1990). Whilst it does not breed in Australia, it is known to forage in the North Marine Region, in particular north-west of the Wellesley Islands (over 1000 km south-east of the operational area) (DSEWPaC 2012c). Given the shearwaters migratory times it is unlikely that this species would be present in the AMBA.

Lesser frigatebirds are usually observed in tropical waters around the coast of northern Western Australia, Northern Territory, Queensland and New South Wales (DSEWPaC 2012a). They are often found foraging far offshore, especially during the non-breeding season where some large movements have been recorded (DSEWPaC 2012b). During the breeding season (March - November), the lesser frigatebird’s range remains close to the breeding colonies. The National Conservation Values Atlas identifies a Biologically Important Area for breeding 300 km south-west of the AMBA. As the survey is planned to be undertaken during the breeding season where the lesser frigatebirds remain close to their colony, it is unlikely that this species would be present in the AMBA.

The great frigatebird is widespread and breeds on numerous tropical islands including Adele Island and Ashmore Reef. Breeding mostly occurs between March and November. The species is pelagic, although breeding birds probably forage within 100 – 200 km of the colony during the early stages of the breeding season (DSEWPaC 2012a). Based on these distances it is unlikely that this species would be present in the AMBA.

No Recovery Plans have been given for these marine bird species, however, the North-west Marine Bioregional Plan identify the following threats to a number of the bird species; marine debris, oil pollution and collision with vessels. These threats are discussed in Sections 7.6, 7.11, 7.12 and 7.8., respectively.

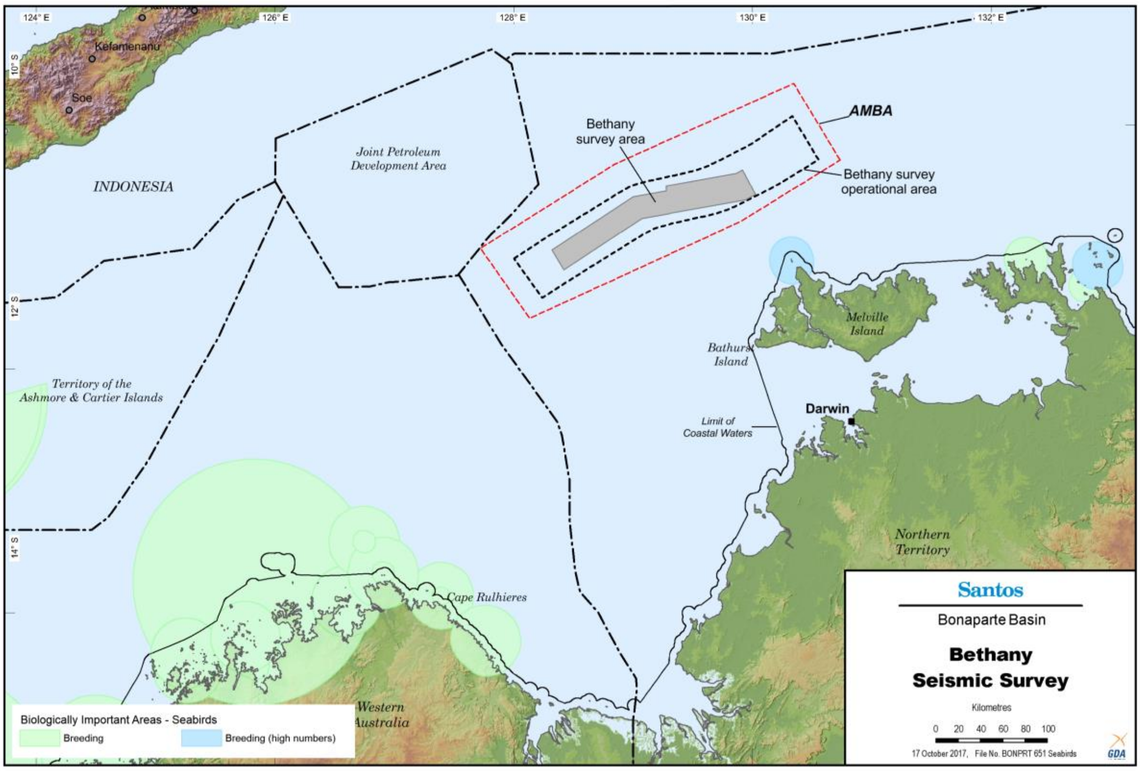


Figure 5-27: Marine Bird Species' Biologically Important Areas for breeding.

5.5.9 Mammals

The Protected Matters Database searches identified four species of threatened and migratory cetaceans. The sei whale (vulnerable), blue whale (endangered), fin whale (vulnerable) and humpback whale (vulnerable). A further five species (Antarctic minke whale, Bryde's whale, spotted bottlenose dolphin, killer whale and sperm whale) were identified as migratory.

Sei whales (*Balaenoptera borealis*) are moderately large whales growing up to 18 m. It is less studied than other great whales and its population status, distribution and movements are not well known. They are similar in appearance to Bryde's whale which has led to confusion as to their distribution, especially in warmer waters where Bryde's whales are more common (DEH 2005b). There are no known mating or calving areas in Australia and Antarctic waters and the Bonney Upwelling are known feeding areas (DoEE 2017n). The movements and distributions of sei whales are unpredictable and not well documented with information suggesting that they have the same general pattern of migration as most other baleen whales although it is timed a little later and they do not go to such high latitudes (DoEE 2017n). There are no important biological areas for sei whales near the AMBA, however, as there is limited information on the movements of sei whales these whales may be transit through the AMBA.

Blue whales are the largest living animals, growing to a length of over 30m and weighing up to 180 tonnes (DEH 2005b). In Australia, there are two recognised sub-species of blue whale; the Antarctic or true blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*B. m. brevicauda)*. Blue whales have a worldwide distribution but tend to move between warm water (low latitudes) for breeding and cold water (high latitudes) for feeding. Pygmy blue whales are thought to migrate from Australian feeding areas to breeding grounds that include Indonesia based on sightings in Indonesia in the austral winter, while Antarctic blue whale winter migratory destinations include lower latitudes of the Pacific and Indian Oceans (DoE 2015b). Thus, the pygmy blue whale is more likely to be encountered in tropical waters and hence the information provided is based on the pygmy blue whale.

Tracking of pygmy blue whales identified that they migrate north from the Perth Canyon (known feeding area) in March/April reaching Indonesia by June where they remain until at least September. Southern migration from Indonesia may occur from September and finish by December after which the animals may make their way slowly northwards towards the Perth Canyon by March/April (Double et al. 2014).

Blue whale migration is thought to follow deep oceanic routes and the tagging study by Double et al. (2014) identified that the shallowest waters occupied was ~ 1300 m. Figure 5-28 shows the migratory route for pygmy blue whales.

A distribution map for pygmy blue whales is shown in Figure 5-29 and shows that though the AMBA is within the area where they may occur this is based on occasional observations within the area and nearby areas. There are no important biological areas for pygmy blue whales near the AMBA, however, as they have been occasionally observed in the area they may transit through the AMBA.

The Conservation Management Plan for the Blue Whale 2015-2025 (DoE 2015b) identified noise interference and vessel collision as threats which are relevant to the activity (Table 5-19).

Table 5-19: Conservation Management Plan for the Blue Whale Relevant to Activity

Relevant Objectives	Relevant Threats	Relevant Actions
Anthropogenic threats are demonstrably minimised	Noise interference	EPBC Act Policy Statement 2.1—Interaction between offshore seismic exploration and whales is applied to all seismic surveys. Management of noise is detailed in Section 7.1 and 7.1.
	Vessel disturbance – vessel collision	Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented. Management of vessel/fauna interactions is detailed in Section 7.8.

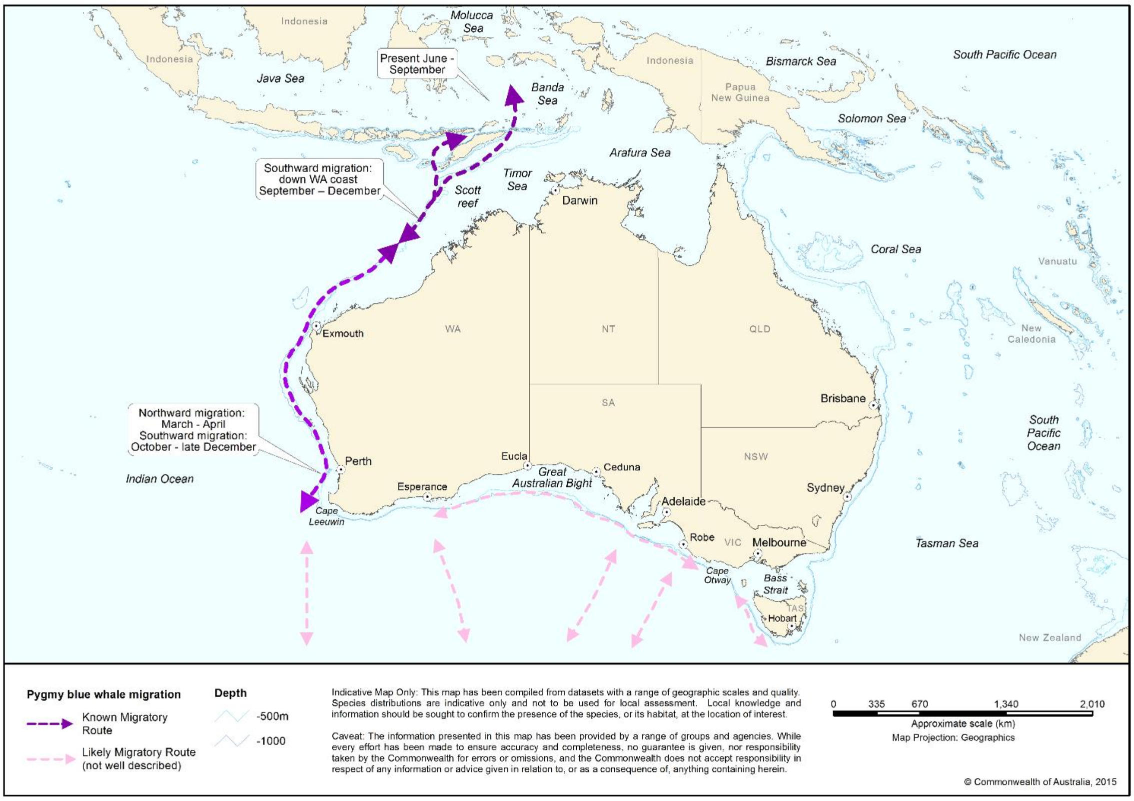
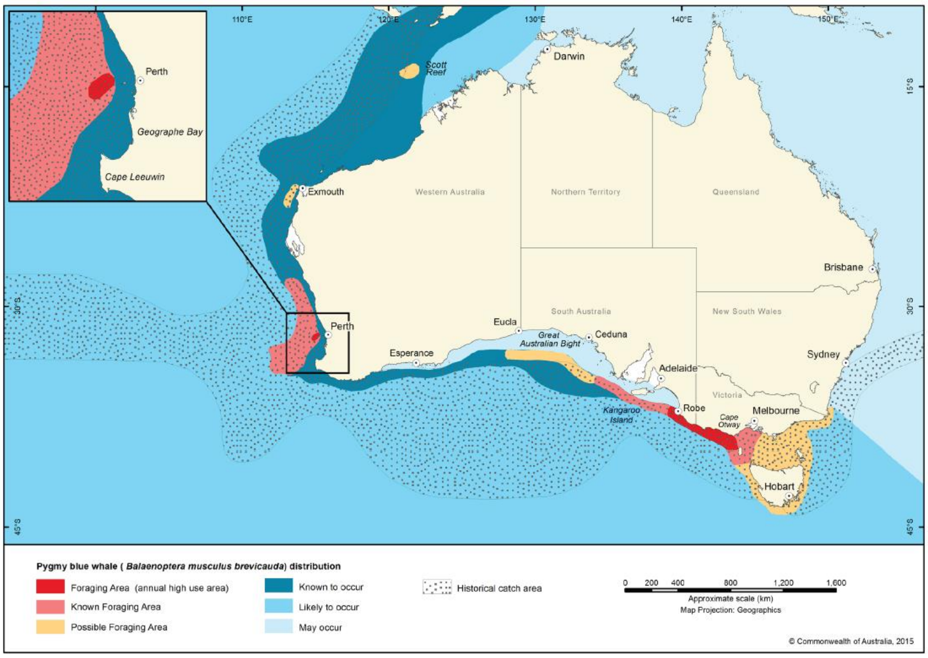


Figure 5-28: Migratory Map for Pygmy Blue Whales



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

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

Figure 5-29: Distribution Map for Pygmy Blue Whales

The fin whale is the second-largest whale species, after the blue whale. Fin whales have been observed during aerial surveys in South Australian waters between November and May. Fin whale distribution in Australian waters is known primarily from stranding events and whaling records from Western Australia, South Australia, Victoria and Tasmania (DoEE 2017o). There are no known mating or calving areas in Australian waters and feeding seems to be in more temperate waters (DEH 2005b). Based on this information it is unlikely that the fin whale would be present in the AMBA.

The Blue, Finn and Sei Whale Recovery Plan (DEH 2005b) is no longer in force. In this plan acoustic pollution from seismic survey was identified as a threat and is assessed in Section 7.1.

Humpback whales in the southern hemisphere undertake an annual migration during the austral winter from Antarctic feeding areas to tropical calving grounds (DoEE 2017p). In the North-West Region, humpback whales are known to have breeding and foraging grounds between Broome and the Northern end of Camden Sound (approximately 270 km south of the AMBA, with the highest concentrations occurring between June and September (DEWHA 2008). Camden Sound appears to be the northern most limit for the majority of the west coast whales (Jenner et al 2001). Based on this it is unlikely that humpback whales would be present in the AMBA.

The Humpback Whale Recovery Plan 2005 – 2010 (DEH 2005c) is no longer in force, however, applicable threats to the activity are detailed in (Table 5-20). Additional actions from the Conservation Advice *Megaptera novaeangliae* are also included in (Table 5-20).

Table 5-20: Humpback Whale Recovery Plan 2005 – 2010 and Threats Relevant to the Activity

Relevant Threats	Relevant Actions
Acoustic pollution (e.g. commercial and recreational vessel noise, and seismic survey activity)	Assess and manage acoustic pollution – including the development and application of administrative guidelines under the EPBC Act such as the “Guidelines on the application of the EPBC Act to interactions between offshore seismic operations and larger cetaceans”. All seismic surveys must be undertaken consistently with the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales. Should a survey be undertaken in or near a calving, resting, foraging area, or a confined migratory pathway then Part B. Additional Management Procedures must also be applied. Management of noise is detailed in Section 7.1 and 7.2.
Vessel disturbance and strike	Vessel strike incidents must be reported in the National Ship Strike Database. Enhance education programs to inform vessel operators of best practice behaviours and regulations for interacting with humpback whales. Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike. Management of vessel/fauna interactions is detailed in Section 7.8.
Entanglement – marine debris	Encourage best practice approaches that will reduce the likelihood of humpback whales being entangled in marine debris. Management of waste is detailed in Section 7.6.
Changing water quality and pollution (e.g. runoff from land based agriculture, oil spills, outputs from aquaculture)	Assess and manage physical disturbance and development activities (such as ship-strike, aquaculture, pollution, recreational boating, naval activities, and exploration and extraction industries) – including the application of environmental impact assessment and approvals and the development of industry guidelines and State/Commonwealth government regulations. Management of waste water discharges is detailed in Section 7.5. Management of oil spills is detailed in Section 7.11 and 7.12.

Antarctic minke whales (*Balaenoptera bonaerensis*) have been recorded from all states but not in the Northern Territory (DoEE 2017r). Information on their distribution on the west coast of Australia is currently unknown. Antarctic minke whales appear to occupy primarily offshore and pelagic habitats within cold temperate to Antarctic waters though they do migrate to temperate/tropical waters to breed, though the exact location of their breeding grounds is unknown. Within Australian waters the reported latitudinal range is (21° S to 65° S for this species (DoEE 2017r) which is below NT waters. Based on this information and no sightings in NT it is unlikely that Antarctic minke whales would occur in the AMBA.

Currently there are no adopted recovery plans or conservation advice documents given for the Antarctic minke whale. The IUCN identifies that besides pelagic catching under a scientific permit, no other anthropogenic threats have bene identified for this species.

There is some confusion regarding the taxonomy of Bryde’s whales (*Balaenoptera edeni*as) for many years the sei whale was recorded as Bryde’s whale (DoEE 2017q) as was Omura’s whale (*Balaenoptera omurai)* which was previously thought to be a pygmy form of the Bryde’s whale (IUCN 2017).

Noise monitoring by ConocoPhillips within the permits NT/RL5 and NT/RL6 (Bethany operational area overlaps) identified Omura’s whale throughout April to September inclusive, with a peak in June and July (CoP 2016). Thus, Omura’s whale may be present in the AMBA. Omura’s whales are not listed under the EPBC Act but are listed on the IUCN Red List of Threatened Species as ‘Data Deficient’.

Bryde’s whale is restricted to tropical and temperate waters and has been recorded off all Australian states with exception of the Northern Territory (Bannister et al. 1996). Bryde’s whales can be found in both oceanic (500 to 1000 m isobar) and inshore waters (<200 m isobar) (DoEE 2017q). Population estimates are not available for Bryde’s whales, globally or in Australia, and no migration patterns have been documented in Australian waters (DoEE 2017q). Bryde's whale is considered to be an opportunistic feeder and it appears that the coastal and offshore forms may be distinguished by their prey preferences, with the smaller coastal form feeding on schooling fishes, such as pilchard, anchovy, sardine, mackerel, herring and others. In contrast, the larger offshore form appears to feed on small crustaceans such as euphausids, copepods, pelagic red crabs and cephalopods. Based on this information Bryde’s whales may transit through the AMBA.

Currently there are no adopted recovery plans or conservation advice documents given for the Bryde’s whale. In addition, the IUCN does not identify any relevant threats (Reilly et al. 2008).

Spotted bottlenose dolphins occur in coastal waters, primarily in continental shelf waters (less than 200 m deep), including coastal areas and oceanic islands (DSEWPaC 2012b). They are mainly found in four regions around Australia, including the Arafura-Timor seas (DSEWPaC 2012b). Whilst knowledge of their seasonal migration and breeding is largely unknown, it is inferred that only the Arafura-Timor Sea population is migratory (DSEWPaC 2012b). Biologically important areas identified for foraging and breeding during April to November, include the Darwin harbour (approximately 350 km north-east of the AMBA) and near the Camden Sound (approximately 380 km south-west of the AMBA). Bottle nosed dolphins (*Tursiops truncates)* have been recorded within the OSMP (Nichol 2013) and therefore the bottlenose and spotted bottlenose dolphins may transit through the AMBA.

Whilst there is no specific management plan used for the spotted bottlenose dolphin, it is listed in the Marine bioregional plan for the North Marine Region. This plan identifies marine debris, chemical and noise pollution to be of potential concern to the spotted bottlenose dolphin and oil pollution and collision with vessels to be less of a concern (DSEWPaC 2012b). These threats as assessed in Sections 7.6, 7.5, 7.1, 7.2, 7.11, 7.12 and 7.8, respectively.

The killer whale is known to occur from polar to equatorial regions of all oceans and has been recorded off all states of Australia (Bannister et al. 1996). Killer whales appear to be more common in cold, deep waters; however, they have often been observed along the continental slope and shelf, particularly near seal colonies (Bannister et al. 1996). Thought there are no biologically important areas for killer whales near the AMBA they have been reported within the OSMP (Nichol 2013) and therefore they may transit through the AMBA.

Currently there are no adopted recovery plans or conservation advice documents given for the killer whale. The IUCN however identifies bioaccumulation due to chemical pollution, noise pollution, boat strike and oil spills as relevant key threats (Taylor et al. 2013). These threats are assessed in Sections 7.5, 7.1, 7.2, 7.8, 7.11 and 7.12 respectively.

The sperm whale (*Physeter macrocephalus*) is listed as migratory under the EPBC Act and is the largest species of toothed whale, with males reaching up to about 16 m in length. Only adult males move into latitudes higher than 45° in both hemispheres to feed, although seasonal movements from higher to lower latitudes between summer and winter do occur in some segments of populations. Sperm whales are sighted frequently in deeper waters and form large aggregations (100 to 1000 individuals) in foraging grounds of high oceanic productivity (Whitehead 2002). Female sperm whales have restricted home ranges in water deeper than 1000 m and less than 40° latitudes (Whitehead 2002). Male sperm whales remain with their mothers for several years until early adulthood (4 to 21 years), at which time they join larger, male-only herds that migrate to polar waters to feed, and return to tropical and temperate waters to breed (Whitehead 2002).

In Australia, sperm whales are most commonly found in deep waters (greater than 600 m deep) off the continental shelf of all Australian states (Bannister et al. 1996). There are no population estimates for sperm whales in Australia, with information regarding their presence and distribution gathered from incidental sightings and stranding records (DoEE 2017s). Concentrations of sperm whales are found where the seabed rises steeply from great depth, and are probably associated with concentrations of major food in areas of upwelling (Bannister et al. 1996). Given the location of the Bethany survey, sperm whales are not expected to be encountered within the AMBA.

5.6 Socio-economic Environment

5.6.1 Settlements

There are no settlements within the AMBA. The closest major community to the AMBA is Pirlangimpi approximately 140 km north of Darwin and approximately 80 km south of the AMBA (Figure 3-1)

5.6.2 Commonwealth Managed Fisheries

Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA) under the *Fisheries Management Act* 1991 (Cth). AFMA's jurisdiction covers the area of ocean from 3 nm from the coast out to the 200 nm limit (the extent of the Australian Fishing Zone). Fisheries with jurisdictions to fish within the permit area are given in Table 5-21. Based on discussions with AFMA and information from the ABARES Fishery Status Report (Patterson et al. 2016) it was identified that only the Northern Prawn Fishery (NPF) actively fishes in the area.

Table 5-21: Commonwealth Managed Fisheries within the Environment that May Be Affected

Fishery	Actual Catch Effort within Permit Area/s	Comments
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 (Patterson et al. 2016). The fishery has a maximum of 52 active vessels.
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.
Western Skipjack Fishery	No	No fishing effort since 2008-2009.
Western Tuna and Billfish Fishery	No	Efforts have been concentrated off south-west Western Australia over recent years.

5.6.2.1 Northern Prawn Fishery

The NPF operates off Australia's northern coast from Cape York (QLD) to Cape Londonderry (WA) (AFMA 2017). The NPF is restricted to 52 vessels. The area of the NPF and actual catch effort for 2015 is shown in Figure 5-30. The main fishing area for the NPF is the Gulf of Carpentaria with low intensity within the Joseph Bonaparte Gulf. Data obtained from the NPF Industry (NPFI) for catch effort from 2010 to 2016 within the northern portion of the Joseph Bonaparte Gulf (closest to the AMBA) has been consolidated to show an area and not individual locations as requested by the NPFI (Figure 5-31).

The following information in regards to the NPF is from ABARES (Patterson et al. 2016).

The NPF uses otter trawl gear to target a range of tropical prawn species. White banana prawn and two species of tiger prawn (brown and grooved) account for around 80% of the landed catch. White banana prawn (*Fenneropenaeus merguiensis*) is mainly caught in the Gulf of Carpentaria, whereas red-legged banana prawn (*F. indicus*) is mainly caught in Joseph Bonaparte Gulf. Byproduct species include endeavour prawns (*Metapenaeus spp.)*, scampi (*Metanephrops spp.*), bugs (*Thenus spp.*) and saucer scallops (*Amusium spp*.).

Total NPF catch in 2014 was 8,707 t at a value of $117.2 million and in 2015 was 7,825 t at a value of $106.8 million. Annual catches tend to be quite variable from year to year because of natural variability in the banana prawn component of the fishery.

The NPF operates during two seasons. The first season from the 1 April to 15 June and during this time banana prawns are mainly caught. Conversely, during the second season (1 August – 1 December) tiger prawns are predominately caught.

The survey area is within the NPF Melville statistical area (Figure 5-32) where the main catch is from banana prawns (88% from 1998 – 2015) compared to tiger prawns (6% from 1998 -2015) (Laird 2015) and endeavour prawns (5% from 1998 – 2015).

The following is from the AFMA website (http://www.afma.gov.au/portfolio-item/prawns/) except where noted.

Banana prawns inhabit tropical and subtropical coastal waters. They are found over muddy and sandy bottoms in coastal waters and estuaries. Juveniles inhabit small creeks and rivers in sheltered mangrove environments. White banana prawns can generally be found at depths of 16-25 m but can occur to depths of 45 m. Red-legged banana prawns are found at depths of 35-90 m. Advice from the NPFI is that banana prawns spawn offshore near to the fishing area throughout the year with two spawning peaks: the late dry season (September-November) and the late wet season (March-May). The dry season peak spawning periods is within the period of the survey timing.

Tiger prawns inhabit coastal waters to depths of 200 m. Adult brown tiger prawns are found over coarse sediments. Adult grooved tiger prawns are found in fine mud sediments. Juvenile tiger prawns are found in shallow waters, often in association with seagrass beds, and sometimes on top of coral reef platforms. Spawning occurs throughout the year, in both inshore and offshore areas for brown tiger prawns and in offshore areas for grooved tiger prawns. Brown tiger prawns have a spawning peak between July and October. Grooved tiger prawns have a spawning peak in in August-September, with a secondary peak in February.

Endeavour prawns inhabit tropical coastal waters. Blue endeavour prawns can be found over sandy or mud-sand substrates to depths of about 60 m. Red endeavour prawns prefer muddy substrates and have been found to depths of 95 m. Juveniles blue endeavour prawns are commonly associated with seagrass beds in shallow estuaries, while juvenile red endeavour prawns are more widely distributed across seagrass beds, mangrove banks, mud flats and open channels. Spawning occurs throughout the year. Blue endeavour prawns have spawning peaks in March and September. Red endeavour prawns have a spawning peak in September-December. Based on the endeavour prawns spawning habitat preferences it is unlikely that they would spawn in the offshore area of the survey.

Advice from the NPFI is that prawn species reach a commercial size at six months, and can live for up to two years. Larger sizes bring the highest price. Growth rates vary considerably between species and sexes, with females generally growing faster and to a larger size than males. Most species are sexually mature at six months, but fecundity increases with age. A twelve-month-old female can produce hundreds of thousands of eggs at a single spawning and may spawn more than once in a season. The eggs sink to the bottom after release, where they hatch into larvae within about 24 hours. Less than 1% of these offspring survive the two to four week planktonic larval phase to reach suitable coastal nursery habitats where they may settle. After one to three months on the nursery grounds, the young prawns move offshore onto the fishing grounds.

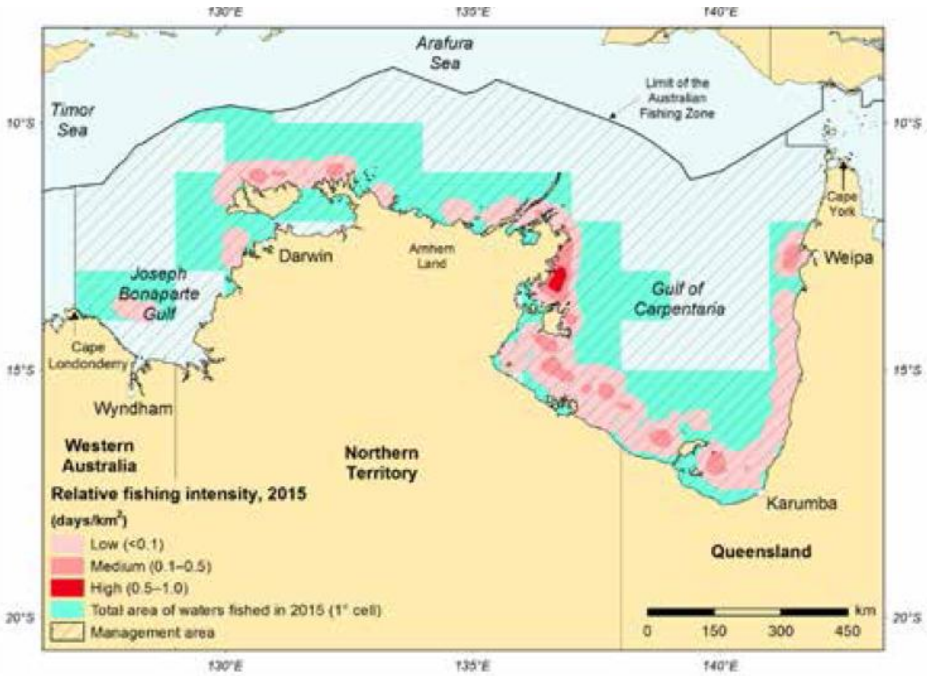


Figure 5-30: Northern Prawn Fishery Management Area and 2015 Fishing Intensity (Patterson et al. 2016).

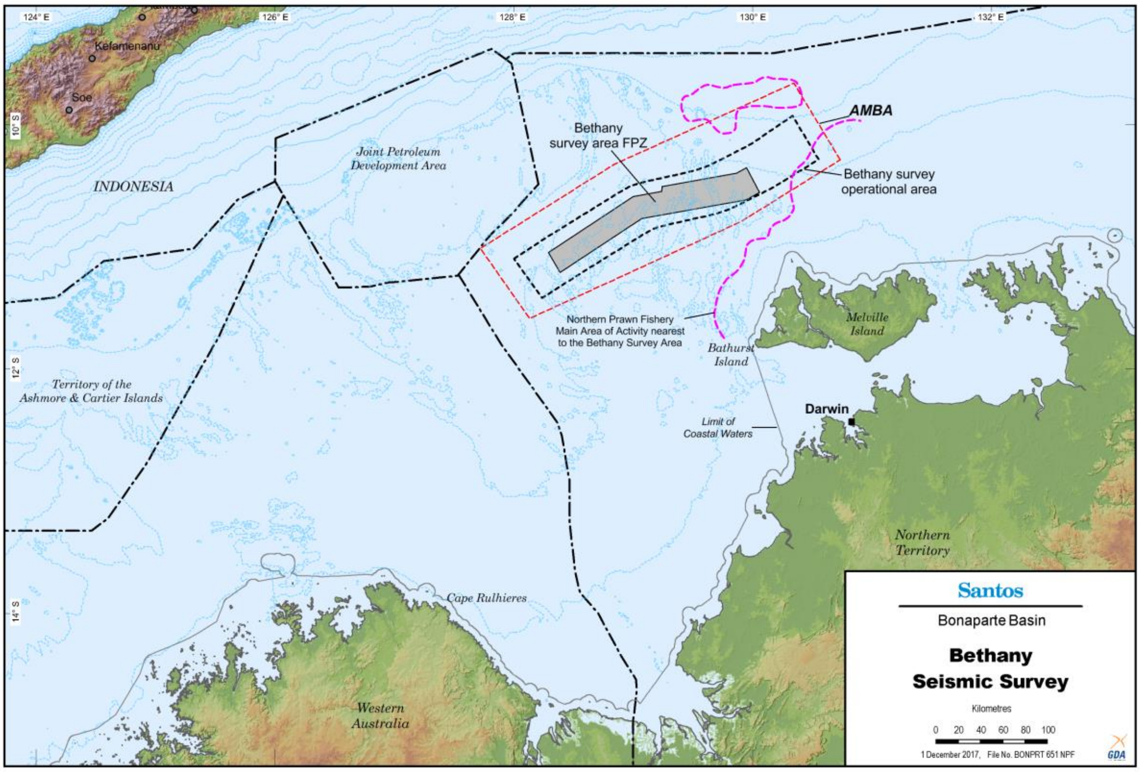


Figure 5-31: Northern Prawn Fishery Main Area of Activity Nearest to the AMBA

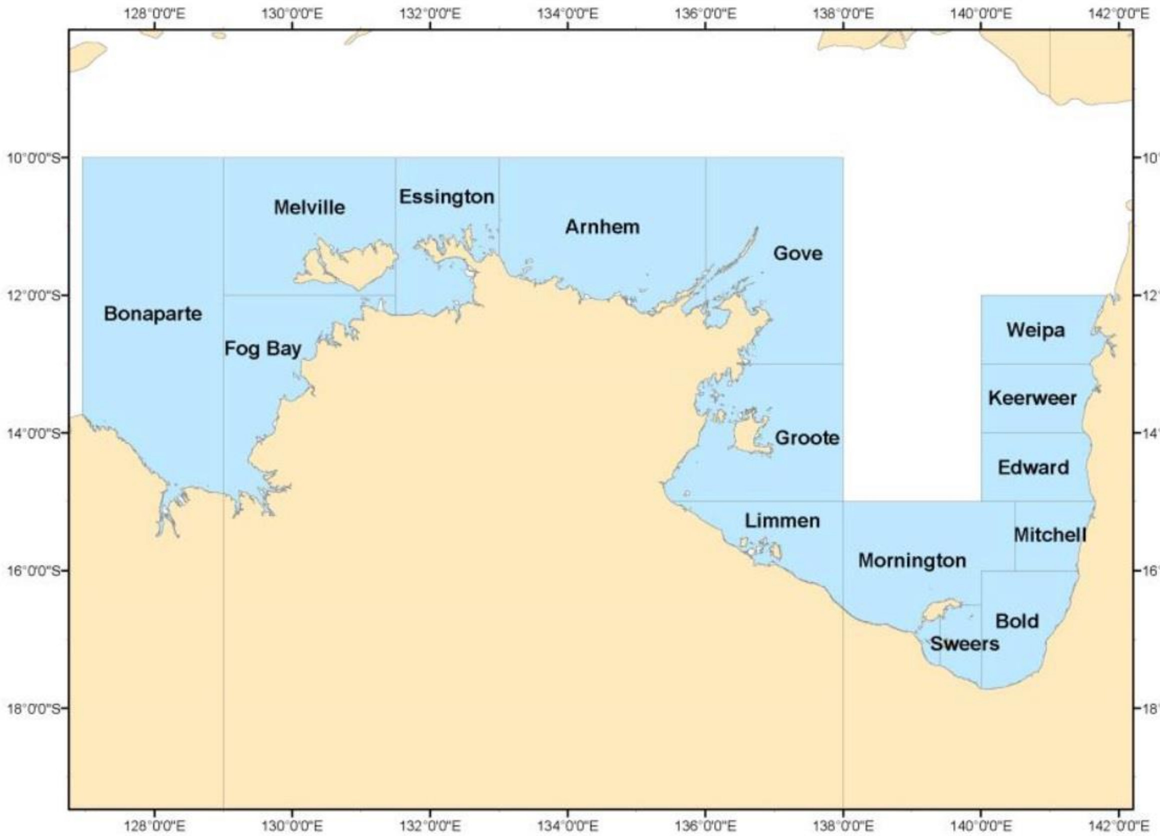


Figure 5-32: Northern Prawn Fishery Statistical Areas

5.6.3 Northern Territory Managed Fisheries

Northern Territory fisheries are managed by the Department of Primary Industry and Resources (DPIR) under the *Fisheries Act 2016* (NT). In 2014–15, the gross value of production of the Northern Territory's fisheries and aquaculture increased by 21 per cent to $55 million (Patterson et al. 2016). The value of the Northern Territory's annual fisheries production has averaged around $55 million (in 2014–15 dollars) since 2004–05 (Patterson et al. 2016)

A review of data from the 2014 Status of Key Northern Fish Stocks Report as well as consultation with the NT DPIR, Northern Territory Seafood Council (NTSC) and licenced fishers was used to identify NT managed fisheries licenced to operate within the AMBA (Table 5-23).

Information provided by the NT DPIR in regards to the percentage of NT Fishery catch within the Operational Area shows that the main fishery in the area is the Timor Reef Fishery (Table 5-22). The data provided is based on average catch for 2013 – 2017. The NT DPIR stated that the Pearl Oyster and Aquarium fisheries recorded no catch in this area during this time period.

Table 5-22: Percentage NT Fishery Catch 2013 – 2017 within the Operational Area

Fishery	% Catch within Operational Area 2013 - 2017
D2- Fishing tour operators	0.43
A6- Demersal fishery- Trap only	0.03
A5- Offshore Net and Line Fishery	0.08
A4- Spanish Mackerel fishery	0.64
A18- Timor Reef Fishery- trap, line and trawl allowed under permit	32.14

Data provided by the NT DPIR

Table 5-23: NT Managed Fisheries within the AMBA

Fishery	Actual Catch Effort within Operational/ Survey Area	Comments See Section 4 for stakeholder engagement records.
Aquarium Fishery	No	The aquarium fishery is a small-scale, multi-species fishery. It includes freshwater, estuarine and marine habitats to the outer boundary of the Australian fishing zone, which is 200 nm offshore. Most marine species are collected within 100km of Nhulunbuy and Darwin (NT Government 2017a). 11 licences and around 3 boats active each year (NTSC 2017). Information from Chair of the Aquarium Fishery Licence Committee is that they scuba dive to a maximum of 30 m and one licence holder operates at Evan Shoal, east of Lyndoch Shoal, Blackwood Shoal and Money Shoal in Arafura and within Timor Reef Fishery Area. June, July, Aug period least impact period for aquarium fishery. These shoals are within the AMBA but outside the operational/survey area.
Demersal Fishery - NT Fishery Joint Authority	Yes	Information from Status of Key Northern Territory Fish Stocks Report 2015 (NT Government 2016). The NT Demersal Fishery extends from 15 nm from the low water mark to the outer limit of the AFZ (excluding the area of the Timor Reef Fishery) and targets a range of tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.). Information provided by the NT DPIR identified that on average for 2013 -2017, 0.03% of the total catch for the Demersal Fishery was within the operational area (Table 5-22). Via consultation one licensee was identified to operate in the operational/survey area. Information on the Demersal Fishery is provided in Section 5.6.3.2.

Fishery	Actual Catch Effort within Operational/ Survey Area	Comments See Section 4 for stakeholder engagement records.
Offshore Net and Line Fishery - NT Fishery Joint Authority	No	Information from Status of Key Northern Territory Fish Stocks Report 2015 (NT Government 2016). The NT Offshore Net and Line Fishery (ONLF) extends seaward from the high water mark to the outer limit of the AFZ and targets Australian blacktip sharks (*Carcharhinus tilstoni*), common blacktip sharks (*C. limbatus*) and grey mackerel (*Scomberomorus semifasciatus*). A total of 669 t of fishes were harvested by Offshore Net and Line Fishery licensees in 2014. Demersal longlines can be used throughout the fishery whereas pelagic gillnets and pelagic longlines can only be used beyond 2 nm and 3 nm off the coast, respectively. Pelagic gillnets are the primary gear used by this fishery and are generally set within 15 nm of the coast, in the Gulf of Carpentaria. Longlines have not been used in the fishery since 2013, primarily as a result of the drop in shark fin price. The AMBA is within the area where demersal longline fishing would occur, as longline fishing has not been undertaken since 2013 there is no fishing activity within the AMBA. Information provided by the NT DPIR identified that on average for 2013 -2017, 0.08% of the total catch for the ONLF was within the operational area (Table 5-22).
Spanish Mackerel Fishery	Yes	Information from Status of Key Northern Territory Fish Stocks Report 2015 (NT Government 2016). The NT Spanish Mackerel Fishery extends seaward from the high water mark to the outer limit of the Australian Fishing Zone (AFZ) and targets Spanish mackerel (*Scomberomorus commerson*) using trolled lures or baited lines. The primary fishing grounds include waters near Bathurst Island, New Year Island, the Wessel Islands around to Groote Eylandt and the Sir Edward Pellew Group of islands. A total 290 t of fish were harvested by Spanish Mackerel Fishery licensees in 2014. Information provided by the NT DPIR identified that on average for 2013 -2017, 0.64% of the total catch for the Spanish Mackerel Fishery was within the operational area (Table 5-22). Via consultation no licensees were identified to operate in the operational/survey area.
Timor Reef Fishery - NT Fishery Joint Authority	Yes	Information from Status of Key Northern Territory Fish Stocks Report 2015 (NT Government 2016). The Timor Reef Fishery (TRF) operates offshore in a zone covering roughly 8,400 nm^2 to the north-west of Darwin and targets tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.). Information provided by the NT DPIR identified that on average for 2013 -2017, 32.14% of the total catch for the TRF was within the operational area (Table 5-22). Via consultation one licensee using traps and one licensee using trawl were identified to operate in the operational/survey area. Information for the TRF is in Section 5.6.3.3.
Pearl Oyster Fishery NT Fishery Joint Authority	Yes	Information from Northern Territory Government Commercial Fishing Website (NT Government 2017a). The Pearl Oyster Fishery extends from high water mark to the outer boundary of the AFZ and targets the Pearl Oyster – *Pinctada maxima*. There is a Pearl Oyster Fishery area within the AMBA (Figure 5-33). The NT DPIR confirmed that there had been no effort in this fishery since 2008. However, this conflicts with information provided by the Pearl Producers Association (PPA). Thus, one licence holder was identified that may operate in the operational/survey area.

5.6.3.1 Pearl Oyster Fishery

The Pearl Oyster Fishery extends from the high water mark to the outer limit of the AFZ and targets the pearl oyster, *Pinctada maxima.* Fishing efforts are restricted to water depths less than 35 m, as deeper oysters are relied on as broodstock to support recruitment and prevent over-fishing. This fishery is only permitted to operate by hand, and consequently, individual oysters are hand-harvesting (by drift divers). The fishery is seasonal, and fishing can occur between the months of April and October.

P. maxima has a widespread distribution in the Indo-west Pacific as shown in Figure 5-34. *Pinctada* species are mostly found on the seafloor in shelly, rocky gravel areas and reef environments that provide crevices and substrates for their byssus threads to attach to, including live and dead coral, some individuals have been found on sandy bottoms (Southgate and Lucas 2008). Individuals are mostly found in shallow waters of the littoral and sub-littoral zone, on occasion reaching the maximal recorded depths of 100 to 120 m (Southgate and Lucas 2008).

Since the 1880’s pearl oysters have been collected in NT waters for the production of Mother of Pearl (MOP), used for buttons, ornaments and additives in paint and cosmetics. In the 1960’s the introduction of plastics reduced the demand for MOP. Coincidently, the switch of the Australian pearl industry to the culture of *P. maxima* for pearls was also responsible for the dramatic decline in production (Southgate and Lucas 2008) (Oengpepa 2006). Recent low catches have been around 2 t (to supply niche markets), there has been no harvest in the Northern Territory since 2008 and currently no active vessels in the Fishery (Figure 5-33; FRDC 2016). The peak spawning period for oysters is in October and a possible secondary spawning in March/April, both of which are outside of the proposed timing of the survey (Knuckey 1995).

Historical overfishing was thought have caused overfishing in many areas in the Northern Territory (Knuckey 1995) (FRDC 2016). However, during a study conducted in 1991 to 1993 it was apparent that NT pearl oyster stocks consisted of a high proportion of large oysters although they are unsuitable for round pearl culture. Patchy, irregular or low recruitment to NT beds and minimal harvesting are suggested as possible causes (Knuckey 1995). There is no evidence of extensive recruitment on any of the beds in the study area, which overlaps the operational area, suggesting that space, food or another mechanism are limiting settlement of oysters around larger adult oysters (Knuckey 1995). Condie et al. (2006) conducted a study of transport and recruitment of the pearl oyster *P. maxima* in Western Australia and found that the longstanding hypothesis that the deeper ‘unfished’ stocks are a broodstock for the commercially inshore stock is not likely to be true. The inshore stock (<30 m) are self-sustaining and may even be providing the larvae to deeper stocks in irregular recruitment events.

Though not specifically mentioned in the above surveys, it was noted by the Pearl Producers Association that at the proposed depths where the Bethany survey is to take place, there will most likely be a variable distribution of *Pinctada maxima* (silver lipped pearl oyster) which are known to be present at less dense quantities in the Joseph Bonaparte Basin out to the 100 m isobath. Figure 5-34 shows that *P. maxima* have a wide distribution throughout northern Australia and into Asia. Consultation with the Pearl Producers Association identified that *P. maxima* are not abundantly distributed and the western grounds, within the AMBA, is less abundant than the south west grounds. Consequently, they may be present within the survey area at low distribution levels.

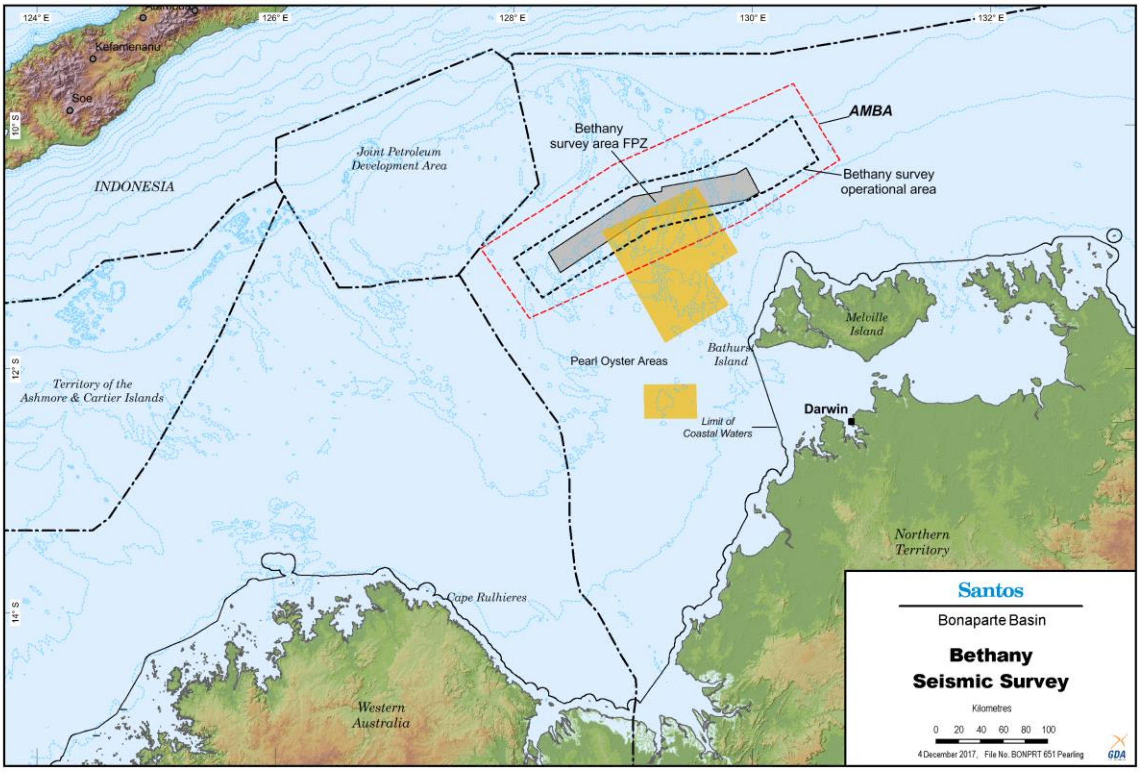


Figure 5-33: Areas of the Pearl Oyster Fishery

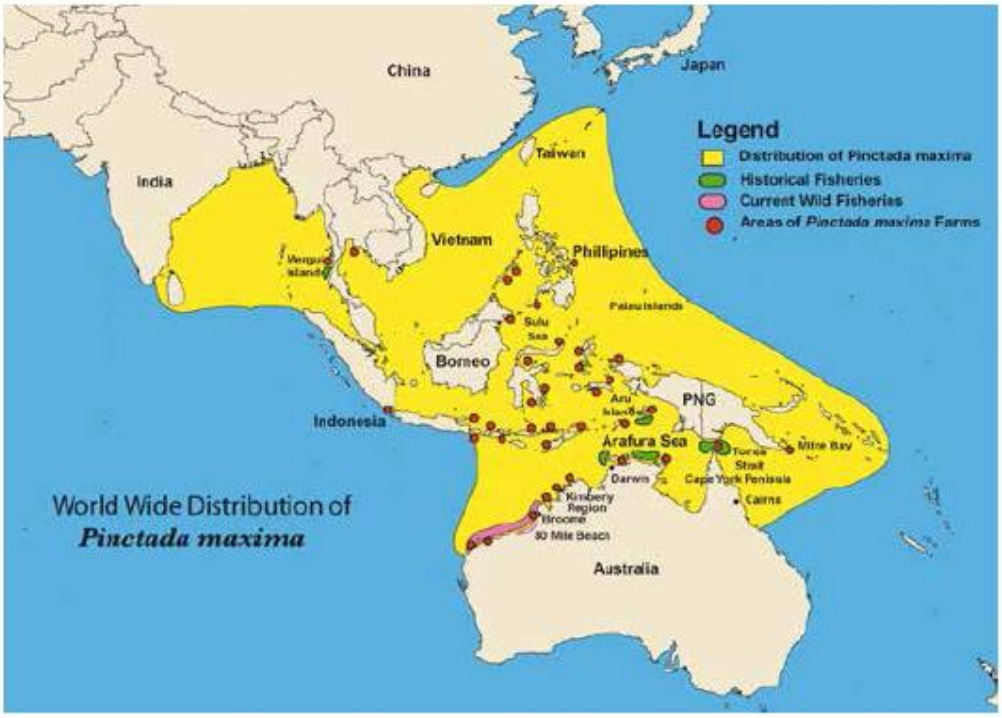


Figure 5-34: Distribution of *Pinctada maxima* and Area of Historical and Current Wild Fisheries (Hart et al. 2016)

5.6.3.2 Demersal Fishery

The NT Demersal Fishery extends from 15 nm from the low water mark to the outer limit of the AFZ (excluding the area of the Timor Reef Fishery) and targets a range of tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.). A total of 3,107 t of fishes were harvested by Demersal Fishery licensees in 2015 (NT Government 2016).

The harvest by the Demersal Fishery is limited through a set of total allowable catches (TACs) applied to goldband snappers (*Pristipomoides* spp.) (400 t), red snappers (*L. malabaricus* and *L. erythropterus*) (2,500 t) and a “grouped fish” category (915 t). The latter group includes all fishes other than barramundi (*Lates calcarifer*), king threadfin (*Polydactylus macrochir*), Spanish mackerel, shark and mud crabs (*Scylla* spp.) (NT Government 2016).

The AMBA is within the Demersal Fishery area where fish traps, hand lines and droplines are permitted, and demersal trawls nets are excluded (Figure 5-39). Based on data from the NT DPIR (Table 5-22) only trap fishing occurs in the survey. Traps used in the fishery are set on the seabed with an identifying float on the sea surface.

In 2012, the total commercial catch from trap vessels was 178 t comprising of 60% (~106 t) goldband snapper, 33% (~58 t) saddletail and 7% (~ 12 t) group species including crimson snapper, red emperor, cods and mixed reef fish. As detailed in Figure 5-35, catch and effort for trap vessels varies from year to year. NT Government (2014) states that the substantial variability in trap effort since 2009 generally reflects movement between the Demersal Fishery and the nearby Timor Reef Fishery. Correspondingly, trap and line catch per unit effort (CPUE) has fluctuated considerably over the history of this fishery (Figure 5-36). NT Government (2014) states that Stock Reduction Analysis evidence suggests that this is not due to changes in fish abundance or sustainability concerns that the fluctuating CPUE reflects the small number of operators and their developing knowledge of the fishery.

Through consultation with the NT DPIR, NTSC and licence holders, one licence holder was identified as potentially fishing in the area.

The Demersal Fishery covers an area of 356,200 km^2, of which the Bethany operational area overlaps 3,442 km^2 of the Demersal Fishery (0.97%) and the Bethany FPZ overlaps 1,269 km^2 of the Demersal Fishery (0.36%) (Figure 5-39).

The fishery is monitored primarily through logbook returns, which operators are required to fill out daily during fishing operations. The logbooks provide detailed catch and effort information, as well as information on the spatial distribution of the fishing operations (NT Government 2014). Data provided by the NT DPIR (Table 5-22) show that the average percentage catch for the Demersal Fishery for 2013 – 2017 within the operational area, was 0.03%.

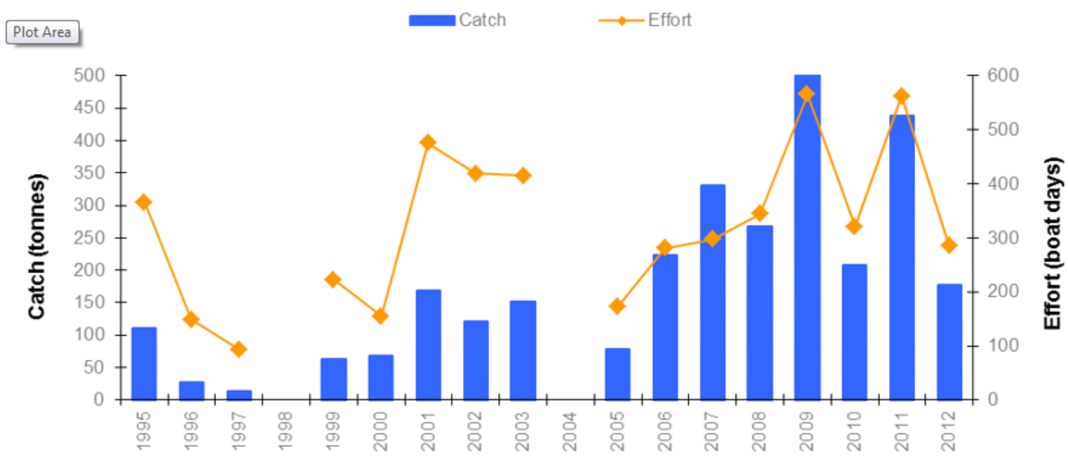


Figure 5-35: Commercial catch and effort for the trap and line component of the Demersal Fishery, 1995 to 2012*

* Due to confidentiality constraints (i.e. fewer than five operators working in a single fishery) data collected in 1998 and 2004 is not been published.

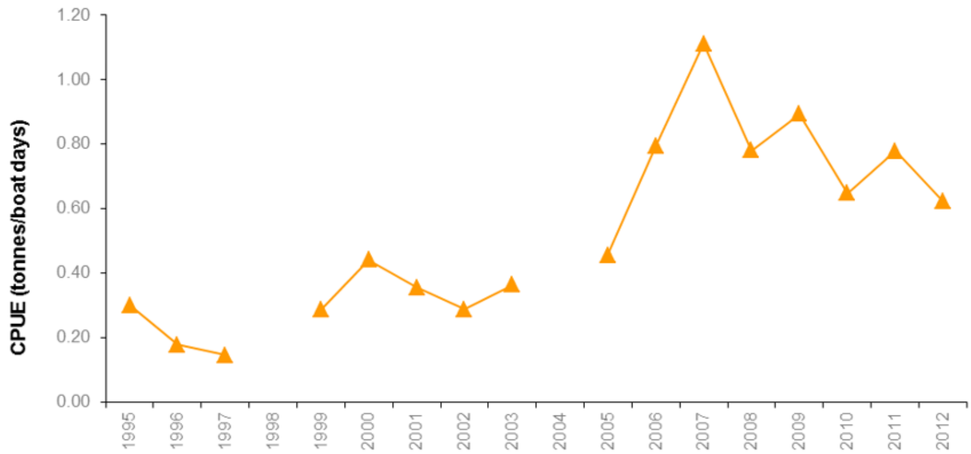


Figure 5-36: Total catch per unit effort (CPUE) for the trap and line component of the Demersal Fishery, 1995 to 2012*

* Note: Due to confidentiality constraints (i.e. fewer than five operators working in a single fishery) data collected in 1998 and 2004 is not been published.

5.6.3.3 Timor Reef Fishery

The Timor Reef Fishery (TRF) operates offshore to the north-west of Darwin and targets tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.). The majority of the catch is taken using baited traps, but hand lines, droplines and demersal longlines may also be used. A trawl trial has been undertaken since 2015 within the fishery.

The harvest by this fishery is limited through a set of TACs applied to goldband snappers (900 t), red snappers (1300 t) and “group fish” (415 t). A total of 590 t of fishes were harvested by licensees in 2014, with goldband snappers and red snappers constituting most of the harvest (44% and 35% of the total, respectively). However, actual catch is below the TAC and the average catch between 2013 and 2015 was 642.5 t.

Figure 5-37 shows the commercial catch and effort and Figure 5-38 shows the CPUE for the TRF for 1995 to 2012. NT Gov (2014) states CPUE has steadily increased since 1999, which reflects the introduction of traps and increasing efficiency in the fishery.

Traps used in the fishery are set on the seabed with an identifying float on the sea surface. Based on information from the NT DPIR, in 2016 and 2017 one licence holder operated three trap vessels. A trawl fishing trial in the TRF has been running for past two years by one licensee with one vessel. A trawl trial commenced in 2015 and consultation with the NT DPIR indicates that this trial is expected to conclude at the end of 2017.

The AMBA is within the TRF area (Figure 5-39). The TRF covers an area of 30,170 km^2, the Bethany operational area overlaps 9,172 km^2 of the TRF (30%) and the Bethany FPZ overlaps 3,295 km^2 of the TRF (11%).

The fishery is monitored primarily through logbook returns, which operators are required to fill out daily during fishing operations. The logbooks provide detailed catch and effort information, as well as information on the spatial distribution of the fishing operations (NT Gov 2014).

Data provided by the NT DPIR (Table 5-22) show that the average percentage catch for the TRF for 2013 – 2017 within the operational area, was 32.14%. The NT DPIR confirmed that there are differences in species composition for 2016-2017, as the trawl gear catches more red snappers compared to the traps which catch more goldband snapper.

The percentage catch by species caught in the operation area for the TRF is shown in (Table 5-25). This data identifies the main species caught within the operational area are goldband snapper (8.55%), red snapper (6.70% and saddletail sea perch (5.38%).

Further information provided by the NT DPIR showed the percentage of total catch for the TRF within the survey area (where acquisition will take place) plus a 3.6 km buffer (based on the largest area or potential impact from noise) by trap and trawl (Table 5-24). The data shows that total catch for 2013 to 2017 within the survey area, with the inclusion of a 3.6 km buffer, ranges from 4% - 12% of the total

TRF catch, with an average of 7.8%. In 2017, the trap percentage catch increased to 4% while the trawl percentage increased to 12%.

Table 5-24: TRF percentage catch within the survey area with a 3.6 km buffer

Year	Trap	Trawl	Total
2013	10%	NA	10%
2014	7%	NA	7%
2015	2%	2%	4%
2016	0%	6%	6%
2017	4%	8%	12%

Data provided by the NT DPIR

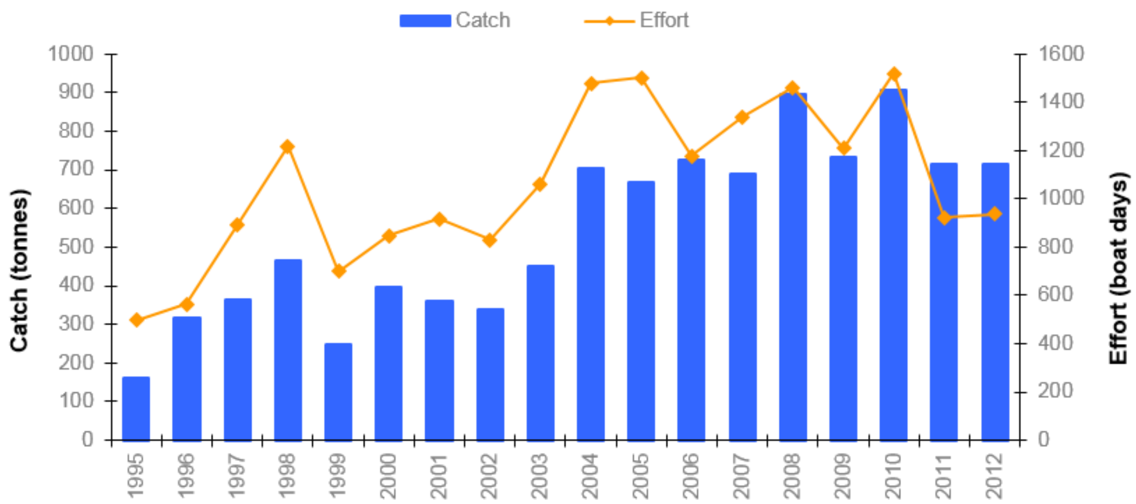


Figure 5-37: Commercial catch and effort for the Timor Reef Fishery, 1995 to 2012

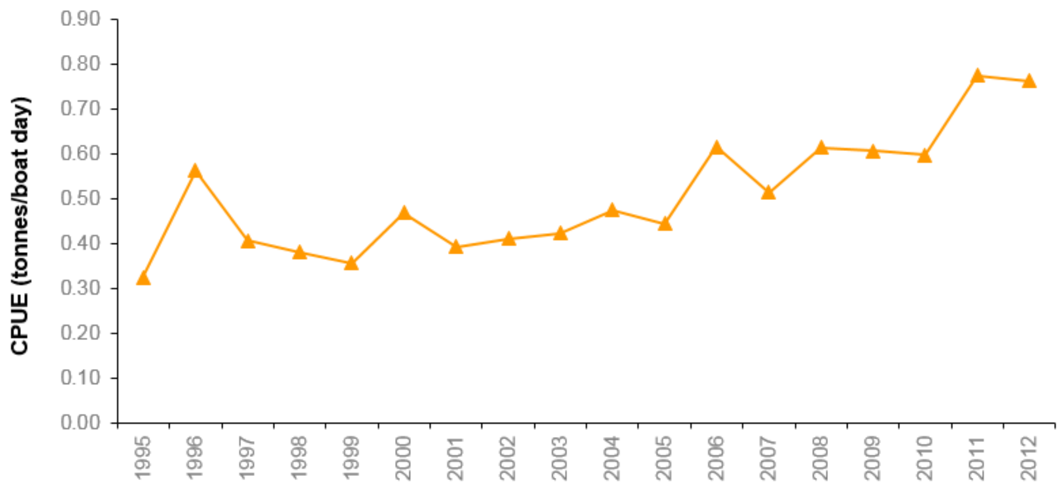


Figure 5-38: Commercial catch per unit effort (CPUE) for the Timor Reef Fishery, 1995 to 2012

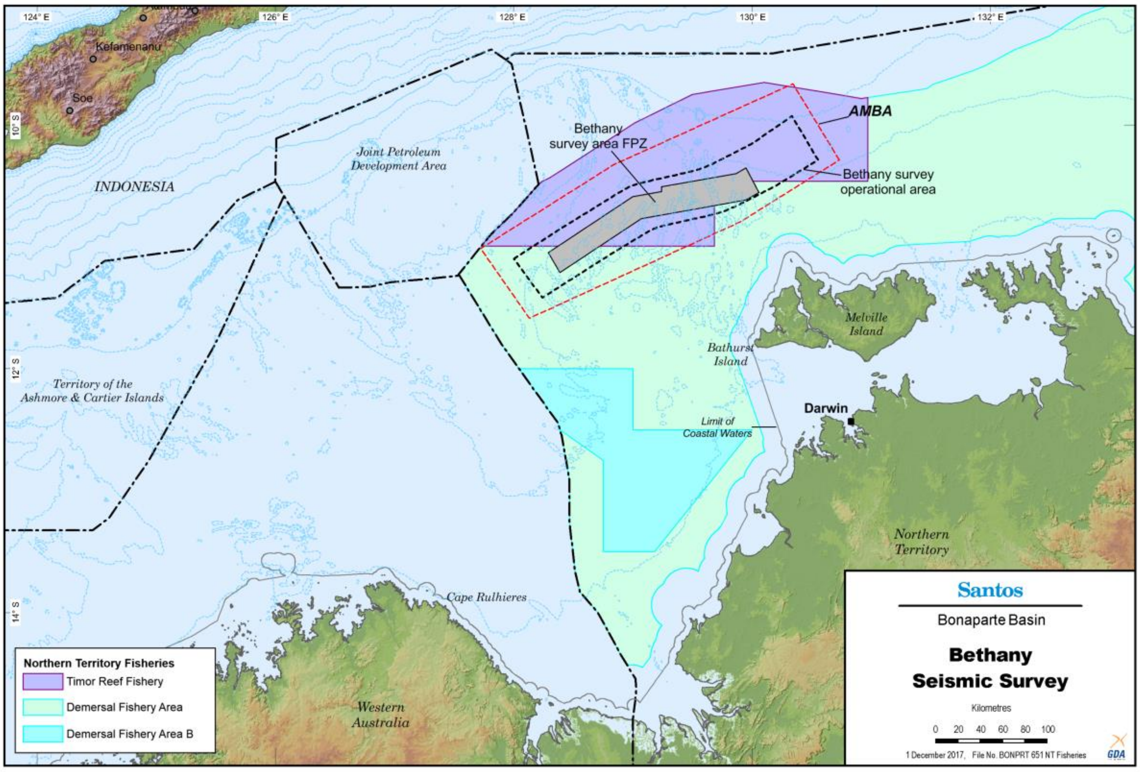


Figure 5-39: Timor Reef and Demersal Fishery Areas

Table 5-25: Percentage catch by species in the Bethany survey area for the Timor Reef Fishery during 2013-2017

Species	% of catch in Bethany Survey Area 2013-2017
ALFONSINOS	4.16
BARRAMUNDI COD	18.28
BIGEYES	15.90
BLACK JEWFISH	5.48
COBIA	20.71
COD-GENERAL	6.65
CORAL TROUT	36.39
CUTTLE FISH	7.07
FRYING PAN SNAPPER	12.71
GIANT TREVALLY	3.23
GOATFISH	22.69
GOLD BANDED SNAPPER	7.15
GOLDEN SNAPPER	6.76
GRASS EMPEROR	44.95
GREEN JOBFISH	15.94
HASSAR	13.75
JAVELIN FISH	15.89
MANGROVE JACK	3.02
MAROON PERCH	4.97
MIXED FISH	7.97
MOSES PERCH	25.96
PINJALO (PINJALO LEWISI)	6.25
POMFRET	9.70
RANKIN COD	19.07
RED BASS	12.82
RED EMPEROR	14.75
RED SNAPPER	5.96
RED SPOT EMPEROR	24.80
ROBINSON'S SEA BREAM	6.77
ROSY SNAPPER	9.53
SADDLETAIL SEA PERCH	8.33
SEA BREAM	6.69
SPANGLED EMPEROR	4.84
SPANISH FLAG	45.09
SWEETLIP	16.11
TREVALLY-GENERAL	7.55
YELLOWSPOTTED ROCKCOD	10.07

Data provided by the NT DPIR

5.6.4 Recreational Activities

Most recreational activities occur in Northern Territory coastal waters (i.e. within three nautical miles of the shore), notably in bays and estuaries. However, increasingly, recreational fishing is taking place in Commonwealth waters (West et al. 2012). Consultation with NT DPIR indicates that there is only one only charter licence holder that potentially operates in the area with charters to Tassie, Evans or Flinders shoals. Tassie Shoal is within the AMBA but not the operational area. The licence holder, via consultation, did not raised any objections or claims. See Section 4 for stakeholder engagement records.

Consultation with the Amateur Fishermen's Association of the NT (AFANT) identified that the June to August period is the period with the least disruption to recreational fishers. However, due to the distance from Darwin and Melville Island recreational activities in the area would be limited. See Section 4 for stakeholder engagement records.

5.6.5 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.

Figure 5-40 shows the oil and gas permits 100 km of the Bethany Operational Area. This distance is used to identify if impacts could occur with other oil and gas activities. Titleholders were contacted to identify if there were any proposed activities during the timing of the survey. Section 4 details the stakeholder records and Table 5-26 details the potential activities in the area.

Two potential activities were identified:

- PGS Rollo Multi Client 3D Seismic Survey. Survey restricted to Commonwealth waters off WA, which is at a minimum is ~ 55 km from the Bethany Operational Area and ~ 80 km from the survey acquisition area.
- Polarcus Zénaïde 3D Marine Seismic Survey: Survey restricted to Commonwealth waters off WA, which is at a minimum is ~ 190 km from the Bethany Operational Area and ~ 225 km from the survey acquisition area.

The Bureau of Ocean Energy Management (BOEM 2014) published a final environmental review of geological and geophysical survey activities off the mid- and South Atlantic coast. To minimise the impacts to marine life by providing a 'corridor' between vessels, the environmental impact statement from this review included a requirement for a 40 km geographic separation distance (based on worst case scenarios) between the sources of simultaneous seismic surveys.

As the two seismic surveys identified are not within the BOEM (2014) separation distance requirement of 40 km, cumulative impacts were not assessed.

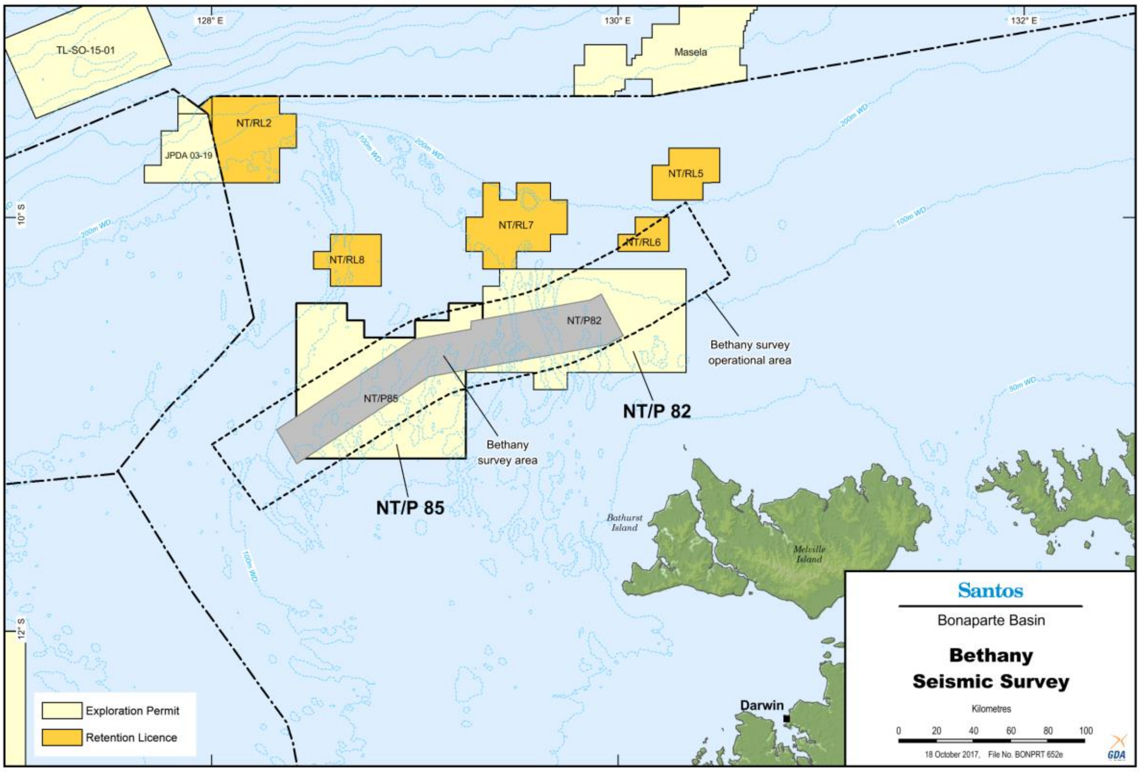


Figure 5-40: Oil and Gas Permits within the Bonaparte Gulf

Table 5-26: Oil and Gas Permits within the 100 km of the Bethany Survey Area

Permit	Permit Type	Titleholder/ Operator	Activity in 2018 or 2019	Distance to Bethany Survey
Masela	Exploration	INPEX	No activity	60 km
NT/RL5	Retention Lease	ConocoPhillips	Appraisal drilling of up to 3 wells. Completed in 2017.	1.3 km
NT/RL6	Retention Lease	ConocoPhillips	No activity	Intersect
NT/RL7	Retention Lease	Shell Australia Pty Ltd	No activity	13.5 km
NT/RL8	Retention Lease	Eni Australia Limited	No activity	24 km
Multiple	Special Prospecting Authority	PGS	Rollo Multi-client 3D seismic survey	~ 55 km

5.6.6 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 (Figure 5-41). As shown in Figure 5-41, there is some low level shipping traffic passing through the AMBA.

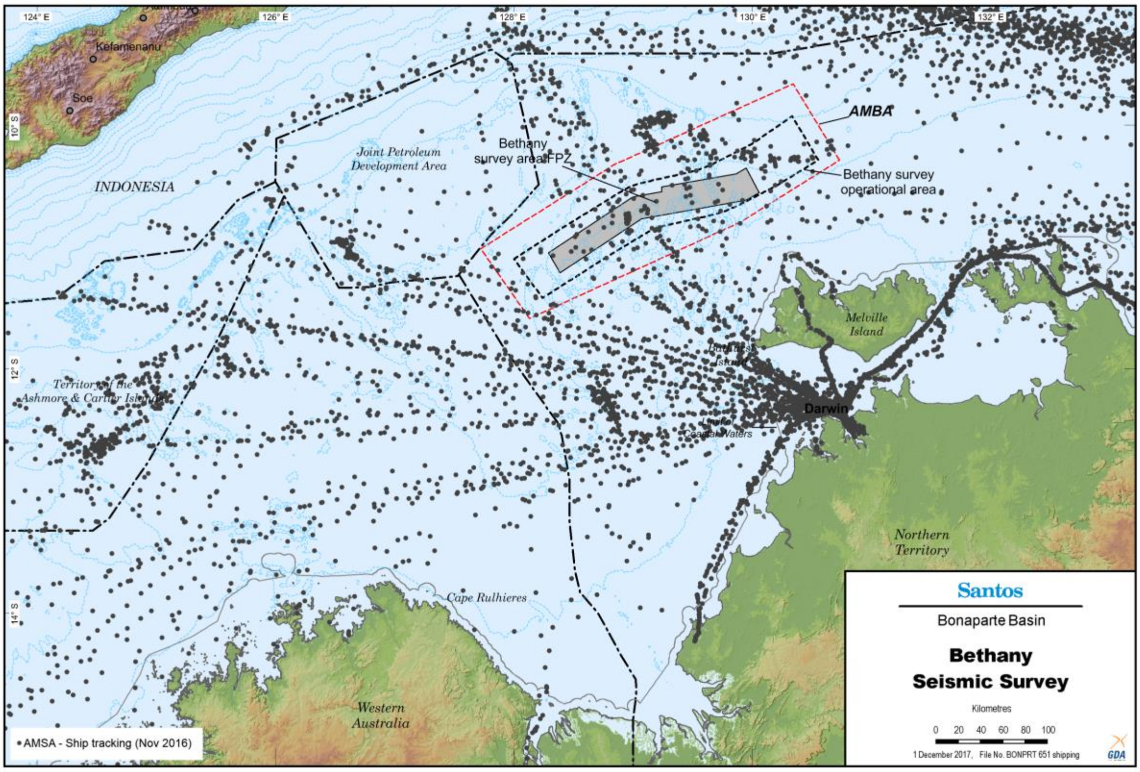


Figure 5-41: Shipping Traffic (AMSA Nov 2016)

5.6.7 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. The AMBA is adjacent to two Military Prohibited, Restricted and Danger (PRD) Areas where exercises such as operational flying training or live weapons firing may occur (Figure 5-42). There are also two Air to Air Refuelling (AAR) and Airborne Early Warning and Control (AEW&C) airspaces associated with these PRD areas.

Operation Kakadu

A major military exercise, Exercise KAKADU 2018, will be conducted within the Northern Australian Exercise Area (NAXA) over the period 31 August – 15 September 2018. The NAXA is comprised of the two PRD shown in Figure 5-42. The Bethany Operational Area and FPZ overlap the Due Regard Area (DRA) that will be established for the exercise.

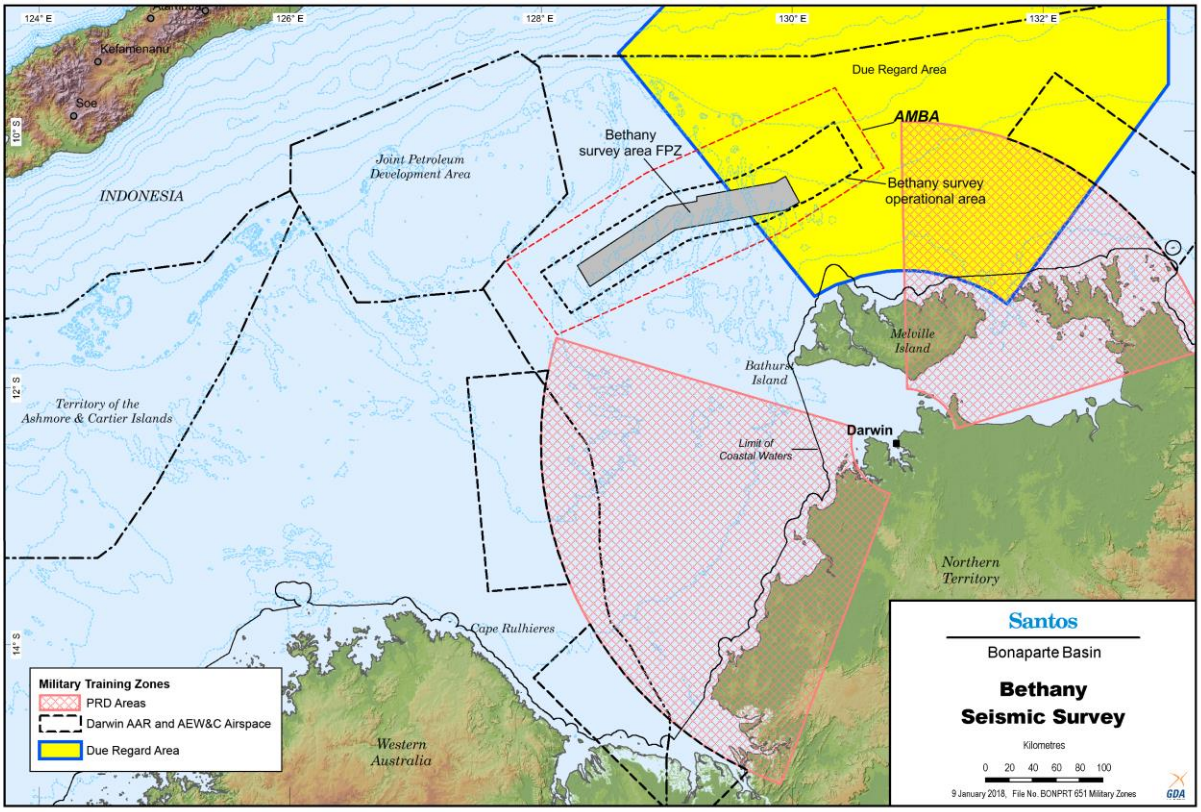


Figure 5-42: Military Training Areas

5.7 Indigenous and European Heritage

A search of the Northern Territory Government's Heritage register did not identify any registered heritage sites within the AMBA (NT Government 2017b).

A search for sacred sites protected by the Aboriginal Areas Protection Authority under the *Northern Territory Aboriginal Sacred Sites Act 1989* did not identify any sites to be present within the AMBA (AAPA 2017).

A search of the Australian Heritage Database did not identify any indigenous heritage areas within the AMBA.

5.8 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 AMBA. The nearest known shipwreck is the Florence D approximately ~45 km from the AMBA Figure 5-43.

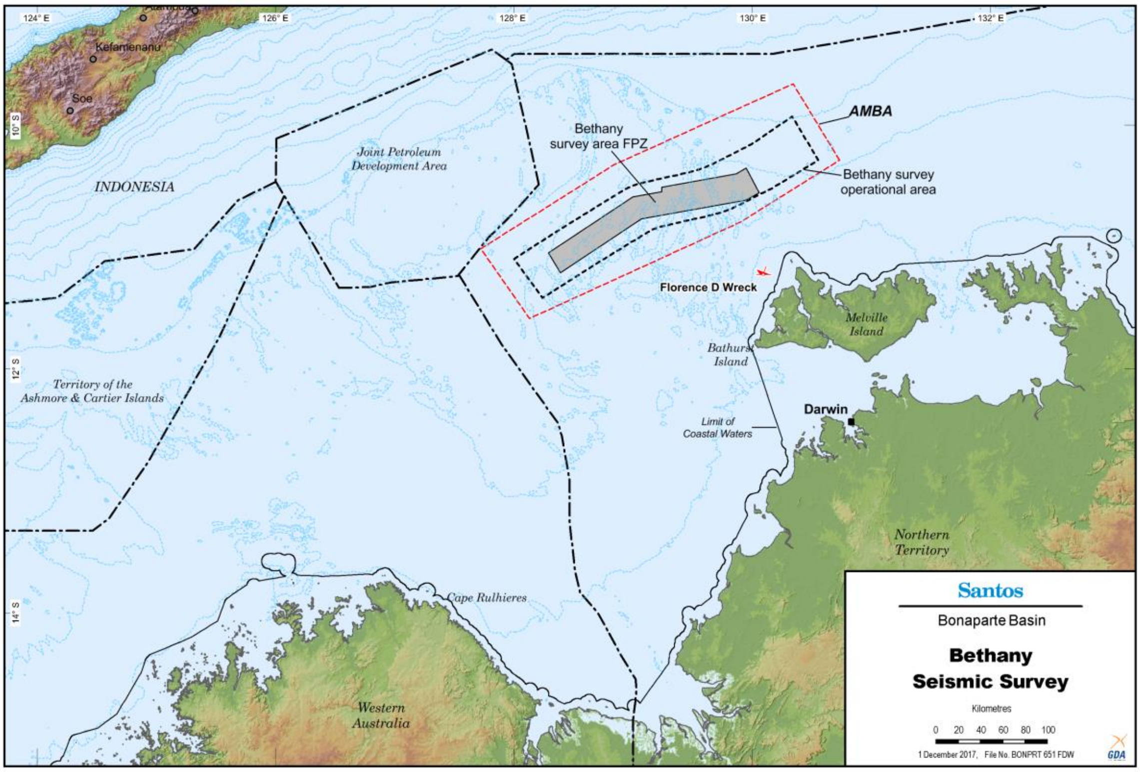


Figure 5-43: Known Shipwrecks

5.9 Commonwealth Protected Areas

The DoEE Protected Matters Database search (Section 5.2) identified that the AMBA is within the North Network - Oceanic Shoals Marine Park (OSMP) Multiple Use Zone (IUCN VI) (Figure 5-44). This zone allows commercial activities such as fishing, tourism, and oil and gas exploration, where the activities are consistent with the park values (DNP 2017). The AMBA does not overlap any World Heritage Properties, National Heritage Properties, Ramsar wetlands, State or Territory Marine Parks, or Indigenous Heritage Sites (Section 5.2).

Marine Park zoning depends upon the conservation values present within the park. The Oceanic Shoals Marine Park is classified as 'Type B'[5] (NOPSEMA 2015) and is not covered by a management plan at this time. DNP has issued approval under Section 359B of the EPBC Act 1999 which permits a range of activities, including mining operations (seismic activities) subject to the approval of an EP.

Santos recognises that the draft North Marine Park Network Management Plan (DNP 2017) has been released, and the Oceanic Shoals Marine Park Management Plan may come into effect during the validity of the Bethany EP (and may vary in relation to the IUCN management areas as currently proposed). Consequently, Santos shall comply with any legislative requirements associated with the proclaimed Marine Park (see MoC Section 8.4).

The OSMP covers an area of 71,743 km^2 and its 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.

[5] Type B: New CMRs that were first proclaimed in 2012 and then re-proclaimed in 2013. https://www.nopsema.gov.au/assets/Guidance-notes/A433426.pdf

- Four key ecological features are represented in the OSMP:
    - carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature).
    - carbonate banks of the Sahul Shelf (unique sea-floor feature), (~81 km from the FPZ)
    - pinnacles of the Bonaparte Basin (enhanced productivity, unique sea-floor feature), (~20 km from the FPZ).
    - shelf break and slope of the Arafura Shelf (unique sea-floor feature), (~3.5 km from the FPZ).

In determining the zones and rules of the Marine Parks, the Director has considered the best available science, the advice of stakeholders, Indigenous people and the public, the goals and principles of the National Representative System of Marine Protected Areas (NRSMPA) and the Australian IUCN reserve management principles (DNP 2017). Additionally, the Director of National Parks considers any positive impacts associated with allowing an activity, such as socio-economic or cultural benefits, and ensure that activities are undertaken in a manner that minimises negative impacts. Commercial fishing and mining activities are recognised as important social and economic values, these activities contribute to the wellbeing of regional communities and the prosperity of the nation (DNP 2017).

The Commonwealth Marine Reserves Review identified the following proposed changes to the OSMP zoning within the AMBA (Figure 5-45):

- Create a new Habitat Protection Zone to improve protection of the representative benthic habitat within the park. This new zone would exclude oil and gas activities.
- Create a new Special Purpose Zone which will allow demersal and mid-water trawling. This new zone would not exclude oil and gas activities.

The review recommended the creation of a new Marine National Park Zone, outside of the AMBA, which covers one of the recent Geoscience Australia survey sites (Area B in Figure 5-10).

Where there is no specific management plan in place for a Commonwealth marine park, the IUCN reserve management principles must be considered. The International Union for the Conservation of Nature (IUCN) sets out guidelines for categorising protected areas, which Australia and many other countries have adopted as a national standard (DNP 2017). The IUCN has identified seven categories that form the basis of the reserve management principles.

The OSMP is categorised as IUCN VI protected area with sustainable use of natural resources under the IUCN Management Principles for Commonwealth Marine Protected Areas; i.e. a managed resource protected area (DNP 2017) (Environment Australia 2002). The OSMP area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs [EPBC Regulations 2000 (Schedule 8)]. The management principles relevant to this category and how they will be met for the Bethany survey are detailed in Table 5-27.

Table 5-27: Australian IUCN Reserve Management Principles for Commonwealth Marine Protected Area Category VI and Management of the Activity Consistent with these Principles

Reserve Management Principles for IUCN VI	Management of the Activity Consistent with the Principles
The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles.	Section 7 of the EP details the risk assessment process undertaken for the activity and identifies potential impacts and risks to the OSMP conservation values. The risk assessment process includes demonstrating that environmental impacts and risks of the activity will be of an acceptable level. The assessment did not identify any impacts or risks to the OSMP conservation values that were unacceptable.
The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term.	Section 7 of the EP details the risk assessment process undertaken for the activity and identifies potential impacts and risks to the OSMP conservation values. The assessment identifies appropriate controls to manage potential impacts and risks to ALARP and an acceptable level to ensure the biological diversity and other natural values of the reserve are protected and maintained in the long term.

Reserve Management Principles for IUCN VI	Management of the Activity Consistent with the Principles
Management practices should be applied to ensure ecologically sustainable use of the reserve or zone.	Section 7 of the EP details the risk assessment process undertaken for the activity and identifies potential impacts and risks to the OSMP conservation values. The risk assessment process includes demonstrating that environmental impacts and risks of the activity will be of an acceptable level. One of the criteria for this demonstration is have the principles of ecologically sustainable development met? All impacts and risks identified from the activity demonstrated that the principles of ecologically sustainable development can be met.
Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.	The activity is proposed to identify gas resources in the region. This could lead to potential development which would contribute to regional and national development. As detailed via the principles above the survey will be undertaken consistent with the reserve management principles.

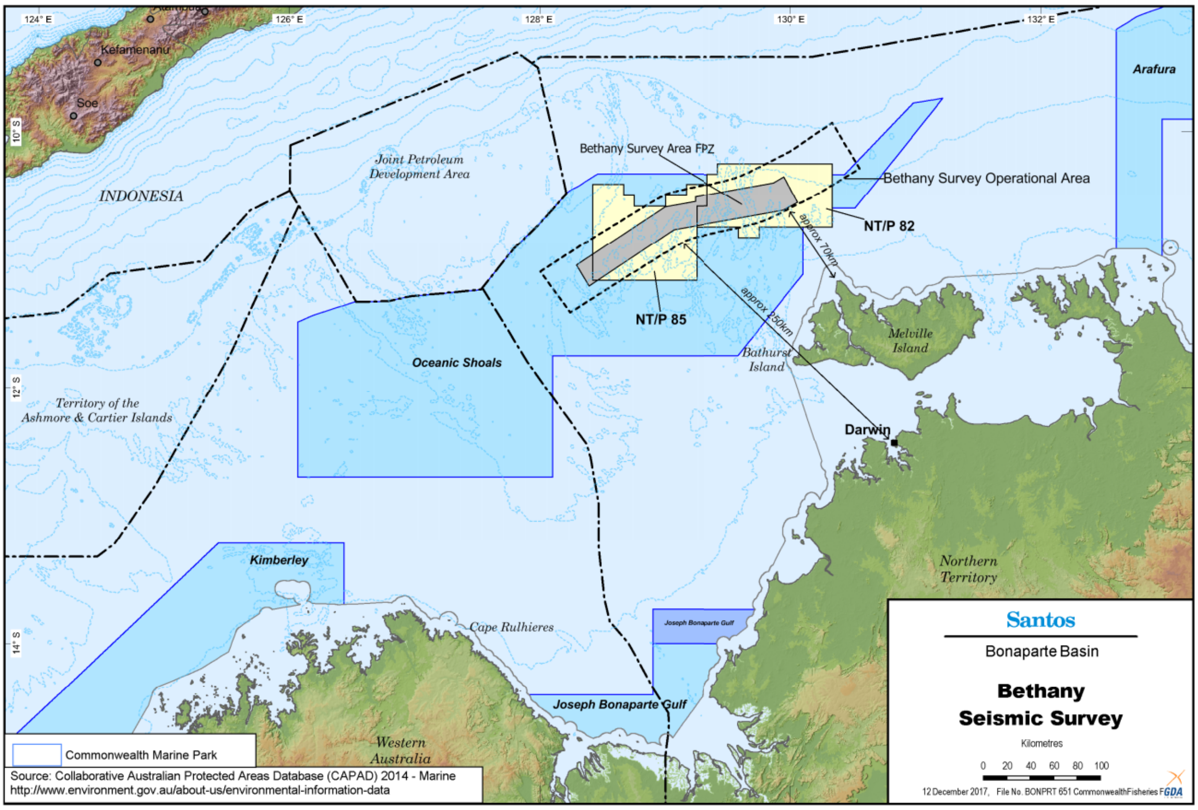


Figure 5-44: Current Proclaimed Marine Parks

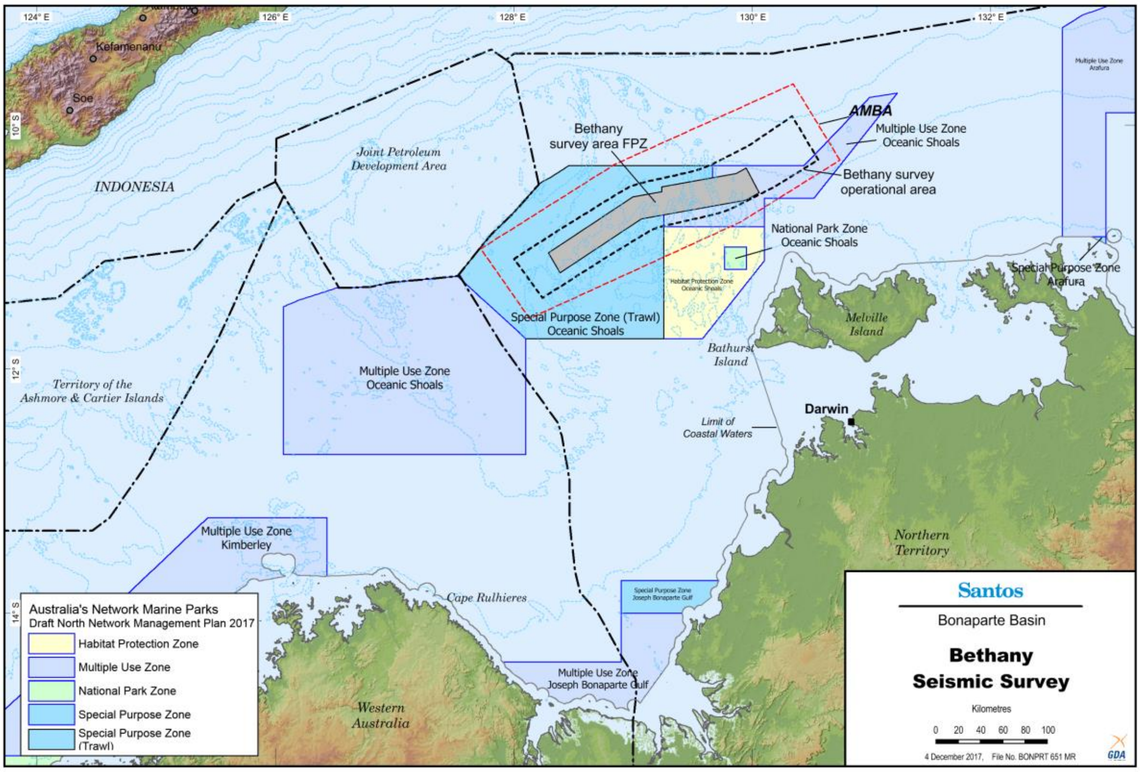


Figure 5-45: 2017 Proposed Draft Marine Parks and Zoning

5.10 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 AMBA (Figure 5-46).

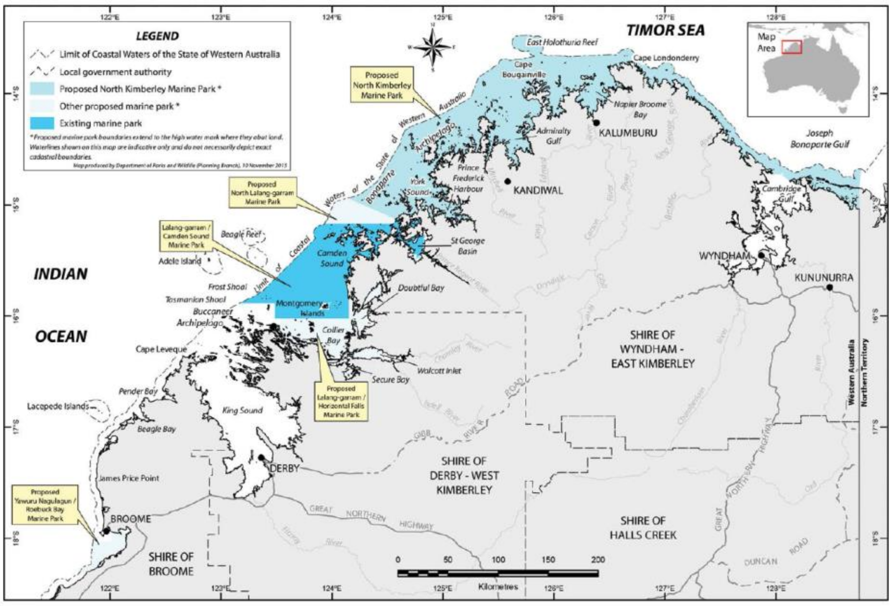


Figure 5-46: Location of Proposed North Kimberley Marine Park

6 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

The outcome of the risk assessment process is detailed in the Section 7 Environmental Risk Assessment.

6.1 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.

6.2 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 undertaken in Section 7 the AMBA by a diesel spill resulting from a vessel collision was identified as the largest for the survey.

6.3 Description of Environment that may be Affected

The environment that may be affected (EMBA) for the AMBA was then described. Section 5 describes the existing environment within this area including any relevant cultural, social and economic aspects.

6.4 Identification of Particular Values and Sensitivities

Based on Santos' and publicly available information a review of the existing environment (Section 5) was undertaken to identify the environmental values and / or sensitivities with the potential to occur within the AMBA. Table 5-1 provides a summary of these values and sensitivities. These were used to inform the risk assessment as they provide the potential worst-case consequence.

6.5 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

6.6 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.

6.6.1 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). Decision types and methodologies to establish ALARP are outlined in Table 6-1.

Figure 6-1: Impact and Risk 'Uncertainty' Decision Making Framework

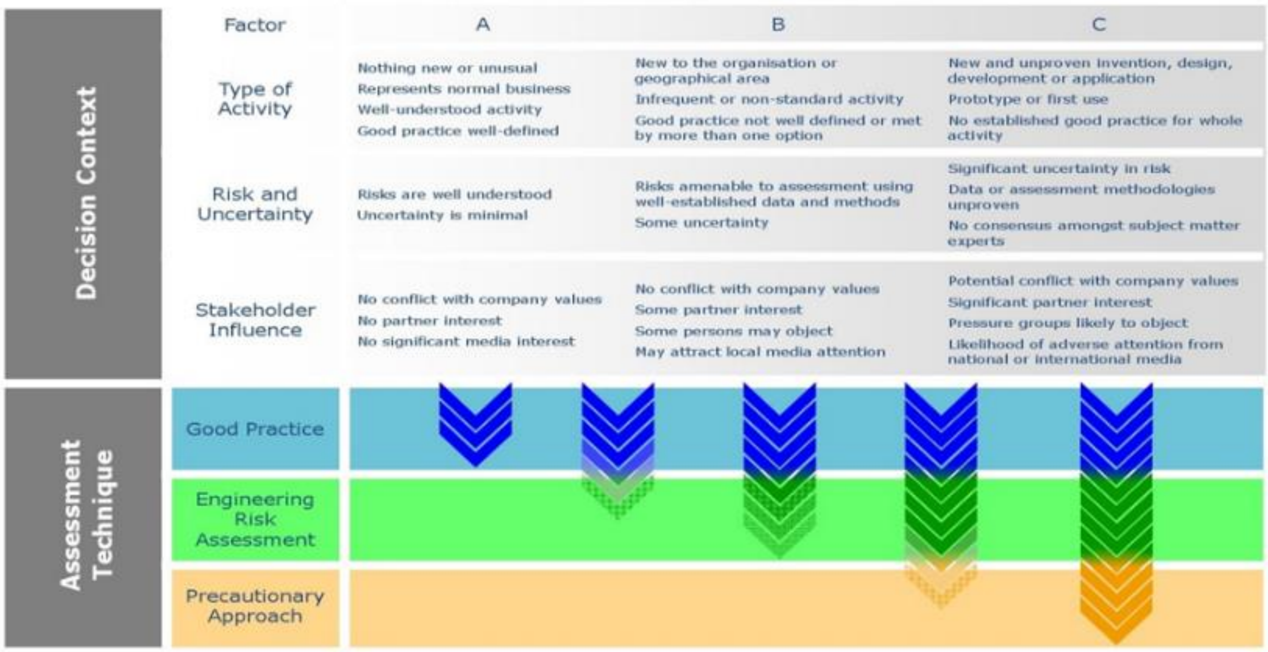


Table 6-1: ALARP Decision Making based upon Level of Uncertainty

Decision Type	Description	Decision Making Tools
A	Risks classified as a Decision Type A are well-understood and established practice	Good Practice Control Measures are considered to be: Legislation, codes and standards: Identifies the requirements of legislation, codes and standards that are to be complied with for the activity. Good Industry Practice: Identifies further engineering control standards and guidelines that may be applied over and above that required to meet the legislation, codes and standards. Professional Judgement: Uses relevant personnel with the knowledge and experience to identify alternative controls. When formulating control measures for each environmental impact or risk, the 'Hierarchy of Controls' philosophy, which is a system used in the industry to identify effective controls to minimise or eliminate exposure to impacts or risks, is applied.
B	Risks classified as a Decision Type B are typically in areas of increased environmental sensitivity with some stakeholder concerns.	Risk-based tools such as cost based analysis or modelling: Assesses the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost benefit analysis to support the selection of control measures identified during the risk assessment process.

Decision Type	Description	Decision Making Tools
C	Risks classified as a Decision Type C will typically involve sufficient complexity, high potential impact, uncertainty or stakeholder interest	Precautionary Approach: OGUK (2014) state that if the assessment, taking account of all available engineering and scientific evidence, is insufficient, inconclusive or uncertain, then a precautionary approach to hazard management is needed. A precautionary approach will mean that uncertain analysis is replaced by conservative assumptions that will result in control measures being more likely to be implemented.

6.6.2 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:

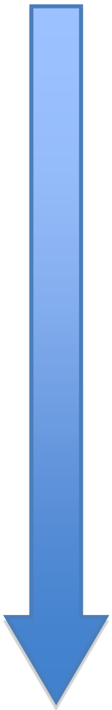
- Identifying a risk control
- Assessing the risk control
- Deciding whether residual risk levels are tolerable
- If not tolerable, identifying a new risk control
- Assessing the effectiveness of that control

Santos uses a hierarchy of control (Table 6-2) 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 6-2: 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.

6.7 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 6-3) from the Santos Operational Risk Matrix. The consequence level for each hazard is documented in the risk assessment tables in Section 7.

Table 6-3: Santos Environmental Consequence Classification

Level	Environment
VI	Regional and long term impact on an area of significant environmental or social value. Destruction of an important population of plants and animals with recognised conservation value. Complete remediation impossible. Complete loss of trust by affected community leading to long-term social unrest and outrage.
V	Destruction of an important population of plants or animals or of an area of significant environmental or social value. Complete remediation not practical or possible. Prolonged community outrage that impacts the viability of the business.
IV	Extensive and medium term or localised and long term impact to an area, plants or animals of recognised environmental or social value. Remediation possible but may be difficult or expensive. High potential for complaints from interested parties.
III	Localised and medium term or extensive and short term impact to areas, plants or animals of significant environmental or social value. Remediation may be difficult or expensive. Immaterial effect on community.
II	Localised and short term impact to an area, plants or animals of environmental or social value. Readily treated.

	One off community protest requiring intervention and management.
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 AMBA
Long Term: Greater than 12 months	**Regional**: Outside of the AMBA

6.8 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 6-4) from the Santos Operational Risk Matrix.

Table 6-4: 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”

6.9 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 6-5) 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 6-6) 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 6-5: 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 6-6: 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

6.10 Determination of Impact and Risk Acceptability

The model Santos used for determining acceptance of residual risk is detailed in Figure 6-2. In summary:

A Level 5 residual risk is intolerable, and Risks will require further investigation and mitigation to reduce the risk to a lower and more acceptable level. If after further investigation the risk remains in the severe category, the risk 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)

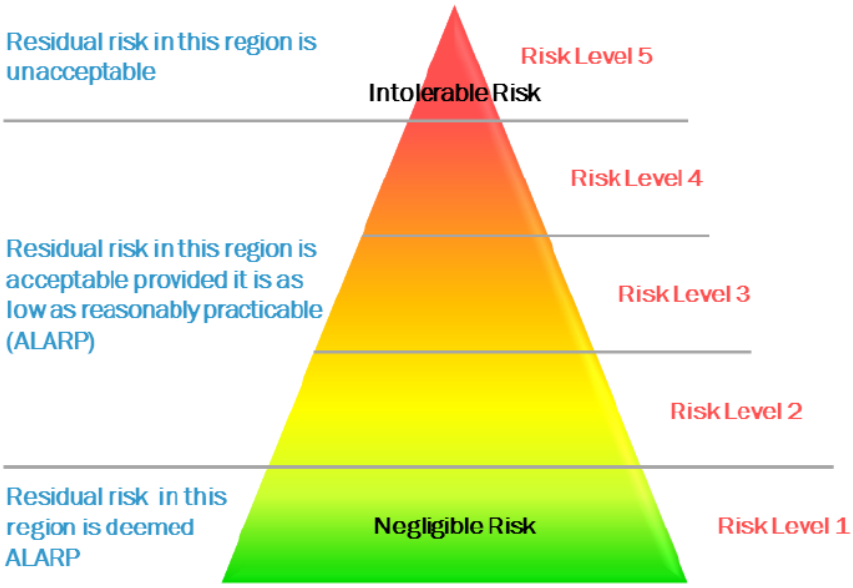


Figure 6-2: Santos Residual Risk Acceptance Model

7 ENVIRONMENTAL RISK ASSESSMENT

7.1 Seismic Underwater Noise

7.1.1 Hazard

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

7.1.2 Area that Might be Affected by the Hazard

Marine seismic surveys involve the use of seismic source arrays that produce high intensity, low frequency impulsive sounds at regular intervals. Though the aim of a seismic survey is to direct the seismic sound energy downwards towards the sea floor, energy will also radiate at angles close to horizontal potentially propagating this sound energy over long distances (Laws and Hedgeland 2008). The rate at which the sound energy attenuates with distance from the source is based on the oceanography, bathymetry and seabed properties of the area (Urick 1983).

Acoustic Modelling

JASCO Applied Sciences conducted an assessment of underwater noise levels for the Bethany 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 full report is available in Appendix 3.

The modelling approach accounted for the acoustic emission characteristics of a 2,380 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), and both single shot (i.e., per-pulse) or accumulated sound exposure levels (SEL) as appropriate. The 2,380 in^3 airgun array proposed for the Bethany survey is an 11.2 x 15 m array consisting of three strings towed at a 6 m depth. The firing pressure will be 2,000 psi. The modelling is based on 12.5 m shot point interval (based on triple source mode), and a 600 m line space interval. A single sound speed profile that provided the greatest propagation is applied, which occurs during July. Analysed sound speed profiles indicated that this month had the greatest noise transmission, making it the most conducive month for sound propagation, and as such it was selected for modelling to ensure that the study did not underestimate distances to received sound level thresholds over the entire survey period.

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. Predicted source sound levels for the 2,380 in^3 seismic source array are shown in Table 7-1.

Table 7-1: Source level specifications for the 2,380 in^3 array at 6 m tow depth

Direction	Peak pressure level (dB re 1 μPa @ 1 m)	SEL (dB re 1 μPa^2·s @ 1 m)	
		10–2,000 Hz	2,000–25,000 Hz
Broadside - Perpendicular to the travel direction of a source	248.0	223.2	182.7
Endfire - Parallel to the travel direction of a source	245.9	223.1	187.4
Vertical (no ghost)	254.6	227.8	194.4

For the Bethany survey four site-specific locations were selected as modelling sites, based on the proposed acquisition plan and the variation in bathymetry in the area (Figure 7-1). Water depths at these four modelling sites ranged from 41 m (Site 1) to 84 m (Site 2). An additional five sites, Sites A through E, with water depths ranging from 35–75 m, were assessed for seafloor PK, PK-PK and per-pulse SEL. These sites do not have a specific location, but rather are representative of a specific water depth, as the geoacoustic and sound speed profiles are consistent across the survey region.

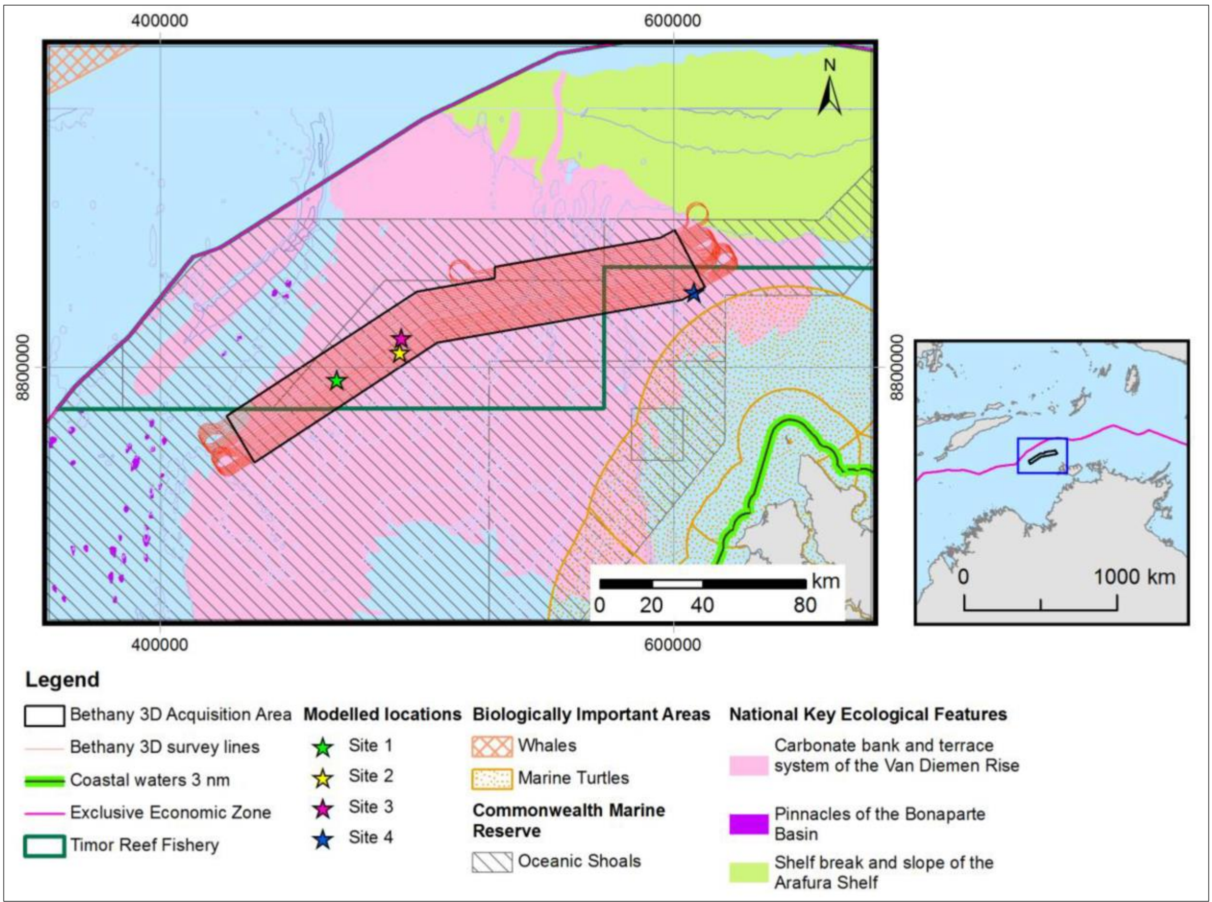


Figure 7-1: Location of noise modelling sites

SEL$_{cum}$ vs SEL$_{ss}$

For the seismic noise impact assessment, Santos has used standard guidelines and guidelines suggested by the best scientific evidence available. In regards to the SEL$_{cum}$ metric, Popper et al. (2014) note "*One major difference between pile driving and seismic airguns is that it is harder to determine SEL$_{cum}$ for airguns. This is because the received SEL$_{ss}$ changes from shot to shot since the seismic vessel is moving and at different distances from the fish. Thus, a guideline ultimately based on the closest peak level or the closest SEL$_{ss}$ may actually be more useful than one based on the SEL$_{cum}$.*" This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be near a sound source (i.e., overlap in space and time between the source and receiver). For example, the accumulation time for fast moving (relative to the receiver) mobile sound sources is driven primarily by the characteristics of source (i.e., speed, duty cycle) (NMFS 2016).

TTS and SEL$_{24h}$

For temporary threshold shift (TTS) a cumulative threshold is more appropriate and the time period over which this is done has been based on the best available scientific evidence and fauna specific guidelines. For seismic surveys in Australian waters, the EPBC Act Policy Statement 2.1 determines suitable exclusion zones for whales with an unweighted per-pulse SEL threshold of 160 dB re 1 µPa^2·s (DEWHA 2008). Thus, threshold has been applied to the seismic noise impact assessment for marine mammals.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time period. The Popper et al. (2014) sound exposure guidelines for TTS effects in fish are based upon data from Popper et al. (2005) for exposure of several riverine species to a seismic airgun array. This study showed that exposure to an SEL$_{cum}$ of 186 dB re 1 µPa^2·s accumulated over five seismic pulses within about five minutes resulted in about 20 dB of TTS in the lake chub (a hearing specialist) and northern pike (a hearing generalist).

In all cases, fish that showed TTS recovered to normal hearing levels within 18–24 hours (Popper et al. 2005). This is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014).

The Popper et al. (2005) study was done using a static source (airgun array) and static receptors (fish in cages at 13-17 m from the array), and therefore is not representative of a marine seismic survey with a moving source. Hence, the Popper et al. (2005) experiment represents a worst-case scenario, as the source was fixed rather than moving – i.e. the five seismic pulses that were found to have caused TTS effects over five minutes would have all been of identical intensity. This would not be the case with a moving source.

Since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures. Given the Bethany survey plan, the time period before the vessel is again in proximity to specific location will be greater than 24 hours. As such, assuming a stationary receptor experiences TTS on one pass it will have at least 24 hours until the possibility of receiving an SEL of sufficient magnitude that could induce TTS to occur again. On this basis, and given that the only data available for TTS recovery in fish exposed to airgun noise indicates a recovery period from a substantial TTS of 20 dB of less than 24 hours, a 24 hour period is seen as appropriate for modelling cumulative SEL.

The modelling has considered a single 24 hour period of seismic operation, along two sequential lines in the acquisition pattern to assess a conservative scenario in terms of SEL_{24h}. The two sequential acquisition line sections assessed are 85 and 84.9 km long, and 4.5 km apart. The seismic vessel is assumed to start at the eastern end of the northern line, and traverse the survey lines at ~4.5 knots, with an impulse interval of 12.5 m. The survey has been modelled considering a triple source array, with a source separation of 37.5 m, with each source activated individually according to a set sequence. The modelling accounts for the location of the active source for each seismic impulse. In total, 13,592 impulses are accounted for in the scenario.

Because modelling the thousands of impulses needed to represent 24 hours of seismic operation is time consuming, JASCO estimated the acoustic fields based on single-impulse model sites from representative source locations that formed the library of representative footprints. As the geoacoustics are the same throughout the region, only the bathymetry needs to be considered when determining the location of the representative source locations. An analysis of the bathymetry along the acquisition lines in the modelled scenario determined that consideration of three representative sites would provide a sufficient representation. The three single-impulse sites selected encompass the shallower flatter sections of the lines (Site 1), the shallower sections of the canyon features (Site 2), and the bottom of the canyon features (Site 3). The survey lines within the 24 hour exposure calculation were segmented by classifying impulse points to one of the three representative sites based on geographic similarity (see Figure 2 in the JASCO report, Appendix 3).

To produce maps of cumulative received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level and level at the seafloor are calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse are then resampled (by linear triangulation) to produce a regular Cartesian grid. The single-impulse SEL fields are computed over model grids ~150 km × 150 km in range, which encompass the full area of the cumulative grid (the entire survey area). The unweighted (fish) and frequency-weighted SEL_{24h} results are rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the airgun array are rendered.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours, based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The radii that correspond to SEL_{24h} typically represent an unlikely worst case scenario for SEL-based exposure since, more realistically, marine fauna (mammals or non-site attached fish) would not stay in the same location or at the same range for 24 hours. Therefore, a reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source will be injured, but rather that it could be injured if it remained in that range for 24 hours. The reported radii represent the perpendicular distance from to the closest survey line to the relevant isopleth.

Results

Full results for the modelling study are provided in the JASCO report (Appendix 3). The report focuses on PK levels at the seafloor that are relevant to fish. These levels are highly dependent upon the depth of the water at close range. The first reflection is the sound from the sea surface, followed by a reflection from the seafloor, these two reflections then interact with each other prior to subsequent reflections. As the distance from the source increases beyond approximately three water depths, a complex pattern of destructive surface reflection and constructive critical angle bottom reflections dominate over sounds due to any direct path transmission. Consequently, the PK level compared with range does not follow a simple relationship with water depth, and the distance to PK levels relevant to fish at the seafloor is site specific, with no consistent pattern between site depth and distance to isopleth.

The 2,380 in^3 airgun array is does not exhibit strong directionality, which combined with the shallow water depth, resulted in footprints with directionality determined more by bathymetry than by the airgun array itself. The ranges to the per-pulse SEL isopleths were similar across all four sites for levels higher than 160 dB re 1 $\mu Pa^2 \cdot s$. For lower sound levels, the distances to isopleths were greatest at the two shallowest modelled sites (Sites 1 and 4, with depths of 40.9 and 43.9 m respectively), and shortest at the deepest site, Site 2 (84 m). This is partly due to the bathymetry surrounding the modelling sites, with the canyon feature at Site 2 influencing the wider area propagation, while at Sites 1 and 4 the sound propagates towards the deeper offshore water in an environment that gradually becomes deeper. These predictions demonstrate the influence of site-specific bathymetry along the survey transects.

The accumulated SEL scenario considers 24 hours of seismic operation along two specified acquisition lines. The model measured the accumulated effects of noise, accounting for the change in location and the azimuth of the source at each impulse point. These accumulated SEL results were used to assess possible PTS and TTS in marine mammals, along with SEL_{24h}-based fish and turtle criteria.

The assessed survey lines are ~4.5 km apart and in total comprise 13,592 single impulses. At receiver locations close to the survey lines the modelled noise level was dominated by those shots nearest to them with little to no influence from the other line where the nearest shot was within a few kilometres of the receiver. The greater propagation in the offshore direction seen in the single shot results was reflected here, as again the ranges to isopleths at lower levels were greater in this direction, which is because propagation towards the north encountered the gradual increase in depth. This was even apparent in the 180 dB re 1 $\mu Pa^2 \cdot s$ isopleth. For levels above 183 dB re 1 $\mu Pa^2 \cdot s$, the isopleths were evenly distributed around the track lines, with only a slight extension of ranges in the broadside direction

The vertical slice plots (Figure 7-2 and Figure 7-3) 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. 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.

Therefore, when modelling of PK levels to assess mortality and potential mortal injury to fish, turtles, fish eggs and larvae, the horizontal distances to the level at the seafloor for this survey will also predominantly represent the maximum-over-depth distance. For species which live at or close to the seafloor, the modelling approach for assessing the distance to PK levels associated with fish is appropriate.

The modelling approach applied is appropriate to determine the relevant sound levels (PK, SEL or SPL), and therefore the distances to thresholds, for all fauna of concern, be they at the seafloor or within the water column. The criteria for either possible mortality and potential mortal injury in fish, turtles, fish eggs, and fish larvae was not reached at the seafloor using the SEL_{24h} metric based on Popper et al. (2014).

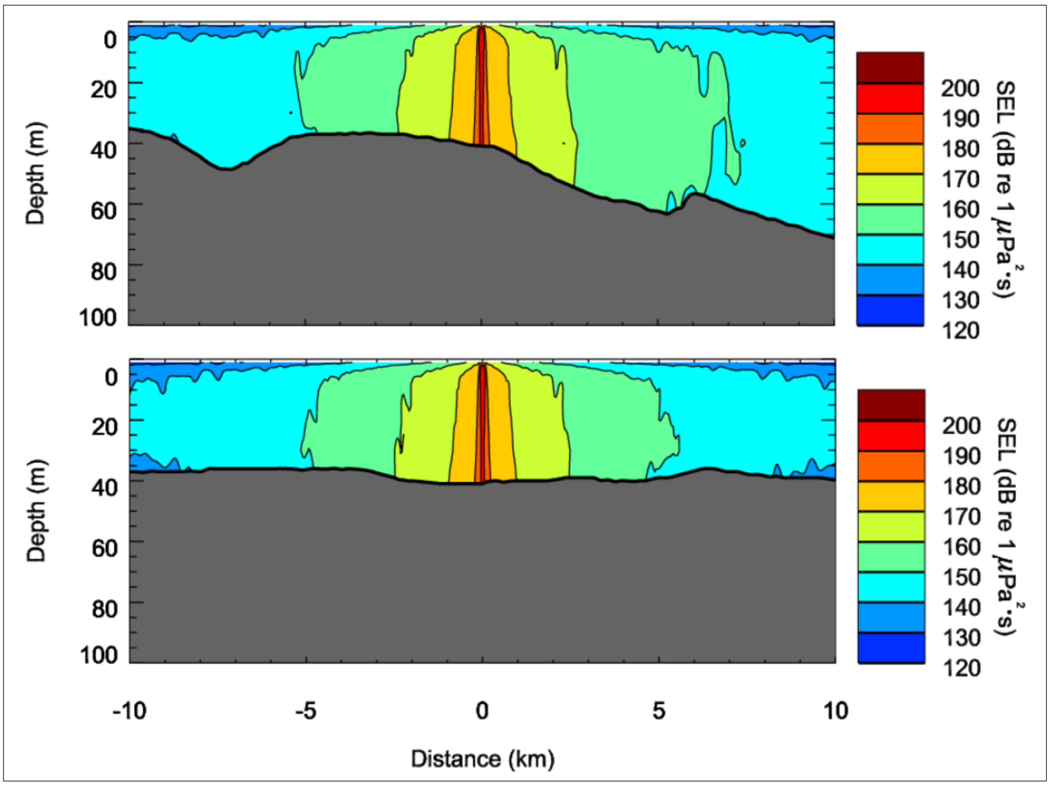


Figure 7-2: Site 1 - Predicted unweighted per-pulse SEL for the 2,380 in^3 array as vertical slices

(Levels are shown along a single transect from broadside (top) and endfire (bottom). Source depth is 6 m)

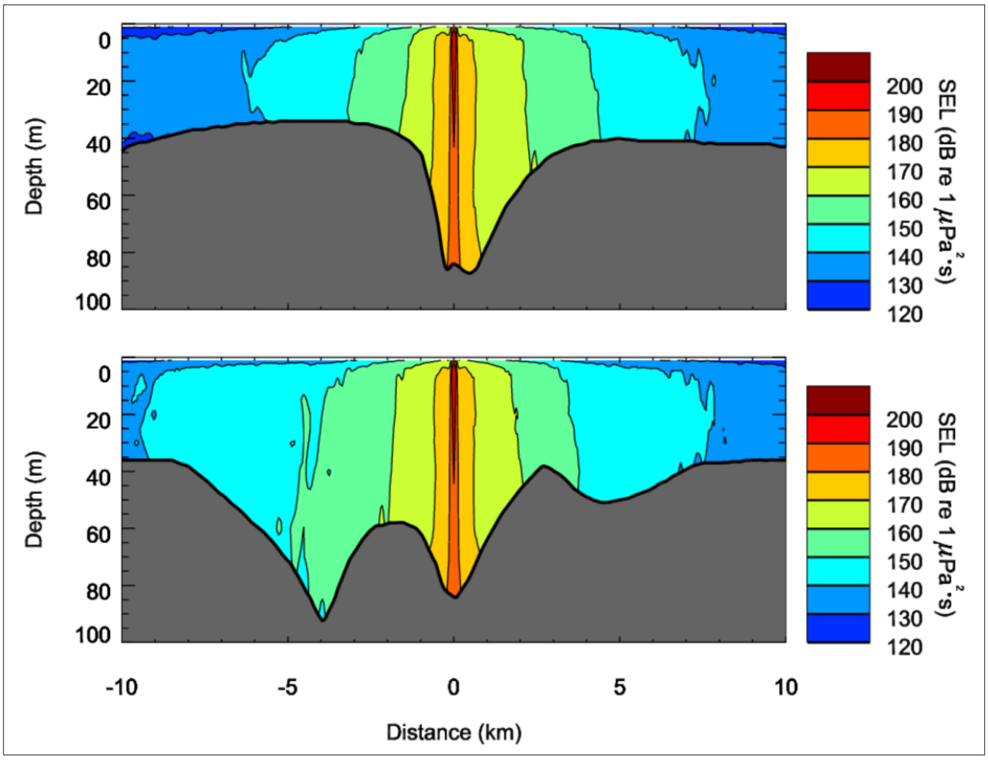


Figure 7-3: Site 2 - Predicted unweighted per-pulse SEL for the 2,380 in^3 array as vertical slices

(Levels are shown along a single transect from broadside (top) and endfire (bottom). Source depth is 6 m)

Sound Source Verification

Prior to commencement of the Bethany survey the seismic contractor will be required to demonstrate that the proposed airgun array has equivalent source levels that match the specifications used in the modelling (Table 7-1). This sound source verification (SSV) process will be a requirement of the seismic contract tender process.

The in-field measurement process, which can be conducted at any suitable location worldwide using any survey vessel in the contractor's fleet, will have the following general requirements:

- Reputable service provider with demonstrated track record (grey or peer reviewed literature) in field of measurement of airgun arrays.
- Water depth can be determined by the operator.
- Measurement line:
    - minimum of a single line pass, directly over hydrophone; and
    - must commence firing of array being measured 3 km before passing over the hydrophone; firing of array can stop 3 km beyond hydrophone position.
- Array-hydrophone separation: 50-500 m.
- Hydrophone must be directly on the vessel track line to allow characterisation of the vertical direct path.
- In water depths < 100 m, the seabed should be relatively flat.
- Hydrophone(s) specifications:
    - operator to determine sensitivity as required to accurately record the impulses without clipping;
    - must have an appropriate frequency response in the sensitivity range required to accurately measure the airgun array from 10 to at least 15,000 Hz;
    - the frequency response should be flat between 10-10,000 Hz; and
    - systems with a sharp roll of over 1,000 Hz are not appropriate.
- Recorder specifications: 24 bit, 64 ksps minimum sample rate.
- SSV report must quantify:
    - airgun layout and depth (x,y,z location for each individual gun);
    - locations of array(s) behind vessel;
    - vessel speed, shot interval and other pertinent details;
    - approximate geology down to 500 m below seabed;
    - sound speed profile through water column measurement;
    - measurement system specifications;
    - measurement system sensitivity, including frequency response curve for hydrophones;
    - bathymetry of measurement location;
    - measurement methodology;
    - estimate of far-field source level from the measured values;
    - level vs slant range plots for PK, PK-PK, SEL and 125 ms SPL metrics; and
    - data points in plots (level and range values) to be provided digitally.

Variations in recorded sound levels up to 3 dB are considered within the margin of error for the majority of methodologies and technology used for in-field SSV and ground-truthing, including autonomous loggers deployed on the seabed directly beneath a measurement line.

To allow for the fact that there could be some outlier shots, due to highly reflective sections of seabed, or misfires of the airguns, the acceptability criteria will be set at 90%—i.e. >90% of shots must be within 3 dB of the source specifications provided in Table 7-1. If greater than 10% of the measured values exceed the modelling predictions by more than 3 dB, the seismic contractor will be required to retrieve the airgun array from the water, reconfigure, redeploy and then repeat the measurement line. This process will have to be repeated until the airgun array meets the required source specifications.

The SSV report and associated digital data will be provided by the seismic contractor to Santos, and to a suitable independent peer reviewer, for checking and verification.

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

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

- Plankton
- Corals
- Invertebrates including commercial prawn species and pearl oyster shell
- Fish including commercial species
- Sharks and rays
- Turtles and sea snakes
- Marine mammals – whales and dolphins (cetaceans)
- Pearl oyster divers
- Marine Parks
- Key Ecological Features

7.1.4 Known and Potential Environmental Impacts

Potential biological, ecological and economic 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.
- Localised changes in abundance and catch levels of commercially targeted species of invertebrates or fish that may occur from physical, physiological and/or behavioural changes.

7.1.5 Evaluation of Environmental Impacts

7.1.5.1 Plankton

<u>Receptor Sensitivity</u>

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. 2017).

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 cumulative 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 of 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.

The recently published study by McCauley et al. (2017), conducted in temperate waters of south-east Tasmania, is the first large-scale field experiment on the impact of seismic activity on zooplankton. This study measured zooplankton abundance and the proportion of the population that was dead at three distances from a single 150 in^3 airgun—0, 200 and 800 m. The experiment estimated the proportion of the zooplankton that was dead, both before and after exposure to airgun noise, using net samples to measure zooplankton abundance, and bioacoustics to identify the distribution of zooplankton. In this study, copepods dominated the mesozooplankton (0.2-20 mm), and impacts were not assessed on microzooplankton (0.02-0.2 mm) or macrozooplankton (>20 mm). There was movement of water through the experimental area, which made interpreting their results more difficult (Richardson et al. 2017).

McCauley et al. (2017) provide three findings from the experiment to show that zooplankton were affected by the seismic source:

(i) the proportion of the mesozooplankton community that was dead increased two- to three-fold;
(ii) the abundance of zooplankton estimated by net samples declined by 64%; and
(iii) the opening of a “hole” in the zooplankton backscatter observed via acoustics.

They found that exposure to airgun noise significantly decreased zooplankton abundance, and increased the mortality rate from a natural level of 19% per day to 45% per day (on the day of exposure, and that these impacts were observed out to the maximum range assessed (1.2 km) (Richardson et al. 2017).

Scientists from CSIRO’s Oceans and Atmosphere Business Units were contracted by APPEA to undertake a desktop study that: a) critically reviewed the methodologies and findings of the McCauley et al. (2017) experiment; and b) simulated the large scale impact of a seismic survey on zooplankton in the Northwest Shelf region, based on the mortality rate associated with airgun noise exposure reported by McCauley et al. (2017).

The CSIRO review of the McCauley et al. (2017) study found that there were three primary questions raised by the results of the experiment, all of which warrant further investigation (Richardson et al. 2017):

1. Why was there no attenuation of the impact with distance?

   There is no consistent decline in the proportion of zooplankton that are dead with increasing distance away from the airgun. The energy of the sound waves at a distance of 1.2 km is substantially lower than at the source.

2. Why was there an immediate decline in abundance?

   It is unclear why there would be a near immediate drop in zooplankton abundance as measured by net samples and acoustic data. If zooplankton were killed, they would not immediately sink from the surface layers, or be rapidly eaten. A drop in abundance would be more likely once the dead zooplankton either sunk to the bottom or were removed by predation. Richardson et al (2017) conclude it is difficult to explain this immediate decline in zooplankton abundance.

3. Was there sufficient replication to be confident in the study findings?

   The conclusions were based on a relatively small number of zooplankton samples. A total of 24 samples were collected – 2 tows each sampling time x 3 distances from the gun (0 m, 200 m, 800 m) x 2 levels (Control, Exposed) x 2 replicate experiments (Day 1, Day 2). This means that there were only 12 samples collected under conditions exposed to the airgun, six on each day of the two experiments. The main potential confounding explanation in the study would be that a different water mass entered the area on each day of the experiment and had lower abundance and higher quantities of dead zooplankton. Richardson et al. (2017) conclude that: “*although this is relatively unlikely it cannot be discounted because of the relatively few samples collected and only two replicate experiments conducted*.”

Independently of the APPEA/CSIRO study, the International Association of Geophysical Contractors (IAGC) conducted its own review of the McCauley et al. (2017) paper. This review came to the following conclusion:

> "*While we found the study interesting, we are also troubled by the small sample sizes, the large day-to-day variability in both the baseline and experimental data, and the large number of speculative conclusions that appear inconsistent with the data collected over a two-day period. Both statistically and methodologically, this project falls short of what would be needed to provide a convincing case for adverse effects from geophysical survey operations*." (IAGC 2017).

The second component of the CSIRO study was to estimate the spatial and temporal impact of seismic activity on zooplankton on the Northwest Shelf from a large-scale seismic survey, considering mortality estimates of McCauley et al. (2017), and accounting for typical growth rates, natural mortality rates, and the ocean circulation in the region The approach modelled a hypothetical 3D survey (2,900 km^2 in size, over a 35-day period, in water depths of 300-800 m) on the edge of the Northwest Shelf during summer. To simulate the movement of zooplankton by currents, the researchers used a hydrodynamic model that seeded 0.5 million particles into CSIRO's Ocean Forecast Australia Model. Zooplankton particles could be hit multiple times by airgun pulses if they were carried by currents into the future survey path. The greatest limitation in this approach was accurate knowledge of the natural growth and mortality rates of zooplankton, and to address this the CSIRO researchers tested the sensitivity of the model to different recovery (growth-mortality) rates, and also the sensitivity of the results to ocean circulation by undertaking simulations with and without water motion (Richardson et al. 2017).

The results of the simulations that included ocean circulation showed that the impact of the seismic survey on zooplankton biomass was greatest in the *Survey Region* (defined as the survey acquisition area with a 2.5 km impact zone around it) (22% of the zooplankton biomass was removed) and declines as one moves beyond it to the *Survey Region + 15 km* (14% of biomass removed), and the *Survey Region + 150 km* (2% of biomass removed). The time to recovery (to 95% of the original level) for the *Survey Region* and *Survey Region + 15 km* recovery was 39 days (38-42 days) after the start of the survey and three days (2-6 days) after the end of the survey (Richardson et al. 2017).

The major findings of the CSIRO study were that there was substantial impact of seismic activity on zooplankton populations on a local scale within or close to the survey area, however, on a regional scale the impacts were minimal and were not discernible over the entire Northwest Shelf Bioregion. Additionally, the study found that the time for the zooplankton biomass to recover to pre-seismic levels inside the survey area, and within 15 km of the area, was only three days following the completion of the survey. This relatively quick recovery was due to the fast growth rates of zooplankton, and the dispersal and mixing of zooplankton from both inside and outside of the impacted region (Richardson et al. 2017).

Whilst the CSIRO modelling was carried out for the Northwest Shelf IMCRA Meso-scale Bioregion (which as an area of 153,987 km^2) the findings of this study are directly applicable in determining the potential impacts of the Bethany survey on zooplankton communities. The Oceanic Shoals (OSS) Meso-scale Bioregion, within which the survey area is located, covers an area of 153,880 km^2, and so spatially is almost identical to the Northwest Shelf Bioregion. Whilst located further to the northeast than the Northwest Shelf Bioregion, it also covers tropical waters of the continental shelf and slope of Northwest Australia and can be expected to have similar, comparable, zooplankton communities. If anything, the OSS Bioregion may well have zooplankton communities that are lower in abundance than those in the Northwest Shelf Bioregion, based on the likelihood that plankton productivity in this area is also limited by light attenuation caused by high levels of turbidity (Burford and Rothlisberg 1999).

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to develop noise exposure criteria. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species, including a peak pressure level threshold of 207 dB re 1 μPa (PK) for mortality and potential mortality injury to fish eggs and larvae (Popper et al. 2014) (Table 7-2).

While the Bethany noise modelling study considered both SEL_{24h} and PK metrics the levels associated with possible mortality and potential mortal injury to fish eggs and larvae from Popper et al. (2014) using the SEL_{24h} metric are not reached within the modelling resolution of 40 m. The PK metric is therefore used to assess mortal and potential mortal injury to fish eggs and larvae at or close to the seafloor (i.e. for site attached and demersal species). Depending upon the location of the seismic array in the survey region, the range to the PK thresholds are different. The modelling study assessed five locations (Sites A through E), as shown in Table 7-3, with the maximum range at which mortality or mortal injury may occur within a horizontal distance of less than 165 m from the source.

Table 7-2: 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 R_{max} (m) at Seafloor
Fish eggs and larvae	207	165

Table 7-3: Maximum (R_{max}) horizontal distances (m) from the 2,380 in^3 array to modelled seafloor PK levels from four transects

Relevant Animal Type	Peak Pressure Level Threshold (dB re 1 µPa)	Distance R_{max} (m)				
		Site A (35 m depth)	Site B (45 m depth)	Site C (55 m depth)	Site D (65 m depth)	Site E (45 m depth)
Fish eggs and larvae mortality and potential mortal injury	207	143	153	160	165	116

The JASCO modelling study for the Bethany survey also predicted maximum horizontal distances in the water column from the 2,380 in^3 array to a PK-PK threshold of 178 dB re 1 µPa, which was the highest received level estimated at 1.2 km range in the McCauley et al. (2017) plankton study. These distances were predicted along the four transects at the shallowest (Site 1 – 40.9 m) and deepest (Site 2 – 84 m) modelling sites. The maximum horizontal distances to the 178 dB PK-PK threshold were 6.2 km at Site 1, and 4.2 km at Site 2.

Extent and Duration of Exposure and Identified Potential Impact

Based on information from the NPFI, commercial prawn species spawn within areas closer to the coast, outside of the AMBA. Consultation with the NTDPIF identified that peak spawning for commercial fish species was between October and May. However, since then the Timor Reef Fishery state that peak spawning is September to May. Thus, the survey was planned to be finished by the peak spawning period of October and so may now overlap the start of the peak spawning season in September.

Pinctada maxima may be present in the survey area at low distributions. *Pinctada maxima* spawn in the spring months of September or October with primary spawning from the middle of October to December, thus the survey may overlap with spawning period for this species.

Based on the noise modelling, the area where received sound levels at the seabed exceed the mortality or mortal injury threshold from Popper et al. (2014) for fish eggs and larvae is restricted to a distance of < 165 m from the seismic source when at full power (Table 7-3).

To be conservative, for this assessment the impact regions as applied in the CSIRO modelling study (Richardson et al. 2017) have been used – i.e. survey acquisition area + 2.5 km (5,709 km^2), and survey acquisition area + 15 km (12,000 km^2). The larger of these areas (survey acquisition area + 15 km) would incorporate an impact area based on the application of the McCauley et al. (2017) maximum received level of 178 dB PK-PK (6.2 km R_{max}).

To put the potential level of impact in context:

- Zooplankton populations' recovery quickly due to their fast growth rates, and the dispersal and mixing of zooplankton from both inside and outside of the impacted area. The CSIRO model (Richardson et al. 2017) identified that the time for the zooplankton biomass to recover to pre-seismic levels inside the survey area, and within 15 km of the area, was only three days following the completion of the survey.

- Any mortality or mortal injury effects to fish eggs and larvae resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates of fish eggs and larvae, which are very high (exceeding 50% per day in some species and commonly exceeding 10% per day). For example, in a review of mortality estimates (Houde and Zastrow 1993), the mean mortality rate for marine fish larvae was $M = 0.24$, a rate equivalent to a loss of 21.3% per day. Sætre and Ona (1996) calculated that under the 'worst case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population, and they concluded that mortality rates caused by exposure to airgun sounds are so low compared to natural mortality that the impact from seismic surveys must be regarded as insignificant.
- The broader area in which the survey is being undertaken - for plankton, the Oceanic Shoals Meso-scale Bioregion (OSS) 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 an area for the OSS Bioregion of 153,880 km^2, the area of potential impact of 5,709 km^2 represents ~4% of this bioregion and 12,000 km^2 represents ~8% of the bioregion. This is in line with the results of the CSIRO model (Richardson et al. 2017), which showed that the impact of the seismic survey on zooplankton biomass was greatest in the Survey Region (survey acquisition area +2.5 km impact zone where 22% of the zooplankton biomass was removed) and declines as one moves beyond it to the Survey Region + 15 km (14% of biomass removed), and the Survey Region + 150 km (2% of biomass removed).
- Based on an area for the OSMP of 71,744 km^2, the area of potential impact of 5,709 km^2 represents ~8% of the Marine Park and 12,000 km^2 represents ~17% of the park.
- Any plankton, including fish eggs and larvae, present at or close to the seafloor or in the water column within the survey area will not be evenly distributed, and are likely to exhibit substantial spatial patchiness and will be moving with the currents in the area.
- The area of potential impact is based a larger seismic source (3,000 in^3 - Richardson et al. 2017) than the Bethany seismic source (~ 2,380 in^3).
- *Pinctada maxima* has a large distribution area (Figure 5-34) and the survey timing is outside of its peak spawning period, impacts and not likely to be significant at a population level, based on the fact that the species is a broadcast spawner where less than 1% of fertilised eggs survive (WA DoF 2017).
- The survey overlaps the start of the peak commercial fish spawning period (Sept to May) for a maximum of 4 weeks. As this spawning period is over 6 months and a broader area than the survey area, impacts are not likely to be significant at a population level compared to natural mortality rates based on the area of impact in the broader OSS Bioregion, and the predicted period of recovery of 39 days after the start of the survey and 3 days after the end of the survey (Richardson et al. 2017).
- The area of potential impact is not identified as an important area for fauna that rely on plankton as a food source such as whale sharks, rays or cetaceans.

Thus, based on this analysis, though mortality or mortal injury may occur to plankton, including fish eggs and larvae, potential impacts are localised (within the operational area) and short term based on estimated recovery times. These potential impacts are not significant when compared to rates of natural mortality in planktonic populations (10 – 50% per day) and recovery rates (days), and impacts are not expected at a regional scale based on a maximum area of predicted impact being ~8% of the OSS Bioregion, or on a local scale based on the area of predicted impact being 17% of the OSMP.

Summary

Consequence Level: If the activity results in mortality or mortal injury effects to fish eggs and larvae, no long term ecosystem or population level effects were identified. The likelihood of full recovery in a short period of time from any adverse effects caused by the seismic survey is very high. There is potential for localised and short term impacts - (I).

Likelihood Level: For this activity, localised and short term impacts to fish eggs and larvae from seismic noise is considered Possible (c).

7.1.5.2 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. 2017). 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 behaviour responses of invertebrates to a wide range of stimuli.

7.1.5.2.1 Coral

Receptor Sensitivity

No peer-reviewed acoustic criteria were available at the time of this analysis against which potential noise impacts to coral could be assessed.

A literature review conducted for Woodside by Dr Mardi Hastings stated that the primary mechanisms for injury of hermatypic corals from seismic airgun noise are: (1) breaking of the external coral skeleton which could also damage the polyp tissue, and (2) rupture or tearing of polyp tissues inside the corallites (Hastings 2008). The forces required to cause injury were predicted by Hastings (2008) in be in excess of 260 dB re 1 µPa (PK-PK received level).

Although injury to corals is theoretically possible as described by Hastings (2008), studies on the actual impacts were very limited prior to the Maxima and Gigas studies at Scott Reef (see below). A survey of coral reefs in Brunei that were subjected to seismic noise did not detect any damage to hard or soft corals, sponges or other sessile benthic organisms (IEC 2003).

The most relevant data currently available are results from exposure studies that Woodside conducted during the Maxima 3D and Gigas 2D Pilot OBC (ocean bottom cable) marine seismic surveys at Scott Reef in Western Australia.

In the Maxima 3D experiments corals in and around the lagoon were exposed to seismic signals (both experimental seismic lines and a full seismic survey) using a 2,055 in^3 source over a 59-day period. The experimental lines passed directly over the coral communities (source at 7 m depth, corals at ~60 m depth) whereas the full seismic survey passed within tens to 100s of metres (horizontal offset). The maximum estimated received seismic signal levels at coral impact sites were 226–232 dB re 1 µPa (PK-PK), 214–220 dB re 1 µPa (SPL rms), 197–203 dB re 1 µPa^2.s (single pulse SEL), and a maximum cumulative SEL of 197–203 dB re 1 µPa^2.s (Salgado Kent et al. 2016). Hence, the highest received PK-PK sound levels directly below the airgun array were considerably less than the 260 dB re 1 µPa (PK-PK received level) predicted by Hastings (2008) to cause physical injury to corals.

For plate corals, *Lobophytum* spp., and various soft corals including *Sarcophytum* spp., the proportion of dead and bare coral cover and the % cover of red algae were documented and no detectable effect was found from one or multiple passes of the seismic airgun array (Battershill et al. 2008). Further, there was no evidence of coral breakage, no signs of physiological impairment in the corals (polyp withdrawal or reduction in soft coral rigidity) and no long-term change in coral community structure related to the experimental or full seismic survey activities (Battershill et al. 2008).

The Gigas 2D Pilot OBC MSS coral monitoring study (SKM 2008) examined the potential for physical damage to a range of shallow water corals in north Scott Reef lagoon from seismic airgun emissions. This study also used a number of sub-lethal indicators of stress and mortality (partial and whole colony mortality) to determine the effects of airgun emissions on corals. The summary conclusion from this study was that emissions from the airgun array did not cause significant injury, tissue damage, sub-lethal stress or mortality to coral colonies, even when colonies are within a few metres of shots fired from the seismic array (SKM 2008). This survey had a measured at source SEL of 206 dB re 1 µPa^2.s (McCauley 2008), and was therefore also well under the theoretical noise impact level predicted by Hastings (2008) to cause physical injury to corals.

Extent and Duration of Exposure and Identified Potential Impact

As detailed in Section 5.5.1, the banks and terraces within the eastern area of the OSMP, where the AMBA is located, are generally characterised by species-rich sponge and octocoral (soft corals) gardens with shallower banks (less than 60 m) supporting more biodiversity than deeper banks, including hard corals in areas <35 m. Within the survey FPZ, where the seismic source will be at full power, approximately a third of the area has water depths between 20 – 60 m, where sponges and octocorals are likely to be present, and very limited areas <35 m water depth (3.6% of the FPZ), where hard corals are likely to be present.

As described in Section 5.5.1.2, benthic habitat predictive modelling for the OSMP has identified 11 benthic habitat categories within the Marine Park. Table 5-10 provides a description of these habitats and shows the percentage overlap of each habitat with the OSMP, the carbonate bank and terrace system of the Van Diemen Rise KEF and the Bethany FPZ. As shown in Table 5-10, Alcyon (soft corals), Hard Coral and Soft Coral habitat categories account for just ~0.8% of benthic habitats within the FPZ, ~1.3% of benthic habitats within the OSMP and 1.9% of benthic habitats within the KEF.

Based on the research findings to date it is highly unlikely that corals (soft or hard) will be exposed to received sound levels of sufficient magnitude to cause any physical or physiological impacts. Corals would have to be within extremely close range (a few metres) of the airgun array operating at full power to be exposed to received levels high enough to potentially cause these effects, based on the source level characteristics for a 2,380 in^3 array at 6 m tow depth derived from the JASCO modelling study (maximum PK pressure level directly below the array of 257 dB re 1 µPa which is less than the 260 dB re 1 µPa (PK-PK received level) predicted by Hastings (2008) to cause physical injury to corals.

Summary

Consequence Level: As modelled noise levels are below predicted noise levels to cause physical injury to soft or hard corals, potential impacts would be localised and short term impacts to fauna of an environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to soft or hard corals is considered Unlikely (b).

7.1.5.2.2 Prawns

Receptor Sensitivity

There has recently been a number of comprehensive reviews of seismic noise impacts to invertebrates—e.g. Carroll et al. (2017), Edmonds et al. (2016) and Salgado Kent et al. (2016). 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 review by Salgado Kent et al. (2016) also supported the finding 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 rock lobsters showed delayed time to right themselves after exposure to airguns and that two out of three experiments found no difference in tail extension reflex, while one showed exposed lobsters had a 23% decrease in ability to maintain tail extension 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 1µPa 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. (2016b), 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. (2016b), 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. (2016b) 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 Bethany 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. (2016b) 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.

The modelling predicted that received levels will be below 202 dB re 1 µPa (PK-PK) at a maximum horizontal distance at the seafloor of 522 m from the 2,380 in^3 array, at Site B (45 m depth).

Though the survey area is not within the main NPF fishing area, there could potentially be prawns within this area as it is 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.

Based on the noise modelling, the area where the conservative threshold, where physiological impacts have not been identified, is within a distance of <522 m from the seismic source at full power.

For this assessment the FPZ of 4,565 km^2 has been used, with the application of an additional buffer of 522 m outside of this (an area of 4,800 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 4,800 km^2 represents only ~0.6% of the total NPF area.
- The survey period does not overlap the main migration of juvenile prawns across the region, 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 75 days.
- Physiological impacts identified are unlikely to result in significant impacts to prawns or prawn populations in light of the small area of impact (~0.6% 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 (~0.6% of the total NPF area) and medium term (6 months) based on the prawns life history parameters.

Summary

Consequence Level: If the activity results in physiological impacts to prawns, there is potential for localised and medium term impacts - (III).

Likelihood Level: For this activity, localised and medium term impacts to prawns is considered Unlikely (b).

7.1.5.2.3 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*). *P*. *maxima* has a very broad 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).

It is likely that the mechanism of impacts for molluscs are not from sound pressure, but rather from particle motion. However, what is unknown is what particle motion levels could lead to a behavioural response, as described in Day et al. (2016b), or potential mortality. Water depth and airgun array size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher levels, which can then be related to effects on molluscs. Despite the results presented in Day et al. (2016b), 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. (2016b) have been used to estimate the area of potential impact from seismic surveys, the metric selection and the associated level to use to conduct an assessment is complex.

At the seafloor interface molluscs are subject to particle motion stimuli from a number of acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. It is unclear which aspect(s) of these waves is/are most relevant to the animals, either when normally sensing the environment or for physiological effects in response to high-level sound. The excitation of Scholte waves arises due to modes with a limited range of wavenumbers and propagation angles. The time of arrival of the Scholte wave is much later than the arrival of the compressional wave even just 100 m laterally away from the source. Therefore, there is not a direct physical connection between the ground roll and waterborne sound wave at any receiver location other than immediately under the source. These waves can travel long distances, due to a low decay rate, and limited information is available to assess their effect on molluscs. However, the strength and propagation of interface waves are dependent on the seismo-acoustic properties of the bottom, particularly the shear speed and attenuations of the bottom.

The initiation of Scholte waves is wavelength dependent, therefore in shallower water, or with larger airgun arrays with more energy at lower frequencies, you are more likely to set them up. As the water depth increases, only the lower frequency components (with longer wavelengths) will generate interface waves. For instance, assuming a sound speed of 1,500 m/s, in 150 m of water, only frequencies below 10 Hz are likely to generate Scholte waves. Assuming based upon the available information that the Scholte waves are more likely to be related to potential effects on molluscs, and given a consistent airgun array, it is more likely that there will be more effect in shallower water. However, the relationship between the magnitude of the waveform, the number or time period of exposures and the effect has not been quantified.

Mortality, Potential Mortal Injury

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 (Salgado Kent et al. 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). 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.

The most recent critical review of the potential impacts of marine seismic surveys on fish and invertebrates (Carroll et al. 2017) found that there was only a single study that indicated a mortality response in bivalve molluscs at realistic exposure levels (Day et al. 2016b, 2017). This study in the Bass Strait found that exposure to a seismic source (single airgun of either 45 in^3 or 150 in^3: maximum exposure levels of 191 – 213 dB re 1µPa PK-PK) did not cause any incidence of immediate mass mortality, however, repeated exposure (54 – 393 shots) significantly increased mortality, and the risk of mortality significantly increased with time as the majority of mortalities were recorded at the 120 day sample point (Day et al. 2016b, 2017).

This dose-dependent increased mortality translates to an annual increase of between 9.4% and 20%. These fall towards the low end of what might be expected when compared with natural mortality rates in wild scallop populations, which range from 11-51% with a six year mean of 38% (Day et al. 2016b, 2017).

Furthermore, there are a number of limitations and aspects of the Day et al. (2016b, 2017) study that mean that the findings of increased mortality must be treated with caution, especially with respect to assessing the potential risk of mortality effects in molluscs for the Bethany survey. As detailed in Przeslawski et al. (2016a), the Day et al. (2016b, 2017) study:

- Used a manipulative approach in which scallops were transplanted to the study area, exposed to an operating airgun, and then held in captivity during subsequent monitoring.
- Used scallop populations obtained from commercial sources or transplanted from other regions to coastal waters, rather than using *in situ* populations in the Bass Strait. Stress associated with handling during transplantation may have contributed to impacts.
    - Transplanted populations (increased mortality, inability to maintain homeostasis, reflex changes, depressed immune response) after they had been exposed to an airgun in shallow water (<10m)
- Used a single airgun at depths of 10-12 m, rather than a commercial airgun array in deeper waters.
- Identified long-term impacts after rearing scallops in suspended lantern nets such that the scallops were not in their natural environment (i.e. buried beneath sediment), thereby adding potential, though undetected, stress.

As pointed out by Salgado Kent et al. (2016) scallops naturally occur on the seabed and hence their sensory organs for detecting sound and vibration would be expected to have evolved to detect sediment borne motions (i.e. airgun signal energy coupled into the seabed). This sensory modality is not available to scallops held in the water column (in lantern nets). Hence, it is reasonable to question the findings of the Day et al. (2016b) study of increased mortality resulting from repeated exposure to airgun noise, as the scallops would not have been exposed to substrate acoustic waves and interface waves (such as Scholte waves).

Therefore, it seems likely that this observation of increased mortality, albeit minimal when compared to natural mortality rates, is probably related to other factors, such as stress caused by transplantation and the rearing of the animals in the water column rather than in seabed sediments. Indeed, in the summer 2015 scallop experiment: "*both control and exposed treatments suffered complete mortality at some point after the day 14 sample point and prior to the day 120 sample point, which was not related to seismic exposure.*" (Day et al. 2016).

Przeslawski et al. (2016a, 2017) 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, although this study has a number of issues with the presented acoustic sound levels, both measured and modelled, and they should not be used to interpret the effects of the sound on scallops. Additionally, the biological components of the experimental design only allowed a limited resolution in terms of effect assessment to be achieved (JASCO, pers. comm., 2017). However, the results of this study, conducted in a low density scallop area, that no mass mortality occurred as a result of the survey, correlate with the results from Day et al. (2016b).

The Przeslawski et al. (2016a, 2017) study used a 2,530 in^3 commercial airgun array at water depths of 36-61 m, and examined an *in situ* scallop population in seabed sediments. As such, it is probably more appropriate to use the findings of this study, rather than Day et al. (2016b, 2017), in the assessment of mortality effects in molluscs for the Bethany survey. Przeslawski et al. (2016a) point out that seabed substrate likely differed between their study and the Day et al. (2016b, 2017) experiment, which can affect the sound pressure and particle velocity to which the organisms are exposed, particularly as distance from the sound source increases. Measured SELs in the Przeslawski et al. (2016a) study were far lower than those predicted from modelling (146 dB re 1μPa^2.s SEL measured versus 170 dB re 1μPa^2.s SEL predicted), and those detected from Day et al. (2016b, 2017) and other airgun arrays.

All the other papers reviewed in the Carroll et al. (2017) review found no response in respect of mortality effects in bivalve molluscs, including two other studies using the scallop *Pecten fumatus* (Parry et al. 2002; Harrington et al. 2010). Parry et al. (2002) 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. Harrington et al. (2010) conducted a scallop (*Pecten fumatus*) dredge before and two months after exposure to a 2,000 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 (Salgado Kent 2016).

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.

The majority of the Bethany FPZ is located in water depths <35 m (96.4%), and therefore there is minimal overlap with the optimal fishing area of *P. maxima*. Additionally, this has to be viewed in the context of:

- The area of potential impacts is very small in context of the Pearl Oyster Managed Fishery (POMF) fishing area in the Joseph Bonaparte Gulf (JBG) where large adult *P. maxima* could be present.
- Based on a spatial extent of 9,680 km^2 for the POMF fishery area in the JBG, the area of potential impact is ~1,039 km^2 (the area of the FPZ overlapped by the POMF fishery area), which represents ~11% of the POMF fishery area.
- The survey period does not overlap the peak spawning period across the region, with the settlement of spat occurring between November and December (Southgate and Lucas 2008),
- 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 75 days.
- Physiological impacts identified are unlikely to result in significant impacts to pearl oyster populations in light of the small area of impact (~11% of the POMF fishery area in the JBG).
- No commercial fishing has occurred in the POMF fishery area in the JBG since 2008. Based on an overlap of ~11%, if 100% mortality was to occur (which is clearly not remotely possible, based on this risk assessment) this would only impact a low percentage of the whole area available to the POMF in the JBG. A mortality rate of ~11% is less than the natural mortality rates of wild scallop populations, which range from 11-51% with a six year mean of 38%, and is also at the low end of the dose dependant mortality rates of 9.4 and 20% (Day et al. 2016b, 2017). No fishing is currently occurring, impacts are considered to be within the ecological sustainable catch limits of this fishery, and are therefore acceptable.

Behavioural Responses

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.

Day et al. (2016b, 2017) found that exposed scallops had 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.

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. 2017). 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.

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, parts of the survey and operational areas are overlapped by an area where hand-harvesting (by drift divers) of individual adult *P. maxima* takes place between April and October.

Based on the research to date, immediate mass mortality of mollusc species have not been reported to occur in experiments relating to seismic surveys. Though Day et al. (2016b, 2017) recorded increased mortality with repeated exposure to a seismic source, it has not been established as to whether this was due to the seismic source exposure or other mechanism related to the study design (Przeslawski et al. 2016a). Using a precautionary approach, if the increased mortality was due to the seismic source then the increased mortality identified translates to an annual increase of between 9.4% and 20%. These fall towards the low end of what might be expected when compared with natural mortality rates in wild scallop populations, which range from 11-51% with a six year mean of 38% (Day et al. 2016b, 2017).

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). However, if mortality impacts did occur to site attached molluscs, it would be within natural mortality rates and unlikely to have long term or population effects based on the small area of impact (~0.7% of the OSS bioregion and ~1.4% of the OSMP) and that molluscs are likely to be widely distributed throughout the broader OSS bioregion. 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 OSS bioregion. The overlap of the FPZ with the POMF fishery area in the JBG fishery is ~11%. Given the water depths in the part of the Bethany survey area overlapped by the pearling area (25 – 160 m), no mortality and mortal injury effects to adult pearl oysters will occur. Any physiological impacts to pearl oysters are unlikely to be significant at a population level, given the very broad distribution of the species.

Summary

Consequence Level: If the activity results in mortality or physiological impacts to molluscs, no ecosystem or population effects were identified. The likelihood of full recovery in a short period of time from any adverse effects caused by the seismic survey is very high. Therefore, potential impacts would be localised and short term - (II).

Likelihood Level: For this activity, localised and short term impacts to molluscs is considered Unlikely (b).

7.1.5.2.4 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. 2017).

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. 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; 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".*

Przeslawski et al. (2016b, 2017) reported the findings of the Gippsland Marine Environmental Monitoring (GMEM) project, an integrated multi-component project which monitored scallop populations and fish behaviour before, during, and/or after an April 2015 seismic survey in the Gippsland Basin, Bass Strait, across multiple sites in an experimental (0-1 km from seismic survey lines) and control (≥ 10 km from seismic lines) zone. This study found that:

> "*There was no indication of adverse effects of the seismic survey on commercial or doughboy scallop abundance, shell assemblages, or gonad condition. In samples collected two months after the seismic survey from the experimental zone there were larger doughboy scallops with different fatty acid profiles, although reasons for this remain unknown.*
>
> *There was no significant interaction between time and seismic survey exposure on commercial scallop types (live, clapper, dead shell, unknown), although short-term or moderate effects could not be determined...*" (Przeslawski et al. 2016b).

Extent and Duration of Exposure and Identified Potential Impact

Research undertaken to date has not identified any changes to invertebrate catch rates from seismic surveys (Carroll et al. 2017). Based on NPF data from 2010 to 2016 (Figure 5-31) the FPZ, is located ~35 km distance from the NPF fishing activity area. Therefore, it is highly unlikely that abundance and catch rates of prawns will be impacted. The survey will be undertaken within the second season for the NPF, which is when tiger prawns are predominately caught. Based on previous catch data for the NPF Melville statistical area, where the survey area is located, tiger prawns make up 6% of the NPF catch in this area.

A received sound level of 202 dB re 1 µPa (PK-PK), which represents a level at which physiological impacts to prawns may occur, occurs at a maximum distance of ~ 520 m from the Bethany seismic source (at the deepest noise modelling site - Site 2). Site 2 is also the closest site to the NPF fishing activity area. Thus, mortality or physiological impacts to prawns within the NPF fishing area are highly unlikely to occur.

A small portion of the operational area, where the seismic source is not constantly at full power, overlaps the NPF fishing activity area. As the seismic source is not at full power in this area mortality or physiological impacts to prawns would be highly unlikely.

With regards to the pearling oyster harvesting area that overlaps parts of the Bethany survey and operational areas, it is highly unlikely that seismic acquisition will result in any significant impacts on catch rates of adult pearl oysters, for the following reasons:

- The FPZ is located ~35 km distance from the NPF fishing activity area.
- The water depth range in the part of the survey area overlapped by the POMF fishery area in the JBG (25 – 160 m) means that most of the area is too deep for hand-harvesting of oysters (harvesting does not occur in depths >35 m).
- Consultation with the Pearl Producers Association identified that *P. maxima* are not abundantly distributed and the western grounds, within the survey area, is less abundant than the south west grounds. Consequently, they may be present within the survey area at low distribution levels.
- Whilst oysters in deeper waters of the pearling area may represent broodstock for the *P. maxima* population in shallower waters, the survey is highly unlikely to have any significant effects on fecundity, survival of fertilised eggs and larval recruitment, as:
    - survey acquisition will not overlap the primary spawning period for *P. maxima* in the region (mid-October to December);
    - the full power zone only overlaps ~11% of the POMF fishery area in the JBG (based on an area of 9,680 km^2);
    - 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); and
    - any mortality or mortal injury effects to pearl oyster eggs and larvae resulting from seismic noise emissions are likely to inconsequential compared to natural mortality rates (see assessment for Plankton).

Summary

Consequence Level: If the activity results in prawn catch rate impacts, there is potential for localised and short term impacts - (I).

Likelihood Level: For this activity, localised and short impacts to prawn catch is considered Remote (a).

Consequence Level: If the activity results in pearl oyster rate impacts, there is potential for localised and short term impacts - (I).

Likelihood Level: For this activity, localised and short impacts to pearl oyster is considered unlikely (b)

7.1.5.3 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, an approach taken by Popper et al. (2014). 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 Bethany seismic source is below 650 Hz, is within the detectable hearing range of most fishes.

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 7-4), 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 (TTS).

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 (Table 7-4).

As detailed in Section 5.5.4 fish that could potentially be within the survey area are:

- Syngnathid species such as pipefish; pipehorses and seahorses.
- Reef and site attached species.
- Demersal fish species including commercial fish species such as tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.).

Tropical snappers (*Lutjanus* spp. and *Pristipomoides* spp.) are included in the category of fish having a swim bladder not involved in hearing.

Table 7-4: Sound exposure criteria for fish (Popper et al. 2014)*

Receptor	Mortality and Potential Mortal Injury	Impairment			Behaviour
		Recoverable Injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{cum} or > 213 dB peak	> 216 dB SEL_{cum} or > 213 dB peak	>> 186 dB SEL_{cum}	N) Low (I) Low (F) Low	N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection	210 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	>> 186 dB SEL_{cum}	N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	186 dB SEL_{cum}	(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).
*For this assessment the standard period of time applied to the SEL metric is 24 hours as detailed in Section 7.1.2.

7.1.5.3.1 Mortality, including injury leading to death

No studies to date have demonstrated direct mortality of adult fish in response to airgun emissions, even when fired at close proximity (within 1–7 m) (DFO 2004; Boeger et al. 2006; Popper et al. 2016; Carroll et al. 2017). Although some fish deaths have been reported during cage experiments, these were more likely caused by experimental artefacts of handling or confinement stress (Hassel et al. 2004, as cited in NSW DPI 2014). For free-swimming fish that are able to move away from seismic sources as they approach, the potential for lethal physical damage from airgun emissions is even further nullified. However, reef or bottom-dwelling fish that show greater site attachment may be less inclined to flee from a seismic sound source and experience greater effects as a consequence.

Boeger et al. (2006) exposed red snapper (*Lutjanus synagris*), schoolmaster snapper (*Lutjanus apodus)* and Atlantic spadefish (*Chaetodipterus faber),* held in cages, to a seismic source with a sound peak pressure of 196 dB PK. No mortality or obvious external damage was recorded, including one specimen that was already in poor health prior to the experiment. Though the sound levels were below the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 μPa (PK), no mortality occurred a very close 0 - 7 m horizontal distance from the air guns.

Wardle et al. (2001) exposed free-ranging marine fish (juvenile saithe (*Pollachius virens*) and cod (*Gadus morhua,* adult pollock (*Pollachius pollachius*) and mackerel (*Scomber scombrus*)) inhabiting a small reef system, to seismic airguns with a sound peak pressure of 195 - 218 dB PK. No mortality was observed at these levels. Thus, this study, using an actual seismic source, did not show mortality at a level higher than the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 μPa (PK) applied to the Bethany survey.

Santulli et al. (1999) undertook an experimental seismic survey in the open sea using caged juvenile sea bass (*Dicentrarchus labrax*). A 2,500 in^3 array was used and no mortality occurred at 210 dB re 1 μPa at 180 m from the seismic source. This seismic source is slightly larger than the ~ 2,380 in^3 source that will be used for the Bethany survey. Thus, this study, did not show mortality at a level higher than the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 μPa (PK) applied to the Bethany survey.

McCauley and Salgado Kent (2007) undertook a study on goldband snapper, commissioned by Santos and in collaboration with the NT Fisheries Department. The study used a series of commercial fish traps set at increasing ranges adjacent to three seismic survey line in 90 – 110 m water depth in the Timor Sea. The seismic vessel towed two 3,090 in^3 air guns. Maximum single air gun signals reached at the closest trap to each seismic pass-by were 175, 187 and 177 dB re 1 μPa^2·s with peak-peak levels around 25 dB higher (200, 212, 202 dB PK). No mortality or mortal injury was identified at these levels of which 212 dB PK is greater than the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 µPa (PK) applied to the Bethany survey.

Despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. In Popper (2014) pile driving data was used as a proxy as the research to date had not identified a threshold level were mortality has been observed. Since the publication of that report, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study (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 seven 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 to those further away. Thus, this study, using an actual seismic source, did not show mortality at a level higher than the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 µPa (PK) applied to the Bethany survey.

Alternative Threshold for Mortality and Potential Mortal Injury Effects in Fish

Based on a comprehensive review of 23 experimental and opportunistic studies on mortality and potential mortal injury effects of seismic airgun exposure on fish (ERM 2017), an alternative, and more relevant threshold criterion of 215 dB re 1 µPa (PK) has also been applied for this assessment of impacts and risks, in addition to the 207 dB re 1 µPa (PK) threshold.

As described in ERM (2017), only three studies of the 23 reviewed observed direct mortality of exposed fish:

- Booman et al. (1996) – at received levels (RL) of 241-231 dB PK;
- Weinhold and Weaver (1972) – at RL of 234 dB PK; and
- Matishov (1992) – at RL of 220 dB PK.

In each case mortalities occurred to caged fish that were constrained within very close proximity to the airguns (<2 m). The results of the Matishov (1992) study should be treated with some caution, given the lack of detail provided for this experiment.

Eleven other studies did not observe mortality effects or injury likely to result in mortality, at RL levels ranging from 246-220 dB PK. Fanta (2004) found no mortality or physical damage in coral reef fishes exposed in cages to RL ranging from 235-215 dB PK. The relevance of the findings of this study are regarded as high, given that the RL were measured and that the experiment involved exposure of 15 different fish species to a full commercial seismic array (3,090 in^3) at a minimum exposure distance of 45 m. As described above, Wardle et al. (2001) did not observe any mortality or physical damage in free-ranging temperate reef fish exposed to RL of 218 dB PK, at a minimum exposure distance of 5.3 m. Again, the relevance of the results of this experiment is regarded as high, in that the RL were measured rather than estimated.

On this basis, a threshold criterion of >215 dB PK for mortality and potential mortal injury effects in fish is considered to represent a conservative predicted effect level for exposure to airgun noise emissions.

Extent and Duration of Exposure and Identified Potential Impact

While the Bethany noise modelling study considered both PK (Table 7-5) and 24 h SEL metrics (Table 7-6) for the levels associated with possible mortality, potential mortal injury and recoverable injury to fish, the SEL_{24h} metric was not reached at the seafloor. Applying the dual criteria from Popper et al. (2014) correctly means the larger horizontal impact distance determined from either the 24 h SEL or PK should be used. Recoverable injury in fish, turtles, fish eggs, and fish larvae could occur within 50 m; however, this distance was less than that predicted considering the PK metric. Therefore, the PK metric was used to assess possible injurious impacts to fish.

Depending upon the location of the seismic array in the survey area, the range to the PK thresholds are different as the modelling study assessed five representative water depths across the entire survey area (Table 7-5).

Table 7-5: Maximum (R_{max}) horizontal distances (m) from the 2,380 in^3 array to modelled seafloor PK levels from four transects

Relevant Animal Type	Peak Pressure Level Threshold (dB re 1 µPa)	Distance R_{max} (m)				
		Site A (35 m depth)	Site B (45 m depth)	Site C (55 m depth)	Site D (65 m depth)	Site E (75 m depth)
Fish: Alternative mortality threshold	215	53	58	53	46	39
Fish: No swim bladder	213	57	67	72	68	61
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing	207	143	153	160	165	116

Table 7-6: Distances to maximum-over-depth and seafloor SEL_{24h} based fish criteria for the 2,380 in^3 array, for the considered scenario within the Bethany acquisition area

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing. A dash indicates the threshold is not reached.

Marine animal group	Threshold for SEL_{24h} (dB re 1 µPa²·s)	Maximum-over-depth		Seafloor	
		R_{max} (km)	*Area* (km^2)	R_{max} (km)	*Area* (km^2)
Fish mortality and potential mortal injury					
I	219	0.08	24.4	-	-
II Fish eggs and larvae	210	0.10	24.9	-	-
III	207	0.10	24.9	-	-
Fish recoverable injury					
I	216	0.08	24.5	-	-
II, III	203	0.10	24.9	0.05	6.10
Fish TTS					
I, II, III	186	3.40	878	2.90	790

As shown in Table 7-5, the sound exposure threshold for mortality and potential mortal injury for fish with a swim bladder (207 dB re 1 µPa PK) is predicted to be exceeded within a distance of <165 m from the seismic source when at full power.

Quantitative Risk Assessment

As described in Section 5.5.1.2, benthic habitat predictive modelling for the OSMP has identified 11 benthic habitat categories within the Marine Park. Table 5-10 provides a description of these habitats and shows the percentage overlap of each habitat with the OSMP, the carbonate bank and terrace system of the Van Diemen Rise KEF and the Bethany FPZ.

For the purposes of this quantitative risk assessment, it is likely that site attached fish assemblages will be restricted to the following eight benthic habitat categories, based on an assumption that these habitats will be associated to areas of seabed with hard substrates and/or high relief / heterogeneous topography, and that the associated epifaunal communities will provide suitable habitat for site attached fish assemblages:

- Alycon
- Filterers
- Gorgonians
- Halimeda
- Hard Coral
- Macroalgae
- Seagrass
- Soft Coral

The remaining three habitat categories (Abiotic; Burrowers/Crinoids; and Unknown) are assumed to be relatively flat areas of seabed with soft substrates (sand and mud sediments). It is likely that pelagic and demersal fish assemblages will occur across all eleven benthic habitat categories.

Table 7-7 provides the full data from this comparison. The data shows that ~77.5% of the FPZ overlaps benthic habitats that are unlikely to support site attached fish assemblages, whilst the remaining 22.5% (comprised of the eight habitat categories listed above) of the FPZ area could potentially support site attached fish assemblages.

Utilising GIS and a spatial analysis, a quantitative risk assessment process has been conducted to examine the potential mortality impacts to both site attached and pelagic/demersal fish assemblages, based on the areas where the received levels at the seabed exceed the mortality and potential mortal injury thresholds shown in Table 7-7. This approach assumes that pelagic and/or demersal species close to the seabed (i.e. non-site attached) could be exposed to received levels similar to those experienced by site attached fish assemblages in and around benthic habitats. For this analysis, the area where the seismic source will be at full power is within the FPZ (4,565 km^2), and it was based on a shotpoint interval of 12.5 m, and line spacing of 600 m.

Table 7-8 shows the results of this spatial analysis for both site attached and pelagic/demersal fish assemblages, based on the application of both the 207 dB PK and 215 dB PK threshold criteria and on the application of the worst case (i.e. most extensive) R_{max} distances shown in Table 7-5—58 m at Site B for 215 dB PK, and 165 m at Site D for 207 dB PK.

As described above, free-swimming pelagic and demersal fish have the ability to move away from an approaching seismic source and are therefore highly unlikely to be exposed to received sound levels that could result in mortality or potential mortal injury.

For this quantitative risk assessment process, an acceptable level of impact has been set at 5%—i.e. <5% mortality in site attached fish assemblages due to underwater noise from the seismic source. This is seen as a precautionary and conservative effect level, based on the fact that tropical reef fish populations routinely fluctuate by 10% or more due to the normal vagaries in reproduction, recruitment and natural mortality from predation and other factors (Eckert 1987; Connell 1996; Woodside 2007; Goatley and Bellwood 2016).

Table 7-7: Areas and percentage overlap between benthic habitat categories and the OSMP, Bethany survey area, FPZ and KEF

Benthic Habitat Category	Oceanic Shoals Marine Park (71,744 km^2)		Bethany Survey Area (4,363 km^2)		Full Power Zone (4,565 km^2)		Carbonate Banks and Terrace System of the Van Diemen Rise KEF (31,278 km^2)		KEF Habitat within the Bethany FPZ (4,464 km^2)	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Abiotic	50595.72	70.52	2917.38	66.87	3046.56	66.76	16787.31	53.70%	2981.98	66.8
Alcyon	202.22	0.28	19.196	0.44	19.11	0.42	119.07	0.40%	19.11	0.43
Burrowers/Crinoids	12618.35	17.59	404.43	9.27	456.81	10.01	2895.14	9.30%	420.92	9.43
Filterers	6948.07	9.68	856.846	19.64	874.22	19.16	5027.22	16.10%	875.43	19.61
Gorgonians	283.54	0.4	30.976	0.71	30.96	0.68	153.32	0.50%	30.97	0.69
Halimeda	46.76	0.07	4.363	0.1	4.46	0.10	34.75	0.10%	4.46	0.1
Hard Coral	509.41	0.7	75.912	1.74	77.11	1.69	353.51	1.10%	77.2	1.73
Macroalgae	73.94	0.1	2.6177	0.06	2.72	0.06	73.26	0.20%	2.72	0.06
Seagrass	2.49	0	NA	NA	0.23	0.01	1	0.00%	0.23	0.01
Soft Coral	242.16	0.34	19.196	0.44	19.22	0.42	124.58	0.40%	19.24	0.43
Unknown	225.87	0.31	31.484	0.73	32.06	0.70	156.59	0.50%	32.05	0.72
Not Classified							5552.47	17.80%		
Totals	71749	99.99	4362	100	4563	100.01	31278.22	100.10%	4464.31	100.01

Table 7-8: Relative areas of the FPZ that could be exposed to received levels in excess of the 207 dB PK and 215 dB PK thresholds

Mortality Threshold	R_{max} Distance (m)	Area (km^2)	Overlap with OSMP (%)	Overlap with KEF (%)
Site Attached Fish Assemblages				
215 dB PK	58	205	0.29	0.66
207 dB PK	165	585	0.81	1.87
Pelagic/Demersal Fish Assemblages				
215 dB PK	58	882	1.23	2.82
207 dB PK	165	2,512	3.50	8.03

As shown in Table 7-8, the total area where received levels exceed a mortality and potential mortality injury threshold of 207 dB re 1 µPa PK for fish with a swim bladder is 2,512 km^2, which represents 3.5% of the total area of the OSMP and ~8% of the Carbonate bank and terrace system of the Van Diemen Rise KEF. By comparison, the area potentially inhabited by site attached fish assemblages where received levels exceed the 207 dB PK threshold for fish with a swim bladder is 585 km^2, which represents just ~0.8% of the total area of the OSMP and ~1.9% of the KEF (Table 7-8).

With the application of the alternative threshold of 215 dB PK for mortality/potential mortal injury the areas drop to 882 km^2 for pelagic/demersal fish assemblages (~1.2% of the OSMP; and ~2.8% of the KEF) and to 205 km^2 for site attached fish assemblages (~0.3% and ~0.7% of the OSMP and KEF, respectively).

To put the potential level of impact in context:

- The area of potential impact assumes that the area will receive the same sound levels at the same time for the period of the survey, which is not the case. The received sound levels at a location will reduce and increase as the seismic vessel moves through the area during the survey for up to 75 days.
- The area of potential impact is likely to be conservative based on a recent study (Popper et al. 2016) and a comprehensive literature review (ERM 2017) that did not identify mortality, potential mortal injury or recoverable injury at levels above the current published thresholds.
- A conservative approach was used to identify the area where the sound source levels exceed the mortality and potential mortality injury thresholds as the furthest distance of 165 m was used, though distances ranged from 116 m at Site E, 143 m at Site A, 153 m at Site B and 160 m at Site C (Table 7-5).
- The broader area in which the survey is being undertaken. For non-site attached fish (i.e. pelagic/demersal fish) the Oceanic Shoals Meso-scale Bioregion (OSS) 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 an area for the OSS of 153,880 km^2, the area of potential impact of 4,565 km^2 (FPZ) represents only 1.63% of the area of this bioregion. For site attached fish assemblages the Oceanic Shoals Marine Park (OSMP) and the Carbonate bank and terrace system of the Van Diemen Rise KEF would be representative of the broader area in which the survey is being undertaken. Based on areas of 71,744 km^2 for the OSMP and 31,278 km^2 for the KEF, the area of potential impact of 2,512 km^2 represents only 3.5% of the OSMP, and <1% of the KEF (see Table 7-8).
- Potential fish mortality, potential mortality injury and recoverable injury to fish are unlikely for pelagic and demersal fish species, with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey.

- For commercial fish species, the area of potential impact is within the area of the Timor Reef Fishery (TRF) where 4 – 12% of their catch has been caught, based on data from 2013 to 2017 (Table 7-9). For the Demersal Fishery, the percentage catch for the much larger operating area is 0.03%, thus the percentage catch from the potential area of impact would be significantly less than 0.03% (Table 5-22).
- It is unlikely that syngnathid species constitute an important component of any site-attached fish assemblages that may occur in the Bethany survey and operational areas based on:
  - Of the 31 syngnathid species identified to potentially occur within the survey area, 19 species have been recorded in water depths <35 m, which constitutes 3.6% of the FPZ. Of the 12 species that may occur in depths >35 m, only eight have been recorded in the NMR, and only two species have been recorded in the deeper offshore waters of the Arafura Sea.
  - From a total of 85 benthic sled samples collected during surveys within the Joseph Bonaparte Gulf (Heap et al. 2010; Anderson et al. 2011), there were just three captures of individual syngnathids. There were no syngnathids in the nine samples within the Bethany survey area and the 13 samples in the operational area (Table 5-14; Figure 5-18).
- Given the very low proportion of shallow waters (3.6% FPZ <35 m depth) overlapped by the FPZ, and the limited presence of bank features (7% of the FPZ) and absence of pinnacles in the FPZ, it is reasonable to conclude that the survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages. These fish communities are more likely to be associated with shallow areas of the banks (< 35 m depth) with high coverage of hard corals, with pinnacle features, or with shallow shoals in the region such as Tassie Shoal and Evans Shoal.
- Three pinnacles where site attached fish may be present are ~ 20 km from the FPZ and do not receive sound source levels above the mortality and potential mortality injury threshold.
- If mortality did occur the resulting impact would be highly unlikely to cause population level or ecosystem effects based on:
  - The relatively small area of impact (~1.6% of the OSS bioregion; 3.5% of the OSMP; and <1% of the KEF) is not significant at the subregional or bioregional scale.
  - The most abundant commercial fish species within the survey area is goldband snapper, at 8.55% of the total TRF catch caught within the operational area.
  - The survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages.
  - Within the survey area it is unlikely that syngnathid species constitute an important component of any site attached fish assemblages.
  - The seismic survey will not result in physical modification or destruction of habitat.
  - The resilience and recovery of reef and site attached fish species (see below).
  - At 600 m line spacing, and with an R_{max} distance of 165 m for all shots within the FPZ, there is a strip of seafloor between each line (270 m in width) that is essentially un-impacted – i.e. received levels in this area do not exceed the 207 dB PK mortality threshold. If mortality effects were to occur in site attached fish assemblages within a distance of 165 m either side of each line, there is still a significant area of un-affected habitat that could provide recruits into the potentially impacted areas.
  - As shown in Table 7-8, the total area where received levels exceed a mortality and potential mortality injury threshold of 207 dB re 1 µPa PK for fish with a swim bladder is 2,512 km^2. This represents 55% of the FPZ, which means that the remaining 45% of the FPZ (2,053 km^2) would be comprised of un-affected habitat for site attached fish assemblages.
- At all of the spatial scales considered in the quantitative risk assessment the predicted levels of impact do not exceed the defined acceptable level of impact for site attached fish assemblages of 5%.

Table 7-9: Percentage catch within the area where mortality and potential mortal injury sound exposure threshold is exceeded for the Timor Reef Fishery by trap and trawl

Year	% catch within the area where mortality and potential mortal injury sound exposure threshold is exceeded		
	Trap	Trawl	Total
2013	10%	NA	10%
2014	7%	NA	7%
2015	2%	2%	4%
2016	0%	6%	6%
2017	4%	8%	12%

Data provided by the NTDPIR

Resilience and Recovery of Reef and Site Attached Fish Species

It is well recognised that coral reef fish assemblages exhibit high resilience and recovery to natural and anthropogenic disturbance, especially in absence of any habitat damage. As reported in Planes et al. (2005), coral reef fish assemblages at Moruroa Atoll were surprisingly resilient to the impacts of French underground nuclear testing. The pressure wave from each nuclear test caused the instantaneous removal of all fish over an area of 12 km^2 (a radius of 2 km around each test site), but left the benthic habitats and invertebrates untouched. In each case, there must also have been a much larger zone of effect where fish would have experienced sub-lethal physiological and behavioural effects, extending out many kilometres from the test site. Yet despite these intense, large scale perturbations, fish assemblages responded rapidly and were found to be restored to pre-test assemblage structure within 1-5 years (Planes et al. 2005). As long as the structural and biological integrity of the habitat is maintained, and there are neighbouring un-impacted areas that can supply recruits, coral reef fish assemblages appear able to respond rapidly to large-scale natural and anthropogenic change.

This observation is supported by another study (Syms and Jones 2000) in the Great Barrier Reef, where it was demonstrated that assemblages disturbed by fish removal were resilient, with recolonization from both immigration and larval settlement. The results of this experiment (albeit at a much reduced scale to the Moruroa Atoll example) supported a model of patch-reef fish assemblages organized by a combination of deterministic factors (such as habitat structure) and stochastic processes (such as recruitment) (Syms and Jones 2000). Similarly, in a study that examined coral bleaching, reef fish community phase shifts and the resilience of coral reefs Bellwood et al. (2006) concluded that:

> "*Coral reef fishes would thus appear to be relatively resilient, in ecosystem terms, to short-term perturbations. It would appear that reef fishes are able to maintain ecosystem processes; the implicit assumption being that no change in the community composition is a reasonable indication that ecosystem processes are intact*."

In a study that monitored coral and fish assemblages over 14 years on fixed sites spread over 80 km of the southern Great Barrier Reef, Halford et al. (2004) found evidence of large-scale resilience and predictable recovery of these assemblages. This study found that although processes such as settlement and immigration are ultimately responsible for replenishment of local populations, the data suggested that habitat plays a strong role in modifying fish assemblages. Tropical reef communities are typically characterized by very high species diversity in a spatially heterogeneous environment, and display stochastic variability in community structure at small spatial and temporal scales. As reported by Halford et al. (2004), both coral and fish assemblages demonstrated resilience to large-scale natural disturbance and predictability in the structure of the assemblages.

Lefèvre and Bellwood (2015) examined the recolonisation of populations of small cryptic fishes on the Great Barrier Reef following experimental removal. After removing resident cryptobenthic reef fish assemblages from otherwise undisturbed coral rubble areas they observed a rapid recovery. Within eight weeks, fish assemblages were similar to their pre-removal structure in terms of fish abundance, species diversity and species richness. The return of larger species was largely mediated by recolonisation, while smaller, less mobile species relied primarily on recruitment, presumably from the plankton.

In terms of impacts to site attached fish species from airgun noise emissions, the immediate impact on individuals or on schools of fish from a conservation perspective is less important than the long term impact on populations and ecosystems, either alone or in combination with other stresses (which will often include fishing). A reduction in the numbers of fish through exposure to sound may or may not have a measurable effect on fish population recruitment. Some fish populations go through a period of density-dependent mortality, and removing a small number of animals may simply result in their replacement through the improved survival of others.

Summary

Consequence Level: If the activity results in mortality or potential mortality injury to fish, no ecosystem or population level effects were identified. The likelihood of full recovery in a short to medium period of time from any adverse effects caused by the seismic survey is very high. Therefore, potential impacts would be localised and medium term - (III).

Likelihood Level: For this activity, localised and medium term impacts to fish populations is considered Unlikely (b).

7.1.5.3.2 Temporary threshold shift

The following is sourced from Popper et al. (2014):

> *"Temporary threshold shift (TTS) is a temporary reduction in hearing sensitivity caused by exposure to intense sound. TTS has been demonstrated in some fishes, and its extent is of variable duration and magnitude. TTS results from temporary changes in sensory hair cells of the inner ear and/or damage to auditory nerves innervating the ear (Smith et al. 2006; Liberman 2015). However, sensory hair cells are constantly added in fishes (e.g., Corwin 1981, 1983; Popper and Hoxter 1984; Lombarte and Popper 1994) and also replaced when damaged (Lombarte et al. 1993; Smith et al. 2006; Schuck and Smith 2009), unlike in the auditory receptors of mammals. When sound-induced hair cell death occurs in fishes, its effects may be mitigated over time by the addition of new hair cells (Smith et al. 2006, 2011; Smith 2012, 2015).*
>
> *After termination of a sound that causes TTS, normal hearing ability returns over a period that is variable, depending on many factors, including the intensity and duration of sound exposure (e.g., Popper and Clarke 1976; Scholik and Yan2001, 2002a, b; Amoser and Ladich 2003; Smith et al. 2004a, b, 2006, 2011; Popper et al. 2005, 2007). While experiencing TTS, fishes may have a decrease in fitness in terms of communication, detecting predators or prey, and/or assessing their environment."*

Popper et al. (2014) recommended a sound exposure criteria for TTS for fish with a swim bladder involved in hearing of >> 186 dB SEL_{cum} and 186 dB SEL_{cum} for fish with a swim bladder not involved in hearing (Table 7-4). For this survey the standard period of time applied to the SEL metric is 24 hours, as detailed in Section 7.1.2.

The results from the Santos commissioned study (in collaboration with the NT Fisheries Department) on goldband snapper (McCauley and Kent 2007), support the 186 dB re 1 $\mu Pa^2 \cdot s$ TTS threshold from Popper et al. (2014), despite the limited sample size. These results show an apparent increasing trend of damage above ~ 190 dB re 1 $\mu Pa^2 \cdot s$. However, this trend of damaged hair cells immediately after air gun exposure is limited to positive results derived from a limited number of samples and should be treated with caution, as stated in the report itself (McCauley and Salgado Kent 2007).

Another study by McCauley et al. (2003) demonstrated that exposure to repeated emissions of a single airgun (source level at 1 m of 222.6 dB re 1µPa peak-to-peak) from 5 to 15 m at the closest approach caused extensive damage to the sensory hair cells in the inner ear of caged pink snapper (*Pagrus auratus*). Although no mortality was observed, the damage was severe with no evidence of repair or replacement of damaged sensory cells up to 58 days post-exposure. The study did not look at if this damage has any effects on fish hearing. The study acknowledged that the fish were caged and therefore not able to swim away from sound source, and that the monitoring video suggested the fish would have fled the sound source if possible. The study also acknowledged that the impact of exposure on ultimate survival of the fish was not clear.

As part of Woodside's Maxima 3D MSS, an extensive field study was undertaken at Scott Reef. A component of this study investigated three potential impacts with regards to fish assemblages: 1) if resident fish species were physically damaged by the seismic signals; 2) if seismic signals damaged fish ears; and 3) how the behavior of fish exposed to seismic signals changed. A summary of findings on potential impacts to fish hearing are as follows:

- There was statistically more ear damage on seismic exposed fish than on control fish but the damage was marginal, and—assuming a linear relationship between hair cell density and hearing capability—this implied that <1% of the fishes' hearing capability was impaired. Hearing damage was monitored through time on *Lutjanus kasmira* (bluestripe snapper) out to 60 days post seismic exposure and did not increase significantly through time, with almost zero damage detected by 60 days (McCauley 2008).
- A study of auditory brainstem response (ABR) in four species of tropical reef fishes following exposure to emissions from the 2,055 in^3 array showed that none of the four species, including the pinecone soldierfish (a hearing specialist) experienced any hearing sensitivity loss (i.e. TTS) following exposure to SEL_{cum} up to 190 dB re 1 μPa^2.s (Hastings et al. 2008; Hastings and Miksis-Olds 2012).
- Fish exposed to the seismic passes were sampled for assessment of gross physiological damage by the NT Museum. Observations by researchers present during dissections were that no detectable gross physiological damage was found in individuals from any of the seven species (McCauley and Salgado Kent 2012).

The data collected from the ABR experiment at Scott Reef are consistent with the sound exposure guidelines proposed in Popper et al. (2014), which indicated that TTS may occur at SEL_{cum} levels >186 dB re 1μPa^2.s (Table 7-4), while other studies (Popper and Hastings 2009; Song et al. 2008) indicate that TTS may occur at levels as high as SPL 205-210 dB re 1μPa (PK).

During development of the EP, fisheries stakeholders raised concerns about the appropriateness of using a 24 hour period to assess SEL_{cum} and the potential for TTS and other effects associated with SEL_{cum}. Following extensive consultation, an independent, expert peer review of aspects relating to concerns raised by stakeholders was conducted by Professor Arthur Popper (Popper 2018; Appendix 4). The review considered the potential impacts of cumulative seismic noise from the proposed Santos Bethany 3D seismic survey on fish, including TTS effects, and length of time for recovery and the applicability of an SEL_{24h} metric.

The review reached the following conclusions (Popper 2018):

- *The time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!*
- *It is highly unlikely that there would be physical damage to fishes as a result of the survey unless the animals are very close to the source (perhaps within a few meters).*
- *The most likely effect (if any) to fishes resulting from cumulative sound exposure is temporary threshold shift (TTS). However:*
  - *Most fishes in the Bethany region, being species that do not have hearing specializations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey.*
  - *If TTS does take place, the duration of exposure to the most intense sounds that could result in TTS will be over just a few hours. Thus, accumulation of energy over longer periods than a few hours is probably not appropriate.*
  - *If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity.*
  - *Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.*
- *Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of its having a significant impact on fish fitness is very low.*

The Northern Territory Seafood Council (NTSC) commissioned Curtin University's Centre of Marine Science and Technology (CMST) to conduct cumulative SEL modelling for a number of different line acquisition scenarios of different durations in order to understand how SEL_{cum} changed. The modelling indicated that SEL_{cum} can increase for periods longer than 24 hours, but confirmed that the main contribution to accumulated energy occurred at relatively close range and over a relatively short period of time.

A key limitation of the SEL_{cum} modelling by JASCO (2017) and CMST (2018)[8] is that they are only a calculation of SEL_{cum} for their respective scenarios. Neither of them account for the hearing abilities of fish or biological effects of the SEL_{cum}.

Calculations (i.e. modelling) of SEL_{cum} over periods of 24 hours or longer assume that very distant SELss will be audible to fish and contribute to hearing fatigue that may eventually result in TTS. In reality, fish will not hear sound over these distances, hence including the accumulated sound energy from distant shots over a full 24-hour period SEL_{cum} is considered to be conservative. The 24-hour modelled scenario accounts for a) the relatively rapid accumulation of sound at close range to a fish, plus b) a significantly greater amount of sound produced over the 24 hours that fish are unlikely to actually hear.

The impact assessment included in this section of the EP and the findings of Popper (2018) add further context to the modelling by considering how much of this CSEL is relevant and the biological effects. Specifically, Popper (2018) highlights that it is important to consider how much of the sound is received (heard) by individual fish in a population. Fish will only hear and be exposed to relatively "loud" sounds for a relatively short period of time, relatively close to the sound source (Popper 2018).

Popper (2018) further explains within the report that the effects of TTS are unlikely to show up in fishes until the intensity of the sound is well above the fish's hearing threshold. For fish species that are free swimming (which include key commercially targeted species such as snappers) it is likely that there would be no TTS effect whatsoever since fish will likely move away from the sound source.

Based on the independent, expert peer review by Popper (2018) and review of CMST (2018), it is confirmed that the 24-hour period selected to assess SEL_{cum} and any associated effects is likely to be highly conservative for assessing the potential effects to commercially targeted fish.

Extent and Duration of Exposure and Identified Potential Impact

As shown in Table 7-6, 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 3.4 km (within the water column) or 2.9 km (at the seafloor) of the array, based on the predicted R_{max} radii. These radii represent the perpendicular distance from the closest survey line to the isopleth. Based on a predicted R_{max} radius of 3.4 km the associated region of TTS ensonification within the water column over 24 hours is 878 km^2 (for pelagic/demersal fish), and based on a predicted R_{max} radius of 2.9 km the associated region of TTS ensonification at the seafloor over 24 hours is 790 km^2 (for site attached fish).

To put the potential level of impact in context:

- A conservative approach was used to identify the associated region of TTS ensonification over 24 hours by using the furthest distance (3.4 km) from the modelled scenario.
- This area represents ~19% of the FPZ. In a broader context, this area of TTS ensonification over 24 hours represents just ~0.6% of the OSS bioregion, ~1.2% of the OSMP and ~2.8% of the Carbonate bank and terrace system of the Van Diemen Rise KEF.
- For commercial fish species, the area of potential impact is within the area of the Timor Reef Fishery where 8 – 16% of their catch has been caught, based on data from 2011 to 2016. For the Demersal Fishery, the percentage catch for the much larger operating area is 0.03%, thus the percentage catch from the potential area of impact would be significantly less than 0.03% (Table 5-22).
- Applying this same 3.4 km range to the entire 4,565 km^2 FPZ, for example, is 6,130 km^2 which represents ~4.2% of the OSS bioregion, ~8.4% of the OSMP, ~19.5% of the Carbonate bank and terrace system of the Van Diemen Rise KEF, and 21% of the total Timor Reef Fishery area. Please note that the overlap with the Timor Reef Fishery is a percentage overlap with the overall fishery area, not a percentage of the catch, as the same spatial catch data considered for the 24-hour subset of lines is not available to Santos for the entire fishery area.
- The spatial overlap from the FPZ does not represent the area or duration where individual fish will be exposed. The seismic source is always moving so these areas represent the total area where individual fish in a population may be briefly exposed to the effects of SEL_{cum} at some point in time during the entire 75-day duration of acquisition.

[8] Please contact Santos if you would like to request a copy of this report.

- In reality, the individual fish that have the potential to be exposed at one location and point in time in the survey are not the same fish that will be exposed at another distant location elsewhere at another time in the survey. Individual fish in a population are likely to be exposed in a single location for significantly less than 24 hours and the footprint where TTS may occur is likely to be limited to within a few kilometres of the moving source. Given that demersal fish targeted by the fishery are also likely to move in response to the approaching noise, TTS effects or other physical effects of SEL_{cum} to individual fish are unlikely to occur at all.
- It is unlikely that syngnathid species constitute an important component of any site-attached fish assemblages that may occur in the Bethany survey and operational areas based on:
  - Of the 31 syngnathid species identified to potentially occur within the survey area, 19 species have been recorded in water depths <35 m which constitutes 3.6% of the FPZ. Of the 12 species that may occur in depths >35 m, only eight have been recorded in the NMR, and only two species have been recorded in the deeper offshore waters of the Arafura Sea.
  - From a total of 85 benthic sled samples collected during surveys within the Joseph Bonaparte Gulf(Heap et al. 2010; Anderson et al. 2011), there were just three captures of individual syngnathids. There were no syngnathids in the nine samples within the Bethany survey area and the 13 samples in the operational area (Table 5-14; Figure 5-18).
- Given the very low proportion of shallow waters (3.6% FPZ <35 m depth) overlapped by the FPZ, and the limited presence of bank features (7% of the FPZ) and absence of pinnacles in the FPZ, it is reasonable to conclude that the survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages. These fish communities are more likely to be associated with shallow areas of the banks (<35 m depth) with high coverage of hard corals, with pinnacle features, or with shallow shoals win the region such as Tassie Shoal and Evans Shoal.
- Three pinnacles where site attached fish may be present are ~20 km from the FPZ and do not receive sound source levels above the TTS exposure criteria.
- TTS is less likely to occur for pelagic/demersal fish species, with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey.
- TTS may be experienced in fish that cannot or do not avoid or move away from the area (i.e. site attached species).
- The period over which fish would regain normal hearing ability is dependent upon several factors including the intensity and duration of sound exposure. Research to date has not established a recovery time for TTS. While experiencing TTS, fishes might have a decrease in fitness in terms of communication, detecting predators or prey, and/or assessing their environment which could lead to increased likelihood of mortality. If mortality resulting from TTS effects did occur the impacts would be highly unlikely to cause population level or ecosystem effects based on:
  - The relatively small area of impact (~0.6% of the OSS bioregion; ~1.2% of the OSMP; and ~2.8% of the KEF) is not significant at the subregional or bioregional scale.
  - The most abundant commercial fish species within the survey area is goldband snapper, at 8.55% of the total TRF catch caught within the operational area.
  - The survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages.
  - Within the survey area it is unlikely that syngnathid species constitute an important component of any site attached fish assemblages.
  - The resilience and recovery of reef and site attached fish species.

In summary, the key points of the assessment of SEL_{cum} and TTS effects in fish are as follows:

- Modelling of SEL_{cum} alone does not take into account the hearing abilities of animals that may receive the sound and do not consider biological effects in these calculations. Popper (2018) and the EP puts these results in to context by considering the biological effects.
- The 24-hour SEL_{cum} modelling considers the period when the greatest accumulation of sound will occur, plus additional SEL accumulated from seismic shots at distance over 24 hours. Fish may be able to hear and accumulate sound from the closer shots but will not in reality accumulate sound from distant shots that are below their threshold of hearing. Therefore, modelling SEL_{cum} over the 24-hour period accounts for both and is highly conservative.
- As Popper (2018) highlights, there is no scientific basis for considering periods longer than 24 hours.

- Fish are more likely to hear sound from the seismic source at close range and over a relatively short period of time when the greatest accumulation of sound will occur. However, free-swimming commercially-targeted fish will move away from the source if the sound becomes too loud and TTS is unlikely to occur.
- The effects of TTS to individual fish in a population (should they ever occur) will be short term and temporary. If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity (Popper 2018). Even if TTS occurs, the effects are quickly recoverable. Recovery will start as soon as the most intense sounds end, and recovery is likely to occur within 24 hours (or less) (Popper 2018).

Summary

Consequence Level: If the activity results in TTS, no ecosystem or population level effects were identified. The likelihood of full recovery in a short period of time from any adverse effects caused by the seismic survey is very high. Therefore, potential impacts would be localised and short term - (II).

Likelihood Level: For this activity, localised and short term impacts to fish populations is considered Possible (c).

7.1.5.3.3 Behavioural changes

For fish behaviour Popper et al. (2014) uses a relative risk criteria (Table 7-4) that range from high, close to the seismic source (‘near’ distances) to moderate at longer distances ranges (‘far’ distances). For these criteria the ranges, relative to the source, were quantified as near—within tens of metres—intermediate—within hundreds of metres—and far—in thousands of metres. These criteria do not use specific acoustic thresholds, but instead gauge impacts based on general distances from the noise source. It is difficult to predict the population impacts due to behavioural response because behaviour is context dependent. Behavioural responses of wild animals to sound are likely to vary by species, size, and age class, with animal motivation, and in different contexts. Behaviour may be more strongly related to the particular circumstances of the animal, the activities in which it is engaged, and the context in which it is exposed to sounds (Ellison et al. 2012; Penä et al. 2013).

Based on the risk criteria proposed by Popper et al. (2014) and the information assessed, behavioural responses are more likely to occur near the seismic source (tens of metres) with diminishing responses further from the seismic source (hundreds to thousands of metres). Thus, behavioural responses from fish to the seismic source are likely within a localised area (tens to hundreds of metres) and would be of a short term duration as the seismic source passes (minutes).

Understanding the effects of seismic or any other man-made sound on fishes is difficult in the field as studies are costly to perform and many factors can influence the results (Popper et al. 2014).

The studies associated with Woodside’s Maxima 3D survey at Scott Reef included a component that examined how the behavior of fish exposed to seismic signals changed. A summary of results relevant to how the behavior of fish exposed to seismic signals changed is as follows (Woodside 2011a, 2011b; Miller and Cripps 2013):

- Behavioural observations of free swimming fish:
  - Airgun noise emissions did not cause lethal or sub-lethal effects on fish in the vicinity of the operating array.
  - At close range, airgun noise emissions appeared to have caused prominent, short term, effects on fish behaviour. As the vessel approached, fish ceased normal behaviours and moved downward from the water column towards the seabed.
  - Fish began to feed and behave normally again within 20 minutes after the passage of the survey vessel. Once the vessel had travelled beyond a distance of ~1.5 km fish numbers and behaviour had returned to normal, baseline levels.
- Behavioural observations of caged fish:
  - Alarm responses were too infrequent to analyse.
  - Agitation levels increased with increasing received sound exposure level for the three holocentrid (squirrelfishes and soldierfishes) species, but were not detectable for the bluestripe seaperch.
- Sonar observations of free-swimming fish:
  - Individual fish tended to move lower in the water column towards the seabed on approach of the operating airgun array, consistently out to 400 m either side of the survey test line.

   - Within 200 m of the survey test line, fish schools moved to the seabed after passage of the operating airgun array and stayed significantly closer to the seabed out to 63 minutes post-exposure.
- Fish choruses:
   - For the period overlapping the survey, fish choruses followed predictable and relatively smooth trends with regards to timing and chorus level (at daily, lunar and seasonal scales), suggesting that in the long term the survey had little effect on the fish which produced the choruses.
- Fish diversity and abundance:
   - Shallow-slope fish surveys using underwater visual census:
      - No significant decreases were detected in the diversity and abundance of both Pomacentridae (damselfishes and clownfishes) and non-Pomacentridae fish species after the seismic survey compared to the long-term temporal trend before the survey.
   - Analysis of baited remote underwater video stations:
      - There were no detectable effects of the seismic survey on the diversity and abundance of deeper water fish communities at the spatial and temporal scales examined.
      - There were no signs of loss of individuals or of systematic re-distribution of individuals and species at any of the time scales examined.

The findings from the research at Scott Reef support those by Wardle et al. (2001), who exposed free-ranging marine fish inhabiting an inshore reef to sounds from a seismic source (195-218 dB re 1 µPa PK). The study found:

- Fish exhibited a startle response to all received levels, but no avoidance behaviour were observed.
- Fish showed no signs of moving away from the reef.
- Exposure to the seismic noise did not interrupt a diurnal rhythm of fish gathering at dusk.
- Slight changes were recorded to the long-term day-to-night movements of two tagged pollack, particularly when positioned within 10 m of their normal living positions.
- The seismic sound had little effect on the day-to-day behaviour of the resident fish and invertebrates.

Carroll et al. (2017) noted that studies by Slotte et al. (2004), Chapman and Hawkins (1969) and Przeslawski et al. (2016b) indicate that vertical movement rather than horizontal movement could be a short-term reaction to seismic sound.

For caged fish, seismic sound has been reported to elicit varying degrees of startle and alarm responses (Carroll et al. 2017).

Santos commissioned a study on goldband snapper in collaboration with the NT Fisheries (McCauley and Salgado Kent 2007) using cameras placed inside fish traps to quantify fish behaviour. No dramatic behavioural responses of fish to the passing airgun array were observed. Fish generally displayed increased activity immediately after entering a trap presumably as they searched for a way out, with this activity reducing with time. Fish which had been in a trap for some time showed increased activity levels as the operating airgun array approached but were ‘quiet’ when the array passed at the point of closest approach.

Masking impairs an animal’s hearing impairment with respect to the relevant biological sounds normally detected within the environment and can have long lasting effects on survival, reproduction and population dynamics of fishes. The consequences of masking for fishes, however, have not been fully examined. Popper et al. (2014) surmised that “*It is likely that increments in background sound within the hearing bandwidth of fishes and sea turtles may render the weakest sounds undetectable, render some sounds less detectable, and reduce the distance at which sound sources can be detected. Energetic and informational masking may increase as sound levels increase, so that the higher the sound level of the masker, the greater the masking*.” If impulsive sounds are generated repeatedly by many sources over a wide geographic area (such as concurrent seismic survey activity across the Timor Sea), there is a possibility that the separate sounds might merge and that the overall background noise be raised (e.g. Nieukirk et al. 2004). However, masking only occurs while the interfering sound is present, and therefore, masking resulting from a single pulse of sound (such as an airgun shot) or widely separated pulses would be infrequent and not likely affect an individual’s overall fitness and survival.

Extent and Duration of Exposure and Identified Potential Impact

There are no recommended exposure criteria for fish behaviour. For fish behaviour Popper et al. (2014) use relative risk criteria (Table 7-4), which range from high, close to the seismic source ('near' distances) to moderate at longer distances ranges ('far' distances). For these criteria the ranges, relative to the source, were quantified as near—within tens of metres—intermediate—within hundreds of metres—and far—in thousands of metres. These criteria do not use specific acoustic thresholds, but instead gauge impacts based on general distances from the noise source. It is difficult to predict the population impacts due to behavioural response because behaviour is context dependent. Behavioural responses of wild animals to sound are likely to vary by species, size, and age class, with animal motivation, and in different contexts. Behaviour may be more strongly related to the particular circumstances of the animal, the activities in which it is engaged, and the context in which it is exposed to sounds (Ellison et al. 2012; Penä et al. 2013).

Based on the risk criteria proposed by Popper et al. (2014) and the information assessed, 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 will experience a low to moderate behavioural impact, while fish that have swim bladders involved in hearing will experience a moderate to high behavioural impact. Goldband snapper are included in the category of fish having a swim bladder not involved in hearing (i.e. hearing generalist rather than a hearing specialist).

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. Any dispersion of spawning aggregations will depend on the biology of the species and the extent of the dispersion or deflection (DFO 2004). No information is available on the locations of spawning aggregations for fish species targeted in the TRF. The planned survey timing does not overlap any peak spawning activity including target species in the TRF. Therefore, the activity is unlikely to have significant effects on fish fecundity and spawning for target species within the TRF.

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. Effects of this magnitude are not expected to occur as a result of the Bethany survey.

Thus, behavioural responses from fish to the seismic source is likely within a relatively localised area (hundreds to thousands of metres) and would be of short term duration as the seismic source passes (minutes to hours). Population level effects are unlikely to occur as the survey is not being undertaken during the spawning season and the area is not identified as signification aggregation area.

Summary

Consequence Level: If the activity results in fish behavioural changes, there is potential for localised (operational area) and short term impacts (75 days) - (II).

Likelihood Level: For this activity, localised and short term impacts to fish is considered Possible (c).

7.1.5.3.4 Commercial Catch Rate

Receptor Sensitivity

As noted by Salgado Kent et al. (2016) "The issue of changes in commercial fisheries catch rates due to seismic surveys is almost always contentious in Australia". They acknowledge that there has been some effort to relate fisheries catch data to seismic survey effort, but to date none of the Australian efforts to relate fin-fish catch rates with seismic surveys have yielded results of any meaning.

The potential effects of seismic surveys on fish distribution, local abundance or catch has been examined for some teleost species with varying results (Carroll et al. 2017). A range of responses has been observed when the behaviour of wild fishes has been studied in the presence of anthropogenic sounds. Studies suggest that fish will generally move away from a loud acoustic source in order to minimise their exposure, but this response might depend on the animal's motivational state. Anthropogenic sounds have been shown to cause changes in schooling patterns and distribution, including in relation to seismic operations (Engås et al. 1996; Engås and Løkkeborg 2002; Slotte et al. 2004; Løkkeborg et al. 2012a, 2012b; Popper et al. 2014; Streever et al. 2016).

The effects of seismic activity on long-line and trawl catch rates of cod were explored in Norway, and in areas exposed to seismic a 55-80% reduction in long-line catches and 80-85% reduction in trawl catches were observed immediately after the seismic survey. These observations likely reflected the physical movement of demersal fishes away from the sound source, however the study only explored effects shortly after the seismic passes with catches returning to pre-seismic levels within 24 hrs (Løkkeborg and Soldal, 1993).

In contrast, other studies have found positive, inconsistent or no effects from seismic surveys on catch rates or abundance.

The studies associated with Woodside's Maxima 3D survey at Scott Reef, that examined effects on site attached coral reef fish and mobile roaming demersal species, found no detectable effect on species richness or abundance (Woodside 2011b, Miller and Cripps 2013).

Løkkeborg et al. (2012a) noted that reduced fish catches have been observed in commercial line and trawl fisheries during and after seismic surveys, but that catches also increased in some cases, with the increase attributed to a change in fish activity in response to the airgun sounds.

Sonar observations by Penä et al. (2013) looked at real time behaviour of herring schools exposed to a seismic survey and found no changes were observed in school size, swimming speed or direction.

The GMEM project provided no clear evidence of adverse effects on scallops, fish, or commercial catch rates due to the 2015 seismic survey (Przeslawski et al. 2016b):

> "*Catch rates in the six months following the seismic survey were different than predicted in nine out of the 15 species examined across both Danish Seine and Demersal Gillnet sectors. Across both fishing gear types, six species (tiger flathead, goatfish, elephantfish, boarfish, broadnose shark and school shark) indicated increases in catch subsequent to the seismic survey, and three species (gummy shark, red gurnard, sawshark) indicated decreases in catch. These results support previous work in which the effects of seismic surveys on catch seem transitory and vary among studies, species, and gear types*."

Research to date has identified effects and no effects from seismic surveys on catch rates and abundance. This is likely due to the importance of the context of exposure, as discussed above. In many instances, fish may move away from an area when a seismic survey is being undertaken. This could impact on the catchability and catch rates for the target species of any commercial fisheries occurring in the same area at the same time.

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

Based on the risk criteria proposed by Popper et al. (2014) for behavioural responses this is likely to occur near the seismic source (tens of metres) with diminishing responses further from the seismic source (hundreds to thousands of metres). What is not clear from the research is what this effect may have on catchability and when catches return to pre-seismic levels.

Initial consultation (November 2016) with the TRF indicated that they had experienced reduced catches by 50% from just after the Caldita-Barossa 3D survey started, with rates reducing from X to X tonne per day reducing to X to X tonne per day[10], and that, with the survey having finished on 11 October 2016, advice was that there may be seeing some improvement but still too early. Consultation in April 2017 indicated that catch rates had not returned to normal after 9 months.

Based on this information it is possible that there could be potential impacts on catchability of commercial species which is likely to be localised (within the operational area) and based on anecdotal evidence recovery to pre-seismic levels may take up to a year.

For this assessment the area where the seismic source will be at full power is within the survey area (4,363 km^2) and 4.0 km at each end of the survey area, as the source ramps up on entering and ramps down on leaving the survey area. Thus, an additional 202 km^2 has been applied to the survey area giving a total area for the Full Power Zone (FPZ) of 4,565 km^2. This is assumed to be the area within which effects on catchability and catch rates could occur for the duration of the survey, and perhaps for a period (months) after completion of acquisition.

[10] Fishery catch data for the TRF provided by licensees is commercial-in-confidence information that has been redacted from this EP Summary.

To put the potential level of impact in context:

- The area of potential impact represents ~11% of the area of the Timor Reef Fishery (based on an area of 30,170 km^2, and only taking into account the portion of the FPZ that is within the TRF area) and an average of 7.8% of the TRF catch is within this area based on data from 2013 – 2017 (Table 5-24).
- The area of potential impact represents 0.36% of the area of the Demersal Fishery (based on an area of 386,300 km^2, and only taking into account the portion of the FPZ that is within the Demersal Fishery area) and 0.03% of the Demersal Fishery catch is within the operational area so the percentage catch within the FPZ would be even less.
- 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 75 days.

Summary

Consequence Level: If the activity results in changes to commercial fish catch rates, there is potential for localised and medium term (< 1 year) impacts to a social value - (III).

Likelihood Level: For this activity, localised and medium term impacts to fish catch rates is considered - Possible (c).

Commercial Catch Rate - Consultation and Control Measures

Consultation with commercial fishing operators potentially affected by the survey began in 2015, with early notification of the proposed seismic survey and provision of information. This consultation showed that some operators would not be affected, but that others who may be should continue to be consulted with.

Table 4-2 shows the commercial fishing operators who were consulted with, and the *Extent and Duration of Exposure and Identified Potential Impact* section above shows the commercial fisheries most affected. In summary, these fisheries are the Timor Reef Fishery and the Demersal Fishery. The area of potential impact from the survey represents ~11% of the area of the Timor Reef Fishery (based on an area of 30,170 km^2, however, the full power zone extends outside the TRF area) and an average of 7.8% of the TRF catch is within this area based on data from 2013 – 2017 (Table 5-24). For the Demersal Fishery the survey will have a potential impact on approximately 0.36% (based on an area of 386,300 km^2) and 0.03% of the Demersal Fishery catch is within the operational area so the percentage catch within the FPZ would be even less.

In October 2016, the potentially affected commercial fishing operators were advised that the survey was planned for mid-2017 and EP development had commenced, and the operators were provided with information for the purpose of determining how the survey would impact them. Additional information was then provided in January 2017, including a description of Santos' proposed control measures and management strategies. Negotiations also commenced about a potential commercial agreement to compensate commercial fishing operators who suffered a loss of catch because of the survey as Santos and the fishers considered this would be an appropriate control measure for the potential impact of them.

Santos expects to reach a commercial arrangement with the Timor Reef Fishery before the survey commences, however there is no final agreement as at the EP submission date.

Due to the state of negotiations with the commercial fishing operators during the development of the EP, Santos developed a payment model as an alternative appropriate control measure in the EP to ensure that potential impacts to commercial catch rates was reduced to as low as reasonably practicable and be acceptable. The model is proposed in Table 7-16, see the "Loss of Catch Payment" good practice control measure and the "Commercial fishing licence holders are no worse or better off as a result of the survey" performance outcome/control measure/performance standard/measurement criteria.

Santos consulted with an independent fisheries economist at the CSIRO about the payment model and whether it was as an appropriate control measure in the EP to ensure that potential impacts to commercial catch rates was reduced to as low as reasonably practicable and be acceptable. CSIRO

(2017) has confirmed that the approach proposed by Santos for compensating fishers for their potential lost income is generally consistent with international best practice.

Santos has based the Loss of Catch payment model control measure included in the EP on what it understands to be industry standard for an appropriately evidence based compensation model.

Santos also based the Loss of Catch payment model control measure on the fact that during consultation with the commercial fishing operators the fishers referenced impacts to catch in regards to impacts from the previous ConcoPhillips seismic survey (Stakeholder Consultation Records, Appendix 2), thus leading Santos to understand that catch rates would be able to be used to identify any impacts from the survey.

Summary

Taking into account the relatively low level of the potential impact of the survey on the Timor Reef and Demersal Fishery, the advice from the independent expert, industry practice and feedback during consultation, the Loss of Catch Payment is an appropriate control measure to ensure commercial fishing licence holders are no worse or better off as a result of the survey and ensures survey impacts on commercial catch rates are both appropriate and acceptable.

In addition, Santos expects to reach a commercial arrangement with the Timor Reef Fishery before the survey commences. In the event that Santos does reach commercial agreement with a commercial fishing operator, that agreement will replace the Loss of Catch Payment as the appropriate control measure in respect of potential impact on commercial catch rates.

7.1.5.4 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 AMBA 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 7-4) for fish without a swim bladder mortality, potential mortality injury and recoverable injury peak pressure level threshold of > 213 dB re 1 µPa (PK) has been used for this assessment. Based on the modelling, this threshold would be exceeded within a maximum distance of 72 m (R_{max}) from the sound source at full power (Table 7-5).

For this assessment the 72 m R_{max} was applied for all shots within the FPZ, which equates to an area of 1,095 km^2.

Thus, the area where the received levels are predicted to be above the mortality, potential mortality injury and recoverable injury threshold applicable to sharks and rays equates to 1,095 km^2.

To put the potential level of impact in context:

- The broader area in which the survey is being undertaken - for shark and rays the Oceanic Shoals meso-scale bioregion (OSS) 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 OSS bioregion of 153,880 km^2, the area of potential impact of 1,095 km^2 represents ~0.7% of this region.
- As the specified conservation values of the OSMP include the values of the Carbonate bank and terrace system of the Van Diemen Rise KEF (which recognise sharks as a value), it is appropriate to assess the level of impact within this area. The OSMP covers an area of 71,744 km^2, which represents ~1.5% of the OSMP, based on an area of impact of 1,095 km^2.

- There is no indication that the area of predicted impact, the FPZ or the broader operational area 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.
- 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 75 days.
- Mortality, potential mortality injury and recoverable injury to sharks or rays are remote 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 remote and if occurred would not result in population level impacts due to the localised area of impact (1.53% of the OSMP) and that the survey area is not a significant habitat for sharks or rays.

<u>Summary</u>

Consequence Level: If the activity results in mortality, potential mortality injury and recoverable injury to sharks and rays, there is potential for localised and short term impacts to fauna of environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to sharks and rays is considered Remote (a).

7.1.5.5 Marine Reptiles

7.1.5.5.1 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 50–2,000 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 ad 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 caretta*) 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 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}) – a threshold not reached according to the modelling results. Accordingly, the Popper et al (2014) 207 dB PK threshold is used in this assessment of mortality/potential mortal injury effects to marine turtles, as it is based on the latest information to date.

Noise modelling was undertaken to assess underwater sound levels. The modelling was undertaken at four sites within the FPZ in a range of water depths (Table 7-11). Site 4, located in 43.9 m water depth is the closest site to the habitat critical to the survival of the species for flatback turtles. Site 1, located in 40.9 m water depth is the closest site to the olive ridley turtle foraging BIA.

An additional five sites, with depths from 35 m to 75 m were assessed for seafloor PK, PK-PK, and per-pulse SEL (Table 7-10).

Table 7-10: Maximum (R_{max}) horizontal distances (m) from the 2,380 in³ array to modelled seafloor PK levels from four transects

Relevant Animal Type	Peak Pressure Level Threshold (dB re 1 µPa)	Distance R_{max} (m)				
		A (35 m depth)	B (45m depth)	C (55 m depth)	D (65 m depth)	E (75 m) depth
Turtles	207	143	153	160	165	116

Table 7-11: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances from the 2,380 in³ array to modelled maximum-over-depth NSF (2011) criterion for applied turtle behavioural response threshold, for Sites 1 to 4

Threshold	Site 1 (40.9 m)		Site 2 (84 m)		Site 3 (60.5 m)		Site 4 (43.9 m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
NFS (2011) turtle behaviour SPL 166 dB re 1 µPa	3.6	3.2	3.0	2.8	4.5	4.0	4.1	3.6

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

A habitat critical to the survival of the species for flatback turtles is ~ 7.1 km from the FPZ and an olive ridley foraging BIA overlaps the operational area and is ~13 km from the FPZ. Other turtle species have also been identified as likely to be present in the area, however, impacts to flatback and olive ridley turtles would be seen as the worst case for this assessment.

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 the seismic source starts 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.

7.1.5.5.1.1 Mortality, potential mortality injury and recoverable injury

Based on the noise modelling, the received levels exceed the turtle mortality or mortal injury threshold (207 dB re 1 μPa PK) at a maximum distance of <165 m (R_{max} distance) from the seismic source when at full power (Table 7-10).

For this assessment the 165 m (R_{max}) distance was applied for all shots within the FPZ. This equates an area of 2,512 km^2 that is predicted to receive noise levels above the mortality and potential mortality injury threshold for turtles.

To put this in context:

- Based on the application of this threshold to the Bethany survey area, noise levels above the mortality or mortal injury threshold are not received at the habitat critical to the survival of the species for flatback turtles or the olive ridley foraging BIA from any location within the Bethany survey area.
- As the specified conservation values of the OSMP include important internesting areas for flatback and olive ridley turtles and important foraging area for loggerhead and olive ridley turtles, it is appropriate to assess the level of impact within this area. The OSMP covers an area of 71,744 km^2, the area of potential impact is 2,512 km^2, which represents 3.5% of the OSMP.
- 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 75 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 if occurred would be unlikely to result in population level impacts due to impacts are not predicted at either the habitat critical to the survival of the species for flatback turtles or olive ridley foraging BIA.

<u>Summary</u>

Consequence Level: If the activity results in mortality or physiological impacts to turtles, no population effects were identified therefore potential impacts would be localised and short term to fauna of environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to turtles is considered Unlikely (b).

7.1.5.5.1.2 Behavioural disturbance

Based on the noise modelling, the sound received levels exceed the turtle behavioral disturbance threshold (SPL 166 dB re 1 μPa) at a maximum distance of 4.5 km (R_{max} distance) from the seismic source when at full power (Table 7-11). For this assessment the area where the seismic source will be at full power is within the FPZ (4,565 km^2), thus the total area where the sound received levels exceeds the behavioural disturbance threshold for turtles is 6,651 km^2.

To put this in context:

- Based on the application of this threshold to the Bethany survey area, noise levels above the turtle behavioral disturbance threshold are not received at the habitat critical to the survival of the species for flatback turtles or the olive ridley foraging BIA from any location within the Bethany survey area.
- The maximum distance of 4.5 km (R_{max} distance) is for Site 3, which is not adjacent to habitat critical to the survival of the species for turtles or any BIAs.
- At Site 1, which is closest to the olive ridley foraging BIA, the sound received levels exceed the turtle behavioral disturbance threshold (SPL 166 dB re 1 µPa) at a maximum distance of 3.6 km (R_{max} distance). As the olive ridley foraging BIA is 13 km from the FPZ impacts are not predicted as the behavioural threshold level is not exceeded.
- At Site 4, which is closest to habitat critical to the survival of the species for flatback turtles, the sound received levels exceed the turtle behavioral disturbance threshold (SPL 166 dB re 1 µPa) at a maximum distance of 4.1 km (R_{max} distance). As the habitat critical to the survival of the species for flatback turtles is ~7.1 km from the FPZ impacts are not predicted as the bevioural threshold level is not be exceeded.
- The broader area in which the survey is being undertaken, for turtles the Oceanic Shoals meso-scale bioregion (OSS) 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.
- As the specified conservation values of the OSMP include important internesting areas for flatback and olive ridley turtles and important foraging area for loggerhead and olive ridley turtles, it is appropriate to assess the level of impact within this area. The OSMP covers an area of 71,744 km^2, the area of potential behavioural impact is 6,651 km^2, which represents 9.3% of the OSMP.
- Based on the area for the OSS bioregion of 153,880 km^2, the area of potential impact of 6,651 km^2 represents 4.3% 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 75 days.

Thus, based on this analysis, behavioural impacts to turtles may occur within a localised area of 4.3% of the OSS bioregion or 9.3% of the OSMP, and turtles would be exposed to noise levels above threshold levels for a short period as the vessel moves through an area through the survey (up to 75 days).

Summary

Consequence Level: If the activity results in behavioural disturbance to turtles there is potential for localised and short term impacts to fauna of environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to turtles is considered Possible (c).

7.1.5.5.2 Sea snakes

Little information is available about the effects of seismic surveys on sea snakes. In the absence of observations of sea snake exposed to air gun noise, either of captive animals or in the field, it is assumed that they will respond in a similar way to turtles, such as exhibiting behavioural change to an approaching sound source.

Three characteristics suggest that sea snakes could be vulnerable to seismic impacts:

- Sealed nostrils and an air-filled lung extending the length of the body, plus slower swimming speeds than other marine vertebrates, might mean they are unable to avoid tissue damage at close range.

- Scale sensillae that allow sea snakes to detect the vibrations of their prey show peak sensitivity to low frequencies that overlap those produced by seismic sources, this may disrupt feeding (via acoustic masking) and provoke avoidance behaviour.
- Translocation (a common response to seismic sources) is associated with high mortality in sea snakes; habitat displacement might have long term consequences for highly isolated populations.

A current research project – "Investigating the impact of seismic surveys on threatened sea snakes in Australia's North West Shelf" (http://www.apscience.org.au/projects/APSF_12_5/apsf_12_5.html), is being undertaken at the School of Earth and Environmental Sciences, the University of Adelaide, supervised by Dr Kate Sanders. To date no data is available from this research project.

One of the findings of the research and monitoring studies conducted at Scott Reef to study the effects of Woodside's Maxima 3D survey was that the seismic survey did not cause any observed physiological effects or mortality in marine fauna, including sea snakes (Woodside 2008).

As described in Section 5.5.7, most sea snakes have shallow benthic feeding patterns and live in shallow, coastal tropical waters; rarely found in water depths exceeding 30 m (Cogger 1975; Guinea 2013). Based on the spatial analysis of bathymetric data for the Bethany survey and operational areas, water depths <30 m comprise 0.26% of the full power zone where the seismic source is at full power. Therefore, it is unlikely that a high abundance of sea snakes will be present in the survey area. Sea snakes are not sedentary and, like turtles, can swim away from an approaching sound source.

Using turtles as a surrogate, sea snakes could experience mortality, potential mortal injury and recoverable injury within a distance of <165 m (R_{max} distance) from the seismic source at full power (Table 7-10). Similarly, sea snakes could be exposed to sound levels that cause behavioural effects at a distance of 4.5 km (R_{max} distance) of the sound source at full power (Table 7-11).

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

- The low likelihood that a high abundance of sea snakes will be present in the area exposed to the seismic source at full power. Normal habitat for sea snakes (shallow waters <30 m depth) comprise only 0.26% of the FPZ.
- The Bethany survey and operational areas do not overlap any important habitats for sea snakes, or any locations with sea snake populations with a high diversity and abundance (e.g. Ashmore Reef; Hibernia Reef).
- 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 75 days.
- Potential mortality or mortal injury effects to sea snakes are unlikley, 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 and behavioural impacts to sea snakes may occur within a very localised area of 0.26% of the FPZ.

<u>Summary</u>

Consequence Level: If the activity results in mortality, potential mortality injury and recoverable injury to sea snakes there is potential for localised and short term impacts to fauna of environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to sea snakes is considered Unlikely (b).

Consequence Level: If the activity results in behavioural disturbance to sea snakes there is potential for localised and short term impacts to fauna of environmental value - (II).

Likelihood Level: For this activity, localised and short term impacts to sea snakes is considered Possible (c).

7.1.5.6 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).

7.1.5.6.1 Temporary and Permanent Hearing Loss

Receptor Sensitivity

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 $\mu Pa^2 \cdot s$ (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 Bethany AMBA 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 for the Bethany survey, the low-power zone distance required by Policy Statement 2.1 is required to be 2 km, as the R95% 160 dB re 1 $\mu Pa^2 \cdot s$ single-impulse SEL distances at the modelled sites are greater than 1 km, at a maximum of 3.0 km (Table 7-12).

Based on the noise modelling, the area where the sound received levels exceed the cetacean TTS threshold (SEL 160 dB re 1 $\mu Pa^2 \cdot s$) is within a maximum of 3.3 km (R_{max} distance) from the seismic source at full power (Table 7-12). This equates to an area of 6,083 km^2.

Table 7-12: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2,380 in^3 array to modelled maximum-over-depth TTS thresholds for marine mammals

Threshold	Site 1		Site 2		Site 3		Site 4	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
DEWHA (2008), Unweighted per-pulse SEL: 160 dB re 1 µPa2·s	2.7	2.5	2.4	2.2	3.3	3.0	3.2	2.7

Thus, the area in which marine mammals could experience noise levels above the TTS threshold levels would equate to 6,083 km^2.

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

- Within the area of potential impact there are no marine mammal biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition.
- TTS to cetaceans is unlikely as they are likely to move away from the survey area when noise levels are above behavioural thresholds.
- The activity is being undertaken within the OSMP for which one of the natural values (DNP 2017) is to support a range of species, including species listed as threatened, migratory marine or cetacean under the EPBC Act. For marine mammals no biological important areas, critical habitats or migratory pathways were identified within the area of impact or within the OSMP.
- The area of impact is within the KEF carbonate bank and terrace systems of the Van Diemen Rise. This KEF is part of the natural values of the OSMP, however, have not been identified as supporting marine mammals (DNP 2017).
- For cetaceans the Oceanic Shoals meso-scale bioregion (OSS) 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 OSS bioregion of 153,880 km^2, the area of potential impact of 6,083 km^2 represents 3.95% 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 75 days.

Thus, based on this analysis, TTS 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 (3.95% of the OSS) and short term in that cetaceans would be exposed to noise levels above threshold levels as they move through the area during the period of the survey (up to 75 days).

Summary

Consequence Level: If the activity results in TTS to cetaceans there is potential for a localised and short term impacts to animals of environmental value– (II).

Likelihood Level: For this activity cetacean TTS resulting in a localised and short term impact to animals of environmental values is considered Unlikely (b).

7.1.5.6.2 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 (McDonald et al. 1995; IWC 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 7.2 km of the seismic source (R_{max} distance) (Table 7-13). 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.

Table 7-13: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2,380 in^3 array to modelled maximum-over-depth applied marine mammal behavioural response thresholds

Threshold	Site 1		Site 2		Site 3		Site 4	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
NMFS (2013) Marine mammal behaviour, SPL: 160 dB re 1 µPa	7.1	6.0	4.7	4.0	6.5	5.8	7.2	6.1

Extent and Duration of Exposure and Identified Potential Impact

As the Bethany AMBA 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.

Based on the noise modelling, the area where the sound received levels exceed the behavioural disturbance to marine mammal threshold (SPL 160 dB re 1 µPa) is within 7.2 km (R_{max} distance) from the seismic source at full power (Table 7-13).This equates to an area of 7,962 km^2.

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

- Within the area of potential impact there are no cetacean biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition.
- The broader area in which the survey is being undertaken - for cetaceans the Oceanic Shoals meso-scale bioregion (OSS) 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 OSS bioregion of 153,880 km^2, the area of potential impact of 7,962 km^2 represents 5.17% 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 75 days.

Thus, based on this analysis, behavioural disturbance to cetaceans could occur within an extensive area (within the AMBA) and be short term in that cetaceans would be exposed to noise levels above threshold levels as they move through the area during the period of the survey (up to 75 days).

<u>Summary</u>

Consequence Level: If the activity results in behavioural disturbance to cetaceans there is potential for extensive and short term impacts to animals of environmental value– (III).

Likelihood Level: For this activity behavioural disturbance to cetaceans resulting in a localised and short term impact to animals of environmental values is considered Possible (c).

7.1.5.6.3 Acoustic Masking

<u>Receptor Sensitivity</u>

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 AMBA, 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 Bethany AMBA 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 would be within a localised area and for a short duration until the cetacean has moved away from the survey area.

Summary

Consequence Level: If the activity results in cetacean masking there is potential for extensive and short term impacts to animals of environmental value– (III).

Likelihood Level: For this activity cetacean masking resulting in an extensive and short term impact to animals of environmental values is considered Unlikely (b).

7.1.5.7 Pearl Oyster Divers

As identified in Sections 5.6.3.1 and 7.1.5.2, parts of the survey and operational areas are overlapped by an area where hand-harvesting (by drift divers) of individual adult pearl oyster (*P. maxima*) may take place between April and October. The NT DPIR confirmed that there had been no effort in this fishery since 2008. However, this conflicts with information provided by the Pearl Producers Association. As there is uncertainty in regards to the level of activity in the area impacts will be assessed.

Receptor Sensitivity

Divers exposed to high levels of underwater sound can suffer from dizziness, hearing damage or other injuries to other sensitive organs, depending on the frequency and intensity of the sound. The human auditory system is significantly less sensitive underwater than in air and is further degraded if diving equipment obstructs the ears or face (e.g. diving with a hood or full facemask). Underwater auditory threshold curves indicate that the human auditory system is most sensitive to waterborne sound at frequencies between 400 Hz to 1 kHz (Parvin et al. as cited in Anthony et al. 2009), and these frequencies have the greatest potential for damage. In general, within this frequency band, underwater hearing is 35-40 dB less sensitive than in air.

Parvin et al. (as cited in Anthony et al. 2009) further developed the weighting scale to enable the allowable level of noise underwater to be assessed and directly compared to air levels. Based on this scale, at 200 Hz the weighting applied is 52.8 dB, and at 100 Hz the weighting applied is 61 dB.

Within the literature (all as cited in Ainslie, 2008), there is some variation in acceptable received levels for divers:

- NATO military divers: 177 dB (<250 Hz);
- recreational divers: 154 dB (600 – 2,500 Hz);
- DMAC commercial diver guidelines: 191 dB; and
- Parvin et al.: 176 dB (500-2,500 Hz).

Extent and Duration of Exposure and Identified Potential Impact

Hand harvesting occur in depths <35 m which equates to ~ 3.6% of the FPZ. However, pearl divers operating in shallower waters to the south of the survey area could be exposed to noise emissions from seismic acquisition, if the two activities occur at the same time. The potential impact to pearl divers is unclear, given the lack of an applicable and consistent exposure threshold criterion, and a lack of information as to where the hand-harvesting operations could be taking place, and hence the potential maximum received sound levels.

In line with the guidance note (DMAC 12) issued by the UK Diving Medical Advisory Committee (DMAC) “Safe Diving Distance from Seismic Surveying Operations” (DMAC 2011), where pearl diving and seismic activity during the Bethany survey will occur within a distance of 10 km of each other, a joint risk assessment will be conducted. Santos will work with the Pearl Producers Association (PPA) to prepare this risk assessment and identify any required mitigation and control measures to be implemented in advance of any simultaneous operations. Where possible, concurrent seismic and diving activities will be avoided. If this is not possible, the activities will be prioritised and a simultaneous operations (SIMOPS) plan will be developed.

Summary

Consequence Level: If the activity results in impacts to divers (social value) there is potential for localised and short term impacts – (II).

Likelihood Level: For this activity impacts to divers resulting in a localised and short term impact is considered unlikely (b).

7.1.5.8 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 7-14 have been identified as completed in recent years or planned in the area of Bethany survey.

The Bureau of Ocean Energy Management (BOEM 2014) published a final environmental review of geological and geophysical survey activities off the mid- and South Atlantic coast. To minimise the impacts to marine life by providing a ‘corridor’ between vessels, the environmental impact statement from this review included a requirement for a 40 km geographic separation distance (based on worst case scenarios) between the sources of simultaneous seismic surveys. This 40 km separation distance is used in this assessment to identify cumulative impacts from seismic surveys.

This section assess the potential for cumulative impacts associated with:

- The Bethany survey being undertaken within an area where previous seismic surveys have occurred.
- The Bethany 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 Bethany survey as that should be the responsibility of that titleholder as part of their cumulative impact assessment.

Figure 7-4 shows the location of the surveys detailed in Table 7-14 in relation to the Bethany survey. Figure 7-4 shows the Zénaïde, Gulpener and Fishburn seismic surveys, as these surveys are a greater distance than 40 km from the Bethany survey it is not included in this assessment, as potential impacts are not predicted.

Table 7-14: Completed or Planned Surveys within or near the Bethany Survey Area

Year	Company	Permit	Name	Comment
2012	*GX Technology Australia Pty Ltd*	*NT and WA Permits*	Westralia SPAN Marine Seismic Survey	1 line (AU1-6000) across middle of survey and operational areas. Figure 7-4.
2016	*ConocoPhillips Australia Exploration Pty Ltd*	NT/RL5 NT/RL6	*Caldita-Barossa 3D Marine Seismic Survey*	Acquisition of ~ 3,186 km^2 of 3D seismic data in the period July to 11 October 2016. Figure 7-4.

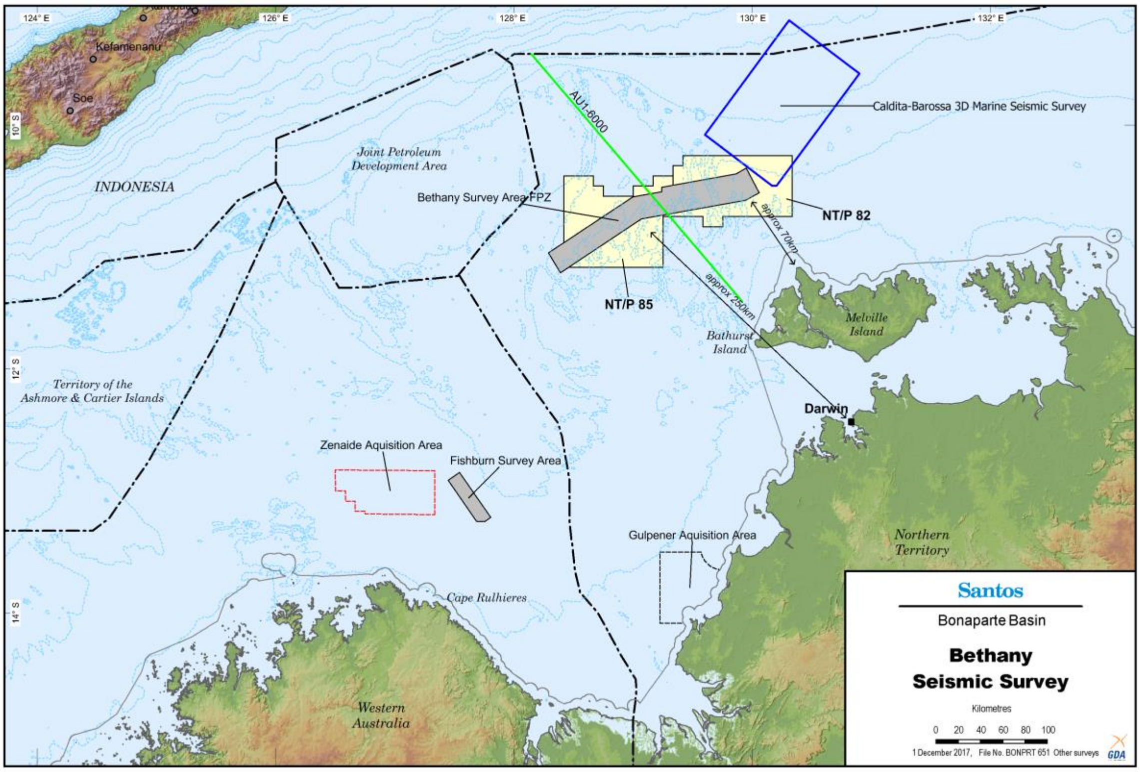


Figure 7-4: Bethany Survey with Previous Seismic Surveys

Previous Seismic Surveys

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

A review of the receptors that overlap within the Bethany survey area and surrounding waters (AMBA) (Section 5 summarised in (Table 7-14) identified the following:

- With the exception of a BIA for foraging olive ridley turtles and a habitat critical to the survival of the species for flatback turtles, no biological important or critical habitats were identified for other species such as cetaceans, sharks and rays.
- Benthic habitats identified are represented across the Oceanic Shoals Marine Park, and the KEF: Carbonate bank and terrace system of the Van Diemen Rise.

- Protected syngnathid species and seasnakes are likely in the area.
- A number of commercial fish species are likely to occur within the AMBA. These fish comprise the main target species for both the Timor Reef Fishery (TRF) and the Demersal Fishery.
- The main commercial fishery overlapped by the survey area and AMBA is the TRF. The Bethany FPZ overlaps ~11% of the TRF and the percentage of catch for the fishery ranges from 4 - 12% with an average of 7.8% from 2013 to 2017. Other fisheries in the area percentage catch rate within the operational area is < 0.5%.
- The AMBA and FPZ overlaps a Pearl Oyster area.
- The AMBA overlap parts of three KEFs: Carbonate bank and terrace system of the Van Diemen Rise; Shelf Break and slope of the Arafura Shelf; and Pinnacles of the Bonaparte Basin. The FPZ only overlaps the Carbonate bank and terrace system of the Van Diemen Rise.
- The AMBA and FPZ overlaps part of the multiple use and special purpose zones of the OSMP.

This assessment will focus on the ConocoPhillips acquired the Caldita-Barossa 3D survey in NT/RL5 and NT/RL6 during the period July to 11 October 2016 as it highly unlikely that one seismic line undertaken 5 years ago would have a level of impact that would not have recovered in that timeframe.

A review of the Caldita-Barossa 3D survey identified that there is no overlap of its acquisition area with the Bethany survey acquisition area. Based on this cumulative impacts from the two surveys would not occur to:

- Localised species such as corals, invertebrates or syngnathid species as impacts would not occur from the distances between the two survey acquisition areas.
- Migratory and other transiting species such as cetaceans, sharks, rays and turtles as impacts would be short term while the survey was operating and the species in the area.
- Pearl Oyster Shell area due to the distances between the two survey acquisition areas.
- Habitat critical to the survival of the species for flatback as the Caldita-Barossa 3D acquisition are was over 20 km from this area.
- Olive Ridley foraging BIA as neither survey acquisition area overlaps the BIA.
- Plankton, including fish eggs and larvae, as recovery rates are estimate to be within three days after the end of the survey (Richardson et al. 2017).

During consultation with stakeholders in the TRF for the Bethany survey Santos was informed by a representative of the TRF that catch rates were affected by up to 50% and recovery to pre-seismic levels was only starting to recovery (Nov, ~ 1 month) following acquisition of the Caldita-Barossa survey. Consultation in April 2017 indicated that catch rates had not returned to normal after 9 months. However, to date there has been no data to support the reduced catch rates.

Previous claims have been made for the TRF that seismic surveys (particularly 3D surveys with tighter line spacing, covering smaller areas) have impacted on catch levels within areas immediately adjacent to the survey polygon, and that some of these surveys overlapping the more productive areas of the TRF have forced operators to temporarily relocate fishing activities to other areas within the TRF, or outside the TRF to the waters of the Demersal Fishery.

Whilst the Caldita-Barossa and Bethany survey areas are relatively close to each other, and both are located within the TRF, cumulative impacts to any of the identified sensitive receptors resulting from acquisition of the Bethany survey are unlikely to occur given the temporal separation between the two activities. The earliest commencement date for the Bethany survey is May 2018. This means that there will have been a gap of at least 18 months between completion of the Caldita-Barossa survey and commencement of the Bethany survey. If claims of reduced catch levels and recovery times resulting from the Caldita-Barossa survey are correct, the Bethany survey may commence while catch levels have recovered to pre-seismic levels.

To date data has not been made available to validate the reduced catch rates and recovery time period from the Caldita-Barossa survey and hence, Santos will implement a Loss of Catch Payment as a control measure in the event that catch rates are impacted by the Bethany Survey.

Variability in seasonal production in the TRF makes it difficult to make meaningful comparisons within seasons or between successive years. Both the Demersal Fishery and the TRF are characterised by sudden changes in catch rates that are accompanied by lower water temperatures over very short time periods. Hence, it is extremely difficult to distinguish impacts on these fisheries, including cumulative effects, from anthropogenic sources versus natural variability caused by changes in environmental parameters, such as water temperature, prey availability etc.

Seismic Surveys within Same Time Period

Based on the consultation undertaken with the permit holders in the area of the Bethany survey and geophysical contractors with Environment Plans being assessed by NOPSEMA (see Section 4), no seismic surveys were identified as likely to be acquired during or close to the same time period as the Bethany survey, within the survey area or in adjacent waters.

7.1.5.9 Disturbance to Conservation Values

The Bethany FPZ overlaps the Oceanic Shoals Marine Park (IUCN VI – Multiple Use Zone). The conservation values of the Oceanic Shoals Marine Park is described in Section 5.1 and 5.3 and the potential impacts of underwater sound to those values is assessed in this section.

The Oceanic Shoals Marine Park zone IUCN VI allows commercial activities such as fishing, tourism, and oil and gas exploration. The AMBA does not overlap any World Heritage Properties, National Heritage Properties, Ramsar wetlands, State or Territory Marine Parks, or Indigenous Heritage Sites (Section 5.2). Marine Park zoning depends upon the conservation values present within the park. The Oceanic Shoals Marine Park is classified as 'Type B'[12] (NOPSEMA 2015) and is not covered by a management plan at this time. DNP has issued approval under Section 359B of the EPBC Act 1999 which permits a range of activities, including mining operations (seismic activities) subject to the approval of an EP.

Table 7-15 identifies the major conservation values and KEF of the Oceanic Shoals Marine Park and summarises potential impacts and risks from the discharge of the 2,380 in^3 array.

With the implementation of the controls (refer to Table 7-16), impacts to marine fauna which may be present in the FPZ are slight to minor. Implementation of mitigation controls ensures acoustic impacts from the Bethany survey are continuously reduced to a level which is ALARP. The residual risk level for acoustic impacts ranges from Very Low (1) to Low (2) and acoustic impacts from the activity is therefore considered acceptable (Section 6.10), and thereby complying with the requirements of the DNP approval for mining activities in Type B CMRs.

Table 5-27 demonstrates that potential impacts from the survey on conservation values of the Oceanic Shoals Marine Park (within the FPZ) will be consistent with the relevant Australian IUCN Reserve Management Principles and management plan objectives, which define the acceptable levels of impact for the Oceanic Shoals Marine Park multiple use zone.

From the acoustic modelling results, broadside source level specifications in the horizontal plane (per-pulse and un-weighted) within the OSMP will be maximum PK pressure level directly below the array (@ 1m) of 257 dB re 1 µPa (Table 7-1).

<u>Values of the Oceanic Shoals Marine Park</u>

1. Important internesting area for flatback and olive ridley turtles.
See Evaluation of Environmental Impacts for marine turtles in Section 7.1.5.5.1.

The flatback turtle 60 km internesting buffer BIA is >7 km from the FPZ (Figure 5-26). Predicted noise levels within the internesting BIA are predicted to be 140-150 dB re 1 µPa (SPL). Therefore, acoustic impacts to flatback turtles potentially within the internesting BIA within the OSMP and outside of the FPZ are not predicted to exceed the marine turtle behavioural threshold of 166 dB re 1 µPa (SPL) (Table 7-11). As such, acoustic impacts within the flatback turtle internesting BIA is reduced to ALARP, as distances >4.5 km will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >7 km (distance of BIA to FPZ) from the FPZ to the BIA would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts.

[12] Type B: New CMRs that were first proclaimed in 2012 and then re-proclaimed in 2013. https://www.nopsema.gov.au/assets/Guidance-notes/A433426.pdf

The olive ridley turtle internesting BIA is ~49 km from the FPZ. Therefore, acoustic impacts to olive ridley turtles potentially within the internesting BIA within the OSMP are not predicted, as received levels are predicted to be well below the marine turtle behavioural threshold of 166 dB re 1 µPa (SPL) (Table 7-11). As such, acoustic impacts within the olive ridley turtle internesting BIA is reduced to ALARP, as distances >4.5 km will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >49 km (distance of BIA to FPZ) from the BIA to the FPZ would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts.

2. Important foraging area for loggerhead and olive ridley turtles.

See Evaluation of Environmental Impacts for marine turtles in Section 7.1.5.5.1.

The operational area is within an olive ridley turtle foraging BIA, however the FPZ is located ~13 km from the boundary of the BIA (Figure 5-25). At this distance, noise levels within the foraging area are not predicted to exceed the marine turtle behavioural threshold of 166 dB re 1 µPa (SPL) (Table 7-11). As such, acoustic impacts to potentially foraging olive ridley turtle within the BIA is reduced to ALARP, as >4.5 km distance will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >13 km (distance of BIA to FPZ) from the FPZ to the BIA would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts.

The loggerhead turtle foraging BIA is >100 km from the FPZ. Therefore, acoustic impacts to potential foraging olive ridley turtles within the BIA within the OSMP are not predicted, as received levels are predicted to be well below the marine turtle behavioural threshold of 166 dB re 1 µPa (SPL) (Table 7-11). As such, acoustic impacts to potential foraging loggerhead turtles within the BIA is reduced to ALARP, as >4.5 km distance will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >100 km (distance of BIA to FPZ) from the BIA to the FPZ would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts.

3. Examples of the ecosystems of the Northwest Shelf Transition

The FPZ is located within the Northwest Shelf Transition provincial bioregion, however the FPZ only overlaps 1.48% of this bioregion. Biological communities identified within the Northwest Shelf Transition and therefore within the FPZ are plankton, corals, invertebrates (sessile filter feeders, sponges, and sea cucumbers), fish – demersal and pelagic, sea turtles, and sharks (DEWHA 2008b; see Figure 5-4). The Evaluation of Environmental Impacts for these species has been undertaken see Sections:

- Plankton –Section 7.1.5.1.
- Invertebrates –Section 7.1.5.2.
- Fish, demersal and pelagic –Section 7.1.5.3.
- Sharks –Section 7.1.5.4.
- Marine turtles –Section 7.1.5.5.1.
- Marine Mammals –Section 7.1.5.6.

Table 7-15 identifies the major conservation values of the Northwest Shelf Transition bioregion within the OSMP multiple use zone and summarises potential impacts and risks from the discharge of the 2,380 in^3 array.

4. Examples of the ecosystems of the Timor Transition

The AMBA is located within the Timor Transition provincial bioregion, however the FPZ is ~26 km from the bioregion. Biological communities identified within the Timor Transition are plankton, corals, invertebrates (sessile filter feeders, sponges, sea cucumbers), fish – demersal and pelagic, sea turtles, and sharks (DEWHA 2008b). The Evaluation of Environmental Impacts for these species has been undertaken see Sections:

- Plankton –Section 7.1.5.1.
- Invertebrates –Section 7.1.5.2.
- Fish, demersal and pelagic –Section 7.1.5.3.
- Sharks –Section 7.1.5.4.

- Marine turtles –Section 7.1.5.5.1.
- Marine Mammals –Section 7.1.5.6.

The Timor Transition Province ~26 km from the FPZ. From the JASCO acoustic modelling, for all sites the received levels at 26 km from the FPZ are not predicted to exceed 150 dB re 1 µPa (SPL) or 140 dB re 1 µPa²s (SEL) (McPherson and Li 2017). Therefore, acoustic impacts to the ecosystems of this region within the OSMP and outside of the FPZ are not predicted to exceed acoustic threshold levels that are known to cause behavioural, temporary/recoverable injury, serious/permanent injury or mortality for marine fauna within the ecosystem.

As such, acoustic impacts to the ecosystems of the Timor Transition Province is reduced to ALARP, as ~26 km distance will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >26 km from the provincial bioregion to the FPZ would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts. At this distance away, received sound levels from the seismic activities will not cause acoustic impacts nor exceed known acoustic threshold criteria for marine fauna, and thus will not impact adversely the corresponding IUCN management principles for the multiple use zone, which define the acceptable levels of impact for the provincial bioregion within the OSMP multiple use zone

5. KEF - Carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature).
The FPZ is located within the carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature) KEF. Biological communities identified within the Van Diemen Rise and therefore within the FPZ are plankton, corals, invertebrates (sessile filter feeders associated with hard substrate sediments of the deep channels - sponges, soft corals, sea cucumbers), fish – demersal and pelagic, sea turtles, sea snakes and sharks (DEWHA 2008b; (DSEWPaC 2012) (see Figure 5-4). The Evaluation of Environmental Impacts for these species has been undertaken see Sections:

- Plankton –Section 7.1.5.1.
- Invertebrates –Section 7.1.5.2.
- Fish, demersal and pelagic –Section 7.1.5.3.
- Sharks –Section 7.1.5.4.
- Marine turtles –Section 7.1.5.5.1
- Sea Snakes – Section 7.1.5.5.2.
- Marine Mammals –Section 7.1.5.6.

Table 7-15 identifies the major conservation values of the KEF within the KEF within the OSMP multiple use zone and summarises potential impacts and risks from the discharge of the 2,380 in^3 array.

6. KEF - Carbonate bank and terrace system of the Sahul Shelf
The carbonate bank and terrace system of the Sahul Shelf (unique sea-floor feature) KEF is located >81 km from the FPZ boundary, and therefore outside of the Scope of this EP. Acoustic impacts to the carbonate bank and terrace system of the Sahul Shelf within the OSMP and outside of the FPZ are not predicted to exceed acoustic threshold levels that are known to cause behavioural temporary/recoverable injury, serious/permanent injury or mortality for marine fauna within the ecosystem.

As such, acoustic impacts to the carbonate bank and terrace system of the Sahul Shelf is reduced to ALARP as distances >81 km provides adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >81 km from the BIA to the FPZ would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts. At this distance, received sound levels from the seismic activities will not cause acoustic impacts nor exceed known acoustic threshold criteria for marine fauna, and thus will not impact adversely the corresponding IUCN management principles for the multiple use zone, which define the acceptable levels of impact for the KEF within the OSMP multiple use zone.

7. KEF - Pinnacles of the Bonaparte Basin (enhanced productivity, unique sea-floor feature)
The Pinnacles of the Bonaparte Basin KEF is outside of the FPZ, the closest pinnacle to the FPZ is >20 km. Biological communities identified within the Pinnacle of the Bonaparte Basin are plankton, high-order pelagic animals such as; sharks, cetaceans, pelagic fish, aggregations of demersal fish, marine

turtles, sea snakes, and sessile benthic invertebrates such as; hard and soft corals and sponges (DEWHA 2008b; (DSEWPaC 2012). The Evaluation of Environmental Impacts for these species has been undertaken see Sections:

- Plankton –Section 7.1.5.1.
- Invertebrates –Section 7.1.5.2.
- Fish, demersal and pelagic –Section 7.1.5.3.
- Sharks –Section 7.1.5.4.
- Marine turtles –Section 7.1.5.5.1.
- Sea Snakes – Section 7.1.5.5.2.
- Marine Mammals –Section 7.1.5.6.

Pinnacles of the Bonaparte Basin KEF is ~20 km from the FPZ. From the JASCO acoustic modelling, for all sites the received levels at 20 km from the FPZ are not predicted to exceed 160 dB re 1 µPa (SPL) or 150 dB re 1 µPa^{2}s (SEL) (McPherson and Li 2017). Therefore, acoustic impacts to the ecosystems of this region within the OSMP and outside of the FPZ are not predicted to exceed acoustic threshold levels that are known to cause behavioural, temporary/recoverable injury, serious/permanent injury or mortality for marine fauna within the ecosystem.

As such, acoustic impacts to the Pinnacles of the Bonaparte Basin KEF is reduced to ALARP, as ~20 km distance will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >20 km from the KEF to the FPZ would not provide additional environmental benefit to the values and sensitivities of the OSMP value nor provide additional protection from acoustic impacts. At this distance away, received sound levels from the seismic activities will not cause acoustic impacts nor exceed known acoustic threshold criteria for marine fauna, and thus will not impact adversely the corresponding IUCN management principles for the multiple use zone, which define the acceptable levels of impact for the KEF within the OSMP multiple use zone.

8. KEF - Shelf break and slope of the Arafura Shelf (unique sea-floor feature)

The shelf break and slope of the Arafura Shelf is >3.5 km from the FPZ. Biological communities identified within the shelf break and slope of the Arafura Shelf are plankton, predatory fish, marine turtles, sharks and some coral communities are found in the euphotic zone of this feature (DEWHA 2008b; (DSEWPaC 2012). The Evaluation of Environmental Impacts for these species has been undertaken see Sections:

- Plankton –Section 7.1.5.1.
- Invertebrates –Section 7.1.5.2.
- Fish, demersal and pelagic –Section 7.1.5.3.
- Sharks –Section 7.1.5.4.
- Marine turtles –Section 7.1.5.5.1.

The shelf break and slope of the Arafura Shelf KEF is ~3.5 km from the FPZ. From the JASCO acoustic modelling, for all sites the received levels at 3.5 km from the FPZ are not predicted to exceed 170 dB re 1 µPa (SPL) or 160 dB re 1 µPa2s (SEL) (McPherson and Li 2017). Therefore, acoustic impacts to the ecosystems of this region within the OSMP and outside of the FPZ are not predicted to exceed acoustic threshold levels that are known to cause serious/permanent injury or mortality for marine fauna within the ecosystem.

As such, acoustic impacts to the ecosystems of the Timor Transition Province is reduced to ALARP, as ~3.5 km distance will provide adequate separation and environmental protection from acoustic impacts caused by the seismic activities. Implementing a separation distance >3.5 km from the KEF to the FPZ would not provide additional environmental benefit to the values and sensitivities of the MP value nor provide additional protection from acoustic impacts. At this distance away, received sound levels from the seismic activities will not exceed known acoustic mortality threshold criteria for marine fauna, and thus will not impact adversely the corresponding IUCN management principles for the multiple use zone, which define the acceptable levels of impact for the KEF within the OSMP multiple use zone.

Table 7-15: Potential acoustic impacts from the Bethany survey to the major conservation values of the Oceanic Shoals Marine Park – IUCN VI

Major Conservation Values	Biological communities identified	EP Section	Distance of MP Value to FPZ (Approx.) km	Acoustic Modelling Sites	Water depth (m)	Predicted received levels at. Value (Approx.)	Horizontal Dist. to modelled seafloor levels from 4 transects	Applied exposure criteria for assessing potential impacts	Predicted received level below exposure criteria? Y/N	FPZ % overlap with OSMP value	Conseq. level (see Table 6-3)	Likelihood level (see Table 6-4)	Residual Risk Rating (see Table 6-5) Level 1 – Acceptable Level 2 – ALARP demonstrated?	Acceptability
Important internesting area for flatback turtles	n/a	7.1.5.5.1.	~7 km	Site 4	43.9	150-160 (SEL) <166 (SPL)	n/a	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or >207 dB PK	Yes	n/a	II	c	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria. A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
								Behavioural disturbance: 166 dB (SPL)[14]	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore,

[13] Popper et al. (2014). For the purposes of this impact assessment process the semi-quantitative distances from the source of Near (N), Intermediate (I) and Far (F) have been determined to be: N – tens of metres; I – hundreds of metres; and F – thousands of metres, as defined in Popper et al. (2014).

[14] NSF (2011).

														impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
Important internesting area for olive ridley turtles	n/a	7.1.5.5.1.	~49 km	Site 4	43.9	<140 (SEL) <150 (SPL)	n/a	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or >207 dB PK	Yes		II	c	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
								Behavioural disturbance[14] 166 dB (SPL)	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting

														BIA is considered Acceptable.
Important foraging area for loggerhead turtles	n/a	7.1.5.5.1.	~100 km	Site 1	40.9	<130 (SEL) <140 (SPL)	n/a	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or >207 dB PK	Yes		II	c	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
								Behavioural disturbance[14] 166 dB (SPL)	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
Important foraging area for	n/a	7.1.5.5.1.	~13 km	Site 1	40.9	<150 (SEL)	n/a	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or	Yes		II	c	Very Low (1)	Acceptable Predicted received level is

olive ridley turtles						<160 (SPL)		>207 dB PK						below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
								Behavioural disturbance[14] 166 dB (SPL)	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP flatback turtle internesting BIA is considered Acceptable.
Examples of the ecosystems of the Northwest	Plankton	7.1.5.1.	Within FPZ	n/a Table 10-13 in JASCO Dec.	65	>207 (PK)	165 m	Mortality, potential mortal injury[13] >210 dB SELcum or >207 dB PK	No	FPZ overlaps 1.48% of the Northwe	I	c	Very Low (1)	Acceptable A level 1 residual risk is considered

Shelf Transition				2017 Report	40.9-84 m	>178 (PK-PK)	n/a	Maximum received level[15] 178 dB PK-PK	No	st shelf transition Province				acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to plankton within the OSMP is considered Acceptable. Though mortality or mortal injury may occur to plankton, including fish eggs and larvae, potential impacts are localised (within the operational area) and short term based on estimated recovery times.
	Invertebrates/ sponges, corals				1 m below array	257 dB re 1 µPa	n/a	260 dB re 1 µPa (PK-PK)[16]	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to invertebrates such as corals and sponges within the OSMP is considered Acceptable.

[15] McCauley et al. (2017)
[16] Hastings (2008)

	Prawns				45	>202 (PK-PK)	522 m	Mortality, potential mortal injury >202 dB PK-PK	No		III	b	Low (2)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: The area of potential impact 4,800 km^2 represents only ~0.6% of the total NPF area. The survey period does not overlap the main migration of juvenile prawns across the region, with the migration of the main cohort occurring between November and March, with a possible second cohort migrating from April to June. Therefore, impacts to prawns within the OSMP is considered Acceptable
	Molluscs				55	>213 (PK)	72 m	213 dB re 1µPa PK-PK[17]	No		II	b	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore,

[17] Day et al. 2016b, 2017

														impacts to pearl oysters within the OSMP is considered Acceptable.
	Fish, demersal and pelagic: Mortality TTS Behaviour	7.1.5.3.			65	>207 (PK)	165 m	Mortality, potential mortality injury and recoverable injury[13] >210 SELcum or >207 dB PK	No		III	b	Low (2)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. If the activity results in TTS and increased mortality, no ecosystem or population level effects were identified. Therefore, impacts to fish within the OSMP is considered Acceptable.
											II	c	Low (2)	
						Moderate	I	Behavioural disturbance[13] (N) High (I) Moderate (F) Low	No		II	c	Low (2)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: see Table 7-16. Behavioural responses from fish to the seismic source is likely within a relatively localised area (hundreds to thousands of metres) and would be of short term duration as the seismic source passes (minutes to hours).

														Population level effects are unlikely to occur as the survey is not being undertaken during the spawning season and the area is not identified as signification aggregation area.
	Sharks	7.1.5.4.			55	>213 (PK)	72 m	Mortality, potential mortality injury and recoverable injury[13] >219 dB SEL_{cum} or >213 dB peak	No		II	a	Very Low (1)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: see Table 7-16. 1.5% of the OSMP will be impacted, based on an area of impact of 1,095 km^2. There is no indication that the area of predicted impact, the FPZ or the broader operational area 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. Therefore, impacts to sharks within the OSMP is

														considered Acceptable
	Marine turtles	7.1.5.5.1.			65	>207 (PK)	165 m	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or >207 dB PK	No		II	c	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP is considered Acceptable.
				Site 4	43.9	>166	n/a	Behavioural disturbance[14] 166 dB (SPL)	No		II	b	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP is considered Acceptable. Noise levels above the turtle behavioral disturbance threshold are not received at the habitat critical to the survival of the species for flatback turtles or the olive ridley foraging BIA from any location within the Bethany survey area. The maximum distance of 4.5 km (Rmax distance) is for Site 3, which is not

														adjacent to habitat critical to the survival of the species for turtles or any BIAs. The OSMP covers an area of 71,744 km2, the area of potential behavioural impact is 6,651 km2, which represents 9.3% of the OSMP.
KEF - Carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature)	Plankton	7.1.5.1.	Within	n/a Table 10-13 in JASCO Dec. Report	65	>207 (PK)	165 m	Mortality, potential mortal injury >210 dB SELcum or >207 dB PK	No	FPZ overlaps 17.37% of the KEF Coincides with % overlap of the FPZ with bank (~7%) and terrace (~10%) features of the OSMP (Table 5-9)	I	c	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to plankton within the OSMP is considered Acceptable. Though mortality or mortal injury may occur to plankton, including fish eggs and larvae, potential impacts are localised (within the operational area) and short term based on estimated recovery times.
					40.9-84 m	>178 (PK-PK)	n/a	Maximum received level 178 dB PK-PK	No					
	Invertebrates: sponges / Coral	7.1.5.2.			1 m below array	257 dB re 1 µPa	n/a	260 dB re 1 µPa (PK-PK)	Yes		II	b	Very Low (1)	Acceptable Predicted received level is below the marine fauna exposure criteria

														A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to invertebrates such as corals and sponges within the OSMP is considered Acceptable.
	Prawns				45	>202 (PK-PK)	522 m	Mortality, potential mortal injury >202 dB PK-PK	No		III	b	Low (2)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: The area of potential impact 4,800 km^2 represents only ~0.6% of the total NPF area. The survey period does not overlap the main migration of juvenile prawns across the region, with the migration of the main cohort occurring between November and March, with a possible second cohort migrating from April to June. Therefore, impacts to prawns

														within the OSMP is considered Acceptable
	Molluscs				55	>213 (PK)	72 m	213 dB re 1µPa PK-PK	No		II	b	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to pearl oysters within the OSMP is considered Acceptable.
	Fish, demersal and pelagic: MortalityTTS Behaviour	7.1.5.3.			65	>207 (PK)	165 m	Mortality, potential mortality injury and recoverable injury >210 SELcum or >207 dB PK	No		III	b	Low (2)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. If the activity results in TTS and increased mortality, no ecosystem or population level effects were identified. Therefore, impacts to fish within the OSMP is considered Acceptable.
											II	c	Low (2)	
						Moderate	I	Behavioural disturbance (N) High (I) Moderate (F) Low	No		II	c	Low (2)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: see Table 7-16. Behavioural responses from fish to the seismic

														source is likely within a relatively localised area (hundreds to thousands of metres) and would be of short term duration as the seismic source passes (minutes to hours). Population level effects are unlikely to occur as the survey is not being undertaken during the spawning season and the area is not identified as signification aggregation area. Therefore, impacts to fish within the OSMP is considered Acceptable
	Sharks	7.1.5.4.			55	>213 (PK)	72 m	Mortality, potential mortality injury and recoverable injury >219 dB SEL_{cum} or >213 dB peak	No		II	a	Very Low (1)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: see Table 7-16. 1.5% of the OSMP will be impacted, based on an area of impact of 1,095 km^2. There is no indication that the area of predicted impact, the FPZ or the broader operational area 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. Therefore, impacts to sharks within the OSMP is considered Acceptable
	Marine turtles	7.1.5.5.1.			65	>207 (PK)	165 m	Mortality, potential mortal injury >210 dB SEL_{cum} or >207 dB PK	No		II	c	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP is considered Acceptable.
				Site 4	43.9	>166	n/a	Behavioural disturbance 166 dB (SPL)	No		II	b	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Therefore, impacts to marine turtles within the OSMP is considered Acceptable. Noise levels above the turtle behavioral disturbance threshold are not received at

														the habitat critical to the survival of the species for flatback turtles or the olive ridley foraging BIA from any location within the Bethany survey area. The maximum distance of 4.5 km (Rmax distance) is for Site 3, which is not adjacent to habitat critical to the survival of the species for turtles or any BIAs. The OSMP covers an area of 71,744 km2, the area of potential behavioural impact is 6,651 km2, which represents 9.3% of the OSMP.
	Sea snakes	7.1.5.5.2.		n/a Table 10-13 in JASCO Dec. 2017 Report	65	>207 (PK)	165 m	Mortality, potential mortal injury[13] >210 dB SEL_{cum} or >207 dB PK	No		II	c	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Based on the assessment, mortality and behavioural impacts to sea snakes may occur within a very localised area of 0.26% of the FPZ. Therefore, impacts to

														sea snakes within the OSMP is considered Acceptable.
	Marine mammals	7.1.5.6.		Site 3	60	>160 (SEL)	3.3 km	TTS to cetaceans 160 dB (SEL)	No		II	b	Very Low (1)	Acceptable A level 1 residual risk is considered acceptable and it is assumed that ALARP has been achieved. Within the area of potential impact there are no marine mammal biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition. TTS to cetaceans is unlikely as they are likely to move away from the survey area when noise levels are above behavioural thresholds. For marine mammals no biological important areas, critical habitats or migratory pathways were identified within the area of impact or within the OSMP. Therefore,

														impacts to cetaceans within the OSMP is considered Acceptable.
						>160 (SPL)	6.5 km	Behavioural disturbance 160 dB (SPL)	No		III	c	Low (2)	Acceptable A level 2 residual risk is acceptable provided that ALARP has been achieved and demonstrated: Within the area of potential impact there are no cetacean biologically important areas or migratory paths, thus it is unlikely that large numbers of cetaceans will be present in the survey area during acquisition. Based on the area for the OSS bioregion of 153,880 km², the area of potential impact of 7,962 km² represents 5.17% of this region. Therefore, impacts to cetaceans within the OSMP is considered Acceptable.

Notes: dB SPL (Sound pressure level, dB re 1 µPa); dB PK (PK - Peak pressure level threshold, dB re 1 µPa); dB SEL (SEL – Sound Exposure Level, dB re 1 µPa²s); SELss (per-pulse SEL - dB re 1 µPa².s); SELcum, [SELss+10log10(N)] - for piling driving and VSP, to apply it to seismic surveys is highly conservative.
If the SEL_{ss} is approximately the same for all events, then the SEL cum can be estimated as SEL_{ss} +10log 10 (N), where N is the number of impulsive events (Popper, 2014).

Table 7-16: Seismic Noise Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
B	3D seismic surveys are commonly undertaken in both Australian and international waters. There has been numerous studies on the effects of seismic sound on receptors with a range of effects to no effects identified. Seismic surveys in Australia are well regulated and guidance is available for managing potential impacts to sound sensitive marine fauna. Sound sensitive marine fauna (whales, sharks, rays) have been identified as having the potential to transit through the area, and the operational area overlaps a BIA for foraging olive ridley turtles, which is 13 km from the FPZ and habitat critical to the survival of the species for flatback turtles is ~7.1 km of the FPZ. The survey acquisition area also overlaps the Timor Reef Fishery, Demersal Fishery and Pearl Oyster Fishery. The operational area overlaps the Northern Prawn Fishery. During consultation with NTDPIR and commercial fishers concerns were raised in regards to the impacts of seismic surveys on commercial fish and invertebrate species Consequently, Santos believes Decision Context B should be applied to this aspect.

Control Measure Identification			
Good Practice Control Measure	**Cost**	**Benefit**	**Applied**
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A applied to cetaceans and whale sharks	The implementation of Part A of the EPBC policy statement for cetaceans is considered to be a good practice control measure thus has not been evaluated further.	Minimise impacts to cetaceans and whale sharks that maybe transiting through the area. The benefit is considered to outweigh the cost.	Yes
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A applied to turtles.	The implementation of Part A of the EPBC policy statement to turtles has an increased cost as may lead to increased shut downs.	Noise modelling did not identify any impacts to the turtle internesting or foraging BIA buffers, however, it is likely that turtles will be present in the survey area. Thus, EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A will be applied to turtles as a control to minimise impacts to turtles. The benefit is considered to outweigh the cost.	Yes
Recovery plan for marine turtles in Australia identifies soft start procedures as a control for minimising noise impacts to turtles.	This control measure is covered under the implementation of EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A and thus is not discussed further.	Noise modelling did not identify any impacts to the turtle internesting or foraging BIA buffers, however, it is likely that turtles will be present in the survey area. Thus, EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A will be applied to turtles as a control to minimise impacts to turtles. The benefit is considered to outweigh the cost.	Yes
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part	Employment of experienced MMOs is not considered to result in a significant cost to the project.	The benefit of having trained Marine Fauna Observers (MFOs) ensures controls are implemented and they are better equipped to identify cetaceans and other	Yes

B. B.1.Marine Mammal Observers		fauna. The benefit is considered to outweigh the cost.	
Schedule survey to avoid receptors seasonal timings.	Reducing the survey timing window can lead to increased costs due to stand by time or full acquisition of data not being achieved. This can have a significant cost (> $1 million).	There are no migratory routes, breeding or feeding areas near the survey area with the exception of the BIA for foraging olive ridley turtles (which no impacts from seismic noise are predicted) for which no seasonality is defined, and the habitat critical to the survival of the species for flatback turtles (which no impacts from seismic noise are predicted) for which peak nesting is Jun - Sep. The main fisheries in the area (TRF and Demersal) do not have a closed season and peak spawning occurs from Sept to May. The survey was planned on original information that period of least intensity (June – mid August) and prior to the start of spawning in October. This requirement meant that the survey does overlap with the NPF second season which commences in September but there is only a very small overlap with this fishery (<1%). The benefit is considered to outweigh the cost. There is generally less seasonality in zooplankton biomass in tropical regions, and thus the time of the year that a survey is conducted is less important (from a zooplankton perspective (Richardson et al. 2017).	Yes
Undertake the survey during the day when potentially less zooplankton is near the surface	Only conducting the survey during the day would double the survey time and cost this can have a significant cost (> $1 million).	No significant spawning or fauna reliant on plankton are identified in the area. It is also unclear how effective this control would be considering the increased costs and time of the survey, as such the costs outweigh the environmental benefits.	No
Conduct survey into or across the prevailing currents to reduce likelihood of plankton being impacted multiple times by the seismic source	The predominant current direction during the period of the survey area are north-northwest (across the survey line) and south-west (direction of survey lines) thus for the majority of this can be achieved. If the currents are south-west the one line will be into the current and the next will be with the current. However, to always be into the	Conducting the survey across and into the prevailing currents may reduce likelihood of plankton being impacted multiple times by the seismic source. The planned survey lines will achieve this with the exception of if the currents are south-west as some lines will be with the current. Implementation of the planed survey lines on an approximate south-west/north east line will reduce potential	Yes

	current would increase the time of the survey increasing cost and moving the survey further into peak spawning season.	impacts to plankton without additional cost.	
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part B. B.2.Night-time/poor visibility	Increased restrictions for poor visibility / night time conditions may potentially double the time to undertaken the survey and significantly increase costs (~ $12 M at a daily survey cost of ~ $165,000). In addition to the economic cost associated with extending the survey duration this would extend the period of restricted access to commercial fishers in the area and move the survey into the peak snapper spawning period (Oct). EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: A3.6 Night-time and Low Visibility Procedures will be implemented which accounts for if the observed numbers of fauna are higher than expected.	No impacts from seismic noise are predicted within the BIA for foraging olive ridley turtles or the habitat critical to the survival of the species for flatback turtles and neither area overlaps the FPZ. EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: A3.6 Night-time and Low Visibility Procedures will be implemented which accounts for if the observed numbers of fauna are higher than expected. As such costs for the implementation of further night time controls outweigh the environmental benefits.	No
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part B. B.3.Spotter Vessel(s) and Aircraft	For the survey there will be two support vessels allowing one vessel to be used as a spotter in areas where numbers of fauna are greater than anticipated.	A support vessel will be available to be used as a spotter vessel to be able to implement adaptive management procedures. The benefit is considered to outweigh the cost.	Yes
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part B. B.4 Increased Precaution zones and Buffer Zones	The application of existing low power and shut down zones have been applied to turtles. As such there is the potential that the application of these zones when turtles are observed will result in increased non-productive time at a cost to the project.	The environmental benefit of applying EPBC Act Policy Statement 2.1 Part A controls to turtles is considered marginal given the current information regarding the sensitivity of turtles to sound. As no impacts from seismic noise are predicted within the BIA for foraging olive ridley turtles or the habitat critical to the survival of the species for flatback turtles, further controls are not required above the requirements of EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part A which will be applied to turtles as a control to minimise impacts.	No
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic	The cost to implement PAM is considerable as it requires additional personnel and equipment that needs to be run for the duration of the program.	PAM only applies for cetaceans and as there are no BIAs associated with cetaceans in or near the survey area large numbers of cetaceans are not	No

exploration: Part B. B.5. Passive acoustic Monitoring		expected to be encountered. As such the costs outweigh the environmental benefits.	
EPBC Act Policy Statement 2.1 - Interaction between Offshore seismic exploration: Part B. B.6. Adaptive Management	Fauna numbers are expected to be low as most fauna identified in the area are transitory. The survey area is outside the habitat critical to the survival of the species for flatback turtles and foraging area for olive ridley turtles, thus it is it is unlikely that significant numbers of turtle will be encountered. In the event that observed numbers of fauna are higher than expected and result in higher than expected shutdowns the implementation of an adaptive management program would ensure that the survey can continue without significant time delays and therefore costs.	If the observed numbers of fauna are higher than expected, as determined by there being 3 or more shutdown/power-down for fauna in 24 hours: the following will be implemented: A support vessel, with a MFO, will travel along the acquisition line at a distance in front of the survey vessel of not greater than 8 km (allows 1 hour for the survey vessel to react). If 3 or more fauna are observed with a 2 km horizontal radius of the support vessel or are on a trajectory to enter the 2 km horizontal radius of the survey vessel the survey vessel will change acquisition lines. Three or more shutdowns indicated that fauna numbers are greater than predicted and also will affect the acquisition of data creating delays and increasing costs. The 2 km low power zone is used as this would result in the survey vessel having to power down.	Yes
Restrict the survey area to reduce the area of overlap with commercial fisheries	Full restriction of the areas of overlap with the fisheries, especially the TRF would have a significant impact on the survey making it not feasible as the TRF overlaps 3,295 km^2 of the FPZ which is 4,565 km^2, therefore 72% of the acquisition area would not be available. The survey acquisition area within the EP shows the area necessary to obtain the acquisition information required. The boundaries of the operational area has been set to define the maximum limit of where the seismic and support vessels will operate. Minor refinements can be made to these areas in consultation with marine users without significant cost.	Restricting the area of the survey so it does not overlap the fisheries areas would eliminate any restrictions to fishers requiring them to move from areas while being surveyed. Impacts can be minimised via ongoing consultation/communication with fishers and marine users where minor refinements can be made to the acquisition and operational areas to help facilitate access to areas, where it does not have an impact on obtaining the acquisition information required.	Partial
Reduce the survey area	Full restriction of the areas of overlap with the fisheries, especially the TRF would have a significant impact on the	Restricting the area of the survey so it does not overlap the fisheries areas would eliminate any restrictions to fishers requiring	Partial

	survey making it not feasible as the TRF overlaps 3,295 km^2 of the survey acquisition area which is 4,565 km^2, therefore 72% of the acquisition area would not be available. The survey acquisition area within the EP shows the maximum area to obtain the acquisition information required. The boundaries of the operational area has been set to define the maximum limit of where the seismic and support vessels will operate. Minor refinements can be made to these areas in consultation with marine users without significant cost.	them to move from areas while being surveyed. Impacts can be minimised via ongoing consultation/communication with fishers and marine users where minor refinements can be made to the acquisition and operational areas to help facilitate access to areas, where it does not have an impact on obtaining the acquisition information required.	
Decrease the source array volume	The cost associated with reducing the source array volume is minimal where it does not compromise the integrity of the survey data or objectives. A review of the sound source volume identified that a reduction of the source from 3,480 to ~ 2,380 in^3 would not compromise the integrity of the survey data or objectives.	An evaluation of the benefits associated with reducing the source array to ~ 2,380 in^3 indicates that the maximum (R_{max}) horizontal distances are slightly reduced (10 m). Although this is only an incidental change, given the potential for impact associated with underwater sound emissions this control measure has been adopted. This will reduce impacts to site-attached fish and invertebrates in the survey area.	Yes
Reducing the number of lines or shot points	The survey design has been developed to obtain the acquisition information in the most effective manner. The shot point spacing, which impacts the number of shots, has been optimised to be able to adequately image the data. If the shot point spacing is increased (reduction in shots) it becomes less effective to be able to differentiate between the primary signal and unwanted noise. The survey lines have been designed to be the least number and shortest survey duration while still meeting the acquisition objectives. The survey lines have been design to be the least and shortest while still meeting the acquisition objectives. The shortest and least numbers of lines reduces the time and therefore the cost of the survey.	Reducing the number of shots and lines would reduce noise associated impacts to fauna. The number of shots and lines have been reduced to the minimum required to achieve the acquisition objectives most efficiently and cost effectively. Further reductions would compromise the acquisition of data.	No

Increase minimum number of streamers for the survey to 16.	Whilst increasing the number of streamers would reduce the number of vessel passes for the survey, and result in a shorter survey duration, there are several issues that would result. Geophysically, due to the shallow water depths, an increased tow width means a lesser percentage of the survey area will adequately image the seabed, which in turn will significantly affect Santos's ability to remove the multiple energy within processing utilising 3D SRME algorithms, thus potentially compromising the geophysical objectives of the survey. Operationally, an increased number of streamers will result in increased depth of the lead-ins at the front end of the array, thus limiting the water depth the survey vessel can operate within. This has already been identified as a problem for a significant percentage of the survey area Commercially, there is a lack of survey vessels capable of towing 16 x 6/8 km spreads at 100 m+ separation, which means that the competitive tender becomes more of an issue, Furthermore, this raises issues related to availability of vessels. Whilst the Santos acknowledges that the larger in-sea towing configurations will reduce the number of vessel passes, the above factors also need to be taken into account. Santos considers operational constraints, geophysical objectives, environmental concerns and commercial viability when determining the optimum towing configuration. In this case, the primary factor is that of operational water depths, which precludes the usage of large streamer spreads.	Increasing the minimum number of streamers would increase line spacing, thereby reducing the number of lines and the area affected by peak received noise levels, and also reducing survey duration.	No
Avoiding infill activities/ overlapping sail	Methods for reducing the requirement for infill activities are:	Reducing the requirement for infill activities reduces survey duration and overlapping survey lines.	Yes

lines during infill activities	Steerable streamers to help maintain consistent cable shape which leads to less areas requiring infill. Using a using meet technique where towed streamers are wider at tail than front. This has proven to significantly reduce infill requirements without affecting technical objectives. The aim is to minimise the amount of infill required as this increases the survey time and costs. Reducing the amount of infill also means a reduction in overlapping lines.	These both reduce noise exposure to fauna as well as costs.	
Limiting operations to deeper-water areas where the abundance of site attached species are reduced	The survey acquisition area follows a fault plain on the northern side of the acquisition area. The width of the acquisition area boundary to the south is the minimum distance required to be able to adequately image the fault. Thus avoiding the shallower waters in this area will compromise the acquisition of data. The full power zone overlaps water depths <35 m where diverse and abundant site attached fish communities (including are syngnathid species) are likely to occur, by 3.6%.	Limiting operations to water depths >35 m will reduce impacts to site-attached fish and invertebrates likely to be more abundant in water depths < 35 m the survey area. However, the area <35 m equates to 3.6% of the FPZ where the source will be at full. Also as the survey lines will take approximately 27 hours to traverse sound exposure levels to these site attached species will be reduced.	No
Undertake the two permit area surveys as separate surveys.	Both permits have an obligation to undertake a seismic survey in 2017. There is a substantial (millions) cost associated with not undertaking this obligations. Undertaking the surveys is more efficient and cost effective as vessel, mobilisation and support costs are shared between the two permits.	Undertaking the two surveys together leads to more efficient sail lines and a smaller operating area than if the two surveys were undertaken separately as both surveys would need extended operational areas to be able to turnaround. Combining the surveys also leads to a reduction in time then if each survey was undertaken consecutively.	No
Loss of Catch Payment for commercial fishing licence holders for each month there is a loss of catch, based on an assessment of what the commercial fishing licence holder would have caught in the survey area	Increased costs for the survey.	As the survey area overlaps the TRF and there is a possible risk to commercial catch rates, the Loss of Catch Payment control measure adopts a cautious approach and will mean that, if the risk does eventuate, commercial fishing licence holders are no worse or better off as a result of the survey. For details of the measures please see “control measure and performance standard” section below. The Loss of Catch Payment	Yes

in that month "but for" the survey. Or Agreement with commercial fishing operator in relation to the potential impact of the survey on them		control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them. In the event of an agreement, the agreement will replace the Loss of Catch payment as the appropriate control measure.	
Adaptive management program based on monitoring noise levels and/or site attached species including syngnathid species and invertebrates.	Increased costs for the survey. Logistics to organise monitoring.	The mortality and mortal injury threshold for fish is exceeded within a distance of <165 m form the seismic source. Based on the impact assessment no long term impacts to fish or invertebrates were identified. However, syngnathid species are list marine species and site attached fish and invertebrates contribute to the biodiversity of the OSMP. Noise monitoring to validate noise levels during the survey was assessed and was not seen as providing a benefit as a control to reduce impacts to site attached species. In the case where there is no specific habitat where site attached species will be abundant, noise modelling does not provided for adaptive management. Monitoring of site attached species to identify any impacts on a survey prior to the Bethany survey or during the Bethany survey was also assessed. It is unlikely that there are significant site attached species within the previous survey area and the Bethany survey area, making it unlikely that these species would be able to be monitored in situ. As no long term impacts to site attached species were identified the cost and feasibility of monitoring was not seen to provide an environmental benefit.	No

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Physical such as mortality or mortal injury – plankton	I	Possible (c)	Very Low (1)
Physical such as mortality or mortal injury - invertebrates	II	Unlikely (b)	Very Low (1)
Physiological impacts – invertebrates	II	Unlikely (b)	Very Low (1)
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**

Impacts to commercial catch rates – prawn.	III	Unlikely (b)	Low (2)
Impacts to commercial catch rates – pearl oyster	II	Unlikely (b)	Very Low (1)
Physical impacts, such as mortality or mortal injury – fish	III	Unlikely (b)	Low (2)
Physical impacts, such as mortality or mortal injury – turtles and sea snakes	II	Unlikely (b)	Very Low (1)
Physical impacts, such as mortality or mortal injury – sharks and rays	II	Remote (a)	Very Low (1)
Physiological impacts – fish TTS	II	Possible (c)	Low (2)
Behavioural impacts – fish	II	Possible (c)	Low (2)
Impacts to commercial catch rates – fish	III	Possible (c)	Low (2)
Behavioural impacts – turtles, sea snakes, cetaceans	II	Possible (c)	Low (2)
Physical impacts – cetaceans TTS	II	Unlikely (b)	Very Low (1)
Behavioural impacts – cetaceans	III	Possible (c)	Low (2)
Physical impacts – divers	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
Undertake seismic acquisition in a manner that prevents injury and PTS impacts to cetaceans, whale sharks and turtles resulting from seismic sound emissions, consistent with EPBC Policy Statement 2.1	*Survey Timing* Seismic survey will be undertaken within 1 May – 30 September.	Daily reports
	EPBC Act Policy Statement EPBC Act Policy Statement Part A will be implemented for the survey for cetaceans, whale sharks and turtles with the following precaution zones: • 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.	MFO records
	Marine Fauna Observer EPBC Act Policy Statement Part B1: Two MFOs will be available, with one always on the seismic vessel and one on the support vessel when implementing controls for night-time operations within the turtle internesting buffer BIA and adaptive management procedures.	MFO records MFO has previous experience as an MFO.
	Adaptive Management Procedure If the observed numbers of fauna are higher than expected, as determined by there being 3 or more shutdown/power-down for fauna in 24 hours: the following will be implemented: • A support vessel will travel along the acquisition line, with a MFO, at a distance in front of the survey vessel of not greater than 8 km. If 3 or more fauna	MFO records

	are observed with a 2 km horizontal radius of the support vessel or are on a trajectory to enter the 2 km horizontal radius of the survey vessel the survey vessel will change acquisition lines.	
Survey lines are acquired as per survey acquisition plan	*Survey Line Acquisition* • Survey lines are acquired in a south-west/north-east direction • Pre-plot lines are 600 m apart • Survey acquired with a 12.5 m shotpoint interval and 4.5 knot tow speed	Record of survey line acquisition Record of acquisition parameters
Limitation on amount of infill acquired during the survey	*Infill Component* • Infill lines will comprise < 20% of the survey area *Streamer Configuration* • The streamer configuration will consist of: o steerable streamers o fan-mode technique	Record of % infill lines Record of streamer configuration
Delay between acquisition of overlapping pre-plot lines and infill lines	*Temporal Separation* • A period of no less than 24 hours must have elapsed before any infill lines that overlap previously acquired pre-plot lines can be shot	Record of survey line acquisition
Undertake seismic acquisition in a manner that prevents serious or irreversible impacts to plankton or fauna dependent on plankton as a food source	*Array Volume* • A seismic source of ~ 2,380 in^3 will be used to meet the geophysical objectives of the survey *Source Operation* • The source will not be operated at full power outside the FPZ • There will be no discharge of the source in waters outside the operational area *Survey Duration* • The survey will have a maximum duration of 75 days *Acquisition Pattern* • Conduct survey into or across the prevailing currents to reduce likelihood of plankton being impacted multiple times by the seismic source	Record of airgun array configuration Daily reports MFO records Record of survey line acquisition
Undertake seismic acquisition in a manner that prevents long term or population impacts to invertebrates, fish and turtles	*Array Volume and Source Level* • A seismic source of ~ 2,380 in^3 will be used to meet the geophysical objectives of the survey • The airgun array will have the following equivalent at source PK pressure levels: o <258 dB re 1 µ Pa @ 1 m (vertical plane)	Record of airgun array configuration JASCO modelling report SSV report Daily reports MFO records

	○ <251 dB re 1 µ Pa @ 1 m (horizontal plane - broadside) ○ <249 dB re 1 µ Pa @ 1 m (horizontal plane - endfire) The equivalent source level will be verified prior to commencement of the survey via a sound source verification (SSV) process *Source Operation* • The source will not be operated at full power outside the FPZ • There will be no discharge of the source in waters outside the operational area • Soft start procedures will be conducted in accordance with Part A of EPBC Policy Statement 2.1 *Survey Duration* • The survey will have a maximum duration of 75 days *EPBC Act Policy Statement* • EPBC Act Policy Statement Part A will be implemented for the survey for whale sharks and turtles • EPBC Act Policy Statement Part B1: Two MFOs will be available, with one always on the seismic vessel and one on the support vessel when implementing controls for night-time operations within the turtle internesting buffer BIA • *Adaptive management procedure (see above)*	
Undertake seismic acquisition in a manner that prevents significant impacts to listed marine fish, consistent with the MNES Significant Impact Guideline 1.1	*Array Volume* • A seismic source of ~ 2,380 in^3 will be used to meet the geophysical objectives of the survey *Source Operation* • The source will not be operated at full power outside the FPZ • There will be no discharge of the source in waters outside the operational area *Survey Duration* • The survey will have a maximum duration of 75 days	Record of airgun array configuration Daily reports MFO records
Undertake seismic acquisition in a manner that ensures that noise levels above turtle mortality or mortal injury thresholds, or the turtle behavioural disturbance threshold, are not received at the habitat critical to the survival of	*Array Volume* • A seismic source of ~ 2,380 in^3 will be used to meet the geophysical objectives of the survey *Source Operation* • The source will not be operated at full power outside the FPZ	Record of airgun array configuration Daily reports MFO records

the species for flatback or olive ridley turtles	• There will be no discharge of the source in waters outside the operational area • Soft start procedures will be conducted in accordance with Part A of EPBC Policy Statement 2.1 *Survey Duration* • The survey will have a maximum duration of 75 days *EPBC Act Policy Statement* • EPBC Act Policy Statement Part A will be implemented for the survey for whale sharks and turtles • EPBC Act Policy Statement Part B1: Two MFOs will be available, with one always on the seismic vessel and one on the support vessel when implementing controls for night-time operations within the turtle internesting buffer BIA • Adaptive management procedure (see above)	
Undertake seismic acquisition in a manner that ensures that potential impacts from the survey on conservation values of the Oceanic Shoals Marine Park (within the FPZ) will be consistent with the relevant Australian IUCN Reserve Management Principles and management plan objectives	*Array Volume* • A seismic source of ~ 2,380 in^3 will be used to meet the geophysical objectives of the survey *Source Operation* • The source will not be operated at full power outside the FPZ • There will be no discharge of the source in waters outside the operational area • Soft start procedures will be conducted in accordance with Part A of EPBC Policy Statement 2.1 *Survey Duration* • The survey will have a maximum duration of 75 days *EPBC Act Policy Statement* • EPBC Act Policy Statement Part A will be implemented for the survey for cetaceans, whale sharks and turtles • EPBC Act Policy Statement Part B1: Two MFOs will be available, with one always on the seismic vessel and one on the support vessel when implementing controls for night-time operations within the turtle internesting buffer BIA • Adaptive management procedure (see above)	Record of airgun array configuration Daily reports MFO records
Commercial fishing licence holders are no worse or better off as a result of the survey	*Loss of Catch Payment* • Payments to the commercial fishing licence holders for each month there is a loss of catch by the commercial fishing licence holder based on an	Commercial fishing licence holder catch disposal records showing a loss of catch compared to what they would have caught in

	assessment of what the commercial fishing licence holder would have caught in the survey area in that month "but for" the survey. • Payment will be calculated on Kg caught by species as per Catch Disposal Record average less average catch rates by species group multiplied by market price. • Period of payment will be until catch rates return to average for 3 consecutive months. • Where a commercial fishing licence holder wants to receive a loss of catch payment, they will need to provide Santos, or give the NTDPIR permission to provide Santos, with evidence of the average catch rates per species, and the Catch Disposal Records for the month. • If there are any issues with the level of proof of average catch rates or monthly Catch Disposal Records which the evidence given provides, Santos will, in consultation with the commercial fishing licence holders, engage an independent relevant expert to determine the issue. • The Loss of Catch Payment control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them. In the event of an agreement, the agreement will replace the Loss of Catch payment as the control measure.	the survey area in that month "but for" the survey. Loss of catch payment records. Consultation with commercial fishing licence holders about appointment of independent expert (if required). Independent relevant expert assessment record (if required). Or In the event of an agreement with a commercial fishing operator, the agreement will replace the Loss of Catch payment as the appropriate control measure, and the following measurement criteria will apply: Agreement with commercial fishing operator in relation to the potential impact of the survey on them Evidence of Santos adherence to terms of the agreement
	DMAC Safe Diving Distance from Seismic Surveying Operations • Where pearl diving and seismic activity is within 10 km of each other, a joint risk assessment will be conducted. • Where possible, concurrent seismic and diving activities will be avoided. If this is not possible, the activities will be prioritised and a simultaneous operations (SIMOPS) plan will be developed.	Joint risk assessment SIMOPS

Demonstration of ALARP and Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied?	No
If No ALARP must be demonstrated and demonstration of acceptability conducted for impacted receptors below.	
Demonstration of ALARP	
Based on the outcomes of the environmental risk assessment process and through the implementation of appropriate and comprehensive controls during the survey, Santos considers that the underwater noise impacts to environment and social receptors are reduced to ALARP.	

<table>
<tr><td colspan="2">Relevant legislative requirements and standard industry practices/guidelines have been applied to control the impact.
Additional controls have been evaluated and where practicable have been adopted. Additional controls, where there is no reduction in the level impact or the cost of implementation is grossly disproportionate to the potential reduction in the level of impact, have not.</td></tr>
<tr><td colspan="2">Demonstration of Acceptability - Plankton</td></tr>
<tr><td colspan="2">As described in Section 7.1.5.1, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on plankton:
• Mortality.
The assessment in Section 7.1.5.1 has been updated to take into account new research in regards to seismic noise impacts to plankton by McCauley et al. (2017) and modelling of this new data by CSIRO (Richardson et al. 2017). No change in the level of consequence was identified and impacts are still assessed as acceptable.
The worst-case consequence (or impact) associated with the survey was evaluated to have potential localised and short term impacts to this receptor –Consequence level (I).
Based upon the evaluation below, the potential impact to plankton from underwater sound is considered acceptable.</td></tr>
<tr><td>Internal context - Santos policy and standards</td><td>As per Action 3 of Santos EHS policy, Section 7.1.5.1 evaluated the potential impacts to plankton to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts.
As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements.</td></tr>
<tr><td>External context (stakeholders)</td><td>During initial consultation, the NT DPIR raised that there is a potential risk to the fishery, particularly if conducted during the peak spawning time of October to May, thus the survey timing was set to finish at the end of September. Further consultation with the TRF raised that tropical fish breed throughout the year but is thought to intensify Sept to May.
Notification was made to stakeholders on the 27.6.17 in regards to the new plankton research by McCauley et al. (2017). To date there has been no feedback or requests for further information.</td></tr>
<tr><td>Environment Context</td><td>As described in Section 5.5.3, the activity potentially overlaps with the start (September) of the peak/primary spawning season for tropical fish and pearl oyster (P. maxima).
Based on the impact assessment (Section 7.1.5.1):
• Impacts from the survey are estimated to be localised and in the order of up to ~8% of the OSS bioregion and ~17% of the OSMP. For plankton the OSS 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.
• This is in line with the results of the CSIRO model (Richardson et al. 2017) which showed that the impact of the seismic survey on zooplankton biomass was greatest in the Survey Region (survey acquisition area +2.5 km impact zone where 22% of the zooplankton biomass was removed) and declines as one moves beyond it to the Survey Region + 15 km (14% of biomass removed), and the Survey Region + 150 km (2% of biomass removed).
• The area of potential impact is based a larger seismic source (3,000 in^3 (Richardson et al. 2017)) than the Bethany seismic source (~ 2,380 in^3).
• Zooplankton populations' recovery quickly due to their fast growth rates, and the dispersal and mixing of zooplankton from both inside and outside of the impacted area. The CSIRO model ((Richardson et al. 2017) identified that the time for the zooplankton biomass to recover to pre-seismic levels inside the survey area, and within 15 km of the area, was only three days following the completion of the survey.
• Any mortality or mortal injury effects to fish eggs and larvae resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates of fish eggs and larvae, which are very high (exceeding 50% per day in some</td></tr>
</table>

	species and commonly exceeding 10% per day). For example, in a review of mortality estimates (Houde and Zastrow 1993), the mean mortality rate for marine fish larvae was M = 0.24, a rate equivalent to a loss of 21.3% per day. Sætre and Ona (1996) calculated that under the 'worst case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population, and they concluded that mortality rates caused by exposure to airgun sounds are so low compared to natural mortality that the impact from seismic surveys must be regarded as insignificant. • *Pinctada maxima* has a large distribution area, and the survey timing is outside of its peak spawning period, impacts and not likely to be significant at a population level, based on the fact that the species is a broadcast spawner where less than 1% of fertilised eggs survive (WA DoF 2017). • The survey overlaps the start of the peak commercial fish spawning period (Sept to May) for a maximum of 4 weeks. As this spawning period is over 6 months and a broader area than the survey area, impacts are not likely to be significant at a population level compared natural to mortality rates based on the area of impact in the broader OSS Bioregion and the predicted period of recovery of 39 days after the start of the survey and 3 days after the end of the survey (Richardson et al. 2017). • The area of potential impact is not identified as an important area for fauna that rely on plankton as a food source such as whale sharks, rays or cetaceans. • In light of new research on regards to seismic noise impact to plankton (McCauley et al 2017) additional controls as detailed by Richardson et al. (2017) were assessed and it was identified that the survey design, which for the majority of the time the survey lines will be across the predominate currents, will result in plankton being less likely to be impacted multiple times by the seismic source.
Legal and industry best practices	There are no specific legal and other industry best practice guidance to manage impacts to plankton.
Principles of ecologically sustainable development	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance. Specifically, the survey times were selected to avoid peak spawning activity. The assessment of seismic noise impact to plankton was updated to include new research in regards to seismic noise impacts to plankton and further controls assessed to ensure impacts remained ALARP. (b) No threats of serious or irreversible environmental damage to plankton or fauna dependent on plankton as a food source were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be localised and short term. (d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts and risks to plankton are considered to be acceptable. (e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts.

<table>
<tr><th colspan="2">Demonstration of Acceptability - Invertebrates</th></tr>
<tr><td colspan="2">As described in Section 7.1.5.2, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on invertebrates:
• mortality or mortal injury effect
• physiological impacts
The worst-case consequence (or impact) associated with the survey was identified to have potential localised and medium term impacts - Consequence level (III) for prawns and molluscs.
Modelled noise levels are below predicted noise levels to cause physical injury to soft or hard corals.
Based upon the evaluation below, the potential impact to invertebrates from underwater seismic sound is considered acceptable.</td></tr>
<tr><td>Internal context - Santos policy and standards</td><td>As per Action 3 of Santos EHS policy, Section 7.1.5.2 evaluated the potential impacts to invertebrates to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts.
As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements</td></tr>
<tr><td>External context (stakeholders)</td><td>During consultation the NPF raised concerns in regards to impacts to prawns in light FRDC research. Information from the EP provided to NPF and no further concerns raised. NPF acknowledge significant distance between the acquisition area and their main fishing area (23 – 47 km).
During consultation Pearl Producers Association raised concerns in regards to impacts to pearl oyster shell brood stock.</td></tr>
<tr><td>Environment Context</td><td>No listed invertebrate species or critical habitat for invertebrates species were identified within the survey area. Based on the habitat within the survey area several invertebrate species are expected to be present, two of these are commercially important; prawns and the pearl oyster (P. maxima). Based on this, an acceptable level of impact for invertebrates from the survey would be no long term population impacts as this would ensure that the biodiversity of species within the OSS bioregion and the OSMP is maintained.
Based on the impact assessment (Section 7.1.5.2) for invertebrates no long term population impacts were identified to invertebrate species from the survey based on:
• Within the survey acquisition area, where the seismic source will be at full power, approximately a third of the area has water depths between 40 – 60 m, where sponges and octocorals are likely to be present, and very limited areas < 35 m water depth (3.6% of the FPZ), where hard corals are likely to be present. Sound levels model for the survey are less than levels predicted to cause physical injury to corals.
• The NPF comprises 880,000 km^2 and the area of potential impact (4,800 km^2) represents only ~0.6% of the total NPF area.
• The survey period does not overlap the main migration of juvenile prawns across the region, with the migration of the main cohort occurring between November and March, with a possible second cohort migrating from April to June.
• Physiological impacts identified are unlikely to result in significant impacts to prawns or prawn populations in light of the small area of impact (~0.6% 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.
• Commercially targeted molluscs (P. maxima) has a very broad distribution throughout northern Australia and into Asia.
• The overlap of the FPZ with the POMF fishery area in the JBG is ~11%. Overlap of the FPZ with the potential fishing area in water depths <35 m water depth is 3.6%.
• 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). However, if mortality impacts did occur to site attached molluscs, it would be within natural mortality rates and unlikely to have long term or population effects based on the small area of impact (~0.7% of the OSS bioregion and ~1.4% of the OSMP) and that molluscs are likely to be widely distributed throughout the broader OSS bioregion and OSMP.</td></tr>
</table>

Legal and industry best practices met?	There are no specific legal and other industry best practice guidance to manage impacts to invertebrates. The invertebrate species within the survey area contribute to the biological diversity of the OSMP, thus the IUCN Reserve Management Principles for the OSMP Multiple Use Zone are applicable. The following principles applicable to fish: • The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. No long term or population impacts to invertebrates, including site attached molluscs, were identified thus the activity is not in conflict with the principle of sustainable use of natural ecosystems. • The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. No long term or population impacts to invertebrates, including site attached molluscs, were identified, thus the biodiversity and natural values of the reserve will be protected and maintained. • Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. The following management practices have been implemented to ensure that impacts to invertebrates are managed to ALARP to ensure ecologically sustainable use of the reserve is maintained: reducing the seismic sound source and restricting the amount of infill lines to minimise impacts to site attached invertebrates.
Principles of ecologically sustainable development met?	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations such as reduction of noise source to reduce potential impacts. (b) No threats of serious or irreversible environmental damage to invertebrates were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be localised and short-term and hence, would not impact on the biological diversity of the OSMP. (d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts to invertebrates were identified to be localised and short-term and hence, would not impact on the biological diversity of the OSMP. (e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts and include reducing the seismic sound source and restricting the amount of infill lines to minimise impacts to site attached invertebrates.

Demonstration of Acceptability - Fish	
As described in Section 7.1.5.3, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on fish: • Mortality, including injury leading to death • Temporary threshold shift • Behavioral changes • Commercial Catch Rate The worst-case consequence (or impact) associated with the survey was identified to have potential localised and short term impacts to fish –Consequence level (II) and potential localised and medium-term to catch rates – Consequence level (III). Based upon the evaluation below, the potential impact to fish and commercial fishery catch rates from underwater sound is considered acceptable.	
Internal context - Santos policy and standards	As per Action 3 of Santos EHS policy, Section 7.1.6 evaluated the potential impacts to fish and commercial fishery catch rates to ensure that the potential impacts are understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements, where applicable.
External context - Stakeholder expectations	TRF and Demersal fishery position is that site attached fish and fish stocks are either killed or displaced during seismic surveys and take a number of years to recover. Santos has assessed these impacts and through the implementation of

	applicable controls potential impacts can be managed to an acceptable level. See Environment Context. Santos has through its stakeholder consultation made a genuine effort to ensure impacts to stakeholders are minimised and that there is no financial impacts to commercial fishing licence holders from Santos' activities. Santos worked with stakeholders to understand any objection or concerns and implement appropriate controls to ensure impacts are ALARP and acceptable. This included an independent expert peer review and consideration of modelling provided from stakeholders in relation to cumulative sound exposures and potential effects to commercially targeted fish. The outcomes of these reviews have been considered in the assessment of impacts and risks.

Environment Context	An acceptable level of impact for listed marine fish has been identified by applying the significant impact criteria for vulnerable species from the Matters of National Environmental Significance, Significant Impact Guideline 1.1 (DoE 2013). The use of this criteria for determining acceptable levels of impacts is deemed applicable and conservative based on:
	• No syngnathids are listed as threatened or migratory under the EPBC Act; however, they are listed as marine species. The MNES Significant Impact Guideline 1.1 (DoE 2013) does not provide criteria for marine species, hence, using the criteria for the next level of protection, vulnerable, affords of level of conservatism.
	• Syngnathids are the only listed fish species identified in the survey area from the PMST search, hence, using the criteria for vulnerable species, affords of level of conservatism.
	The significant impact criteria applicable to fish species are:
	• *Lead to a long-term decrease in the size of an important population of a species. An important population is a population that is necessary for a species' long term survival and recovery (DoE 2013).* Though the sound exposure threshold for mortality and potential mortal injury for fish is predicted to be exceeded within a distance of < 210 m from the seismic source when at full power. No important fish populations were identified within the survey area based on:
	  ○ Of the 31 syngnathid species identified to potentially occur within the survey area, 19 species have been recorded in water depths < 35 m which constitutes 3.6% of the FPZ. Of the 12 species that may occur in depths >35 m, only eight have been recorded in the NMR, and only two species have been recorded in the deeper offshore waters of the Arafura Sea.
	  ○ From a total of 85 benthic sled samples collected during surveys within the OSMP (Heap et al. 2010; Anderson et al. 2011), there were just three captures of individual syngnathids. There were no syngnathids in the nine samples within the Bethany survey area and the 13 samples in the operational area (Table 5-14; Figure 5-18).
	  ○ Given the very low proportion of shallow waters (3.6% FPZ <35 m depth) overlapped by the FPZ, and the limited presence of bank features (7% of the FPZ) and absence of pinnacles in the FPZ, it is reasonable to conclude that the survey area is unlikely to include a high number of dense aggregations of site attached fish, or reef-associated demersal fish assemblages. These fish communities are more likely to be associated with shallow areas of the banks (<35 m depth) with high coverage of hard corals, with pinnacle features, or with shallow shoals such as Tassie Shoal and Evans Shoal.
	• *Adversely affect habitat critical to the survival of the species.* No habitat critical to the survival of fish species were identified within the survey area. Areas of soft or hard corals are typically associated with increased fish abundance. No physical or physiological impacts to soft or hard corals were identified. Three pinnacles ~20 km from the FPZ, where site attached fish may be present do not receive sound source levels above the mortality and potential mortality injury threshold or above the TTS exposure criteria.

	• *Disrupt the breeding cycle of an important population*. As detailed above no important fish populations were identified within the survey area. • *Interfere substantially with the recovery of the species.* There are no recovery plans in place for fish species identified within the survey area. No fish species identified within the survey area are listed as vulnerable or endangered. For quantitative risk assessment process, an acceptable level of impact has been set at 5%—i.e. <5% mortality in site attached fish assemblages due to underwater noise from the seismic source. As shown in Table 7-10: • The area potentially inhabited by site attached fish assemblages where received levels exceed the 207 dB PK threshold for fish with a swim bladder represents just ~0.8% of the total area of the OSMP and ~1.9% of the KEF. • The area potentially inhabited by site attached fish assemblages where received levels exceed a 215 dB PK threshold for fish with a swim bladder represents just ~0.3% of the total area of the OSMP and ~0.7% of the KEF. Based on the impact assessment (Section 7.1.5.3) in relation to catch rates: • The area of potential impact represents ~11% of the area of the Timor Reef Fishery (based on an area of 30,170 km^2, however, the FPZ extends outside the TRF area) and an average of 7.8% of the TRF catch is within this area based on data from 2013 – 2017 (Table 5-24). • The area of potential impact represents 0.36% of the area of the Demersal Fishery (based on an area of 386,300 km^2) and 0.03% of the Demersal Fishery catch is within the operational area so the percentage catch within the FPZ would be even less. • 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 75 days.

Legal and other requirements	There are no specific legal guidance to manage impacts to fish. Best practice guidance is available from the WA Department of Primary Industries and Regional Development (formerly Department of Fisheries) that details the following controls that have been implemented:
	- Avoid key times of year
	-'Soft starts' for every event
	- Avoid restricting movement of fish away from the source of seismic sounds
	- Minimise the sound intensity and exposure time of surveys.
	IUCN Reserve Management Principles for the OSMP Multiple Use Zone identify the following principles applicable to fish:
	• The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. No long term or population impacts to fish, including listed marine species and site attached fish, were identified, thus the activity is not in conflict with the principle of sustainable use of natural ecosystems.
	• The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. No long term or population impacts to fish, including listed marine species and site attached fish, were identified, thus the biodiversity and natural values of the reserve will be protected and maintained.
	• Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. The following management practices have been implemented to ensure that impacts are managed to ALARP to ensure ecologically sustainable use of the reserve is maintained:
	    • Reduction in the seismic noise source.
	    • Use of soft start procedures.
	    • Restricting the amount of infill lines to minimise impacts to site attached fish.

Principles of ecologically sustainable	a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance including survey

development met?	timing, reduction in sound source and catch loss payment to commercial fishing licence holders in the event that the potential impacts occur. b) No threats of serious or irreversible environmental damage to fish were identified. c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be localised and short-term and hence, would not impact on the biological diversity of the OSMP. d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts to fish were identified to be localised and short-term and hence, would not impact on the biological diversity of the OSMP. e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts and include reduction in the seismic noise source, use of soft start procedures and restricting the amount of infill lines to minimise impacts to site attached fish.
Demonstration of Acceptability – Sharks and Rays	
As described in Section 7.1.7, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on sharks and rays: • Mortality, potential mortality • Recoverable injury The worst-case consequence (or impact) associated with the survey was identified to have potential localised and long term impacts to this receptor –Consequence level (IV). Based upon the evaluation below, the potential impact to sharks and rays from underwater sound is considered acceptable.	
Internal context - Santos policy and standards met?	As per Action 3 of Santos EHS policy, Section 7.1.7 evaluated the potential impacts to sharks and rays to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements
External context (stakeholders)	During consultation, no objections or claims were raised by relevant stakeholders regarding potential acceptable levels of impact to sharks and rays associated with this activity.
Environment Context	As described in Section 5.5.5 and Section 5.5.6, six species of threatened sharks, seven species of migratory sharks and two species of migratory rays have the potential to occur within the area and therefore have the potential to be impacted by this activity. The DoEE SPRAT profile (DoEE 2017d) identifies increased noise levels as a potential threat to whale sharks. As sharks and rays lack a swim bladder it is thought that they are only capable of detecting the particle motion component of acoustic stimuli thus are less sensitive to sound pressures (Myrberg 2001). Based on the impact assessment (Section 7.1.5.4) for sharks and rays: • they are highly mobile and there is no indication that the area of potential impact includes any locations where significant shark or ray numbers occur. • the area of potential impact comprises ~0.7% of the wider OSS bioregion and ~1.5% of the OSMP. EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) will be implemented as a control measure for whale sharks, and additional controls B.3 Spotter vessel and B.6 Adaptive management will be implemented in the event whale shark numbers are greater than expected.
Legal and industry best practices	Recovery Plan for the White Shark (*Carcharodon carcharias)*) does not identify any threats or objectives that are relevant to the activity. The Sawfish and River Sharks Multispecies Recover Plan does not does not identify any threats or objectives that are relevant to the seismic noise. The Whale Shark (*Rhinocodon typus*) Recovery Plan identifies increased noise levels as a potential threat to whale sharks thus additional controls have been implemented for whale sharks.

Principles of ecologically sustainable development	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance and include additional controls for whale sharks. (b) No threats of serious of irreversible environmental damage to sharks or rays were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts though identified to be localised and long term, if eventuated would not be lead to irreversible environmental damage. (d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts to sharks and rays are considered to be acceptable. (e) Cost benefit analysis was undertaken to determine applicable controls based on localised and long term impacts.
Demonstration of Acceptability – Marine Reptiles	
As described in Section 7.1.5.5, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on marine reptiles (turtles and sea snakes): • Mortality, potential mortality • Recoverable injury • Behavioral disturbance The worst-case consequence (or impact) associated with the survey was identified to have potential localised and short term impacts to this receptor – Consequence level (II). Based upon the evaluation below, the potential impact to marine reptiles from underwater sound is considered acceptable.	
Internal context - Santos policy and standards	As per Action 3 of Santos EHS policy, Section 7.1.7 evaluated the potential impacts to marine reptiles to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements.
External context - Stakeholder expectations	The TRF raised concerns in regards mortality impacts to turtles and reputational issues for marine users as turtles an EPBC listed species. Santos has assessed these impacts and through the implementing of applicable controls potential impacts can be managed to an acceptable level.
Environment Context	Based on the impact assessment (Section 7.1.5.5): • Noise levels above turtle mortality or mortal injury threshold and the turtle behavioral disturbance threshold are not received at the habitat critical to the survival of the species for flatback turtles or olive ridley foraging BIA from any location within the Bethany survey area. • Noise levels above the turtle behavioral disturbance threshold are not received at the habitat critical to the survival of the species for flatback turtles or the olive ridley foraging BIA from any location within the Bethany survey area. • The six turtles likely to be present in the survey area are likely to be present with the broader OSS Bioregion. The area where noise levels exceed the mortality or mortal injury threshold represents ~1.6% of the OSS Bioregion, and 3.5% of the OSMP thus impacts at a population level would be unlikely. • Sea snakes are rarely found in water depths exceeding 30 m (Cogger 1975; Guinea 2013) which comprises ~0.3% of the FPZ. EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) will be implemented as a control measure for turtles, and additional controls B.3 Spotter vessel and B.6 Adaptive management will be implemented in the event turtle numbers are greater than expected.
Legal and other requirements	The six turtles that maybe present in the area are listed under the EPBC Act as either endangered or vulnerable. Five seasnakes that may occur in the area are listed marine species. The Recovery Plan for Marine Turtles in Australia 2017 – 2027 identifies seismic noise as a threat to turtles. The plan identifies that soft start

	provisions may afford protection to marine turtles and the action to implement soft start procedures has been identified as a control. The OSMP major conservation values include, internesting area for flatback and olive ridley turtles and foraging area for loggerhead and olive ridley turtles. No impacts from seismic source noise are predicted within any of the loggerhead or olive ridley turtle BIAs. The IUCN Reserve Management Principles for the OSMP Multiple Use Zone principles applicable to turtles are: • The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. No impacts from seismic source noise are predicted within any of the loggerhead or olive ridley turtle BIAs.No long term or population impacts to turtles were identified thus the activity is not in conflict with the principle of sustainable use of natural ecosystems. • The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. No impacts from seismic source noise are predicted within any of the loggerhead or olive ridley turtle BIAs.No long term or population impacts to turtles were identified, thus the biodiversity and natural values of the reserve will be protected and maintained. • Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. The following management practices have been implemented to ensure that impacts to turtles are managed to ALARP to ensure ecologically sustainable use of the reserve is maintained: EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) will be implemented as a control measure for turtles, and additional controls B.3 Spotter vessel and B.6 Adaptive management will be implemented in the event turtle numbers are greater than expected.
Principles of ecologically sustainable development	a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations by implementing the EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) as a control measure for turtles, and additional controls B.3 Spotter vessel and B.6 Adaptive management in the event turtle numbers are greater than expected to ensure impacts are ALARP. b) No threats of serious of irreversible environmental damage to turtles or seasnakes were identified from the risk assessment. c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be localised and short term with no impacts to turtle populations or the loggerhead or olive ridley turtle BIAs. d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts to turtles and seasnakes were identified to be localised and short-term and hence, would not impact on the biological diversity of the OSMP. e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts and include precautionary controls by implementing the EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) as a control measure for turtles, and additional controls B.3 Spotter vessel and B.6 Adaptive management in the event turtle numbers are greater than expected.
Demonstration of Acceptability – Marine Mammals	
As described in Section 7.1.5.6, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on marine mammals: • Temporary and Permanent Hearing Loss • Behavioral Disturbance • Acoustic Masking The worst-case consequence (or impact) associated with the survey was identified to have potential extensive (within the AMBA) and short term impacts to this receptor – Consequence level (III). Based upon the evaluation below, the potential impact to marine mammals from underwater sound is considered acceptable.	
Internal context - Santos policy and standards	As per Action 3 of Santos EHS policy, Section 7.1.9 evaluated the potential impacts to marine mammals to ensure that the potential impact is understood, and the control

	measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements
External context (stakeholders)	During consultation, no objections or claims were raised by relevant stakeholders regarding potential acceptable levels of impact to marine mammals associated with this activity.
Environment Context	As described in Section 5.5.9, four species of marine mammals listed as threatened and migratory under the EPBC Act have the potential to occur within the area though no BIAs were identified in the area. The Conservation Management Plan for the Blue Whale 2015-2025 (DoE 2015b) and Humpback Whale Recovery Plan 2005 – 2010 (DEH 2005c) defines underwater noise as a threat to this receptor thus are considered sensitive to underwater sound generated by this activity. Based upon the impact assessment (Section 7.1.9): • There is no indication that the area of potential impact includes any biologically important areas or migratory paths for marine mammals. • Cetaceans are highly mobile and expected to transit through the area. • The area of potential impact (temporary and permanent hearing loss) comprises 3.95% of the wider OSS bioregion. • The area of potential impact (behavioural disturbance) comprises 5.17% of the wider OSS bioregion. • As cetaceans are likely to be transiting through the area masking may occur until the cetacean has moved away from the survey area. EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) will be implemented as a control measure, and additional controls B.3 Spotter vessel and B.6 Adaptive management will be implemented in the event cetacean numbers are greater than expected.
Legal and industry best practices	The Conservation Management Plan for the Blue Whale 2015-2025 (DoE 2015b) and Humpback Whale Recovery Plan 2005 – 2010 (DEH 2005c) specifically identifies underwater noise as a threat to marine mammals. EPBC Policy Statement 2.1 has been developed to manage underwater sound impacts to cetaceans from seismic surveys. Part A and Part B (MMO) and will be implemented as a control measure.
Principles of ecologically sustainable development	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance. (b) No threats of serious of irreversible environmental damage to marine mammals were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be extensive but short term. (d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts and risks to marine mammals are considered to be acceptable. (e) Cost benefit analysis was undertaken to determine applicable controls based on extensive (within AMBA) and short term impacts.
Demonstration of Acceptability – Pearl Oyster Diving	
As described in Section 7.1.5.7, the following impacts were evaluated to understand the potential severity from underwater sound generated by this activity on commercial pearl divers. The worst-case consequence (or impact) associated with the survey was identified to have potential localised and medium term impacts to pearl diving activities– Consequence level (III). Based upon the evaluation below, the potential impact to pearl diving from underwater sound is considered acceptable.	
Internal context - Santos policy and standards	As per Action 3 of Santos EHS policy, Section 7.1.10 evaluated the potential impacts to pearl diving to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements

External context (stakeholders)	During consultation, no objections or claims were raised by relevant stakeholders regarding potential acceptable levels of impact to pearl diving associated with this activity.
Environment Context	As described in Sections 5.6.3 and 7.1.5.2, parts of the survey and operational areas are overlapped by an area where hand-harvesting (by drift divers) of individual adult pearl oyster (*P. maxima*) takes place between April and October. Harvesting occurs in waters depths <35 m which equates to ~3.6% of the pearl oyster area that overlaps the operational area. Impacts to divers will be managed by the implementation of UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations". NT DPIR data shows that no activity occurred in the area in 2013 -2015.
Legal and industry best practices	There are no specific legal and other industry best practice guidance to manage impacts to pearl divers, however the UK Diving Medical Advisory Committee (DMAC) guidance note "Safe Diving Distance from Seismic Surveying Operations" has been used to inform control measures to manage interactions with pearl diving activities.
Principles of ecologically sustainable development	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance. (b) No threats of serious of irreversible environmental damage to pearl divers were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be localised and medium term. (d) Conservation of biological diversity and ecological integrity is not relevant to pearl divers. (e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts.
Demonstration of Acceptability – Marine Parks	
As described in Section 7.1.5.1. to 7.1.5.7. and Section 7.1.5.9 impacts were evaluated to understand the potential severity from underwater sound generated by this activity on the multiple values of the Oceanic Shoals Marine Park: • Mortality, potential mortality • Recoverable injury • Behavioral Disturbance The worst-case consequence (or impact) associated with the survey was identified to have potential localised and long term impacts to the receptor sharks–Consequence level (IV) Based upon the evaluation below, the potential impact to the Oceanic Shoals Marine Park from underwater sound is considered acceptable.	
Internal context - Santos policy and standards met?	As per Action 3 of Santos EHS policy, Section 7.1.7 evaluated the potential impacts to sharks and rays to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements
External context (stakeholders)	During consultation, no objections or claims were raised by relevant stakeholders regarding potential acceptable levels of impact to the OSMP associated with this activity.
Environment Context	As described in Section 5.9 and Section 7.1.5.9. there is one KEF - carbonate bank and terrace system of the Van Diemen Rise (unique sea-floor feature) and one IMCRA provincial bioregion - Northwest Shelf Transition, that have the potential to be impacted by this activity. The FPZ is not within any biologically important areas (BIA). Biological communities identified within the KEF and IMCRA bioregion and therefore within the FPZ are plankton, corals, invertebrates (sessile filter feeders associated with hard substrate sediments of the deep channels - sponges, soft corals, sea cucumbers), fish – demersal and pelagic, sea turtles, sea snakes and sharks. Based on the impact assessment undertaken for these species see Sections: • Plankton –Section 7.1.5.1. • Invertebrates –Section 7.1.5.2. • Fish, demersal and pelagic –Section 7.1.5.3.

	• Sharks –Section 7.1.5.4. • Marine turtles –Section 7.1.5.5.1 • Sea Snakes – Section 7.1.5.5.2. • Marine Mammals –Section 7.1.5.6. The area of potential impact within the OSMP: • FPZ overlaps ~1.5% of the IMCRA provincial bioregion within the OSMP. • FPZ overlaps 17% of the KEF within the OSMP, and of this 10% is comprised of terrace features and 7% banks.
Legal and industry best practices	There are no specific legal and other industry best practice guidance to manage impacts to plankton or invertebrates. The IUCN Reserve Management Principles for the OSMP Multiple Use Zone are applicable. The following principles applicable to invertebrates, fish and turtles: • The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles. No long term or population impacts to invertebrates, including site attached molluscs, fish, including listed marine species, site attached fish and turtles, were identified thus the activity is not in conflict with the principle of sustainable use of natural ecosystems. • The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term. No long term or population impacts to invertebrates, including site attached molluscs, fish, including listed marine species, site attached fish and turtles were identified, thus the biodiversity and natural values of the reserve will be protected and maintained. • Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. The following management practices have been implemented to ensure that impacts to invertebrates and fish are managed to ALARP to ensure ecologically sustainable use of the reserve is maintained: reducing the seismic sound source, use of soft start procedures, and restricting the amount of infill lines to minimise impacts to site attached invertebrates and fish. • Management practices should be applied to ensure ecologically sustainable use of the reserve or zone. The following management practices have been implemented to ensure that impacts to turtles are managed to ALARP to ensure ecologically sustainable use of the reserve is maintained: EPBC Policy Statement 2.1 Part A and Part B.1 (MMO) will be implemented as a control measure for turtles, and additional controls B.3 Spotter vessel and B.6 Adaptive management will be implemented in the event turtle numbers are greater than expected. There is no specific legal guidance to manage impacts to fish. Best practice guidance is available from the WA Dept. of Fisheries that details the following controls that have been implemented: • Avoid key times of year • Soft starts' for every event • Avoid restricting movement of fish away from the source of seismic sounds • Minimise the sound intensity and exposure time of surveys. Recovery Plan for the White Shark (*Carcharodon carcharias)*) does not identify any threats or objectives that are relevant to the activity. The Sawfish and River Sharks Multispecies Recover Plan does not does not identify any threats or objectives that are relevant to the seismic noise. The Whale Shark (*Rhinocodon typus*) Recovery Plan identifies increased noise levels as a potential threat to whale sharks thus additional controls have been implemented for whale sharks. The six turtles that maybe present in the area are listed under the EPBC Act as either endangered or vulnerable. Five sea snakes that may occur in the area are listed marine species. The Recovery Plan for Marine Turtles in Australia 2017 – 2027 identifies seismic noise as a threat to turtles. The plan identifies that soft start provisions may afford protection to marine

	turtles and the action to implement soft start procedures has been identified as a control. The OSMP major conservation values include, internesting area for flatback and olive ridley turtles and foraging area for loggerhead and olive ridley turtles. No impacts from seismic source noise are predicted within any of the loggerhead or olive ridley turtle BIAs. The Conservation Management Plan for the Blue Whale 2015-2025 (DoE 2015b) and Humpback Whale Recovery Plan 2005 – 2010 (DEH 2005c) specifically identifies underwater noise as a threat to marine mammals. EPBC Policy Statement 2.1 has been developed to manage underwater sound impacts to cetaceans from seismic surveys. Part A and Part B (MMO) and will be implemented as a control measure.
Principles of ecologically sustainable development	(a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance and include additional controls for marine fauna mitigation. (b) No threats of serious of irreversible environmental damage to values of the OSMP were identified. (c) The principal of inter-generational equity is not compromised as potential disturbance impacts though identified to be localised and long term, if eventuated would not be lead to irreversible environmental damage. (d) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts to the OSMP are considered to be acceptable. (e) Cost benefit analysis was undertaken to determine applicable controls based on localised and long term impacts.

7.2 Vessel and Helicopter Noise

7.2.1 Hazard

Noise emission subsea will occur from:

- Vessel engines and thrusters
- Helicopter rotors

7.2.2 Area that Might be Affected by the Hazard

All vessels emit underwater noise via machinery on the vessels transmitting sound through the hull and from propeller cavitation which is the loudest source. Kent et al. (2016) details that propeller cavitation noise is broadband due to the range of bubble sizes involved, from a few Hz to tens of kHz. Survey vessels in the absence of an operating acoustic source have been measure to have a broadband source level (SLbb) of 180–191 dB re 1 µPa @ 1 m (Hannay et al. 2004; Wyatt 2008 in Kent et al. 2016). This is on par with fishing vessels that have been measured to have a broadband source level (SLbb) of 174–195 dB re 1 µPa @ 1 m (Kent et. al. 2016).

Studies of the radiating underwater sound generated from the thrusters and propellers of support vessels when holding position indicate highest measured levels of up to 182 dB re 1Pa with levels of 120 dB re 1 µPa SPL RMS measured at 3–4 km (McCauley 1998).

Sound pressure in the water directly below a helicopter is greatest at the surface and diminishes with increasing receiver depth. Richardson et al. (1995) reports figures for a Bell 214 helicopter (stated to be one of the noisiest) being audible in air for four minutes before it passed over underwater hydrophones but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. Thus, noise from helicopter activities would be localised.

7.2.3 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 vessel and/or helicopter underwater sound include:

- Fish
- Sharks and rays
- Turtles

- Marine mammals - whales and dolphins (cetaceans)

7.2.4 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.

7.2.5 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 too 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. Based on the information from Richardson et al. (1995) that helicopter noise is detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth, underwater noise from a helicopter would be localised.

Reactions of cetaceans to circling aircraft (fixed wing or helicopter) are sometimes conspicuous if the aircraft is below an altitude of 300 m, uncommon at 460 m and generally undetectable at 600 m (NMFS, 2006).

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 vessel 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.

Underwater noise generated by the presence of the survey vessel 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.

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

The operational area overlaps an olive ridley foraging biologically important area, and is ~5.7 km from a habitat critical to the survival of the species for flatback turtles. Fish including commercial species are likely to be present in the area. Based on the support vessel noise levels there could be temporary behavioural disturbance to turtles and fish in the area.

Based on the extremely short duration that helicopter noise is likely to be heard underwater and the low frequency of helicopter flights to the seismic vessel during the survey (once a fortnight for crew change) impacts to transiting fauna such as shark, rays, cetaceans, fish that may be in the area and foraging and internesting turtles impacts from helicopter noise would be localised and short term (seconds).

Summary

Consequence Level: If the activity results in a disturbance to marine fauna from vessel or helicopter noise, there is potential for localised and short term impacts to animals of environmental value – (II).

Likelihood Level (Vessel): For this activity, localised and short term impacts to animals of environmental value resulting from vessel noise is considered Possible (c).

Likelihood Level (Helicopter): For this activity, localised and short term impacts to animals of environmental value resulting from helicopter noise is considered Unlikely (b).

Table 7-17: Vessel and Helicopter Noise Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The use of vessel and helicopters offshore is well practiced and potential impacts from vessel underwater sound well studied and understood. Sound levels associated with vessels and helicopters are not large enough to result in significant impacts. No objections or concerns were raised by relevant stakeholders regarding the generation of underwater noise from vessel or helicopters. Consequently, Santos believes that decision context A be applied to this hazard.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
EPBC Regulations 2000 - Part 8 Division 8.1 interacting with cetaceans describes the process to be followed when in proximity of cetaceans. Specifically, this requires: • Caution zones to be implemented. • Vessel speeds to be restricted within caution zones. • Height restrictions for helicopters within proximity of cetaceans	The Australian National Guidelines for Whale and Dolphin Watching (DEWHA, 2005) was developed jointly by the Australian and all state and territory governments through the Natural Resource Management Ministerial Council and describes strategies to ensure cetaceans are not harmed or disturbed from interactions with vessels and helicopters. These guidelines will be applied to turtles. By implementing this guideline, and restricting / minimising distances to marine fauna, exposure of noise emissions from vessels and helicopter operation will be minimised.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Disturbance to marine fauna from vessel noise	II	Possible (c)	Low (2)
Disturbance to marine fauna from helicopter noise	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
Vessels and helicopters meet the requirements of the EPBC Regulations Part 8	*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).	MFO records

<table>
<tr><td rowspan="2"></td><td>

- 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.

</td><td></td></tr>
<tr><td>

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.

</td><td>MFO records</td></tr>
<tr><th colspan="3">Demonstration of ALARP and Acceptability</th></tr>
<tr><td colspan="2">Is residual risk determined to be 1 and the ALARP Decision Framework A applied?</td><td>No</td></tr>
<tr><td colspan="3">If No ALARP must be demonstrated and demonstration of acceptability conducted for impacted receptors below.</td></tr>
<tr><th colspan="3">Demonstration of ALARP</th></tr>
<tr><td colspan="3">Based on the outcomes of the environmental risk assessment process and through the implementation of appropriate and comprehensive controls during the survey, Santos considers that the underwater noise impacts to environment and social receptors are reduced to ALARP.
Relevant legislative requirements and standard industry practices/guidelines have been applied to control the impact.
Additional controls have been evaluated and where practicable have been adopted. Additional controls, where there is no reduction in the level impact or the cost of implementation is grossly disproportionate to the potential reduction in the level of impact, have not.</td></tr>
<tr><th colspan="3">Demonstration of Acceptability</th></tr>
<tr><td colspan="3">As described, the following impacts were evaluated to understand the potential severity from vessel noise to fauna:

Predicted potential impacts to fauna would be limited to non-physiological effects such as

Behavioural changes.

Localised avoidance.

The worst-case consequence (or impact) associated with the survey was identified to have potential local (within the operational) and short term impacts to this receptor – Consequence level (III).
Based upon the evaluation below, the potential impact to marine fauna from vessel noise is considered acceptable.</td></tr>
<tr><td>Internal context - Santos policy and standards</td><td colspan="2">As per Action 3 of Santos EHS policy, Section 7.1.9 evaluated the potential impacts to marine mammals to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts.
As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements</td></tr>
<tr><td>External context (stakeholders)</td><td colspan="2">During consultation, no objections or claims were raised by relevant stakeholders regarding potential acceptable levels of impact to marine from vessel noise.</td></tr>
<tr><td>Environment Context</td><td colspan="2">Underwater noise generated by the presence of the survey vessel 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.
As there are no breeding, feeding or resting area for cetaceans, sharks or rays in or near the survey area, impacts would be to transiting cetaceans, sharks or rays and would be limited to local avoidance of the area.
The operational area overlaps an olive ridley foraging biologically important area and is ~ 5.7km from a habitat critical to the survival of the species for flatback turtles. Fish including commercial species are likely to be present in the area. Impacts from vessel noise will be short term as the vessel transits through an area.</td></tr>
</table>

Legal and industry best practices	EPBC Regulation Part 8 will be implemented to cover both cetaceans and turtles. Policies, guidelines, plans of management, recovery plans, threat abatement plans and other relevant advice issued by government agencies relevant to noise sensitive receptors have been taken into account in assessing potential risks and impacts. The Recovery Plan for Marine Turtles does not identify vessel noise as a threat. The Conservation Management Plan for Blue Whales identifies shipping as a threat. Actions form this plan were only relevant to Blue whale BIAs which are not in or near the survey area. Blue, Finn and Sei Whale Recovery Plan, though no longer in force, did identify vessel noise as a threat. Recommended action of assess and manage physical disturbance and development activities, has been implemented via this impact assessment.
Principles of ecologically sustainable development	(f) Decision making processes integrated long and short term economic, environmental, social and equitable considerations on balance. (g) No threats of serious of irreversible environmental damage to fauna were identified. (h) The principal of inter-generational equity is not compromised as potential disturbance impacts were identified to be short term. (i) Conservation of biological diversity and ecological integrity have been considered in decision making as potential impacts and risks to fauna are considered to be acceptable. (j) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts.

7.3 Light Emissions

7.3.1 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.

7.3.2 Area that Might be Affected by the Hazard

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.

7.3.3 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 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 marine mammals (cetaceans). Cetaceans predominantly utilise acoustic senses to monitor their environment rather than visual sources (Simmonds et al. 2004).

7.3.4 Known and Potential Environmental Impacts

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

- Localised attraction

7.3.5 Evaluation of Environmental Impacts

Turtles

The operational area overlaps an olive ridley foraging biologically important area and is ~5.7 km from a habitat critical to the survival of the species for flatback turtles. Lighting from moving vessels has not been identified as a risk to foraging or internesting 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 (EA 2003). Internesting habitat is used by marine turtles to rest between laying eggs, and any incidental attraction during resting is not expected to impact on breeding success and given the distance offshore not expected to impact species recruitment.

Extent and Duration of Exposure and Identified Potential Impact

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 (75 days).

Flatback turtle nesting areas have been identified at the Tiwi Islands, with nesting occurring all year with peak nesting between June to September (DoEE 2017t. The Recovery Plan for Marine Turtles in Australia 2017 - 2027 (DoEE 2017t) has recently been released and specifies a 60 km internesting buffer for flatback turtles. Figure 5-26 shows that the internesting buffer is 5.7 km from the Operational Area and thus unlikely to be impact from light from vessels.

The operational area overlaps an olive ridley foraging biologically important area (~ 9% based on the BIA is 3,246 km^2 and the area of overlap with the operation area is 292 km^2) (Figure 5-25). Hence, it is likely that these turtle species may be present in the area.

Lighting from moving vessels has not been identified as a risk to foraging or internesting turtles. Consequently, as light emissions would be localised, within metres of the vessel, and short term as the vessel moves through these areas at 4.5 - 5 knots (8-9 km/hour) for a duration of up to 75 days, impacts to fauna of environmental value are unlikely.

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). No biologically important area for marine birds have been identified in or near the AMBA.

Extent and duration of exposure and identified potential impact

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 (75 days). Though the Operational Area overlaps an olive ridley foraging biologically important area (~ 9%) lighting from moving vessels has not been identified as a risk to foraging or internesting turtles. Consequently, as light emissions would be localised, within metres of the vessel, and short term as the vessel moves through the area for a duration of up to 75 days, impacts to fauna area unlikely.

Summary

Consequence Level: If the activity results in a localised attraction of fauna to vessel lighting, there is the potential for localised and short-term impacts to animals of environmental value – (II).

Likelihood Level: For this activity, the localised attraction of fauna to vessel lighting resulting in a localised and short-term impacts to animals of environmental value is considered Unlikely– (b).

Table 7-18: Lighting Risk Assessment

<table>
<tr><th colspan="3">ALARP Decision Context</th></tr>
<tr><th>Decision Context</th><th colspan="2">Justification</th></tr>
<tr><td>A</td><td colspan="2">The use of vessels offshore and lighting at night is normal operations. Impacts of light to sensitive receptors is well understood. Though light sensitive marine fauna were identified as having the potential to be present in the area, there is a high level of certainty that in the unlikely event of localised attraction, any impact would be localised and temporary due to the size of the vessels, transitory nature of the vessels and short duration of the survey. There is little uncertainty associated with this aspect. No objections or concerns were raised by relevant stakeholders regarding light emissions from vessels. Santos believes that decision context A be applied to this hazard.</td></tr>
<tr><th colspan="3">Control Measure Identification</th></tr>
<tr><th colspan="2">Good Practice Control Measure</th><th>Control Measure Source</th></tr>
<tr><td colspan="2">Vessel lighting limited to that required for safe navigation under: Marine Order Part 30 (Prevention of Collisions) 2016</td><td>Lighting is required on vessels to ensure safe operations:
Marine Order Part 30 (Prevention of Collisions) 2016</td></tr>
</table>

Marine Order 59 (Offshore Support Vessel Operations) 2011 which describes the minimum requirements for navigational lighting	Marine Order 59 (Offshore Support Vessel Operations) 2011 Lighting not required to meet navigational and safe operational requirements will be prevented.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Localised attraction of fauna to vessel lighting	II	Unlikely (b)	Very Low (1)

Performance Outcome	Control Measure & Performance Standard	Measurement criteria
Lighting reduced to that required for navigational and safe operations to limit localised attraction of marine fauna.	*Vessel lighting requirements* External lights will be directed on deck, except where required for navigational purposes or safe operations.	Lighting inspection

Demonstration of Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.	Yes

7.4 Atmospheric Emissions

7.4.1 Hazard

The following vessel activities will generate atmospheric emissions:

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

7.4.2 Area that Might be Affected by the Hazard

Air emissions will disperse rapidly in prevailing winds and, given the volumes involved, are expected to result in a temporary and highly localised effect on ambient air quality.

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

No receptors identified in Table 5-1 are expected to be exposed to atmospheric emissions.

7.4.4 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

7.4.5 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 (75 days) and proximity to settlements (70 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 impact are unlikely.

<u>Summary</u>

Consequence Level: It is expected that a localised and temporary reduction in air quality and contribution to global greenhouse gas emissions has the potential to result in localised and short term environmental impacts – (I).

Likelihood Level: For this activity, a localised and short term decrease in air quality or contribution to global greenhouse gas emissions resulting in localised and short term impacts to sensitive environmental receptors is Unlikely– (b).

Table 7-19: Atmospheric Emissions Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The use of vessels offshore and generation of atmospheric emissions is normal operations. The management of vessel air emissions is well practiced and understood. Given the remote offshore location of the Bethany Survey, no sensitive environmental receptors were identified. There is little uncertainty associated with this aspect. The management of vessel air emissions is well regulated. No objections or concerns were raised by relevant stakeholders regarding atmospheric emissions from vessels. Santos believes that decision context A be applied to this hazard.

Control Measure Identification	
Good Practice Control Measure	**Control Measure Source**
IMO MARPOL 73/78 Annex VI which requires that: • Sulphur content of fuel oil not to exceed 3.5% thus reducing quantities of sulphur oxides produced. • Vessels with gross tonnage > 400 t have International Air Pollution Certificate (IAPP).	Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007 gives rise to MARPOL 73/78. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations. MARPOL includes 6 Annexes of which Annex VI provides regulations for the prevention of air pollution from ships.
IMO MARPOL 73/78 Annex VI, Chapter III Regulation 16 and Appendix IV specifically requires that if using an incinerator: • The incinerator has an IMO certificate. • Personnel responsible for operation of the incinerator are trained.	Maritime Legislation Amendment (Prevention of Air Pollution from Ships) Act 2007 gives rise to MARPOL 73/78. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations. MARPOL includes 6 Annexes of which Annex VI provides regulations for the prevention of air pollution from ships. Specifically, Appendix IV - Requirements for Control of Emissions from Ships describes the requirements for shipboard incineration.
Contractor Vessel Planned Maintenance System	Ensure that generators and engines are maintained in accordance with the Planned Maintenance System.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Localised and temporary decrease in air quality	I	Unlikely (b)	Very Low (1)
Contribution to global greenhouse gas (GHG) effect	I	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
Atmospheric emissions from diesel combustion are limited to those necessary for operation to minimise contribution to GHG effect.	*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 source.	Bunker receipts confirm the use of low-sulphur marine grade diesel.
	Equipment maintenance Vessel engines will be maintained in accordance with Planned Maintenance System.	Maintenance records confirm engines are maintained to schedule.

	Air Pollution Certificate Vessels with gross tonnage > 400 t will have International Air Pollution Certificate (IAPP).	IAPP certificate
	MARPOL Annex VI; Control of Emissions from Ships – Shipboard Incineration If incineration is undertaken, incinerator has IMO certificate.	IMO incinerator certificate
	Training Personnel responsible for operation of the incinerator are trained.	Training records
Demonstration of Acceptability		
Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.		Yes

7.5 Waste Water Discharges

7.5.1 Hazard

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

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

7.5.2 Area that might be affected by the Hazard

Monitoring of waste water discharges (sewage, cooling water and produced water) from a floating production, storage and offloading (FPSO) facility did not detect elevated contaminants within ~250 m down-current of the vessel (the first sample site) (GHD 2014). The volume of discharges from a FPSO would be significantly higher than from the seismic or support vessels so it is conservatively assumed that the area that might be affected by waste water discharges would be < 250 m from a vessel.

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

Based upon the receptors identified in Table 5-1, the following could be exposed to planned waste water discharges:

- Key ecological features
- Plankton
- Fish
- Sharks and rays
- Turtles
- Marine mammals – whales and dolphins (cetaceans)
- Commercially targeted fish and invertebrates

7.5.4 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 leading to toxic effects to marine fauna or habitats.

7.5.5 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>

As the vessels will be moving whilst discharging sewage and greywater, any changes to water quality will be limited to surface waters. Open marine waters are typically influenced by regional wind and large scale current patterns resulting in the rapid mixing of surface and near surface waters where sewage discharges may occur. Therefore, nutrients from discharge of sewage will not accumulate or lead to eutrophication due to the highly dispersive environment (NOPSEMA 2017).

As such, the receptors with the greatest potential to be impacted are those in the immediate vicinity of the discharge. Given that sewage discharges from vessels and facilities are at or near the surface, and are buoyant discharges, the receptors with the potential to be impacted are also those within or on surface waters; for example, plankton, fish and cetaceans (NOPSEMA 2017). Therefore, impacts are not predicted for benthic habitat sensitive receptors identified within the AMBA, such as Burrowers/Crinoids, Alcyon, Filterers, Gorgonians, Halimeda, Hard Coral, Macroalgae, Seagrass, and Soft Coral. The topographic complexity of the deep terrace features is likely to enhance vertical mixing of the water column and promote rapid mixing of nutrients.

Plankton communities have a naturally patchy distribution in both space and time (ITOPF, 2011). They are known to have naturally high mortality rates (primarily through predation), however in favourable conditions (e.g. supply of nutrients), plankton populations can rapidly increase. Once the favourable conditions cease, plankton populations will collapse and/or return to previous conditions. Plankton populations have evolved to respond to these environmental perturbations by copious production within short generation times (ITOPF, 2011). However, any potential change in phytoplankton or zooplankton abundance and composition is expected to be localised, typically returning to background conditions within tens to a few hundred metres of the discharge location (e.g. Abdellatif, 1993; Axelrad et al., 1981; Parnell, 2003).

Effects on environmental receptors along the food chain, namely, fish, reptiles, birds and cetaceans are therefore not expected beyond the immediate vicinity of the discharge in deep open waters.

While there is a potential for social values to be affected in the vicinity of ongoing discharges, due to the presence of particles and pathogens, far field impacts on social receptors such as recreational and commercial operators of fishing, diving and boating operations, are also not expected, due to the localised nature of the discharges and the rapid dispersion and dilution in open waters.

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 75 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 75 days, impacts to fauna including fauna or habitats of an environmental value or KEFs 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.

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

Given the small volumes of deck drainage, 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 (75 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 75 days, therefore, impacts to fauna including fauna of an environmental value or KEFs 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.

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

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 (75 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 75 days, therefore, impacts to fauna including fauna of an environmental value or KEFs 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.

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

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 (75 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 75 days, therefore, impacts to fauna including fauna of an environmental value or KEFs 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).

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

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 (75 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 75 days, therefore, impacts to fauna including fauna of an environmental value or KEFs are unlikely.

<u>Summary</u>

Consequence Level: It is expected a localised and short term impact on water quality from increased temperature, salinity, nutrients and hydrocarbons has the potential to result in localised and short-term impacts to KEFs or animals of environmental value– (II).

Likelihood Level: For this activity, impacts on water quality resulting in localised and short-term impacts to KEFs or animals of environmental value is Unlikely – (b).

Table 7-20: Waste Water Discharge Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The use of vessels and subsequent discharge of waste waters is normal during offshore operations. Impacts are well understood and the management of vessel waste waters is well practiced and understood. There is little uncertainty associated with this aspect. Discharge of waste water is regulated under internationally recognised and accepted practices and standards for some specific classes of vessels, no objections or concerns were raised by relevant stakeholders regarding waste water management, decision context A will be applied to this aspect.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
IMO MARPOL 73/78 Annex IV specifically requires that sewage discharges are treated via a MARPOL approved STP.	AMSA Marine Orders Part 96 (Sewage) gives effect to MAPOL Annex IV. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations.
Regulations 12 & 14 of IMO MARPOL 73/78 Annex I specifically requires that: • bilge water is treated through an Oil Water Separator to prevent the discharge of water with a >15 ppm oil in water content • discharge of bilge while en route	AMSA Marine Orders Part 91 (Marine pollution prevention – oil) gives effect to MARPOL Annex I. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations.
Santos Offshore Chemical Assessment Process	Santos' offshore chemical assessment process ensures that chemicals are evaluated and approved if there is the potential for release to the environment.
MARPOL Annex III requires that packaged harmful substances to be properly packed, marked, labelled, stowed and secured.	AMSA Marine Orders Part 91 (Marine pollution prevention – oil) gives effect to MARPOL Annex I. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations.
MARPOL Annex I requires that a vessel have an approved SOPEP on-board.	Under Marine Order 91 – a Shipboard Oil Pollution Emergency Plan is required to be in place and approved.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Localised and temporary impact on water quality	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
No discharge of untreated waste water discharges	*Sewage treatment plant* Sewage treated via a MARPOL approved sewage system prior to overboard discharge.	Valid International Sewage Pollution Prevention certificate.
		Maintenance records confirm sewage system maintained in accordance with the PMS.

	Oil-water separator Bilge water passes through a MARPOL approved oil-water separator and discharges do not exceed 15 ppm OIW content and will only be discharged en-route.	Oil Pollution Prevention certificate. Maintenance records confirm OWS calibrated and maintained in accordance with the PMS. Oil record book shows bilge water only discharged when <15 ppm OIW content and en-route.
	Operating Parameters Cooling water systems and fresh water generators operated within operating parameters.	Vessel inspection
	Chemical Assessment Santos Offshore Chemical Assessment Process used to assess and approve fluids with potential to be discharged to marine environment.	Completed and approved chemical assessment.
No spills to marine environment.	*Containment* Equipment, chemicals and hydrocarbons with the potential for spillage are contained.	Inspection records confirm equipment, chemicals and hydrocarbons with potential for spills are contained within appropriately bunded areas.
	Vessel SOPEP In the event of a vessel spill the vessel SOPEP will be implemented.	Records from oil spill response incident
	Vessel SOPEP kits will be available on vessels and stocked.	Vessel inspection

Demonstration of Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.	Yes

7.6 Waste

7.6.1 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.

7.6.2 Area that Might be Affected by the Hazard

Macerated food scraps (putrescible wastes) will be the only wastes discharged from the vessels and it is conservatively assumed that the area that might be affected would be < 250 m from a vessel given that it is expected to be much less than that of planned wastewater discharges documented in Section 7.5.

7.6.3 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 food scrap discharges are:

- Fish

Those that maybe impacted by windblown waste are:

- Fish
- Rays and Sharks
- Turtles
- Cetaceans

7.6.4 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
- Localised and temporary increase in nutrient matter

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

7.6.5 Evaluation of Environmental Impacts

Putrescible Wastes

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.

Extent and Duration of Exposure and Identified Potential Impact

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 75 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 75 days, therefore, impacts to fauna including fauna of an environmental value are unlikely.

Summary

Consequence Level: There is the potential for a localised and short term increase in nutrient matter to result in localised and short term impacts to animals of environmental value – (II)

Likelihood Level: For this activity, impacts on water quality resulting in an impact to animals of environmental value is considered Unlikely – (b)

Windblown Wastes

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

Extent and Duration of Exposure and Identified Potential Impact

Ingestion or entanglement of 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.

Summary

Consequence Level: If the activity results in the generation of marine or onshore litter, there is the potential for localised and short term impacts to animals of environmental value – (II).

Likelihood Level: For this activity, it is expected that the generation of marine and onshore litter resulting in a localised and short term impact to the environment is Unlikely – (b).

Table 7-21: Waste Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The use of vessels and subsequent discharge of macerated food scraps is normal during offshore operations. The management of vessel waste is well practiced and understood. There is little uncertainty associated with this aspect. The management of vessel waste is well regulated. No objections or concerns were raised by relevant stakeholders regarding waste management. Consequently decision context A will be applied to this aspect.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
IMO MARPOL 73/78 requires that food waste is macerated to ≤25 mm in size prior to overboard discharge.	AMSA Marine Order Part 95 (Marine pollution prevention — garbage) gives effect to MARPOL Annex V. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations.
Regulation 9 of MARPOL Annex V requires that a garbage / waste management plan and garbage record book is in place and implemented.	AMSA Marine Order Part 95 (Marine pollution prevention — garbage) gives effect to MARPOL Annex V. MARPOL is the International Convention for the Prevention of Pollution from Ships and is aimed at preventing both accidental pollution, and pollution from routine operations.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Marine and onshore litter	II	Unlikely (b)	Very Low (1)
Localised and temporary decrease in water quality	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
No unplanned discharge of waste to the marine environment.	*Waste Management Plan* Waste will be handled according to the vessel waste management plan.	Vessel waste management plan. Garbage Record Book details waste sent to shore and incinerated.
	Waste Management Plan Waste with potential to be windblown will be stored in covered containers.	Inspection records confirm waste with potential to be windblown is stored in covered containers.
	Waste Management Plan Waste blown overboard is recovered if possible.	Incident report
	Waste Management Plan Food scraps will be macerated to <25 mm size, and are only discharged overboard when vessel is greater than 3 nm from land.	Garbage Record Book details food macerated.

Demonstration of Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied?	Yes

If No ALARP must be demonstrated and the following must be met.	

7.7 Seabed Disturbance

7.7.1 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.

7.7.2 Area that might be affected by the Hazard

The area that may be affected by this hazard is limited to the survey operational area.

7.7.3 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

7.7.4 Known and Potential Environmental Impacts

Predicted potential impacts of seabed disturbance are:

- Disturbance to and/or loss of benthic habitat
- Damage to fishing equipment (from lost equipment)

7.7.5 Evaluation of Environmental Impacts

7.7.5.1 Disturbance to and/or loss of benthic habitat

As described in Section 5.3 the operational area overlaps three Key Ecological Features including:

- The carbonate bank and terrace system of the Van Diemen Rise,
- Pinnacles of the Bonaparte Basin and
- Shelf Break of the Arafura Shelf.

Based upon studies undertaken within proximity of the survey area (Section 5.5.1) it is expected that the most diverse benthic habitats (banks) would be comprised of sponges and octocorals. In addition to the benthic habitat, epifauna such as feather stars, sea pens, sea fans, sea whips, bryozoans and hydroids may also be present. Other habitats within the survey area are expected to comprise sandy substrates with low abundances of epibenthic fauna.

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

Seabed disturbance is not planned activity for this survey the reasons for this are:

- Anchoring will only occur in an emergency situation.

Streamer drag is not expected given that water depths across ~ 96% of the FPZ range from 35 m to 157 m. Streamer tow depth is 15-20 m, which means that there will be at least 15 m separation between streamers and the seabed. 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 case that one of the events above 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.

<u>Summary</u>

Consequence Level: If the activity results in seabed disturbance / loss of benthic habitat there is potential for localised and short term impacts to an area of environmental value – (II).

Likelihood Level: For this activity, it is expected that disturbance to and/or loss of benthic habitat resulting in localised and short term impacts to an area of environmental value is Unlikely – (b).

7.7.5.2 Damage to fishing equipment (from lost equipment)

As described in Section 5.6.7 the survey area overlaps the TRF which is currently conducting a trawl fishing trial and there is the potential that trawling occurs within the survey area. Currently there is one licensee undertaking trawling. The TRF covers an area of 30,170 km^2, the Bethany operational area covers 9,172 km^2 of the TRF (30%) and the Bethany FPZ covers 3,295 km^2 of the TRF (11%).

In the unlikely event that a piece of equipment is lost and unable to be recovered, there is the potential to create a snag risk to trawl fishing operations. This could lead to damage to trawling equipment. To prevent this the location of any unrecoverable equipment would be communicated to the fishery.

<u>Summary</u>

Consequence Level: Lost equipment (that can't be recovered) could result in damage to trawl equipment. There is the potential for a localised and short term impact to a social value that would be readily treated – (II).

Likelihood Level: For this activity, the likelihood of losing equipment and it damaging trawl equipment is considered Unlikely (b).

Table 7-22: Seabed Disturbance Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	Seabed disturbance is not a planned aspect of this activity. As such there is an inherently low risk that seabed disturbance would occur. As the events that could create seabed disturbance are known and well understood, there is a high level of certainty that the event would result in a limited environmental impact. Several Key Ecological Features are present within the area and hard corals also have the potential to be present in water depths < 30 m (<0.8% of the Operational Area). However, any unplanned disturbance would be small in extent, and very unlikely to impact hard corals. As seabed disturbance is not a planned component of this activity, and as no objections or concerns were raised by relevant stakeholders regarding seabed disturbance, decision context A will be applied to this hazard.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
AMSA Marine Order 32, specifically requires that cargo is lifted in accordance with safe working loads.	The Navigation Act 2012 enacts Marine Order 32 (Cargo handling equipment). The purpose of this marine order is to prescribe matters for machinery and equipment on-board vessels that are used for loading or unloading cargo.
The IAGC Environment Manual for Worldwide Geophysical Operations 2013 specifically requires that: • Local traffic and the appropriate regulatory agencies should be notified when equipment is lost.	IAGC Environment Manual for Worldwide Geophysical Operations serves as guide for identifying factors to consider when developing an environmental management plan, and summarises industry best practice control measures for seismic surveys.

• Lost equipment must be retrieved as soon as possible after a sighting is reported.	
Streamers fitted with pressure activated, self-inflating buoys	Streamers fitted with pressure activated, self-inflating buoys is standard practice in the industry.
Vessel anchoring undertaken in emergency situations only	Vessel anchoring in emergency situations only is standard practice in the industry.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Disturbance to and/or loss of benthic habitat	II	Unlikely (b)	Very Low (1)
Damage to fishing equipment (from lost equipment)	II	Unlikely (b)	Very Low (1)

Performance Outcome	Control Measure & Performance Standard	Measurement criteria
No impact to benthic habitat from anchoring or dropped objects.	*Lifting management* Lifts across water will be undertaken within safe work loads.	Lifting checklists identify safe work loads.
	Vessel anchoring requirements Vessel anchoring will only occur in emergency situations	Vessel log of any anchoring.
	Streamer equipment Streamers will be fitted with pressure activated, self-inflating buoys.	Pre-start audit.
	Dropped object management Dropped objects will be recovered where feasible.	Log of dropped object recovery. Documented assessment if dropped object recovery not feasible.

Demonstration of Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.	Yes

7.8 Fauna Interactions

7.8.1 Hazard

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

7.8.2 Area that Might be Affected by the Hazard

The area that may be affected by this hazard is limited to the survey operational area.

7.8.3 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 fauna interaction include:

- Turtles
- Sharks and rays
- Cetaceans

7.8.4 Known and Potential Environmental Impacts

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

- Injury and/or death from vessel strike.

7.8.5 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 7-5).

There is limited data on other potential fauna such as turtles, sharks and rays potentially due to lack of collisions being notices 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 FPZ and operational area over the survey duration of the survey (up to 75 days). Within these areas, it is expected that numbers of cetaceans, sharks or rays present will be low and transitory as no feeding, breeding, aggregation or migration areas are present. The operational area is 5.7 km from a habitat critical to the survival of the species for flatback turtles and overlaps an olive ridley foraging biologically important area (~ 9% based on the BIA is 3,246 km^2 and the area of overlap with the operation area is 292 km^2). Hence, it is likely that these turtle species may be present in the area.

Though fauna with the potential to be struck or become entangled in equipment may be present in the area, 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 with 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.

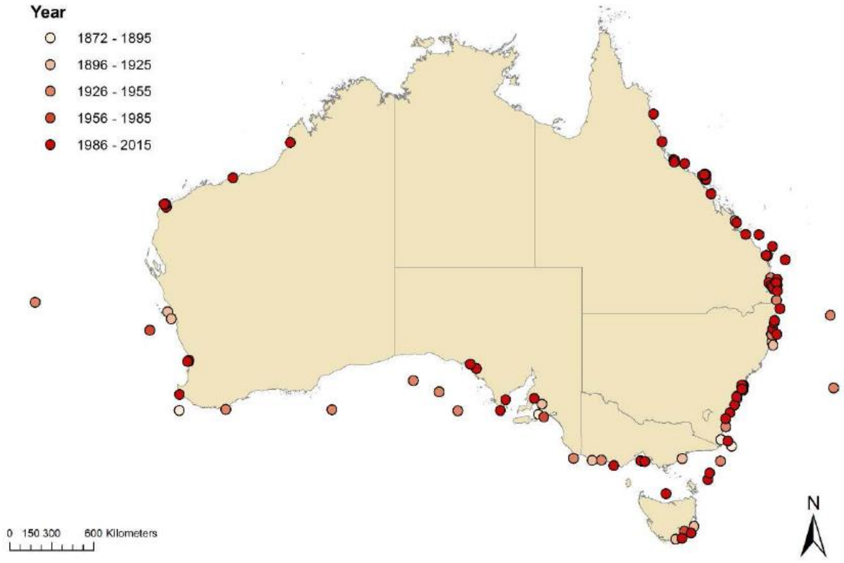


Figure 7-5: Approximate Locations of Fauna Vessel Strikes Causing Death (Peel et al. 2016)

Summary

Consequence Level: If the activity results in a vessel strike or entanglement there is potential for a localised and short term impacts to animals of environmental value– (II).

Likelihood Level: For this activity fauna injury or death resulting in a localised and short term impact to animals of environmental values is considered Unlikely (b).

Table 7-23: Fauna Interaction Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	Vessel interaction with marine fauna is not a planned activity. As such there is an inherently low risk that it would occur. The potential for vessel interaction with marine fauna is well understood. Although the Bethany Survey area overlaps a turtle foraging BIA the vessels will be slow moving and as such potential interactions were considered to be unlikely. The offshore management of fauna interactions is well regulated in Australia. No objections or concerns were raised by relevant stakeholders regarding fauna strike / interaction, and decision context A will be applied to this hazard.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
EPBC Regulations 2000 - Part 8 Division 8.1 interacting with cetaceans describes the process to be followed when in proximity of cetaceans. Specifically, this requires: • Caution zones to be implemented. • Vessel speeds to be restricted within caution zones. • Height restrictions for helicopters within proximity of cetaceans.	The Australian National Guidelines for Whale and Dolphin Watching (DEWHA, 2005) was developed jointly by the Australian and State and Territory governments through the Natural Resource Management Ministerial Council and describes strategies to ensure cetaceans are not harmed or disturbed from vessel and aircraft interactions.
EPBC Act Policy Statement 2.1. Part B.1 describes the engagement of engaging Marine Mammal Observers	EPBC Act Policy Statement 2.1 has been developed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) with the purpose of providing practical standards to minimise the risk of acoustic injury to whales in

(MMO) where there is a likelihood of interaction with cetaceans.	the vicinity of seismic survey operations. By implementing Part B.1 MMO the risk of physical interaction with fauna will be reduced.
Turtle guards	The use of tail buoy turtle guards on towed streamers to avoid trapping turtles in the equipment is a typical control utilised in the industry.
Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna requires that fauna strikes are reported.	Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna, specifically requires fauna strikes to be documented in the national Vessel Strike Database.

Residual Risk Ranking

Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Injury and/or death from vessel strike or entanglement	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
No injury and/or death to marine fauna caused by vessel strike or entanglement in streamers	*EPBC Regulations 2000 - Part 8 Division 8.1* Vessels with no streamers, 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). • Do not approach closer than the caution zones for whales and dolphins. • If cetacean shows signs of disturbance move away at a constant speed less than 6 knots.	MFO records
	EPBC Act Policy Statement 2.1. Part B.1 Seismic vessel with streamers deployed, will meet requirements of EPBC Act Policy Statement Part A and Part B.1: MMO.	MFO records
	Vessel/Fauna Requirements – streamers deployed Turtle guards fitted to tail and head buoys.	MFO records
	Fauna Strike Reporting Requirements Collisions with fauna will be reported via the online National Ship Strike Database.	National Ship Strike Database records

Demonstration of Acceptability

Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.	Yes

7.9 Marine Users Interactions

7.9.1 Hazard

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

7.9.2 Area that Might be Affected by the Hazard

The area that may be affected by this hazard is limited to the survey operational area.

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

Based upon the receptors identified in Table 5-1, marine users with the potential to occur within the survey operational area are:

- Shipping vessels
- Charter boat operator
- Northern Prawn Fishery
- Demersal Fishery
- Timor Reef Fishery
- Pearl Oyster Fishery
- Defence Activities (Exercise Kakadu)

7.9.4 Known and Potential Environmental Impacts

The known and potential environmental impacts of interactions with potential receptors are:

- Displacement of activities resulting in increased operating costs from operating in another area.
- Interference with movements of surface vessels, submarines and aircraft (Exercise Kakadu)
- Underwater noise impacts from airgun noise emissions on active and passive sonar operations (Exercise Kakadu)

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

7.9.5 Evaluation of Environmental Impacts

Transiting Vessels - Shipping Vessels and Charter Boat Operator

As described in Section 5.6.4 and Section 5.6.6, vessel activity within the AMBA is low. Low level commercial shipping traffic has been identified as passing through the AMBA, and only a single charter operator is known to operate within the AMBA.

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

Vessels transiting through the area, such as shipping vessels and charter boat operators, will not be restricted in their activities. Normal navigation at sea processes are undertaken whereby shipping vessels will move through the area using navigational aids to avoid the seismic vessel as they do any other vessels. In the worst case a vessel may need to go around the survey vessel which may result in them having to go 6.5 km from their route. 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 for vessel/streamer to pass).

<u>Summary</u>

Consequence Level: If the activity results in the displacement of transiting vessels, there is the potential for a localised and short term impact that is readily dealt with– (I).

Likelihood Level: For this activity, displacing transiting vessels resulting in a localised and short term impact is considered Possible (c) based on the low level of transiting vessels in the area.

Fishing Vessels

In the operational area, impacts to some of the fisheries can be minimised by coordinating access to fishing areas prior to and after the seismic vessel has surveyed an area. For safe operations, the seismic vessel will require other vessels to maintain a distance of 3 km from the vessel and seismic array to take into account any horizontal movement of the 6.5 km streamers.

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 – 5.0 knots (8-9 km/hr) along the sail lines. The long operational area around the survey acquisition area is required to allow the seismic vessel to turnaround without entanglement of the streamers. It takes approximately 27 hours to complete a sail line.

Coordinating access to fishing areas prior to and after the seismic vessel has surveyed an area will be managed by working with the fishers to coordinate the planned location of the survey vessel, on a frequency (daily, weekly etc.) that allows the fishers to be able to plan ahead. However, if fishers have to move from area to area prior to and/or after an area has been surveyed, this has the potential to result in increased costs of operation. Santos believes that fishers should not be financially disadvantaged from its operations and will make good additional operating costs associated with having to fish in another area due to the Bethany seismic survey.

Northern Prawn Fishery

The survey operational area overlaps a small proportion of the Northern Prawn Fishery main fishing area (Figure 5-31). The survey will overlap with the NPF Season 2 (1 August – 30 November) potentially for the period of August and September, depending on the survey start date.

The NPF is a trawl fishery and hence is moving within an area where the prawns are present. The operational area (where the vessel will turn-around) overlaps a small area (133.5 km^2) of NPF main fishing area (Figure 5-31). However, displacement of activities can be avoided by coordinating each party's activities so as not to restrict either party. Potential impacts will be within a localised area that needs to be avoided (~ 133.5 km^2 where areas overlap) and short term (in the order of hours as the vessel/streamers move from the overlap area).

<u>Summary</u>

Consequence Level: If the activity results in the displacement of the NPF, there is the potential for a localised and short term impact to a social value (II).

Likelihood Level: For this activity, displacement of the NPF resulting in a localised and short term impact is considered Unlikely (b) based on the very small area of overlap.

Demersal Fishery

Information provided by the NT DPIR in regards to the percentage of the Demersal Fishery catch (Table 5-22) shows that the there is a very low level of fishing activity in the operational area for the Demersal Fishery (0.03%) also the area of overlap of the operational area and the Demersal Fishery is 0.36% (see Section 5.6.6 for area calculation), hence interactions would be unlikely.

Displacement of activities can be avoided by coordinating each party's activities so as not to restrict either party. Potential impacts will be within a localised area that needs to be avoided (~ 133.5 km^2 where areas overlap) and short term (in the order of hours as the vessel/streamers move from the overlap area).

<u>Summary</u>

Consequence Level: If the activity results in the displacement of the Demersal Fishery, there is the potential for a localised and short term impact to a social value – (II).

Likelihood Level: For this activity, displacement of the Demersal Fishery resulting in a localised and short term impact is considered Unlikely (b) based on the very small area of overlap.

Timor Reef Fishery

Information provided by the NT DPIR shows that up to 32.14% of the Timor Reef Fishery (TRF) catch comes from the operational area (Table 5-22) hence interactions would be likely. There are currently two licensees operating in the operational area, one using trawling, as part of a trial, and one using trap and line.

The TRF does not have a closed season and consultation with the licensees is that they operate all year round.

The fishing methods used by the two licensees within the TRF, trawl and traps, mean the fishing vessels are not as mobile to be able move out of the way and return when the survey vessel has passed. Thus, fishing activity by the TRF is likely to be restricted within the operational area to ensure the safety of all parties. The area that is restricted can be minimised by daily communications to coordinate each party's activities.

Summary

Consequence Level: If the activity results in the displacement of the TRF, there is the potential for a localised and medium term impact– (III).

Likelihood Level: For this activity, displacement of the TRF resulting in a localised and medium term impact is considered Likely (e) based on the area of overlap.

Pearl Oyster Fishery

As described in Section 5.6.3, the operational area overlaps the Pearl Oyster Fishery. This fishery is seasonal and the survey will overlap the fishing season (April – October) potentially for the period of August and September, depending on the survey start date. Based on consultation with the Pearl Producers Association there is one licence holder (Paspaley) that potentially operates in this area with most of their fishing effort elsewhere. The NT DPIR confirmed that there had been no effort in this fishery since 2008.

The Pearl Oyster Fishery area is 9,680 km^2, with diving restricted to water depths less than 35 m. Within the area of overlap between the Pearl Oyster Fishery and operational area, water depths < 35 m are within an area of 560.6 km2 which equates to 6% of the operational area where the Pearl Oyster Fishery is likely to operate.

Displacement of pearl oyster diving can be avoided by coordinating each party's activities so as not to restrict either party.

Summary

Consequence Level: If the activity results in the displacement of the Pearl Oyster Fishery, there is the potential for a localised and short term impact to a social value – (II).

Likelihood Level: For this activity, displacement of the Pearl Oyster Fishery resulting in a localised and short term impact is considered Unlikely (b) based on the small area of overlap and one licence holder that operates in the area.

Fishing Vessels - Consultation and Control Measures

Consultation with commercial fishing operators potentially affected by the survey began in 2015, with early notification of the proposed seismic survey and provision of information. This consultation showed that some operators would not be affected, but that others may be and should continue to be consulted with.

In October 2016 the potentially affected commercial fishing operators were advised that the survey was planned for mid-2017 and EP development had commenced, and the operators were provided with information for the purpose of determining how the survey would impact them. Additional information was provided in January 2015, including a description of Santos' proposed control measures and management strategies. Negotiations also commenced about a commercial agreement to compensate commercial fishing operators who suffered loss because of the survey.

Table 4-2 shows the commercial fishing operators who were consulted with, and the *Extent and Duration of Exposure and Identified Potential Impact* section above shows the commercial fisheries most affected. In summary, information provided by the NT DPIR in regards to Northern Prawn, Demersal and Pearl Oyster fisheries shows that displacement can be avoided by coordinating each party's activities so as not to restrict either party. Santos has therefore proposed a good practice control measure of ongoing consultation with fishers, prestart notices and daily notifications of planned survey areas to facilitate access where possible and provide adequate notice to fishers and other marine users of activities. The survey has also been timed to avoid peak fishing and spawning times where possible. Taken together these control measures represent an appropriate response to consultation with the fishing vessel operators about potential interactions between them and survey vessels and the survey itself.

In respect of the Timor Reef Fishery (TRF), information provided by the NT DPIR shows that up to 12% of the TRF catch (7.8% 5-year average) comes from the operational area (Table 5-24) hence interactions would be likely. Santos has therefore proposed an additional good practice control measure for this potential impact on the TRF to ensure that potential impacts to this marine interaction will be reduced to as low as reasonably practicable and be acceptable, by way of a relocation expenses payment where TRF commercial fishing licence holders relocate to fish in another area during the survey and have operational expenses which are in addition to those they would have borne but for the seismic survey.

Santos expects to reach a commercial arrangement with the TRF commercial fishing licence holders before the survey commences, however there is no final agreement as at the EP submission date.

Due to the state of negotiations with the commercial fishing operators during the development of the EP, Santos developed a relocation expenses payment model as an appropriate control measure in the EP to ensure that potential impacts because of marine interactions are reduced to as low as reasonably practicable and are acceptable. This control measure is proposed in the EP Table 7-24 below, see the "Relocation expenses payment where commercial fishing licence holders relocate to fish in another area during the survey and have operational expenses which are in addition to those they would have borne but for the seismic survey" good practice control measure and the "Commercial fishing licence holders are no worse or better off as a result of the survey" as a performance outcome/control measure/performance standard/measurement criteria.

Santos consulted with an independent fisheries economist at the CSIRO about the model and whether it was as an appropriate control measure in the EP to ensure that potential impacts because of marine interactions are reduced to as low as reasonably practicable and are acceptable. CSIRO (2017) has confirmed the approach proposed by Santos for compensating fishers for their potential lost income is generally consistent with international best practice.

Santos has based the payment model control measure included in the EP on what it understands to be industry standard for an appropriately evidence based compensation model.

<u>Summary</u>

Taking into account the relatively low level of the potential impact of the survey on the fisheries, the advice from the independent expert, industry practice and feedback during consultation, the ongoing consultation during the survey and the Relocation expenses payment are appropriate control measures to ensure commercial fishing licence holders are no worse or better off as a result of the survey and ensure survey impacts because of potential marine interactions are appropriate, acceptable and reduced to as low as reasonably practicable.

In addition, Santos expects to reach a commercial arrangement with the TRF commercial fishing operators before the survey commences. In the event that Santos does reach commercial agreement with a TRF commercial fishing operator, that agreement will replace the Relocation expenses payment as the appropriate control measure in respect of compensation for potential impact on marine impacts.

Defence Activities – Exercise Kakadu

As described in Section 5.6.7, a major military exercise, Exercise KAKADU 2018, will be conducted within the NAXA over the period 31 August – 15 September 2018. The NAXA is comprised of the two PRD shown in Figure 5-42. The Bethany Operational Area and FPZ overlap the DRA that will be established for the exercise.

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

If the acquisition of the Bethany survey were to overlap Exercise Kakadu there is the potential for significant interference with the activities of military surface vessels, submarines and aircraft within and adjacent to the operational area. The physical presence of the survey vessel and towed array, and of the support vessel and helicopters, have the potential to disrupt and interfere with the movements of vessels, submarines and low-flying aircraft engaged in activities during this international military exercise.

Additionally, underwater noise emissions from the airgun array would potentially impact on active and passive sonar operations from both submarines and surface vessels engaged in the exercise. Conversely, underwater noise from sonar operations could significantly impact on the data quality of the returning seismic signals recorded on the streamer hydrophones.

During the stakeholder consultation process the Department of Defence expressed a view that Exercise Kakadu would be severely impacted by the Bethany survey under the proposed schedule. The nominated acquisition and operational areas for Bethany encroach on the DRA established for the exercise (see Figure 5-42). Defence have advised that the DRA is necessary to provide a suitable area with sufficient water depth to conduct required operations during the exercise, a requirement that cannot be met elsewhere within the surrounding area. Defence have proposed that acquisition of the Bethany survey be brought forward such that it is completed no later than 30 August 2018, and that this would be of mutual benefit to both Santos and Defence by removing any possibility of unintended impacts on each other's activities. Alternatively, postponing survey commencement to after 16 September 2018 would also achieve this aim.

Summary

Consequence Level: If the activity does not overlap with the timing of Exercise Kakadu, any potential impacts are of the lowest consequence level (I).

Likelihood Level: If the activity does not overlap with the timing of Exercise Kakadu, localised and short term impacts are considered Likely the likelihood of any impacts occurring is Remote (a).

Table 7-24: Marine User Interactions Risk Assessment

ALARP Decision Context			
Decision Context	**Justification**		
B	The survey area overlaps four commercial fisheries with various levels of impact and transiting vessels. Consultation with the Demersal and TRF have raised concerns in regards to being displaced from their fishing areas and increased costs of having to fish in other areas. These fisheries do not have a closed season so the survey timing has been scheduled to coincide with the lowest catch months. Defence have raised concerns in regards to impacts to activities during Exercise Kakadu. The management of vessel interactions is well regulated and seismic surveys have been successfully undertaken with fishers being able to access areas prior to and after they have been surveyed. As concerns have been raised by relevant stakeholders in regards to displacement from fishing area, Santos believes that decision context B be applied to this hazard.		
Control Measure Identification			
Good Practice Control Measure	**Cost**	**Benefit**	**Applied**
Navigation Act 2012 (enacted by AMSA Marine Orders 31, Vessel; Surveys and Certification) requires vessel class certification	Legal requirement thus has not been evaluated further.	The marine order requires vessel class to be certified to ensure that it meets the Navigational Act 2012 requirements thus minimising the likelihood of vessel collisions.	Yes
Navigation Act 2012 (enacted by AMSA Marine Orders 30, Prevention of Collisions) requires supply of information to the AHS enabling Notice to Mariners to be published.	Legal requirement thus has not been evaluated further.	Under the Navigation Act 2014, it is the responsibility of the Australian Hydrographic Service (AHS) to maintain and disseminate hydrographic and other nautical information and nautical publications including Notices to Mariners (NTM). NTM ensures vessels know about the seismic vessels being in the area and that it has limited capacity to manoeuvre thus minimising the likelihood of vessel collisions.	Yes
COLREGS - International Regulations for Preventing Collisions at Sea - International Regulations for preventing Collisions at Sea, 1972 - Rule 27 requires towed equipment to be identifiable.	Legal requirement thus has not been evaluated further.	As required by the COLREGS Rule 27 - Vessels not under command or restricted in their ability to manoeuvre, it is best practice to clearly marked or light streamer tail buoys to identify streamer ends to other users.	Yes

Use of support vessel to alert fishers and other users of the seismic vessel and associated streamers.	Increased operating costs of hiring a support vessel.	Two support vessels have been contracted with one to be used to alert fishers and other users of the seismic vessel presence. This will minimise the risk of a vessel collision or vessel running over the streamers.	Yes
Restrict the survey area to avoid areas of overlap.	Full restriction of the areas of overlap with the fisheries, especially the TRF would have a significant impact on the survey making it not feasible as the TRF overlaps 3,295 km^2 of the FPZ which is 4,565 km^2, therefore 72% of the acquisition area would not be available. The survey acquisition area within the EP shows the maximum area to obtain the acquisition information required. The boundaries of the operational area has been set to define the maximum limit of where the seismic and support vessels will operate. Minor refinements can be made to these areas in consultation with marine users without significant cost.	Restricting the area of the survey so it does not overlap the fisheries areas would eliminate any restrictions to fishers requiring them to move from areas while being surveyed. Impacts can be minimised via ongoing consultation/communication with fishers and marine users where minor refinements can be made to the acquisition and operational areas to help facilitate access to areas, where it does not have an impact on obtaining the acquisition information required.	Partial
Ongoing consultation with fishers and other marine users, prestart notices and daily notifications of planned survey areas to facilitate access where possible and provide adequate notice to fishers and other marine users of activities.	Additional costs to facilitate consultation and communications.	Ongoing consultation/communication with fishers and marine will allow fishers to be able to fish in areas before and after the area has been surveyed reducing impacts.	Yes
Undertake the two permit area surveys as separate surveys.	Both permits have an obligation to undertake a seismic survey in 2017. There is a substantial (millions $) cost associated with not undertaking these obligations. Undertaking the surveys together is more efficient and cost effective as vessel, mobilisation and support costs are shared between the two permits.	Undertaking the two surveys together leads to more efficient sail lines and a smaller operating area than if the two surveys were undertaken separately as both surveys would need extended operational areas to be able to turnaround. Combining the surveys also leads to a reduction in time than if each survey was undertaken consecutively. Thus, impacts to marine users would increase rather than decrease.	No

Undertake the survey lines in a north-west to south-east direction.	The sail lines on a south-east to north-west direction is the most efficient to allow the vessel to minimise the number of sail lines and hence turnarounds. A north-west to south-east direction would significantly increase the number of sail lines and would require a much larger area to the north-west to south-east areas to accommodate turns. This would increase the area over the Demersal Fishery, TRF and Pearl Oyster Fishery and where the charter boat operator operates. It would not eliminate the area that overlaps the NPF as this would change to another part of the NPF.	No benefit as the area of overlap for fishers and marine users would increase.	No
Timing of survey to avoid peak fishing and charter times	Based on stakeholder consultation with the main fishery that the survey overlaps (TRF) there is no closed season, the survey timing was based on there being less activity during June to mid-August. This also applies to the charter operator. The NPF season commences on 1 August to 1 December. The survey is planned to commence early July, after the Santos Fishburn survey being undertaken in the southern portion of the Joseph Bonaparte Gulf, which via commitments to the NPF will not be able to start until the 15 June, which is the start of the NPF closed season until 1 August. Options assessed were: Commence the Bethany survey in May, stop the survey to go and do the Fishburn survey and then recommence the Bethany survey. This option was not implemented as it had the potential to move the Bethany survey into October which is the spawning season for fish targeted by the Demersal and TRF.	The timing of May to end September was selected to avoid peak fishing, charter and spawning times where possible.	Yes

	Undertake the Fishburn and Bethany surveys with different vessels. This option was not implemented as it had a significant cost associated with contracting, mobilising and supporting two vessels.		
Relocation expenses payment where commercial fishing licence holders relocate to fish in another area during the survey and have operational expenses which are in addition to those they would have borne but for the seismic survey. Or Agreement with commercial fishing operator in relation to the potential impact of the survey on them.	Increased costs for the survey.	Allows commercial fishing licence holders to relocate their operations to another area during the survey without bearing the costs of operational expenses which are in addition to those they would have borne but for the seismic survey. For details of the measures please see "control measure and performance standard" section below. The Relocation expenses payment control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them. In the event of an agreement, the agreement will replace the Relocations expenses payment as the control measure.	Yes
Timing of survey to avoid Exercise Kakadu	Increased survey duration and costs if acquisition has to be stopped prior to commencement of Exercise Kakadu and then recommenced afterwards.	Eliminates the potential for any interference with activities of surface vessels, submarines and aircraft involved in the military exercise. Eliminates the potential for any impacts on seismic data quality from sonar operations.	Yes

Residual Risk Ranking

Potential Impact	Consequence	Likelihood (of consequence)	Residual Risk
Displacement of transiting vessels	I	Possible (c)	Very Low (1)
Displacement of NPF, Demersal Fishery and Pearl Oyster Fishery resulting	II	Unlikely (b)	Very Low (1)
Displacement of Timor Reef Fishery	III	Likely (e)	High (4)
Interference with activities of vessels, submarines and aircraft engaged in Exercise Kakadu	I	Remote (a)	Very Low (1)

Performance Outcome	Control Measure & Performance Standard	Measurement criteria
No unplanned interactions with marine users	*Navigational requirements* Class certificate demonstrates vessels comply with the Navigation Act 2012 and applicable Marine Orders.	Class Certificate
	Navigational requirements Tail buoys clearly marked / lighted to identify streamer ends to other users.	Pre-start audit
	Notifications Notice to Mariners via notifications to Australian Hydrographic Service a minimum of 3 weeks prior to commencement of activities.	Notification records to AHS Notice to Mariners
	Communication Daily communication will be undertaken with relevant fishers and other marine users. At a minimum the daily report will include: Current survey vessel position 72 hour look ahead for survey activities and location Support vessel activities and location Contact details for the survey and support vessel.	Daily communication report to fishers and marine users.
	Survey Planning Stakeholder requests to modify acquisition and operational areas will be met, where it does not have an impact on obtaining the acquisition information required.	Stakeholder consultation records. Documented assessment if stakeholder request not implemented, detailing how change requested would impact on obtaining the acquisition information required.
	Support Vessel A dedicated support vessel will be engaged to alert fishers and other users of the seismic vessel and towed streamers.	Daily report showing engagement of support vessel.
Commercial fishing licence holders are no worse or better off as a result of the survey	*Relocation Expenses Payment* • Where a commercial fishing licence holder relocates their operations to another area during the survey, Santos will make a one off payment to reimburse operational expenses which are in addition to those the commercial fishing licence holder would have borne but for the seismic survey. • Where a commercial fishing licence holder wants to be reimbursed any operational expenses, they will need to provide Santos with evidence of the operating costs of bait, fuel, wages and any other costs that are	Commercial fishing licence holder operating costs records. Relocation expenses payment records. Consultation with commercial fishing licence holder about appointment of independent expert (if required). Independent relevant expert assessment record (if required). Or

<table>
<tr><td></td><td>additional to the costs that would have been incurred to catch the fish but for the relocation.
• Following receipt of sufficient evidence of these additional operational expenses, Santos will make such payment within 30 days.
• If there are any issues with the level of proof of operational expenses which the evidence given to Santos provides, Santos will, in consultation with the commercial fishing licence holder, engage an independent accountant or other relevant expert to determine the issue.
• The Relocation expenses payment control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them. In the event of an agreement, the agreement will replace the Relocation expenses payment as the control measure.</td><td>Agreement with commercial fishing operator in relation to the potential impact of the survey on them.
Evidence of Santos adherence to terms of the agreement</td></tr>
<tr><td>No interactions with vessels, submarines and aircraft engaged in Exercise Kakadu</td><td>• Acquisition of the Bethany survey will not overlap the period 31 August – 15 September 2018.</td><td>Daily reports.
Stakeholder consultation records.
Survey commencement and cessation notifications to Defence.</td></tr>
<tr><th colspan="3">Demonstration of ALARP and Acceptability</th></tr>
<tr><td colspan="2">Is residual risk determined to be 1 and the ALARP Decision Framework A applied?</td><td>No</td></tr>
<tr><td colspan="3">If No ALARP must be demonstrated and demonstration of acceptability conducted for impacted receptors below.</td></tr>
<tr><th colspan="3">Demonstration of ALARP</th></tr>
<tr><td colspan="3">Based on the outcomes of the environmental risk assessment process and through the implementation of appropriate and comprehensive controls during the survey, Santos considers that the displacement impacts to marine users are reduced to ALARP.
Relevant legislative requirements and standard industry practices/guidelines have been applied to control the impact.
Additional controls have been evaluated and where practicable, have been adopted. Additional controls, where there is no reduction in the level impact or the cost of implementation is grossly disproportionate to the potential reduction in the level of impact have not.</td></tr>
<tr><th colspan="3">Demonstration of Acceptability</th></tr>
<tr><td colspan="3">As described in Section 7.9.5, impacts to marine users from being displaced from the seismic survey area for the period of the survey (up to 75 days) were evaluated to identify the potential level of impact (consequence). In the worst case this was identified to be localised (within the operational area) and medium term (75 days) for the Timor Reef Area – Consequence level – III.
Based upon the evaluation below, the potential impacts to marine users if they are displaced from the operational area for all or part of the survey duration is considered acceptable.</td></tr>
<tr><td>Internal context - Santos policy and standards met?</td><td colspan="2">As per the EHS Policy Santos is committed to manage the impact of our operation on the environment. Santos has through its stakeholder consultation made a genuine effort to ensure impacts to stakeholders</td></tr>
</table>

	are minimised and that there is no financial impacts to commercial fishing licence holders from Santos' activities. Environmental considerations were taken into account in the business planning and decision making process for the survey such as timing and area of acquisition. Via consultation with stakeholders Santos has been able to understand the impacts of the survey on marine users and implement controls to manage those impacts. All relevant laws will be implemented. Santos has been pro-active and collaborative when working with stakeholders to understand any objection or concerns and implement appropriate controls.
External context - Stakeholder expectations met?	No concerns were raised in regards to displacement from fishing areas from the NPF, charter operator or Pearl Oyster Fishery. Concerns have been raised by the TRF and Demersal Fishery in regards to increased operating costs and loss of catch if they have to move to another area to fish. Santos has committed to a Relocation Expenses Payment and a Loss of Catch Payment as detailed in the performance outcomes and standards in this Table (Table 7-24) and Table 7-16, respectively. Daily communications will also be implemented to coordinate each party's activities so as not to restrict either party. Changes to the survey area can also be facilitated where it does not impact on obtaining the acquisition information required. The Department of Defence request that there be no overlap in timing of the survey and Exercise Kakadu has been addressed and the relevant control will be complied with. This has been communicated to Defence accordingly.
Environment Context	Based on the impact assessment (Section 7.9.5): • NPF – the area of displacement is very small and can be managed via coordinating each party's activities so as not to restrict either party. • Pearl Oyster Fishery – the area of displacement is 6% and can be managed by coordinating each party's activities so as not to restrict either party. There is one licence holder that operates within the Pearl Oyster Fishery that overlaps the survey operational area. • Demersal Fishery – the average percentage catch in the area where displacement would occur is 0.03% of the fishery. There is one active licensee within the Demersal Fishery area that overlaps the survey operational area. • TRF - the average percentage catch in the area where displacement would occur is 32.14% of the fishery. There are two active licensees within the TRF area that overlaps the survey operational area. • Santos has committed to a Relocation Expenses Payment and a Loss of Catch Payment as detailed in the performance outcomes and standards in this Table (Table 7-24) and Table 7-16, respectively. • The period of displacement, in the worst case, would be for the full survey period which is up to 75 days.
Legal and other requirements met?	The applicable navigational requirements will be implemented to minimise the likelihood of a vessel collision.
Principles of ecologically sustainable development met?	Decision making processes integrated long and short term economic, environmental, social and equitable considerations by selecting a timing where marine user activity is lowest, facilitating changes to the survey area, where there is no impact to obtaining the required acquisition information and committing to a Relocation Expenses Payment and a

	Loss of Catch Payment where commercial fishing licence holders are impacted. No threats of serious of irreversible environmental damage were identified from the risk assessment. The principal of inter-generational equity are not compromised as potential disturbance impacts were identified to be localised and medium term (less than 12 months). Conservation of biological diversity and ecological integrity are not relevant to this hazard. Cost benefit analysis has been used to determine applicable controls.

7.10 Introduction of Marine Pests

7.10.1 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.

7.10.2 Area that Might be Affected by the Hazard

The area that may be affected by this hazard is limited to the survey operational area.

7.10.3 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 Features
- Commercial Fisheries
- Recreational fishing

7.10.4 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.

7.10.5 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. Three KEFs are present within the area, and are regionally important and as they provide areas of hard substrate in an otherwise soft sediment environment. Based upon studies undertaken within proximity of the survey area (Section 5.5.1) it is expected that the most diverse benthic habitats (banks) would be comprised of sponges and octocorals. In addition to the benthic habitat, epifauna such as hard corals, feather stars, sea pens, sea fans, sea whips, bryozoans and hydroids may also be present. In the event that an invasive marine pest was introduced, there is the potential for localised impacts to an area that supports high diversity of fauna included commercial fish species and although possible, remediation would be difficult or expensive.

The vessels will be required to meet all quarantine requirements in regards to biofouling and ballast management, and the majority of the operational area is in water depths > 35 m (94.8%) 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.

Summary

Consequence Level: If the activity results in the introduction and establishment of marine pests, there is potential for a localised and long term impact to an area of significant environmental value– (IV).

Likelihood Level: For this activity, the introduction and establishment of a marine pest resulting in a localised and medium term impact to an area of significant environmental is considered Remote (a).

Table 7-25: Invasive Marine Species Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The introduction of marine pests is not a planned activity. As such there is an inherently low risk that it would occur. The use of vessels offshore is well practiced and the pathways for the introduction of an invasive marine pest well understood and regulated. Several Key Ecological Features are present within the area and threatened hard corals also have the potential to be present. However, the introduction of an IMP into this area is not expected to rapidly spread due to the fragmented nature of the marine habitat in the region. The introduction of marine pests was raised by the WA DoF and advice provided in relation to guidance material to minimise the risk of an introduction. These guidelines have been identified as control measures and consequently decision context A will be applied to this hazard.

Control Measure Identification	
Good Practice Control Measure	**Control measure source**
Biosecurity Act 2015 specifically: Pre-arrival information must be reported through the Maritime Arrivals Reporting System (MARS) prior to arrival in Australian waters	This ensures that the biosecurity risk of the vessel is identified, and that biosecurity inspections undertaken prior to arrival in Australian waters.
Australian Ballast Water Management Requirements Version 7 (DAWR 2017) specifies the standard requirements for managing ballast water discharges	Australian Ballast Water Management Requirements Version 7, specifically: • The survey vessel will have a Ballast Water Management Plan (BWMP) and a Ballast Water Management Certificate (BWMC) • Maintenance of a Ballast Water Record System, and ensuring that all operations are recorded in this system • Ballast Water Reports are to be submitted through the MARS • If the survey vessel intends to discharge internationally sourced ballast water a Ballast Water Report must be submitted through MARS at least 12 hours prior to arrival • The survey vessel will only use ballast water exchange methods described in the BWMP
Guidelines for the Control and Management of Ships' Biofouling to Minimize the	The Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species (Biofouling

Transfer of Invasive Aquatic Species (Biofouling Guidelines) MPEC.207(62)) 2011	Guidelines) MPEC.207(62)) 2011 Specifically required to be available and maintained: • Biofouling management plan • Biofouling record book
Protection of the Sea (Harmful Anti-fouling Systems) Act 2006 (enacted by AMSA Marine Order Part 98 (Marine pollution - anti-fouling systems).	An anti-fouling certificate is required to be in place for vessels.

Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Introduction and establishment of marine pests	IV	Remote (a)	Low (2)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
No introduction of marine pest species	*AQIS requirements* Overseas vessels contracted will receive AQIS clearance to enter Australian waters.	Record of formal AQIS quarantine clearance.
	Ballast Water requirements The survey vessel will have a Ballast Water Management Plan (BWMP) and a Ballast Water Management Certificate (BWMC) The survey vessel will maintain of a Ballast Water Record System, and all operations will be recorded in this system Any Ballast Water Reports will be submitted through the MARS If the survey vessel intends to discharge internationally sourced ballast water a Ballast Water Report will be submitted through MARS at least 12 hours prior to arrival The survey vessel will only use ballast water exchange methods described in the BWMP	BWMP & BWMC Ballast Water Record System Records of MARS submissions Records of ballast water exchange
	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.	Antifouling certificate Biofouling Management Plan Biofouling Record Book
	In-water equipment inspection In-water equipment will be inspected for biofouling and cleaned prior to deployment.	In-water equipment inspection records
	Reporting Suspected or confirmed marine pests or diseases will be reported to the Aquatic Biosecurity Unit of NT Fisheries within 24 hrs (Section 8.7).	Notification report to Aquatic Biosecurity Unit of NT Fisheries

Demonstration of Acceptability	
Demonstration of ALARP and Acceptability	
Is residual risk determined to be 1 and the ALARP Decision Framework A applied?	No
If No ALARP must be demonstrated and demonstration of acceptability conducted for impacted receptors below.	
Demonstration of ALARP	
Based on the outcomes of the environmental risk assessment process and through the implementation of appropriate and comprehensive controls during the survey, Santos considers that the risk of introducing marine pests is reduced to ALARP. Relevant legislative requirements and standard industry practices/guidelines have been applied to control the impact. Additional controls have been evaluated and where practicable, have been adopted. Additional controls, where there is no reduction in the level impact or the cost of implementation is grossly disproportionate to the potential reduction in the level of impact have not.	
Demonstration of Acceptability – Introduction of Marine Pests	
As described in Section 7.10.5, the following impacts were evaluated to understand the potential severity from the introduction of marine pests: • The survival, colonisation and spread of foreign species that may compete with native species for resources, reducing species diversity and abundance. The worst-case consequence (or impact) associated with the introduction of marine pests was to have potential localised and medium term impact to an area of significant environmental value - Consequence level (IV). Based upon the evaluation below, the potential impact to plankton from underwater sound is considered acceptable.	
Internal context - Santos policy and standards	As per Action 3 of Santos EHS policy, Section 7.1.5.1 evaluated the potential impacts to plankton to ensure that the potential impact is understood, and the control measures identified for this program are considered suitable for managing these potential impacts. As per Action 4 of Santos EHS policy, all legal requirements relevant to this receptor have been identified, and environmental performance standards set for these requirements.
External context (stakeholders)	During consultation, no objections or claims were raised by relevant stakeholders regarding the introduction of marine pests.
Environment Context	For introduced species to become pests they need to colonise and survive. In the event that a marine pest was introduced to the area it could potentially outcompete local species. This is more likely to occur in the area of shallow banks of the KEF present in the area typically above water depths which make up 5.2% of the operational area. The support vessels are already in Australian waters and the seismic vessel will undertake a biofouling inspection prior to leaving Singapore reducing the risk of introducing a marine pest.
Legal and industry best practices	Ballast water and biofouling are regulated under the Biosecurity Act 2015 and the Australian Ballast Water Management Requirements Version 7 and the seismic vessel will be required to pass quarantine before entering Australia. The survey vessel will meet the requirements to have a BWMP and BWMC in place. Vessels will meet the IMO Guideline requirements of having a biofouling management plan and record book and the Protection of the Sea (Harmful Anti-fouling Systems) Act 2006 requirement to have a valid antifouling certificate.
Principles of ecologically sustainable development	a) Decision making processes integrated long and short term economic, environmental, social and equitable considerations by ensuring that contracted vessels that come into Australian waters meet all biosecurity requirements prior to entry and where required have had a marine pest inspection.

	b) Introduction of marine pest have been known to lead to serious irreversible environmental damage but this is highly unlikely in offshore marine environments where establishment is unlikely due to water depths. c) The principal of inter-generational equity are not compromised as the likelihood of introducing a marine pest and it establishing in an offshore area is remote. d) Conservation of biological diversity and ecological integrity have been considered in decision making as activity seen as acceptable as potential impacts may be long term the likelihood of occurrence is remote. e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts.

7.11 Diesel Refuelling Spill

7.11.1 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.

7.11.2 Area that Might be Affected by the Hazard

The area that may be affected by this hazard is expected to be localised within the operational area and from surface oil only (see Section 7.12.2 which details modelling of a larger diesel spill).

7.11.3 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 surface oil from a diesel refuelling spill are:

- Turtles
- Marine birds
- Cetaceans

7.11.4 Known and Potential Environmental Impacts

The potential environmental impacts of a MDO spill are:

Toxic effects to the marine environment including marine fauna

7.11.5 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 7.12 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.

Summary

Consequence Level: If the activity results in a diesel spill during refuelling, there is potential for toxic effects to the marine environment resulting in localised and short term impacts to animals of environmental value – (II).

Likelihood Level: For this activity, a refuelling incident resulting in short term and localised impacts to animals of environmental value is considered Unlikely (b).

Table 7-26: Diesel Refuelling Risk Assessment

ALARP Decision Context			
Decision Context	**Justification**		
A	A MDO refuelling spill has an inherently low risk that it would occur. Offshore refuelling (bunkering) of vessels is a frequently practiced activity with the causes of spills well understood and managed. Although there is the potential for sensitive receptors to be present within the survey area, exposure to surface hydrocarbons would be low due to the dispersive nature of MDO. No objections or concerns were raised by relevant stakeholders regarding potential spills from refuelling. Consequently decision context A will be applied to this aspect.		
Control Measure Identification			
Good Practice Control Measure	**Control measure source**		
Vessel Bunkering Procedure	It is considered good practice to have a ship-ship bunkering procedure in place to ensure that procedural controls are followed and specified equipment is in place to minimise impacts and risks to the environment.		
MARPOL Annex I (enacted by AMSA Marine Order Part 91, Marine pollution prevention – oil) requirement for an approved SOPEP.	Under Marine Order 91 – a Shipboard Oil Pollution Emergency Plan is required to be in place and approved.		
OPGGS(E) Regulations requirement for an approved OPEP	Under the OPGGS(E) Regulations, NOPSEMA require that the petroleum activity have an accepted Oil Pollution Emergency Plan in place prior to that activity commencing.		
Residual Risk Ranking			
Potential Impact	**Consequence**	**Likelihood (of consequence)**	**Residual Risk**
Toxic effects to the marine environment including marine fauna	II	Unlikely (b)	Very Low (1)

Performance Outcome	**Control Measure & Performance Standard**	**Measurement criteria**
No spills to the marine environment	*Vessel Bunkering Procedure* Bunkering undertaken as per the 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 records

	Bunkering Equipment At a minimum bunkering hose will have floats and dry-break couplings.	Vessel inspection
Oil spill response implemented in accordance with accepted OPEP to minimise impacts from spilled hydrocarbons	*SOPEP Response* Vessel SOPEP implemented for spills on-board vessel.	Records from oil spill response incident
	OPEP implementation Bethany Oil Pollution Emergency Plan implement for spills to water.	Records from oil spill response incident
Demonstration of Acceptability		
Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.		Yes

7.12 Diesel Spill from Vessel Collision

7.12.1 Hazard

Vessel collision with other users within the Bethany survey and operational areas such as commercial fisheries (Timor Reef Fishery, Demersal Fishery and Northern Prawn Fishery) and transiting shipping vessels.

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.

7.12.2 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 2017). 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 7-6).

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 7-27). 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 7-27: Marine Diesel Oil Properties

		Marine Diesel Oil
	API Gravity	37.6
	Density @ 25ºC g/mL	0.83
	Viscosity @ 20 ºC (cSt)	4.0@25^{0}C
	Pour Point ºC	-14
Distillation % mass	Volatiles (<180ºC)	6
	Semi-Volatile (180ºC - 265ºC)	34.6
	Low Volatility (265ºC - 380ºC)	54.4
	Residual (>380ºC)	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 30 September, 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 7-28 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 September period (inclusive).
- No shoreline contact.
- No contact to State or Territory waters.
- Low (0.5-10 g/m^2) oil exposure on the sea surface was observed up 330 km from the release site, moderate (10-25 g/m^2) oil exposure on the sea surface was observed up 44 km from the release site and high (>25 g/m^2) oil exposure was limited to 11 km from the release site.
- The relatively small spill volume and evaporative nature of MDO resulted in surface exposure of visible levels (0.5 g/m^2) not exceeding 20 day duration following the initial release.
- 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 7-7. 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 7-8). 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, a review of receptors in Table 5-1 was undertaken to identify those sensitive to surface oil exposure. It was identified that there were no receptors that would be affected 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 7-8.

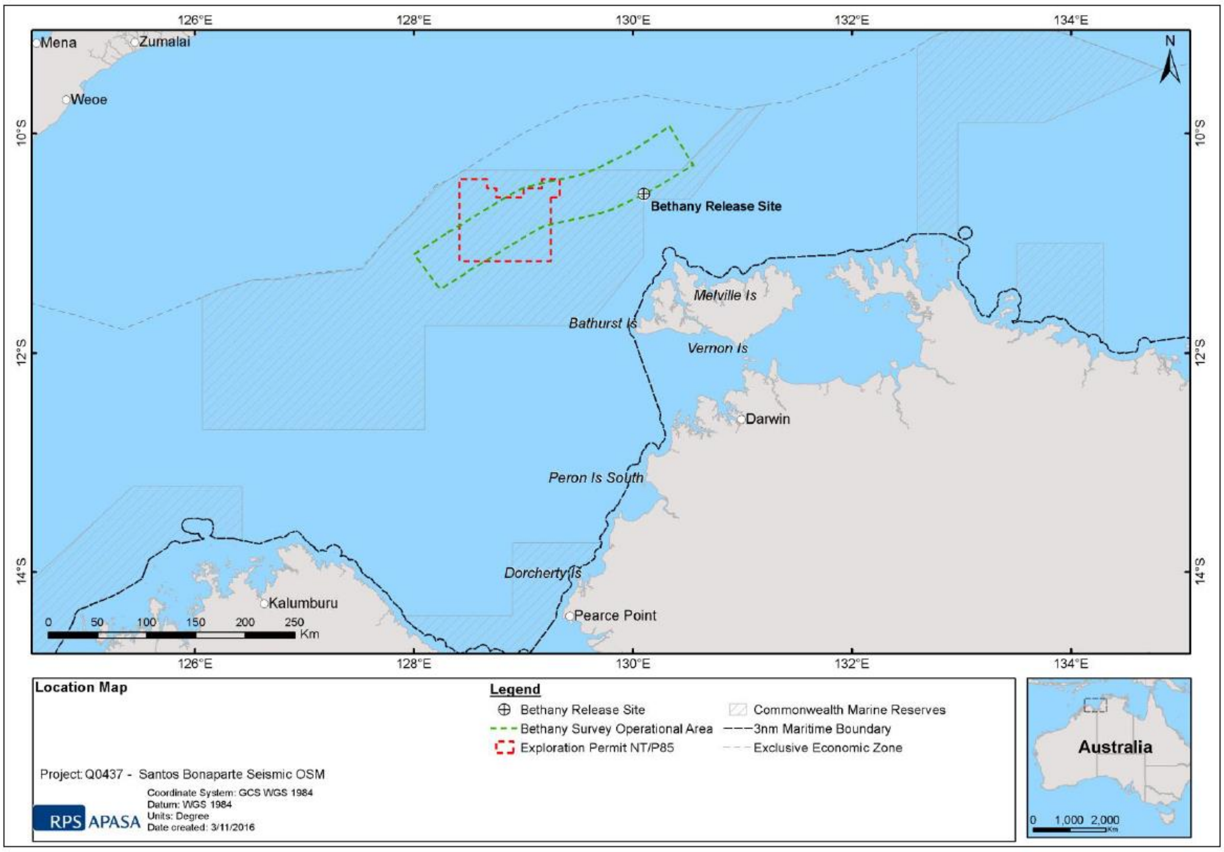


Figure 7-6: Diesel Spill Modelling Location

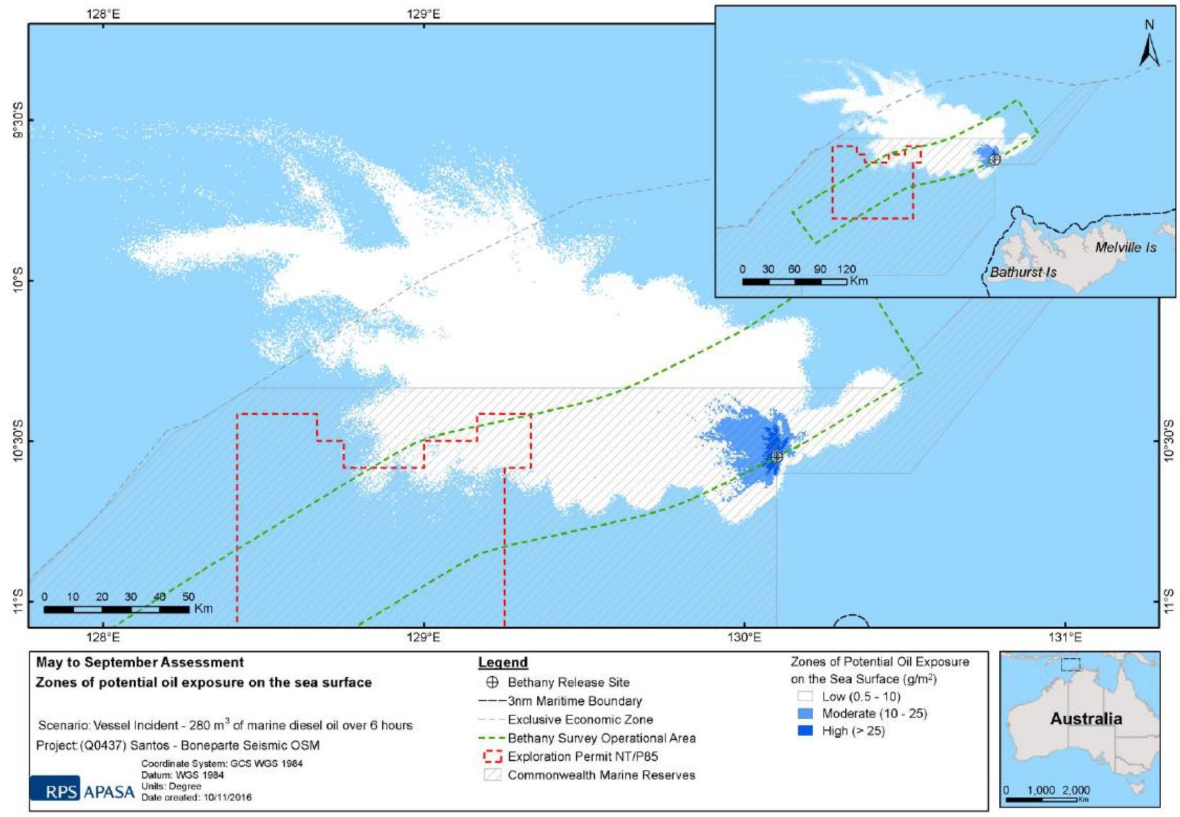


Figure 7-7: Area of Potential Surface Oil Exposure for Modelling Location Release

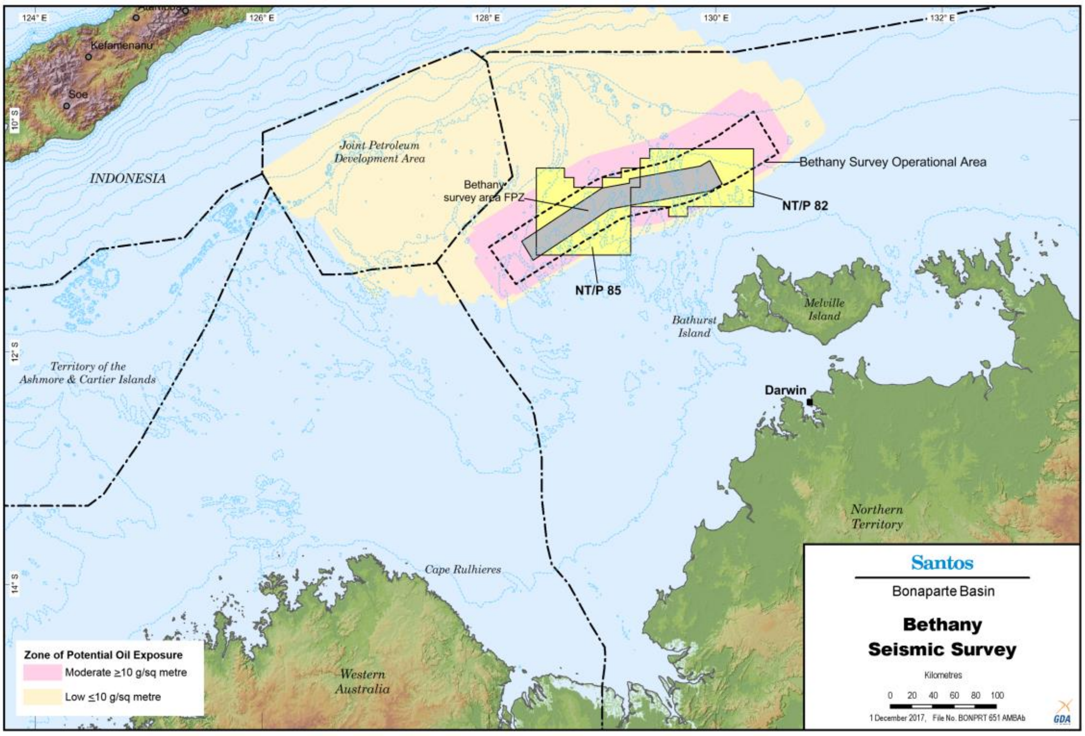


Figure 7-8: Area of Potential Surface Oil Exposure from a 280 m^3 MDO Spill within the Survey Operational Area and AMBA

Table 7-28: Oil Spill Modelling Tresholds

Threshold Value	Description of Potential Effect
Surface hydrocarbons	
Low exposure: 0.5 – 10 g/m^2	The 0.5 g/ m^2 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 2015). 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/ m^2	Ecological impact has been estimated to occur at 10 g/ m^2 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/ m^2 or µm	Studies have indicated that a concentration of surface oil above 25 g/ m^2 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/ m^2	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/ m^2, 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/ m^2 of oil during the growing season would be required to impact marsh or mangrove plants significantly.
Moderate exposure: 100 - 1,000 g m^2	
High exposure: > 1,000 g/ m^2	
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).

7.12.3Sensitive Environmental Receptors with the Potential to Occur within the AMBA

A review of receptors in Table 5-1 identified those receptors within the AMBA sensitive to surface oil exposure. These are detailed in Table 7-29.

7.12.4Known and Potential Environmental Impacts

The potential environmental impacts of a MDO spill are:

- Toxic effects to the marine environment including marine fauna
- Avoidance of the area by charter operator and commercial fisheries

7.12.5Evaluation of Environmental Impacts

Toxic effects to the marine environment including marine fauna

Potential receptors and an assessment of impacts from a MDO spill are detailed in Table 7-29. 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 2017) 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 unlikely 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 AMBA and would be short term, hydrocarbons are predicted not persist beyond 20 days.

Thus, though a vessel collision would be remote, impacts would be extensive (within the AMBA) and short term (up to 20 days) to fauna of environmental value.

<u>Summary</u>

Consequence Level: If the activity results in a diesel spill from a vessel collision, there is potential for toxic effects to the marine environment resulting in extensive and short term impacts to animals of environmental value – (III).

Likelihood Level: For this activity, a vessel collision incident resulting in extensive and short term impacts to animals of environmental value is considered Remote (a).

Avoidance of the area by charter operators and commercial fisheries

As identified during stakeholder consultation as described in Section 5.6.2 – Section 5.6.4, there is the potential for a number of commercial fisheries and a single charter operator to operate within the AMBA.

Although this level of spill would result in clean-up exclusion zones, the charter operator and commercial fisheries may move away from areas that have surface hydrocarbon exposures. Based upon the modelling surface exposures are expected to dissipate (through evaporation and in water entrainment) within 20 days of the event, this may result in commercial activities avoiding the area during this time.

Based on the threshold levels, avoidance of the area by commercial vessels would be short term as hydrocarbons are predicted not persist beyond 20 days, but the area that would may be avoided would be considered extensive due to the rapid spread and dispersion of surface hydrocarbons.

Summary

Consequence Level: If the activity results in a diesel spill from a vessel collision, there is potential for an extensive short term impact to commercial vessels at specific locations within the AMBA– (III).

Likelihood Level: For this activity, a vessel collision incident resulting in a localised and short term impact to a single charter operator is considered Remote (a).

Table 7-29: 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.
Plankton	No	No impact as entrained and aromatic concentrations did not trigger the lowest exposure thresholds.
Fish	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 within biological important foraging area. Sea turtles can be affected by oil spills via oiling, direct ingestion of oil and prolonged exposure to oil vapours (NOAA 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 hence is unlikely to result in turtles ingesting significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS APASA 2017) 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. 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 (IPIECA 2017) Due to the weathering nature of MDO a spill spreads rapidly and thinly and hence is unlikely to result in marine birds ingesting significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS APASA 2017) 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. Cetaceans may become exposed to oil on surfacing to breathe where they can be affected by oiling, exposure to oil vapours and ingestion of oil. There is little documented evidence of effects of oiling on whales (IPIECA 2017).

Environment Receptor	Potential Impact to Receptor	Summary of Potential Impacts
		Due to the weathering nature of MDO a spill spreads rapidly and thinly and hence is unlikely to result in cetaceans ingesting significant volumes or result in persistent oiling. Most evaporation of MDO is within the first 48 hours (RPS APASA 2017) 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	Yes	Commercially targeted species associated with commercial fisheries in the area require exposure to entrained and aromatic hydrocarbons for impacts to occur. No impact as entrained and aromatic concentrations did not trigger the lowest exposure thresholds. Fisheries may avoid areas where surface hydrocarbons are observed.
Recreational activities	Yes	One charter operator potentially operates at Tassie, Evans and Flinders Shoals. There would be no impact directly to these shoals as they are submerged and entrained and aromatic concentrations did not trigger the lowest exposure thresholds. Surface exposure of visible levels of oil (0.5 g/m^2) may occur up to 20 days. Thus, depending on the location of the slick as it breaks down it may be visible to the charter operator and not conducive to charter operations in the area of these shoals.
Petroleum Activities	No	There is no oil and gas infrastructure within the AMBA.
Shipping	No	As the diesel will spread thinly and break down rapidly exposures will not result in exclusion zones that could impact shipping activities.
Maritime Heritage	No	No maritime heritage values identified.
State Protected Areas	No	No State Protected Areas identified.
Commonwealth Protected Areas	Yes	Oceanic Shoals Marine Park may encounter surface hydrocarbons. Impacts to Key Ecological Features within the OSMP 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, Pinnacles of the Bonaparte Basin and Shelf Break and slope of the Arafura Shelf are submerged features and entrained and aromatic concentrations did not persist in the water column long enough to trigger the lowest exposure thresholds.

Table 7-30: Vessel Collision Diesel Spill Risk Assessment

ALARP Decision Context	
Decision Context	**Justification**
A	The potential for a vessel collision is limited due to the absence of other offshore activity in the Bethany Survey area. The management of offshore vessels is well regulated and understood. Risk are well understood and managed. No objections or concerns were raised by relevant stakeholders regarding vessel collisions or resulting spill events. Consequently, decision context A be applied to this aspect.
Control Measure Identification	
Good Practice Control Measure	**Control measure source**
Navigation Act 2012 (enacted by AMSA Marine Orders 31, Vessel; Surveys and certification) describes the requirements for vessel class certification.	The marine order requires that the vessel class be certified to ensure that it meets the Navigational Act 2012 requirements. This will ensure that collision risk is reduced as the systems integral to vessel operation are tested to ensure incidents associated with their malfunction is reduced.

Navigation Act 2012 (enacted by AMSA Marine Orders 30, Prevention of Collisions) describes the minimum notifications required which enable obstacles to be identified.	Under the Navigation Act 2014, it is the responsibility of the Australian Hydrographic Service to maintain and disseminate hydrographic and other nautical information and nautical publications including Notices to Mariners.
OPGGS(E) Regulations requirement for an approved OPEP	Under the OPGGS(E) Regulations, NOPSEMA require that the petroleum activity have an accepted Oil Pollution Emergency Plan in place prior to that activity commencing. In the event of a vessel collision the OPEP will be implemented.

Residual Risk Ranking

Potential Impact	Consequence	Likelihood (of consequence)	Residual Risk
Toxic effects to the marine environment including marine fauna	III	Remote (a)	Very Low (1)
Avoidance of the area by charter operator and commercial fisheries	III	Remote (a)	Very Low (1)

Performance Outcome	Control Measure & Performance Standard	Measurement criteria
No spills to the marine environment	*Navigational requirements* Class certificate demonstrates vessel complies with the Navigation Act 2012 and applicable Marine Orders.	Class Certificate
	Notifications Notice to Mariners via notifications to Australian Hydrographic Service a minimum of 3 weeks prior to commencement of activities.	Notification records to AHS Notice to Mariners
Oil spill response implemented in accordance with accepted plans to minimise impact from spilled hydrocarbons	*OPEP implementation* Bethany Oil Pollution Emergency Plan implemented for spills to water.	Records from oil spill response incident

Demonstration of Acceptability

Is residual risk determined to be 1 and the ALARP Decision Framework A applied? If No ALARP must be demonstrated and the following must be met.	Yes

8 IMPLEMENTATION STRATEGY

Santos will undertake the Bethany survey for and on behalf of the:

- titleholders of NT/P85 - being Santos and Origin; and
- titleholder of NT/P82 - being Magellan.

The Bethany survey will be carried out by a contracted seismic company under a seismic acquisition contract. Under the seismic acquisition contract, Santos administers the contract as the agent of the above titleholders.

As Santos will be undertaking the Bethany survey on behalf of the titleholders of both NT/P85 and NT/P82, it will be Santos' management systems and processes that will apply during the course of the Bethany survey to manage the environmental impacts and risk of the activity.

The Implementation Strategy described in this section is a summary of the Santos systems, practices and procedures in place to manage the environmental impacts and risks of the Bethany survey. The strategy aims to ensure that the control measures, environmental performance outcomes and standards, detailed in Section 7 and within the OPEP, are implemented and monitored to ensure environmental impacts and risks are continually identified and reduced to a level that is ALARP and acceptable.

As Santos is a titleholder and the operator for NT/P85 its Environment, Health and Safety Policy is provided in Appendix 1.

As Magellan is the titleholder for NT/P82 its Environmental Protection Policy is provided in Appendix 1.

8.1 Santos EHS Management System

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 Santos Environment, Health and Safety Policy is provided in Appendix 1.

The framework for the SMS is provided in Figure 8-1 and includes:

Constitution, Board Charters, Delegation of Authority - These documents define the purpose and authorities of the Santos Limited Board, Board Committees

Code of Conduct and Policies – outline the key requirements and behaviours expected of anyone who works for Santos. The Policies are set and approved by the Board.

Management Standards - prescribe the minimum performance requirements and expectations in relation to the way we work at Santos (the 'What').

Processes, procedures and tools - support implementation of the Management Standard and Policy requirements by providing detail of 'How' to achieve performance requirements.

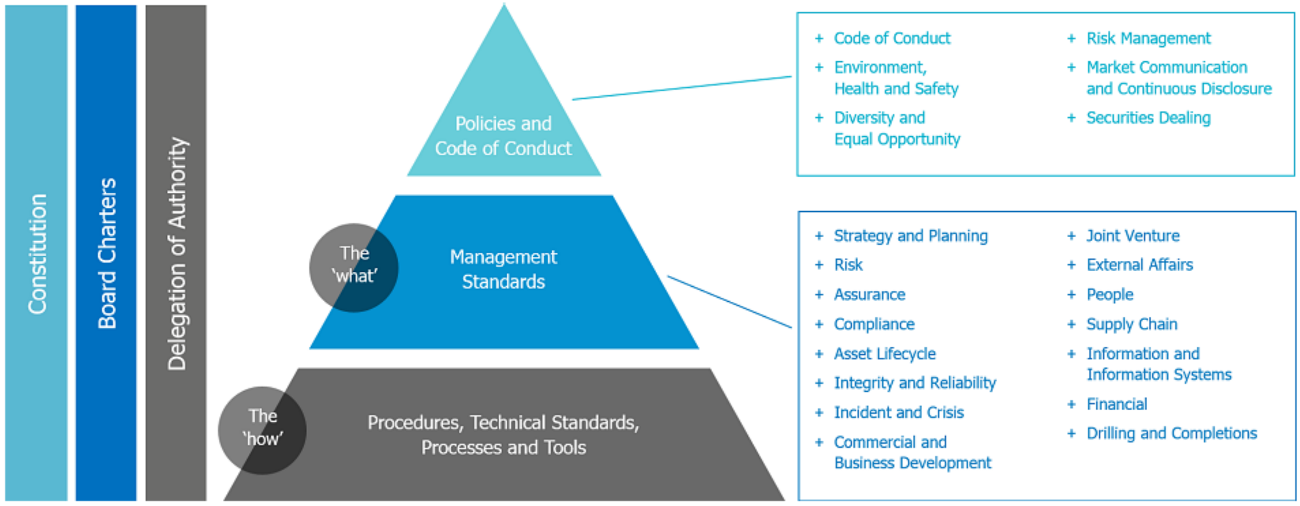


Figure 8-1: Santos Management System Framework

8.2 Roles and Responsibilities

The organisation structure for the Bethany survey is detailed in Figure 8-2. Key roles and environmental responsibilities for the survey are detailed in Table 8-1 and will be communicated to these positions prior to the survey commencing and when any changes are made to these positions.

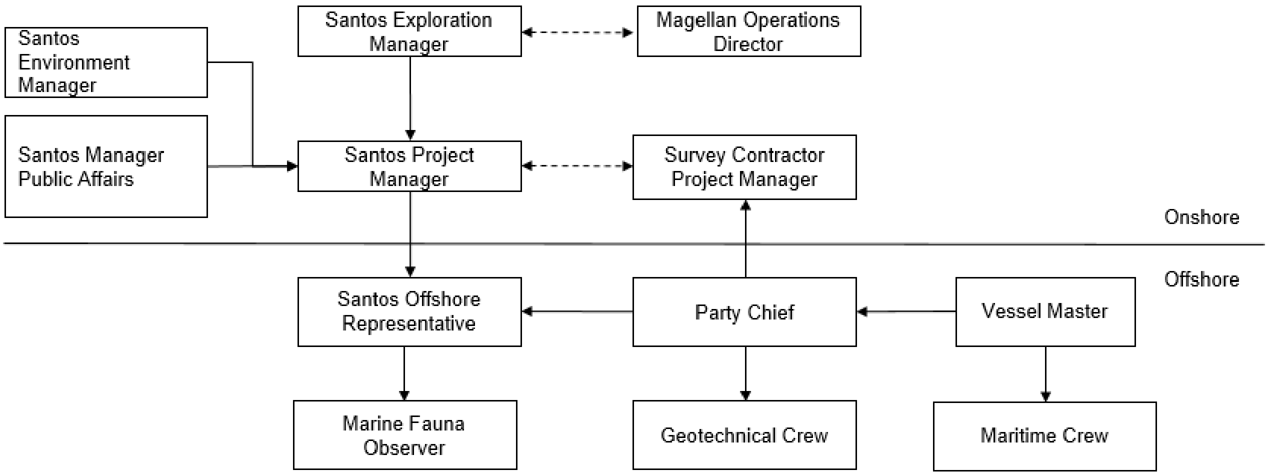


Figure 8-2: Bethany Seismic Survey Organisation Structure

Table 8-1: Bethany Seismic Survey Key Personnel Roles and Environmental Responsibilities

Role	Responsibilities
Santos Exploration Manager	Ensure compliance with SMS including the EHS Policy. Ensure adequate resources are in place to meet the requirements within the EP and OPEP. Ensure adequate emergency response capability is in place for the survey. Ensure incidents and non-conformances are managed as per Section 8.7 and 8.8.4, respectively. Notify NOPSEMA of a change in titleholder, a change in the titleholder's nominated liaison person or a change in the contact details for either (Section 8.4). Review information received from external sources in regards to lessons learnt and non-conformances, relevant to the survey, with the project team to identify if there are actions relevant to the survey. If actions are relevant implement as per Section 8.8.4.

Role	Responsibilities
Magellan Operations Director	Ensure Santos is compliant with the accepted EP via: Review of daily reports. Review of audit, performance and non-conformance reports (Section 8.8.3, 8.8.4). Submit incident reports for incidents (Table 8-3) that occur in NT/P82 permit and ensure investigations undertaken. Ensure the EP Performance Report is prepared and submitted to NOPSEMA (Section 8.8.5). Review information received from internal (Magellan) and external sources in regards to lessons learnt and non-conformances relevant to the survey, and communicating to the Santos Exploration Manager.
Santos Project Manager	Ensure compliance with SMS including the EHS Policy. Ensure overall compliance with the EP. Ensure relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy as documented in this EP are: • Communicated to the onshore and offshore survey key personnel as detailed in Figure 8-2. • Included in the HAZID and resulting risk register. • Audited to inform the EP Performance Report. Ensure contractors are competent for the role they are employed for (Section 8.3). Ensure the response arrangements in the OPEP are tested prior to the survey commencing as per Section 8.3 of the OPEP. Report environmental incidents to the Exploration Manager and Magellan Operations Director and ensure notifications, reporting (Table 8-3) and investigations undertaken. Provide copies of all incident reports to the Magellan Operations Director. Ensure records and documents are managed so they are available and retrievable (Section 8.8.2). Ensure non-conformances identified are communicated, raised in EHS Toolbox and corrective actions completed (Section 8.8.4). Review information received from external sources in regards to lessons learnt and non-conformances, relevant to the survey, with the project team to identify if there are actions relevant to the survey. If actions are relevant implement as per Section 8.8.4. Review daily Santos Incident Summary Report and communicate relevant incidents and learnings to the Santos Offshore Representative (Section 8.8.4). Ensure the EP Performance Report is prepared and submitted to NOPSEMA (Section 8.8.5).
Santos Public Affairs Manager	Undertake ongoing consultation with relevant persons providing feedback and information as required. Identify any claims or objections raised by relevant persons and ensure they are assessed as per the Management of Change process (Section 8.4). Document consultation with relevant persons. Ensure any commitments to relevant persons are undertaken. Review information received from external sources in regards to lessons learnt and non-conformances, relevant to the survey, with the project team to identify if there are actions relevant to the survey. If actions are relevant implement as per Section 8.8.4.
Santos Environment Manager	Identify and communicate relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP and OPEP to the Exploration Manager, Project Manager and Offshore Representative. Develop the environmental component of the survey induction (Section 8.3). Assess any environmentally relevant changes (Section 8.4). Review any non-conformances relevant to environment performance to ensure corrective actions are appropriate to prevent recurrence (Section 8.8.4). Review information received from external sources in regards to lessons learnt and non-conformances, relevant to the survey, with the project team to identify if there are actions relevant to the survey. If actions are relevant implement as per Section 8.8.4.

Role	Responsibilities
	Prepare and submit the annual EP Performance Report to NOPSEMA within 3 months of the activity finishing (Section 8.8.5).
Santos Offshore Representative	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP. Ensure survey inductions undertaken all offshore personnel (Section 8.3). Ensure changes are assessed and approved by Santos (Section 8.4). Ensure chemicals that have the potential to be discharged to the marine environment are assessed and approved using the Santos Offshore Chemical Assessment Process (Section 8.6). Report all incidents to the Santos Project Manager (Section 8.7). Ensure relevant monitoring records (Section 8.8.2) are collated and provided to the Santos Project Manager on completion of the program. Ensure non-conformances and actions are discussed at the vessel daily meeting including those relevant from other areas of Santos. Ensure corrective actions identified from incidents or inspections are implemented (Section 8.7 and 8.8.4).
Survey Contractor Project Manager	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP. Ensure adequate resources are in place to meet the requirements within this EP. Ensure adequate emergency response capability is in place for the survey.
Party Chief	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP.
Geotechnical Crew	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP.
Vessel Master	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP
Vessel Crew	Ensure compliance with relevant environmental legislative requirements, performance outcomes, control measures, performance standards, measurement criteria and requirements in the implementation strategy in this EP.

8.3 Training and Competencies

Key roles for the Bethany survey, as detailed in Section 8.2, have position descriptions that outline the competency requirements including experience, training and qualifications. Specific requirements set out in this EP will be communicated to key personnel prior to commencement of the survey and if personnel change.

Competency of contractors is assessed as part of the contracting qualification and via the prestart audit.

All offshore personnel will be required to complete an induction that will cover the requirements in this EP and OPEP. At a minimum the induction will cover:

- Activity description
- Key receptors in the area
- Environmental impacts and risks, and associated controls to be implemented
- Management of change process
- Roles and responsibilities
- Incident and non-conformance reporting and management
- Oil spill response

8.4 Management of Change

The SMS establishes the processes required to ensure that when changes are made to a project, control systems, an organisational structure or to personnel, the EHS risks and other impacts of such changes are identified and appropriately managed.

The SMS requires that all environmentally relevant changes must obtain environmental approval (internal i.e. within Santos and/or external i.e. regulatory) prior to undertaking any activity.

8.4.1 EP Review

In order to ensure that impacts and risks are continually reduced to ALARP and acceptable levels and the requirements of legislation will continue to be met, Santos will undertake periodic verification of environmental inputs used to inform the evaluation of impacts and risks in the EP, including identifying updates to legislative requirements and environmental information.

Review and verification of information in the EP will be undertaken:

- 4 weeks prior to commencement of the survey; and
- Annually from the date of acceptance of the EP.

In the event that this EP is accepted by NOPSEMA within less than 4 weeks prior to the commencement of the survey, a review and verification process will be completed prior to commencement of the survey/survey phase.

In the event that an annual review is undertaken, another review will not be required 4 weeks prior to commencement if the date of such a review would occur within 4 weeks following the annual review.

The review and verification will include a review of all of the environmentally relevant changes identified in Section 8.4.2 below.

In addition, if new relevant information is provided by stakeholders in relation to new or existing objections or claims during the life of this EP, these will be considered and an assessment of merit will be undertaken in accordance with Section 4.1.2.

8.4.2 Environmentally Relevant Changes

For the purposes of this EP, environmentally relevant changes are as follows:

a) The commencement of any new activity, or any significant modification, change, or new stage of an existing activity, not provided for in this EP.
b) New activities, assets, equipment, processes or procedures proposed to be undertaken or implemented that have potential to impact on the environment and have not been:
   - assessed for environmental impact previously, in accordance with the requirements of the Offshore Environment Management of Change (MoC) Process; and
   - authorised in the existing management plans, procedures, work instructions, or maintenance plans.
c) The introduction of any new legislative requirements that apply to the activity and are relevant to the environmental management of the activity, or amendments to the existing legislative requirements (Table 2-1).
d) Proposed changes to activities, assets, equipment, survey parameters as per Section 3, or processes or procedures that have potential to impact the environment or interface with an environmental receptor.
e) Any significant change to the receiving physical, biological or socio-economic environment within, or immediately adjacent to, the operational area.
f) The identification of any:
   - KEF not already described in this EP;
   - threatened species of cetacean, marine reptile, sharks and ray-finned fish and seabirds not already described in this EP;
   - listed marine species not already described in this EP; and
   - habitat critical to the survival of a species or BIA for threatened or migratory species not already described in this EP, which has spatial overlap with the operational area.
g) New information or changes of information from research, stakeholders, and any other sources used to inform the EP.
h) Identification of a new relevant stakeholder.

i) The draft North Marine Park Network Management Plan (DNP 2017) has been released. If this plan comes into force prior to or during the survey, the MoC Process will be used to ensure activities are not inconsistent with the principles and plans in force.

8.4.3 MoC Process

Where an environmentally relevant change is identified, the Offshore Environment MoC Process is undertaken by a Senior Environmental Adviser.

The MoC Process defines the procedure for assessing changes or proposed changes to circumstances or operations that differ from, or are not provided for in the accepted EP, and is undertaken to ensure that any additional impacts and risks resulting from the change can be managed to ALARP and acceptable levels. If required, appropriate technical and/or legal advice is sought during this process. When completed, the documented outcomes of the MoC Process are approved by the Santos Environment Manager and Project/Activity Manager.

The change assessment is documented using the MoC Assessment Form, which is used in conjunction with the documented MoC procedure to record how the proposed change will be managed compared with the accepted EP. The accepted EP is considered the basis against which all changes are to be assessed against.

The first step of the assessment involves identifying what sections of the EP the change will impact and how it will differ from the accepted EP. For changes that are permanent and/or will affect the EP the change is to be made within the EP, taking into account all sections that the change may impact. Sections of the EP impacted by the change are recorded on the Assessment Form.

The next step in the MoC Process is to undertake an assessment against the requirements of the OPGGS (Env) Regulations, specifically Regulations 17(1), 17(5) and 17(6). The MoC Process includes criteria for determining if an environmentally relevant change represents:

1. A new activity;
2. A significant modification or new stage of the activity;
3. A significant new environmental impact or risk; or
4. A significant increase in an existing environmental impact or risk.

Significant new impacts or risks, or increases in existing impacts or risks, include those where:

- Compliance with legal and other requirements, performance objectives and standards or the implementation strategy can no longer be demonstrated;
- The impacts or risks are no longer ALARP and acceptable; and
- The impacts or risks have a greater extent, severity, duration or uncertainty than is detailed in the accepted EP.

As an example, a new environmental impact or risk may be significant if:

- The environment consequence of the impact is greater than II as per the Santos Environment Consequence Classification.
- The risk level is greater than very low (1) as per the Santos Risk Matrix.
- Impacts and risks are no longer ALARP and acceptable.
- It has the potential to impact on sensitive receptors, including other marine users and matters of national environmental significance or State/NT protected matters (species, heritage, reserves etc.), which is not accounted for in the accepted EP.
- The magnitude and extent of the impact is outside the bounds of the accepted EP.

The findings of the OPGGS (Env) Regulations assessment are documented in the MoC Assessment Form.

8.4.4 EP Revision and Resubmission

In the event that the proposed change represents a new activity, a significant modification or new stage of the activity, or 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, this EP will be revised and submitted for re-assessment and acceptance by NOPSEMA.

Where a change results in the EP being updated, the change/s are to be logged in the EP Change Register.

Notwithstanding the ongoing consultation requirements described in Section 4.1, if the MoC Process results in a revision and resubmission of the EP this will trigger additional stakeholder consultation. As soon as is practicable, all relevant persons will be notified of the EP revision and resubmission, and of the identified significant new environmental impact or risk, or increase in existing impact or risk, which has resulted in this process being implemented. Stakeholders will also be notified when the revised EP has been accepted by the regulator.

8.4.5 Changes to Titleholders and Nominated Liaison Person

Section 1.2 details the titleholders, survey nominated liaison person and contact details for both. A change in any of these details are required to be notified to NOPSEMA.

8.5 Emergency Response

Contracted vessels will have an Emergency Response Plan (ERP) and a Shipboard Oil Pollution Emergency Plan (SOPEP). For vessel emergencies, the vessel contractor documentation and processes will be implemented. For an oil spill to water, the Santos Bethany OPEP will be implemented.

The response arrangements in the OPEP will be tested prior to commencing the survey as per Section 8.3 of the OPEP.

8.6 Chemical Assessment Process

HSHS08 Chemical Management mandates that new chemicals must be approved prior to use and that EHSMS12 Management of Change is used to identify the hazards associated with the way the chemical will be used, stored and disposed of and consider potential consequences to personal health and safety, the environment and process safety. The Santos Offshore Chemical Environmental Risk Assessment Process (0010-650-RIS-0001) is used to assess chemicals that have the potential to be discharged to the marine environment to ensure the lowest toxicity chemicals are selected that meet the technical requirements. A summary of the process is detailed in Table 8-2.

Table 8-2: Santos Offshore Chemical Environmental Risk Assessment Process Summary

Step No.	Evaluation Step	Inputs	Action
1	Determine chemical proposed for use	Confirm: Chemical name & supplier Chemical Function/purpose Formulation, CAS number Ecotoxicity data, where available Estimated use, dosage and discharge	Proceed to Step 2
2	Determine whether the chemical is to be discharged to the marine environment	Refer to EP to determine proximity to priority sensitivities	Where chemical is to be used in a closed loop system no further action is required. Where chemical is to be discharged – proceed to Step 3
3	Determine whether the chemical is on the OSPAR PLONOR List	Refer to OSPAR PLONOR List	Where the chemical is listed as PLOONR no further action required. Where the chemical Is not listed go to Step 4
4	Determine whether the chemical is on the OCNS Definitive Ranked Lists of Registered	Refer to the Definitive Ranked Lists of Registered Substances and determine the Hazard Quotient	Is the HQ Band "Gold" or "Silver," or OCNS Group "E" or "D"? If yes go to Step 5 Where the chemical is not listed go to Step 6

Step No.	Evaluation Step	Inputs	Action
	Substances and the Hazard Quotient		
5	Determine whether the chemical has a substitution or product warning	Refer to OCNS Definitive Ranked Lists of Registered Substances or obtain from the current CEFAS template.	Where the chemical does not have a product or substitution warning no further action is required.
			Where the chemical has a product or substitution warning go to Step 7
6	Assess the Eco-toxicity	LC50 or EC50 concentrations for representative species; Octanol-water partition coefficient (logPow); and Biodegradation information (% biodegradation in 28 days).	Requires a Hazard Assessment and ALARP justification where:
			Toxicity = LC50 <100 mg/L or EC50 <100mg/L
			Bioaccumulate = Log Pow >3
			Biodegradability <20%
7	Consider an alternative or complete ALARP justification	Technical justification required to proceed with selected chemical	If there is no technical justification for the chemical it is not accepted for use. If there is a technical justification complete Chemical Selection ALARP Justification form. Approval required from Environmental Team Lead.

8.7 Incident Reporting

EHSMS15 Incident Investigation and Response sets out the requirements for incident notification, reporting and investigation. Incidents that impact on the environment or have the potential to impact on the environment (near-miss) are to be reported and entered into the EHS Toolbox Incident Management System (IMS).

Table 8-3 details the external incident notification, reporting requirements and timeframes for environmental incidents associated with the Bethany survey.

Santos will undertake any initial notification reporting requirements for incidents within both NT/P82 and NT/P85. Where an incident occurs in a specific permit area the titleholder for the permit where the incident occurred (Santos for NT/P85 and Magellan NT/P82) will be responsible for any further reporting requirements. Where an incident is not associated with a specific permit area, Santos will be responsible for all notifications and reporting and will provide Magellan copies of all documentation for their records.

Table 8-3: Incident Reporting Requirements

Requirements	How and By When
Incident involving cetacean	
Death or injury to a cetacean (whales and dolphins). All cetaceans are protected in Commonwealth waters and, the EPBC Act requires that all collisions with whales in Commonwealth waters are reported and submitted to the National Ship Strike Database.	Secretary of the Cth Department of Environment within seven days. 1800 803 772 protected.species@environment.gov.au DEWLP Cetacean Hotline – 1300 136 017 https://data.marinemammals.gov.au/report/shipstrike

Requirements	How and By When
Recordable Incident Reporting	
A recordable incident is a breach of an environmental performance outcome or environmental performance standard, in the environment plan that applies to the activity; and is not a reportable incident.	Submit written report to NOPSEMA by 15th of every month
The recordable incident report must contain: (i) a record of all recordable incidents that occurred during the calendar month; and (ii) all material facts and circumstances concerning the recordable incidents that the operator knows or is able, by reasonable search or enquiry, to find out; and (iii) any action taken to avoid or mitigate any adverse environment impacts of the recordable incidents; and (iv) the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the recordable incident; and (iv) the corrective action that has been taken, or is proposed to be taken, to prevent similar recordable incident.	
Reportable Incident Notification	
A reportable incident is an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage. Based on the Santos Risk Matrix this is an incident that has an actual or potential consequence ≥ III. Incidents should also be reported to NOPSEMA and WA DMP if it has been reported to another government department or agency or there is the potential for media or stakeholder interest.	Report verbally (or by email if phone contact is not possible) to NOPSEMA as soon as practicable and in any case not less than 2 hours. As soon as practicable provide a written record of the notification to NOPSEMA, the Titles Administrator (NOPTA) and WA DMP. NOPSEMA 08-6461 7090 submissions@nopsema.gov.au NT DPIR 08 8999 6350 petroleum.operations@nt.gov.au NOPTA info@nopta.gov.au
The verbal notification must include: (i) all material facts and circumstances concerning the reportable incident that the titleholder knows or is able, by reasonable search or enquiry, to find out; and (ii) any actions taken to avoid or mitigate any adverse environmental impacts; and (iii) any corrective actions that have been taken, or is proposed to be taken, to stop, control or remedy the reportable incident. Written notification: The titleholder is not required to include in the record anything that was not included in the notification.	
Reportable Incident Reporting	
The initial notification of a reportable incident must be followed up by a written report. As a minimum, the written incident report will include: (i) all material facts and circumstances concerning the reportable incident that the titleholder knows or is able, by reasonable search or enquiry, to find out; and (ii) any actions taken to avoid or mitigate any adverse environmental impacts; and (iii) the corrective action that has been taken, or is proposed to be taken, to stop, control or remedy the reportable incident; and	As soon as practicable, and not later than 3 days following the incident NOPSEMA submissions@nopsema.gov.au NT DPIR 08 8999 6350 petroleum.operations@nt.gov.au NOPTA info@nopta.gov.au

Requirements	How and By When
(iv) the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future. Within 7 days after giving a copy of the reportable incident report to the NOPSEMA a copy must be given to the Titles Administrator and WA DMP.	
Vessel Based Oil Spill in Commonwealth Waters	
AMSA must be notified immediately of a vessel based oil spill incident in Commonwealth waters.	Oil spill: 02-6230 8111 mdo@ amsa.gov.au
DNP must be notified as soon as possible of a vessel based oil spill incident within the Oceanic Shoals Marine Park. Notification should include: • Titleholder details • Time and location of the incident • Proposed response strategies as per OPEP • Contact details for the response.	Marine Reserve Compliance Duty Officer Telephone: 0419 293 465.
Suspected or Confirmed Marine Pest or Disease	
The Aquatic Biosecurity Unit of NT Fisheries will be notified within 24 hours of a suspected or confirmed presence of any marine pest or disease.	Email: aquaticbiosecuroty@ny.gov.au Telephone: 0413 381 094

8.8 Environmental Performance Monitoring and Reporting

8.8.1 Emissions and Discharges Monitoring

Table 8-4 details the emissions and discharges monitoring that will be undertaken during the activity.

Table 8-4: Emission and Discharge Monitoring

Aspect	Monitoring	Frequency	Requirement
Atmospheric emissions	Vessel fuel use	Daily	Total fuel used
Bilge water discharge	Bilge water OIW content	Daily (if discharged)	Bilge water OIW exceedance > 15 ppm
Waste	Waste sent onshore Waste incinerated	As required	Volume of waste sent onshore Volume of waste incinerated
Ballast water discharge	Discharge of vessel ballast water	As required	Volume discharged and location
Waste	Discharge of putrescible waste	As required	Volume of food scraps discharges, ensuring they are <25 mm in size and discharged >3 nm from land
Waste	Waste	As required	Volumes and location of waste accidentally discharged overboard
Spills	Spills	As required	Volumes and location of fuel spilled to sea

8.8.2 Record Management

SMS Information and Information Systems details the requirements to ensure that information is kept current and accurate, stored in a manner to facilitate retrieval, and is accessible to personnel who need it.

Document control and record keeping requirements including record retention periods are specified in the SMS. Where no record retention requirement is specified, the default for physical records is 10 years and 'life of plant' for electronic records.

8.8.3 Audit

To ensure that the EP requirements have been effectively implemented and that the performance outcomes and standards in the EP have been met the following audits will be undertaken:

- Contractor Pre-start– to ensure the EP requirements will be implemented by the contractor.
- Contractor During the activity – to ensure EP requirements have been implemented by the contractor.
- Santos Pre-start – to ensure EP requirements will be implemented by Santos.
- Santos During the activity – to ensure EP requirements have been implemented by Santos.

These audits will be undertaken by a qualified third party.

Audits findings including actions will be communicated to the Santos Exploration Manager, Magellan Operations Director, Santo Environment Manager, Santos and Contractor Project Managers and Santos Offshore Representative via an audit report.

Actions are agreed with the Environment Manager, Santos and Contractor Project Managers and assigned an actioner and required completion date. The audit and actions are recorded in the Santos EHS Toolbox Audit & Compliance Manager which notifies the actioner and their manager when actions are due. If actions are not closed within the due date the system has a hierarchy notification system based on the number of days an action is overdue as to the level of manger who receive notification of the overdue action.

8.8.4 Management of Non-Conformances

For the activity a non-conformance is classed as:

- A breach of an environmental performance outcome or environmental performance standard (described in Section 7). This triggers the requirement to report as a "recordable incident" as per Section 8.7.
- Failure to implement a requirement in the implementation strategy.

Non-conformances are identified via:

- Audits and inspections (Section 8.8.3)
- Emissions and discharge monitoring (Section 8.8.1)
- Incident reporting and investigations (Section 8.7)
- Preparation of the Annual Performance Report (Section 8.8.5)

Where a non-conformance is identified actions are implemented to correct the non-conformance and prevent reoccurrence. Effectiveness of the actions is reviewed via auditing (Section 8.8.3) and performance reporting (Section 8.8.5) to ensure that non-conformances are not re-occurring and environmental performance is improving.

To ensure that non-conformances lead to learning and improvements for the survey and on a company-wide basis, non-conformance are:

- Communicated to the Santos Exploration Manager and Magellan Operations Director via the daily report, weekly meetings and the appropriate reports (i.e. audit, performance, incident investigation) to ensure they are made aware of non-conformances and the corrective actions to help prevent recurrence of similar incidents.
- Communicated to the Project and Contract Managers and Santos Offshore Representative via Santos EHS Toolbox (see below), daily and weekly meetings and the appropriate reports (i.e. audit, performance, incident investigation) to ensure personnel are made aware of non-conformances and corrective actions to help prevent recurrence of similar incidents.

- Communicated to survey vessel and support vessels crews at daily pre-start meeting via the Santos Offshore Representative to ensure personnel are made aware of non-conformances and corrective actions to help prevent recurrence of similar incidents.
- Communicated internally within Santos as per the Santos Internal Incident Notification Guide and where there are lessons learnt that are applicable to other areas of the business a Flash Notification is issued.
- Agreed with the Santos and Contractor Project Manager and actions assigned an actioner and required completion date.
- Recorded in Santos EHS Toolbox and actions tracked to completion.
- Reviewed by the actioner's manager prior to being closed to ensure actions are completed and implemented.
- Reported externally as per the requirements are detailed in Section 8.7 and Section 8.8.5.

The Santos EHS Toolbox consists of modules for recording audits, incidents, emergency response exercises, obligations, and actions. The toolbox includes initial notification of non-conformances to be sent at a minimum to the responsible manager though other personnel can be selected as required. The toolbox also has an action tracking and reporting component which notifies the actioner and their manager when actions are due. If actions are not closed within the due date the system has a hierarchy notification system based on the number of days an action is overdue as to the level of manger who receive notification of the overdue action.

For incidents a companywide daily report is sent to registered personnel which for the survey would be at a minimum the Santos Project Manager and Environment Manager. This allows for the sharing of incidents and lesson learnt between different parts of the business. Any incidents raised from other parts of the business applicable to the survey will be communicated to the Santos Offshore Representative to discuss at the daily meeting.

The Santos Exploration Manager, Project Manager, Environment Manager and Public Affairs Manager receive formal and informal information via industry associations, engagement with stakeholders including community, other oil and gas companies, regulators and Joint Ventures. Where information is received from external sources in regards to lessons learnt and non-conformances, relevant to the survey, these will be discussed by the project team to identify if there are actions relevant to the survey. If actions are relevant they will be implement as per Santos non-conformance process detailed in this Section.

8.8.5 Annual Performance Report

Santos and Magellan will submit an EP Performance Report to NOPSEMA with sufficient information to enable the regulator to determine whether the environmental performance outcomes and standards in the EP have been met.

The report will be submitted within 3 months of the end of the activity.

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Appendix 1: Santos Environment, Health and Safety Policy and Magellan Environmental Protection Policy

Environment, Health and Safety

Santos

Policy

Our Commitment

Santos is committed to a workplace where we all go home without injury or illness and manage the impact of our operations on the environment.

Our Actions

We will:

1. implement a structured and systematic approach to environmental, health and safety management and monitor its effectiveness
2. include environmental, health and safety considerations in business planning and decision-making processes
3. understand and manage the impact of our operations on the environment
4. comply with all relevant environmental, health and safety laws
5. promote a strong and consistent safety culture across all aspects of business
6. work pro-actively and collaboratively with our stakeholders and the communities in which we operate
7. set, measure and review objectives and targets which drive continuous improvement
8. report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety & Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This Policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Naomi James, Executive Vice President, EHS & Governance		
Approved by:	The Board	Version:	1

MAGELLAN PETROLEUM AUSTRALIA PTY LTD
ABN 62 009 728 581

ENVIRONMENTAL PROTECTION POLICY

Magellan Petroleum Australia considers protection of the natural and social environment to be of the highest priority in all its activities, both domestic and international. Magellan is therefore committed to conducting its operations in an environmentally responsible manner upholding the principles of ecologically sustainable development, minimizing greenhouse gas emissions and assisting in minimizing global climate change resulting from human activities.

It is Magellan's policy to:

- Comply, at a minimum, with applicable laws, regulations, standards, codes and guidelines for the protection of the environment and cultural heritage, and in their absence, adopt the best practicable means to prevent or minimise adverse environmental and cultural heritage impacts;
- Cooperate with governments and industry in the formulation of rational and practical environmental and cultural heritage guidelines and legislation;
- Continuously develop the company's environmental management system and cultural heritage management plans to identify, control and monitor risks and compliance with government regulations and industry guidelines, utilising the most appropriate technology available;
- Commit all levels of management to accept responsibility for environmental and cultural heritage management in all Magellan activities;
- Promote environmental and cultural heritage awareness in all Magellan employees and contractors through induction and training programs;
- Maintain cooperative and positive relationships with indigenous people with custodial responsibility for the land where Magellan operates to minimize the impact of those operations on the cultural heritage of the indigenous people, and cooperate with other legitimate land users so that, where appropriate, multiple land use is possible;
- Conduct all Company operations in such a way as to minimize disturbance to the environment, protect native flora and fauna, avoid the pollution of land, water and air, and to avoid disturbance of known sites of archaeological, cultural heritage, historical, natural or scientific significance; and
- Maintain an active rehabilitation program that will restore operational areas to a condition which is compatible with the prior land use.

Mervyn Cowie
Director **1 July 2016**

Appendix 2: Stakeholder Consultation Records

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Northern Territory Seafood Council	NTSC-24	19/03/2018	Dea[redacted] Thank you for providing a copy of Duncan (2018), A comparison study of cumulative sound exposure levels (CSELs) from typical 3D seismic surveys. Santos has also been provided with a copy of this report from NOPSEMA, along with a copy of the matters you detail in your letter to NOPSEMA, dated 8th March 2018. NOPSEMA has provided this information to Santos for consideration in respect to the environmental impact and risk assessment for seismic surveys, particularly with relevance to the issue of temporary threshold shift (TTS) in fish as addressed in the Bethany 3D Seismic Survey Environment Plan (EP). We have reviewed Duncan (2018) in detail and provided response to each of your queries and concerns below. The CSEL information and conclusions presented by Duncan (2018) is in agreement with our approach to the assessment of impacts and the conclusions reached in the EP, as well as the conclusions reached by Dr Art Popper in his paper on this topic (Popper 2018) (attached for reference). Further explanation is provided below. I trust that the responses we have provided below address your queries and may alleviate your concerns regarding the potential for impacts to fish and the interests of NTSC members. Should you still have any further queries regarding this issue, we would be happy to meet with you and [redacted] at a time and place of your choosing, to discuss in more detail. Kind regards, [redacted] 1. Use of the 24 hour period for CSELs modelling only considers lines in separate racetracks (approx. 5km apart), a scenario that fails to consider survey lines in close proximity (approx. 500m); The acquisition line plan proposed for the Bethany survey comprises survey lines that are approximately 200 km long and each will take approximately 27 hours to acquire and turn around. These lines are sailed in a ñracetrackò sequence, similar to the scenario 3 and scenario 4 examples represented in Figure 7 of Duncan (2018). Therefore, the next acquisition line sailed in the sequence will be approximately 5 km from the first line as the vessel returns in the opposite direction. The line following this one will occur approximately 500 m from the first line, approximately 48 hours later. As you are already aware, the assessment modelled a 24-hour subset of acquisition lines. During this period, no lines will be sailed within 500 m of another line. We appreciate that you disagree with the 24-hour approach, but the reasons why any sound exposures beyond the 24-hour period would not be biologically relevant are addressed in Popper (2018) and are discussed again below against your other queries. Essentially, sound exposure from these later passes is not going to contribute significantly to cumulative sound exposures that could result in TTS or other physical effects to commercially-targeted demersal fish. If a fish was in close proximity to the passing vessel and seismic source, any effects would likely have fully recovered within 24 hrs (or less) (Popper 2018) and hence sound exposure from later passes (such as when the vessel is next within 500 m of the original location) is not going to result in any additional effects from cumulative sound exposures 2. The titleholder claims that the 24 hour period is precautionary, because fauna would have to remain stationary for this period to receive accumulated energy, fails to consider actual accumulation times; The findings of Duncan (2018), Popper (2018) and our assessment are in agreement with one another. Duncan (2018) presents the fundamental principles of CSEL in a clear manner with a number of simplistic scenarios that are indicative of seismic survey acquisition lines of different length, spacing and duration. The more single seismic shot SELs (SELss) that are included in the calculation will naturally result in a higher overall CSEL, hence the conclusion in Duncan (2018) that long range CSELs increase for the scenarios that include longer lines and more lines. However, a key limitation of the Duncan (2018) study is that it is purely a calculation of CSEL that does not take into account the hearing abilities of fish or biological effects. Calculations (i.e. modelling) of CSEL over periods of 24 hours or longer assume that very distant SELss will be audible to fish and contribute to hearing fatigue that may eventually result in TTS. For example, in the case of the Bethany seismic survey, some of the seismic shots that were included in the JASCO modelling of CSEL were located over 85 km apart. In reality, fish will not hear sound over these distances, hence including the accumulated sound energy from distant shots over a full 24-hour period CSEL is always going to be conservative. The JASCO modelling referenced in the EP provides a calculation of CSEL over a 24-hour period and, like Duncan (2018), does not account for biological effects. However, our EP assessment and Popper (2018) adds context to the modelling by considering how much of this CSEL is relevant and the biological effects. Specifically, Popper (2018) highlights that it is important to consider how much of the sound is received (heard) by individual fish in a population. Fish will only hear and be exposed to relatively ñloudò sounds for a relatively short period of time, relatively close to the sound source (Popper 2018). The key target species in the Timor Reef Fishery (primarily demersal snapper) are species that have relatively low hearing sensitivity i.e. they possess a swim bladder but this is not involved in hearing, so they only detect the particle motion component of sound at close range and donõt detect the sound pressure component of a sound wave.	An assessment of the merits of the claims made is included in the full response to the NTSC (see left), and also in Response NTSC-21, as detailed below.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
			Popper (2018) further explains within the report that the effects of TTS are unlikely to show up in fishes until the intensity of the sound is well above the fishӳ hearing threshold. For fish species that are free swimming (which include key commercially targeted species such as snappers) it is likely that there would be no TTS effect whatsoever since fish will likely move away from the sound source. In his conclusions, Popper (2018) emphasizes that the time over which the energy is accumulated should be limited to the time over which fishes get maximum exposure. Popper (2018) further concludes that 24 hours is likely far too long a period for calculation of accumulation of energy, as accumulation of energy over longer periods than a few hours is not appropriate in the context of biological effects. Therefore we continue to stress that accounting for CSEL accumulated over 24-hours, during which the fish receiving the sound is assumed to remain stationary, is highly conservative. Your concern that modelling needs to account for longer accumulation times has therefore been considered, but for the reasons above, this issue does not have any scientific basis. The 24-hour modelled scenario already accounts for a) the relatively rapid accumulation of sound at close range to a fish on first pass, plus b) a significantly greater amount of sound produced over the 24 hours that fish will not actually hear. 3. The 24 hour period CSELs values provided in Environment Plans are shown to be reached in minutes. Meaning the CSELs are less a precautionary level in 24 hours, and more a certainty as the survey vessel passes in a matter of minutes. We agree that the majority of modelled accumulated sound energy received by a fish is received during a relatively short period when the vessel passes within short range of a fish. This point is demonstrated in both Duncan (2018) and Popper (2018) and is consistent with the Bethany 3D seismic survey EP assessment. Figure 19 and Figure 22 in Duncan (2018) plots of the maximum received SEL in the water column with distance from the towed seismic source. These figures generally indicate that the sound accumulated within close range to a given point over a relatively short period of time contributes a greater amount to the CSEL than sound that is more distant. This is because shots on the nearest survey line dominate the CSEL calculation (Duncan 2018; Popper 2018). This principle is better demonstrated in Popper (2018). Figure 1 and Figure 2 in Popper (2018) present the received SELss (orange lines) and the received CSEL (blue lines) for a stationary fish exposed at a distance of 100 m and then for the next acquisition line at 5 km distance. Popper (2018) explains that the maximum contribution to the CSEL will be for the sounds at or near the closest point to the fish, and the sounds from greater distances will contribute far less to the CSEL. Therefore, we agree with that the greatest contribution to received CSEL will occur at short distance over a relatively short period of time. However, this does not necessarily mean that fish will experience temporary threshold shift effects, but if they do, it would be temporary ï as the name implies. To provide you with some additional context on what this means with respect to the CSEL assessment in the Bethany 3D seismic survey: Å The conservative 24-hour CSEL modelling indicates that the maximum range at which the most sensitive fish species may experience TTS is 3.4 km. Å Applying this range to the 24-hour subset of survey lines modelled, this area represents an overlap with the Timor Reef Fishery that represents less than 0.03% of the catch, based on the historical catch information for the fishery. Å If we were to apply this same conservative 3.4 km range to a larger subset of lines than the 24-hours, for example the entire 4,565 km2 Full Power Zone (FPZ), it is acknowledged that this will obviously indicate a larger area (6,130 km2 or 21% of the total Timor Reef Fishery area) where there is the potential for exposure to occur at some point during the survey. However, the spatial overlap from the FPZ is immaterial in terms of actual impacts as it does not represent the area or duration where fish may be exposed. The seismic source is always moving so these areas represent the total area where individual fish in a population may be briefly exposed to the effects of CSEL at some point in time during the entire 75-day duration of acquisition. Å In reality, the individual fish that have the potential to be exposed at one location and point in time in the survey are not the same fish that will be exposed at another distant location elsewhere at another time in the survey. Individual fish in a population are likely to be exposed in a single location for significantly less than 24 hours and the footprint where TTS may occur is likely to be limited to within a few kilometres of the moving source. Given that demersal fish targeted by the fishery are also likely to move in response to the approaching noise, the effects of CSEL to individual fish are unlikely to occur at all. In summary: Å The results of Duncan (2018) are consistent with our assessment and the independent, expert peer review by Popper (2018). Duncan (2018) does not contradict our findings and we consider our current assessment of the risk of potential TTS to fish to be appropriate. Å Modelling by Duncan (2018) and by JASCO (2017) for the purposes of our EP, model CSEL that does not take into account the hearing abilities of animals that may receive the sound and do not consider biological	

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
			effects in these calculations. Popper (2018) and our assessment puts these results in to context by considering the biological effects. Å Fish are more likely to hear sound from the seismic source at close range and over a relatively short period of time. This is also the period of time when the greatest accumulation of sound will occur, as NTSC acknowledge. However, free-swimming commercially-targeted fish will move away from the source if the sound becomes too loud and TTS is unlikely to occur. Å Even if TTS occurs, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity (Popper 2018) and the effects are quickly recoverable. Recovery will start as soon as the most intense sounds end, and recovery is likely to occur within 24 hours (or less) (Popper 2018). Å Modelling of CSEL for 24 hours considers the period when the greatest accumulation of sound will occur, plus additional SEL accumulated from seismic shots at distance over 24 hours. Fish may be able to hear and accumulate sound from the closer shots but will not in reality accumulate sound from distant shots that are below their threshold of hearing. Therefore, modelling CSEL over the 24-hour period accounts for both and is highly conservative. Å As Popper (2018) highlights, 24 hours is likely too long a period for calculation of accumulation of energy in determining potential harm (e.g. TTS). There is no scientific basis for considering periods longer than 24 hours. Å The potential effects of CSEL (e.g. TTS) to individual fish in a population will be short term and temporary The main concerns shared by NTSC and other fisheries stakeholders is that 24-hour CSEL is not precautionary and that TTS effects will occur in fish. Evidently, all sources of information presented are in agreement that the most significant and relevant sound accumulation occurs within significantly shorter durations than 24 hours. 24-hour CSELs are therefore conservative. When accounting for biological effects, fish hearing and behaviour, TTS effects are unlikely to occur. In the unlikely event that they do occur, it is unlikely to have any implications on the fitness and survival of individual fish and certainly not on fish stocks. On this basis, we do not consider that the Duncan (2018) study presents any new information that contradicts our assessment, but is in fact consistent with our assessment.	

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Northern Territory Seafood Council	NTSC-23	19/03/2018	Santos email with NTSC response letter: [redacted] Santos was provided a copy of Duncan (2018), A comparison study of cumulative sound exposure levels (CSELs) from typical seismic surveys and has considered this correspondence with respect to the environmental impact and risk assessment for seismic surveys, please refer to attachment. Should you have any further queries regarding this issue, we would be happy to meet with you and [redacted]n if appropriate, at a time and place of your choosing, to discuss in more detail. Kind regards [redacted] NTSC email: [redacted] Thank you for the correspondence, confirming receipt. Please note I also sent a copy of the report to [redacted] directly on 9 March 2018. Warm Regards [redacted]	An assessment of the merits of the claims made is included in Response NTSC-21, as detailed below.
Austral Fishing	AF-12	19/03/2018	Santos email: Hi [redacted] review of the Popper report as well as the new modelling report (Duncan 2018) that was recently provided by NTSC. The results of Duncan (2018) are consistent with our assessment and the independent peer review by Popper (2018). There appears to be some confusion with respect to the interpretation and application of the results and conclusions in the Duncan report. We are responding directly to NTSC to clarify this with them. I will be in Perth next week and [redacted] and myself would welcome the opportunity to meet to discuss further if you are available. [redacted] will follow up with you directly. Kind Regards, [redacted]	An assessment of the merits of the claims made is included in Response AF-12, in reply to the Response to AF-11, as detailed below.
Timor Reef and Demersal Relevant	TRD-202	19/03/2018	Santos email: Hi [redacted], Thanks for your email. Popperõs review does not confirm that the 24-hour period is incorrect. It highlights the reasons why 24-hours is conservative and precautionary. The greatest contribution to cumulative SEL and potential for TTS occurs during a relatively short period of time when the vessel and seismic source pass close by. This is clearly demonstrated in Popperõs review and also now in modelling completed by CMST (Duncan 2018), which NTSC has recently provided to us. The 24-hour calculation of cumulative SEL accounts for the short-term contribution to cumulative SEL and also accounts for additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away. The cumulative SEL calculation doesnõt however factor in fish hearing abilities, which are not sensitive enough to be able to hear these more distant sounds, hence the 24-hour scenario accounts for more sound energy than is even relevant and is therefore conservative. The 100 m distance presented in the extracted data is given as a simplistic example for received levels for a stationary fish at close range. Other distances could have been used to demonstrate this concept, but it would not change the conclusions of the assessment in any way; as explained before and in the Popper review, fish such as snapper will move away from the source if the sound becomes too loud and TTS or any other physical effects are unlikely to actually occur. Our assessment and modelling has considered the effects of both the peak pressure levels from single seismic shots and cumulative SEL from multiple shots. The cumulative SEL is of particular relevance to your concerns regarding TTS and hence the focus of the recent review by Popper and engagement with you. The conclusions of Professor Popperõs report make it very clear as to why modelling 24-hours is precautionary and why modelling periods greater than 24 hours is irrelevant: ñThe time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!ò Should the review have indicated that there was a reason for us to update our assessment in our EP, we would have done so, but the review and all other information are overwhelmingly conclusive and support our assessment. Your email implies that you understand that the short-range and short duration cumulative SEL that is most relevant (as outlined above, this has been accounted for along with additional accumulated sound over a 24 hour period), but you also request cumulative SEL should be considered for longer periods across the survey. Therefore, to summarise the key findings of the modelling, our assessment and Popperõs review: 1. The modelling of 24-hours of accumulated SELs demonstrates that the greatest contribution to cumulative SEL occurs during a relatively short period of time when the vessel and seismic source pass close by to a fish; 2. The modelling of 24-hours of accumulated SELs is therefore conservative as it accounts for this main	An assessment of the merits of the claims made is included in the Response 202, in reply to TRD-201, as detailed below.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
			contribution to cumulative SEL, plus additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away (e.g. tens of kilometres, if not more) 3. The modelling of cumulative SEL doesn't account for fishes hearing abilities or the biological effects of sound. In reality, an individual fish will only hear and be exposed to the sound at short-range and for a much shorter duration than 24 hours. While this short timeframe is the period in which most of the received cumulative SEL occurs, fish will move away from the source if the sound becomes too loud and TTS or any other physical effects are unlikely to actually occur. 4. In the unlikely event that TTS did occur in a fish, Popper (2018) highlights that the level of TTS is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity and the effects are quickly recoverable. Recovery will start as soon as the most intense sounds end, and recovery is likely to occur within 24 hours (or less). 5. Therefore, to provide additional context and consider your concern about the potential cumulative SEL across the entire survey, we can apply the (conservative) 24-hour cumulative SEL effects range of 3.4 km to a larger subset of lines than the 24-hours, for example the entire 4,565 km2 Full Power Zone (FPZ). It is acknowledged that this will obviously indicate a larger area where there is the potential for exposure to occur at some point during the survey. However, the spatial overlap from the FPZ is immaterial in terms of actual impacts as it does not represent the area or duration where individual fish may be exposed. The seismic source is always moving so these areas represent the total area where individual fish in a population may be briefly exposed to the effects of CSEL at some point in time during the entire 75-day duration of acquisition. In reality, the individual fish that have the potential to be exposed at one location and point in time in the survey are not the same fish that will be exposed at another distant location elsewhere at another time in the survey. Individual fish in a population are likely to be exposed in a single location for significantly less than 24 hours and the footprint where TTS may occur is likely to be limited to within a few kilometres of the moving source. Given that demersal fish targeted by the fishery are also likely to move in response to the approaching noise, the effects of CSEL to individual fish are unlikely to occur at all. In acknowledgement of this and the information provided in Duncan (2018) and Popper (2018), we are updating the EP to better reflect and clarify this information. However, it does not alter the predicted impacts or risks. If you would like further clarification on this, we would be happy to meet with you at a convenient time and location to discuss further. Kind regards [redacted]	

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-203	19/03/2018	Hi [redacted] Thanks for your email. My previous email was not implying that industry had involvement in the initial modelling design with JASCO for the two modelling studies conducted for Bethany. It was during the peer review process that [redacted]h was given the opportunity to have input into the additional modelling and data analysis/extraction conducted by JASCO at Professor Popperõs request. The peer review process was conducted in an open, transparent manner and [redacted] was given the opportunity to exchange concerns, issues and thoughts directly with Professor Popper, who took these into account in developing the findings and conclusions of his review, particularly with respect to cumulative SEL and TTS effects/recovery. Throughout all of the communications over the past 12 months or more Santos has always treated the concerns and issues that the Timor Reef Fishery licence holders have raised with respect, and has consistently provided additional information to try and address issues and concerns raised by [redacted] and yourself. The scope and criteria for the additional data extraction and analysis conducted by JASCO was discussed at length between [redacted] and Professor Popper (please see email from [redacted] dated 14/02/2018 in which you were ccõd). [redacted] requested modelling for a longer time frame of 60 hours, but in the email exchange with [redacted] Professor Popper explained a number of times why modelling periods greater than 18-24 hrs has no relevance from the point of view of TTS or other potential effects in fish. In fact, the modelling extracted over 24 hours and presented in Popperõs review clearly demonstrates why modelling of 24 hours is conservative. The greatest contribution to cumulative SEL and potential for TTS occurs during a relatively short period of time when the vessel and seismic source pass close by. The 24-hour calculation of cumulative SEL in the modelling accounts for this main short-term contribution to cumulative SEL and also accounts for additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away. The cumulative SEL calculation doesnõt, however, factor in fish hearing abilities, which are not sensitive enough to be able to hear these more distant sounds, hence the 24 hour scenario accounts for more sound energy than is even relevant and is therefore conservative. The 100 metres distance presented in the extracted data is given as an example for received levels at close range. As you point out, any other distance could have been used, but it would not change the conclusions in any way. The main contribution to cumulative SEL over short range and short duration is demonstrated in both Popperõs review and also in the modelling completed by CMST (Duncan 2018), which NTSC have provided to us. All studies are consistent in supporting our method of assessment. Therefore, in response to the two numbered items you raise in your email: 1. The JASCO modelling reports explain why the different modelling locations were selected. They are representative of the different water depths along the survey lines. 2. The 24 hour period modelled for cumulative SEL is conservative for the reasons explained, hence why it is a commonly used (i.e. standard) approach to assessing the potential for TTS effects. The conclusions of Professor Popperõs report make it very clear as to why modelling periods greater than 24 hours is irrelevant: ñThe time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!ò Popperõs conclusions are not saying the approach is not supported, but confirms why the approach is conservative and precautionary. At no point have we been selective with information or misrepresented any information. NOPSEMA are aware of what information has been provided to stakeholders and all supporting information used in the assessment. All of the information considered, including the new CMST modelling provided from NTSC, supports our assessment of cumulative SEL and potential effects to fish. If you would like further clarification on this, we would be happy to meet with you at a convenient time and location to discuss further. Kind regards [redacted]	An assessment of the merits of the claims made is included in Response TRD-203, in reply to TRD-200, as detailed below.
Northern Territory Seafood Council	NTSC-22 including attachment BZ	13/03/2018	Correspondence between NTSC and NOPSEMA received via IAGC (International Association of Geophysical Contractors) - NOPSEMA reply to NTSC Correspondence - request for urgent attention to new modelling report.	An assessment of the merits of the claims made in relation to the Duncan (2018) modelling provided by NTSC is included in Response NTSC-21, as detailed below.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Austral Fishing	AF-11	9/03/2018	AF email: H[redacted], It seems we now have Scientist vs Scientist at 50 paces! We share the concerns expressed raised by [redacted] and [redacted] in the lack of concise information that is available for projects like the Bethany 3D Survey and am quite amazed at the diversity of opinion and reports available. Given that , we also recognise the right of companies like Santos to explore on permits that may overlap or encompass fishing grounds. After meeting with [redacted] and his team, I am firmly of the view that a smaller project that has been proposed by [redacted] would be complimentary to help prove interactions between seismic and demersal fish species. I am happy to discuss this further if of any interest in moving this forward. I had left a message earlier in the week. Cheers [redacted] Santos email: Hi [redacted]n Thank you for forwarding the information through. This was the first I had seen of both the NTSC work as well as the AIMS proposal. I will review these over the next few days and get back to you if I have any questions. I will be in Perth in a couple of weeks and it may be worthwhile catching up to discuss. Kind regards [redacted] AF email: I am really surprised that you have only just seen the AIMS proposal. This survey is very important for Austral as we are new entrants to the fishery and have provided catch data to Santos with the intent of proceeding in good faith. I have also provided you this information based on the same. I would like to know where Santos is at with the EP and NOPSEAMA. As you would be aware, this may impact financially on all operators and I would like clear lines of communications and no surprises. Regards [redacted]	An assessment of the merits of the claims made is included in the Response to AF-11: Santos reviewed the CMST report (Duncan 2018) in detail and consider it entirely consistent with the Popper (2018) review and the assessment in the EP. Duncan (2018) confirms that the most relevant accumulation of sound energy occurs over a relatively short period of time when the seismic source passes at the closest point to a receptor such as a fish. The Duncan (2018) paper, like the modelling we commissioned from JASCO, is a mathematical calculation of CSEL that does not consider the actual hearing abilities of fish or the biological effects. This is where the Popper (2018) review and the Santos assessment in the EP adds the relevant context. The CSEL received by a fish, and potential for temporary effects to their hearing (TTS), would be limited to within a short range and a short duration when the vessel and seismic source pass close by. The 24-hour calculation of CSEL in the JASCO modelling used in our assessment accounts for the main short-term contribution to CSEL that is highlighted in both Popper (2018) and Duncan (2018), but also accounts for the additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away. Fish hearing abilities are not sensitive enough to be able to hear these more distant sounds. Therefore, both Popper (2018) and Duncan (2018) support our assessment and demonstrate why the 24-hour period that we have selected will be precautionary. Of course, TTS is unlikely to actually occur as fish will swim away from the approaching seismic source before sound levels get too high, as discussed in Popper (2018). Santos agree that the research proposed by [redacted] Principal Research Scientist at NT DPIR, will be useful and Santos and potential timing and funding were discussed with him in January. Santos are continuing to liaise with [redacted] on this matter.

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Northern Territory Seafood Council	NTSC-21 and attachment BZ	9/03/2018	NTSC email: [redacted] Got your messages, please find copy of the report you were seeking. We provided it to nopsema yesterday. Warm Regards [redacted] <u>NTSC queries and claims:</u> New noise modelling has been commissioned by the NTSC to provide better understanding of potential impacts. As a result NTSC ask NOPSEMA to consider its implications and provide to titleholders to ensure their modelling and EP correctly addresses the impacts of sound accumulated during proposed seismic operations. A comparison study of cumulative sound exposure levels (CSELs) from typical 3D seismic surveysòprepared for the NTSC by Dr Alec Duncan, Centre for Marine Science and Technology, Curtin University was attached. NTSC memberõs have raised concerns about CSELs modelling. Specifically: a) use of the 24 hour period for CSELs modelling only considers lines in separate racetracks (approx. 5km apart), a scenario that fails to consider survey lines in close proximity (approx. 500m); b) the titleholder claim that the 24 hour period is precautionary, because fauna would have to remain stationary for this period to receive accumulated energy, fails to consider actual accumulation times; and c) 24 hour period CSELs values provided in Environment Plans are shown to be reached in minutes. Meaning the CSELs are less a precautionary level in 24 hours, and more a certainty as the survey vessel passes in a matter of minutes.	An assessment of the merits of the claims made in relation to the Duncan (2018) modelling provided by NTSC is included in the Response NTSC-22 in reply to NTSC-21: a) The CSEL modelling of a 24 hour period of acquisition does not include lines in close proximity because the acquisition line plan proposed for the Bethany survey comprises survey lines that are approximately 200 km long and each will take approximately 27 hours to acquire and turn around. Therefore, the next acquisition line sailed in the sequence will be approximately 5 km from the first line as the vessel returns in the opposite direction while the line following this one will occur approximately 500 m from the first line, approximately 54 hours later given the 27-hour line duration proposed. The assessment modelled a 24-hour subset of acquisition lines, and during this period, no lines will be sailed within 500 m of another line. b) Accounting for CSEL accumulated over 24-hours is precautionary because it accounts for the main contribution to CSEL during the relatively short period of time when the source passes at close range to a fish, plus a significantly greater amount of distant sound produced over the 24 hours that the fish is unlikely to be able to hear in reality. Sound exposures beyond the 24-hour period considered are not expected to be relevant with respect to accumulated exposure in fish, as explained in the Popper (2018) peer review which concluded that 24 hours is likely far too long a period for calculation of accumulated energy and any period longer than 24 hours has no scientific basis. The concerns that modelling needs to account for longer accumulation times has been considered, but do not have any scientific basis. c) NTSC are correct in highlighting that the majority of modelled accumulated sound energy received by a fish is received during a relatively short period when the vessel passes within short range of a fish. This point is acknowledged above and has at no point been disputed. This is also demonstrated clearly by both Duncan (2018) and Popper (2018) and is consistent with the Bethany 3D seismic survey EP assessment. Figure 1 and Figure 2 in Popper (2018) present the received single shot SEL (SELss; orange lines) and the received CSEL (blue lines) for a stationary fish exposed at a distance of 100 m and then for the next acquisition line at 5 km distance. Popper (2018) explains that the maximum contribution to the CSEL will be for the sounds at or near the closest point to the fish, and the sounds from greater distances will contribute far less to the CSEL. Therefore, the results for 24 hours of CSEL are conservative. A key limitation of both the JASCO (2017) modelling and Duncan (2018) modelling is that they are only a calculation of CSEL for their respective scenarios. Neither of them account for the hearing abilities of fish or biological effects of the CSEL. Calculations (i.e. modelling) of CSEL over periods of 24 hours or longer assume that very distant SELss will be audible to fish and contribute to hearing fatigue that may eventually result in TTS. For example, in the case of the Bethany seismic survey, some of the seismic shots that were included in the JASCO modelling of CSEL were located over 85 km apart. In reality, fish will not hear sound over these distances, hence including the accumulated sound energy from distant shots over a full 24-hour period CSEL is always going to be conservative. The EP assessment and Popper (2018) add context to the modelling by considering how much of this CSEL is relevant and the biological effects. Specifically, Popper (2018) highlights that it is important to consider how much of the sound is received (heard) by individual fish in a population. Fish will only hear and be exposed to relatively ñloudò sounds for a relatively short period of time, relatively close to the sound source (Popper 2018). Popper (2018) further explains within the report that the effects of TTS are unlikely to show up in fishes until the intensity of the sound is well above the fishõs hearing threshold. For fish species that are free swimming (which include key commercially targeted species such as snappers) it is likely that there would be no TTS effect whatsoever since fish will likely move away from the sound source.

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Austral Fishing	AF-10	6/03/2018	AF email: Hi [redacted] Can you please send Austral a copy of the report by Popper. Thanks [redacted] Santos email: Hi [redacted] Please find attached a copy of the Popper report. Please let me know if you have any questions regarding this. Kind regards [redacted]	Provision of information - Dr. Popper peer review report
Timor Reef and Demersal Relevant	TRD-200	6/03/2018	[redacted] email: Hi [redacted] It is concerning your email implies industry has had involvement in modelling design with Jasco and discussion have occurred, however at no time was industry consulted about format or parameters of modelling before Jasco was commissioned for modelling. Further, given Professor Popperõs report was finalised before discussion had concluded, or even industry being advised he had completed his work is a disgrace and illustrates a high level of disregard for industry not to mention I waste of resources. In saying that, thank you for doing part of the modelling [redacted] and industry has been discussing with Santos and Nopsema for nearly 12 months. It highlights to me that [redacted] was correct in requesting the shorter time frame given it shows how quickly the level is reached. However, it is very concerning the way the modelling has been completed and provided given you went to that level why choose 100 metres and not multiple distances (50m, 150m, 200m) and longer time frames? Why only provide results and not detail of criteria? We note the following areas of concern: 1) Modelling sites appear to have impacted results significantly. Yet have not determined relevance of sites as yet. 2) Standards ï Throughout this process I have been quoted ñindustry standardò a number of times yet one person (albeit a respected person) appears to be able to make all standards irrelevant. Effectively, why have a workgroup who created standards, create modelling to support the standards and assess your environmental plan on the same standards but then say we do not believe them. Selective use of information can be a misrepresentation of facts and if overdone the regulator should be able to identify and request corrections. We are at a point we are more than happy to continue what I am now calling engagement (not consultation), however, if the regulator cannot or more importantly do not act on the inconsistencies here than it does make it difficult to allocate time to this process. Regards, [redacted]	An assessment of the merits of the claims made is included in Response 203, in reply to TRD-200: Santos was not implying that industry had involvement in the initial modelling design with JASCO for the two modelling studies conducted for Bethany. It was during the peer review process that licensees were given the opportunity to have input into the additional modelling and data analysis/extraction conducted by JASCO at Professor Popperõs request. The peer review process was conducted in an open, transparent manner and licensees were given the opportunity to exchange concerns, issues and thoughts directly with Professor Popper, who took these into account in developing the findings and conclusions of his review, particularly with respect to cumulative SEL and TTS effects/recovery. Throughout all of the communications over the past 12 months or more Santos has always treated the concerns and issues that the Timor Reef Fishery licence holders have raised with respect, and has consistently provided additional information to try and address issues and concerns raised. The scope and criteria for the additional data extraction and analysis conducted by JASCO was discussed at length between a TRF licensee and Professor Popper. The licensee requested modelling for a longer time frame of 60 hours, but in the email exchange with [redacted] Professor Popper explained why modelling periods greater than 18-24 hrs has no relevance from the point of view of TTS or other potential effects in fish. In fact, the modelling extracted over 24 hours and presented in Popperõs review clearly demonstrates why modelling of 24 hours is conservative. The greatest contribution to cumulative SEL and potential for TTS occurs during a relatively short period of time when the vessel and seismic source pass close by. The 24-hour calculation of cumulative SEL in the modelling accounts for this main short-term contribution to cumulative SEL and also accounts for additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away. The cumulative SEL calculation doesnõt, however, factor in fish hearing abilities, which are not sensitive enough to be able to hear these more distant sounds, hence the 24 hour scenario accounts for more sound energy than is even relevant and is therefore conservative. The 100 metres distance presented in the extracted data is given as an example for received levels at close range. As you point out, any other distance could have been used, but it would not change the conclusions in any way. The main contribution to cumulative SEL over short range and short duration is demonstrated in both Popperõs review and also in the modelling completed by CMST (Duncan 2018), which NTSC have provided to us. All studies are consistent in supporting our method of assessment. Therefore, in response to the two numbered items raised in the email: 1. The JASCO modelling reports explain why the different modelling locations were selected. They are representative of the different water depths along the survey lines. 2. The 24 hour period modelled for cumulative SEL is conservative for the reasons explained, hence why it is a commonly used (i.e. standard) approach to assessing the potential for TTS effects. The conclusions of Professor Popperõs report make it very clear as to why modelling periods greater than 24 hours is irrelevant: ñThe time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in

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				determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!" Popper's conclusions are not saying the approach is not supported, but confirms why the approach is conservative and precautionary. At no point has Santos been selective with information or misrepresented any information. All of the information considered, including the new CMST modelling provided from NTSC, supports our assessment of cumulative SEL and potential effects to fish.
Timor Reef and Demersal Relevant	TRD-201	6/03/2018	[redacted] email: [redacted] For clarification the review confirmed that the 24hr period was incorrect, as pointed out last May. Also that there is no basis for longer periods if the fish is 100m from the first survey line. This is because the pk to pk impact dominates as expected. Despite finding the 24 hr period is incorrect are you stating the EP will not be revised? Its not clear therefore what the purpose of the review was. As you will can see from our correspondence throughout review (and highlighted specifically 23 Feb) we expected this to be the case. It would seem by finalising the report before properly understanding our issue SANTOS have again failed to model our area of concern. If you were to carry the modelling on the impact on SELcums as you move from this point at 100m towards the same point at the next proximity line you will see a far greater summation of energy. In fact for the very reasons Dr Popper has outlined. The differential between the highest sound level and those before and following becomes less, increasing the cumulative impact of shot numbers not peak levels. This information was provided during the review but it is now clear the work had already been finalised. The reason to request the longer periods is to show the impact occurs across the survey – as we know this accumulation from vessels in close proximity not the full period. The longer periods will show that SELcums don't just compound through this time (as concluded by Dr Popper from your restricted modelling results) – they do show however concerning increases in the space between two survey lines in closest proximity. This impact is compounded in certain areas of the survey. Its unclear noting the reviews findings in relation to the 24 hr period and the failing to model the areas of concern re SELcum how one concludes the EP is still valid and risks not increased. Warm regards [redacted]	An assessment of the merits of the claims made is included in the Response 202, in reply to TRD-201: Popper's review does not confirm that the 24-hour period is incorrect. It highlights the reasons why 24-hours in conservative and precautionary. The greatest contribution to cumulative SEL and potential for TTS or other physical effects occurs during a relatively short period of time when the vessel and seismic source pass close by. This is clearly demonstrated in Popper's review and also now in modelling completed by CMST (Duncan 2018), which NTSC recently provided to Santos. The 24-hour calculation of cumulative SEL accounts for the short-term contribution to cumulative SEL and also accounts for additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away. The cumulative SEL calculation doesn't however factor in fish hearing abilities, which are not sensitive enough to be able to hear these more distant sounds, hence the 24 hour scenario accounts for more sound energy than is even relevant and is therefore conservative. The 100 metres distance presented in the extracted data is given as a simplistic example for received levels for a stationary fish at close range. Other distances could have been used to demonstrate this concept, but it does not change the conclusions of the assessment in any way; as explained before and in the Popper review, fish such as snapper will move away from the source if the sound becomes too loud and TTS or any other physical effects are unlikely to actually occur. The EP assessment and modelling has considered the effects of both the peak pressure levels from single seismic shots and cumulative SEL from multiple shots. The cumulative SEL is of particular relevance to TTS and hence the focus of the recent review by Popper and engagement with the TRF licensees. The conclusions of Professor Popper's report make it very clear as to why modelling 24 hours is precautionary and why modelling periods greater than 24 hours is irrelevant: "The time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!". Should the review have indicated that there was a reason to update the assessment in the EP, Santos would have done so, but the review and all other information are overwhelmingly conclusive and supports the assessment. Therefore, no changes will be made to the EP. To summarise: 1. The modelling of 24-hours of accumulated SELs demonstrates that the greatest contribution to cumulative SEL during a relatively short period of time when the vessel and seismic source pass close by to a fish; 2. The modelling of 24-hours of accumulated SELs is therefore conservative as it accounts for this main contribution to cumulative SEL, plus additional sound energy accumulated over the rest of the 24-hour period from seismic shots that are far away (e.g. tens of kilometres, if not more) 3. The modelling of cumulative SEL doesn't account for fishes hearing abilities or the biological effects of sound. In reality, an individual fish will only hear and be exposed to the sound at short-range and for a much shorter duration than 24 hours. While this short timeframe is the period in which most of the received cumulative SEL occurs, fish will move away from the source if the sound becomes too loud and TTS or any other physical effects are unlikely to actually occur. 4. In the unlikely event that TTS did occur in a fish, Popper (2018) highlights that

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				the level of TTS is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity and the effects are quickly recoverable. Recovery will start as soon as the most intense sounds end, and recovery is likely to occur within 24 hours (or less). 5. Therefore, if the potential cumulative SEL across the entire survey area and the full duration of the survey are considered, then the potential for TTS to occur exists across the entire area. However, this does not represent the area or duration where TTS will occur in individual the fish population, but instead represents the total area where different fish in the population may be briefly exposed to the effects at some point in time during the acquisition. The individual fish that have the potential to be exposed at one location and point in time in the survey are not the same fish that will be exposed at another distant location elsewhere at another time in the survey. By the time the vessel and seismic source returns to within 5 km of a previously exposed area (during the next survey line), more than 24 hours will have elapsed and any previous TTS will have recovered (if it even occurred in the first place). Really, the potential for a fish to receive sound exposures that have the potential to result in TTS is limited to significantly shorter durations than 24 hours and the fish will likely move away from the source to avoid such exposures.
Timor Reef and Demersal Relevant	TRD-199 and attachment BY	5/03/2018	Santos email: [redacted] I have endeavoured to address your questions in the table below. Please advise if you require any additional information or clarification. Kind regards [redacted] Environment Plan Section Detail in Environment Plan Question SANTOS RESPONSE Section - Demonstration of Acceptability - Fish External context - Stakeholder expectations Santos has assessed these impacts and through the implementation of applicable controls potential impacts	Santos response to TRD-196 and TRD-198.

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			Santos worked with stakeholders to understand any objection or concerns and implement appropriate controls to ensure impacts are ALARP and acceptable. I am not sure how this could be stated when [redacted] has been asking for months for clarification on one issue that could actually finalise these discussions. Santos has received a final report detailing the finding of the independent, expert peer review by Professor Art Popper. This peer review did not reach any conclusions or provide any new information that changes the prediction of impacts described in the EP. A copy of Professor Popperõs report has been provided to [redacted] and is attached for your information. During the peer review, [redacted] was given the opportunity to have input into the process, particularly with regards to the additional modelling and data analysis/extraction conducted by JASCO. Environment Context The significant impact criteria applicable to fish species are: - Lead to a long-term decrease in the size of an important population of a species. Please advise what is this based on. This is one of the significant impact criteria applicable to species listed as Vulnerable under the EPBC Act, as described in the MNES: Significant Impact Guideline 1.1. (DoE 2013)[1] In the EP, application of this criterion relates directly to syngnathid species (seahorses, pipehorses and pipefishes), which are listed marine species under the EPBC Act. The MNES Significant Impact Guideline 1.1 does not provide criteria for marine species, hence, using the criteria for the next level of protection, vulnerable, affords of level of conservatism. Syngnathids are the only listed fish species identified in the survey area, hence, using the criteria for vulnerable species, affords of a level of conservatism. Principles of ecologically sustainable development met? e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts and include reduction in the seismic noise source, use of soft start procedures and restricting the amount of infill lines to minimise impacts to site attached fish. I do not believe reducing air gun size is a mitigation method for when the survey is being conducted. Given speed of vessel and the lack of knowledge regarding potential effects how do soft start procedures and widening the vessel lines by 100m mitigate impacts? During line run-ins, soft-start procedures occur for a minimum of 30 minutes (approximately 4 ï 5 km), which begins with the operation of the single smallest source element and gradual ramp-up to include additional source elements until the seismic source is operated at full volume for the commencement of the acquisition line at the Full Power Zone boundary. This process provides some prior õwarningô to fishes in the area at the start of the acquisition line, and also ensures that free-swimming fishes in the immediate vicinity of the airgun array are not exposed to noise emissions from the array operating at full volume. If the fish can hear the sound of the seismic source and the sound becomes too loud, it is reasonable to assume that the fish will move away from the source unless they are restricted to a particular spot for behavioural reasons. Widening the line separation by 100 m reduces the overall number of lines and the area affected by peak received noise levels, and also reduces the survey duration. 7.1.5.3 For free-swimming fish that are able to move away from seismic sources as they approach, the potential for lethal physical damage from airgun emissions is even further nullified. I am not sure how õnullifiedô can be stated when it has been agreed numerous times fish do not have the capacity to swim away from a vessel travelling at 5 knots. Please advise your understanding of fish movement. Free-swimming fishes, such as demersal lutjanids that are not site-attached, would have the ability to move over the relatively short distances (tens of metres) which would put them outside the zone within which mortality of potential mortal injury effects may occur. As stated above, if the fish can hear the sound of the seismic source and the sound becomes too loud, it is reasonable to assume that the fish will move away from the source unless they are restricted to a particular spot for behavioural reasons. Pink snapper (Pagrus auratus) have been recorded as having a strong swimming capacity, with individual fish attaining critical swimming speeds of up to 7.1 body lengths per second[2], which for an adult fish of ~38 cm length would equate to ~2.6 m/s-1 (~5 knots). If the TRF licence holders have relevant information relating to the swimming speeds of key target species within the fishery (e.g. goldband snapper, red emperor) it would be appreciated if it could be shared with Santos. The area of potential impact is likely to be conservative based on a recent study (Popper et al. 2016) and a comprehensive literature review (ERM 2017) that did not identify mortality, potential mortal injury or recoverable injury at levels above the current published thresholds I am concerned about the reliance on Popper given his recent emails regarding speculative nature of effects on	

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			wild fish. Refer email attached in particular: I do appreciate that TTS is an issue for fishes, but the potential impact on wild fish has only been speculated upon and there is no good work (in my view - I do know the lab studies, which I think are not very useful or informative vis a vis wild animals). Santos has received a final report detailing the finding of the independent, expert peer review by Professor Art Popper. This peer review did not reach any conclusions or provide any new information that changes the prediction of impacts described in the EP. A copy of Professor Popperõs report has been provided to [redacted] and is attached for your information. For commercial fish species, the area of potential impact is within the area of the Timor Reef Fishery (TRF) where 4 ï 12% of their catch has been caught, based on data from 2013 to 2017 (Table 7-9). The most abundant commercial fish species within the survey area is goldband snapper, at 8.55% of the total TRF catch caught within the operational area. Please advise your understanding of the correlation between catch rates and biomass. These data were provided by the NT Department of Primary Industries and Resources (Fisheries). The data provided in Tables 5-24 and 7-9 of the EP relate to the percentage of catch within the survey area with application of a 3.6 km buffer, as calculated by NT DPIR. No information on correlation between catch rates and biomass has been provided by NT DPIR. At 600 m line spacing, and with an Rmax distance of 165 m for all shots within the FPZ, there is a strip of seafloor between each line (270 m in width) that is essentially un-impacted ï i.e. received levels in this area do not exceed the 207 dB PK mortality threshold. If mortality effects were to occur in site attached fish assemblages within a distance of 165 m either side of each line, there is still a significant area of un-affected habitat that could provide recruits into the potentially impacted areas Again based on Popper are we assuming no impact? Yes. Based on the modelling outputs, the impact assessment incorporated into the EP, and the findings of the expert peer review, the statement highlighted in bold remains valid.E694	
Timor Reef and Demersal Relevant	TRD-198	1/03/2018	[redacted] email: Hi [redacted] [redacted] remains tied up with other matters this week and will be coming back soon. Have you had a chance to answer any of questions raised in email below? Regards, [redacted]	Email from [redacted] to ERM following up on TRD-196.
AMSA	AMSA-5	28/02/2018	Santos email: Dear [redacted] Please be advised that the Bethany 3D seismic survey (subject of emails to you 25/06/2017 and 12/07/2017) is now planned to be undertaken within the period of 1 May to 30 September 2018 or 2019, and will have a maximum duration of 75 days. Note that Santos will inform AMSA, AHS and ADF Airspace a minimum of three weeks prior to commencement of activities, to facilitate the Notice to Mariners process. Please do not hesitate to contact me should you require any additional information. Best regards, [redacted] Note from M.[redacted] FYI ï have received a ñreadò message from AHS, and a phone call from RCC (assigned ref# 2018/1440), so theyõve essentially acknowledged receipt Cheers [redacted]	

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AMSA	AHS-4	28/02/2018	Santos email: Dea[redacted] Please be advised that the Bethany 3D seismic survey (subject of emails to you 25/06/2017 and 12/07/2017) is now planned to be undertaken within the period of 1 May to 30 September 2018 or 2019, and will have a maximum duration of 75 days. Note that Santos will inform AMSA, AHS and ADF Airspace a minimum of three weeks prior to commencement of activities, to facilitate the Notice to Mariners process. Please do not hesitate to contact me should you require any additional information. Best regards, [redacted] Note from M.[redacted] [redacted] FYI ï have received a ñreadò message from AHS, and a phone call from RCC (assigned ref# 2018/1440), so theyôve essentially acknowledged receipt Cheers [redacted]	
Department of Defence	DoD-28	28/02/2018	Santos email: Dea[redacted] Please be advised that the Bethany 3D seismic survey (subject of emails to you 25/06/2017 and 12/07/2017) is now planned to be undertaken within the period of 1 May to 30 September 2018 or 2019, and will have a maximum duration of 75 days. Note that Santos will inform AMSA, AHS and ADF Airspace a minimum of three weeks prior to commencement of activities, to facilitate the Notice to Mariners process. Please do not hesitate to contact me should you require any additional information. Best regards, [redacted]	
Department of Defence	DoD-27	24/02/2018	Santos email: Hi [redacted] Further to my email of 12 December 2018 regarding acquisition of the Bethany and Beehive seismic surveys, I would like to provide Defence with an update on the proposed control measure to eliminate the possibility of any negative interactions between seismic acquisition and surface vessels, submarines and aircraft that will be engaged in activities during Exercise Kakadu. Santos would like to confirm that no survey operations will be undertaken for the Bethany or Beehive surveys during the period 31 August ï 15 September 2018, to avoid any overlap with Exercise Kakadu. Additionally, as requested in your letter to our environmental consultants dated 13th December 2017, Santos will notify Defence prior to the commencement of each survey and will follow up with a further notification upon cessation of acquisition and completion of the surveys. We also acknowledge your comments regarding the possibility of unexploded ordinance in the survey area. Please contact me if you require any additional information. Regards, [redacted] DoD email: Hi [redacted] Thanks for your email, I have passed this information on to the relevant stakeholders for their awareness. Kind Regards, [redacted]	

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Austral Fishing	AF-9.1	23/02/2018	Santos email: [redacted] I just want to advise you that I will now be your principal contact in Santos with regards to any matters in relation to the Bethany Seismic survey. I will follow up internally with the Santos team to understand the status of any pending questions or information requests that we owe you and ensure we respond as soon as possible. Please let me know if you have any queries. Kind regards [redacted] AF email: Thanks [redacted] Just to be clear ï are you the new [redacted] Regards [redacted] Santos email: [redacted] I am not the new [redacted] ï though I can confirm I am now your primary contact for Santos. If you have any questions please give me a call to discuss. Kind regards [redacted] AF email: Thanks [redacted] All rather curious and sudden. It would be nice to meet with you should you find yourself in Perth at some stage. Meantime, I have included [redacted] and [redacted] from our office on copy. When we met with [redacted] and [redacted] last week we were left to believe that the NOPSEMA where to announce their decision on the EP for this survey as soon as yesterday. Are you able to provide update on the status of this? Regards [redacted] Santos email: [redacted] It would be good to catch up next time I am in Perth. With regards NOPSEMA ï we have not received a decision on the EP. I understand that we have received a request for further information (RFI) yesterday that we are currently reviewing. Kind regards [redacted]	
Timor Reef and Demersal Relevant	TRD-197	23/02/2018	[redacted] email: [redacted] On a process issue our understanding was that for transparency we would be copied into all corrrespondance for the review. Unfortunately I have no emails between SANTOS/ERM, ART and whoever carried out current modelling. Could you please provide relevant correspondence. Also it would be helpful to understand [redacted] (ERM) role in EP process. As you would be aware as yet we have made no comment on the new EP and not sure who I should be talking to. Regards [redacted]	Email from [redacted] requesting copies of emails sent between Santos and ERM and JASCO concerning additional data extraction and analysis from second modelling study.
Timor Reef and Demersal Relevant	TRD-197.1	23/02/2018	Santos email: [redacted] I just want to advise you that I will now be your principal contact in Santos with regards to any matters in relation to the Bethany Seismic survey. I will follow up internally with the Santos team to understand the status of any pending questions or information requests that we owe you and ensure we respond as soon as possible. Please let me know if you have any queries. Kind regards [redacted]	

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Timor Reef and Demersal Relevant	TRD-195	22/02/2018	[redacted] email: Art In addition to previous concerns an issue remains with longer accumulation periods. Unfortunately the format of the modelling for extended periods means that our concerns still remain unanswered. As outlined in my response on proposed modeling scenarios I was expecting the modelling to be in the same format as results in JASCOs report. This would have given us results at a range of distances. The fact at 100 m the impact is limited is consistent with expectations at such distances - the magnitude of individual shot impacts dominates results (less reliant on shot numbers) This is not the expected result at increased distances (100 to 500m or more from survey line). At these distances and further we would have seen far greater impacts. As these areas are cited as unimpacted areas providing for essential recruitment I hope you can understand my concerns. Do you think itộs possible that the results are available at a range of distances as provided in the standard SELcum results? Warm regards [redacted] AP email: Hi [redacted] I need to spend some time on your other (longer) email and try and better understand the issues you raise. But, want to respond re the additional modeling. Since all these emails go to [redacted] and others, they can respond re providing additional modeling. I, however, personally see no need for them. As I will share after I've reviewed your other email, I am more and more convinced that far too much is being made of SELcum, and certainly, longer accumulations won't take place. The major accumulation of energy, unless a fish follows a seismic vessel around, is on closest pass of the vessel to the fish, and there is little or no accumulation on top of that later on. Any additional accumulation (which I suspect is not close to anything that could result in TTS) is going to be on fish that have recovered from the first exposure. Indeed, I am finding a literature (albeit not on fishes) that suggests that there is some recovery from TTS even in the approximately 12 sec. between seismic pulses. But, more later (maybe 24-hours) so I can be sure and give careful consideration to your issues. (And, as a favor, please do not color responses in green - that is how some have come and they are really hard to read for some reason!). Best wishes. Art [redacted] email: Art As counter intuitive as it maybe I am not uncertain about the modelling requested. There is considerable difference between accumulation 100 m from the first track and say 200 m from the third. Also the new modelling suggests a SELcum of approx 200db from first pass. So from this am I right in concluding we would predict TTS as the likely impact? The fish receives ppSEL of approx 185db. It would be greatly appreciated if it could be explained why these results are so inconsistent with previous JASCO reports and impacts predicted in EP. Warm regards [redacted] Apologies re text colours a habit I picked up in Canberra many years ago to keep Hansard quotes with associated authors.	Email from [redacted] to Art Popper, and response, concerning peer review process.

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Timor Reef and Demersal Relevant	TRD-196 with TRD-186 through TRD-193 attached	21/02/2018	[redacted] email: Hi [redacted] I can see [redacted] discussion with Professor Popper is taking some time and there is obviously more to come. Given this and the fact [redacted] is busy this week I felt we needed to engage a little. To start I will go back to purpose of why we are engaging. The fishing industry has raised major concerns regarding the effects of seismic surveys on the environments in which they operate and are asking for clarification on what can support the argument that the seismic surveys are not detrimental. To state the obvious, to make an assessment we need to know the potential impact. In order to make notes easier, I have sourced a few items from the last Environmental Plan V5 which is the last we received. Environment Plan Section Detail in Environment Plan Question Section - Demonstration of Acceptability - Fish External context - Stakeholder expectations Santos has assessed these impacts and through the implementation of applicable controls potential impacts Santos worked with stakeholders to understand any objection or concerns and implement appropriate controls to ensure impacts are ALARP and acceptable. I am not sure how this could be stated when [redacted] has been asking for months for clarification on one issue that could actually finalise these discussions. Environment Context The significant impact criteria applicable to fish species are: - Lead to a long-term decrease in the size of an important population of a species. Please advise what is this based on. Principles of ecologically sustainable development met? e) Cost benefit analysis was undertaken to determine applicable controls based on localised and short term impacts and include reduction in the seismic noise source, use of soft start procedures and restricting the amount of infill lines to minimise impacts to site attached fish. I do not believe reducing air gun size is a mitigation method for when the survey is being conducted. Given speed of vessel and the lack of knowledge regarding potential effects how do soft start procedures and widening the vessel lines by 100m mitigate impacts? 7.1.5.3 For free-swimming fish that are able to move away from seismic sources as they approach, the potential for lethal physical damage from airgun emissions is even further nullified. I am not sure how ňullifiedôcan be stated when it has been agreed numerous times fish do not have the capacity to swim away from a vessel travelling at 5 knots. Please advise your understanding of fish movement. The area of potential impact is likely to be conservative based on a recent study (Popper et al. 2016) and a comprehensive literature review (ERM 2017) that did not identify mortality, potential mortal injury or recoverable injury at levels above the current published thresholds I am concerned about the reliance on Popper given his recent emails regarding speculative nature of effects on wild fish. Refer email attached in particular: I do appreciate that TTS is an issue for fishes, but the potential impact on wild fish has only been speculated upon and there is no good work (in my view - I do know the lab studies, which I think are not very useful or informative vis a vis wild animals). For commercial fish species, the area of potential impact is within the area of the Timor Reef Fishery (TRF) where 4 ï 12% of their catch has been caught, based on data from 2013 to 2017 (Table 7-9). The most abundant commercial fish species within the survey area is goldband snapper, at 8.55% of the total TRF catch caught within the operational area. Please advise your understanding of the correlation between catch rates and biomass. At 600 m line spacing, and with an Rmax distance of 165 m for all shots within the FPZ, there is a strip of seafloor between each line (270 m in width) that is essentially un-impacted ï i.e. received levels in this area do not exceed the 207 dB PK mortality threshold. If mortality effects were to occur in site attached fish assemblages within a distance of 165 m either side of each line, there is still a significant area of un-affected habitat that could provide recruits into the potentially impacted areas Again based on Popper are we assuming no impact? Could you also please provide cited report: ERM (2017) Regards, [redacted]	Email from [redacted] to ERM requesting further information about issues covered in Rev 4 of the EP.

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Timor Reef and Demersal Relevant	TRD-194	20/02/2018	AP email: Hi [redacted] [redacted] has said I was welcome to share the attached with you. This is the additional modeling data from JASCO. Note that the title page (which lists the things requested) was added by me, and I modified a few of the graphs to make them have less empty areas and focus on the curves. But, nothing else has been modified. Art [redacted] email: Hi Art Thanks for forwarding information. Good to see short accumulation times confirmed as predicted ï turns out Iôm not mad after all. I am concerned regarding the PPSEL figures used 100m from the vessel. Below are some peak levels provided from modelling to date (differences relate to choice of 4 representative sites). From this it is unclear why the new modelling has a 187 dB ppSEL 100m from the survey line. Could you outline why this level is so low and where in the survey area the fish modelled is located. I will respond to other modelled scenarios over weekend. Your help in getting requested modelling started is very much appreciated. Talk soon [redacted] Diagram AP email: [redacted] will respond about other things later, but just this morning realized you might be interested in www.an-2019.org. this is a meeting I founded that you might find of real interest. (And location is great.) It attracts hundreds from around the world and includes scientists, regulators, industry, etc. You might find the discussions and the networking of real interest. Art [redacted] email: Thanks Art. Are you happy for me to forward to industry contacts? Understanding the impacts from surveys is a key priority for many fisheries and our new national body so there maybe others interested. Cheers [redacted] AP email: BY all means share. In fact, we are also looking for financial support for the meeting and offering sponsorships to companies and groups that give them PR (e.g., paying to have their names on the lanyards that hold name tags, paying for a meal) and then we use the funds to help support students and others who could not otherwise afford to come to the meeting. If anyone would be interested in that, have them contact me. Art	Email from Art Popper to [redacted] concerning peer review process.
Timor Reef and Demersal Relevant	TRD-193	15/02/2018	AP email: Hi [redacted] I'll get material probably in a week or so. On another note, with this very long email chain, I am feeling I am missing the answer, which you probably gave, to a question I asked about why you are so concerned with TTS. I do appreciate that TTS is an issue for fishes, but the potential impact on wild fish has only been speculated upon and there is no good work (in my view - I do know the lab studies, which I think are not very useful or informative vis a vis wild animals). So, is your concern based on speculation, and do you have specific thoughts as to its implication? And, can you be a bit more specific (for my benefit - I trust you've shared some of this with [redacted] and others) as to how you see TTS as impacting the fishing industry? I look forward to learning your perspective. Thanks, and very best wishes. Art	Email from Art Popper to [redacted] concerning peer review process.

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Timor Reef and Demersal Relevant	TRD-192	14/02/2018	[redacted] email: Art re Modelling Scenarios The SElcum modelling and associated heat maps will provide us with modelled SELcum for stationary fishes at a range of distances from the survey lines Scenario 1 Assuming fish is stationary at 100 m from a line, model the SELcum at the fish for: a. 30 minutes (15 on each side of the closest point), b. 60 minutes (30 minutes on each side), c. 90 minutes (45 minutes on each side), and d. 120 minutes (60 minutes on each side). Art these will certainly provide information required. 2. Assuming fish stays in same spot, do the same modelling for when the source is on the return path (presumably about 27 hours later). a. Calculate SELcum for the same runs as in #1a and 1b. Assume that the fish has shown complete recovery from initial exposure. b. Do the same as 2a for 30, but assume that there is no recovery from the initial exposure (add the additional exposure to the maximum SELcum that the fish I am not sure why we need these. We already have both scenarios (admittedly modelling for the longer 24 hrs but this shouldnt matter based on scenario 1. Scenario 2a will provide the same as 1a and 1b. Noting that if the SELcum levels are achieved in 30 minutes we have this modelling also ï this is the return line SELcum modelling supplied in the JASCO report. We would know achieved from when the vessel is close from results to scenario 1. Of note the time period for this scenario to occur is approx. 3hrs up to to a max 27hrs. The fact that this has had little effect in the 24hr SELcum modelling also supports our expected results in scenario 1. 3. Assuming fish is still in the same spot, do the modeling for when the source is on the next closest track (presumably about 54 hours later, and something like 500 m further away). Do as in 2. Again we dont need modelling for 2a. I would carryout modelling for 60 hours. This would be very useful in considering the impacts of longer and shorter runs. For example, in the north east track of the proposed survey these SELcum scenarios would likely be achieved in less than 24 hrs and the modelling would be applicable. Based on the above modelling Scenario one and a Scenario with a SELcum of 60hrs would provide the information we need. Based on the results from these two scenarios we could then consider the need for any further scenarios. Warm regards [redacted] For info the way the models work they would just model survey line achieved in that time so for 60hrs something like as follows. The model itself doesn't consider the times between these lines just the accumulated sound energy. Diagram	Email from [redacted] to Art Popper concerning peer review process.

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Timor Reef and Demersal Relevant	TRD-191	13/02/2018	AP email: Hi [redacted] Thanks for getting back. And it does like we are in agreement on most things. To clarify, when about adult and young fish, I was referring to our 2005 study with northern pike, not Bethany. In our study, we did see TTS in adult pike but not juveniles, and we have no reasonable explanation. I think my writing could have been clearer. I was not suggesting anything about Bethany fishes. As for what would happen with increased shots in our 2005 study - Iôd like to know that as well. We were not able to do more and, as you appreciate, this was supposed to mimic a riverine situation and so we focused on ñworst casesò in the river. The big question of concern to all of us now, of course, is what would happen to Bethany fishes in a reasonable exposure scenario. The only potentially relevant data are from Hastings and Miksis-Olds, and they found no TTS in several species of caged fishes exposed to a moving airgun (work headed by [redacted] McCauley), including fishes that are likely to have enhanced hearing sensitivity. Considering that these fishes could not move, this is a really interesting finding. A critical question is, in a normal situation, how to account for the fact that many fishes will move, and would that prevent any hearing impacts. Of course, there is another interesting issue to consider, and that is the population effect (often referred to in the literature these days as ñpopulation consequencesò). I think that most of my colleagues concerned with potential impact of man-made sound on fishes would agree that an impact (whether it be as benign as TTS or dramatic as death) on a few fishes in a large population is not going to have any consequence to fitness of the population, survival, reproduction, etc. This is very different than the concerns of my colleagues working on marine mammals where there are few animals. But, there are generally numerous fishes (and invertebrates) and one can argue that loss of a few animals is of little consequence in the ñgrand scheme of things." Moreover, I think it is reasonable to extrapolate that if one is fishing for a particular species, the loss of just a few animals as a result of TTS would not have any consequence on catch rate. Indeed, the majority of fishes are likely to be sufficiently far from seismic exposure so that TTS is minimal (or non-existent). And, even if there is some TTS, we need to ask what constitutes a TTS of consequence to a fish? In the 2014 guidelines paper we strongly suggest that a 6 dB TTS is not significant and within the scope of normal hearing sensitivity variation over time (minutes, hours, days) in any animal (and that includes you and me!). Iôd go further and suggest that even a 10 dB temporary hearing loss (and perhaps more) will have no consequence for an individual animal, and even if it does, the effect is only very short-term. Where Iôm going with this is that I have yet to hear an argument as to why there is concern about TTS. If one is concerned about an individual animal or a small per cent of a local population, then TTS is, to my thinking, not an issue of consequence. Iôd very much value knowing a bit more as to why you see TTS being of concern. On a total other note, I have been thinking of a few analyses that might get modeled by JASCO if there are the funds and opportunity. I think these, given below, would be of potential interest, but certainly not answer the fundamental issues youôve raised of degree of TTS or its duration. Still, this information could have long-term value in considering this and other seismic studies. Iôd value your thoughts on the questions I intend to ask if a tiny bit of additional modeling can be done. Very best wishes. Art 1. Assuming fish is stationary at 100 m from a line, model the SELcum at the fish for: a. 30 minutes (15 on each side of the closest point), b. 60 minutes (30 minutes on each side), c. 90 minutes (45 minutes on each side), and d. 120 minutes (60 minutes on each side). 2. Assuming fish stays in same spot, do the same modeling for when the source is on the return path (presumably about 27 hours later). a. Calculate SELcum for the same runs as in #1a and 1b. Assume that the fish has shown complete recovery from initial exposure. b. Do the same as 2a for 30, but assume that there is no recovery from the initial exposure (add the additional exposure to the maximum SELcum that the fish 3. Assuming fish is still in the same spot, do the modeling for when the source is on the next closest track (presumably about 54 hours later, and something like 500 m further away). Do as in 2.	Email from Art Popper to [redacted] concerning peer review process.

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Timor Reef and Demersal Relevant	TRD-190	9/02/2018	[redacted] email: Art Thank you regards modelling. I did ask for simple modelling back in May last year but am hoping you will have more influence. The important issue for me in your 2005 paper was that TTS occurred in all species at 20 shots which is an increase in TTS even if in this instance recoveries were similar. My concern is the magnitude of the 3D survey in comparison. I provide the following as demonstration. Popper 2005 (apologies if figures off just from memory) SELss 178 dB time Shot interval Number of shots 3.3 minutes 40s 5 13 minutes 40s 20 3D Seismic Survey SELss 178dB 2km from source. Distance from array Time (178 dB) SELss or above* Number of shots Shot interval 2km 1 1.92 km 13 minutes 97 8 secs 1.8km 19 mins 145 8 secs 1.6km 26 mins 200 8 secs 1.4km 31 mins 238 8 secs 1.2km 35 mins 266 8 secs 1km 38 mins 288 8 secs 500 42 mins 322 8 secs *except for the first and last shot every other shot is above 178 db Do you think we are likely to see different recovery times for these types of exposure? I have highlighted the comparison at 13 minutes. These fish experience 77 more shots that in your experiment with far less recovery between shots. Warm regards [redacted] AP email: Hi [redacted] I do not see any difference in the outcome from the way we exposed fish in Popper (2005) and the outcome of a 3D survey from the perspective of the fish. The issue is not how the survey is done. The issue is the exposure at the fish. Similarly, and I trust you will agree, the relevant sound level for our discussions is that at the fish and not at the source. Indeed, a fish could be exposed to 195 dB (skipping rms, peak, etc, since not relevant for this specific point) that is the result of being very close to a source that is producing 195 dB or very far from a source that is producing 240 dB. It is the 195 dB at the fish that is what will be detected and potentially cause TTS (note, I am NOT saying it will!). (Note, there are other issues from being really close to the source, but I dond think these are of any relevance to the fish or to our discussions). I do agree that tings like time between pulses, instantaneous time course for recovery (e.g., recovery between pulses), the spectrum of the sound, the onset time of the pulse, and lots of other things may have an impact on whether there is TTS - and we have no clue as to how these (and many other) variables play out. Doing that kind of study would take an immense amount of work, and cost a great deal, though I have argued (and will continue to argue) that these kinds of questions must be asked. So, no one can honestly answer your question about recovery times for different exposures since the (high quality) science needed to do that does not exist. However, the data only shows TTS from seismic exposure in two species, one of which (lake chub) has far better hearing than most species likely to be exposed at Bethany. However, the third species in our study, and all of the species (including ones with specializations to enhance hearing) studied by Hastings and Miksis-Olds (2012) at Scotts Reef show no TTS at all (if you do not have that paper Id be glad to provide a copy, but trust you do). So, the bulk of the (albeit very limited) evidence shows either no TTS or rapid recovery. That is not to say that there will be no TTS in the Bethany study (due to more exposure, as you are arguing), but I am very uncomfortable extrapolating from one species that hears well, and the adults (but no the young) of another species to say that there will be TTS at Bethany that will impact the lives of the fishes there in any meaningful way. Art [redacted] email: Hi Art Firstly an apology I think somehow communication of our concerns may have increased confusion so I will try and be clearer in explanations. I do not see any difference in the outcome from the way we exposed fish in Popper (2005) and the outcome of a	Email from [redacted] to Art Popper, and response, concerning peer review process.

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			3D survey from the perspective of the fish. The issue is not how the survey is done. The issue is the exposure at the fish. Similarly, and I trust you will agree, the relevant sound level for our discussions is that at the fish and not at the source. Indeed, a fish could be exposed to 195 dB (skipping rms, peak, etc, since not relevant for this specific point) that is the result of being very close to a source that is producing 195 dB or very far from a source that is producing 240 dB. It is the 195 dB at the fish that is what will be detected and potentially cause TTS (note, I am NOT saying it will!). (Note, there are other issues from being really close to the source, but I don't think these are of any relevance to the fish or to our discussions). I agree with you completely on this which makes me think I may have not presented issue well. I do agree that tings like time between pulses, instantaneous time course for recovery (e.g., recovery between pulses), the spectrum of the sound, the onset time of the pulse, and lots of other things may have an impact on whether there is TTS - and we have no clue as to how these (and many other) variables play out. Doing that kind of study would take an immense amount of work, and cost a great deal, though I have argued (and will continue to argue) that these kinds of questions must be asked. 100% agreed So, no one can honestly answer your question about recovery times for different exposures since the (high quality) science needed to do that does not exist. However, the data only shows TTS from seismic exposure in two species, one of which (lake chub) has far better hearing than most species likely to be exposed at Bethany. However, the third species in our study, and all of the species (including ones with specializations to enhance hearing) studied by Hastings and Miksis-Olds (2012) at Scotts Reef show no TTS at all (if you do not have that paper I'd be glad to provide a copy, but trust you do). So, the bulk of the (albeit very limited) evidence shows either no TTS or rapid recovery. That is not to say that there will be no TTS in the Bethany study (due to more exposure, as you are arguing), but I am very uncomfortable extrapolating from one species that hears well, and the adults (but no the young) of another species to say that there will be TTS at Bethany that will impact the lives of the fishes there in any meaningful way. I understand your reservations of extrapolating your results to other species. Could you please clarify your reference about the adult and not the young of another species in the Bethany survey. In your 2005 work on the results from moving to 20 shots you expressed concerns about the impact of the additional shot numbers, "One concern is that our results show that exposure to 20 airgun shots is very likely to cause a TTS in every species exposed, except juvenile northern pike. It is unlikely that fish would encounter 20 shots in a river seismic survey unless they were "herded" with the survey vessel." This limitation on number of shots doesn't occur in a marine 3D survey. My question really isn't about how close to the source a fish is or species specific. I would like to know what results we would expect if looking at the same species as your 2005 work, but we increased shot numbers to say 97 in 13 minutes at the same SELss or in fact over 230 shots in 30 minutes? Hopefully this clarifies issue. Warm regards [redacted]	

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Timor Reef and Demersal Relevant	TRD-189	7/02/2018	AP email: Hi [redacted] Just want to follow up with a few more points. First, I am exploring getting a bit more modeling done. I have suggested that once I come up with what I think we need, we share the ideas with you and get your feedback so that we get the answers we might both want. I doubt we can get much done, but I will ask for a few things and let you know. Need a few days on that. Second, I want to push a slightly different way of thinking. That is, one of the unique thing about the auditory system in all vertebrates that have been studied, is that it is able to deal with an immense range of intensities - in humans from 0 dB to over 120 dB, which is many order of magnitude of intensity. (This is, by the way, one reason we use the dB scale since it allows a log transformation of energy and thus we can more readily grasp, and express, the very great dynamic range of the auditory system.) My point in mentioning this is that even if there is a 4, 6, 10 dB increase in SELcum, it does not necessarily mean the same log scale of effect or TTS. So, how any increase in SELcum affects TTS is not likely to be a 1:1 relationship. Indeed, I went back and looked at our 2005 data. The mean SELss was about 178 dB. This means that the SeLcum for 5 shots was (and I just calculated this, it is not in the paper) about 185 dB and for 20 shots it was about 191 dB. And yet the recovery was less than 18 hours for both. So, even with a doubling of energy, both 5 and 20 shot animals recovered within 18 hours or less. (Note, even though you are saying 18-24 hours for recovery, we did not test during the time immediately post-exposure and 18 hours, and so recovery took less than 18 hours, and potentially much less.) Have a great weekend and looking forward to our continuing discussions. Art AP email: Hi [redacted] Just want to make one point at the moment, then try and respond more later. You say below (and I think in other places) that you are concerned (if that is the right word) about applicability of results from a riverine study (my 2005 work) to a marine environment or to a 3D survey. I would suggest that this is not an issue since what we are dealing with is the SELcum at the fish and the exposure at the fish and not the source itself. And, the question we are dealing within recovery from TTS and not really how the TTS was produced. Indeed, I suspect we could consider any fish TTS since we are concerned with the aftereffects (recovery) and not the stimulus itself. That said, there are caveats. For one, the nature of the received signal may, in fact, be a bit different in the very shallow river than in the marine environment due to propagation differences - in shallow water the low frequencies do not propagate as far as in deeper water. As a result , the spectrum of the signal received at the fish may be a bit different. How different is open to some conjecture since depth is not the only factor in propagation - the nature (type of material) of the bottom is also a big factor. Another caveat might be the precise characteristics of the signal onset, but this is something for which we have virtually no knowledge. Art	Email from Art Popper to [redacted] concerning peer review process.

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Timor Reef and Demersal Relevant	TRD-185	6/02/2018	[redacted] email to AP: Art It would be greatly appreciated if you could provide some update on the review of material provided. As some background our initial concerns were raised about the applicability of a single SELcum time period to all marine fauna (see email below). Can you let me know if you have access to modelling for SELcum over shorter periods ï say two hours? Also is this available for longer periods where we have lines in closer proximity. I think with such modelling at hand we would be far more informed about the applicability to a range of species. Based on the speed of the survey vessel and breadth of impacts many species of fish cannot physically avoid the survey so this additional modelling is essential to consider impacts. It would seem the 24hr metric applicable to cetaceans has simply been used for fish and other marine life. Warm regards [redacted] Email chain requesting modelling be carried out at longer and shorter periods Emails On 26 May 2017 at 17:39, [redacted] wrote: [redacted] Whilst I thank you for your responses to date it is fair to say I am becoming increasingly concerned with the process. In relation to your response to citing of recommendations from Popper re SELcum I think it should be noted we are very concerned with the nature of such a claim and now further with the response. The claim is repeated in your EP using the same citation. ñPopper et al. (2014) recommended a sound exposure criteria for TTS for fish with a swim bladder involved in hearing of >> 186 dB 24 h SEL and 186 dB 24 h SEL for fish with a swim bladder not involved in hearing (Table 7 5) The SEL metric integrates noise intensity over the period of exposure. Because the period of integration for regulatory assessments is not well defined, for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, which is applied in this risk assessment.ò The citation never existed and now the 24hr metric is being portrayed as an industry standard. This is defended by a statement that ñn all cases fish that showed TTS recovered to normal in 24hrs. Therefore, ñthe 24hr metric is used as an industry standard.ò The recovery time for TTS is simply not known. The exposure you refer to is a SELcum of 186 dB re 1 εPa 2 ľs accumulated over ýve seismic pulses within about ýve minutes. It is agreed these fish all recovered in 24 hrs, but as Popper clearly states has little relevance to fish experiencing the same SELcum in 5 shots in 40s. To use this number to suggest that fish recover from TTS in 24hrs in all cases is simply misleading. We would expect fish subjected to the SELcum criteria to be the quickest to recover. However the range of impacts as we approach the source will be vast and no estimates of recovery can be made.	Email from [redacted] to Art Popper, and response, concerning peer review process.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
			Even if we had a known recovery time its not clear of the relevance in selecting metric for SELcum. It would be greatly appreciated if this issue can be properly reviewed as the cumulative impacts are of great concern to industry. Warm regards [redacted] [redacted] to SANTOS [redacted] <[redacted] Subject: Re: EP - comments on risk assessment and likelihood of events. [redacted] Having reviewed the recommendations on setting metrics for SELcum it would seem prudent to look at several time periods. I am not certain of the practicalities of JASCO modelling but can you inquire if it is a simple process to alter this metric. Warm regards [redacted] SANTOS to [redacted] On 31 May 2017 at 12:53, [redacted] <[redacted]santos.com> wrote: Hi [redacted] The SEL24 measures the cumulative sound levels of shots within the 24 hour time period. I am presuming you are asking if we can do this over a longer time period? I have spoken to Jasco and this is not a simple process and hence Jasco modelled the SEL24 for two scenarios (eastern and western) rather than using a straight line for the 24 hr calculation. Jasco did the assessment from the middle point of the survey so that the 24 hrperiod includes two line passes rather than one for each scenario (see below which is Figure 5 from the Jasco report). Thus the SEL24 result is an accumulation of the received sound levels for two lines. With each line the seismic source is moving further away from a fixed receptor, and hence received noise levels are reducing, thus the potential for impact is also reducing. For receptors that are not fixed, whether they are exposed to the cumulative sound over a 24 hr or longer period will depend on their behaviour as to whether they stay in the vicinity of the sound or move away. In applying the SEL24 threshold distance to the Bethany assessment we used the furthest distance from the two scenarios to be conservative. Thanks, [redacted] [redacted] to SANTOS [redacted] I asked that the measure be reviewed and relevant and this will need consideration of shorter and longer time periods. The information you have provided is all already in the EP and I can only apologise if I have failed to explain/clarify my concerns. As a suggestion perhaps you could ask JASCO for sound level contour maps for SEL 2hrs and one for SEL 84 hrs. Both can be started at center of survey as outlined. I would hope you agree on seeing these results that also important would be some longer SELcum values up to and including 75 days. While appreciated, using the furthest distance from the two scenarios the SEL24 threshold distance provides no conservatism while the time period is not more relevant. In fact the 24hr period seems to greatly down play the risks from repeated runs. Happy to discuss [redacted]	

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Timor Reef and Demersal Relevant	TRD-186	6/02/2018	AP email: Hi [redacted] I'm still trying to understand the implications of the JASCO report. I am anticipating talking to some of their folks soon so that I have a better understanding of their models. I rather avoid giving any suggestions until I have that understanding - hopefully in the next few days. I will say, however, that my view is that the actual potentially effective exposure for a stationary animal (worst case) is on the order of minutes when the source is relatively close to the animal. Considering how SEL accumulates (basically, a log addition), signals from greater distances will not add measurably to the SELcum. More as soon as I understand more. Best wishes, and thanks for getting back to me. Art [redacted] email: Thanks Art and agreed. A shorter modelling time will show stationary receivers accumulate their relevant SELcum from first 24 hrs in far less time. We estimate about 52 mins for levels that are predicted to have immediate impact. This would be easily shown with a shorter modelling duration say 2 hrs. Of concern however is that within just over 48 hrs these receivers will be subjected to higher levels again from a closer source without time to recover and this is not considered in current modelling or EP. Warm regards [redacted]	Email from Art Popper to [redacted] and response, concerning peer review process.
Timor Reef and Demersal Relevant	TRD-187	6/02/2018	[redacted] email: Hi Art: Where did you get the 52 minutes from? So while modelling would have been a little rough on this one I tested theory by using the log addition equation for SELcum. From single shot modelling and relevant log summation I factored in some lower sound levels then used chord of circle equations to calculate distance and number of shots. Its is rough but did show that the accumulation in 24hrs occurred as the vessel passed. JASCO could easily model these shorter periods to confirm say 2 hrs. Of course, again assuming that a fish is stationary, what is the signal level from the next pass, which I suspect is greater than 48 hours (considering that each track is suggested to be 27 hours and then turning time)? Next pass time must have increased ï happy to take it out to 60 hours. The signal level from the next pass is different depending on location. The survey lines in the 24 hr modelling are 5km apart. The third survey line is approx. 500m from the first and so on. This pattern is shown in my original email. After the first 24 hrs receivers between the first 2 survey lines have already received SELcum of over 190dB. They are then exposed to higher levels again within approx 60 hrs. This repeats compounding through survey. Regards [redacted] AP email: Hi [redacted] Where did you get the 52 minutes from? Of course, again assuming that a fish is stationary, what is the signal level from the next pass, which I suspect is greater than 48 hours (considering that each track is suggested to be 27 hours and then turning time)? FYI, going offline for the evening shortly so if you don't get response it is because of that. I think you are 13 hours ahead of us if in Perth. Art	Email from [redacted] to Art Popper, and response, concerning peer review process.
Timor Reef and Demersal Relevant	TRD-188	6/02/2018	[redacted] email: Art I think we are thinking pretty much the same on the overall analysis of the sounds and when they impact the SELcum. We can see if we can get more things modeled so we have better numbers than your estimate (which, by the way, seems "within the ballpark" [if that analogy makes sense to Aussie's]). I＇d be impressed if it was in the same city! The modelling was just to make sure I was close. To establish impacts on marine fauna it would be really helpful to have modelling when 186db SELcum reached 3km from the survey line. It might be also worth modelling the time required for SELcum to reach 186 dB 2 km from survey. One quick comment, however, deals with the accumulation on the second close pass (which you have as 60 hours, but the time needs to be determined). I gather you are making the assumption that there is no recovery from TTS in the period between the closest pass and this next pass. I haven＇t actually assumed any recovery time. In fact despite numerous requests for information on this the only reference I have been provided is your 2005 work. What I am certain is that within 24hrs there is no way that all the marine fauna has recovered from impacts of the	Email from [redacted] to Art Popper, and response, concerning peer review process.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
			survey in the modelled SELcum scenario. The recovery in your 2005 work was from 5 shots in five minutes in a shallow riverine environment and I have the same concerns about the application of these results to 3D marine surveys as outlined in your report. Importantly I am not questioning its appropriateness as a guideline for TTS onset. It of course forms the advice provided in your important 2014 guidelines. My concern relates using this recovery rate from your 2005 work to set an appropriate SELcum period. The 24 hr SELcum sees this level reached over 3km from the survey line. I think we can agree these levels will be reached in well under 24hrs. This threshold is shown with a thin blue line in the JASCO modelling. Even noting my previous concerns about applicability, I support the fact that marine fauna or fish found on or near this boundary are likely to recover within 24 hrs as predicted by your 2005 work. Where this falls down is as we approach closer to the survey line. As you can see from the modelling large areas are exposed to SELcums of over 190dB and up to 200 or more. These are levels vastly different from the 186dB from the 2005 work. It is fish and fauna exposed to these levels whose recovery times seem unclear. I find the 10dB scales in this mapping a little difficult. The 190dB SELcum represents over twice as much energy as the 186dB guideline for TTS. 200dB would be over 12 times the energy. The reality is there is a very large increase in energy as we approach the survey lines which unfortunately is presented in two colour steps. Are we expecting all these fish to fully recover in 24hrs or just those on the 186dB contour and beyond? Noting your previous work on pink snapper and the work of Mr McCauley I am concerned that fish and marine life cannot have recovered from these impacts within 24hrs. In fact, virtually all TTS data, whether it be for fish or for chinchilla (a very common species studied in TTS and PTS) or humans (including federal standards in the US and I suspect Australia) show that TTS rapidly recovers. Indeed, even if you don't accept my 18-24 hours (which, I think is probably a very valid time frame for impulsive sound exposure), there is no doubt, based on extensive science, that there will be substantial recovery over any time frame. We can discuss that more of course, but even if the 2nd pass does add to SELcum, the starting point for the residual exposure is likely very low. Apologies if I have presented this as in some way questioning your 18 - 24 hr recovery as this was not my intent. My concern is recovery rates for fauna impacted at >>>186dB SELcum. (As an aside, several years ago we attended a Paul McCartney concert with 25,000 others and I came away with a great example of TTS. However, even after this massive noise exposure for many hours - and McCartney was fantastic - I was fully recovered within about 8 hours. I grant I am not a fish, and McCartney not a seismic device, but this brought home to me the nature of TTS recovery and its time course.) Using the same analogy I think my question is what would be the impacts if the concert produced twice as much sound energy or even ten times? What would impact be if you were lucky enough to have tickets for the whole week? It seems well established that repeated exposure to sound levels that cause TTS in humans, even after recovery, ie weekly trip to nightclub etc have been proven to cause long term damage. I think its fair to say a little TTS to see one of the Beatles play live is a more than reasonable sacrifice! Cheers [redacted] AP email: Hi [redacted] I think we are thinking pretty much the same on the overall analysis of the sounds and when they impact the SELcum. We can see if we can get more things modeled so we have better numbers than your estimate (which, by the way, seems "within the ballpark" [if that analogy makes sense to Aussie's]). One quick comment, however, deals with the accumulation on the second close pass (which you have as 60 hours, but the time needs to be determined). I gather you are making the assumption that there is no recovery from TTS in the period between the closest pass and this next pass. In fact, virtually all TTS data, whether it be for fish or for chinchilla (a very common species studied in TTS and PTS) or humans (including federal standards in the US and I suspect Australia) show that TTS rapidly recovers. Indeed, even if you don't accept my 18-24 hours (which, I think is probably a very valid time frame for impulsive sound exposure), there is no doubt, based on extensive science, that there will be substantial recovery over any time frame. We can discuss that more of course, but even if the 2nd pass does add to SELcum, the starting point for the residual exposure is likely very low. (As an aside, several years ago we attended a Paul McCartney concert with 25,000 others and I came away with a great example of TTS. However, even after this massive noise exposure for many hours - and McCartney was fantastic - I was fully recovered within about 8 hours. I grant I am not a fish, and McCartney not a seismic device, but this brought home to me the nature of TTS recovery and its time course.) Best wishes. Art	

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Timor Reef and Demersal Relevant	TRD-184	2/02/2018	[redacted] email: [redacted] On reading current EP all the issues we had agreed on have reverted back to original claims - perhaps easier if you could explain why 2 years of consultation has been ignored and provide relevant references including agreed positions in minutes from meetings. Thanks [redacted] Santos email: Hi [redacted] Good morning and thank you for your note. Santos has been engaging with relevant stakeholders on proposed seismic acquisition in permit areas NT/P85 and NT/P82 since late April 2015. Throughout this entire period all consultations have been conducted in accordance with regulatory requirements and NOPSEMA guidelines. Santos has strived to ensure that all communications have been transparent, collaborative and mutually beneficial. As you are aware, regarding the specific concerns and issues that you have raised on TTS effects in fish, modelling of SELcum and recovery periods, the findings of the modelling study and impact assessment (as incorporated into Revs 4 and 5 of the Environment Plan) are being reviewed by Professor Popper. Rev 5 of Environment Plan cites over 300 sources of information, included papers in peer reviewed scientific journals, unpublished reports, grey literature and material posted on government and other websites. Copies of a significant number of these references have already been provided to stakeholders. As indicated in my email to [redacted] on 2 February, if could you pass-on a list of particular references that you require access to we will, where possible, make arrangements to upload them to the FTP site. Regards, [redacted]	Email from [redacted] and response from Santos.
ConocoPhillips	CoP-17 with CoP-13 as attachment	1/02/2018	[redacted] email: Hi [redacted] Left a phone message with your reception in reference to the proposed Bethany seismic survey. Last year you'd recall we held discussions to ensure co-ordination of this operation with our work program for the Barossa Project (attached email). Your potential window does again overlap with some work planned along our proposed southern pipeline route so just wanted to ensure we were again co-ordinated. Our contact is now [redacted] and if you or the appropriate person could please contact [redacted] that would be appreciated. Thanks again for your assistance. [redacted] Santos email: Hi [redacted] Many thanks for your email ï unfortunately I haven't received the message from reception, so apologies for not returning it. We are still in the early planning phases on the survey, but I will [redacted] in the loop as timing etc firm up, to ensure we minimise impact to either project. Best regards [redacted] [redacted] email: Thank you	
ConocoPhillips	CoP-18	1/02/2018	CoP email: Hi [redacted] We will get our tenders back later this month for the Geotech scope at which point I will be able to give you a better idea of when we will be offshore. From what I have seen of your survey areas I expect the impacts will be minimal as we only have a short section of our gas export pipeline route within the operational area of your survey. Kind Regards, [redacted]	

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-183 with attached Transmittal receipt	31/01/2018	[redacted] email: Hi [redacted] Sorry it took so long. Could you also give me an update when you expect cited reports to be uploaded please. Santos email: [redacted] Thank you for the transmittal. Please note that the reports cited in your e-mail of 24 Jan have now been added to the FTP site. Where there any other cited items that you were seeking? Regards, [redacted] [redacted] email: Hi [redacted] If you could provide the supporting reports/documentation that the Environmental Plan references is obviously the preference for all concerned. This is what was done last year and I believe it reduced time involved for both parties when we needed to reference items in the Santos Environmental Plan. If all cannot be uploaded for some reason, we primarily need reports/documentation regarding impacts on fisheries and noise. Richardson, Jacobs, NT fisheries, Willis are all sources that I have read in sections I have reviewed. I will obviously need to discuss further with other stakeholder representatives to get a complete list. Santos email: [redacted] Please could you pass-on a list of particular references that you require access to and we will where possible make arrangements to upload them to the FTP site. Have a good weekend. Regards, [redacted]	Dialogue between [redacted] and Santos regarding material cited in the EP for upload to the ftp site.
Timor Reef and Demersal Relevant	TRD-182	29/01/2018	[redacted] email: Hi [redacted] Could you advise when you are expecting the dropbox to be updated please. Santos email: [redacted] For increased security Santos have upgraded the Dropbox site to a Santos-hosted FTP site. The FTP site contains revision 5 of the Bethany EP. The site can be accessed as follows. Site URL: [redacted] Firstly, please copy as paste the URL into an internet browser and follow the instructions to download. Secondly, complete the enclosed transmittal and return [redacted] copying stakeholder.[redacted]santos.com. Kind regards, [redacted] [redacted] email: Thanks [redacted] Problem with printer so I will get transmittal document to you in the morning. Do you plan to add cited reports to this or dropbox?	Email from Santos explaining that the project Dropbox folder option had been changed to a Santos hosted ftp site for improved security.

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Timor Reef and Demersal Relevant	TRD-179 and TRD-174 as attachment	24/01/2018	[redacted] email: Hi [redacted] In order for us to get a full understanding of the work Mr Popper is doing. Could you please provide the terms of reference under which he has been appointed. Santos email: Hi [redacted] Professor Popper has been engaged to conduct an independent, expert peer review. Outline of the scope: Independent, expert peer review of aspects relating to impacts of seismic noise from the proposed Bethany 3D seismic survey on fish, focused on TTS effects, and length of time for recovery and the applicability of an SEL24h metric. Inputs: Å seismic noise and fish impact assessment section from the Bethany Environment Plan; Å underwater noise modelling report from JASCO; and Å feedback from stakeholders (primarily [redacted] See attached email to [redacted] sent 8 Jan. You were ccd on that email. Regards, [redacted]	Email from [redacted] asking for information about the independent, expert peer review process, and response from Santos.
Timor Reef and Demersal Relevant	TRD-180	24/01/2018	[redacted] email: Hi [redacted] I have been obviously concentrating on our businesses operational matters recently and with the current work still being conducted I am now surprised to see lodgement of the Environmental Plan. It does not appear correct process. However, could you please add to the dropbox a copy of the lodged Environmental Plan and supporting documentation Santos email: Hi [redacted] The Bethany EP (Rev 5) was resubmitted to NOPSEMA, 23 January 2018. The EP has been revised to address the issues raised in NOPSEMAs OMR (Opportunity to Modify and Resubmit) letter to Santos of 18 July 2017. These changes were incorporated into Rev 4 of the EP, which was provided to stakeholders for review and comment on 8 December. Thus, stakeholders were given a period of over 6 weeks to review and respond to Rev 4 of the EP. New feedback and comments were received last week from the NT DPIR (Fisheries). Some additional edits were made to the EP based on this new information, and a response was sent to NT DPIR on 19 January. These communications are captured in the stakeholder consultation and correspondence records appended to the EP, as are communications between Professor Popper and [redacted] concerning the independent peer review process. Furthermore Santos states that even though the EP has been resubmitted that does not mean that consultation stops. Santos will continue to engage and consult with all relevant stakeholders during the process of EP assessment, acceptance and implementation. Throughout this EP revision and resubmission all regulatory requirements and due process have been followed by Santos. A copy of Rev 5 of the EP will be provided via the Dropbox shared folder. Regards, [redacted]	Email from [redacted] following resubmission of Rev 5 of the EP, and response from Santos.
Timor Reef and Demersal Relevant	TRD-181	24/01/2018	[redacted] email: Hi [redacted] It appears possibly a few more reports have been cited. Could you also add to the dropbox please. Items noticed Jacobs (2017). Bethany Seismic Survey, Santos Limited ñSite Attached Fish Assemblagesò IW166300-000-NM-TNE-0001 | D, Jacobs, Perth. Jacobs (2016) Barossa Environmental Studies ï Benthic Habitat Report. Prepared for ConocoPhillips. Santos email: [redacted] Thank you. The Dropbox will be updated shortly. [redacted]	Request from [redacted] for two reports cited in Rev 4 of the EP to be added to the project Dropbox folder.
Timor Reef and Demersal Relevant	TRD	23/01/2018	Stakeholder engagement post EP Rev 5 submission on 23 January 2018	

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-178	20/01/2018	AP email: Hi [redacted] First of all, I would be most pleased if you call me Art - no formality. I need to review all the material and think about the issues before commenting on specifics or in any depth. However, I do want to make the point that knowing the most important species in the area(s) of concern will be critical. This is no way we can come up with potential impact levels for each species - there are far too many species of fish (>32,000 as of now) and we know minimal amounts about the hearing system of most. One way to approach this, however, is the way we did it in the Guidelines (Popper et al., 2014) where we decided that it is likely highly valid to "divide" fishes into "hearing groups" based on how they detect sound. If we do this now, we can probably deal with a diverse array of species in a reasonable and useful way. I look forward to insight into the species, and particularly those of most concern to the fishers. Have a great weekend. Art	In response to TRD-177.

NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-79	19/01/2018	ERM email: Hi [redacted] Thanks for reviewing the EP and providing comments/edits. My responses are provided in red below. General comment The current consequence and likelihood ratings appear to be underestimating the risk of the activity. According to current scientific understanding, seismic testing has the potential to cause extensive medium term and localised long term impact to fish populations based on the fact that there are fish species that have both broad and fine-scale population structure in the area and that seismic activity emits noise at levels that can cause mortality. Based on the spatial and temporal scales defined in Table 6-3 of the EP, and on the noise modelling results and risk assessment process, it is apparent that in the case of the proposed Bethany survey underwater noise from the airgun array has the potential to cause localised (within the Operational Area) impacts over short (days/weeks) and medium (<12 months) timescales. The modelling/risk assessment does not indicate effect ranges that would be consistent with a definition of "extensive" – i.e. within the broader AMBA. There is merit in considering the use of a consequence rating of level IV in the risk matrix used. The likelihood would then vary depending on which aspect of impact is being examined. For immediate mortality, there isn't any strong indication that this occurs in fish but the fact that there will be noise levels emitted by the activity that are above the mortality thresholds the likelihood should technically be 'possible' (c) resulting in a level 3 risk rating. I have reviewed the consequence and likelihood categories assigned to fish mortality, TTS, Behaviour and Commercial Catch impacts in the risk assessment section of the EP. Again, based on the spatial and temporal scales defined in Table 6-3 of the EP, and on the noise modelling results and risk assessment process, I agree that there is merit in making some changes to the consequence and likelihood categories. For mortality, I think a consequence rating of III is more appropriate than the level II currently assigned to this impact, based on the potential for localised impacts over the medium term - i.e. any mortality/potential mortal injury (if it were to occur) would be confined to the Full Power Zone, but it could potentially take months for fish numbers to recover to pre-impact levels. That said, I don't believe that there is enough evidence to suggest that a likelihood level of possible (c) is appropriate for mortality effects from Bethany, based on the extensive literature review that I conducted for [redacted] Santos on mortality effects in fish from seismic airgun noise. I'm happy to provide a copy of this review if you are interested. On this basis I have revised the consequence rating for mortality from II to III, the likelihood level stays at unlikely (b), giving a revised risk ranking of Low (2), rather than Very Low (1). For Temporary Threshold Shift (TTS) a likelihood of 'occasional' (d) would be more appropriate given that it is more likely to occur than immediate mortality resulting in a level 4 risk rating. For TTS I think that the currently assigned consequence rating of II is appropriate, based on localised (within Operational Area) and short-term (days/weeks) impacts. I don't think that a likelihood rating of occasional (d) is applicable in this case, but rather that a possible (c) rating is more appropriate than the currently assigned unlikely (b) rating – this takes into account some of the uncertainty around TTS effects, particularly in terms of the numbers of fish that could be impacted and recovery rates. On this basis, TTS effects now have a Low (2) risk ranking, rather than Very Low (1). Given there isn't any detailed knowledge of the abundance and distribution of fish populations in the survey area (just catch from commercial fishers- see detailed comment below) the only piece of evidence that can lower these likelihoods is the sound modelling. While the results indicate that the above likelihoods could be lowered given the relatively small areas that are exposed to mortality and TTS noise levels the assumptions behind the sound modelling have some potential issues. These are: how were the four sites chosen to represent all of the depth/habitat types in the fishery and wouldn't it have been more conservative to have more sites for the modelling? and; the 24 hr period used for maximum accumulated Sound Exposure Level (SEL) is probably an underestimate of sound impact accumulation given there have been studies that have indicated epithelial cell damage remaining at least 58 days after exposure(e.g. McCauley et al. 2003). I would be inclined to have a range of times for SEL accumulation in the models so that the full array of outputs from this parameter can be identified. Santos has engaged Professor Art Popper (lead author on the Popper et al. 2014 guidelines) to conduct an independent, expert peer review of the TTS risk assessment included in the EP. This review, which will incorporate input from concerned fishers, will be on TTS effects (i.e. mortality/PMI, behavioural, and commercial catch impacts are excluded), especially with regards to length of time for recovery and the applicability of an SEL24h metric. Professor Popper has been provided with a copy of the JASCO noise modelling report, plus the fish & noise risk assessment section from the EP. He will be commencing his review in the next day or so, and I'm happy to keep you informed of progress and outcomes if you are interested. Given the level 4 risk rating promotes a detailed investigation, maybe this should trigger the red emperor acoustic tagging experiment we have been discussing to be conducted during the survey. However, as discussed this would mean the seismic survey would probably have to be conducted in 2019 to accommodate the timing of this research. Based on the rationale outlined above, I don't think an overall risk ranking of High (4) is appropriate with respect to TTS effects in fish from the Bethany survey. As discussed during our phone call on Tuesday this week, Santos is hoping that the EP will be accepted within a timeframe that allows for acquisition in 2018, rather than 2019. However, Santos is still keen to support the proposed research programme, including the tagging component, and will continue to work collaboratively with the Department and other stakeholders to try and implement this during 2018 acquisition of the Bethany survey, if at all possible.	Santos response to NT DPIR comments on Rev 4 of the EP. The independent review by Art Popper has been commissioned as part of Santos' ongoing stakeholder relationship management and is not reflective of any uncertainty regarding the modelling, application of standards or impact assessment.

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			Specific comments - We are Department of Primary Industry and Resources (DPIR) not (DPIRF) Noted ï necessary edits included in the EP - Figure 5-12 the % for the FPZ and OSMP are the reverse of whats in table 5-9. This is an error ï the text in Figure 5-12 has been changed. The percentages listed in Table 5-9 for FPZ and OSMP are correct. - Using the fishery catch data provided as an estimate of abundance and as a consequence and indicator of the likely impact of seismic is problematic as fishery catch doesnõt always reflect abundance. Using the logic in the EP species like Grass Emperor and Redspot Emperor that have 45% of their catch taken in the survey area could suffer very significant population impacts if they suffer sub lethal TTS particularly given the fine-scale population structure of the former (Barton et al. 2018) As indicated in my previous email this morning, I have deleted these statements from the fish & noise risk assessment section as they are no longer accurate/relevant. - Table 7-2 has a confusing caption as it is suggesting the total survey area is receiving sound above TTS levels whereas earlier it is suggested that this is more like 19% of the area with the sound modelling used. Please can you clarify ï doesnõt seem to match with what we currently have as Table 7-2. Perhaps let me know what full caption is. References used McCauley, R., Fewtrell, J. & Popper, A. (2003). High intensity anthropogenic sound damages fish ears. The Journal of the Acoustical Society of America, 113(1), 638-642 Barton, D.P., Taillebois, L., Taylor, J., Crook, .D.A, [redacted] T., Hearnden, M., Greig, A., Welch, D.J., Newman, S.J., Travers, M.J., [redacted] R.J., Errity, C., Maher, S., Dudgeon, C. and Ovenden, J. (2017). Stock structure of Lethrinus laticaudis (Lethrinidae) across northern Australia determined using genetics, otolith microchemistry and parasite assemblage composition. Marine and Freshwater Research.69: 1-15.	
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-80	19/01/2018	NTDPIRF email: Hi [redacted] Thanks for your responses. Consequence and likelihood ratings always engender a lot of discussion in the risk assessments we have run and there is often differences in opinion amongst participants (as there is between us!). We tend to get around that by getting an independent reviewer to look at the risk ratings on any of the assessments we do so that there is an added level of justification to the final results. I believe our differences in opinion may be related to the fact of the different risk assessment processes weõve been involved in. We tend to look at the impacts of fishing which there tends to be a known impact on the fish (mortality) so the consequence of targeted fishing will always be that it could cause population level decreases. I was using the same rationale for seismic with the consequence as there are noise levels emitted that have the potential to kill fish. As mentioned below we typically use the likelihood to control whatõs the chance of this consequence occurring. With the questions I had regarding the sound modelling I struggled to justify the lower likelihood ratings you have assigned but the review by Popper should help clarify the issues Iõve identified. To be clear I agree there is no strong evidence to suggest substantial, immediate mortality in fishes exposed to seismic but we are concerned about TTS as any medium term sensory incapacitation of fish is likely to lead to predation given the high abundance of sharks we have in our waters. Iõd be happy to receive the literature review you undertook as well as the review of the sound modelling when its completed. In terms of the last specific comment on the EP version ignore it as I thought Iõd picked up a typo but that table appears to be accurate. Thanks again for taking the time to look at my comments. [redacted]	NT DPIR response to NTDPIRF-79.

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Timor Reef and Demersal Relevant	TRD-177	19/01/2018	[redacted] email: Professor Thank you for your quick response. I am aware that the level of TTS is species dependant and I am sure we can get a list of species in the area when required. This is probably best obtained from fisheries so I will make contact to get ball rolling. We are of course interested in the impact on all species of fish and fauna in the area not just those of key target species. In the simplest terms a field of cows not much use with no grass. Our understanding of this process is that you are providing an expert opinion on the rationale provided by SANTOS to limit the SELcum accumulation to the 24hr period; ie is their explanation defendable? As indicated the limitation to 24 hrs ensures we dond consider survey lines in close proximity. Noting this it is then impossible for fishers to consider recovery rates irrespective of species as we dond have applicable SELcum modelling/levels. While it is agreed your 2005 work provided the basis for the 186 Db SELcum criteria in the 2014 guidelines, the error that we believe has occurred is that SANTOS have used the recovery time of less than 24hr for northern pike and lake chub in your 2005 work to suggest that all fish in their survey will be fully recovered whin 24hrs. We must assume this is recovered from all immediate impacts else there is no rational to reset SELcum period. Your opinion on the following might help address this and allow for more relevant modelling at longer time periods to be commenced as a priority. Do the recovery rates shown by northern pike and lake chub in Popper 2005 demonstrate that all fish impacted by the proposed 3D survey will have recovered from TTS or any other immediate impact within 24hours? For clarity I personally believe that that such a statement is not defendable at all and in fact is in direct conflict with the caveats in your 2005 report. However, this is the argument being put forward by SANTOS at this time. My apologies if this sounds petty but this issue has now dragged on for some time despite indicating some serious concerns about the claim over 7 months ago. We really just need some modelling carried out for lines in close proximity. I look forward to your response Warm regards [redacted] With regards to email chain they were simply the names indicated to me that must be included in our correspondence by SANTOS. [redacted] has been the contact point for negotiations wit SANTOS while I am tasked with providing industry advice on possible impacts on the fishery. I have access to SKYPE if required	Email from [redacted] to Art Popper in response to TRD-176.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-77 and attachment BX	18/01/2018	NTDPIRF email: Hi [redacted] We have now consulted with appropriate stakeholders to advise them of why we are providing the data attached. To expedite the process in the future we would encourage direct dialogue between Santos and commercial fishers regarding data requests. We also caveat the use of this information to be restricted to the risk assessment in the EP and for it not to be used in any discussions with commercial fishers around compensation. Im happy to discuss the data as the species percentages caught in the survey area have changed dramatically with increased trawling activity which influences some of the statements made in your EP risk assessment. Im about to send another email with some of my concerns around the impacts of seismic on fish which Im also happy to discuss. Thanks. [redacted] ERM email: Hi [redacted] Thanks for this, we really appreciate receiving these data this week, as it can be incorporated into the revised EP prior to resubmission. I have updated the various parts of the EP as necessary. On the species percentages caught within the survey area ï I have deleted the statements referring to this in the fish/noise risk assessment section, as they are no longer accurate/relevant. I will respond to your other email separately. Cheers, [redacted] NTDPIRF email: Yes thanks [redacted] If you could provide us with the submitted version of the EP for our records that would be great. [redacted] always had to do it through dropbox as it was too big. ERM email: Hi [redacted] Sure, no problem. I will set up a new dropbox folder, share with you, and then let you know when the Rev 5 EP is available in there for download. Cheers, [redacted]	Provision of updated catch data for NT managed fisheries for period 2013-2017. See NTDPIRF 69, 70, 71,72,74, 75 & 76.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-78	18/01/2018	NTDPIRF email: Hi [redacted] Ive had a chance to look through the EP and Ive listed our concerns below, happy to discuss. [redacted] General comment The current consequence and likelihood ratings appear to be underestimating the risk of the activity. According to current scientific understanding, seismic testing has the potential to cause extensive medium term and localised long term impact to fish populations based on the fact that there are fish species that have both broad and fine-scale population structure in the area and that seismic activity emits noise at levels that can cause mortality. There is merit in considering the use of a consequence rating of level IV in the risk matrix used. The likelihood would then vary depending on which aspect of impact is being examined. For immediate mortality, there isnt any strong indication that this occurs in fish but the fact that there will be noise levels emitted by the activity that are above the mortality thresholds the likelihood should technically be possibleô(c) resulting in a level 3 risk rating. For Temporary Threshold Shift (TTS) a likelihood of óccasionalô(d) would be more appropriate given that it is more likely to occur than immediate mortality resulting in a level 4 risk rating. Given there isnt any detailed knowledge of the abundance and distribution of fish populations in the survey area (just catch from commercial fishers- see detailed comment below) the only piece of evidence that can lower these likelihoods is the sound modelling. While the results indicate that the above likelihoods could be lowered given the relatively small areas that are exposed to mortality and TTS noise levels the assumptions behind the sound modelling have some potential issues. These are: how were the four sites chosen to represent all of the depth/habitat types in the fishery and wouldnt it have been more conservative to have more sites for the modelling? and; the 24 hr period used for maximum accumulated Sound Exposure Level (SEL) is probably an underestimate of sound impact	NT DPIR response based on their review of Rev 4 of the EP. Santos response in NTDPRIF-80.

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			accumulation given there have been studies that have indicated epithelial cell damage remaining at least 58 days after exposure(e.g. McCauley et al. 2003). I would be inclined to have a range of times for SEL accumulation in the models so that the full array of outputs from this parameter can be identified. Given the level 4 risk rating promotes a detailed investigation, maybe this should trigger the red emperor acoustic tagging experiment we have been discussing to be conducted during the survey. However, as discussed this would mean the seismic survey would probably have to be conducted in 2019 to accommodate the timing of this research. Specific comments - We are Department of Primary Industry and Resources (DPIR) not (DPIRF) - Figure 5-12 the % for the FPZ and OSMP are the reverse of whats in table 5-9. - Using the fishery catch data provided as an estimate of abundance and as a consequence and indicator of the likely impact of seismic is problematic as fishery catch doesn't always reflect abundance. Using the logic in the EP species like Grass Emperor and Redspot Emperor that have 45% of their catch taken in the survey area could suffer very significant population impacts if they suffer sub lethal TTS particularly given the fine-scale population structure of the former (Barton et al. 2018) - Table 7-2 has a confusing caption as it is suggesting the total survey area is receiving sound above TTS levels whereas earlier it is suggested that this is more like 19% of the area with the sound modelling used. References used McCauley, R., Fewtrell, J. & Popper, A. (2003). High intensity anthropogenic sound damages fish ears. The Journal of the Acoustical Society of America, 113(1), 638-642 Barton, D.P., Taillebois, L., Taylor, J., Crook, .D.A, [redacted] T., Hearnden, M., Greig, A., Welch, D.J., Newman, S.J., Travers, M.J., [redacted] R.J., Errity, C., Maher, S., Dudgeon, C. and Ovenden, J. (2017). Stock structure of Lethrinus laticaudis (Lethrinidae) across northern Australia determined using genetics, otolith microchemistry and parasite assemblage composition. Marine and Freshwater Research.69: 1-15.	
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-76	16/01/2018	ERM email: Hi [redacted] Good to catch up on the phone earlier this afternoon. As discussed, Santos is planning to resubmit the Bethany EP this Friday 19th January. In advance of this, if at all possible, it would be good if NT Fisheries can provide: a) Updated catch data for the TRF, as requested by [redacted] in her email of 28 November. b) Any comments/feedback on the revised EP (Rev 4), as provided via Dropbox on 13 December. Cheers, [redacted]	Follow-up on request for updated NT Fisheries information to update the Bethany EP.
Timor Reef and Demersal Relevant	TRD-175 and attachment AW	15/01/2018	[redacted] email: Professor A. Popper My name is [redacted] and as outlined in previous SANTOS correspondence I represent the fishing industry in the area of the proposed SANTOS survey. For clarification I am not a fisher, I have a degree in marine biology and post grad fisheries management. I worked for the Federal fisheries department and have now worked directly with industry for over 20 years. We have spoken before when I contacted you mid last year to clarify some questions. Our understanding of this process (review) was that you would review the rationale and assumptions used by SANTOS in their EP to limit the SELcum accumulation period to 24 hrs. Of great concern to industry is the fact that this limited time period ensures we never consider the cumulative impact of two or more survey lines in close proximity. The limitation to a period of 24 hrs is now based on the recovery shown in your 2005 paper. We cannot understand how these recovery rates could be relevant. I note that copies of correspondence on this issue have not been provided so the following as brief background to key issue. I can provide a copy of email chain on the issue if this would help. Please feel free to call me to discuss. Warm regards [redacted] Background	Email from [redacted] to Art Popper.

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			We were provided with SANTOSõs sound modelling and EP. This is the information on which through the Australian legislative process we are supposed to consider any risks to our interests. In this consideration we were concerned that in modelling SELcum the use of the 24 hr time period means that survey lines in close proximity are never properly addressed. This of course relates not only to TTS but also the impacts of mortality and mortal injury and recoverable injury. To ensure our concerns are understood the following is the track of vessel in 24hrs. The blue circles represent the area of immediate impacts from a single shot for fish. The wide turn required for these vessels means that on the first run back these high impact areas (above TTS guidelines) are well separated (>5kms apart). Diagram The following diagram represents the cumulative impact that is not being addressed. The simple scale of these surveys and speed of vessels means most fish/fauna couldnõt possibly avoid one pass never mind multiple passes. Diagram The information provided referenced yourself as recommending the 24 hr integration period; ñThe SEL metric integrates noise intensity over the period of exposure. Because the period of integration for regulatory assessments is not well defined, for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, which is applied in this risk assessment.òSANTOS Unable to find any recommendation in your paper I requested more detail from SANTOS. The response was as follows, ñThe reference to Popper 2014 is in the noise modelling report. While Popper 2014 did not specifically suggest a 24hr resetting period, they do point out that cumulative SEL may be defined over a standard period or for the duration of the activity, or over the total period that the animal will be exposed (Pg 27 Section 6.1.7). On page 45, Section 7.5.3, they state that óIn all cases, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours.ô Thus, within the industry 24 hours is used as this standard.ò SANTOS We believe this rationale /assumption to support the 24 hr period as an industry standard is in error. The following additional information was provided by SANTOS in support of their rationale; ñFor the seismic noise impact assessment, Santos has used standard thresholds and thresholds suggested by the best available science. In regards to the SELcum metric, Popper et al. (2014) note ñOne major difference between pile driving and seismic airguns is that it is harder to determine SELcum for airguns. This is because the received SEL ss changes from shot to shot since the seismic vessel is moving and at different distances from the fish. Thus, a guideline ultimately based on the closest peak level or the closest SEL ss may actually be more useful than one based on the SEL cum.ò As detailed in the EP, the SEL24h threshold associated with possible mortality and potential mortal injury to fish was not reached within the modelling resolution of 40 m, thus the peak level was applied. For recoverable injury	

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			criteria both the peak and SEL24h threshold were reached and the PK impact distance was used as this was the furthest. For both these impacts the peak threshold is a more appropriate threshold as it is more likely that mortality and potential mortal injury would occur at a peak level rather over a period of cumulative time. This is supported by Popper et al. (2014) statement above. For TTS a cumulative threshold is more appropriate and the time period over which this is done has been based on the research information available in regards to recovery times for fish. In relation to the application of SEL24 for the TTS threshold, Santos maintains that this is an appropriate period for assessing potential temporary threshold shift to fish and based on the current scientific information available. The Popper et al. (2014) sound exposure guidelines for TTS effects in fish are based upon data from Popper et al. (2005) for exposure of several riverine species to a seismic airgun array. This study showed that exposure to an SELcum of 186 dB re 1 εPa2Ls accumulated over five seismic pulses within about five minutes resulted in about 20 dB of TTS in the lake chub (a hearing specialist) and northern pike (a hearing generalist). In all cases, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours (Popper et al. 2005). This is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). The Popper et al. (2005) study was done using a static source (airgun array) and static receptors (fish in cages at 13-17 m from the array), and therefore is not representative of a marine seismic survey with a moving source. Hence, the Popper et al. (2005) experiment represents a worst case scenario, as the source was fixed rather than moving ï i.e. the five seismic pulses that were found to have caused TTS effects over five minutes would have all been of identical intensity. This would not be the case with a moving source. As detailed in the Bethany EP Section 7.1.2, since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures. Given the Bethany survey plan, the time period before the vessel is again in proximity to specific location will be greater than 24 hours. As such, assuming a stationary receptor experiences TTS on one pass it will have at least 24 hours until the possibility of receiving an SEL of sufficient magnitude that could induce TTS to occur again. On this basis, and given that the only data available for TTS recovery in fish exposed to airgun noise indicates a recovery period from a substantial TTS of 20 dB of less than 24 hours, a 24 hour period is seen as appropriate for modelling cumulative SEL.ò [redacted] SANTOS 3 July 2017 This misrepresentation of statements from your 2005 work was of serious concern. I have provided the fishing industries response in attachment. SANTOS are maintaining their claim that all fish will recover in 24 hrs based on your 2005 work. ñTo answer your question ï yes, based on the best available information and the findings of the impact assessment process, any fish that experience TTS effects during acquisition of the Bethany survey are expected to recover within timeframes of minutes to hours, and will certainly have full recovery within 24-hours. As pointed out above, we will test this finding (and any assumptions that sit behind it) via the independent, expert review	

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			process. SANTOS 22/12/2017 The crux of our concern is how SANTOS are defending not carryout modelling for longer periods that would incorporate survey lines in close proximity. Following citing a recommendation that doesn't exist this is now being done by using your 2005 work to suggest all fish will be fully recovered in 24 hrs. This of course doesnt consider the fish exposed to higher SELcum in this 24 hours. The following is the graphical representation of SELcum previously provided by SANTOS. The claimed 24hr recovery, if relevant, would only be made by fish on the blue line or outside (that is if the survey was in 1.9m of water in a river). Now every fish inside these lines receives a SELcum of over 186dB, inside the pink area fish receive a SELcum of between 190 and 200dB, the red area of over 200dB. The distance between the two blue lines is over 16 kms. Diagram There will be at least 10 more survey lines between the lines currently considered in the SEL24 (estimated survey line positions added in black). We believe the use of 24hr period greatly underestimates the cumulative sound impact on marine life in the area. In fact we would contend that claiming the impacts of the survey are the same after day one as after day 75 are less than unconvincing. [redacted] email: My apologies but to correct last sentence in background, "In fact we would contend that claiming the impacts of the survey are the same after day one as after day 75 are less than convincing."	
Timor Reef and Demersal Relevant	TRD-176	15/01/2018	AP email: Hi [redacted] Thanks for sending the material. I look forward to going over it and suspect I'll have a number of questions. If you can send the email chain at some point I suspect that might be of some use. I would also be important for me to know the species of concern (both common and scientific names please). This is critical since, as I suspect you appreciate, the degree of TTS is likely to be very species-dependent. While there are limited data on TTS, I think we know enough to be certain that the degree of TTS (or even its occurrence) may be related to the hearing sensitivity of the species of concern. At some point it is likely that it would be useful to talk - though I think a phone call will be a tad expensive (I'm just outside of Washington [redacted] in Silver Spring, Maryland. Do you have access to Skype? Otherwise, I could set up a conference call that would have a local number in Australia if that would work for you (and anyone else involved). Thanks, and I look forward to discussions with you. Art P.S. For my understanding, I see that two others are on this email chain. Do they stay on the chain and we discuss thing? And, if so, I would be grateful to know who they are. ERM email: Hi Art, To answer the question in your P.S. below – [redacted] is the Offshore Exploration Manager at Santos. [redacted] represents a company called Northern Seafoods – Ill leave [redacted] to explain what his involvement is in this issue. And yes, please copy [redacted] and I in on any emails between yourself and [redacted] Cheers, [redacted]	Response from Art Popper to TRD-175 and attachment AW.

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Austral Fishing	AF-9	12/01/2018	ERM email: Hi [redacted] Thanks for your time again this morning to meet with [redacted] and I, much appreciated. In terms of progressing [redacted] he most efficient way forward would be for [redacted] to contact [redacted] and [redacted] at [redacted] directly: [redacted] With regards to the NW Shoals to Shore project (https://www.aims.gov.au/nw-shoals-to-shore), which is funded by Quadrant Energy under the Good Standing Agreement entered into with the National Offshore Petroleum Titles Administrator (NOPTA), as discussed we suggest that you contact [redacted] and [redacted] at Quadrant: [redacted] Cheers, [redacted] [redacted] email: Thanks [redacted] That is terrific. I am neighbours with [redacted] from Quadrant and was hinting at the likely encounter with some of her people. That will have to wait til I get back from tour down under. Cheers [redacted]	
Timor Reef and Demersal Relevant	TRD-174 with TRD-173 as attachment	8/01/2018	Santos email: Hi [redacted] I hope you have had a good break, and best wishes for the New Year. We have been in email contact with Art Popper over the past week or so. He has indicated that he is available and willing to get involved in the peer review process. To date, we have provided Art with copies of the seismic noise and fish impact assessment section of the Bethany EP, plus the JASCO modelling report, and have indicated that the focus of the review should be on TTS effects, especially with regards to length of time for recovery and the applicability of an SEL24h metric. See attached emails between Art and [redacted] Art has indicated that he would like to contact you directly to get better understanding of your issues and concerns. Please can you email him [redacted] to initiate the dialogue ï we have let him know that you will be making contact. For the sake of transparency I would appreciate it if you could copy [redacted] and myself in on any emails back and forth between you. Regards, [redacted]	Email to [redacted] providing Art Popper's email address.
Timor Reef and Demersal Relevant	TRD-173	30/12/2017	ERM email: Hi Art, The stakeholder who will be contacting you is [redacted] is ex-Chairman of the Northern Territory Seafood Council (NTSC) and a current Board member. He is representing several licence holders in the Timor Reef Fishery, which is the commercial fishery partially overlapped by the planned Santos Bethany 3D survey. And yes, I would need to be copied in on any communication between yourself and [redacted] I will initiate contact with the ERM office in Washington [redacted] and start putting the wheels in motion for a contracting process. I will be on leave next week, but will be picking up emails, and will be back in the office on Monday 8th Jan. Cheers, [redacted] AP email: Hi [redacted] Back to you with costs in day or two. I'm ok with giving my email, but please let me know who will be contacting me. And, do you want to stay in the loop (if you know what expression!) on any communication? As for location, I'm just north of Washington [redacted] - in fact, will be passing your [redacted] office when i go to the theatre on Sunday. Best wishes for the new year. Art	Email to Art Popper providing details for [redacted]

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-75	29/12/2017	ERM email: Hi [redacted] I hope you had a great Xmas. Just a quick follow up as we didnʼt manage to catch up last week as originally planned. Has there been any progress on the updated catch data? I am on leave next week (2-5 Jan) but will be back in the office on the 8th. Happy to schedule a call sometime that week if itʼs convenient. Best wishes for the New Year. Cheers, [redacted]	Follow-up on request for updated NT Fisheries information to update the Bethany EP.
Timor Reef and Demersal Relevant	TRD-172	29/12/2017	ERM email: Hi Art, Thanks for getting back to me and good to hear that you are willing to get involved in this review. Probably the best way for you to get an understanding of the issues from the fisheries stakeholder is to put you directly in contact with him, so he can spell out exactly what his arguments and concerns are. This is preferable to sending you the very extensive record of emails back and forth over the past 12 months or so. The stakeholder has expressed his support for this peer review process. Are you happy for us to provide him with your email address so that he can communicate directly with you? On the timeframe you have outlined ï ideally less than 8 weeks would be better, as the debate back and forth with the stakeholder, and this review, are linked to an approval process. If there is anything that you can do to shorten the timeframe on this it would be most appreciated, acknowledging that you are doing this consulting work part time. It is probably easiest if you quote a lump sum (flat fee) for this. I can get the ball rolling on getting the ERM guys in the US to start the process of raising a purchase order for this. We have offices in various eastern state cities, including Annapolis and Washington [redacted] ï not sure where you are currently based? Best wishes for the New Year. Cheers, [redacted] AP email: Hi [redacted] I finally had a chance to skim the material you sent - reading in detail will take more time, but I think I have enough of an idea to share some thoughts. However, if we decide to go ahead with my providing input I would want to review the material in more depth. I would, of course, like to know more about the argument(s) from the fisheries stakeholders that there is a longer	Email to Art Popper progressing independent peer review process.

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			period of accumulation for TTS and that this will have a negative impact on hearing. In particular, are they grouping all species together, or distinguishing between species, and do they have specific species in mind? Also, are they focusing on fishes that would stay in an area, or fishes that are likely to move around? Do they have particular thoughts on how the fish behave when they are exposed to seismics and are their arguments based on the science or more on their (very important) fishing observations? What I'm getting at is that without knowing more of the arguments for a longer period of accumulation, I am not really able to address the major issues. Indeed, there is also a lack of science since most all of the TTS exposure studies involved continuous sounds (other than those McCauley did showing no effect - Hastings work), and that is rather different from seismic where the sounds are impulsive. And, accumulation of energy is not straight-forward with seismics since, as the Santos reports points out, the levels of sound are increasing and decreasing as seismic vessels move. So, even if a fish is stationary, it may only get "maximum" exposure a few times during a seismic study, or at least perhaps only a few times a day. And, between shots, and particularly when sound levels are relatively low (compared to the maximum to which a fish is exposed), recovery is likely. Bottom line, the determination of TTS and the accumulation of energy leading to TTS, makes things far more complicated. All that said, I suspect you are in a "debate" that is one of those that is not based on substantial data or knowledge - but more a "guessing game" of possible consequences. If an analysis of what is known, as well as considering the issues along the lines I outline, is what you want, then perhaps I can find some time over the next eight week or so (though if you gave me 12 weeks that would be better). I am guessing (and I am really not very good at making predictions) is that I'd need in the range of 40 hours on this, and perhaps somewhat more. Time is needed to really understand the Santos report (which is quite good) and the JASCO modeling, plus developing and writing "arguments." As I have already suggested, this is not the kind of thing I can do without renumeration since I am retired and my only "job" is consulting. I'm willing to set a "flat fee" rather than hourly if that makes things easier for your consideration. Glad to discuss this further, and even get together via Skype if that would be of use. Very best wishes. Art	
Austral Fishing	AF-7	22/12/2017	ERM email: Thanks [redacted] I will liaise with [redacted] and let you know what time suits. On the CA ï [redacted] sent this through on Weds pm ï see attached. Cheers, [redacted] [redacted] email: Hi [redacted] I can be around for that catch up so let me know if you have a time and I can patch it in. By the way, we still have [redacted] and if we don't get it today the [redacted] will be on leave for a couple of weeks etc etc you know the drill at this time of the year. Cheers [redacted] ERM email: Morning [redacted] An issue I forgot to raise during our meeting on Wednesday ï would you be available for meeting on 12th January? [redacted] will be over from Adelaide and it would be good to catch up and review progress on the actions from the last meeting. Let me know what time suits if you are available that day. Have a safe and festive Xmas break. Cheers, [redacted]	
Austral Fishing	AF-8	22/12/2017	[redacted] email: Hi [redacted] We retrieved your email after our filter blocked it and attach [redacted] Please note we amended the term [redacted] Any queries let me know. Rgds [redacted]	

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Timor Reef and Demersal Relevant	TRD-169	22/12/2017	Santos email: [redacted] Acknowledging the caveats that Popper et al. (2005) include with reference to applicability of the findings of their study to 3D surveys it is still the case that it is probably the best and most thorough study of seismic impulse-induced TTS, and the basis for the TTS threshold of 186 dB SELcum in Popper et al. (2014), which has been used for the noise impact assessment process for Bethany. Again, I suggest that we park further debate on this issue until the independent, expert review process has been conducted. The new modelling study predicts that an area of 878 km2 in the water column, and 790 km2 at the seafloor will receive SELcum levels >186 dB, and that an area of 24.9 km2 in the water column, and 6.10 km2 at the seafloor will receive SELcum levels >203 dB ï see Table 15 of the modelling report, and Table 7-8 of the revised EP. The impact assessment has been based on these modelled predictions of distances to different isopleths and the areas contained within these isopleths. To answer your question ï yes, based on the best available information and the findings of the impact assessment process, any fish that experience TTS effects during acquisition of the Bethany survey are expected to recover within timeframes of minutes to hours, and will certainly have full recovery within 24-hours. As pointed out above, we will test this finding (and any assumptions that sit behind it) via the independent, expert review process. Regards, [redacted]	In response to TRD-166.
Timor Reef and Demersal Relevant	TRD-170 and attachment BW	22/12/2017	Santos email: Hi [redacted] Just to let you know that we have contacted Professor Popper in the US to see if he is willing and available to get involved. I will keep you informed as things progress. As you are no doubt aware there isnđ a published industry standard or guideline that recommends the use of a 24-hour period for recovery of TTS effects in fish. What Santos means by using the term ñindustry standardò in this context is that a 24-hour recovery period is what is routinely applied during modelling studies and impact assessment processes for marine seismic surveys in Australia. For instance, see attached document, which presents the modelling results and impact assessment of effects of seismic noise on fish for the Pelican 3D MSS off the Gippsland coast. The 24-hour period is based on the findings of Popper et al. (2005), which is probably the best and most thorough study of seismic impulse-induced TTS in fish, and the basis for the TTS threshold of 186 dB SELcum in Popper et al. (2014). With respect to your last point below on recovery times, please refer to my email sent through to you earlier this morning. Best wishes for the festive season. Regards, [redacted]	In response to TRD-168.
Timor Reef and Demersal Relevant	TRD-168	21/12/2017	[redacted] Email: [redacted] More than happy to wait for expert opinion on this issue and look forward to receiving all correspondence as outlined in your proposal. Also my request for this information started in 2015 as previously discussed not just the last 7 months as you keep repeating. Please can you provide copy of stated industry standard as I have those relating to cetaceans but cant find references to fish and other fauna. Also does this put all consultation on hold or can I expect response on recovery times? This is also now outstanding for some time. Warm regards [redacted]	Email response provided addressing issues / questions raised - see TRD-170 and attachment BW.

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Austral Fishing	AF-6	20/12/2017	Santos email: [redacted] & [redacted] [redacted] asked me to forward on the [redacted] Please find this attached. Regards & Happy Christmas [redacted] Santos email: [redacted] - resending the CA from 20 Dec. [redacted] [redacted] email: [redacted] for some reason you guys have been blocked by our spam filter. We are on to it now and whitelisted you but that is defiantly a trap for young playersé Independent of this, [redacted] Cheers [redacted]	
Austral Fishing	AF-5	20/12/2017	AF email: Thanks [redacted] impressive turn around on the summary of our meeting. You seem to have covered all the key points and actions so now just a matter [redacted] issue. Seasons greetings. [redacted] ERM email: Hi [redacted] Thanks for meeting with [redacted] and I this morning. We do appreciate the time during what is clearly a very busy period for you. Hereõs a summary of the key points of discussion ï please let me know if I have missed or misinterpreted any relevant information: Å[redacted] introduced [redacted] and explained that he has taken over as project manager for the Bethany Environment Plan (EP). Å[redacted] asked for an update on timeline for resubmission of the EP to NOPSEMA. [redacted] indicated that 19th January is target date. Å[redacted] indicated that it would be very difficult for Austral to provide a response to Santos in time to meet this deadline ï the EP contains a lot of complex information to process in a very short timeframe. Need to fully understand implications and potential impacts on this new opportunity for Austral. Å[redacted] acknowledged the fact that Santos has set up a compensation scheme ï i.e. Santos were accepting of the fact that acquisition could cause impacts, and this approach was a way of dealing with some of the uncertainties. Å[redacted] asked what would happen if no feedback was received from Austral prior to EP resubmission date. [redacted] indicated that NOPSEMA would need to assess whether the stakeholders had been given sufficient time to process new information and ascertain the potential impacts to their interests and activities. Generally, NOPSEMA regards 4 weeks as a minimum consultation period. [redacted] outlined the timeline for EP resubmission and how it is linked to Santos going out to tender for a seismic contractor/vessel, and intended window of acquisition, which is described in the EP as 1st May to 30th September 2018 or 2019. Å[redacted] explained that consultation doesnõt stop with resubmission or acceptance of the EP ï there is a regulatory requirement for ongoing consultation and NOPSEMA will want to see framework and process for this described in the EP. If significant new information comes to light after EP acceptance, there is a requirement for Santos to assess this, and potentially revise and resubmit the EP as part of a management of change process. Å[redacted] provided high level view of scope and content of the EP, and focused on CPUE data for trap and trawl components of the TRF, and breakdown of catch by species taken with Bethany operational area 2013-2015. Pointed out that this high level data was all that NT Fisheries could provide, and the impact assessment had to	Austral Fisheries and Santos [redacted]

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			be based on these data. [redacted] A [redacted] provided [redacted] with a hard copy of the EP. Actions: o [redacted] will get Santos to provide a copy of [redacted] Donť hesitate to contact me if you require further information or clarification of any aspects of the EP. I will be working through next week. Best wishes for a safe and festive Xmas. Cheers, [redacted]	

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Timor Reef and Demersal Relevant	TRD-165	20/12/2017	Santos email: [redacted] Thank you for your note. We have prepared the following answers to your questions. Regarding your first question of expected recovery times for fish exposed to SELcum between 190 - 200 dB - the amount of TTS potentially experienced by fish exposed to seismic airgun noise depends on a number of factors in addition to the received noise level, e.g. rise time, duration, duty cycle, spectral characteristics etc. For instance ï duty cycle (i.e. schedule of seismic sound interspersed with periods of background, ambient sound): a seismic pulse of 0.01 second (10 millisecond) duration repeated every 5.4 seconds (parameters that will apply for Bethany acquisition) would represent a duty cycle of 0.19%, meaning that 10,526 seconds or almost 175 minutes (~3 hours) would elapse before 20 seconds of cumulative seismic sound exposure was achieved. This assumes the worst case of a static source, and a static receiver. Thus, information about the duty cycle of a sound provides a measure of how likely an animal is to receive a little or a lot of accumulated sound exposure. The recovery times will directly relate to the extent of TTS caused by the sound stimulus - recovery time will relate directly to the extent of TTS caused - i.e. if the extent of TTS is ~6 dB, then recovery will probably be on the scale of minutes to a few hours, vs a TTS of 20 dB where recovery is likely to take longer e.g. 18-24 hours. With respect to the biological significance of a threshold shift in the best hearing range of a fish, this depends on the shift duration as well as amount. Thus, the biological significance of a mild TTS that recovers within minutes or hours will be negligible or very minor, as is also the case for longer term shifts below ~6 dB (particularly on coral reefs where background levels vary widely, almost continuously and often rapidly from <80 to >120 dB re 1 uPa). Shifts need to be >15 dB before they can be considered capable of consistently reducing a reef fishõs ability to perceive important sounds such as approaching prey, predators or schooling conspecifics, or substantially reducing a sonic fishõs ability to perceive courtship communications or other social signals. In answer to your second question on the increase in energy between SELcum of 187 dB, 190 dB and 200 dB ï it is important to note that the base-10 logarithmic nature of the dB scale means that each 10 dB increase is a ten-fold increase in acoustic power (intensity): ÅA doubling in intensity adds 3 dB; ÅA 10-fold increase in intensity adds 10 dB; ÅA doubling in pressure adds 6 dB. The intensity of a sound wave is the average amount of energy transmitted per unit time through a unit area in a specified direction. The amount of energy per unit time is power, and intensity is therefore the amount of power transmitted through a unit area in a specified direction. A ten-fold increase in acoustic power does not mean that the sound is perceived as being ten times louder. Humans perceive a 10 dB increase in sound level as only a doubling of sound loudness. So, the acoustic power received by a sensitive receptor at 190 dB is twice the power received at 187 dB, all other factors being equal, and the power received at 200 dB would represent a 12-fold increase on that received at 187 dB. Regards, [redacted]	In response to TRD-164.

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Timor Reef and Demersal Relevant	TRD-166	20/12/2017	[redacted] email: [redacted] Thank you for response on clarifying intensity and power issues with dB scale. re: TTS If you are aware of these factors affecting TTS then i'm certainly a little surprised you claim recovery times of 24 hrs from an experiment in a river would be relevant to your survey. This is compounded when the reports author notes his concerns about relevance to 3D seismic surveys. In any event what I was looking for was a straight answer on the expected time for recovery. I will clarify my concerns again. In your modelling an area of approximately 1600 km2 receives a SELcum of over 186 dB. This area is marked on your attached map with a sky blue line (fish injury threshold). The pink area covering approximately 1200 km2 receives a SELcum of 190 to 200dB. Within a 24hr period thresholds for impacts have been met. Will all the fauna in this area be recovered in 24hrs? Warm regards [redacted]	Email response provided addressing issues / questions raised - see TRD-169.
Timor Reef and Demersal Relevant	TRD-167	20/12/2017	Santos email: [redacted] Thanks for your support for the concept of getting an independent, expert opinion on the issues that have been at the core of your concerns over the past 7 months. We will contact Art Popper to ascertain his willingness and availability to conduct this review, and will keep you informed as this process proceeds. On your point "It would also be prudent to seek advice on the impact of not considering SELcum for the impacts of mortality and or injury leading to death for fish". The original noise modelling study for Bethany considered both PK and 24-hour SEL metrics for the levels associated with possible mortality, potential mortal injury and recoverable injury to fish, but the levels exceeding the SEL24h metric were not reached either in the water column or at the seafloor within the modelling resolution of 40 m. Applying the dual criteria from Popper et al. (2014) correctly meant that the larger horizontal impact distance determined from either the 24-hour SEL or PK should be used. While levels associated with the 24-hour SEL recoverable injury criteria for fish are reached, the ranges are smaller than those estimated using the PK based metric. The PK metric was therefore used to assess possible injury impacts to fish. Furthermore, the SEL24h metric was considered in the new modelling study and in the relevant impact assessment section in the revised EP. Levels exceeding the SEL24h metric were not reached at the seafloor, but were reached within the water column – see Table 15 of the modelling report, and Table 7-8 of the EP. Whilst there was an error in the original citation of "Popper et al. (2014) recommend an integration time of 24 hours" Santos wishes to reiterate that the 24-hour period for SELcum assessment is the industry standard, based on the best information available at present and on the reasoning presented in my email to you dated 5th December. I suggest that, at this point, we park further debate back and forth on this issue until the independent, expert review process has been conducted. Regards, [redacted]	In response to TRD-163.

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Timor Reef and Demersal Relevant	TRD-171	20/12/2017	AP email: [redacted] back to you in a few days with my thoughts on this. Lots to look at. Art ERM email: Hi Art, Thanks for getting back to me so quickly. I have attached: a. The seismic noise and fish impact assessment section from the Environment Plan; and b. The modelling report from JASCO. The focus of the review would be very much on TTS effects, especially with regards to length of time for recovery and the applicability of an SEL24h metric, as these are the key issues of concerns as I have explained in my email below. So, there wouldnđ be a need to cover mortality/PMI or behavioural impacts. On renumeration ï I appreciate where you are coming from on this. Once we have an understanding of whether you are able to take this review on or not, plus your estimate on the length of time required, we can progress this issue further. There may be mechanisms to sort this out via ERM entities/offices in the US. Cheers, [redacted] AP email: Hi [redacted] Good to hear from you and thanks for asking me to participate. My problem is that I am really tied up with things at the moment, and I gather, from your note, that you need responses pretty quickly. I am concerned that the analysis you need is going to take more than a few hours to work up, and, in truth, the arguments are going to be based on minimal data since there is nothing new at all with regard to TTS over the past few years. However, if you want to send me the material to look at, I can give you a better estimate of the time doing this might involve, and how soon I could get it done. But, understand that I make no promises as to what I could do until I've seen the material. And, I also assume that there is renumeration for my time on a project like this. Art ERM email: Dear Arthur, Back in early 2016 you were kind enough to take the time to respond to a query from one of my colleagues here at ERM ([redacted] who was seeking clarification and advice on thresholds for the onset of TTS in fish from seismic airguns. In recent months I have been working on an EIA process for Santos, an Australian oil and gas company, who wish to conduct a 3D survey in the Timor Sea off the coast of Australia, approximately 250 km northwest of Darwin. The survey area overlaps a commercial fishery ï the Timor Reef Fishery ï which is a trap and trawl fishery targeting high value lutjanid and lethrinid species. Over the past 7 months Santos have been sharing information with licence holders within the fishery on the acquisition parameters, noise impact assessment etc. JASCO Applied Sciences has conducted a detailed modelling study based on the application of various sound exposure thresholds, including those for fish mortality/PMI, recoverable injury and TTS from Popper et al. (2014). One of the fisheries stakeholders has repeatedly raised concerns around TTS effects in fish, and the applicability of SELcum based on a 24-hour period. In their view, there is the potential for significant TTS effects to occur, and 24-hours is too short a recovery period. They have asked for SELcum modelling to be done for periods much longer than 24-hours, as they think that the application of an SEL24h metric is not relevant for assessing TTS effects. A debate with them has bounced back and forth for the past 7 months, without making much headway. From the point of view of trying to address their concerns and issues I have suggested that we get an independent, subject matter expert to review the modelling study, and the relevant impact assessment section of the Environment Plan (combined EIA and approvals document). Would you be interested in conducting a short and focused SME review of the key aspects? If so, and conscious of the Xmas and New Year holiday period, when would be the earliest date that you may be available for this? Regards, [redacted]	Email correspondence with Art Popper to set up review process.

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Department of Environment and Energy	DoEE-6	19/12/2017	Santos email: Hi [redacted] Not sure if you were planning on sending us a response. If so or you would like any further information could you please send to stakeholder.[redacted]santos.com I am finishing up with Santos tomorrow. Regards, [redacted]	Follow-up and provision of information. No response received from DoEE.
Timor Reef and Demersal Relevant	TRD-163	19/12/2017	[redacted] email: [redacted] Re SELcum time period I fully support the use of an independent, expert opinion on the appropriateness/applicability of the 24-hour period for SELcum, and of the application of this via the modelling study to assess TTS effects in fish for the Bethany survey. It would also be prudent to seek advice on the impact of not considering SELcum for the impacts of mortality and or injury leading to death for fish. Iõm sure you are aware the NOAA policy requires applicants to consider both metrics if they are included in the guidelines. There is very good reason. Further they are clear that the 24hr period is a baseline requirement for cetaceans. SELcum times need to be considered based on the issue you are trying to address. For TTS the critical point for assessing impact on hearing is whether the fauna has long enough time at low enough exposure levels for the auditory system to recover from any temporary effects of noise exposure. It may be more efficient in the first instance for SANTOS to seek a review of its current reasoning for the use of 24hrs. Its not clear where this rationale came from, perhaps you could outline how it was developed following the initial error in citing Popper 2014. I look forward to working with SANTOS on progressing this important matter. [redacted]	Response from [redacted] to TRD-162.
Timor Reef and Demersal Relevant	TRD-164	19/12/2017	[redacted] email: [redacted] As requested could you provide details on expected recovery times for fish exposed to SELcum between 190 - 200 dB. Also can you indicate the increase in energy between SELcums of 187db, 190db and 200db ie Is the energy received by a receiver at 190db 3 times the energy received at 187db? Further is the energy received at 200 db 30 times the energy received at 187 db? Warm regards [redacted]	Email response provided addressing issues / questions raised - see TRD-165.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-74	14/12/2017	ERM email: Just to follow up on [redacted] email below. I am in the process of taking over as project manager for the Bethany survey EP. Going forward, please direct any communications regarding the catch data and the proposed research scope through me. I would be grateful if you could provide the updated data as soon as it is available, so we can incorporate it into the revised EP prior to resubmission. Iõm looking forward to working with you. [redacted] NTDPIRF email: Thanks for the email. Ill keep you updated with catch data. Ill send an email to our director reminding him. Also it would be good to try and catch up on a few things Id been discussing with [redacted] Are you available next week for a phone call? ERM email: Hi [redacted] Sure ï Iõm not in Monday, but will be available on Tues through to Friday next week. Let me know what day/time suits you. Cheers, [redacted] NTDPIRF email: No worries [redacted] are you based in Perth? I might try and give you a call around 1500 your time on Wednesday? Ill confirm on Tuesday. Cheers. [redacted]	Follow-up on request for updated NT Fisheries information to update the Bethany EP.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-73	13/12/2017	NTDPIRF email: Yes please could I have a look at the draft EP, dropbox is fine. Santos email: You should have received an email invite to a dropbox. I have added Bethany Seismic EP Rev 4 and a word document that has a table that details the changes from the previous version. NTDPIRF email:Yep got it!	Provision of Bethany Seismic Survey EP Rev 4 TRF, Jasco Bethany 3D MSS Modelling Report Dec 2017 and Bethany 3D Seismic Survey EP TRF Changes - table detailing where change made compared to EP Rev 3.
Timor Reef and Demersal Relevant	TRD-161	13/12/2017	[redacted] email: Can you please confirm that you were in receipt of my email dated 7 July 2017. Santos email: Thank you for your note. Yes, we confirm that we received your email dated 7 July 2017. The content of your email was taken into account in the response below. [redacted] email: Just to confirm SANTOS is claiming that all fish have recovered from the impacts of your survey within 24 hrs? Santos email: With respect to TTS effects in fish exposed to seismic airgun noise the 24-hour period for SELcum assessment is the industry standard, based on the best information available at present. In the context of the impact and risk assessment, modelling and evaluation of TTS effects in fish for longer time periods is not necessary, based on the recovery periods indicated in the literature. As detailed in the EP (Section 7.1.5.3.3), any behavioural changes in fish exposed to seismic airgun noise during the Bethany survey have been assessed to be of short term duration as the seismic source passes (minutes to hours).	Email response provided addressing issues / questions raised.
Timor Reef and Demersal Relevant	TRD-162	13/12/2017	[redacted] email: [redacted] it would be appreciated if you paid our concerns a bit more respect. The recovery of fish in 1.9m of water from 5 shots in 5 minutes is simply not relevant to your survey. Whats the recovery time for fish exposed to SELcums of 190 - 200dB? Santos email: Throughout all of the communications over the past 7 months or so Santos has always treated the concerns and issues you have raised with respect, and has consistently provided additional information to try and address your comments. We have offered the option of a face-to-face meeting to properly discuss your concerns, particularly with respect to TTS effects in fish, appropriate sound exposure thresholds, and the use of a 24-hour resetting period for SELcum. At this point, I think there would be benefit in getting an independent, expert opinion of the appropriateness/applicability of the 24-hour period for SELcum assessment, and of the application of this via the modelling study to assess TTS effects in fish for the Bethany survey, probably directly from Art Popper (Professor Emeritus & Research Professor, University of Maryland), lead author for the Popper et al. (2014) guidelines, or a suitable alternative subject matter expert. Should this process be undertaken, Santos/ERM will copy both [redacted] and yourself in on all communications with the peer reviewer. Your thoughts on this approach would be appreciated. Secondly, I would like to let you know that [redacted] will be leaving Santos at Christmas. Her last day here will be Weds 20th December. [redacted] who is a Technical Director at ERM (Environmental Resources Management), will be working with Santos to manage the Bethany EP going forward. [redacted] is very experienced with seismic surveys and was involved in the research program undertaken by Woodside for the Maxima seismic survey undertaken at Scott Reef, and has prepared numerous seismic EPs.	Email response provided addressing issues / questions raised - see TRD-167. The independent review by Art Popper has been commissioned as part of Santos' ongoing stakeholder relationship management and is not reflective of any uncertainty regarding the modelling, application of standards or impact assessment.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Department of Defence	DoD-26 and attachment BU	12/12/2017	Santos email: Thanks for your response. In summary, it seems we need to treat both the DRA and NAXA areas as exclusion during the Operation Kakadu period. In answer to your queries, the Seismic survey is split into two areas, namely the survey area and the operational area. The survey area is where the seismic source array will be operating at full power and seismic data is being recorded. The operational area is primarily used for the following purposes: ÅDeployment of in sea equipment (streamers & airguns) at the start of the survey. ÅVessel turning / manoeuvring adjacent the full power zone (typically within approx. 20km of the full power area). ÅA working area where the vessel can have longer straight runs during maintenance times if required. ÅRecovery of in sea equipment at the end of the survey. ÅIt should be noted that the airguns may be active in the operational area for testing purposes and on the run-ins to the survey area. I have attached a map that shows the seismic sail lines and indicative vessel turns which is the majority of the vessel activity. The remainder of the operational area would be used significantly less however we do not know when the vessel may be required to use it.	Ongoing engagement to obtain information in regards to the defence areas for Exercise Kakadu.
Austral Fishing	AF-4	11/12/2017	Santos email: Just to let you know that I will be finishing up with Santos next week and am going to have a break for a while. [redacted] from a consultancy company called ERM will be working with [redacted] to manage the Bethany Seismic Environment Plan. [redacted] will be in touch to organise a time for him and [redacted] to catch up with you in the New Year. [redacted] is very experienced with seismic surveys and will be able to answer any of your questions in regards noise impacts. [redacted] was involved in a research program undertaken by Woodside for the Maxima seismic survey undertaken at Scott Reef. Attached is a video that may be of interest to you and your team. At ~ 7.50 mins it has some video of fish reactions when the seismic vessel is nearby and you can hear the actual seismic source noise. [redacted] McCauley was involved in the research and there have been a number of papers produced that did not show impacts to fish, coral or the long term sustainability of the reef. [redacted] can provide with the papers if you would like them. https://www.youtube.com/watch?v=f3XztyNbceA A couple of things I wanted to follow-up. We have updated the Bethany Seismic EP based on NOPSEMAŝ feedback and the integration of new noise modelling. On Friday we provided copies of the EP, new modelling report and a table of the EP changes to [redacted] and [redacted] If you would like us to provide you with this information let me know and I can put into a dropbox as they are too large to send. We asked for comments prior to the Xmas break (22nd Dec) but realise this might a push so are aiming for the as soon as possible after Xmas, preferable the week of the 8th Jan. Also have you had a chance to map up the trap areas with our planned survey areas. The reason I ask is that the latest information we have from the NT Dept. of Fisheries is from 2011 ï 2016 (see below) and shows a decreasing trend of trap activity within the Bethany survey area. I have asked the NT Dept. of Fisheries if they have any more recent data but it is taking a while to get it from them. Year Trap 2011 8% 2012 13% 2013 16% 2014 9% 2015 5% 2016 1% Last I have had a chat to [redacted] and he will be in contact. AF email: Crikey [redacted] That is a bit of a surprise, I do hope that the change is for the good for you. I am in Mauritius for a couple of days but the meeting last week was interesting but has not shed any more light on this area for us. Yes please to a copy of the documents and timing is tight for sure with all else that is going on. Santos email: It was a bit of a quick decision but all good. Have uploaded documents to a dropbox and you should get a message with the location. Think [redacted] going to try and see if your around next week and if so can go over the EP.	Ongoing consultation with stakeholder and provision of information. Provision of Bethany Seismic Survey EP Rev 4 TRF, Jasco Bethany 3D MSS Modelling Report Dec 2017 and Bethany 3D Seismic Survey EP TRF Changes - table detailing where change made compared to EP Rev 3. Meeting to further discuss EP and survey set for 20.12.17

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Department of Defence	DoD-25	11/12/2017	DoD email: Please see below for the responses to your queries: As I understand it, during the operational window of operation Kakadu (31/8/18 ï 15/08/18) the DRA is a complete exclusion zone. Does this complete exclusion include all of the NAXA areas ï i.e. NAXA NE and NAXA SW (as per my map) or is it just limited to the DRA area as marked (or something else). If operation Kakadu does not have any operations planned for NAXA SW, is there any restrictions on us during the operation Kakadu timeframe or any restrictions during other times in that area for our Beehive survey? The area outlined for the Beehive Survey would potentially have an impact on the scale of manoeuvre of surface ships during the exercise. The proximity to the Blacktip Racon B well head makes this portion of the NAXA valuable in terms of training scenarios. Defence notes that there has been a separate consultation request made in relation to the proposed Beehive survey. Defence will review the information provided and provide further guidance in relation to the separate request. Whilst the DRA is a complete exclusion zone during the exercise, If we were to operate outside the DRA area (but adjacent to the boundary) on Bethany during Operation Kakadu, would the noise generated from our airgun arrays have an impact on the defence operations? Defence has no concerns regarding Santos operating adjacent to the DRA. However, please note that units will operate right up to the boundary of DRA during the Exercise, with commensurate levels of radiated noise that may affect surveying activities. Defence considers that the noise generated from airgun arrays is unlikely to have impacts in the Beehive area, but may possibly have impacts in the Bethany Survey Area. Additionally, Defence would like to request further information regarding the larger ñOperational Areasò of the surveys. Can you please advise what activities will be undertaken in these areas and what the significance of these areas are to the surveys overall. Please contact me if you have any further queries.	
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-72	11/12/2017	NTDPIRF email: Hi [redacted] Yes apologies, I saw your missed calls and was trying to get information to see where the process was at. Donõ stress about putting pressure on Ian, probably better if it comes from me. Ill give your January deadline to him. Thatõs exciting your having a break. No problems re the assistance, apologies that it takes a while sometimes. Best of luck! [redacted] NTDPIRF email: Apologies [redacted] last week ended crazily for me as I was in workshops in Melb as well as trying to put out fires in Darwin. I take it from your email you havenõ received the updated information. It is currently sitting with our Director and he is drafting an email to the commercial sector before he provides it to you. Santos email: As yet we have not had any updated data so have sent out the updated EP to [redacted] with the previous data which was up to 2016. Can we do anything to get the Director to get this moving as we would like to include the updated data into the EP prior to submission to NOPSEMA in mid-Jan 2018. In the end we didnõ use the SAFE analysis but did use the trawl by catch data. If you want the updated EP I can put into a dropbox as it is too large to send. Just to let you know that I will be finishing up with Santos next Wednesday and am going to have a break for a while. [redacted] from a consultancy company called ERM will be working with Santos to manage the Bethany Seismic Environment Plan. [redacted] is very experienced with seismic surveys and was involved in the research program undertaken by Woodside for the Maxima seismic survey undertaken at Scott Reef. Can you please liaise with him about the data and also regarding the research scope. Thanks so much for spending that time with me I learned a lot about the way fishing assessments are undertaken. I am still keen to look at how we could apply a process such as SAFE to impacts to fish and fisheries from oil and gas activities and might be something I work on next year. If so I will let you know.	Follow-up on request for updated NT Fisheries information to update the Bethany EP. Fishers are not supportive of providing this information. Bethany EP sent to [redacted] and [redacted] with existing fisheries data as NTDPIRF had not made available. Provided information on change of environmental contact.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-160	8/12/2017	Santos email: Good morning. I am re-sending this note from Friday 8th December. I had some problems with my mailbox over the weekend and I want to be sure this note was properly circulated. The following has been put into the Dropbox: Santos Bethany 3D Seismic Survey EP Rev 4 TRF Santos Bethany 3D MSS Modelling Report Dec 2017 Santos Bethany 3D Seismic Survey EP Rev 4 TRF Changes The document Santos Bethany 3D seismic Survey EP Rev 4 TRF Changes details the changes in the EP. The main change is the integration of the updated modelling. If possible we would like to obtain comments prior to the Xmas break (22nd Dec) but realise this might a push. If not would we be able to get comments as soon as possible after Xmas ï week of the 8th Jan. We are also happy to meet at time that is convenient to discuss the changes and your feedback. Santos email: Hi [redacted] The following has been put into the Dropbox: Santos Bethany 3D Seismic Survey EP Rev 4 TRF Santos Bethany 3D MSS Modelling Report Dec 2017 Santos Bethany 3D Seismic Survey EP Rev 4 TRF Changes The document Santos Bethany 3D seismic Survey EP Rev 4 TRF Changes details the changes in the EP. The main change is the integration of the updated modelling. If possible we would like to obtain comments prior to the Xmas break (22nd Dec) but realise this might a push. If not would we be able to get comments as soon as possible after Xmas ï week of the 8th Jan. We are also happy to meet at time that is convenient to discuss the changes and your feedback.	Provision of Santos Bethany 3D Seismic Survey EP Rev 4 TRF, Santos Bethany 3D MSS Modelling Report Dec 2017, Santos Bethany 3D Seismic Survey EP Rev 4 TRF Changes. Request to have comment pre Xmas if possible and at the latest week of 8th Jan 2018.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-71	7/12/2017	Santos email: Just trying to contact you to see if we are likely to get this information by tomorrow. If so we will delay sending EP to [redacted] so we can incorporate. If not likely to get tomorrow we will send the EP without the updated data and update when received. Could you let me know.	Follow-up on request for updated NT Fisheries information to update the Bethany EP. Fishers are not supportive of providing this information.
Austral Fishing	AF-2 and attachment BT	6/12/2017	Santos email: Re phone call. As mentioned this paper by Carroll et al is a good summary of the research to date in regards to seismic impacts to fish and invertebrates. Provided contact details for [redacted] (NT Fisheries Research) in regards to research scope developing for fish tagging study for Bethany survey. Lastly will give [redacted] an update about the Airscope work and joint media/PR issues and get him to get back to you. Did you manage to map up the Bethany survey area against the fishing areas? If not let us know and is there a way we can help as would be good to understand the overlap. Let me know how you go with WAFIC.	Provision of information to fain an understanding of current literature on impacts to fish and invertebrates from seismic surveys (Carroll et al).
Austral Fishing	AF-3 and attachment BV Part 1	6/12/2017	AF email: Thanks and thatõs looks pretty comprehensive. I have not been able to find any software on this machine to open the shape files but will share with the team here and they might be able to help. I provided an overview of our session to the team who are on copy here and we can see some opportunities in this otherwise unwelcome intrusion into our newly acquired interest in Timor snapper. As I said, we certainly acknowledge the importance of this sort of exploration given that we are ourselves (currently at least) considerable consumers of fossil fuels and it would be churlish for us to simply deny this type of development coz its in our back yard or offends our sensibilities in some way. That being the case and with the growing body of evidence that appears to suggest that 3D seismic is indeed impacting these ecosystems we are driven us to want to better understand just what these impacts are. This creates an opportunity to jointly develop plans or commission research that can help to put measures around the impact and use this as a basis for compensation. I have a call into [redacted] from the FRDC to see what is happening in this space at the moment. As we discussed on Thursday, we have [redacted] attending the meeting in Darwin next week and we are keen to get a feel for the mood of the industry before making any big commitments. We are also brand new to this type of interaction and therefore needing to turn our hand to thinking about the science of seismic and the concepts around measuring economic impact and the principles about making good on that impact so there are some pretty big issues in here that we need to get across before we feel comfortable that we can make good decisions. The Santos commitment to making good on damages and inconvenience in this space are welcome and constructive and we will be looking for ways to drive some win win outcomes for Santos, Austral the state of knowledge for interactions between fisheries and seismic.	Ongoing consultation with stakeholder and provision of information.

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Austral Fishing	AF-3 and attachment BV Part 2	6/12/2017	On copy here is: [redacted] ï science grad, Nuffield student, keeper of our carbon accounting, fishing rights and understudy to policy and environment guru [redacted] ï Policy Science guru, based in Hobart. Also science graduate, well respected in Govt, science and NGO world and was formally Chair of Commonwealth Fisheries Association when we were talking to APPEA about impact of seismic in Bass Straight [redacted] ï Perth based but currently in Mauritius building our new prawn boat but is operationally responsible for [redacted] just done a stint as Chair of the WA Fishing Industry Council, knows well all the players in the NT and served his early years as a shrimp boat captain in the Northern Prawn Fishery. [redacted] ï company secretary and CFO [redacted] has taken a person interest in this fishery and our move to diversify and is keen to see that his baby performs to expectation. We have canvassed a couple of folks that could be of assistance with a project to grab all this and formulate the right questions. I mentioned [redacted] who we have known for a while and has just been freed up from CCAMLR. There is another chap in Darwin by name o[redacted]hat is past CSIRO and past NT Fisheries and [redacted] had another suggestion but I think we need to really get clear on what we need to deliver from here and that view will be better formed after a chat with FRDC and a report from Darwin next week. The maps of the past surveys is really handy and yes, lets try to touch base after the Darwin meeting. Next week is a little difficult for me as I have a few days in Port Louis and the back end of the week also consumed by a combination of personal and professional distractions.	Ongoing consultation with stakeholder and provision of information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-70	5/12/2017	Santos email: Sorry to harass you. We have committed to getting the updated EP to [redacted] and [redacted] by Monday 11th Dec so just wanted to know whether we would have the updated information by the end of the week. If not I may have to add later and then resend the EP. Could you let me know. NTDPIRF email: Yeh no worries, am just getting director approval today noting that he may mull over it for a bit given Industry’s position on not wanting us to provide any of their data to Santos. A decision should get made this week. Santos email: If we can’t get the data in time I will just leave what is in the EP for [redacted] Interesting as it’s hard to assess the level of impact if we don’t have the data. Was just speaking to [redacted] at Austral Fishing who has purchased [redacted] boat. I have passed on your details as he is new to seismic and is trying to gain an understanding of issues/impacts. I gave him an overview of the study your putting together and he is interested in getting more information. NTDPIRF email: That is exactly our point, we suggested that your risk assessment process needed improvement last round so am fairly confident Ian wont hold back the data. Thanks for contacting [redacted]	Follow-up on request for updated NT Fisheries information to update the Bethany EP. Fishers are not supportive of providing this information.

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Timor Reef and Demersal Relevant	TRD-159	5/12/2017	Santos email: In relation to your emails of 28 November and 3 November. We are planning to resubmit the updated EP to NOSPEMA mid-January 2018. We will provide you (via dropbox) the updated EP with track changes, the noise modelling report and a table to show where changes relevant to your activities have been made. We would be available to meet to go over the changes prior or after Xmas at a time suitable to you. In relation to the information you have been requesting, as per previous emails and within the Bethany EP, Santos has explained why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In their discussion of the criteria, Popper et al. (2014) acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiverõs accumulated level (Gedamke et al. 2011). As previously pointed out, the Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a ôresettingô of SELcum to zero after 24-hours is based on the best information available at present. In the US, the NOAA Fisheries uses a 12-hour recovery period for fish exposed to pile driving noise, and accumulates the SEL from all pile strikes that occur prior to a 12-hour break in pile driving. If the thresholds have not been exceeded prior to this break, then the accumulated SEL is reset to zero (Stadler and Woodbury 2009). The rates and total amounts of impulses produced over a given period of time or area differ markedly between pile driving and marine seismic surveys. There are several reports and reviews in the literature noting the relatively rapid rise times of pile driving impulses (typically much faster than airgun pulses) and, unlike seismic surveys, evidence of fish kills and serious injuries to the organs and tissues of various fish species in the vicinity of pile driving operations (e.g. Caltrans 2001, 2004; Hastings & Popper 2005; Popper et al. 2006). During pile driving operations the most significant impacts routinely occur when a static receptor (i.e. a site-attached fish) is exposed to impulses from a static source. This is obviously not the case with marine seismic surveys. Hence, a resetting period of 24-hours for SELcum for seismic airguns is regarded as precautionary and conservative. References Caltrans 2001. Fisheries impact assessment for the Pile Installation Demonstration Project, San Francisco ï Oakland Bay Bridge East Span Seismic Safety Project. August 2001. Caltrans, 2004. Fisheries and Hydroacoustic Monitoring Program Compliance Report ï San Francisco ï Oakland Bay Bridge East Span Seismic Safety Project. Report 04-SF-80 KP, State of California Department of Transportation, San Francisco. Gedamke J, Gales N & Frydman S, 2011. Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation. Journal of the Acoustical Society of America 129(1): 496-506. Hastings MC & Popper AN 2005. Effects of Sound on Fish. Technical report under Jones & Stokes for the California Department of Transportation, Sacramento, CA. 82 pp. Popper AN, Carlson TJ, Hawkins AD, Southall BL & Gentry RL 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper. May 2006. 15 pp. Stadler JH & Woodbury DP, 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. Assessing the effects to fishes from pile driving: application of new hydroacoustic criteria. Inter-Noise 2009, Ottawa, Ontario, Canada. 8 pp.	In response to TRD-158 and TRD-155.

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Austral Fishing	AF-1 and attachments BQ, BR and BS	4/12/2017	Santos email: Thank you for meeting with [redacted] and I at what must be a very busy time for you. The main points I took away from our discussion were: Austral fishing have taken on [redacted] licence and vessel with a quota of 230t. [redacted] will be managing this part of the business. The vessel does about 21 trips a year and is typically out for 2 weeks. They do about 60 traps a day which are out for ~ 12 hours. Vessel comes in to offload, restock and go back out. Little down time. [redacted] the vessel captain, has been in the industry for over 20 years and is very experienced. He feels that fish catch is impacted by about half and for 12-18 months after a seismic survey. You are not sure about seismic impacts but concern is damage to fish that could impact fitness to reproduce. Santos has put forward a make good agreement to cover displacement of fishing vessels from the survey area and also for any impacts to catch. Would appreciate your view. Confidentiality agreement is for any data provided by the fisherman. A number of studies were discussed: ÅCorrelating catch data with seismic surveys to identify any impacts. Santos has offered to fund a fisheries data person to do this. ÅUse of sonar for identifying fish and monitoring behaviour during seismic surveys. Would be interested in what the fishing vessels use. ÅTagging of fish to monitor behaviour during the seismic survey. [redacted] at NTDPIF is putting together a scope to be able to discuss with collaborators and identify funding. Meeting of the fishery on the 12th in Darwin that [redacted] attending. Will obtain lay of the land from that meeting. Let me know if I have missed or misinterpreted anything. I have attached the shape file for the operational area so that you can map up previous fishing locations. We would be interested in understanding how much fishing is undertaken within the area of the survey. I have also attached maps showing seismic surveys for 2D from 2000 to 2012 and 3D from 1990 to 2012. This is the latest publicly available information. Please let me know if you would like any further information. We will touch base after the 12th Dec meeting. Thanks again and we are looking forward to working with you.	Introductory meeting. Discussed seismic survey and licensee fishing arrangements. Provision of information including: Shape files of the Bethany operational area to be able to map against previous fishing locations. Maps showing previous seismic surveys in the JBG.
Department of Defence	DoD-24	4/12/2017	Santos email: Hi [redacted] Just wondering if there was any updates re my email below ï the management team here have a Joint Venture meeting tomorrow so were hoping to provide them with an update. Regards [redacted] DoD email: Hi [redacted] Apologies for the delay, we are still awaiting comments back from Navy. We are expecting to have a response for you early next week. Kind Regards, [redacted]	Follow-up on request for information DoD-23

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-69	28/11/2017	Santos email: As mentioned I am updating the Bethany EP and would like to update the NT Fisheries information if available. There are three tables as per below. ó Let me know if you need more information etc. Table 1: % Catch within Operational Area for each fishery. Table 2: TRF % Catch within the survey area with a 3.6 km buffer. Would you be able to update with the new survey area and a 3.4 km buffer. Table 3: % of total catch by fish species caught in the Bethany Operational Area 2013 - 2015 NTDPIRF email: Sorry but I assumed the shape files you attached were for the new survey area + 4km. has it not changed now and we just use the old survey area? Santos email: In regards to the areas we have change the areas and terminology. As per the attached map there are now only two areas: Full power zone (FPZ) ï this is the survey area with the 4km extension either end. Itôs the area where the seismic source will be at full power. This area is approximately 4,565 km2. This is what I have given you the shape files of. We use this area for looking at the seismic noise impacts hence the 3.4 km buffer as the is the distance from the FPZ that the noise levels will be above threshold levels that could have some impact on fish. Survey operational area ï this is outside the full power zone and where activities like set-up, testing of equipment and vessel turn-arounds (to undertake the next line) take place. This area is approximately 12,610 km2. You should have the shape files for this. We use this area to look at where we might displace the fishers during the survey. Sorry should have explained that up front.	Request for updated NT Fisheries information to update the Bethany EP.
Timor Reef and Demersal Relevant	TRD-158	28/11/2017	[redacted] email: Thank you for your call and advising the update that Santos will provide further information in the next couple of weeks and is looking to lodge a revised EP with the regulator in early 2018. We did not discuss a date for lodgement of the EP with the regulator but I do hope it is a decent amount of time given the December timing. As discussed please advise what data Santos expects to upload to the dropbox on or about the 11th December (EP, Sound Modelling etc.). We also request that the information we have been requesting and summarised in my email of the 3rd November 2017 be provided. Santos additions to phone call: References to addressing [redacted] issues. Santos offered a get-together after w/c 8 January and submission of EP in Mid-January. Discussed the [redacted] transfer of licences to Austral and is only one of 12 licences in the fishery. Payment for expenses. I re-emphasised that we can cover their costs on the commercial basis outlined previously.	Update on status of: EP and when it will be available to stakeholder. Offer of meeting after have had time to review EP. Payment of expenses.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Department of Defence	DoD-22 and attachments BM & BO	22/11/2017	DoD email: Apologies for the delay, please see below responses to your queries below: Would you be able to let us know if there are any other exercises planned in this area in the next 2 - 3 years? Exercise KAKADU is undertaken on a bi annual basis in the Northern Australian Exercise Area (NAXA). Exercise KAKADU 18 will take place in August/September 2018. Would you be able to confirm that the Bethany survey area shown in the attached map would encroach on the DRA? The DRA appears to overlap the area identified as ñBethany survey operational areaò on the map you have provided. Are we able to get a map or shape file of the DRA so we can understand the area of overlap? We have overlayed the DRA (yellow shaded area with blue outline) onto the map you have provided. Please see the attached DRA & MSS map for your reference, please also note that this is approximate only. Could you let us know what the issues are from the seismic survey that would potentially impact on the exercise? It is not possible to operate submarines beneath the survey vessels and their towed bodies. In addition, ambient noise from the large number of surface ships may interfere with the survey results and the extensive length of tow would make it dangerous to operate a large force of warships in proximity to the survey vessels. Therefore, the survey area would have to be deemed an ôexclusion zoneö This would mean that both surface and subsurface units would have to transit around the survey area, making for large time delays for the repositioning of units during different phases of the exercise. This is the primary area of concern and that such an exclusion zone is also unrealistic and provides a host of problems for the exercise planners. Please let me know if you have any further questions or would like anything clarified. Santos email: Thanks for the information which I have passed on to the project team and will get back to you.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)

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Department of Defence	DoD-23 and attachment BP	22/11/2017	Santos email: Hi [redacted] I am the project manager for one of the 2 seismic surveys west & north west of Darwin that [redacted] contacted you about recently (see email trail below). Given we are now more into scheduling issues I will take over discussions from her for both surveys so we can clarify exactly what Defence requirements are. I have attached a simplified map showing the 2 proposed seismic surveys and the defence restriction areas as we understand them. I have labelled the Northern Australia Exercise Areas (NAXA) as SW and NE just for my clarity. As can be seen, the Bethany 3D survey area impacts on the Due Regard Area (DRA) and the Beehive 3D survey area impacts on the area marked as NAXA (SW). My questions are as follows: 1. As I understand it, during the operational window of operation Kakadu (31/8/18 ï 15/08/18) the DRA is a complete exclusion zone. Does this complete exclusion include all of the NAXA areas ï i.e. NAXA NE and NAXA SW (as per my map) or is it just limited to the DRA area as marked (or something else). 2. If operation Kakadu does not have any operations planned for NAXA SW, is there any restrictions on us during the operation Kakadu timeframe or any restrictions during other times in that area for our Beehive survey? 3. Whilst the DRA is a complete exclusion zone during the exercise, If we were to operate outside the DRA area (but adjacent to the boundary) on Bethany during Operation Kakadu, would the noise generated from our airgun arrays have an impact on the defence operations? Many thanks for your time on this. Obviously Operation Kakadu is a major undertaking for Defence and Santos does not wish to adversely impact on its success. Operating seismic vessels (with cables deployed) around other vessels is also not something we would want to undertake for safety and financial reasons so understanding your requirements early in the piece is important to our project scheduling. Iôm more than happy to discuss this on the phone with you at any time if you think it is easier. Regards [redacted] DoD email: Hi [redacted] Thank you for your email. I will pass your queries on to Navy and will send you a response as soon as possible Kind Regards, [redacted]	Ongoing engagement to obtain information in regards to the defence areas for Exercise Kakadu.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Department of Environment and Energy	DoEE-5 and attachment E & BM Part 1	20/11/2017	Santos email: Thank you for your response and providing information regarding the Director of National Parks (DNP) expectations for consultation for activities proposed within a Marine Park. As requested, please find attached a Marine Seismic Survey Information Sheet for Santos' Bethany survey. Please note the survey area has changed slightly and will now cover an area of 4363 km2. The attached location map shows the updated survey area and Oceanic Shoals Marine Park boundaries (BONPRT 651 Bethany AMBA and Marine Reserves.pdf). The Bethany survey information sheet contains a summary of the following information requested: ÅActivity overview including; type of activity (3D seismic survey), proposed equipment and vessels, expected start and completion date of activities that overlap the Oceanic Shoals Marine Park. Please note that as the environment plan (EP) is still going through the NOPSEMA assessment process the survey will now take place during 2018 or 2019 depending on NOPSEMAc̃s acceptance of the EP. The survey will take up to 75 days and is planned to be undertaken in the period between 1 May and 30 September to avoid the peak tropical fish spanning period. ÅSee Pages 2-5 ÅDescription of the environment within or near the Bethany survey area. ÅSee Table 3, Page 6 ÅA brief description of the planned aspects of the activity within or that may impact on the values of a CMR ÅSee Table 4, Page 7 - Potential Risks, Impacts and Controls identified for the Bethany seismic survey ÅDemonstration of how the above outcomes (a, b & c) have been achieved ÅSee Table 4, Page 7 - Potential Risks, Impacts and Controls identified for the Bethany seismic survey ÅProposed stakeholder consultation during Bethany survey. ÅPage 9	Information provided in response to DoEE-2.
Department of Environment and Energy	DoEE-5 and attachment E & BM Part 2	20/11/2017	Santos email: The Bethany EP and Oil Pollution Emergency Plan (OPEP) has been updated as per your request and includes notification and incident reporting to the DNP in the event that an oil spill occurs within or is likely to impact the Oceanic Shoals Marine Park. The unplanned environmental incident assessment undertaken for diesel spill scenarios (refuelling incident and diesel tank rupture from collision) identified the Oceanic Shoals Marine Park has the potential to be exposed to surface hydrocarbons. The area of exposure is shown on the attached map as the AMBA (area that may be affected). The OPEP details the management responses to a diesel spill. As a diesel spill will rapidly disperse, management response will consist of monitor and evaluate. Environmental impact monitoring will be undertaken as follows: 1. Provide observations to ascertain presence of turtles, marine birds and cetaceans within proximity of hydrocarbons; and if they have been exposed to surface hydrocarbons. 2. Verify that exposure to surface hydrocarbons has not adversely affected turtles, marine birds or cetaceans. 3. Verify surface, entrained and aromatic hydrocarbon exposure levels within the Oceanic Shoals Marine Park and Demersal Fishery, Timor Reef Fishery and Northern Prawn Fishery areas. Following on from your discussion with [redacted] Santos understanding is that the DNP does not wish to receive the Bethany EP as the DNP will not be assessing the EP, this is the responsibility of the Regulator NOPSEMA. Therefore, Santos confirms that the Bethany EP which will be re-submitted to NOPSEMA for assessment contains a thorough impacts and risk assessment, which demonstrates how the impacts and risks of the activity will be managed to reduce to ALARP, is of an acceptable level, and has consideration of the relevant IUCN zones of management for Marine Parks. If you require any further information, please contact me, my details are below.	Information provided in response to DoEE-2.
Department of Defence	DoD-21	17/11/2017	Santos Phone Call: 17/11/2017 Phoned [redacted] to follow-up if any response to email on 23.10.17. He said that he had been in touch with the Navy and that they were undertaking an exercise and would get back to him next week. I said that we have our team meeting on a Friday so if I donť hear from him would follow-up next Friday (24.11.17).	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)

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Department of Environment and Energy	DoEE-4	14/11/2017	Santos internal email: I called [redacted] regarding the DNP response yesterday and she got back to me today. [redacted] advised DNP would not review the complete EP if we provided it. She appreciated the offer but insisted they don't have the time or capacity to do so, they rely on NOPSEMA's assessment. DNP would be happy with a fact sheet and a brief summary of the 'specific information requirements' listed in the response. [redacted] also mentioned the items under the 'Outcomes' heading in the response letter is a reminder to make sure the EP contains this information for NOPSEMA's assessment, DNP do not expect to receive the complete impacts and risk assessment as they won't be providing advice on these EP sections at this stage. I confirmed with [redacted] a response to the 'Outcomes' section of the DNP letter can be along the lines of :.... "Santos confirms that the Bethany EP re-submitted to NOPSEMA for assessment contains an impacts and risk assessment managed to an acceptable level, with consideration of the relevant IUCN zones of management for Marine Parks." And last of all, DNP met with NOPSEMA yesterday and they are currently finalising a new guidance document aimed to clarify the consultation requirements with the DNP- date of release is not known, but should be soon.	Information provided as per DoEE-5.
Timor Reef and Demersal Relevant	TRD-157	10/11/2017	Santos email: Thank you for your note. We understand you have outstanding concerns. We are working on our assessment and updating the EP. Once this information is available we will be in touch and we will allow a reasonable period for its consideration.	Update on status of EP.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-68	9/11/2017	NTDPIRF email: Please see the SAFE assessment (attached) we have developed for assessing impacts of trawl catch on non-target species in our offshore snapper fisheries that we discussed last time we met. Please note that we are providing this information to try and assist you with improving your risk assessment process. However, there are some caveats on the appropriateness of this model for assessing the impacts of seismic activity. These are: 1/. This method was specifically designed to assess fishing impacts so you really need to discuss the most appropriate way to use it with [redacted] from CSIRO who developed the methodology 2/. The spreadsheet only has fish species caught in trawl and is not representative of all the species that inhabit the area so I would encourage you to include additional species that inhabit the area (can be sourced from the living atlas of Australia https://www.ala.org.au/) Thanks and happy to discuss any questions you have about the use of the assessment. Santos email: Tried to ring to say thank you for this information and hope it hasnꞌt put you in a bad position. Agree with your caveats and as discussed I will show you how we use the information and how we detail in the EP. You had a cheat sheet/instructions for the spreadsheet ï any chance I could get that? I am sure I will have a few questions but will try not to bombard you. First one - Is the data you have given me for the full trawl area, the trawl area within our survey area or from areas similar to our survey area or none of these?? Also Santos is looking at the possibility of looking at doing some BRUVS work to look at how site attached fish behave during the survey. Wouldnꞌt mind getting your thoughts. This would be in addition to the fish tagging you're looking at. Give me a ring if easier to chat.	Provision of Trawl trial by-catch species composition data for trawl area within TRF. Information utilised in EP Section 5.5.4 Fish to identify the types of fish species that may be present in the survey area. SAFE methodology not utilised for Bethany EP impact assessment.
Department of Defence	DoD-20	6/11/2017	DoD email: Thank you for your email. Apologies for the delayed response, I have been on leave for the past few weeks. Can you please ensure that in future you contact [redacted] directly, so your query can be actioned in my absence. I will need to clarify these queries with our stakeholders, we will forward you our response as soon as possible. Santos email: Thanks for letting me know and I will ensure we use the generic email.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)
Timor Reef and Demersal Relevant	TRD-156	6/11/2017	Santos email: Good morning. I am following up on this. Do you have any questions for us?	Follow-up on email TRD-154. Santo was notified via Austral Fisheries that they had purchased [redacted] licence and vessel. See consultation records for Austral Fisheries.

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Timor Reef and Demersal Relevant	TRD-155	3/11/2017	[redacted] email: To be frank, you advised that your email provided answers to our questions but I am sure you can see that in actual fact you provided an overview with little to no detail. Without some detailed information provided in advance of any meeting we believe the process is an inefficient use of resources. Accordingly, a meeting at this point is unlikely to deliver relevant or sufficient information required to assess the impacts and or risks on our operations and interests in the fishery. We are yet to be provided information despite numerous previous requests. As a minimum we will need the following; 1. As previously stated we need SELcum modelling carried out at relevant timeframes. To date we have been provided two fallacious defences for the 24hr time period. To assess the impacts on the fishery we must have the SELcum modelled at the appropriate time frames (please see previous correspondence) 2. Information on any new threshold levels. We havenꞌt seen any material to suggest the standards in Popper et al should be amended but if this is to occur we will need sufficient time to consider any changes. 3. Any new sound modelling to be relied on in EP. 4. Copy of revised risk assessment. Once we have this information we will need a reasonable period to consider the risks and respond to SANTOS with any objections or claims. Once SANTOS has had time to consider these issues then this would seem a sensible time for stakeholders to meet and SANTOS could outline how it proposes to address our objections and claims. This process needs to occur prior to submission of the next Environmental Plan. We look forward to receiving the information requested. Once received we will be in position to outline a time table for responses.	Concerns raised regarding SELcum are addressed via response TRD-112 and TRD-130. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiverꞌs accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a ꞌresettingꞌ of SELcum to zero after 24-hours is based on the best information available at present. Information on any new thresholds will be provided in the updated EP that will be made available to stakeholder. A copy of the new modelling report will be made available to stakeholder. Risk assessment will be within the EP that will be made available to stakeholder. Santos will provide a 4 - 6 week window for stakeholder to consider information and respond. Extended timeframe takes into account Xmas and New Year period.
Timor Reef and Demersal Relevant	TRD-154 and attachments BD, BE and BL	1/11/2017	Santos email: [redacted] Further to our conversation last week. I re-issue our proposal re: consultation costs. If this proposal is acceptable to you I will instruct the lawyers to re-draft the agreement to [redacted] only. We propose to carry out the survey in the same survey time frame in 2018/19, subject to the EP being approved and the support of our joint venture partners. Attached you will find: 1) a Mutual Confidentiality Agreement; 2) a Draft Fisheries management Agreement (previously issued on 11 August 2017); and 3) our new survey area. The Bethany 2018 survey area is a 4.1% areal increase from the original (4190km2 to 4363km2). The new area has an overlap with the Timor Reef Fishery of 10.8%, the original area was 11.4%. For the demersal fishery the new area is 0.34% and the original was 0.22%. Returning to the consultation costs, we propose the following way forward: • Santos will pay [redacted] for its reasonable consultation costs to date, subject to completion of each and all of the following to ensure future consultation is efficient and effective: o The Licensee to provide an executed copy of the Confidentiality Agreement (attached) to preserve the confidentiality of the Licenseeꞌs data (reasonable amendments will be considered) o The Licensee providing all the data necessary to enable us to meet and calculate, or agree a formula for, the adjusted baseline average catch rate to be used in the loss of catch calculation as set out in the draft Fisheries Management Agreement, including: ▪ Catch Disposal Record (CDR)s for Trap Vessels catch in the Timor Reef Fishery since 30 May 2014. ▪ Details and dates where changes in fishing gear or other events occurred. o Licensee meeting with Santos to allow us to resolve the baseline catch rate, outstanding issues in the draft Fisheries Management Agreement, as well as the amendments to the EP which may affect your interests. We suggest meeting in late November 2017. • Santos will pay [redacted] subject to the survey going ahead and a Fisheries Management Agreement being signed, within 30 days of the survey commencing.	Agreement proceeding individually with [redacted] Notification of change in survey area.
Department of Defence	DoD-19	31/10/2017	Santos email: Realise you are probably busy but just wanted to follow-up on this. Happy for you to give me a ring if it is easier to discuss.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-67	31/10/2017	Santos email 31/10/17: Tried to ring but missed you. Just following up after our last meeting on a couple of things. I have received the draft of the mapping of likely fish families within the survey area and was hoping to be able to get the trawl bycatch data that would be comparable to the survey area so I can start validating the types of fish that maybe present in the area. Also you were checking some of the calculations in the SAFE analysis of the data before you sent it through so I could then use to look at if I could use for assessing impacts. Can you let me know where you are at and when this would be available. Last is how are you going with the research scope? I am hoping you may have something in the next 2 weeks as I want to be able to go through the scope and costs with the Exploration Manager and VP so that we can think about costs and budgeting as we will need to get our joint ventures on board. NTPDPIRF email 1/11/17: Sorry [redacted] I've got it all lined up just need to ask one last question of [redacted] about the SAFE assessment and also to be courteous I'm just letting [redacted] know what we are giving you. Two weeks is a definite for the research scope, otherwise I think we'd be struggling to make it happen, I've given FRDC a heads up so they will be expecting an EOI. I just need to interact with [redacted] If you don't hear from me by lunchtime on Friday please give me a nudge because it just means other things are taking over! NTPDPIRF email 3/11/17: No need to nudge. [redacted] doesn't want me to provide you (Santos) the information below so Ill have to leave it to [redacted] to make a decision. Ill try and fast track this process to happen today. Ill keep you informed. Santos email 3/11/17: That's disappointing. I was under the impression that the by catch data was not confidential. We will wait and see what [redacted] decisions is. NTDPIRF email 3/11/17: Just awaiting one last approval but looks like everyone has left here for the day so sorry will have to wait until Monday.	Received Trawl trial by-catch species composition data for area of survey on 9/12/17. See NTDPIRF-68. Information utilised in EP Section 5.5.4 Fish to identify the types of fish species that may be present in the survey area. As at 19/12/2017 have not received research scope in regards to fish tagging seismic study to be undertaken for the Bethany survey.
Timor Reef and Demersal Relevant	TRD-153	27/10/2017	Phone call 24/10/2017: For the records: 0948 AEST 25/10/2017 Phone call with [redacted] - [redacted] wished to re-engage on engagement costs from 2017 Bethany. - I stated that as per our previous proposal we needed access to the catch data to progress any payment. - [redacted] said this would be agreeable to him. - I said I would re-issue paperwork. - This agreement would be between [redacted] and Santos, [redacted] and colleagues are not involved. [redacted] Follow up email 27/10/2017: [redacted] Thank you for your call on Wednesday. I've not been able to follow-up your request yet. I will be back in touch next week.	Agreement proceeding individually with [redacted]
Department of Environment and Energy	DoEE-3	24/10/2017	Santos email: I am currently putting this information together for you and will get to you within the next week. I have been asked by NOPSEMA to review the updated Guidance Note ï Activities within Commonwealth marine reserves which coincides well with undertaking this consultation with the DNP. DNP email: Thanks for letting us know, we look forward to your response and any comments you have on the draft updated Guidance Note.	Information provided as per DoEE-5.

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Timor Reef and Demersal Relevant	TRD-152 and attachment BK	24/10/2017	Santos email: [redacted] Thank you for your note of 23 October. We have the following answers to your questions: 1.Noise queries raised by [redacted] be answered. How have issues re risk assessment and SELcum modelling been addressed? As part of the resubmission of the EP, Santos is redoing the impact assessment in regards to impacts to fish from seismic noise. This consists of: ÅReviewing the threshold levels used for the assessment. ÅRebuilding the modelling taking into account the new survey area, as a number of the previous modelling locations are outside of the new survey area shape. ÅRecreating the risk and acceptability assessment. It would be useful to discuss the process we are going through and to clarify the SELcum issues as part of the assessment and remodelling. 2.Anticipated changes to the survey outline for 2018. Meeting not required for Santos to advise changes. Santos has revised the survey area to facilitate a more efficient survey. The area of seismic acquisition will now be 4363 km2 which is a 4.1% increase from the original area of 4190 km2. The new area has an overlap with TRF of 10.8% and the original shape was 11.4%. For the Demersal Fishery the new area overlap is 0.34% and the original was 0.22%. The map attached shows the new survey shape with the TRF and Demersal Fishery areas. As part of redoing the impact assessment, this new survey area will be used to determine the area of potential impact. 3. Timeline for activity. Meeting not required for Santos to advise changes. Santos proposes to undertake the survey within the June to end of September 2018 period. The survey duration of a maximum of 75 days has not changed. 4. Offer the opportunity to discuss relevant aspects of the revised EP. After we have time to consider how issues have been addressed per explanations above we would be happy to meet and both parties would have a good basis for discussion. As mentioned above we thought it would be a good opportunity to discuss how we are approaching the impact assessment in regards to impacts to fish from seismic noise while we are in the scoping/information gathering phase to enable feedback during the preparation of the updated EP. A meeting would also allow the opportunity to discuss and clarify the SELcum issues. The initial discussion could be undertaken via a phone and then followed up with a meeting if required. If you think this approach will help to move our discussion forward please propose some suitable dates for an initial phone call.	Response to TRD-51.
Department of Defence	DoD-18 and attachment BJ	23/10/2017	Santos email: Thanks for the further information. I have some further questions and information below. In your email on the 12th October you said that the "nominated survey area is expected to encroach on the Due Regard Area (DRA) established for the exercise" Would you be able to confirm that the Bethany survey area shown in the attached map would encroach on the DRA? I realised that the map I sent you had a bigger red dashed outline delineating the AMBA (Area that maybe affected). However, the outline in the attached map is are where the vessels will be operating within. Are we able to get a map or shape file of the DRA so we can understand the area of overlap? Could you let me know what the issues are from the seismic survey that would potentially impact on the exercise? Santos is also looking at the feasibility of undertaking a seismic survey (within the red outline on the attached map) prior to the Bethany survey. This survey area is within the Northern Prawn Fishery trawl area and hence it is likely that we could only do the survey during their closed season of 15 June – 1 Aug. This survey would take approximately 3 – 4 weeks (~ 15 July). We would then commence the Bethany survey which could take up to 75 days (~ 28 Sept). As per the timeline below, for the Bethany survey we have been requested to avoid the tropical fish and pearl oyster spawning seasons which are from Oct. Hence, we have a number of restrictions in regards to our timing which we need to manage. Once we understand the area of overlap and potential impacts may I suggest we have a phone hook-up to look at how we can minimise the impact to each other's activities.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)

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Timor Reef and Demersal Relevant	TRD-151	23/10/2017	[redacted] email: Hi [redacted] We are really seeing major flaws in this process. Ask a question, get no answer and move on with what appears to be a tick and flick program. Whilst we are more than happy to have another meeting, we recommend the following cause to ensure time/money is not wasted. 1.Noise queries raised by [redacted] be answered. How have issues re risk assessment and SELcum modelling been addressed? 2.Anticipated changes to the survey outline for 2018. Meeting not required for Santos to advise changes. 3. Timeline for activity Meeting not required for Santos to provide timeline. 4. Offer the opportunity to discuss relevant aspects of the revised EP. After we have time to consider how issues have been addressed per explanations above we would be happy to meet and both parties would have a good basis for discussion.	Concerns raised regarding SELcum are addressed via response TRD-112 and TRD-130. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiverǿs accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a ǵresettingǿ of SELcum to zero after 24-hours is based on the best information available at present. Anticipated changes and timeline are detailed in TRD-152.
Timor Reef and Demersal Relevant	TRD-150	20/10/2017	Santos email: [redacted] Further to our previous note of 18 September, Santos asks that we schedule a meeting between Santos, yourself, [redacted] [redacted] & [redacted] to discuss the Bethany survey in 2018. Can I suggest 1 or 2 November? We can meet in Darwin, Adelaide or like last December in Melbourne if that is more convenient. Santos has been working hard with our Joint Venture partners on a revision to the Bethany EP. We expect re-submission in early December. The topics we want to discuss in the meeting are: 1) Noise queries raised by [redacted] 2) Anticipated changes to the survey outline for 2018. 3) Timeline for activity 4) Offer the opportunity to discuss relevant aspects of the revised EP. Please advise if these dates are convenient and what items you would like to add to the meeting agenda. Kind regards, [redacted]	As concerns in regards to SELcum have not been able to be addressed to the satisfaction of the stakeholder it was thought it was appropriate to provide a noise expert to work through the issues with [redacted] prior to recommencing the modelling and updating the EP.
Department of Defence	DoD-16 and attachment BI	17/10/2017	Santos email: Thank you for your reply. We are currently looking at our scheduling so this information is pertinent at this time. Would you be able to share where the Northern Australian Exercise Area (NAXA) is. The information we have in regards to defence areas is attached and I want to ensure we have the correct areas. Once we have looked at our scheduling I will get back to you. Would you also be able to let me know if there are any other exercises planned in this area in the next 2 - 3 years.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)
Department of Defence	DoD-17	17/10/2017	DoD email: I can confirm that the two red hatched areas on the attached map are consistent with the Northern Australian Exercise Area (NAXA). I will have to get back to you regarding your query about future exercises in the NAXA.	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26)

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Department of Defence	DoD-15	12/10/2017	DoD email: Thank you for your email of 15 September 2017, advising that Santos is planning to undertake a marine seismic survey during June ï September 2018. After reviewing the information provided, Defence would like to advise that it has concerns regarding the location and timing of the proposed survey activities. The proposed location and timing of the survey will conflict with a major military exercise, Exercise KAKADU 2018, which will be conducted within the Northern Australian Exercise Area (NAXA) over the period 31 August ï 15 September 2018. The exercise would be severely impacted by the Bethany Seismic Survey under the proposed schedule. The nominated survey area is expected to encroach on the Due Regard Area (DRA) established for the exercise. This DRA is necessary to provide a suitable area with sufficient water depth to conduct required operations during the exercise. This requirement cannot be met elsewhere within the surrounding area. Defence has experienced issues previously with a seismic survey compromising Defenceõs ability to operate for the entire duration of an exercise in 2016. Defence proposes that the Santos Bethany Seismic Survey be brought forward such that it is completed no later than 30 August 2018. This would be of mutual benefit to both industry and Defence by removing any possibility of unintended impacts on each otherõs activities. Alternatively, postponing the surveyõs commencement to 16 September 2018 would also achieve this aim. Defence would also like to ensure that Santos has the appropriate contact details, in order to facilitate any required de-confliction. Please ensure that the following are contacted prior to the commencement of any activities: [redacted] If you have any further queries, please donõt hesitate to contact me directly or email [redacted]	Notification of Exercise Kakadu 2018 potentially within the survey area. Ongoing engagement to clarify areas of overlap (DOD-16 - DoD-26) EP Section 4.1 Ongoing Consultation updated to notify: [redacted] a minimum of 3 weeks prior to commencement of activities and Department of Defence [redacted] of any updates and commencement of activity.
Eni Australia Limited	ENI-5 and attachment BF	10/10/2017	Santos email: I am trying to determine who is likely to be undertaking any seismic surveys in the Bonaparte Gulf in the next few years. Santos has rescheduled its Bethany survey over NT/P82 and NT/P85 to mid 2018/2019. We need to know of any surveys to be able to assess cumulative impacts in the region. Would you be able to let me know if ENI is planning any seismic surveys in the next few years in any of their permits in this area?	Provision of information to determine level of activity within permits in 2018/2019. No response
Inpex	IN-3 and attachment BF	10/10/2017	Santos email: Santos had to rescheduled its Bethany survey over NT/P82 and NT/P85 to mid 2018/2019, as we couldnõt get our EP accepted by NOPSEMA in time. I am trying to determine who is likely to be undertaking any seismic surveys in the Bonaparte Gulf in the next few years as we need to assess cumulative impacts as part of the EP. Would you be able to let me know if Inpex is planning any seismic surveys in the next few years in any of their permits in this area? Inpex email: We donõt operate any exploration permits in the area!	Section 5.6.5 Oil and Gas Activities updated to include information in regards to Inpex not undertaking any activities in Masela Permit.
Shell Australia	SA-3 and attachment BF	10/10/2017	Santos email: Santos had to rescheduled its Bethany survey over NT/P82 and NT/P85 to mid 2018/2019, as we couldnõt get our EP accepted by NOPSEMA in time. I am trying to determine who is likely to be undertaking any seismic surveys in the Bonaparte Gulf in the next few years as we need to assess cumulative impacts as part of the EP. Would you be able to let me know if Shell is planning any seismic surveys in the next few years in any of their permits in this area?	Section 5.6.5 Oil and Gas Activities update to include information in regards to Shell not undertaking any activities in NT/RL7 in 2018 or 2019.
Shell Australia	SA-3 and attachment BF	10/10/2017	Shell email: We donõt have any plans to add to the cumulative effects of your seismic surveys. Cheers	Section 5.6.5 Oil and Gas Activities update to include information in regards to Shell not undertaking any activities in NT/RL7 in 2018 or 2019.

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Department of Environment and Energy	DoEE-2 Part 1	9/10/2017	DNP email: Thank you for seeking clarification on the Director of National Parkôs (DNP) expectations for consultation on environment plans (EPs). We are currently working with NOPSEMA to update the NOPSEMA Guidance Note ï Activities within Commonwealth marine reserves (N-04750-GN 1565) to provide more clarity on consultation requirements with the DNP. I am hopeful that this will be available within the next month or two. I apologise that this guidance was not available at the same time as the recently updated Australian Government Guidance to include the DNP as a relevant person. Transitional management arrangements: The DNP has issued a general approval under section 359B of the EPBC Act that allows a range of activities, including mining operations, in marine reserves that were proclaimed in 2012 (including the Oceanic Shoals CMR). These approvals do not replace the need for titleholders to have an approved EP from NOPSEMA. Titleholders should consider the proposed petroleum activity taking into account the relevant marine reserve context. For new CMRs (i.e. those proclaimed after 2012, including the Oceanic Shoals), titleholders are expected to consider the impacts and risks of activities in the context of the known reserve conservation values and Australian IUCN reserve management principles. Outcomes: The DNP expects that EPs will describe how the petroleum activity will be managed to ensure the following outcomes are achieved: a) Impacts and risks will be managed to an acceptable level. In defining the acceptable level(s), the relevant zone objectives, reserve values and Australian IUCN reserve management principles should be considered. b) Impacts and risks on reserve values will be managed to as low as reasonably practicable (ALARP). In demonstrating how impacts will be managed to reduce to ALARP, consideration should be given to identifying and evaluating alternative, additional and improved control measures that may further reduce impacts and risks. c) There are appropriate measures in place to ensure the DNP will be kept informed during implementation of the activity. Specific information requirements: In addition to the information you have already provided below (including title numbers, map, company name etc.), the DNP considers sufficient information for the purpose of initiating consultation to be: ÅActivity overview including; type of activity (e.g. 2D or 3D survey, drilling, pipeline construction and/or operation, decommissioning etc.), expected start and completion date of activities that overlap a marine reserve. ÅA brief description of any planned aspects of the activity within or that may impact on the values of a CMR (e.g. drilling cuttings and fluids discharges, produced formation water discharges, noise emissions) ÅDemonstration of how the above outcomes (a, b & c) have been achieved ÅSpecifically for unplanned environmental incidents (mainly well or pipeline leaks): names of which reserves are likely to be impacted by an emergency incident, description of the risks to reserves and management responses planned in reserves.	Information provided as per DoEE-5. EP Section 4.1 Ongoing Consultation updated to include providing DNP with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.

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Department of Environment and Energy	DoEE-2 Part 2	9/10/2017	DNP email: Emergency responses: By way of background, the DNP has put in place a general approval to enable emergency response activities to occur within marine reserves proclaimed prior to 2012. It provides for titleholders to undertake required actions to respond to oil pollution incidents, including environmental monitoring and remediation, provided that the activities are taken in accordance with: •the Offshore Petroleum and Greenhouse Gas Storage Act 2006, Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009, and the oil pollution emergency plan contained within the approved environment plan; and •Other applicable Commonwealth and State laws. The DNP should be made aware of oil spills which occur within marine reserves or are likely to impact on a reserve as soon as possible. This function can be fulfilled through notification to the Marine Reserve Compliance Duty Officer [redacted]. The notification should include: •titleholder details •time and location of the incident •proposed response arrangements as per the OPEP (e.g. dispersant, containment, etc.) •contact details for the response coordinator. Please don't hesitate to contact [redacted]u if you have any further questions.	Information provided as per DoEE-5. EP Section 8.7 Incident Reporting updated to include: DNP must be notified as soon as possible of a vessel based oil spill incident within the Oceanic Shoals Marine Reserve. Notification should include: •Titleholder details •Time and location of the incident •Proposed response strategies as per OPEP •Contact details for the response. Marine Reserve Compliance Duty Officer Telephone: [redacted]
Department of Environment and Energy	DoEE-1 and attachment BH	5/10/2017	Santos email: Santos is proposing to undertake the Bethany Seismic Survey over two permit areas (NT/P85 and NT/P82) which are within the Oceanic Shoals Commonwealth Marine Reserve. See attached map for location. The Bethany 3D Seismic Survey Environment Plan is currently being assessed by NOPSEMA with the plan to commence the survey in June 2018. As per the recently updated Australian Government Guidance – Consultation with Commonwealth Agencies with Responsibilities in the Commonwealth Marine Area, Santos is contacting the Director of National Parks (DNP) as a relevant agency to obtain information on the DNP's expectations for consultation.	The Australian Government Guidance Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area was updated in October 2017 and under this guidance the DNP is a relevant stakeholder as the Bethany survey is within the Oceanic Shoals Marine Reserve. EP Section 4 Consultation updated to include DNP as a relevant stakeholder.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-66 and attachment BG	5/10/2017	Santos email: Thanks for the 2015 status report. I have attached the new Bethany survey shape which I am calling Bethany4363 to avoid confusion. The operational area will stay the same.	Shape files for new survey area sent as per NTDPIRF-65 28/9/2017.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-65	28/09/2017	NTDPIRF email: I'm still drafting the 2016 status report as had to get a few other things off my desk. Please see the link below to all of our status reports including 2015. Ill try and get approval to flick you our offshore snapper ERA asap. When you get back could you please forward me the shape files for the new survey area? I assume the operational area is the same?	Shape files for new survey area sent NTDPIRF-66 5/10/2017. Operational area the same.
Timor Reef and Demersal Relevant	TRD-149	22/09/2017	[redacted] email: Hi [redacted] We are happy to look at meeting with Santos but very conscious of cost. We are trying to work out what benefit Santos believes meeting with a noise expert will achieve. We have no problem with modelling provided to date however we are seeking urgent clarity as to why [redacted] queries cannot be satisfied in particular, SELcum at greater time frames.	As concerns in regards to SELcum have not been able to be addressed to the satisfaction of the stakeholder it was thought it was appropriate to provide a noise expert to work through the issues with [redacted] prior to recommencing the modelling and updating the EP.
Timor Reef and Demersal Relevant	TRD-148	18/09/2017	Santos email: [redacted] To follow-up on this message and our recent discussions. We have engaged a noise expert to review your concerns. We want to meet with you to discuss: 1) This issue 2) Anticipated changes to the survey outline for 2018. 3) Timeline for activity & resubmission of the EP. In my last call, [redacted] took an action to suggest a suitable time and place to re-open discussions between both parties. We look forward to hearing from you. Regards, [redacted]	As concerns in regards to SELcum have not been able to be addressed to the satisfaction of the stakeholder it was thought it was appropriate to provide a noise expert to work through the issues with [redacted] prior to recommencing the modelling and updating the EP.

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Amateur Fishermenӳ Association of the NT (AFANT)	AFANT-25 and attachments BF and E	15/09/2017	Santos email: Dear Stakeholder Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing AFANT with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Aquarium Fishery	AQ-23 and attachments BF and E	15/09/2017	Santos email: Dear Stakeholder Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing Aquarium Fishery Chair of the Licensee Committee with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
ConocoPhillips	CoP-16 and attachments BF and E	15/09/2017	Santos email: Dear Stakeholder Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing CoP with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Department of Defence	DoD-14 and attachments BF and E	15/09/2017	Santos email: Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area.

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Northern Prawn Fishery	NPF-32 and attachment BF and E	15/09/2017	Santos email: Dear Stakeholder Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing NPF with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Northern Territory Seafood Council	NTSC-20 and attachments BF and E	15/09/2017	Santos email: Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing NTSC with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
NT Department of Primary Industry and Resources	NTDPIR-12 and attachments BF and E	15/09/2017	Santos email: Dear Stakeholder Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details notifying NT Department of Primary Industry and Resources 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
Pearl Producers Association	PPA-21 and attachments BF and E	15/09/2017	Santos email: Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. No reply. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing PPA with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.

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Spanish Mackerel	NTFSM-20 and attachments BF and E	15/09/2017	Santos email: Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing Spanish Mackerel Licensee with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Spanish Mackerel	SMF-17 and attachments BF and E	15/09/2017	Santos email: Further to our email of 11 July 2017 (advising of our decision not to proceed with the Bethany seismic survey at that time), we wish to advise that planning is now underway for survey to go-ahead next year (2018), within the June to end of September period. We plan to submit a revised Environment Plan (EP) for the survey to the offshore petroleum regulator, NOPSEMA, in early November this year (2017). Once Santos has an accepted EP, contracting for a seismic vessel will commence. The revised EP to be submitted includes a change in the survey area where the seismic acquisition will occur (first attachment). This change increases the survey area by 4.1% from the original, from 4190km2 to 4363km2. The revised survey area is within the existing broader operational area which was used to undertake the impact assessment for the survey. A review of the impacts and risks as detailed in Information Sheet 2 (second attachment) sent to you on 23 January 2017 has not identified any new or changed impacts or risks. If you would like any further information in regards to the proposed survey, please feel free to contact us.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing Spanish Mackerel Licensee Committee Chair with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-64 Part 1	14/09/2017	Santos email: Santos Bethany Seismic Survey - NTDPIR Fisheries 7 Sept Meeting Notes Thank you for your time to go through were we are at with the Santos Bethany Seismic Survey and the way forward working with the Department. It was good to be able to work through the issues. I have attached the slide pack we presented with notes and actions below: ÅSantos plan to resubmit the Bethany Seismic Survey Environment Plan to NOPSEMA in early November 2017. ÅThe aim is to undertake the survey, which will take a maximum of 75 days, between June to 30 September 2018. ÅThe timing for the survey has been chosen to avoid peak tropical fish spawning periods. ÅThe area where the seismic acquisition will be undertaken has changed slightly for technical reasons and covers an area of 4363 km2 compared to the previous area of 4190 km2. ÅThe new survey area shape does not change the area of overlap with the NT Fisheries. ÅPearl Oyster Shell Fishery ï the Department advised that it was an area for brood stock but confirmed that there had been no activity since 2008. The Department would not know of any planned future activity. ÅTrawl trial ï trial will finish end of 2017. A submission on whether it becomes an ongoing activity will be put to the Minister and take some months. ÅTrawl trial ï Department obtained by-catch data by species. ÅDepartment acknowledge that survey area is within a multi-use area. Concerns are more to do with long term impacts on the TRF from cumulative seismic surveys rather than one of surveys. Can we identify future seismic programs over next 5 years? ÅIn regards to Conoco seismic survey, catch data dropped for a month but impacts from individual surveys hard to identify due to natural variation in catch rates. ÅDiscussed the need to be able to determine how to measure seismic impacts. ÅDiscussed research options and agreed to meet to workshop the questions we are trying to answer and what would be appropriate research projects. ÅSantos provided details of the loss of catch and relocation expenses payments committed to in the EP.	Recommencement of engagement via meeting to discuss Santos planning to undertake the Bethany survey within June to end of September 2018 and that they survey area has increased by 4.1% from the original, from 4190km2 to 4363km2.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-64 Part 2	14/09/2017	Actions Department: Send to Santos: 2015 NT State of Fisheries and 2016 draft report data for TRF. Trawl trial by-catch species composition data for area of survey to be able to build species list for area. Any information able to share in regards to assessment of trawl trial impacts within Oceanic Shoals Marine Reserve. Fisheries impact assessment process ï Done. [redacted] to liaise with AIMS to gain details on fish tagging seismic study to discuss at Santos/Dept. workshop. Actions Santos: Identify potential seismic surveys in the Joseph Bonaparte Gulf within the next 3-5 years. Set up workshop meeting for [redacted] and [redacted] to review; potential impacts to fisheries, how to assess impacts, how to determine level of impact from survey and review research options. ï Done. Booked for 12 Oct in Darwin. [redacted] to let AIMS know Santos working with the Department to look at research options during the Bethany survey and [redacted] will be the contact with AIMS. Done. Spoke to [redacted] on Friday 8 Sept.	Recommencement of engagement via meeting to discuss Santos planning to undertake the Bethany survey within June to end of September 2018 and that they survey area has increased by 4.1% from the original, from 4190km2 to 4363km2. Action Status 19/12/2017 Dept.: Received 2015 Status of Key NT Fish Stock Report. 2016 report not yet available. See NTDPIRF-65. Information in Bethany EP updated to reflect 2015 report information. Received Trawl trial by-catch species composition data for area of survey. See NTDPIRF-68. Information utilised in EP Section 5.5.4 Fish to identify the types of fish species that may be present in the survey area. No information was able to be shared in regards to assessment of trawl trial impacts within Oceanic Shoals Marine Reserve. Received Fisheries impact assessment process for information. NTDPIRF liaising with AIMS to develop scope for fish tagging seismic study to be undertaken for the Bethany survey. Santos/Dept. workshop held 12 Oct 17 in Darwin. Santos: Maps showing historic and potential seismic surveys in the Joseph Bonaparte Gulf within the next 3-5 years provided to NTDPIRF at workshop in 12 Oct 17. Bethany EP section 7.1.5.8 Cumulative Impacts covers past and future seismic surveys. Workshop meeting for [redacted] and [redacted] to review; potential impacts to fisheries, how to assess impacts, how to determine level of impact from survey and review research options held 12 Oct 17 in Darwin. [redacted] let AIMS know Santos working with the Department to look at research options during the Bethany survey.
Timor Reef and Demersal Relevant	TRD-147	12/09/2017	[redacted] As SANTOS now intends to carryout the proposed survey in 2018 can you please now respond to my previous emails in relation to to the SELcum metrics. It would be greatly appreciated if firstly you could address the expected recovery times requested in my email of 7 July 2017. I was more than a little surprised to see that your last EP didnt address or even acknowledge any of the concerns we had raised. Can you let me know when you might be able to provide this information?	Concerns raised regarding SELcum are addressed via response TRD-112 and TRD-130. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiverôs accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a óresettingô of SELcum to zero after 24-hours is based on the best information available at present.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-146	4/09/2017	Notes from [redacted] call with [redacted] 04/09/2017: Aim to re-start conversation post-TCMs. As always, a good tone to the conversation. Fishers position: - [redacted] remains frustrated with our position re: costs incurred so far. Needed some ‘good faith’ to proceed further. - Fishers concerned about the amount of time this will now take. - Not against survey or oil and gas industry - Concerned how any catch data, if released, will be used in our EP - Wanted answer to [redacted] technical questions. Our position: - I re-stated on several occasions that to move forward we need to see the data (where, how, when, how much they fish the area) - With that disclosure we can understand venture exposure - Confidential means, confidential. Data disclosed for the purposes of make-good will only be used for that purpose. - When the fishers agree to the CA and data disclosure we can make a consultation costs payment - If required we can bring technical specialists in to support the conversation between [redacted] and ourselves. [redacted] agreed to: - Talk to the licensees about the CA & data release as a way to move forward. - Propose a date when we can all meet again. [redacted] & [redacted] – I think you are going to Darwin soon, what are those dates? I will follow up with [redacted] again in a week or so.	Ongoing consultation in regards to engagement costs and confidentiality agreement. Concerns raised regarding SELcum are addressed via response TRD-112 and TRD-130. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver’s accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a ‘resetting’ of SELcum to zero after 24-hours is based on the best information available at present.
Timor Reef and Demersal Relevant	TRD-145	21/08/2017	Email from Santos 21.08.17: By way of information, we are holding Management Committees for the Bethany Joint Ventures next week. I will call you during w/c 4th September to discuss the observations below and the way forward. Regards, [redacted] [redacted] email 21.08.17: I am glad to see this is moving forward but we seem to have gone from small rocks to boulders in our paths. Engagement costs were to cover costs incurred by industry to ensure that they understood the impacts of your proposal – both environmental and legal. Industry has expended funds accordingly. What you are now proposing is linking the success of your applications to NOPSEMA with the costs you are prepared to pay stakeholders for engagement. Discussions over the past week illustrates to me how quickly good faith erodes when principal understandings change. I will continue discussing your requests below but once bitten twice shy. Can you now please arrange for previous emails to be answered, particularly between [redacted] and [redacted] Also, please provide report by [redacted] CSIRO) referred to in the last EP you provided industry in June. In addition, I do not believe you attached a table as advised, please provide.	Ongoing consultation in regards to engagement costs. Concerns raised regarding SELcum are addressed via response TRD-112 and TRD-130. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver’s accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a ‘resetting’ of SELcum to zero after 24-hours is based on the best information available at present.

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Timor Reef and Demersal Relevant	TRD-144 and attachments BD & BE	14/08/2017	Santos email 14.08.17: Apologies for the delay in responding, Iǿve been discussing the consultation fees with my management, and in the meantime Santos has been given an opportunity to amend and re-submit the EP. We therefore now propose to carry out the survey in the same survey time frame in 2018/19, subject to the EP being approved and the support of our joint venture partners. In light of this, we propose the following way forward: ÅSantos will pay [redacted] for its reasonable consultation costs to date, subject to completion of each and all of the following to ensure future consultation is efficient and effective: o The Licensees to provide an executed copy of the Confidentiality Agreement (attached) to preserve the confidentiality of the Licenseeǿs data (reasonable amendments will be considered) o The Licensees providing all the data necessary to enable us to meet and calculate, or agree a formula for, the adjusted baseline average catch rate to be used in the loss of catch calculation as set out in the draft Fisheries Management Agreement, including: Ä Catch Disposal Record (CDR)s for Trap Vessels catch in the Timor Reef Fishery since 30 May 2014. Ä Catch Disposal Records (CDR)s for Trawl Vessel catch in the Timor Reef Fishery since 1 August 2015. Ä Details and dates where changes in fishing gear or other events occurred. o Licensees meeting with Santos to allow us to resolve the baseline catch rate, outstanding issues in the draft Fisheries Management Agreement (a table showing the history and positions up to 30 June is attached), as well as the amendments to the EP which may affect your interests. We suggest meeting in mid-September and mid-October 2017. ÅSantos will pay [redacted] subject to the EP being approved and the survey going ahead, within 30 days of the survey commencing.	Response to consultation costs emails (TRD-141, 142, 143).
Timor Reef and Demersal Relevant	TRD-143 and attachment AS	4/08/2017	[redacted] email 04.0817: Given Santos is not proceeding with the Bethany Survey at this time, per your and other emails from Santos, we request that the engagement costs for the work conducted to date be finalised. When you plan to re-commence your consultation, please advise to ensure that stakeholders have sufficient resources available to ensure time is allocated to consider your revised plans. We request that Santos please arrange for the invoice previously provided be paid (copy attached).	Response in regards to consultation costs provided in TRD-144.
Timor Reef and Demersal Relevant	TRD-142 - Phone summary	18/07/2017	[redacted] spoke to [redacted] at 13.14 18.07.17:. Subjects discussed: 1) Invoice for costs incurred: Santos reviewing payment request with management. 2) [redacted] indicated he had contacted NOPSEMA 3) Calling for information 4) The decision not to proceed was not the outcome he was expecting 5) The Fishers desire to come to an agreement and do not want to stop engagement and pick it up again in a year. 6) The separate agreement prepared for [redacted] did not mean he had diverged from the other fishers. [redacted] summary from 26.07.2017 - Thank you for your time last week on the telephone. It was good to get some understanding of Santosǿs position on the Bethany survey proposal. We now need to look at how to move this forward. Firstly, we need have more understanding of why the EP requires further modification ï We request - Could you please provide a copy of the last EP and add it to the dropbox as we do not have a copy. - Details of NOPSEMA decision that are not publicly available clarifying the items that need to be attended too. Secondly, please advise when Santos is planning to lodge an amended EP. Lastly, please answer my emails regarding engagement costs. As I am sure you understand communication is the only thing that ensures the unknown does not lead to anger. I would have thought this is straight forward but please respond. Santos reply 26.07.2017 - Santos is reviewing the EP feedback, the request for engagement costs and our go-forward options. I will be in touch when those reviews are complete.	Response in regards to consultation costs provided in TRD-144.

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ConocoPhillips	CoP-15	17/07/2017	CoP email: ConocoPhillips wishes to advise the completion of the two-well appraisal drilling campaign within Petroleum Retention Lease Area NT/RL5, located in the Bonaparte Basin about 300 kilometres offshore of Darwin, Northern Territory. Further to the last update, provided 30 June 2017, all activities at the location of the second and final well, Barossa-6, have now been completed. The Atwood Osprey Mobile Offshore Drilling Unit (MODU), accompanied by support vessels Far Sirius and Far Saracen, is currently exiting the permit area. Other marine users that may be in the vicinity, please continue referring to the automatic broadcasts provided via the Navtex system. The co-ordinates of the Barossa-6 well are: Latitude 9Á47' 38.44341" S Longitude 130Á11' 19.83649"E ConocoPhillips would like to thank all fellow users of the marine environment for their co-operation during the appraisal drilling period. Further detail of the activity is available at http://www.conocophillips.com.au/our-business-activities/our-projects/Pages/caldita-barossa.aspx. A summary of the accepted Environment Plan is available at https://www.nopsema.gov.au/environmental-management/activity-status-and-summaries/details/373	CoP drilling campaign completed. EP Section 5.6.5 Oil and Gas Activities updated to show that appraisal drilling campaign completed in 2017.
Timor Reef and Demersal Relevant	TRD-141	14/07/2017	[redacted] email: I admit your email was quite a surprise. Obviously, it is not the result either party was anticipating. Could you please advise the status of our invoice for the agreed engagement costs as despite the current outcome these are costs we have already incurred. We note from our last correspondence that this issue was being considered separately.	Response in regards to consultation costs provided in TRD-144.
Timor Reef and Demersal Relevant	TRD-140	13/07/2017	Santos email: The risk rating is based on mortality is considered unlikely, with a number of peer reviewed literature to date reporting no evidence of direct mortality of fish as a result of seismic survey activity at levels above the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 εPa (PK) i.e. Wardle et al. (2001), Santulli et al. (1999), McCauley and Salgado Kent (2007) and Popper et al. 2014. Thus, using the consequence classification in Table 6-3 of the EP, the impact was seen as localised and short term as mortality impacts not predicted. Santos is not progressing with the Bethany Seismic Survey at this stage. We will re-engage with stakeholders including yourself once we have a forward plan.	Response to query from TRD-138.
AMOSC	AMOSC-4	12/07/2017	Please note that the Santos Fishburn Seismic Survey has been completed and the vessels have left the operational area. Santos will not be progressing with the Bethany Seismic Survey at this time. Could you please update your records. Thanks for your support.	For information that Bethany survey will not go ahead at this time. EP Section 4.1 Ongoing Consultation details providing AMOSC a copy of the OPEP once accepted and notify of when survey starts and finishes.
AMSA	AMSA-4	12/07/2017	Please note that the Santos Fishburn 3D seismic survey has now completed, and the vessels, Polarcus Naila and support vessels, have left the area of operation. Also, please note that the follow on Bethany 3D seismic survey (subject of email to you 25/06/2017) has been cancelled and will not be proceeding, so please disregard that previous notice. Please do not hesitate to contact me should you require any additional information	Notification that the Bethany survey will not proceed at this time. EP Section 4.1 Ongoing Consultation details notify AMSA a minimum of 3 weeks prior to commencement of activities.
Australian Hydrographic Service (AHS)	AHS-3	12/07/2017	Santos email: Please note that the Santos Fishburn 3D seismic survey has now completed, and the vessels, Polarcus Naila and support vessels, have left the area of operation. Also, please note that the follow on Bethany 3D seismic survey (subject of email to you 25/06/2017) has been cancelled and will not be proceeding, so please disregard that previous notice. Please do not hesitate to contact me should you require any additional information	Notification that the Bethany survey will not proceed at this time. EP Section 4.1 Ongoing Consultation details notify AHS a minimum of 3 weeks prior to commencement of activities.
Department of Defence	DoD-13	12/07/2017	Santos email: Please note that the Santos Fishburn 3D seismic survey has now completed, and the vessels, Polarcus Naila and support vessels, have left the area of operation. Also, please note that the follow on Bethany 3D seismic survey (subject of email to you 25/06/2017) has been cancelled and will not be proceeding, so please disregard that previous notice. Please do not hesitate to contact me should you require any additional information	Notification that the Bethany survey will not proceed at this time.

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Northern Prawn Fishery	NPF-31 and attachment BA	12/07/2017	Santos email: Hope things are going well for you both. [redacted] is away but wanted to let you know that we finished the Fishburn Seismic Survey and the vessels have left the operational area early this morning. The survey went well and we a couple of shut downs for some whales in the area. At this stage we wonþ be progressing with the Bethany Seismic survey as NOPSEMA have informed us that they cannot accept the EP within the timeframe we require. We will get a notice from them next Monday as to what our options are. Once we have a plan we will let you know. Did you have a chance to look at the plankton information [redacted] sent through? CSIRO have done some work on the implications of the plankton study (attached). A summary of their findings is below: CSIRO developed a model to look at the predicted impacts within the survey area and in the broader bioregion. The model showed that the impact of the seismic survey on zooplankton biomass was greatest in the Survey Region (22% of the zooplankton biomass was removed) and declines as one moves beyond it to the Survey Region + 15 km with no discernible effect on the entire Northwest Shelf Bioregion. The time to recovery (to 95% of the original level) for the Survey Region and Survey Region + 15 km recovery was 39 days (38-42 days) after the start of the survey and 3 days (2-6 days) after the end of the survey. Zooplankton populations recovered quickly after seismic exposure due to their fast growth rates, and the dispersal and mixing of zooplankton from both inside and outside of the impacted region. If you or your members want any further information from us or CSIRO just let us know.	For information update on the Fishburn and Bethany seismic surveys. Provision of information in regards to CSIRO on plankton and offer if further information required. No reply.
PGS	PGS-8	12/07/2017	Santos email: Just to let you know that the Santos Fishburn WA-459-P Seismic Survey finished today and all vessels have left the operational area. As discussed, at this stage we wonþ be progressing with the Bethany Seismic survey as NOPSEMA have informed us that they cannot accept the EP within the timeframe we require.	Provision of information. EP Section 4.1 Ongoing Consultation details providing PGS with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Amateur Fishermenõs Association of the NT (AFANT)	AFANT-24	11/07/2017	Santos notification that Bethany survey not going ahead at this time. Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time.
Aquarium Fishery	AQ-22	11/07/2017	Dear Stakeholder Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time.
ConocoPhillips	CoP-14	11/07/2017	Dear Stakeholder Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Provision of information. Notification of survey going ahead in 2018 and change in survey area. No reply. EP Section 4.1 Ongoing Consultation details providing CoP with ongoing information regarding the Bethany survey such as when/if EP accepted, start date (2 weeks in advance of starting), cessation date and when operating, provision of a daily report unless advised they have no need for this information.
Department of Defence	DoD-12	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Notification that the Bethany survey will not proceed at this time.
Northern Prawn Fishery	NPF-30	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time. No reply.

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Northern Territory Seafood Council	NTSC-19	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time. No reply.
NT Department of Primary Industry and Resources	NTDPIR-11	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time. No reply.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-63	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Notification that the Bethany survey will not proceed at this time.
Pearl Producers Association	PPA-20	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time. No reply.
PGS	PGS-7	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time.
Spanish Mackerel	NTFSM-19	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time.
Spanish Mackerel	SMF-16	11/07/2017	Santos email: Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the Environment Plan. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	Santos notification that Bethany survey not going ahead at this time.
Timor Reef and Demersal Relevant	TRD-139	11/07/2017	Santos email: I am writing to inform you that Santos has decided not to proceed with the Bethany survey at this time based on advice from NOPSEMA that they are going to refuse to accept the EP. We thank you for your time in undertaking consultation for the Bethany survey and will re-engage with you if the Bethany survey goes ahead at another time.	For information that Bethany survey will not go ahead at this time.
ConocoPhillips	CoP-13 and attachments AL, AX, AY and AZ	10/07/2017	CoP email: Thank you for the update email. I would appreciate if you could also send the daily reports to the following: Å[redacted] The ConocoPhillips Barossa Bathymetry and Environmental Survey is being undertaken at the same time as the Bethany Survey. Mobilisation begins on 17th July and the campaign may run into the first week of August. Iǿve attached details of the overlap between Bethany and Barossa surveys (ARC-170013.pdf), based on coordinates provided by [redacted] 26th June. It would be useful to have a copy of the Bethany line plan so that we can determine which region you are referring to in daily reports. Alternatively you could quote general Easting/Northing ranges on the 72hr look ahead. I have also attached the contact details of the Bhagwan Marine Lauri J, which has been chartered by Fugro for the survey. Fugro will phone/email the Bethany Polarcus Naila to provide notification of the [redacted]s approach to the SIMOPS area. Please let me know if you require any further information.	See CoP-14 as Bethany survey did not go ahead so no overlap.
Timor Reef and Demersal Relevant	TRD-138	10/07/2017	[redacted] email: I have reviewed the changes to EP regarding fish and the large reduction in risk ratings seems inconsistent. For the potential impacts of Mortality and Injury leading to mortality can you outline how the duration of these potential impacts was revised down from greater than twelve months to weeks?	Response detailed in TRD-140. The risk rating is based on mortality is considered unlikely, with a number of peer reviewed literature to date reporting no evidence of direct mortality of fish as a result of seismic survey activity at levels above the mortality, potential mortal injury and recoverable injury to fish threshold of 207 dB re 1 εPa (PK) i.e. Wardle et al. (2001), Santulli et al. (1999), McCauley and Salgado Kent (2007) and Popper et al. 2014. Thus, using the consequence classification in Table 6-3 of the EP, the impact was seen as localised and short term as mortality impacts not predicted.

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Amateur Fishermenõs Association of the NT (AFANT)	AFANT-23	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyõs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Aquarium Fishery	AQ-21	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyõs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
ConocoPhillips	CoP-11	7/07/2017	ConocoPhillips wishes to provide the following update on the appraisal drilling campaign currently being undertaken within Petroleum Retention Lease Area NT/RL5, located in the Bonaparte Basin about 300 kilometres offshore of Darwin, Northern Territory. Further to the last update, provided 30 March 2017, please be advised that drilling of the second and final well, Barossa-6, is nearing completion. We currently anticipate that the Atwood Osprey Mobile Offshore Drilling Unit (MODU), accompanied by support vessels Far Sirius and Far Saracen, will commence exiting the permit area between the 15th and 18th of July 2017. Other marine users that may be in the vicinity, please continue referring to the automatic broadcasts provided via the Navtex system. The co-ordinates of the Barossa-6 well are: Latitude 9Å47' 38.44341" S Longitude 130Å11' 19.83649"E It is recommended that other vessels continue to remain well clear of the MODU during the drilling campaign. The drilling operational area is based on a circle with a 1,500 metre radius around the MODU when located at the well centre. This radius encompasses the 500m petroleum safety zone (PSZ) around the MODU and accommodates installation of anchor moorings and support vessel movements in immediate vicinity of the MODU. The 500m traffic exclusion zone will be in effect around the MODU for the duration of the drilling campaign. In addition to support vessel movements, helicopters will transport equipment, supplies and personnel from shore locations. Further detail of the activity is available at http://www.conocophillips.com.au/our-business-activities/our-projects/Pages/caldita-barossa.aspx. A summary of the accepted Environment Plan is available at https://www.nopsema.gov.au/environmental-management/activity-status-and-summaries/details/373 If you have any queries regarding this activity please contact ConocoPhillips at [redacted]	For information - Bethany survey will not be within 1500 m of the MODU.

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ConocoPhillips	CoP-12	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǒs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Department of Defence	DoD-11	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǒs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Northern Prawn Fishery	NPF-29	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǒs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Northern Territory Seafood Council	NTSC-18	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǒs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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NT Department of Primary Industry and Resources	NTDPIR-10	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-62	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Pearl Producers Association	PPA-19	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
PGS	PGS-6	7/07/2017	Santos email: Just to let you know that the start date is looking like being earlier as we look like finishing Fishburn earlier than scheduled. If we get approval in time we could start as early as the afternoon of Tuesday 11th July. We have put you on the mailing list for the daily report.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Spanish Mackerel	NTFSM-18	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǿs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Spanish Mackerel	NTFSM-19	7/07/2017	Dear Stakeholder The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǿs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports. Regards Santos Bethany Stakeholder Enquiries Team	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Spanish Mackerel	SMF-15	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the surveyǿs progress. We propose to email you daily with a report containing the following details: Current survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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Timor Reef and Demersal Relevant	TRD-135 and attachment AW	7/07/2017	[redacted] email: I am becoming increasingly concerned in how this issue is being considered. First, we had a citation that didn't exist followed by a rationale about recovery from TTS in 24hrs. Having outlined some serious flaws in the argument for a SEL24 back in May I hope you will understand my concern when such claims are simply repeated over a month later. Worse still we have now been provided a completely misrepresented consideration of Popper et al 2005. I have responded to the claims made in your email in the attached table. Even if the recovery in 24 hrs from a SELcum of 186db was relevant to a 3D seismic survey (Popper 2005 explains that it is not) it is simply not relevant to what we are asking. The recovery if relevant would only be made by fish on the blue line or outside (that is if your survey was in 1.9m of water in a river). Now every fish inside these lines receives a SELcum of over 186dB, inside the pink area fish receive a SELcum of between 190 and 200dB, the red area of over 200dB. The distance between the two blue lines is over 16 kms. Instead of this irrelevant consideration of recovery times from an experiment in a 1.9m deep river, it would be much appreciated if SANTOS could outline its expectation of recovery times for fish or fauna within these high impact areas. The next survey line is approx 500m from the northern survey line. There will be at least 10 more survey lines between the lines currently considered in the SEL24 (estimated survey line positions added in black). Noting the above and previous information provided it would be appreciated if the modelling of SELcum at relevant time frames be carried out as a priority. As previously outlined without this you are greatly underestimating the impact of your proposed survey.	Concerns raised in email are addressed via response TRD-112 and TRD-130. The scenario modelling for a 24hr period represent the actual survey lines that would be acquired within 24 hrs, which because a "race track" method is used, makes the lines 4.5km apart. Santos has explained in why SELcum over 24-hours is an appropriate period for identifying TTS impacts to fish. In Popper et al. (2014) they acknowledge the complications in determining a relevant period for SELcum for mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source. Popper et al. (2014) state that a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level. Popper et al. (2005) is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). On this basis, a 'resetting' of SELcum to zero after 24-hours is based on the best information available at present.
Timor Reef and Demersal Relevant	TRD-136	7/07/2017	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. The timing of the Bethany survey is likely to change to as early as Tuesday 11th July 2017, dependent on obtaining environmental approval. As detailed below, you advised us that you would like to be kept informed of the survey's progress. We propose to email you daily with a report containing the following details: Current survey vessel position • 72 hour look ahead for survey activities and location • Support vessel activities and location • Contact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of change in commencement date for survey and ongoing communication process via daily report. No reply - stakeholder included on daily report email listing.
Timor Reef and Demersal Relevant	TRD-137	7/07/2017	Santos email: Thanks for your response, I'm pleased to hear you say we are close to agreement. You mentioned that your primary point of concern is Santos' position on the calculation of loss of catch payment. I am very happy to discuss that further. In the mean time, we think Santos' position has been consistent: 1. Santos has always said that the loss of catch payment should be determined by reference to loss suffered as a result of the seismic survey. 2. Santos did not agree to the position put by the Licensees at the meeting on 29 April. As reflected in the terms sheet on 6 June, Santos agreement was for a payment for a loss in the fishery because of the impact of the survey. 3. The area affected by the survey is 8-16% of where the catch has been caught in 2011 – 2016, so the entire area of the fishery is not appropriate for assessing the impact of the survey. 4. Consistent with this position and the EP, Santos considers that it is reasonable to use the area of the seismic acquisition zone plus the operational buffer zone (12,610km2) as the basis for the calculation in the agreement. This is 2.5 times larger than the 4,190m2 survey acquisition area. We think that approach is reasonable and gives all parties certainty.	Ongoing discussions in regards to compensation package. See latest information in TRD-131.

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Timor Reef and Demersal Relevant	TRD-133 and attachment AT	6/07/2017	Santos email: Please see attached a revised Agreement with the [redacted] Licensee only and incorporating some minor changes from the documents circulated on Friday. There remain some placeholders that you will need to fill in such as: 1) co-ordinates of the fishery 2) confirmation of the map Under separate cover I will forward the preliminary shooting plan and vessel contact details. Please note, we have estimated engagement costs for the [redacted] Licensees [redacted] Our assumption is based on [redacted] for the services of [redacted] I will call in the morning to discuss.	Agreement proceeding individually with [redacted]
Timor Reef and Demersal Relevant	TRD-134	6/07/2017	[redacted] email: Starcat will head to sea tomorrow for 2 weeks yet we do not have any information to identify seismic vessel movements. Could you please provide vessels line plan. Santos email on 07.07.2017: When Santos receives the relevant approvals to commence the survey we will immediately circulate the line plan.	Bethany survey did not go ahead at this time thus information was not provided.
Timor Reef and Demersal Relevant	TRD-132 and attachments AL, AM, AN and AU	5/07/2017	Santos emails: forward of Attachment AM - Notice To Mariners - Bethany 3D; forward of Attachment AL Santos Bethany Seismic Survey Operational Area with Coordinates; forward of Attachment AN - Vessel Exclusion Zone [redacted] email: I have had discussions with [redacted] and we have both agreed for various reasons to deal with Santos on separate Contracts for the upcoming Survey in the Timor Box could you please forward to me the final contract draft adding any recent changes that may have occurred. Also could you please forward information on track lines, operation procedures, relevant contacts, starting point of survey, etc. Please send me a list of information you require from Fisheries regarding our past history I can then consider the information and authorise Fisheries to release the relevant information a CA would be required for this release. The [redacted] is presently in port conducting annual survey we hope to leave port next Monday 10th July, as we have not been informed of a definite start date we have moved our traps from the Western end of the prospect to the North. (Our traps are now spread from a centre point of [redacted]) Santos email 05.07.2017: Thank you for your note. I have instructed the lawyers to draft up a copy of the agreement for you only. The other materials will be forwarded as available.	The location of the traps was mapped and is outside of the operational area by ~ 5nm. Thus no impact or displacement of fishing activity. Agreement proceeding individually with [redacted]

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Timor Reef and Demersal Relevant	TRD-130 Part 1	3/07/2017	Santos email: For the seismic noise impact assessment, Santos has used standard thresholds and thresholds suggested by the best available science. In regards to the SELcum metric, Popper et al. (2014) note ñOne major difference between pile driving and seismic airguns is that it is harder to determine SELcum for airguns. This is because the received SEL ss changes from shot to shot since the seismic vessel is moving and at different distances from the fish. Thus, a guideline ultimately based on the closest peak level or the closest SEL ss may actually be more useful than one based on the SEL cum.ò As detailed in the EP, the SEL24h threshold associated with possible mortality and potential mortal injury to fish was not reached within the modelling resolution of 40 m, thus the peak level was applied. For recoverable injury criteria both the peak and SEL24h threshold were reached and the PK impact distance was used as this was the furthest. For both these impacts the peak threshold is a more appropriate threshold as it is more likely that mortality and potential mortal injury would occur at a peak level rather over a period of cumulative time. This is supported by Popper et al. (2014) statement above. For TTS a cumulative threshold is more appropriate and the time period over which this is done has been based on the research information available in regards to recovery times for fish. In relation to the application of SEL24 for the TTS threshold, Santos maintains that this is an appropriate period for assessing potential temporary threshold shift to fish and based on the current scientific information available. The Popper et al. (2014) sound exposure guidelines for TTS effects in fish are based upon data from Popper et al. (2005) for exposure of several riverine species to a seismic airgun array. This study showed that exposure to an SELcum of 186 dB re 1 εPa2Ls accumulated over five seismic pulses within about five minutes resulted in about 20 dB of TTS in the lake chub (a hearing specialist) and northern pike (a hearing generalist). In all cases, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours (Popper et al. 2005). This is the only study in the published literature that includes information on TTS recovery period in fish exposed to seismic airgun noise, and is the basis for the fish TTS exposure thresholds included for seismic airguns in Popper et al. (2014). The Popper et al. (2005) study was done using a static source (airgun array) and static receptors (fish in cages at 13-17 m from the array), and therefore is not representative of a marine seismic survey with a moving source. Hence, the Popper et al. (2005) experiment represents a worst case scenario, as the source was fixed rather than moving ï i.e. the five seismic pulses that were found to have caused TTS effects over five minutes would have all been of identical intensity. This would not be the case with a moving source.	Response to query from TRD-129.

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Timor Reef and Demersal Relevant	TRD-130 Part 2	3/07/2017	As detailed in the Bethany EP Section 7.1.2, since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures. Given the Bethany survey plan, the time period before the vessel is again in proximity to specific location will be greater than 24 hours. As such, assuming a stationary receptor experiences TTS on one pass it will have at least 24 hours until the possibility of receiving an SEL of sufficient magnitude that could induce TTS to occur again. On this basis, and given that the only data available for TTS recovery in fish exposed to airgun noise indicates a recovery period from a substantial TTS of 20 dB of less than 24 hours, a 24 hour period is seen as appropriate for modelling cumulative SEL. In regards to other fauna within the area, Santos has applied appropriate criteria based on the latest science and or guidelines to determine potential impacts as detailed in the appropriate sections of EP. In regard to line spacing: There are two parameters, survey lines and survey tracks. Survey lines are 500 ï 600 m apart. The survey tracks are the tracks that the vessel will take to survey the lines. The distance between lines that make up a track is 5 ï 6 km. The email from [redacted] (on your behalf) asked for the distance between the tracks when the vessel travels back and forth ï i.e. Track 1 heading east, Track 2 heading west, what would the distance be between the tracks. This, at a minimum, will be 5 km. This distance between tracks of ~5 km was in the information provided on the 19th June 2017. In regard to broader cumulative impacts from other surveys, EP Section 7.1.5.8 assesses potential impacts from previous surveys and simultaneous surveys within the area. Cumulative impacts can occur when the timing between surveys is less than the recovery rate of any potential impacts to receptors. In relation to simultaneous surveys, the Bureau of Ocean Energy Management (BOEM 2014) final environmental review of geological and geophysical survey activities off the mid- and South Atlantic coast recommended a 40 km geographic separation distance (based on worst case scenarios) between the sources of simultaneous seismic surveys to minimize the impacts to marine life by providing a ócorridorô between vessels. No seismic surveys were identified to be occurring at the same time as the Bethany survey within an area of 200 km. Thus, cumulative impacts from the Bethany, Fishburn and Gulpener survey would be highly unlikely based on the separation distance and that the Fishburn and Gulpener surveys are not occurring at the same time as the Bethany survey. Thus, the Bethany EP seismic noise impact assessment appropriately assesses cumulative impacts based on the best available thresholds, guidance and science.	Response to query from TRD-129.

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Timor Reef and Demersal Relevant	TRD-131 and attachment AS and AV	3/07/2017	[redacted] email: I took the time over the weekend to compare the agreement signed in 2006/07 with the current deed that has been drafted. Overall it has highlighted for me despite the meetings, multitude of emails and of course telephone conversations the key points of dispute remain the same from our first meeting being methodology/detail of loss of catch payment and later the Release clauses. Discussions with [redacted] and [redacted] over the last couple of days have also served to highlight the primary purpose of any agreement was to provide some certainty around what could be expected only if catch rates dropped. In the current format of the deed this cannot be done and is unlikely to be achieved prior to the survey commencing if we work on a start date of next week. The discussions and review process has cost [redacted] and [redacted] a significant amount and I do not believe they should have to fund such activities. I therefore suggest we settle the engagement cost to ensure payment is made in a timely fashion. I attach an invoice for your review. It is more important that any deed/contract provides certainty and suits both parties otherwise I do not believe in preparing them. We can discuss the deed further upon your return. Santos email: Thank you for your response. We are disappointed as we had thought we were close to agreement on the aspects you've mentioned. We will consider your comments and we welcome any further suggestions you have on the proposed terms. We will also separately consider the invoice for the engagement costs youŷve sent through. We appreciate the time youŷve all spent on this matter. [redacted] email: You obviously misinterpreted parts of my email given your response. 1) I thought you were away this week and as you were to remain the contact point I was not anticipating further engagement this week. 2) I believe as I have stated to you before that we are close to an agreement. 3) I raised 2 key points of concern in my email and felt this was better dealt with upon your return. This decision was based on the timeframe of when you suggested the survey was starting and the timing of your return I did not anticipate finalising agreement before the survey commencing. 4) Given the above and the amount we have spent on this process I forwarded you an invoice to get the ball rolling on this element. I think it is best we concentrate on the primary point of concern being calculation of loss of catch payment. To help you understand my frustration I attach a summary of discussions on the loss of catch area. I think it highlights the circle we have taken since commencement to when the deed was drafted. The fisherman would like an agreement with Santos however there needs to certainty for both parties.	Ongoing discussions in regards to compensation package. In December 2016, negotiations commenced about a potential commercial agreement to compensate commercial fishing operators who suffered a loss because of the survey as Santos and the fishers considered this would be an appropriate control measure for the potential impact of them. Negotiations are advanced and Santos expects to reach a commercial arrangement with the Timor Reef Fishery before the survey commences, however there is no final agreement as at the EP submission date. Due to the state of negotiations with the commercial fishing operators during the development of the EP, Santos developed a payment model as an alternative appropriate control measure in the EP to ensure that potential impacts to commercial catch rates were reduced to as low as reasonably practicable and be acceptable. This model will apply if a commercial agreement with commercial fishing operators is not reached. The model is proposed in the EP table 7-16 and 7-24. Santos consulted with an independent fisheries economist, [redacted] (CSIRO) about the model and whether it was as an appropriate control measure in the EP to ensure that potential impacts to commercial catch rates were reduced to as low as reasonably practicable and be acceptable. [redacted] 2017) has confirmed: ÅThe approach proposed by Santos for compensating fishers for their potential lost income is generally consistent with international best practice. The proposed approach aims to compensate fishers for any forgone revenue as well as any increase in cost due to relocating to different fishing areas. ÅThe data proposed to be provided to Santos for the estimation of these costs are appropriate, and consistent with data used elsewhere for such a purpose. Given that the fishery is operating under individual transferable quotas, the catch disposal records should reflect the commercial catch. Misreporting of such data would be an offence. ÅIn the cases identified elsewhere, it was the responsibility of fishers to demonstrate this loss and seek compensation. In this case, Santos is attempting to facilitate this process on behalf of the fishery. ÅCompensation for future risks to the fishery has not been applied in any case study that could be identified. Longer term impacts of seismic testing on fisheries are highly uncertain, and most studies found no long term impacts on stocks or fish behaviour. Santos also based the payment model control measure included in the EP on what it understands to be industry standard for an appropriately evidence based compensation model, on past agreements it has had with fishers in the area, and the fact that the fishers have referenced impacts to catch in regards to impacts from the CoP survey (TRD-9, TRD-50, TRD-55) thus catch rates would be able to be used to identify any impacts from the Bethany survey. Note that Santos expects to reach commercial agreement before the survey commences. In the event that Santos does reach commercial agreement with a commercial fishing operator, that agreement will replace the payment model in the EP as the appropriate control measure in respect of potential impact on commercial catch rates.

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Timor Reef and Demersal Relevant	TRD-129	2/07/2017	[redacted] email: Response to email of 30 June at 7.35pm. Santos response on issues from May SANTOS committed to providing the response over a month ago. Please can you finalise your response as a priority. These issues were raised in mid-May. SELcum at distance from survey line No I am certainly NOT saying that modelling SELcum over a longer period than 24 hrs showed a 220 dB SELcum out to 3 km. As I am sure you are aware this is an impossible construct once you actually consider survey lines in closer proximity. The concept of distance from the survey line can only be used while we artificially limit the consideration of SELcum to one survey line (or two so far apart they have little impact). The concept of distance from the survey line is not relevant once SELcum is considered for the appropriate times. 186dB being very precautionary You seem to have these issues a little confused. The precaution used in our consideration of SELcum for your proposed survey assumed no fauna received any sound level above 186dB. This has no relation to Popper et al. (2014). The precaution was in not overestimating SELcum and noting the sound levels predicted in the EP I hope you can understand our serious concerns. As SANTOS has refused to supply details on distance between survey lines we have used 500m in our projections. If the survey lines are to be closer this will of course increase the SELcum predictions Providing our modelling As stated our simple modelling provides a precautionary guide to possible SELcums for longer time periods. Noting the levels predicted I believe it is incumbent now on SANTOS to model these extended times for SELcum.	Response to SELcum issues provided in TRD-130 3/7/2017
Timor Reef and Demersal Relevant	TRD-126 and attachments AL, AM and AN	30/06/2017	Santos email: To enable briefing of your crew during their port visit. Please find attached: 1) Notice to Mariners including all vessel contact details. 2) Diagram of the operational exclusion zone around the vessel. 3) Map showing Seismic survey Operational Area and Survey Area. Our survey planners are creating another a diagram that has illustrative line turn areas, I will forward this when available. [redacted] email 30.06.2017: Thank you for your prompt reply to our conversation yesterday. Having the indicative shooting plan will allow me to structure a working programme for the [redacted] o organise communication with ship and support vessels, advice on position of traps when actively operating and when in port this will prevent any interaction between the two operations. If Santos can cover costs on email communication we can utilize that option if not radio and Satphone would have to be used (not my preferred option), for emails we could forward relevant invoices at each billing period to you for reimbursement to [redacted] his simplifies the procedure. I will talk to [redacted] and inform him I will release my information outside the prospect area I will require a CA for this information ! The [redacted] will be unloading this Sunday I will instruct the Skipper to download relevant information including trap numbers used this will take a few days. Can you please confirm re our conversation yesterday if the [redacted] is initially fishing in the survey area during seismic operations and our catches significantly drop below our average landings because of the seismic operations we can move out of the prospect area in an attempt to increase our catches we will still receive compensation for below average catch. Please contact me for clarification on any forward issues relating to my operations.	Provision of detailed survey information to allow fisherman to planwork programme. Ongoing negotiation in regard to data, confidentially agreement and compensation.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Timor Reef and Demersal Relevant	TRD-126 and attachments AL, AM and AN (continued correspondence)	30/06/2017	Santos email 30.06.2017: Please find attached comments below (in red). Thank you for your e-mail.. Please note that I am out of the office on leave next week. I will continue to progress these discussions during my leave, however my response time will be longer than normal. Thank you for your prompt reply to our conversation yesterday. Having the indicative shooting plan will allow me to structure a working programme for the [redacted] to organise communication with ship and support vessels, advice on position of traps when actively operating and when in port this will prevent any interaction between the two operations. Please see (in addition to the documentation yesterday) an illustrative shooting plan, showing possible line turn dimensions. This will assist your trap layout. If Santos can cover costs on email communication we can utilize that option if not radio and Satphone would have to be used (not my preferred option), for emails we could forward relevant invoices at each billing period to you for reimbursement to [redacted] his simplifies the procedure. At this time Santos does not have an approved Environmental Plan (EP) for the Bethany survey, nor do we have a make-good arrangement with yourself. If you can execute the Management Agreement and Santos receives an approved EP, we can proceed to make payment for additional expenses until Clause 4.1. If you, as [redacted] would like to complete the Agreement separately from the other fishers I can have a revised copy drawn up. I will talk to [redacted] and inform him I will release my information outside the prospect area I will require a CA for this information ! The [redacted] will be unloading this Sunday I will instruct the Skipper to download relevant information including trap numbers used this will take a few days. As indicated yesterday, we will supply a CA for your review. Can you please confirm re our conversation yesterday if the [redacted] s initially fishing in the survey area during seismic operations and our catches significantly drop below our average landings because of the seismic operations we can move out of the prospect area in an attempt to increase our catches we will still receive compensation for below average catch. I refer you to Clause 4.2 of the Management Agreement that covers the arrangements.	Ongoing negotiation in regard to data, confidentially agreement and compensation.
Timor Reef and Demersal Relevant	TRD-127 and attachment AM, AN and AQ	30/06/2017	Santos email: As promised, please find attached revision to the Commentary attached. We share your view that we are close to concluding an Agreement. Substantive issues remain and Santos is committed to discussing these issues constructively and in good faith. The attached commentary is a step towards resolving the outstanding issues. If the outstanding issues are resolved then the Agreement can undergo a final update. I include a number of other attachments that will assist conclusion of our discussions. I have listed these below: 1) Commentary 30 June ï Santos mark-up. 2) Notice to Mariners ï Contact details of the seismic acquisition vessel. 3) Diagrammatic illustration of the Polarcus Vessel Operational Exclusion Zone. 4) Link to Santos Privacy policy: https://www.santos.com/privacy-policy/ I have asked my colleagues for an illustrative confidentiality agreement. I will forward this separately. Please note I am out of the office on leave next week. I will remain contact point for these discussions.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Timor Reef and Demersal Relevant	TRD-128	30/06/2017	[redacted] email: I was sincerely hoping your response today to my previous concerns from mid May would alleviate what is now a far more serious concern. As no one was willing to provide modelling for SELcum over 24 hrs I have had some simple modelling carried out to provide a precautionary guide to possible SELcums for longer time periods. I am sure you will agree the results are of considerable concern. Fauna approx 3 kms out from the first survey line was assumed not to move more than 100m. The sound exposure was limited to 186db despite the fact we know such fauna would be exposed to far higher levels. With this strong limitation on SELcum levels we still see fauna receiving over 220 dB SELcum. By limiting the sound level to 186 dB this is unfortunately a very precautionary estimate of how high cumulative impacts will be in the proposed survey. It was noted that fauna could receive a third of the shots predicted and SELcum figures will still be of serious concern. This matter now needs your urgent attention. Santos email: I was just finishing my response to you but will hold in light of your email below. In regards to your email, the results of your modelling are not clear. Are you saying that modelling SELcum over a longer period than 24 hrs showed a 220 dB SELcum out to 3 km? In regards to your comment ñlimiting the sound level to 186 dB this is unfortunately a very precautionary estimate of how high cumulative impacts will be in the proposed survey,ò this is an incorrect statement in relation to that sound level. The 186 dB SELcum is the Popper et al. (2014) recommended sound exposure criteria for TTS for fish with a swim bladder and has only been used in the context to identify TTS impacts to fish. For us to understand what modelling you have had done, and the results of this modelling, we would request that you provide a copy of the report. This would allow us to further understand your concerns and determine an appropriate way forward.	Response to SELcum issues provided in TRD-130 3/7/2017
Timor Reef and Demersal Relevant	TRD-124 and attachment AL	29/06/2017	Santos email: In your conversation with [redacted] today I understand you said you had not received the email sent yesterday (TRD-122), so we are sending it again from my address.	Follow-up as no response to Bethany pre-start email in regards to daily reports see TRD-122. Information provided as per TRD-125.
Timor Reef and Demersal Relevant	TRD-125 and attachment AP	29/06/2017	Santos email: Thank you for your time and the constructive conversation this morning. I had some actions: 1) To forward the Bethany Survey email from Stakeholder Enquiries. a. This was sent from Santosõ system at 2.01pm ACST entitled: Bethany survey: your advice on how you would like to be kept informed. b. The sender details were: stakeholder[redacted]santos.com. If you did not get this email please check your deleted items/spam folders and then advise us. c. We have also copied the text in below. You will see that we will email daily a 72 hr look ahead to all stakeholders. 2) To forward the latest copy of the agreement that we have been discussing with [redacted] This is attached. 3) To forward an indicative survey shooting plan. I will forward this later today/tomorrow. 4) To forward vessel contact details. I will forward separately. 5) To clarify if Santos can cover costs of vessel internet connectivity during the Survey. When the Agreement is in place, Clause 4.1 can be used to be reimbursed for additional operating costs that were incurred during the Survey Period. 6) Confidentiality. All data passed to Santos can be protected under a Confidentiality Agreement (CA). I can supply a draft CA on request.	Follow-up as no response to Bethany pre-start email in regards to daily reports see TRD-122. Information provided as per TRD-125. Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Amateur Fishermenōs Association of the NT (AFANT)	AFANT-22 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyōs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Aquarium Fishery	AQ-20	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyōs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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ConocoPhillips	CoP-10 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Department of Defence	DoD-10 and attachments AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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Northern Prawn Fishery	NPF-28 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Northern Territory Seafood Council	NTSC-17 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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NT Department of Primary Industry and Resources	NTDPIR-9 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-61 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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Pearl Producers Association	PPA-18 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
PGS	PGS-5 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyô s progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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Spanish Mackerel	NTFSM-17 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Spanish Mackerel	SMF-14 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyôs progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.

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Timor Reef and Demersal Relevant	TRD-120	28/06/2017	[redacted] email: Unfortunately, timing is an issue with [redacted] having limited time to work on this. Therefore, whilst [redacted] can access his email today he dictated the following as he wanted to respond as soon as possible. The basis of his lawyerҳ advice is as follows: 1) [redacted] lawyer reviewed the deed and background information [redacted] provided him yesterday with the main issues raised being: a. Loss of catch basis is concerning given: i. Area is defined as survey area not fishery ii. Payment of compensation open to further negotiating which provides no certainty in the arrangement b. Release and indemnity clauses added providing no recourse for damages if fishery is impacted c. Overall the only item certain in this deed is the [redacted] or conducting this process. Which all of this and more has been spent conducting this engagement process. [redacted] also raised he is very concerned operational requirements are not being considered. Given his experience working with these boats he is concerned about having enough time to ensure his traps are correctly located prior to the survey and a proper plan is in place to minimise impact on fishing/the seismic vessel during the survey. [redacted] requested the survey plan is released as soon as possible and the persons responsible for operations make time available to ensure both parties can plan their activities.	Ongoing negotiation in regard to data, confidentially agreement and compensation. See TRD-126,132,133,153.156.
Timor Reef and Demersal Relevant	TRD-122 and attachment AL	28/06/2017	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. Santos is preparing to undertake the Bethany 3D Marine Seismic Survey within the Bonaparte Basin, approximately 260 kilometres north-west of Darwin in Commonwealth waters. The survey is expected to take approximately 75 days to complete, dependant on weather conditions, using the Polarcus Naila seismic vessel. An exclusion zone of 3 nautical miles around the vessel, and the cables (known as streamers or acoustic receivers) that it will be towing, will be requested from all vessels in the vicinity of the survey during operations. Please see attached a map showing the operational area of the survey. The current schedule has the survey commencing around 17 July 2017, though please note timing is dependent on obtaining environmental approval and the duration of another survey the vessel is currently undertaking. In earlier engagement with you, you advised us that you would like to be kept informed of the surveyҳ progress. We propose to email you daily with a report containing the following details: ÅCurrent survey vessel position Å72 hour look ahead for survey activities and location ÅSupport vessel activities and location ÅContact details for the survey and support vessel. Please advise if there is other information you would like to receive in the daily report. Alternatively, you may only wish to receive advice relating to the start and finish of the survey (i.e. you do not wish to receive the daily report). If this is the case, please reply to this email with that advice. In the absence of that advice, we plan to send you daily reports.	Santos email to notify stakeholder of commencement date for survey and ongoing communication process via daily report. No reply - stakeholder including on daily report email listing.
Timor Reef and Demersal Relevant	TRD-123	28/06/2017	[redacted] email: Further to our discussions on Monday, We have been working on the wording to hopefully assist in making this agreement fairer. Suggested adjustment to clause 4.2 Santos will make payments to each Licensee for each month there is a loss of catch suffered by that Licensee. Where the loss of catch can conclusively be proved by Santos to not have been suffered as a result of the seismic survey, the actual loss of catch will be assessed. We look forward to any suggestions Santos may have. [redacted] email 30.06.2017: Could you please advise update on any revisions of the deed. Santos email 30.06.2017: Thank you for your note & phone message. We will revert later today. [redacted]	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Amateur Fishermenҳ Association of the NT (AFANT)	AFANT-21 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WAҳ north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please donҴ hesitate to contact us.	Provision of information on new seismic study on plankton.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Aquarium Fishery	AQ-19 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.
ConocoPhillips	CoP-9 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.
Department of Defence	DoD-9 and attachments AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.
Northern Prawn Fishery	NPF-27 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.
Northern Territory Seafood Council	NTSC-16 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.
NT Department of Primary Industry and Resources	NTDPIR-8 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA’s north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don’t hesitate to contact us.	Provision of information on new seismic study on plankton.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-60 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton.
Pearl Producers Association	PPA-17 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton. No reply.
PGS	PGS-4 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton.
Spanish Mackerel	NTFSM-16 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton.
Spanish Mackerel	SMF-13 and attachment AO	27/06/2017	Santos provided information on the new research y Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton.
Timor Reef and Demersal Relevant	TRD-121 and attachment AO	27/06/2017	Santos provided information on the new research by Curtin University which concludes the mortality rate for plankton in the immediate vicinity of seismic noise could be higher than previously thought. The research was published on the online journal Nature: Ecology and Evolution, and it is attached to this email for your information and as part of our commitment to ongoing engagement with relevant stakeholders. We also wish to advise that the CSIRO is assessing the potential local and regional impacts on zooplankton of a typical commercial seismic survey and we understand that this study, conducted off WA's north-west, will be published soon. We will assess both the Curtin University and CSIRO research as they relate to the assessment of the environmental impact or risk of our proposed Bethany survey in the Bonaparte Gulf. If you require further information, please don't hesitate to contact us.	Provision of information on new seismic study on plankton. No reply.

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Timor Reef and Demersal Relevant	TRD-118.1	26/06/2017	[redacted] email after phone conversation. I am writing this email frustrated yet hopeful of getting a resolution. On one hand this process is about compensation for loss (money), but more importantly this process is about fairness. Lack of knowledge or understanding is not a good enough reason to impact the environment or another person(s) business/livehood. Hence why I have spent so much time dealing with this situation. Further to our discussion earlier today I think we are getting close but as I stated we are very concerned. Primarily all the risk is on the fisherman which this contract in no limits given the possible adverse effects. We agree Santos has agreed and will be required to pay fisherman if actual catch varies to average catch. However, there is a number of clauses that could deem all of this a waste of time if for example fisherman cannot categorially prove the change in catch rates are a direct result of the survey. To make things worse, if significant damage is caused to the fishery, Release and indemnity clauses have been added that hold Santos harmless despite what damage may be caused. If it were not for a large corporate dealing with small business and the fact there is good faith amongst the person involved from all parties, this contract or process would not even have been considered. I attach our spreadsheet that will worked through our negotiations on. I also attach a list of Timor Reef License Holders which I will update you once received from NTSC and the updated Contract Commentary Sheet. We are very concerned at the data you are requesting. It is like going on a merry go round. Discuss at a meeting the terms of the deed you had in 2006/07, explain why catch log data is not necessary and then we decide to use Catch Disposal Records, discuss again at next meeting, agree on information to provide and then get a request for catch log data. Can you please advise how Santos would use this information because as you know this is data is extremely important to a fishermanǿs business and not released to anyone lightly. It is also very important you review the wording around payment for ñarea of the fisheryò compared to payment for ñarea of the surveyò. We have had this discussion and as per the attachment we agreed on ñarea of the fisheryò. [redacted] is currently have the contract and other documents reviewed by his lawyer. Accordingly he may request changes. Santos email 27.06.2017 - Thank you for your response. Let us wait for [redacted] feedback. Then we will deal with the remaining issues.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Timor Reef and Demersal Relevant	TRD-119	26/06/2017	Santos email: I have added the Bethany EP Rev 2 to the dropbox. The main changes to the Bethany EP Rev 2 are: Figure 3-2 Map showing more detailed coordinates for the Bethany operational and survey area. Inclusion of % of benthic habitat within the Full Power Zone (Table 5-7). Section 5.5.4.1 Syngnathids updated to provided more detailed information in relation to species distribution based on two studies within the Oceanic Shoals Marine Reserve. Section 5.5.7 Reptiles and Section 7.1.5.5.1 Seismic Noise Turtles ï updated to reflect new Recovery Plan for Marine Turtles in Australia 2017 ï 2027 and change to the Flatback internesting biologically important area (BIA). This change in area means that there are no seismic noise impacts predicted to this BIA. Section 7.1.2 Seismic Noise ï further information provided in regards to SEL24 modelling. Section 7.1.5.2.3 Molluscs ï updated to reflect FRDC scallop research and how it applies to the survey. Section 7.1.5.3.1 Fish Mortality updated to establish the relevance of studies that showed no mortality impacts to the conditions of the Bethany survey. Section 7.1.5.3.1 Fish Mortality and Section 7.1.5.3.2 TTS updated to demonstrate that impacts to Syngnathid species and other fish species are acceptable and unlikely to have impacts at population level due to low abundance of species within the area of impact. Consequence level updated to reflect this based on review of data of fish likely to be in the area. Thus, impacts would be localised and short term as no population effects where identified. Section 7.1.5.3.4 Commercial Catch Rate consequence rating updated to localised and medium term as catch rates likely to return to normal within 1 year. Section 7.1.5.3.4 Commercial Catch Rate Section on Consultation and Control Measure added to detail the appropriateness of the Loss of Catch Payment to manage impacts of the survey to commercial fisheries. Table 7-16 Seismic Noise risk Assessment updated to reflect the changes above. Added in a new control - The Loss of Catch Payment control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them. Section 7.9 Marine Users Section updated to detail the appropriateness of the Relocation Expenses Payment to manage impacts of the survey to commercial fisheries. Added in a new control - The Relocation Expenses Payment control measure will apply unless Santos enters into an agreement with a commercial fishing operator in relation to the potential impact of the survey on them.	As requested (TRD-117) Bethany EP Rev 2 provided in dropbox. Email covers changes in EP from Rev 1 to Rev 2.
AMSA	AMSA-3 and attachments AL, AM and AN	25/06/2017	Please find attached a revised notice to mariners for the upcoming 3D marine seismic survey we will be conducting in the Bonaparte Basin. As mentioned in the attached notice, exact timing of the survey will be dependent on the current survey (Fishburn 3D).	Notification of commencement date for Bethany Survey via Notice to Mariners.

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Australian Hydrographic Service (AHS)	AHS-1 and attachments AL, AM and AN	25/06/2017	Santos email: Please find attached a revised notice to mariners for the upcoming 3D marine seismic survey we will be conducting in the Bonaparte Basin. As mentioned in the attached notice, exact timing of the survey will be dependent on the current survey (Fishburn 3D). AHS email: Thank you for the info. Please let us know if the timing changes.	Notification of revised commencement date for Bethany Survey and provision of information for Notice to Mariners.
Department of Defence	DoD-8 and attachments AL, AM and AN	25/06/2017	Please find attached a revised notice to mariners for the upcoming 3D marine seismic survey we will be conducting in the Bonaparte Basin. As mentioned in the attached notice, exact timing of the survey will be dependent on the current survey (Fishburn 3D).	Notification of revised commencement date for Bethany Survey and provision of information for Notice to Mariners.
AMOSC	AMOSC-3	23/06/2017	Santos email: Please note that the Santos Fishburn Seismic Survey EP and OPEP have been update to EP Rev 4 and OPEP Rev 3 as the survey are has changed. This has no change to the arrangements in the EP or OPEP. Could you please replace previous copies sent to AMOSC with this version. Please note that the vessels are on location. The survey will take between 14 ï 21 days. I will notify you when the vessels are leaving the location to move to the Bethany survey area.	For information that will notify AMOSC when vessels leaving Fishburn Survey area to move to Bethany survey area.
Northern Prawn Fishery	Phone Call	23/06/2017	[redacted] - Phone conversation with Northern Prawn Fishery executive [redacted] on Friday 23 June, following my email alerting her to new McCauley research and our proposed approach. [redacted] said it was concerning and she expected to hear strong views after her members had read the report over the weekend and she would be in contact. She appreciated STO contact on the issue.	Provision of Information
Timor Reef and Demersal Relevant	TRD-116	22/06/2017	[redacted] email: Can you give me some idea what time you are likely to want to discuss Deed today. I just want to make sure I am available.	For information
Timor Reef and Demersal Relevant	TRD-116.1 and attachments AH, BB and BC	22/06/2017	Santos email: I have compiled Santosõ review of the Draft Agreement you returned on Tuesday 20 June. Attached you will find: 1) A revised draft incorporating both your mark-up and further review by Santos. 2) A commentary to explain how the revisions have been incorporated. We look forward to your response. We are happy to schedule a time to walk through the materials.	Ongoing engagement in relation to make good payment.
Timor Reef and Demersal Relevant	TRD-117	22/06/2017	[redacted] email: forwards NOPSEMA's EP lodgement notification. I received this notification last night and understand a revised EP was lodged on Tuesday. Could you put a copy in the Dropbox for review please and if you could identify the changes that would be appreciated. Santos email: I apologise that [redacted] and I have not responded to your prompts today. We are both occupied with vessel and site visits associated with our offshore operations. We are back in the Santos office tomorrow. [redacted] email on 23.06.2017: Could you add revised EP to dropbox please.	Bethany EP Rev 2 provided in dropbox on 26/6/2017 TRD-119.
Timor Reef and Demersal Relevant	TRD-118	22/06/2017	[redacted] email: Can you outline why SELcum wasn't considered for the Fishburn survey? Santos reply email on 26.06.2017: SELcum was not assessed for the Fishburn survey as SELcum is more relevant for site attached species and no significant or abundant site attached species were identified for the Fishburn area. [redacted] email 26.06.2017: For any species with both peak and SELcum thresholds for impulsive sounds, the very papers on which you rely states that proponents must evaluate thresholds using both metrics. SELcum times need to be considered based on the issue you are trying to address. Yes you can use a set time but it needs to be relevant. For example in relation to TTS the critical point for assessing impact on hearing is whether the animal has long enough time at low enough exposure levels for the auditory system to recover from any temporary effects of noise exposure. Of note your own EP recognizes that 24 hrs is far shorter than required. I cant see any reason for the objection to providing this information except to avoid the consideration of SELcum for survey lines in close proximity. Even for cetaceans the 24hr period is stated as the baseline accumulation period and is known to require adjustment based on fauna that are predicted to experience unusually long exposure duration's, as is the case in your extended survey. It is again requested that you urgently address this matter for both the Bethany and Fishburn surveys. Santos email 27.06.2017: I have spoken to Jasco and we are working through your comments for both this email and your email dated 21.6.17. We will try and get you a response by the end of the week. [redacted] email 27.062017: Just to clarify I have requested modelling at longer time frames (issue raised in mid May 2017). If SANTOS is now carrying out this work it is much appreciated. If not can you please clarify the process being undertaken.	Response to SELcum issues provided in TRD-130 3/7/2017

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Timor Reef and Demersal Relevant	TRD-115	21/06/2017	[redacted] email: The Technical Guidance (Popper 2014) relied on presents dual thresholds for impulsive sounds for good reason. The failure of SANTOS to properly evaluate thresholds using both metrics is placing the environment at considerable risk. In the spirit of our consultation we have been willing to consider false citations and new reasoning for maintain the SELcum 24hr period as simply in error. It is clear now that this is not the case. We requested a copy of the survey plan at our meeting back in early May. This was going to be provided in days. The concerns around the citation for 24hr SELcum and subsequent new argument regarding TTS recovery were raised in May. On the 7 June we were told to expect a response on this within 24hrs. We have now been told the survey plan will not be provided. All we requested was the distance between survey lines but this information has not been forth coming a month later. The response received on the 19th June contains some concerning errors and ether a complete failure to understand the issue or an attempt to avoid the issue. ÅWith every pass the seismic source is NOT moving away from a stationary receptor as claimed. ÅThere is NOT a distance of 5km between tracks as claimed. We must estimate based on other surveys as SANTOS will not provide this information. ÅFuture exposures to fish exposed to TTS are certainly NOT less than the first exposure. In fact a fish could be exposed to increasing sound levels for approx. 15 days and be exposed to TTS level for some 20 more. ÅThe concept that these fish will somehow be helped by a soft start procedure is no longer supported. As with the 24hr metric it was designed fir whales and is simply not applicable to other marine fauna. ÅHaving explained now on numerous times why the claims about TTS recovery in 18-24 hours and further the use of this information to defend the 24hr period are misleading I am surprised to see them repeated. The 24hr metric is a recommendation for marine mammals and is a baseline accumulation period. The fact that there are exposure situations where this accumulation period requires adjustment is well supported. ÅIn the response on 19 June we are first informed that ~~e~~each exposure will be less than the first and with 5kms between tracks this would reduce the risk subsequent TTS for stationary fishò Then in the very next section in direct contradiction we are told ~~a~~a stationary fish will have at least 24hrs before until the possibility of receiving another SEL that could induce TTSò This impact will be repeated over and over. (Has anyone considered the avoidance capability of a fish with TTS?)	Response to SELcum issues provided in TRD-130 3/7/2017
Timor Reef and Demersal Relevant	TRD-115 (cont. text)	21/06/2017	ÅThe claim that 24 hrs is the shortest period over which an accumulated SEL of 186 dB re 1 ÕPa2 .s occurs at 3.6 or 3.3 km depending on the location is incorrect. ÅThe biological relevance of longer periods than 24 hrs is easily demonstrated and we donót intend repeating information we have previously provided. We can only encourage you to model the longer periods. These longer periods will see marine fauna exposed to SELs not even considered in the EP and this issue will not simply disappear if the survey commences. Without the relevant SELcum information it is impossible for industry to consider the impact of your proposed survey on our interests. The reality is that any marine fauna that stays in the survey area will be subjected to not a single 24 hr period but in fact 1000s of shots at levels of 186db above. Even ignoring the fact this fauna will be impacted by some levels far higher, the SELcum values at meaningful time periods for these animals are above those that predict mortality in all species of fish. We would hope that noting the considerable risk that this poses to the environment that SANTOS will prioritise consideration of a SELcum metric that is more meaningful for the majority of marine fauna found in the survey area. These cumulative effects become even more important to assess when you consider the recent ConocoPhillips survey, that SANTOS is conducting 2 surveys back to back within 210 kms and Origin is conducting a 3rd at the same time. At present we are failing to consider the cumulative impacts of a single survey.	Response to SELcum issues provided in TRD-130 3/7/2017
Timor Reef and Demersal Relevant	TRD	20/06/2017	Stakeholder engagement post EP submission on 20th June 2017	
Timor Reef and Demersal Relevant	TRD-113 and attachment AJ	20/06/2017	[redacted] email: Revised draft for your review. I attach a mediation clause which I suggest is added to the contract. Thank you for providing framework on calculating amendment. There is still concern on how an adjustment would be determined and I think we need to work through that further. Providing data is not the issue, it would be cleaner if we could specify periods for the average. i.e.. [redacted] ï subsequent to his new vessel starting (24 months), [redacted] ï Prior to Conoco Philips survey.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Timor Reef and Demersal Relevant	TRD-114	20/06/2017	[redacted] email: Obviously we are getting nearer to your project commencing. It is more important for trap fishing but do you have the seismic vessels line plan.	Information not required as survey did not go ahead at this time.
Timor Reef and Demersal Relevant	TRD-111	19/06/2017	Thank you for your call. Santos email: Re: calculation method. The method for calculation of the Loss of Catch Calculation is set out in Schedule 2. Your question is, how the Baseline Average Catch Rate is calculated? Given that the equipment used during the last 36 months has been changing. The 36 months of data is requested in order to establish an average free of background seasonality effects and including sufficient data to identify where changes in fishing gear have made a marked impact to catch rates. Setting that out in a process. Together we would: 1) Examine 36 months of CDRâs for the fishery. 2) Dates are supplied where changes in fishing gear or other relevant events have occurred. 3) Data are used to calculate an Average Catch Rate. a. Where fishing gear has produced a marked improvement in catch rate the Average Catch Rate will be adjusted. 4) Adjusted Average Catch Rate used in Loss of Catch calculation. I hope this addresses your concern.	Ongoing discussions in regards to compensation package. In December 2016, negotiations commenced about a potential commercial agreement to compensate commercial fishing operators who suffered a loss because of the survey as Santos and the fishers considered this would be an appropriate control measure for the potential impact of them. Negotiations are advanced and Santos expects to reach a commercial arrangement with the Timor Reef Fishery before the survey commences, however there is no final agreement as at the EP submission date. Due to the state of negotiations with the commercial fishing operators during the development of the EP, Santos developed a payment model as an alternative appropriate control measure in the EP to ensure that potential impacts to commercial catch rates were reduced to as low as reasonably practicable and be acceptable. This model will apply if a commercial agreement with commercial fishing operators is not reached. The model is proposed in the EP table 7-16 and 7-24. Santos consulted with an independent fisheries economist, [redacted] (CSIRO) about the model and whether it was as an appropriate control measure in the EP to ensure that potential impacts to commercial catch rates were reduced to as low as reasonably practicable and be acceptable.[redacted] (2017) has confirmed: ÅThe approach proposed by Santos for compensating fishers for their potential lost income is generally consistent with international best practice. The proposed approach aims to compensate fishers for any forgone revenue as well as any increase in cost due to relocating to different fishing areas. ÅThe data proposed to be provided to Santos for the estimation of these costs are appropriate, and consistent with data used elsewhere for such a purpose. Given that the fishery is operating under individual transferable quotas, the catch disposal records should reflect the commercial catch. Misreporting of such data would be an offence. ÅIn the cases identified elsewhere, it was the responsibility of fishers to demonstrate this loss and seek compensation. In this case, Santos is attempting to facilitate this process on behalf of the fishery. ÅCompensation for future risks to the fishery has not been applied in any case study that could be identified. Longer term impacts of seismic testing on fisheries are highly uncertain, and most studies found no long term impacts on stocks or fish behaviour. Santos also based the payment model control measure included in the EP on what it understands to be industry standard for an appropriately evidence based compensation model, on past agreements it has had with fishers in the area, and the fact that the fishers have referenced impacts to catch in regards to impacts from the CoP survey (TRD-9, TRD-50, TRD-55) thus catch rates would be able to be used to identify any impacts from the Bethany survey. Note that Santos expects to reach commercial agreement before the survey commences. In the event that Santos does reach commercial agreement with a commercial fishing operator, that agreement will replace the payment model in the EP as the appropriate control measure in respect of potential impact on commercial catch rates.

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Timor Reef and Demersal Relevant	TRD-112 and Attachment AI	19/06/2017	Santos email: Pleased find attached our response to your email 2/6/2017 TRD-101 and attachment AE.	As detailed in Section EP Section 7.1.2 Seismic Underwater Noise ï Area that Might be Affected by Hazard the 24hr period for SELcum is appropriate for the Bethany survey because: The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time period. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours. Given the Bethany survey plan, the time period before the vessel is again in proximity to a specific location will be greater than 24 hrs. As such, assuming a stationary receptor experiences TTS on one pass, it will have at least 24 hours until the possibility of receiving another SEL that could induce TTS. Since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures (Popper et al. 2005).
Timor Reef and Demersal Relevant	TRD-109	16/06/2017	Santos Email: Thank you for working with us to our agreed position. Please find attached a draft Fisheries Management Agreement for the Bethany Seismic Survey. I ask for 2 actions: 1) Considering the Agreement. Please complete those items in yellow highlight/square brackets. 2) If the substantive terms of the agreement are acceptable, to allow us to confirm to NOPSEMA that we have an agreement. Could you confirm by return email that: ÂWe have an agreement with all the relevant commercial fishers about the potential impact of the Bethany seismic survey upon them. ÂThe licensees have agreed that the survey will have an acceptable impact on them subject to Santos complying the agreement now being circulated for all the parties to execute ÂThe parties have agreed all the substantive terms of the agreement, including the terms of any payments for the commercial fishing licensees loss of catch, relocation costs and engagement costs ÂThe parties have agreed on their communication and ongoing consultation during the survey ÂThe parties have also agreed on dispute resolution mechanisms under the agreement should they be needed, including referring their disputes t[redacted] fisheries economist, CSIRO.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Timor Reef and Demersal Relevant	TRD-110 and attachment AH	16/06/2017	[redacted] email: With regard to your statement for NOPSEMA and the impact of the survey on the fishery, I was under the understanding this deed was about compensation for loss not impact to fishery. With regard to impact I believe [redacted] is waiting on further information to fully access. I am concerned the deed that has been drafted is not our agreed position. Example: 4.2 Santos will make payments to each Licensee for each month there is a loss of catch suffered by that Licensee where that loss of catch can reasonably be assessed to have been suffered as a result of the seismic survey (a) All monthly payments will be based on a calculation of what the Licensee would have caught in the Survey Area in that month ñbut forò the seismic survey. Issue: 1) We dealt with this issue and agreed not to include ï How did it get back in? 2) How would it even be assessed under the compensation method we agreed too. I.e. Providing Santos Catch Disposal Records? Example: Schedule 2 ï 2017 Actual Rate per month. I am not sure why 2017 has been added to wording. This wording should be returned to what we agreed. Schedule 2 does not provide a method of calculation to compensate for an adjustment to gear etc. as I requested in my email yesterday. We are working on tonight and will hopefully come back to you tomorrow but could be Monday with our full review. Santos email 17.06.2017: Our drafting was intended to match the agreed position, I apologise if it does not appear that way. Can I suggest we work through the document with a page turn on Monday afternoon? [redacted] email 19.06.2017: We are working on. I will get something to you first then look at telephone conference. I do suggest your lawyers look at what we agreed as per attached. Can you please provide method of adjustment you advised [redacted] would be better at explaining as per my email last week. This is imperative to determine baseline data period as you are aware. Santos email 19.06.2017: Thank you. We look forward to hearing from you	Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Timor Reef and Demersal Relevant	TRD-110 and attachment AH (continued from above record)	16/06/2017	[redacted] email 19.06.2017: I finished with our solicitor half hour ago. I am waiting on wording but I have a meeting shortly and wonõ be able to finalise tonight. Can you please provide calculation method as soon as possible so I can finalise first thing in the morning.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
AMSA	AMSA-2	15/06/2017	Santos email: Please find attached a revised notice to mariners for the upcoming 3D marine seismic survey we will be conducting in the Bonaparte Basin. Further to my previous correspondence, the timing for the vessels arrival has slipped and is now expected into Darwin port around the 21st June.	Notification of revised commencement date for Bethany Survey
Australian Hydrographic Service (AHS)	AHS-2	15/06/2017	Santos email: Please find attached a revised notice to mariners for the upcoming 3D marine seismic survey we will be conducting in the Bonaparte Basin. Further to my previous correspondence, the timing for the vessels arrival has slipped and is now expected into Darwin port around the 21st June.	Notification of revised commencement date for Bethany Survey and provision of information for Notice to Mariners.
Timor Reef and Demersal Relevant	TRD-108	15/06/2017	[redacted] email: Further to our discussion we agree with wording you proposed for mediation: ñIf the parties are unable to agree within 5 Business Days, the parties will request a report to be prepared by the independent relevant expert ([redacted] Fisheries Economist, CSIRO). The report will be distributed to both parties. If after the receipt of the independent relevant expertõs report and after a further 5 Business Days the parties are unable to agree, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council.òI believe the only other term we need to finalise is data. As I advised we request further clarity around method that would be used to calculate variance in averages if for example major changes occur such as in a vessel change or the Conoco Philips seismic survey. A working example would may be advisable using an illustrative change of 15% from year 1 compared to years 2/3. As per your suggestion, given we should only have dates for data to finalise please prepare draft deed for review. Santos email: I will instruct our legal colleagues to prepare a document for execution. Alongside this we will prepare some information on the process to define the average catch rate given the known variables.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Timor Reef and Demersal Relevant	TRD-108	14/06/2017	[redacted] Email: Sorry for the delay back on firm ground today. If I can just deal with independent mediator/expert today please. I believe there is 2 aspects with 1 being adjudication and the other providing both parties sufficient information to make a decision. I therefore suggest: ñIf the parties are unable to agree within 5 Business Days, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council. If the dispute relates to a matter of scientific issue then the parties will request a report to be prepared [redacted] CSIRO, which report will be distributed to both parties prior to the mediation being conducted.ò As discussed, once I have spoken to other stakeholders today I will revert with any other issues. Santos email: In our call we discussed the sequential nature of the process. i.e. The relevant independent expert reporting before the engagement of a mediator. [redacted] and I have conferred, we propose the following text: ñIf the parties are unable to agree within 5 Business Days, the parties will request a report to be prepared by the independent relevant expert [redacted] Fisheries Economist, CSIRO). The report will be distributed to both parties. If after the receipt of the independent relevant expertõs report and after a further 5 Business Days the parties are unable to agree, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council.òPlease indicate if this is agreed. We look forward to the outcome of your discussions with the other stakeholders.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Timor Reef and Demersal Relevant	TRD-107	8/06/2017	[redacted] Email: Can you give me update on when we might get info on TTS and SELcum? Santos email: I have been having to work on something else the last few days. At this stage it maybe Monday before I can reply. [redacted] email: I am sure you will understand my growing concern around this issue. First we had a citation that doesn't exist and then a new rationale for the SEL24 period. On the 26th May I pointed out that this made no logical sense and needed reviewing. Due to the nature of claims being made I have made my own inquiries into this matter. There is no point hiding my surprise in that the 24hr period is not related to either of the reasons provided. Further its simply not relevant for fish and the environment on which they depend. I have previously outlined the timeframes which would seem more relevant. These could perhaps be refined if we are provided with the requested survey lines.	Santos replied TRD-112. The citation "ñThe SEL metric integrates noise intensity over the period of exposure. Because the period of integration for regulatory assessments is not well defined, for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, which is applied in this risk assessment.ò was removed from EP Section 7.1.5.3.2. As detailed in Section EP Section 7.1.2 Seismic Underwater Noise ï Area that Might be Affected by Hazard the 24hr period for SELcum is appropriate for the Bethany survey because: The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time period. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours. Given the Bethany survey plan, the time period before the vessel is again in proximity to a specific location will be greater than 24 hrs. As such, assuming a stationary receptor experiences TTS on one pass, it will have at least 24 hours until the possibility of receiving another SEL that could induce TTS. Since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures (Popper et al. 2005).
Timor Reef and Demersal Relevant	TRD-106	7/06/2017	[redacted] email: Not sure of the relevance regarding my comment on apparent disparity between risk types. In any event it is certainly agreed that any mortality caused is consistent with the longer timeframe >12 months. Can you confirm how such impacts are being confined to a localised area? Can you outline expected time frame to receive responses on TTS and issues surrounding SEL24hrs. Santos email: The extent of potential impact was assessed as localised based on: ÅThe sound exposure threshold for mortality and potential mortal injury for fish with a swim bladder is predicted to be exceeded within a distance of <210 m from the seismic source when at full power (EP Table 7-7). ÅIf 210 m is applied to the boundary of the full power zone (where the seismic source is at full power) this is the furthest that the sound exposure threshold for mortality and potential mortal injury for fish with a swim bladder is reached for the survey. This area (full power zone plus 210m) is within the operational area for the survey. ÅUsing EP Table 6.3 Environmental Consequence Classification, localised is described as within the operational area. Santos email: Am collating our response and will get to you in next 24 hrs. [redacted] email: Like the duration it would seem you are still considering survey not risk / impact. The extent of the impact will of course be related to biological parameters - stocks etc. Of serious note if your extent criteria was correct this would pose serious threats to whole populations.	As per EP Section 7.1.5.3.2 Fish TTS - The extent of potential impact was assessed as localised based on: ÅThe sound exposure threshold for mortality and potential mortal injury for fish with a swim bladder is predicted to be exceeded within a distance of <210 m from the seismic source when at full power (EP Table 7-7). ÅIf 210 m is applied to the boundary of the full power zone (where the seismic source is at full power) this is the furthest that the sound exposure threshold for mortality and potential mortal injury for fish with a swim bladder is reached for the survey. This area (full power zone plus 210m) is within the operational area for the survey. ÅUsing EP Table 6.3 Environmental Consequence Classification, localised is described as within the operational area.
Pearl Producers Association	PPA-15 and Attachment AG	6/06/2017	Santos email: As per our phone conversation in relation to the Bethany Seismic survey and that [redacted] would like more information in regards to potential impacts to broodstock, please find attached information from the Bethany Seismic Survey Environment Plan relevant to the Pearl Oyster Fishery. If you or [redacted] would like to meet or have a phone hook-up to go through the information please let me know. We are looking at commencing the survey early July and I need to confirm the controls below in relation to if they are planning any diving operations during the period of the survey (July- Sep 2017).	Provision of information from the EP in regards to the Pearl Oyster Fishery including EP Section 7.1.5.1 Plankton and 7.1.5.2.3 Molluscs detailing assessment of seismic noise impacts to pearl oyster shell spawning and broodstock and potential impacts provided to PPA.
Pearl Producers Association	PPA-16	6/06/2017	PPA email: Acknowledging receipt of information and would respond as soon as possible.	For information.

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Timor Reef and Demersal Relevant	TRD-105	6/06/2017	[redacted] email: There has been a significant change to the risk assessment for fish. It would be greatly appreciated if you could outline why the impact has moved from short term to long term as I am not clear why the change was made. Santos email: The change was made based on your feedback (that seismic noise impacts to fish were assessed at the same level as light impacts to turtles) at the workshop. The change from short term to long term reflects the proposition that if the impact of mortality occurred, it would be in a localised area but potentially over a longer period, hence the change to long term (greater than 12 months). Other changes are: ÅAdded information provided by the NT Dept. of Primary Industry & Resources (Fisheries) regarding the area of overlap between the survey area and TRF and Demersal Fishery (Section 5.6.3.1, 5.6.3.1 and 7.1.5.3). The Dept. said that you had seen this data. ÅA reduction in the seismic source from a 3480 cubic inch (cui) source to a 2380 cui. As shown in Table 7-7, this will reduce the distance where the sound source levels exceed the mortality and potential injury threshold by between 5 m to 45 m, depending on water depth. Change made as smaller source would still meet survey objectives and further reduced the area of potential impact. ÅUpdated throughout the EP that the TRF and Demersal fisheries do not have a low period of activity and that peak spawning is from Sept to May. Based on feedback from yourself and [redacted] ÅUpdated the controls for Seismic Noise (Table 7-16) and Marine Users Interactions (Table 7-24) to reflect the Loss of Catch Payment and Relocation Expenses Payment process being discussed between Santos and [redacted]	Stakeholder requested information in regards to changes made in the Bethany EP Rev 1. Information on the changes was provided to stakeholder as per stakeholder record.

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Timor Reef and Demersal Relevant	TRD-108	6/06/2017	Santos email: Please find attached our mark-ups (Column I). We have specifically termed: [redacted] a CSIRO Marine Resource Economist who can act as an independent expert. [redacted] Chief Executive, Dept. of Primary Industry and Resources, NT Government as the person who can release fishing location data to us. Please indicate if these terms are agreed. [redacted] Email: If I can just deal with independent mediator/expert today please. I believe there is 2 aspects with 1 being adjudication and the other providing both parties sufficient information to make a decision. I therefore suggest: ĩIf the parties are unable to agree within 5 Business Days, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council. If the dispute relates to a matter of scientific issue then the parties will request a report to be prepared [redacted] CSIRO, which report will be distributed to both parties prior to the mediation being conducted.ò As discussed, once I have spoken to other stakeholders today I will revert with any other issues. Santos email: Thank you for your note and time on the phone earlier. In our call we discussed the sequential nature of the process. i.e. The relevant independent expert reporting before the engagement of a mediator. We propose the following text: ĩIf the parties are unable to agree within 5 Business Days, the parties will request a report to be prepared by the independent relevant expert ([redacted] Fisheries Economist, CSIRO). The report will be distributed to both parties. If after the receipt of the independent relevant expertõs report and after a further 5 Business Days the parties are unable to agree, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council.ò Please indicate if this is agreed. [redacted] Email: Further to our discussion we agree with wording you proposed for mediation: ĩIf the parties are unable to agree within 5 Business Days, the parties will request a report to be prepared by the independent relevant expert ([redacted] Fisheries Economist, CSIRO). The report will be distributed to both parties. If after the receipt of the independent relevant expertõs report and after a further 5 Business Days the parties are unable to agree, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council.ò I believe the only other term we need to finalise is data. As I advised we request further clarity around method that would be used to calculate variance in averages if for example major changes occur such as in a vessel change or the Conoco Philips seismic survey. A working example would may be advisable using an illustrative change of 15% from year 1 compared to years 2/3. As per your suggestion, given we should only have dates for data to finalise please prepare draft deed for review.	Fisheries Management Agreement for the Bethany Seismic Survey updated to included the agreed terms - If the parties are unable to agree within 5 Business Days, the parties will request a report to be prepared by the independent relevant expert ([redacted] Fisheries Economist, CSIRO). The report will be distributed to both parties. If after the receipt of the independent relevant expertõs report and after a further 5 Business Days the parties are unable to agree, the matter is to be referred to a mediation to be conducted by an accredited mediator appointed by the President of the Victorian Bar Council. Ongoing discussions in regards to compensation package. See latest information in TRD-111.
			Santos Email: [redacted] Thank you for your note. I will instruct our legal colleagues to prepare a document for execution. Alongside this we will prepare some information on the process to define the average catch rate given the known variables. We will be in touch again soon. Regards, [redacted]	

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Timor Reef and Demersal Relevant	TRD-101 and attachment AE	2/06/2017	[redacted] email: Please find attached our understanding of TTS impacts and likelihood at this time. There is also a request for some additional information with regards to SELcum. It would be great if you could confirm our understanding and also indicate when the additional information may be available. Santos email 02.06.2017: Thanks for this information. I will review and respond next week. [redacted] email 02.06.2017 - My feedback on the SEL24hr was that the citation relied on didn't exist. I have also outlined why this new reasoning is also incorrect so was little surprised to see it in new report. I am not comfortable with the approach of trying to defend the 24hr period with new reasons instead of addressing the issue raised. If SANTOS is not willing to consider SELcum with longer time periods then please just let us know. Whilst I have provided this information previously perhaps your review of this material on TTS will clarify my concerns and I look forward to your response.	Santos replied TRD-112. The citation "ñThe SEL metric integrates noise intensity over the period of exposure. Because the period of integration for regulatory assessments is not well defined, for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, which is applied in this risk assessment.ò was removed from EP Section 7.1.5.3.2. As detailed in Section EP Section 7.1.2 Seismic Underwater Noise ï Area that Might be Affected by Hazard the 24hr period for SELcum is appropriate for the Bethany survey because: The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time period. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours. Given the Bethany survey plan, the time period before the vessel is again in proximity to a specific location will be greater than 24 hrs. As such, assuming a stationary receptor experiences TTS on one pass, it will have at least 24 hours until the possibility of receiving another SEL that could induce TTS. Since a seismic survey vessel is moving, a stationary receptor is exposed to the maximum sound level once in a sequence of exposures (Popper et al. 2005).
Timor Reef and Demersal Relevant	TRD-102 and attachment AF	2/06/2017	[redacted] email: - Thanks for your and [redacted] time this morning. I am sorry it took so long but a couple of items required agreement and wording is important obviously.	Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Timor Reef and Demersal Relevant	TRD-104	2/06/2017	[redacted] email 02.06.2017 - I contacted JASCO directly to clarify an issue in new sound report and this seemed to raise concerns. Apologies if I have breached protocols. Santos email 02.06.2017 - Jasco is contracted to Santos and as such are not able to discuss information in regards to work under that contract without our approval. Hence, their concern when you contacted them directly. Jasco also commented that you asked whether Santos had made them write information in the Jasco Noise Modelling Report for Fishburn and Bethany. This, I believe was in relation to the TTS recoverable period of 18-24 hours attributed to Popper et al. (2014). Santos, based on feedback from you, asked Jasco to update the modelling report to explain why they used a 24 hr period for modelling of SELcum and why this 24 hr period was applicable for the Bethany survey. Jasco, as an international underwater noise modelling and assessment consultancy, typically use 24 hrs for SELcum, and based on the Bethany survey design had independently assessed that it was an appropriate period to assess SELcum for the Bethany survey. If there are further points you would like clarified in the Jasco report, please let me know and I will work with Jasco to provide you the information.	Stakeholder contacted Jasco directly to ask about Santos modelling for the Bethany Survey. Stakeholder informed that Jasco is contracted to Santos and as such are not able to discuss information in regards to work under that contract without our approval and if there are further points requiring clarification in the Jasco report to let Santos know and will get Jasco to provide the information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-59	1/06/2017	NTDPIRF email: Here is the final report (Optimising the Management of Tropical Reef Fish through the Development of Indigenous Scientific Capability) for work conducted on Golden Snapper, Black Jewfish and Grass Emperor demonstrating fine-scale population structure. Apologies this took so long to publish. Santos email 02.06.2017: Will have a look at in light of our upcoming seismic survey and impact assessment undertaken.	Report reviewed. The three fish species reviewed are at very low catch rates within the survey area. From the survey area black jewfish makes up 0.16% of the TRF catch, golden snapper - 0.03% and grass emperor - 0.03%. The report detailed that the black jewfish stocks had genetic connectivity at the scale of hundreds of kms, golden snapper and grass snapper demonstrated genetic connectivity over hundreds to thousands of kms. Thus impacts from the survey are unlikely to these species based on their low abundance within the survey area.

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Timor Reef and Demersal Relevant	TRD-103	1/06/2017	[redacted] email: [redacted] is not able to email today but is chasing a little information on the seismic vessel tracks. We have spoken at our meetings about a voyage plan being developed for this survey but my understanding is this has not been finalised. If you could please provide an interim voyager plan, confirm size of arc when vessel turns to track back and confirm the distance between the tracks when the vessel travels back and forth ï i.e. Track 1 heading east, Track 2 heading west, what would the distance be between the tracks. Santos email 02.06.2017: I spoke to the project team and they are working on the seismic line information but will be able to provide some information which I will pass onto you once I obtain.	Santos replied TRD-112. Distance between tracks is ~5 km.
ConocoPhillips	CoP-8	30/05/2017	CoP email: Notification to Santos that they will be undertaking marine surveys, including environmental and/or geophysical scopes between the NT/RL5 permit area and Darwin. Survey will commence in July and nominally taking 25 days to complete. If there will be overlap with the Bethany survey, how best to coordinate any required SIMOPS with our contractor and yourselves. Could you please provide me with a contact name and we will enquire further with them. Santos email 31.05.2017: Provided Bethany Project Manager details. CoP email 31.05.2017: Provided details of the Project Lead for the geophysical survey, Who will contact Bethany Project Manager.	The Project Managers/Leads for Santos and CoP are engaged to coordinate the respective surveys. As per EP Section 4.1 Ongoing Consultation CoP will be provided with a daily report during the Bethany survey.
Timor Reef and Demersal Relevant	TRD-100 and attachment AD	30/05/2017	[redacted] email: I have been informed that your Environment Plan was resubmitted yesterday. Could [redacted] update the dropbox to the latest version of the Environment Plan please. Awaiting your response in relation to the compensation package. Santos email 30.05.2017 - I can confirm the EP document was re-submitted Monday evening. We will update the Dropbox. Re: Compensation. [redacted] and I are confirming a few items, we will respond very soon. Santos email 31.05.2017: Please find in the attached spreadsheet our response on the make good terms. I believe we are close to agreement. If the terms are acceptable I will instruct my legal colleagues to prepare an agreement. [redacted] email 31.05.3017: We have started to review. Could you please clarify position on 36 months to calculate average data. We have all discussed this and prior to Conoco Philips survey as you know the trawler was working for 12 months and [redacted] new vessel for approximately 24 months. Hence this is why options for average data of 12 to 24 months were proposed. Santos email 31.05.2017: Thanks for your call earlier. As promised a response to your note sent this morning. We understand through our discussions that there have been changes in equipment, technique and vessels in the fishery. To ensure a robust long-term average is agreed upon the more complete long term data set used the better. This could be shown as: Åaverage catch per month per licence from June 2014 Åfishing effort ï days fished/traps (per licence) Åannotation to indicate at what times new equipment/technique/vessel were implemented Upon reviewing these data we can then discuss what the appropriate long-term average should be. I have amended the text in the term sheet to accommodate where less than 36 months of data is available in any licence. I hope that we can bring this to a conclusion before your trip next week. I have access to email and phone Thursday and Friday, but I am working away from the office.	Bethany EP Rev 1 provided in dropbox on 1/5/2017. Ongoing discussions in regards to compensation package. See latest information in TRD-111.
Timor Reef and Demersal Relevant	TRD-98	30/05/2017	[redacted] Email: Following up on [redacted] email sent 24/5/2017 (TRD-94) Santos email (25/5/17): Thank you for this, much appreciated. I will review with [redacted] on Friday. [redacted] email (28/5/17): Can you let me know how your discussions with [redacted] regarding this went on Friday please. [redacted] email (30/5/17): We really need to keep this moving if we are going to have a chance of completing within your projected time frame of end of June/Beginning of July. Please advise status of your discussions with [redacted] regarding finalising terms for the compensation package. I also note that [redacted] and [redacted] have been corresponding on Environmental Plan issues and request an update on where Santos is at with this process and projected timeframes for lodgement of revisions to NOPSEMA.	Santos Bethany EP Rev 1 and Jasco Modelling Report Rev 2 as submitted to NOPSEMA provided in dropbox. Ongoing discussions in regards to compensation package. See latest information in TRD-111.

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Timor Reef and Demersal Relevant	TRD-99	30/05/2017	[redacted] Email: Having reviewed the recommendations on setting metrics for SELcum it would seem prudent to look at several time periods. I am not certain of the practicalities of JASCO modelling but can you inquire if it is a simple process to alter this metric. Santos email: In relation to your concerns about using the 24hr SEL I am talking to Jasco modelling and will get back to you with a response by Thursday. [redacted] email: To avoid repeating ourselves can you outline what you are discussing with Jasco. There are clear recommendations re SELcum in Popper 2014 and it would be helpful to know these are being addressed. Santos email 31.05.2017 - The SEL24 measures the cumulative sound levels of shots within the 24 hour time period. I am presuming you are asking if we can do this over a longer time period? I have spoken to Jasco and this is not a simple process and hence Jasco modelled the SEL24 for two scenarios (eastern and western) rather than using a straight line for the 24 hr calculation. Jasco did the assessment from the middle point of the survey so that the 24 hr period includes two line passes rather than one for each scenario (see below which is Figure 5 from the Jasco report). Thus the SEL24 result is an accumulation of the received sound levels for two lines. With each line the seismic source is moving further away from a fixed receptor, and hence received noise levels are reducing, thus the potential for impact is also reducing. For receptors that are not fixed, whether they are exposed to the cumulative sound over a 24 hr or longer period will depend on their behaviour as to whether they stay in the vicinity of the sound or move away. In applying the SEL24 threshold distance to the Bethany assessment we used the furthest distance from the two scenarios to be conservative. [redacted] email: I asked that the measure be reviewed and relevant and this will need consideration of shorter and longer time periods. The information you have provided is all already in the EP and I can only apologise if I have failed to explain/clarify my concerns. As a suggestion perhaps you could ask JASCO for sound level contour maps for SEL 2hrs and one for SEL 84 hrs. Both can be started at center of survey as outlined. I would hope you agree on seeing these results that also important would be some longer SELcum values up to and including 75 days. While appreciated, using the furthest distance from the two scenarios the SEL24 threshold distance provides no conservatism while the time period is not more relevant. In fact the 24hr period seems to greatly down play the risks from repeated runs.	Santos obtained advice from Jasco in regards to the suitability of using 24 hrs to assess sound exposure levels for temporary threshold shift. The justification for SEL24 is included in the Jasco Noise Modelling Report and is summarised in EP Section 7.1..2. Popper et al. (2014) summarised that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours. Given the survey plan, the time period before the vessel is again in proximity to specific location will be greater than 24 h. As such, assuming a stationary receptor experiences TTS on one pass it will have at least 24 hours until the possibility of receiving a SEL that could induce TTS can occur again. Jasco modelled the SEL24 for two scenarios (eastern and western) rather than using a straight line for the 24 hr calculation. Jasco did the assessment from the middle point of the survey so that the 24 hr period includes two line passes rather than one for each scenario. Thus the SEL24 result is an accumulation of the received sound levels for two lines. With each line the seismic source is moving further away from a fixed receptor, and hence received noise levels are reducing, thus the potential for impact is also reducing. For receptors that are not fixed, whether they are exposed to the cumulative sound over a 24 hr or longer period will depend on their behaviour as to whether they stay in the vicinity of the sound or move away.
AMSA	AMSA-1 and attachment AM	29/05/2017	Santos email: Please find attached details of upcoming seismic survey to be acquired by the Polarcus Naila on behalf of Santos Offshore Pty Ltd Please do not hesitate to contact me should any additional information be required.	Notification of revised commencement date for Bethany Survey
CSIRO - Marine Resource Economics Team	CSIRO-2	29/05/2017	Santos email: We are currently finalising documentation for the proposed seismic survey and would like to include a summary of your review of the proposed Fisheries Interaction framework. Key points I took from our conversation last week were that: ÅThe proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries; ÅCatch rates are an appropriate mechanism to understand any impact; ÅThe operational relocation expense makes perfect sense to cover additional cost. Would you be comfortable responding to confirm that this is consistent with our discussion. CSIRO email: This is a good summary of the main points so happy for you to use it.	In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries.[redacted] from the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.

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Timor Reef and Demersal Relevant	TRD	29/05/2017	Stakeholder engagement post EP Rev 1 submission on 29th May 2017.	
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-58	26/05/2017	NTDPIRF email: please refer to the table below for the extra information on catch rates by the Trap and Trawl boats in the Timor Reef Fishery. [redacted] explained to me that he had originally calculated from the full operational area rather than the survey area plus the buffers around this area. These include adding 2km on each end of the survey area for turning around and two buffer scenarios 1/. The mortality zone which is a 210 m buffer and the TTS buffer for hearing impairment of 3.6 km. Please be advised that changes in catch rates for the fishery is considered by industry and us to be a poor metric to use to detect impacts of seismic surveying. From a fisheries perspective we remain concerned about the potential for seismic surveys to have both direct and indirect impact on fish resources and that we would encourage a robust process that provides for thorough, appropriately scaled, exploration of risks and risk mitigation strategies. Please liaise with [redacted] if further discussion or clarification is required, Santos email: Thanks for this data. Could you please confirm that is has been run by [redacted] I had asked [redacted] if he could update the attached table with the updated data so we can also understand the level of activity of the other fishers in the area. He was also going to add in the pearl oyster fishery as we need to understand their level of activity in the area. Could you let me know where this information is at. If it is not available for today could you confirm the level of activity for the Pearl Oyster Fishery for 2015 and 2016 in the area. As detailed in our Bethany Environment Plan we have taken the Departmentõs and the fisherõs concerns in regards to the potential direct and indirect impacts to fish resources into account in our assessment of the seismic survey. We have implemented the following mitigation strategies to reduced potential impacts: ÅOn advice from the Department we had planned the survey timing to be outside the commercial fish main spawning period of October to May. However, we have now been told by the fishers that this period is September to May. If you have further information on when the main spawning seasons starts that would be helpful. ÅWe also had planned the survey to try to coincide with the commercial fishing low activity period from mid-June to August. However, the fisher state that there is no low period. Would you have monthly aggregated data that shows fishing trends throughout the year? ÅWe have also recently dropped the sound source size which will reduce the area of where mortality and TTS thresholds are exceeded. ÅWe have also committed to a catch loss payment and operating cost payment to ensure fishers are no worse off if potential impacts eventuate. NTDPIRF Email: Following on from our conversation this morning, I can confirm that the data provided in the table below are representative of recent catches and have been shown to [redacted] I can also confirm that the reason why no other fisheries were included in this table is because the recent catch taken by them in the operational area is negligible. This includes pearl oysters.	Information provided by NTDPIRF. Based on this information the following sections of the EP were updated. EP Section 7.1.5.3.1 Seismic Noise Fish Mortality. Based on data from the NTDPIRF the area of potential mortality impacts is within the area of the Timor Reef Fishery where 5 ï 12% of their catch has been caught based on data from 2011 to 2016 (Table 7 9). EP Section 7.1.5.3.2 Seismic Noise Fish TTS Based on data from the NTDPIRF the area of potential impact is within the area of the Timor Reef Fishery where 8 ï 16% of their catch has been caught based on data from 2011 to 2016 (Table 7 10). In regards to Dept. statement that changes in catch rates for the fishery is considered by industry and us to be a poor metric to use to detect impacts of seismic surveying. Issue raised about if catch rates can be used to show impacts for seismic surveys. Fish catch data for the period that the CoP seismic survey occurred has not been entered yet by the Dept. The fishers have referenced impacts to catch in regards to impacts from the CoP survey (TRD-9, TRD-50, TRD-55) thus catch rates would be able to be used to identify any impacts from the Bethany survey. Santos has also engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries,[redacted]rom the CSIRO. His view is that catch rates are an appropriate mechanism to understand any impact (CSIRO-2).
Pearl Producers Association		26/05/2017	Phone call from PPA. Had spoken to [redacted] who had raised concerns around potential impacts from the survey on the pearl oyster shell brood stock in the area of the survey. Would follow-up with Santos next week as unavailable.	EP Section 7.1.5.1 Plankton and 7.1.5.2.3 Molluscs assess seismic noise impacts to pearl oyster shell spawning and broodstock and potential impacts have been assess as ALARP and acceptable. Information from the EP will be made available to PPA.

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Timor Reef and Demersal Relevant	TRD-96	26/05/2017	TRD email: Can you please just clarify for me how the results of the risk assessment process are utilised. Demonstrating Acceptability My understanding is that in relation to demonstrating acceptability the risk assessment outcomes are used as follows; ÅA Level 5 residual risk is intolerable and must not be accepted or approved by Management. ÅA Level 2 ï 4 residual risk is acceptable provided that ALARP has been achieved and demonstrated. ÅA level 1 residual risk is acceptable and it is assumed that ALARP has been achieved. Demonstrating the principles of ESD are met Level 1-4 residual risks are used to demonstrate that the principles of ESD are met Is there additional material to this or are the principles of ESD built into consequence table? Santos email: Section 6.10 Determination of Impact and Risk Acceptability details how the residual risk levels are used as per your points under Demonstrating Acceptability. The assessment of acceptability, which includes the principles of ESD, is in the Risk Assessment tables in each Hazard Section in Section 7.	Response in TRD-95 detailing that the assessment of acceptability, which includes that the principles of ESD, is in the Risk Assessment tables in each Hazard Section in Section 7.
Timor Reef and Demersal Relevant	TRD-97	26/05/2017	TRD email: Whilst I thank you for your responses to date it is fair to say I am becoming increasingly concerned with the process. In relation to your response to citing of recommendations from Popper re SELcum I think it should be noted we are very concerned with the nature of such a claim and now further with the response. The claim is repeated in your EP using the same citation. ñPopper et al. (2014) recommended a sound exposure criteria for TTS for fish with a swim bladder involved in hearing of >> 186 dB 24 h SEL and 186 dB 24 h SEL for fish with a swim bladder not involved in hearing (Table 7 5) The SEL metric integrates noise intensity over the period of exposure. Because the period of integration for regulatory assessments is not well defined, for sounds that do not have a clear start or end time, or for very long-lasting exposures, Popper et al. (2014) recommend an integration time of 24 hours, which is applied in this risk assessment.ò The citation never existed and now the 24hr metric is being portrayed as an industry standard. This is defended by a statement that ñn all cases fish that showed TTS recovered to normal in 24hrs. Therefore, ñthe 24hr metric is used as an industry standard.ò The recovery time for TTS is simply not known. The exposure you refer to is a SELcum of 186 dB re 1 εPa 2 Ls accumulated over ýve seismic pulses within about ýve minutes. It is agreed these fish all recovered in 24 hrs, but as Popper clearly states has little relevance to fish experiencing the same SELcum in 5 shots in 40s. To use this number to suggest that fish recover from TTS in 24hrs in all cases is simply misleading. We would expect fish subjected to the SELcum criteria to be the quickest to recover. However the range of impacts as we approach the source will be vast and no estimates of recovery can be made. Even if we had a known recovery time its not clear of the relevance in selecting metric for SELcum. It would be greatly appreciated if this issue can be properly reviewed as the cumulative impacts are of great concern to industry.	Addendum 3 Santos Bethany and Fishburn Seismic Survey JASCO Noise Modelling Report Section 2.2 Fish, Turtles and Plankton updated to detail why the 24 hr metric used for SELcum. No change to the modelling outcomes or how the SEL24 hr applied to the assessment of TTS in EP Section 7.1. EP Section 7.1.2 updated to include information as to why 24hr metric applicable.
CSIRO - Marine Resource Economics Team	CSIRO-1 Attachment AC	25/05/2017	[redacted] from CSIRO was identified by Santos as an independent expert marine resource economist specialising in bioeconomic models for fisheries, to advise on the acceptability of the payment model Santos is proposing to fishers who are impacts by the surveys activities. [redacted] was provided a copy of the Draft Fisheries Interaction Management Framework and the latest review of the payment terms with Santos and fishers comments, for him to review and provide comment to ensure that whatever approach is finally agreed is fair and reasonable to all parties.	For information.
Pearl Producers Association	PPA-13 and attachments Z & AA	25/05/2017	Santos email: We had identified that [redacted] may be undertaking diving to collect pearl oyster shell in or near the area of the Bethany seismic survey which we are planning to commence in July 2017. Map attached showing survey area and Pearl Oyster Area. If they are going to be working in the area when the survey is occurring we will need to put in place some controls as per the DMAC Safe Diving Distance from Seismic Surveying Operations ï attached. NOPSEMA have asked to see that PPA and [redacted] agree with the following controls. ÅWhere pearl diving and seismic activity is within 10 km of each other, a joint risk assessment will be conducted. ÅWhere possible, concurrent seismic and diving activities will be avoided. If this is not possible, the activities will be prioritised and a simultaneous operations (SIMOPS) plan will be developed. If there is likely to be diving taking place we will need to work through the risks and develop a simultaneous operations. Can you let me know if you and [redacted] are okay with these controls and will be able to meet to develop a plan. How far out will [redacted] know if they will be diving in that area between July to end Sept. If we could know soon we can arrange to meet to develop the SIMOPS plan. Could you let me know if this is acceptable as soon as possible.	Provision of information to agree controls if diving for pearl oyster shell to occur while the seismic survey is being undertaken.

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Pearl Producers Association	PPA-14	25/05/2017	PPA email: I am also hard to get hold of past two weeks as I am attending an inquest. I will try an call you today when either the court breaks for lunch or adjourn for the day. Santos email: I have been speaking to the NT Dept. of fisheries and they state that there has been no fishing effort in the area overlapping our survey since 2008. I really need to confirm this. Either way can you confirm that if there is fishing in the area that you are okay with the controls I have put into the EP.	For information.
Timor Reef and Demersal Relevant	TRD-95 and attachment AB	25/05/2017	Santos Email: Please find attached our response to your review of the EP risk assessment and likelihood of events. TRD email: Thanks for response. Can you let me know if SANTOS always uses the same consequence tables? I will review your responses ASAP and provide comment. Santos Email: The consequence table in the EP is what we use for our offshore activities. TRD Email: In your response 25 May you state; "Seismic surveys have been undertaken in the area of the TRF over similar habitats and no mortality to fish have been identified from these surveys including the Santos survey in 2006 and the most recent ConocoPhillips survey." Can you outline/provide the data that was considered to reach this conclusion about fish mortality in both these surveys. Santos Email: Discussions with ConocoPhillips confirmed that no dead fish or any other fauna were reported by the Marine Fauna Observers on board the seismic vessel for their Barossa/Caldita survey. The Santos 2006 survey did not identify any mortality in fish, including the study undertaken by McCauley and Salgado Kent (2007) with goldband snapper in traps.	Requests for clarification in regards to mortality impacts to fish. Directed to the EP Section 7.1.5.3.1 which details the assessment of potential mortality impacts and Section 7.1.5.3.2. for impaired hearing leading to mortality. Further information provided on 25/5/17 (TRD-94) as to why Santos had rated the likelihood of mortality impacts as unlikely. There is a high level of certainty that mortality impacts from seismic surveys to fish will not occur based on the activity is not new or unusual. Seismic surveys are routine activities and no mortality impacts to fish have been identified. Seismic surveys have been undertaken in the area of the TRF over similar habitats and no mortality to fish have been identified from these surveys including the Santos survey in 2006 and the most recent ConocoPhillips survey. Based on that fish mortality has not been identified from a seismic survey, we used unlikely to be conservative rather than remote which requires exceptional circumstances for the consequence to occur. Popper (2014) pile driving data was used as a proxy because the research to date had not identified a threshold level were mortality has been observed. As detailed in Section 7.1.5.3.1 of the EP, since the thresholds were published Popper (2016) has undertaken further studies using a seismic source that showed no mortality at a maximum received level of 231 dB re 1 εPa (PK). Thus, actual data from a seismic source has shown no mortality at a level higher than the current published threshold.
Timor Reef and Demersal Relevant	TRD-91	24/05/2017	[redacted] email - Can you please given that the EP is supposed to be lodged on Friday when you are expecting to start the survey. Santos reply: I can confirm the EP is supposed to be lodged on Friday. The survey is expected to start in July.	For information.
Timor Reef and Demersal Relevant	TRD-92 and attachment Y	24/05/2017	[redacted] email: At our meeting May 12th a key area of discussion was in relation to the risk ratings applied to different environmental impacts. It was agreed that I would work our concerns through one example environmental risk so that you could understand and address our concerns. It seems SANTOSs priorities have now changed and you are seeking to resubmit your EP shortly. In any event, for us to consider possible impacts of your proposed trial on our interests we still need clarity around how these impacts are assessed. We have worked through the predicted impact of mortality and or injury leading to death for Fish. We believe we now understand how these predictions are made. What is contested is once established as a predicted environmental risk how SANTOS so readily concludes they would be unlikely events. Obviously the likelihood of any risk to fish is vital to our consideration of impacts. Attached is our overview and comments on the 3 points provided that have been used to refute the likelihood of predicted outcomes. Please can you consider the attached and if you agree with our comments please adjust likelihood ratings as applicable. If you still believe the impacts predicted in Popper guidelines are unlikely can you please detail your reasons. We have been given days to respond to your EP so a timely response would be much appreciated. Santos reply email: Thank you for this information and the time you have spent on it. I will have a response to you later tonight or in the morning.	Requests for clarification in regards to mortality impacts to fish. Directed to the EP Section 7.1.5.3.1 which details the assessment of potential mortality impacts and Section 7.1.5.3.2. for impaired hearing leading to mortality. Further information provided on 25/5/17 (TRD-94) as to why Santos had rated the likelihood of mortality impacts as unlikely. There is a high level of certainty that mortality impacts from seismic surveys to fish will not occur based on the activity is not new or unusual. Seismic surveys are routine activities and no mortality impacts to fish have been identified. Seismic surveys have been undertaken in the area of the TRF over similar habitats and no mortality to fish have been identified from these surveys including the Santos survey in 2006 and the most recent ConocoPhillips survey. Based on that fish mortality has not been identified from a seismic survey, we used unlikely to be conservative rather than remote which requires exceptional circumstances for the consequence to occur. Popper (2014) pile driving data was used as a proxy because the research to date had not identified a threshold level were mortality has been observed. As detailed in Section 7.1.5.3.1 of the EP, since the thresholds were published Popper (2016) has undertaken further studies using a seismic source that showed no mortality at a maximum received level of 231 dB re 1 εPa (PK). Thus, actual data from a seismic source has shown no mortality at a level higher than the current published threshold.

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Timor Reef and Demersal Relevant	TRD-93	24/05/2017	[redacted] email: The EP notes a recommendation in Popper 2014 to use 24hr metric for SELcum. Can you let me know page number for this recommendation. Santos reply email 25.05.2017: The reference to Popper 2014 is in the noise modelling report. While Popper 2014 did not specifically suggest a 24hr resetting period, they do point out that cumulative SEL may be defined over a standard period or for the duration of the activity, or over the total period that the animal will be exposed (Pg 27 Section 6.1.7). On page 45, Section 7.5.3, they state that ‘In all cases, fish that showed TTS recovered to normal hearing levels within 18ï 24 hours.ô Thus, within the industry 24 hours is used as this standard. I will ask the noise modelling consultant to amend the modelling report accordingly.	Addendum 3 Santos Bethany and Fishburn Seismic Survey JASCO Noise Modelling Report Section 2.2 Fish, Turtles and Plankton updated to detail why the 24 hr metric used for SELcum. No change to the modelling outcomes or how the SEL24 hr applied to the assessment of TTS in EP Section 7.1.
Timor Reef and Demersal Relevant	TRD-94	24/05/2017	[redacted] email: In response to TRD-87 with term sheet for compensation payment. Comments provided on term sheet - Please see the text within record.	Ongoing discussions in regards to compensation package. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] from the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost. The information required to implement the loss of catch and relocation expenses payments are available either from the fishers or NTDPIRF as is information the fishers would typically collect (operating costs such as of bait, fuel, wages) or required to collect for submission to NTDPIRF (catch disposal records, average catch rates per species and market price).

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-56	23/05/2017	NTDPIRF email: I've prepared all of the data for proportion of catch data that has occurred by year and gear in the survey area with the two buffer zones applied. You will probably receive this data from [redacted] as am just awaiting final clearance. From my perspective the most representative years are 2013 for trap data and 2016 for the trawl data. This is because 2013 represented the only year after the current quota limits have been implemented where there was no withdrawal of trapping activity to participate in trawling. 2016 is the best year for trawling as it is the only year where the activity was conducted for the full year. It is pertinent to remember that these figures are just what they currently catch- there is still more than 50% of their quota available to catch. I will not be in the office for the next few days and have been pulled into some other work that requires my attention so I have cc'd one of my staff [redacted] to assist you with any further enquiries. I've provided him with all the relevant background material you have provided me but you mentioned that you are resubmitting the EP this week, has it changed? If so could you provide a copy to [redacted]? Thanks. Santos reply email on 25.05.2017: [redacted] sent through this email on Tuesday implying that you were going to send through the data he had prepared for us. As we have not yet received it I was just following up. Could you let me know when we will receive as we are still wanting to resubmit our EP this Friday and was aiming to include the new data.	Data provided on 26/5/2017 (NTDPIRF-58)
Timor Reef and Demersal Relevant	TRD-89a	23/05/2017	[redacted] email: Thank you for response. Unfortunately, by ignoring the outcomes and intent of our workshop on the 13th May it is not open now to suggest you have somehow addressed our concerns. The result is now agreed positions are again contested and industry have wasted considerable time and effort. The outcome of the meeting was that we (fishers) work through an item in your risk assessment process to outline our concerns. I was to look at the impact of the survey on fish, the different predicted impacts and how these risks were assessed. Having commenced this work straight after the meeting we sought some clarification from you on Thurs 18th. At 9pm on Friday 19th instead of answering our query you stated that you were now reviewing the risk ratings and acceptability criteria after our workshop and we would get updated information early this week. At 11.36pm Sunday 21st May Mr [redacted] stated by email that some additional data from fisheries was being added to the EP and that some of the detail from our meeting was being corrected. For reasons unknown, our concerns were not to be addressed and a new EP submitted in 5 days. 10 Days after our workshop where we agreed a process to consider our concerns (in relation to risk analysis and risk ratings) SANTOS has unilaterally decided not to address them at all. The risks in the EP are identified using your sound modelling and guidelines in Popper 2014. Through selective citation you simply deem these predicted impacts unlikely. I am sure you would appreciate the extra information you have included in the EP were examples provided by us as to where this selective citation had occurred. Even before we consider the consequence table provided, for every predicted impact SANTOS has downplayed them to unlikely. Either we accept these guidelines or you need to provide alternates. We cannot support the use of these guidelines and then the use of limited and selected citations to suggest these impacts are unlikely. Such claims necessarily see the guidelines themselves reviewed. It is not clear how we could possibly consider the impacts on our interests from identified risks when SANTOS simply dismisses them as unlikely. In fact, it is now not clear what level of impact you are predicting to our interests. On Friday 12th May we worked through the problems regarding the soft start and fish's ability to avoid the survey. The EP is still very conflicting in relation to this issue. The EP predicts the fish can't avoid high impact areas yet still uses it for mitigation. This is compounded by a failure to address behavioural responses consistent with Popper. In fact there seems several important issues directly in conflict with advice from the guidelines. We still need more information in relation to the risk assessment that we will address in separate emails for clarity. It would however be greatly appreciated if you could confirm that you no longer wish to address these concerns regarding risk assessment, and its use in acceptability and sustainability before the EP is submitted. If this is not the case and our concerns are to be addressed can you outline an acceptable process as the one agreed by all parties on 12 May seems to now lack SANTOS support. The current flip flopping on agreed process is creating considerable unwarranted stress.	Santos response in TRD-89b.

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Timor Reef and Demersal Relevant	TRD-89b	23/05/2017	Santos reply email: Iôm sorry you feel we have ignored the outcomes and intent of the workshop we held with you (or any of our consultation with you) ï please be assured that isnôt the case. In fact the opposite ï weôve included the outcomes from the consultation, so far as it relates to the potential impact on your interests, in our revised EP. Re the risk assessment issues you raise - the outcomes from the issues we specifically discussed with you in the workshop are in section 7.1.5.3 of the EP. In summary, we reviewed the assessed level of impact and likelihood to reflect the discussion at the workshop in regards to the impact of mortality of individual fish as being population-level impacts or a change in catch rates. For catch rates we have assessed that impacts are possible. We have also assessed that behavioural impacts to fish are possible. However the assessment of mortality resulting in population level effects is rated as unlikely (for the reasons given in the revised EP). If it helps, apart from the changeôs weôve made to the EP as a result of our consultation with you, we've also made changes as a result of additional data that we received from Fisheries (which you have seen), and as a result of us responding to issues which NOPSEMA raised with us. None of these changes are significant re the potential impact on your interests though. As for the process going forward - as per my previous email if you have any comments or feedback, including on the risk assessment, I will review and incorporate into the EP prior to our submission where applicable. [redacted] reply email: SANTOS have ignored completely the agreed outcomes from meeting. We will of course provide feedback and comments however it's seems likely our concerns will only be heard after you have submitted your EP.	Santos response to TRD-89a: Changes in Section 7.1.5.3 of the EP: The assessed level of impact and likelihood updated to reflect the discussion at the workshop in regards to the impact of mortality of individual fish as being population-level impacts or a change in catch rates. Additional data received from Fisheries (which [redacted] had seen). Response to issues raised by NOPSEMA.
Timor Reef and Demersal Relevant	TRD-90	23/05/2017	[redacted] email - Can you outline where SANTOS sees the level of impact for mortality of fish in the survey area. This can be from direct mortality, injury leading to mortality or impaired hearing leading to mortality. Within the survey area noting our discussions and agreement that most fish won't avoid these impacts do you have a percentage of fish that may suffer mortality. Is the figure 10% 20% or closer to 80% or more of the fish in the survey area. Santos reply: Santosô assessment of mortality impacts is detailed in the Bethany EP Rev 1 Section 7.1.5.3.1 and impaired hearing leading to mortality is in Section 7.1.5.3.2. [redacted] email: This could not be more unclear. Is the suggestion that the predicted impacts will not occur or that the predicted impacts will not cause population effects?	Requests for clarification in regards to mortality impacts to fish. Directed to the EP Section 7.1.5.3.1 which details the assessment of potential mortality impacts and Section 7.1.5.3.2. for impaired hearing leading to mortality. Further information provided on 25/5/17 (TRD-94) as to why Santos had rated the likelihood of mortality impacts as unlikely. There is a high level of certainty that mortality impacts from seismic surveys to fish will not occur based on the activity is not new or unusual. Seismic surveys are routine activities and no mortality impacts to fish have been identified. Seismic surveys have been undertaken in the area of the TRF over similar habitats and no mortality to fish have been identified from these surveys including the Santos survey in 2006 and the most recent ConocoPhillips survey. Based on that fish mortality has not been identified from a seismic survey, we used unlikely to be conservative rather than remote which requires exceptional circumstances for the consequence to occur. Popper (2014) pile driving data was used as a proxy because the research to date had not identified a threshold level were mortality has been observed. As detailed in Section 7.1.5.3.1 of the EP, since the thresholds were published Popper (2016) has undertaken further studies using a seismic source that showed no mortality at a maximum received level of 231 dB re 1 εPa (PK). Thus, actual data from a seismic source has shown no mortality at a level higher than the current published threshold.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-53 and attachment X	22/05/2017	NTDPRF Email: Apologies. The spreadsheet I sent you in my email was more to give you an indication of the main species that contribute to the catch inside the operational area. I've attached the full table. Regarding the timing of the data, unfortunately all of the data has not been entered for these years, but there has probably been enough entered for 2016 for this purpose which is just to get an indication of % catch inside the area. Given we are still in 2017 I think the data will be less realistic as such a low proportion has been entered and we are still less than halfway through the year. [redacted] also had some questions he requested via [redacted] 1. The data does not include the Pearl Oyster Fishery - is this because there is no activity in the Operational Area? Thatȍs correct no activity 2. For the Timor Reef Fishery, how many trawl vessels and trap vessels are there that operate in the Operational Area? One trawl vessel and three trap vessels (in 2016 and so far in 2017) although this varies depending on whether there is trawling (i.e. the licence holder engaged in trawling as anywhere up to three additional trap vessels when they are not trawling) 3. Of the 29.04% for the Timor Reef Fishery within the Operational Area, what is the percentage of trap and trawl? Ill work through and separate this (see below) So from here: - Ill include data from 2013-2016 for both the operational area and the seismic area broken down by gear [redacted] also to note none of this data is confidential so I do not need to seek ȍpermissionȍ from the commercial sector. I do however, give them an opportunity to look at it so they know what I've provide. I apologies if you are getting frustrated with our timeliness on the data provision. I am doing my best within our other work commitments and the need to communicate to everyone involved in the fishery. Also I am looking at the EP [redacted] provided in late April. Do you mind if I seek some technical advice from my colleagues in the NT Department of Environment and Natural Resources on TEPS as this really their area of expertise.	EP Section 5.6.3.2 Timor Reef Fishery updated with information in regards to number of trap and trawl vessels. Pearl Oyster fishery data shows no activity which does not align with information provided previously by the NTDPIRF (NTDPIRF-36) and PPA (PPA-5 to PPA-11). NTDPIFR updating data and will include Pearl Oyster Fishery in new data set. Confirmed with Dept. on phone 26.5.17 since 2008
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-54	22/05/2017	Santos email: Thanks for the clarifications below. Sorry for the constant clarifications but as we are receiving this data late in the EP development process I am also under a tight timeframe. To clarify the main priority is the % catch data for the survey area. Would you be able to give me a timeframe as to when this will be available as this will determine when we can resubmit the EP to NOPSEMA. Also could you please include the Pearl Oyster Fishery in the summary of the % catch data for the survey area as I need to be able to show NOPSEMA that there has been no activity. In regards to the TEPS could you let me know what advice you would be seeking to obtain from the NT Department of Environment and Natural Resources? If it is in regard to syngnathid species (pipefishes, seahorses and pipehorses) we have updated this section as realised we had incorrectly interpreted the North Marine Region bioregional plan occurrence depth, and acknowledge that there is a potential for these species to occur in the area of the survey. NTDPIRF reply email - Thatȍs ok I realise your timeframes are tight Iȍm trying to get things to you asap. Hopefully Ill get the updated data to you tomorrow given I just need to give it to [redacted] to look at so he knows what we are providing. I can tell you there is no activity by the Pearl Oyster Fishery in that area so we donȍt need to run it through the analyses. Regarding TEPS it would just be on turtle biology and behaviour as I am not an expert in this field. While we have to deal with TEPS under our ESD obligations we are not experts on many of these species. Once I've looked the EP in more detail I can send you the questions I would ask them? NTDPIRF reply email - Reading through your EP I now understand your interest in pearl oysters. To clarify my statement there has been no fishing for pearl oysters since 2008 and even this was at a very low level. The harvest of this species tends to occur closer to shore than the survey area. I've spoken to a colleague who works with the pearl industry and he suggested the furthest they fish offshore would be west of Bathurst Island which is still outside the operational area.	Clarification to NTDPIRF as to what information is a priority. Also to acknowledge that the NMR bioregional plan had been incorrectly interpreted and that there is a potential for syngnathid species (pipefishes, seahorses and pipehorses) to occur in the survey area. EP Section 5.5.4 has been updated to include information in regards to pipefishes, seahorses and pipehorses and an assessment of potential impacts is included in EP Section 7.1.5.3 Seismic Noise Fish.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-55	22/05/2017	NTDPIRF email: I have pulled the data and will just run by [redacted] However, to get the best picture for any potential impacts on this fishery Ill present the data as outlined below: -trap fishing in recent times is best represented during the years 2011-2013 which was before trawling occurred (trawling activity took up to 4 boats out of the trap fishery) -trawl fishing is best represented by 2016 data as this is the only year there has been a full years activity -Also I acknowledge the operational area is much larger than the survey area but to gauge the full impact shouldnd there be some buffer zone put around the survey area as in the EP it suggests some overrun. Is 1 nm appropriate or less? Santos reply email: Thanks [redacted] for following up. In regards to the survey area you area correct. For our impact assessment I have used 2km at either end of the survey which is what we call the full power zone where the vessel starts to ramp up the seismic source between turns. I have then added buffers onto this area based on whether I am looking at the mortality threshold or TTS threshold. I am not sure how long it takes you to collate the data for different areas but would be good to do for. I only need for TRF as other fishery catch rates so small. Survey Area Full power zone (survey area with 2 km at each end Survey area within mortality threshold buffer ï 210m. Survey area with TTS buffer ï 3.6 km	Data provided on 26/5/2017 (NTDPIRF-58)
Timor Reef and Demersal Relevant	TRD-85	22/05/2017	[redacted] email: For clarification [redacted] the data was provided to me but not "checked" with me. I cannot provide clearance for catch data. My understanding was it was consolidated data that you requested and arranged to have released.	For information.
Timor Reef and Demersal Relevant	TRD-86a	22/05/2017	[redacted] email: Its still not clear what you are expecting from us. This was not the agreed process from Fridays (12 May) meeting. This agreed process was changed last Thursday when we were informed that SANTOS were reviewing the risk ratings and acceptability criteria after our workshop and would provide us with information early this week. This has now changed to clarifying some detail with EP resubmitted by Friday. Did you want any input from industry and with the proposed 4 day turn around how did you see this working? It would also be helpful if you could provide other stakeholders views on the risks identified in the EP and risk ratings produced. Are we the only stakeholder with concerns or the only stakeholder that has seen them? How will the changes to the EP be addressed with other stakeholders?	Santos reply TRD-86b.
Timor Reef and Demersal Relevant	TRD-86b	22/05/2017	Santos reply to TRD-86: The aim of providing you and [redacted] a copy of the updated EP to is show how your concerns and issues raised during our consultation with you, most recently including the workshop, have been addressed and how we have incorporated the information recently provided by the Dept. of Fisheries. For example, at the workshop you queried that I had used a TTS recovery time of between 18ï 24 hours and that other work had shown no evidence of repair or replacement of damaged sensory cells up to 58 days post-exposure. On further review I have updated the EP to say that research to date has not established a recovery time for TTS. You also commented that a fish with TTS has a higher risk of being predated. Thus I have acknowledged this impact and used this to assess the level of impact. [redacted] had also commented on the 18/4/17 that our assessment of impacts to catch rates, using previous information (Nov 16) that catch rates had been affected by up to 50% and recovery to pre-seismic levels can take 3 ï 4 months after the CoP survey, was no longer relevant as catch rates had not recovered to date (9 months). I have updated the catch rate Section of the EP to reflect this timing. I have also updated the sections that covered the relocation and loss of catch payments to reflect the information sent to you and [redacted] from [redacted] today. I have updated the sections relevant to your activities and uploaded the EP to the dropbox to which I have given you access to. I have used track changes so you can see where I have updated sections. If you have any comments or feedback prior to our submission I will review and incorporate into the EP were applicable. In regard to other stakeholders they have been provided with information to their satisfaction.	Santos rely to email TRD-86a.

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Timor Reef and Demersal Relevant	TRD-87	22/05/2017	Santos email: Thank you for the table. We have been working hard on our EP submission and with our colleagues to turn our discussions into something Santos and our JV partners can agree to. Please see the text below (within record), as a term sheet. We can arrange a further meeting to progress towards an agreement.	Santos response to TRD-80 with provision of Santos' thoughts on the terms for the compensation payment. Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] rom the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost. The information required to implement the loss of catch and relocation expenses payments are available either from the fishers or NTDPIRF as is information the fishers would typically collect (operating costs such as of bait, fuel, wages) or required to collect for submission to NTDPIRF (catch disposal records, average catch rates per species and market price).
Timor Reef and Demersal Relevant	TRD-88	22/05/2017	[redacted] email: I am very concerned we just wasted a lot of time last week given the recent correspondence between you, [redacted] and [redacted] and I both have full schedules this week and we are very concerned your timeframes do not account for this as we have previously discussed. Can you advice when the revised EP is added to the dropbox. Can you also advice if there has been any movement on my emails below and if not when we can expect something.	Santos response in TRD-87 in regards to terms for compensation payment and TRD-89 in regards to issue of wasted time.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-50	19/05/2017	Santos Email: The data needs some context for us to be able to use it to assess whether there is likely to be a demonstrable impact on the TRF. My questions on the TRF data are: %Inside Area: what area was used for this calculation, the Bethany survey area (where the acquisition will take place and is 4,190 km2) or the Bethany operational area (which is the broader area of 12,610 km2)? Type: could you please explain what the Type means i.e. what is D2, A18, etc. Am I interpreting the table correct that 3.01% of the TRF Type D2 catch is caught in the Inside Area? Is the % of total catch caught in the seismic area a breakdown of the % Inside Area by species? How do these two table relate to each other? For the TRF species breakdown what is the units for catch? For the TRF species breakdown catch, is this for the full TRF area? What is the timeframe for the catch data? Is the data for trap and trawl? Also we have had no data as to the % catch for the Demersal fishery where the survey will overlap. Could you do this for the both the survey and operational area? Your expedience in responding to these question is appreciated as this information is required to update the assessment in our environment plan.	Santos requests clarification of data sent by NTDPIRF (NTDPIRF-49).

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-50	19/05/2017	NTDPIRF Email - I've answered all your questions below. Operational area Type: could you please explain what the Type means i.e. what is D2, A18, etc. D2- fishing tour operators (FTO- guides taking recreational fishers) A6- Demersal fishery- only trapping is permitted in this area A5- Offshore Net and Line Fishery that targets sharks and grey mackerel- only pelagic gill nets have been used since 2013 longlines are also permitted A4- Spanish Mackerel fishery A18- Timor Reef Fishery- trapping and line fishing permitted under licence and trawl allowed under permit Am I interpreting the table correct that 3.01% of the TRF Type D2 catch is caught in the Inside Area? Apologies thatôs FTO A18 is TRF Is the % of total catch caught in the seismic area a breakdown of the % Inside Area by species? How do these two table relate to each other? The larger table is breakdown by species for the TRF For the TRF species breakdown what is the units for catch? Kilograms For the TRF species breakdown catch, is this for the full TRF area? Yes What is the timeframe for the catch data? Average catch between 2013-2015 Is the data for trap and trawl? Both trap and trawl Also we have had no data as to the % catch for the Demersal fishery where the survey will overlap. Could you do this for the both the survey and operational area? Yes done this is A6	EP Section 5.6.3 updated with data provided.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-50	19/05/2017	Santos email: Thanks for the explanations. Would you be able to do the breakdown below for the Bethany survey area as this is the area of potential impact. Type % Inside Area D2 3.01% A18 29.04% A6 0.04% A4 0.48% A5 0.00% If the larger table is a breakdown by species for the TRF and A18 is the TRF, where does the 29.04% inside area come from. This is not clear from the species data. As the data is for the average catch between 2013-2015 is there any reason why this data would not be representative of the likely catch % in the area in 2016 and 2017 such as increased vessels, licences, new techniques?	Request for information provided by NTDPIRF for Bethany operational area (NTDPIRF-49) to be done for the smaller survey area.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-51	19/05/2017	NTDPIRF Email - Also I had requested from [redacted] to provide a copy of your EP for us to look at (in confidence of course). Is that possible? Santos Email - [redacted] sent the Bethany Seismic Survey EP to yourself, [redacted] and [redacted] on the 29/4/2017. Copy of email below. Please let me know if you would like it resent. NTDPIRF Email - No got it, apologies as got caught up in addressing all of his questions [redacted] Thanks.	EP had been sent to NTDPIRF on 29/4/17 (NTDPIRF-36)
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-52	19/05/2017	NTDPIRF Email: Yes ok will provide early next week. Santos Email: Any chance you could answer the question as per below today? If the larger table is a breakdown by species for the TRF and A18 is the TRF, where does the 29.04% inside area come from. This is not clear from the species data. As the data is for the average catch between 2013-2015 is there any reason why this data would not be representative of the likely catch % in the area in 2016 and 2017 such as increased vessels, licences, new techniques? NTDPIRF reply email: The 29.04% is the percentage of the total catch in the TRF that occurs in this area. Unfortunately 2016 and 2017 data hasnôt been entered so we used the 2013-2015 period below that had some trawl catch associated with it. Total catch in the TRF is unlikely to be significantly different in 2016 and 2017 but there will definitely be differences in species as the trawl gear catches more red snappers compared to the traps which catch more Goldband Snapper.	For information ongoing clarification in regards to data provided. The data provided by species had % catch but this number had not been converted to a % hence the confusion. Reasoning why data is from 2013-2015 and that unlikely to be significant different to 2016 - 2017 data though maybe differences in species caught by trawl and traps. This information included on EP Section 5.6.3 Northern Territory Managed Fisheries.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-52	19/05/2017	Santos email: Thanks for this. However, it is still not clear how the 29.04% is obtained. If you look at the percentages for the total catch data below I canơt see how these add up to 29.04%. Could you please show how the 29.04% is obtained from the catch data below. In regard to your comment below that the 2016 and 2017 data has not yet been entered, we were advised by [redacted] at a meeting with [redacted] and [redacted] on 28 April 17, that the fish catch data was "more or less up to date (a few months lag)." Could you let us know when this would be available.	For information ongoing clarification in regards to data provided. The data provided by species had % catch but this number had not been converted to a % hence the confusion. Query as to when the 2016 - 2017 data would be available.
Timor Reef and Demersal Relevant	TRD-84	19/05/2017	[redacted] email: At our meeting last Friday all SANTOS employees were confident in current risk assessment and acceptability criteria. Based on our differing views a key outcome from the meeting was that I was to review risk ratings and criteria and provide feedback. It's not clear if you are reviewing consequence tables or just risk ratings. It would be greatly appreciated if you could provide some guidance on what is expected from us and what is being reviewed. Please can you outline a timeline for our expected input noting the change in direction. Santos reply email on 21.05.2017: Thanks for your respective emails, Friday. We are updating the Environment Plan following receipt of recent information from [redacted] (NT Department of Primary Industry & Resources), which he checked with you, [redacted] before providing to us. We are also clarifying some of the detail in the EP based on the discussion at our workshop and feedback from NOPSEMA. [redacted] will have the sections reviewed at the workshop completed tomorrow (Monday) – she will place the whole EP, with tracked changes, in the drop-box. We are aiming to resubmit the EP on Friday.	Updated EP sent 22/5/2017. EP Section Seismic Noise Fish 7.1.5.3.1 Mortality and Section 7.1.5.3.2 TTS updated in regards to the application of the consequence and likelihoods rating after discussions at the workshop (12/5/17).
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-47	18/05/2017	Santos email: Just chasing up the data weơre still waiting for from you which plots the fisheries catch by species in the survey area? I understand itơs not confidential and so am not quite sure why it needs to be run past [redacted] first. Also just wanted to note that we have been waiting for this for a number of weeks now (you said on the 28th April it would be available within a week) and not having it yet is now holding us up in the EP process (and especially in trying to assess whether there is likely to be a demonstrable impact on fisheries or not), so weơd appreciate it as soon as possible. NTDPIRF Email 18.05.2017: Yes apologies, it was really a courtesy to keep the commercial fishers informed and not meant to be a delay. Ill get back onto [redacted]	Follow-up as catch data that NTDPIRF offered to plot by species within the survey area (NTDPIRF-35 28/4/17) has not been provided.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-48 and attachment W – Record NTDPIRF 4 - NT Dept. Industry and Fisheries letter 05.06.15	18/05/2017	Santos email: We have had a request from [redacted] of Northern Seafoods in regards to providing him a copy of a letter you sent to Santos in regards to our Bethany (NT/P85 and NT/P82) seismic survey. The request is below and I have attached the letter that he is referring to. I wanted to check that you were okay with us providing him a copy of this letter. Could you please let me know. NTDPIRF Email 18.05.2017: No issues with passing that on, thanks Santos email: Thanks [redacted] Will pass onto [redacted]	Letter provided as per TRD-83.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-49	18/05/2017	NTDPIRF Email: I've got confirmation that [redacted] has looked at this so here is the data, happy to chat if any of it is unclear but as discussed I have got our GIS person to use the shapefiles you provided us to calculate the proportion of fisheries catches that occur within the proposed operational area. I have broken it down further by species for the Timor Reef Fishery given that a substantial proportion of the total catch occurs within the proposed seismic area. T Total % area overlap with 3D seismic area and fisheries catch Type % Inside Area D2 3.01% A18 29.04% A6 0.04% A4 0.48% A5 0.00% And TRF here is the species break down.	Catch data NTDPIRF offered to plot by species within the survey area (NTDPIRF-35 28/4/17) provided with no context to interpret what it means. See NTDPIRF-49 requesting clarification.

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Timor Reef and Demersal Relevant	TRD-80	18/05/2017	[redacted] email: Subsequent to our meeting last week I had a brief discussion with [redacted] and [redacted] regarding status of the terms of the compensation package. Could you please review with [redacted] and [redacted] and advise status please. I summaries the current situation as follows: Near Term Payment I believe the structure is agreed and look forward to seeing terms for our solicitors to review. Lump Sum ï Consultation Costs [redacted] has been agreed based on invoices being provided to substantiate costs. Lump Sum ï Risk to Fishery Further discussion is required. I do not believe it is appropriate for Santos to undertake a project such as this and not compensate accordingly for the risk to others livelihoods. [redacted] email on 19.05.2017 - Can you advise your timelines for this process please. Referring to my email below, [redacted] it would be appreciated if you could provide an update.	Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] from the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Timor Reef and Demersal Relevant	TRD-81	18/05/2017	TRD email: At our meetings it was indicated NT Department of Primary Industries provided Santos with a letter regarding spawning seasons. Could you please add a copy to the dropbox. Santos email: As the letter has come from [redacted] from the NT Department of Primary Industries I have sent him an email to confirm that he is okay for me to share the letter. Santos email: [redacted] has given the okay to share so have uploaded to the dropbox. TRD email: Confirmed received.	Santos provided NT Department of Primary Industries letter see TRD-83. Information from this letter states that peak spawning time is October to May, thus the survey timing was planned to finish at the end of September to meet this timing. Fishers advised at meeting in May 2015 (NTSC-2 14/5/2015) that September to May is the sensitive time for fishing and seismic during this period should be avoided. This was independently supported by advice from the Department. Much later, the fishers said they fished all year round, so this was a reference to fish breeding and not fishing activities September to May is the sensitive time for fishing and seismic during this period should be avoided. Fishers clarified (TRD-13 16/12/16) that June to August was a period of least impact on fish breeding but not fishing activities. Further clarification was provided on 9/5/17 (TRD-74) that fishing activity is not seasonal. Tropical fish breed throughout the year but this is thought to intensify September to May and therefore this period was to be of least impact to fish breeding, not current fishing activities. Based on this information EP Section 5.5.3 Plankton and Section 7.1.5.1 Seismic Noise Plankton has been updated to include that peak spawning is from Sept to May. Impacts to spawning has been assessed based on this timings from the fishers within the EP Section 7.1.5.1 Seismic Noise Plankton.

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Timor Reef and Demersal Relevant	TRD-82	18/05/2017	TRD email: Can you please clarify that following is the correct use of the consequence table for the risk of mortality or injury leading to mortality for fish/turtles? The risk is identified to exist. It will occur throughout the survey area. The extent of the impact is deemed local as it occurs within the survey area. The duration is short as fish/turtles are only subjected to the risk levels for days to weeks. Based on this the risk has a consequence level of II. That irrespective of the likelihood of such an event, using the risk matrix provided, this impact would be deemed acceptable, consistent with ESD principles and show no threat of serious or irreversible damage? Santos email on 19.05.2017: Am reviewing the risk ratings and acceptability criteria after our workshop and will get updated information to you early next week.	Updated EP sent which provided more information in regards to the application of the consequence and likelihoods rating used for mortality or injury leading to mortality for fish (TRD-84).
Timor Reef and Demersal Relevant	TRD-83 and attachment W (record NTDPIRF4)	18/05/2017	Santos provides TRD the letter from [redacted] from the NT Department of Primary Industries provided Santos with a letter regarding spawning seasons (NTSC-2).	Letter provided in regards to request TRD-81.
Timor Reef and Demersal Relevant	TRD-79	16/05/2017	Santos email's The implementation of the Impact and Risk ôUncertaintyô Decision Making Framework detailed in Figure 6-1 is within the risk assessment table for each hazard in Section 7 Environmental Risk Assessment. For Seismic Noise this is Table 7-13 (page 131). As requested the noise modelling report was put into the drop box but not sure if [redacted] passed on. Have attached in case you have not received.	Santos response to email request TRD-78 Jasco modelling report also provided as requested at workshop (TRD-76 10/5/17).
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-46	15/05/2017	NTDPIRF Email: To keep everyone happy, I've been requested by [redacted] for him to look at the data first before I send it to you? Ill bug him if he hasnô sent it back to me by tomorrow morning.	Catch data that NTDPIRF offered to plot by species within the survey area (NTDPIRF-35 28/4/17) has not been provided and NTDPIRF requested by [redacted] to review prior to sending to Santos.
Timor Reef and Demersal Relevant	TRD-78	15/05/2017	[redacted] email: Thank you again for information provided Friday. To aid our consideration it would be helpful if you could clarify how you have evaluated and then implemented the uncertainty section of your risk assessment process. This is outlined in Figure 6-1: Impact and Risk ôUncertaintyô Decision Making Framework in the EP. To speed our consideration it would be appreciated if you could direct me to the section that outlines your assessment of issues in this table and how they are implemented.	Santos response in TRD-79
Timor Reef and Demersal Relevant	TRD-77 and attachments V (minutes and email record NTSC-2)	12/05/2017	[redacted] sent Santos minutes of the workshop. Could you please also forward attached email to [redacted] noting when first asking for environmental information.	For information
Timor Reef and Demersal Relevant	TRD-76 and attachments U (agenda and minutes)	10/05/2017	Santos sent agenda for Friday's workshop. [redacted] email's on 11.05.2017 - We have reviewed your draft agenda and we suggest the attached. I also attach draft minutes in the format we used at our last meeting which provided a clear record of discussion for all parties. Whilst it is not part of this meeting could you let me know status of what you are discussing with regard to compensation.	For information.

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Timor Reef and Demersal Relevant	TRD-74	9/05/2017	The following is provided in response to Santos letter of 28 April in response to letter dated 24 April. Consultation is a legislative requirement set out in regulations. It is a process that is easily evidenced on the information provided and process carried out by SANTOS. Having outlined the relevant regulation and provided reference to NOPSEMA guidelines and documentation this does not need repeating. Failure to consider this information is prejudicing everyoneͅs interest. Regulation requires SANTOS provides sufficient information to allow us to make an informed assessment of the possible consequences of the proposed Bethany survey on our functions, interests or activities. Santos must allow us a reasonable period for the consultation. As previously outlined NOPSEMA provides detailed material on their expectations and required EP content. This includes decision making guidelines on consultation. Critically the consultation occurs in EP development. For clarity, this must occur before your EP is submitted. Contrast this to SANTOS asking us to use information in an EP that has already been submitted to assess the possible consequences. The recommendation to voluntarily withdraw your EP was seen as a proactive and timely process to ensure SANTOS meets regulated requirements for EP development. The alternate is that you decide to stay ˝on footò and have the EP rejected at a later date. The regulator cannot accept an EP where this consultation has not occurred. The process you have outlined is not as you are claiming consistent with NOPSEMAs expectations that ˝we continue to consult during and after EP assessment process.ò It is not consistent with any regulations or guidelines. NOPSEMA requires this key consultation during EP preparation and ongoing consultation during the activity. Core concepts and considerations for ongoing consultation are provided in guidance notes and I can assure you there is no allowance for this process to replace consultation in EP development. We are certainly not best served by a June commencement date for your proposed survey if we have failed to follow due process or ignore legislated requirements. This you outline in your response on 28 April 2017. The assertion that these proposed survey dates were based on feedback that the dates would reduce the impact on our operations is incorrect. It is then stated that any delay would prejudice both of us leaving us with NO option but negotiate a make good agreement or accept a unilateral solution. I can assure you the nature of this ˝threatòis not missed nor is it relevant. Prejudicing our interests Your correspondence states ˝This timing (June to September) was chosen in significant part base on feedback from our consultation with you that this would reduce the impact on you.ò You then claim any delay would therefore prejudice both our interests. Firstly, fishing activity is not seasonal. Secondly, SANTOS have committed to a make good provision that ensures we are no worse off because of the proposed trial. On this basis, we are not prejudiced at all by any delay. This information was provided at our meeting Dec 2016 and I note is recorded in TRD-13. Tropical fish breed throughout the year but this is thought to intensify September to May and therefore this period was to be of least impact to fish breeding, not current fishing activities.	Issues raised noted and workshop was held to facilitate provision of information to the fishers and consult with them about the potential impact of the survey on them. Where new information or clarified information provide the EP has been updated such as: EP Section 7.1.5.3 Seismic Noise Fish includes assessment of mortality and TTS impacts to fish. These sections have been updated based on feedback that mortally and TTS that leads to mortality could have a long term (> 12 months) impact on fish and fish populations. EP Section 7.1.5.3.4 Seismic Noise Fish Catch Rates updated based on feedback that impacts to catch rates could have a long term (> 12 months) impact to fishers. EP Section 5.5.4 has been updated to include information in regards to pipefishes, seahorses and pipehorses and an assessment of potential impacts is included in EP Section 7.1.5.3 Seismic Noise Fish. EP Section 5.5.3 Plankton and Section 7.1.5.1 Seismic Noise Plankton has been updated to include that peak spawning is from Sept to May. Section 7.9.5 Marine Users Interactions has been updated to reflect that the TRF operate all year round. EP Table 7-16 Seismic Noise Risk Assessment: assessment of controls was updated to include that the main fisheries in the area (TRF and Demersal) do not have a closed season and peak spawning occurs from Sept to May. The survey was planned on original information that period of least intensity (June ï mid August) and prior to the start of spawning in October. Impacts to fishers and spawning have been assessed based on these timings from the fishers within the EP Section 7.1.5.1 Seismic Noise Plankton, Section 7.1.5.3 Seismic Noise Fish, Section 7.9.5 Marine Users Interactions.

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Timor Reef and Demersal Relevant	TRD-74	9/05/2017	Our interests can only be prejudiced if the proposed survey commences or is endorsed without any adequate consideration of possible consequences for our interests. As owners of fishing rights giving access to a suite of species we need to address more than our current catch rates on two species. We are prejudiced by failing to consult during EP preparation. The current EP cannot be accepted. There was no consultation on impacts, we cannot therefore consider acceptability or adequacy. The most efficient way forward is as suggested to retract the EP, hold a workshop with relevant persons and expertise to allow industry to properly address and understand the potential impacts of your proposed survey. The outcome of this workshop should allow industry time to consider the impacts of your proposed survey and can then be used to guide EP preparation, consistent with regulated requirements. The unreasonable timeframes that are now in place have resulted from failure to provide this information in a timely manner. This is further compounded by your constant requests for information and feedback when the process is dependent on you providing sufficient information. This is a repeated practice which is damaging any long term trust. I hope this can be addressed as a priority. I look forward to gaining a better understanding of possible impacts of your proposed survey at Fridays meeting. It is unfortunate that this has been limited to just three hours. Once industry can make an informed assessment of the possible impacts then the EP can be revised and resubmitted consistent with legislation and policy.	Request for workshop agreed to provide opportunity for TRD to review EP content relevant to TRD interest.
Timor Reef and Demersal Relevant	TRD-75	9/05/2017	[redacted] emails In order for me to be prepared for Friday, can you please email full copies of reports cited in your Environment plan. Obviously, required to give me a full understand of your decision making process. Given I do not have these reports readily accessible adds considerable time when reviewing as I am sure you understand. Santos respond on 10.05.2017, We will set up a dropbox where you can access the reports referenced in the EP - you will receive an email from dropbox as to how to access. We have prioritised the reports based on the fish section of the EP so that you can have this information for the meeting on Friday. Please let me know if you want all reports from all sections as I can then continue adding to the dropbox. Please note some references are websites and this is noted in the reference section of the EP. [redacted] responds on 10.05.2017, I have accessed dropbox and appears working good. I am travelling to Melbourne now so will have a look later. I am not sure of the extent of the reports you have added but I would think given we are looking at the potential impacts of the survey we need to consider all aspects on the environment not just fish directly. Without looking further right now I would suggest more is better is this particular case.	Provision of reports as requested.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-42 and attachment T	8/05/2017	NTDPIRF email: Regarding impacts of seismic, your advice below supports what I said which are that results are equivocal. We have deliberately not provided you with a deliberate research program as we believe it is not just the one oil and gas company that should be funding such a program, hence my suggestion to have a more collaborative arrangement. I also would prefer if the explicit research questions were developed collaboratively. It was more a position from our Division rather than a request for Santos to do anything explicit. I apologies for there not having been any up to date data provided. As I said there has been some confusion with what has been requested. This week I can provide information on the % of species catch by fishery that occurs in the proposed 3D seismic operational area. If I could request a shapefile or more detailed coordinate system of this area that would aid us as the PDF we received is for coordinates at four corners and the shape of the area is not rectangular. I can also provide more up to date catch data from the Timor Reef Fishery but some of this will be confidential as fewer than 5 licences contributed to the catch. To access this information you need to get permission from licence holders. I have discussed this previously with [redacted] and I know he has been in discussions with fishers. Consequently, the data I can provide will have some missing years and/or wont be able to be reported at fine spatial scales. Please advise me if you want me to provide this information in addition to what I have outlined above. Unfortunately verifying anecdotal reports by fishers that the recent Conoco Phillips survey had negative impacts on their catch rates cant be verified in the short term as we are still entering data from this fishery from last year. Also there is the question of what you compare the data to the previous months fishing, the previous years fishing in those months or something else? I have always advocated that catch rates will be a poor indicator of impacts until all of the variability in this data is determined outside of what may or may not occur in relation to seismic testing. Regarding the protected species interactions there has only been one pipefish, one whale shark and two grey nurse sharks noting that the gear is not designed for retaining small species such as pipefish or larger species such as the sharks. Additionally our observer coverage is only approximately 10% so we could be missing additional species. Regarding the trial. I've attached a map of the trial with habitat protection areas identified noting that all gear apart from bottom trawl can currently be used in all areas of the Timor Reef fishery. The trial is permitted until the end of this year where a decision will be made about the viability of this gear in the fishery.	Santos response in NTDPIRF-43. Provision of map of trawl area and restrictions. Issue raised about if catch rates can be used to show impacts for seismic surveys. Fish catch data for the period that the CoP seismic survey occurred has not been entered yet by the Dept. The fishers have referenced impacts to catch in regards to impacts from the CoP survey (TRD-9, TRD-50, TRD-55) thus catch rates would be able to be used to identify any impacts from the Bethany survey. Santos has also engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] from the CSIRO. His view is that catch rates are an appropriate mechanism to understand any impact (CSIRO-2). EP Section 7.1.5.4 assess impacts to whale sharks and sharks in relation to seismic noise impacts and with the implementation of appropriate controls such as the application of EPBC Policy Statement 2.1 Part A and B.6 Adaptive management to whale sharks, potential impacts were assessed as ALARP and acceptable.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-43	8/05/2017	Santos email: Provision of Data - Please find attached the shape files for the Bethany Operational Area and Survey Area. At this stage I will wait and see what data you can provide us. Research - My aim was to let you know that we are looking at research opportunities via our APPEA Marine Environmental Science Program (MESP). As you suggest, the next phase will be to work with researchers, government agencies and fisheries groups to identify research questions and how those questions can be answered. I will ensure your Department is kept up to date with this project as it moves ahead. It is probably a good one to get on the standing agenda for the Bonaparte Fishing Group. Seismic Impacts - The aim of providing the information below was to assure you that we are looking at all research and data as part of our Bethany EP impact assessment, and that where the information is equivocal or not available, we use a conservative approach in our assessment. Protected Species - We will use your information to further inform our understanding of the environment and species that maybe present in the area. Interestingly, I mapped up the pipefish location which is in about 120m water depth with the shelf geomorphic feature. From the information I have obtained to date, I thought pipefish were typically found in water depths < 20m such as banks and shoals. Do you think this is a spatial error or are pipefish found at those water depths and within the shelf geomorphic feature? Trawl trial - Thank you for the map. Would you be able to explain what the Schedule 1 and 2 exclusions are?	Information provided in response to NTDPIRF-42 8/5/17. Response in regards to Schedule 1 and 2 exclusion zones in NTDPIRF-44 8/5/17. Clarification on location of pipefish.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-44	8/05/2017	NTDPIRF email: Schedule 1 areas are larger habitat protection zones that encompass the different habitat classifications in the TRF. The schedule 2 closures are much smaller areas of more complex habitat that have been identified from nautical charts and bathymetry information provided by the commercial operator conducting the trial. The gps mark for the pipefish was the start of the trawl shot but even with the end position it is unlikely to have changed habitat. I'll check the position against the Vms data. Yes please keep me updated regarding possible research projects. As mentioned in my previous emails there is the potential for additional funding from the fisheries research and development corporation. I'll try get you the data later this week, hopefully by Thursday. Thanks for the shape files.	Information on trawl trial schedule areas required further clarification (see NTDPIRF-45). No further information has been obtained on the location of the pipefish. EP Section 5.5.4 Fish Table 5-9 details habitat preference and depth range for syngnathid species (pipefish and seahorses) that may occur in the area. Some species are found within water depths > 100m and shelf type environments.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-45	8/05/2017	Santos email 10.05.2017: To clarify if the trawl trial is allowed within the Schedule 1 and Schedule 2 areas? NTDPIRF email 11.05.2017: Sorry for that yes there are not allowed to bottom trawl in the schedule one areas or to have bottom trawl shots that pass over the features marked in schedule 2.	For information.
Timor Reef and Demersal Relevant	TRD-71	8/05/2017	Santos email to [redacted] to confirm workshop times on Friday, 12th May. Santos also responds to JK's proposed compensation calculations and questions the use of using quota catch data as opposed to actual catch data. Santos is currently basing information on the 2012 Fishery Status Report as catch data, however if the TRD group would like us to use more recent data, they will need to need to give their consent to the NT Department of Fisheries/Primary Industry & Resources. Santos also notes in terms of more immediate payments, we would pay ï within 30 days upon presentation of receipts ï any reasonable additional operational costs associated with having to fish in an alternative location. We would also be ready to cover, up front, your $200,000 engagement costs.	Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries [redacted] from the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Timor Reef and Demersal Relevant	TRD-72	8/05/2017	[redacted] acknowledges Santos's email with attached letter from 27.04.2017, [redacted] advises he will respond to the letter on 09.05.2017.	For information.
Timor Reef and Demersal Relevant	TRD-73	8/05/2017	[redacted] responds to Santos email relating to the compensation calculations, [redacted] provides a breakdown of what needs to be discussed and agreed at the forthcoming workshop. Timeline and subject items are noted in a table within the email. Provision of information in relation to make-good agreement formula. [redacted] follows up on 08.05.2017, requesting Santos to respond to this email as if finalisation of planning is completed early enough, [redacted] does not see how we can arrange the workshop on Friday. Santos responds to [redacted] stating that they believe the workshop timing will be fine and that the purpose of this workshop is not to review the whole EP, but to focus on the areas that TRD have questions or comments on in relation to seismic and fish. Santos will get back to you on the make-good information provided.	Workshop held on 12 May 2017.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-41 Part a	7/05/2017	Santos email: References previous emails where been unable to date to obtain recent data (later than 2004) to understand the catch effort of the TRF and Demersal fisheries within Bethany survey area or to verify anecdotal evidence that catch rates have been affected by recent ConocoPhillips seismic survey. Re catch effort of the TR and Demersal fisheries within Bethany survey area, email cites the latest published data. Based on this data, only the northern end of the Bethany acquisition area would be within the main area of effect for the TRF. States that this is the sort of information trying to obtain to validate level of fishing within survey area. Re information about the TR and Demersal fisheries, states the latest information can find is from Fishery Status Report 2012. Can Santos get updated information on both fisheries on catch value, species value, total allowable commercial catch for all species. Re catch rate impacts from seismic surveys , if data not provided to Santos because confidential, how does Santos verify anecdotal evidence that previous seismic surveys, most recently Conoco Phillips survey, impact to catch rates? Re Department's email referencing McCauley et al. 2003 study (which identified damage to the fish sensory epithelial cells), Santos advises the study also acknowledged that the fish were caged and therefore not able to swim away from sound source, and that the monitoring video suggested the fish would have fled the sound source if possible. Santos states the study identified that localised damage reached 15% and when averaged across the three transects, the number of missing cells was relatively low at 2.7%. Santos states study acknowledged that the impact of exposure on ultimate survival of the fish was not clear. Santos directs Department to Section 7.1.6.1.2 of Bethany EP where more recent studies are detailed including the Santos commissioned study, undertaken in collaboration with the NT Fisheries Department, on goldband snapper (McCauley and Kent 2007) which identified damaged hair cells immediately after seismic exposure, however, positive results were derived from a limited number of samples and should be treated with caution, as stated in the report itself. Section also references the extensive field study undertaken at Scott Reef which used auditory brainstem response (ABR) to look at hearing sensitivity loss after seismic noise exposure. Advises that of the four species of tropical reef fish exposed to seismic noise emissions, none experienced any hearing sensitivity loss. Santos cites Section 7.1.6.1.2 of Bethany EP where it states company has taken conservative approach to assessing TTS impacts to fish, basing the assessment on the sound exposure criteria recommended by the Working Group on the Effects of Sound on Fish and Turtles which undertook a review of experimental findings of sound on fishes and turtles.	Santos response to NTDPIRF-40 5/5/17

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-41 Part b	7/05/2017	Using the recommended criteria, Santos identified that the potential area of TTS ensonification over 24 hours equates to 3.8% of the TRF and 0.3% of the Demersal Fishery. Re Barotrauma impacts, Santos advises review of research on seismic impacts to fish did not identify any incidents of barotrauma, including the study referenced by the Department (McCauley et al. 2003), as well as the Santos-commissioned study on goldband snapper undertaken in collaboration with NT Fisheries Department (McCauley and Kent 2007). Re mortality impacts, Santos directs the Department to Section 7.1.6.1.1 of the Bethany survey where it states that no studies to date have demonstrated direct mortality of adult fish in response to seismic noise emissions, even when fired at close proximity (within 1ï 7 m). However, Santos advises the company has taken a conservative approach to assessing if fish mortality occurs and what potential impact to the fisheries within the survey area could be. Santos advises the assessment was undertaken using the sound exposure criteria recommended by the Working Group on the Effects of Sound on Fish and Turtles. Santos advises that based on this criteria, the area of potential impact represents 14.5% of the Timor Reef Fishery and 1.1% of the area of the Demersal Fishery. Santos state it should be noted that this area is based on the ñif mortality occursò impact, which - based on the research to date - is identified as unlikely. Santos states the area of potential impact is highly conservative as it has been calculated on the full acquisition area (where the seismic source is at full power) being above the threshold criteria. Santos advises this is not realistic as sound levels will increase and decrease as the seismic vessel moves throughout the area. Re research, Santos advises that in 2015, when Santos commenced engagement with the Department on the proposed survey, company twice asked for Department views on proposed research but did not receive a response. Santos advises that Santos, along with ConocoPhillips is a member of the APPEA Marine Environmental Science Program which recently commissioned the Centre for Marine Science and Technology to undertake a review of seismic survey research to identify gaps. Santos advises the next stage is to work with collaborative partners to undertake targeted research. Santos states, as previously raised, the Department should first look at the existing data to identify any short or long term impacts from previous seismic surveys undertaken in the area as well as the proposed Bethany survey. If confidentiality agreements can be obtained, Santos has already offered to assist in this analysis. Re pipefish, Santos states it will map the coordinates of the pipefish sighting but seeks confirmation it was one pipefish at one location. Santos requests advice on how many pipefish and if at more than one location. Re whale shark and several grey nurse sharks reference in Department email, Santos directs Department to Section 5.5.5 of Bethany EP where it states that whale sharks may transit the area, however, the grey nurse shark was not identified in the search of the Commonwealth Department of Environment and Energy (DoEE) Protected Matters Database, which only records this species as far north as the North West Shelf, though information looks to be from 2002 to 2006. Santos states Section 7.1.7 of the EP assesses the impact of seismic noise to sharks as it was identified that a number of species are likely to transit through the survey area. Re trawl trial, Santos repeats previous email request for Departmentõs advice on exact location, coordinates of the trial in the TRF and when it will finish.	Santos response to NTDPIRF-40 5/5/17
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-39	5/05/2017	Santos email: To [redacted] (having left phone messages) expressing frustration at pace Department's response to information requests. States [redacted] advice last week can suddenly ñplot the fisheries catch by species within the area of the survey to provide an indication of potential impactò without breaching confidentialities is a case in point. States he hoped to have data to Santos this week but this week is nearly over. Santos states plans to raise concerns with Department CEO but want to discuss first and requests a call. [redacted] replies on 05.05.2017, stating that [redacted] will call Santos. [redacted] responds on 05.05.2017, stating that there has been an few issues that has not allowed time to compile the data. States will send the data and follow up with a call.	Catch data that NTDPIRF offered to plot by species within the survey area (NTDPIRF-35 28/4/17) has not yet been made available.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-40 and attachment S	5/05/2017	NTDPIRF email: [redacted] [redacted] responds to Santos's email (01.05.2017 NTDPIRF-38). Apologies for Santos frustration at lack of progress on provision of data. States confusion over what data, thinking Santos only wanted the catch and effort data from years before, during and after the previous seismic activity in the region to see if any detectable impacts. States providing finer scale data requires permission of licence holders, and clarifies that data previously offered was plotting the % catch by species in the seismic survey area and this was not confidential as is just a % not an actual catch figure. States that it is a detailed undertaking and his team is working on other issues but will extract information and map it next week. States identified issues that "got really hot" in the final stages of ConocoPhillips EP submission. Apologised for confusing terms of impact used by he and [redacted] takes blame for providing ambiguous advice to [redacted] But states However, the studies examining the impacts of seismic on fish are equivocal. Described as most relevant the study by McCauley et al. 2003 which [redacted] states indicates damage to their sensory epithelial cells with no repair being evident after 58 days. To put context around Department concern, states it conducted barotrauma studies on a species of tropical snapper and while not all fish were killed by the change in pressure, those moderately incapacitated were very prone to attack by sharks abundant in waters. Therefore, want to identify what level of mortality (if any) is caused by seismic activity so can incorporate in our stock assessments. States whilst no time for research, wants to see "some specific work" on the impacts of seismic on fish in this region collaboratively with oil and gas companies, research agencies and fishers. Believes will provide more certainty and perhaps "take out some of the heat" in future activities. States that has already approached ConocoPhillips to do a research project involving operators in the region especially as potential for some federal funding. Extends thanks for references to habitat mapping work, states that aware of the studies. States there is a substantial amount of habitat in the area that hasnȇ been mapped so interested if additional work to see if giant clams identified or habitat that would support colonies. Confirms that pipefish reported by on-board observers during the current trawl trial. The details of capture are: 10/9/2016 lat: 10Á15ȏ long: 130Á07ȏ Also advises of interactions with "a whale shark and several grey nurse sharks" during the trawl trial.	Santos response provided in NTDPIRF-41 7/5/2017. Catch data that NTDPIRF offered to plot by species within the survey area (NTDPIRF-35 28/4/17) will be available in another week. Santos maps up the pipefish location which is in ~121 m water depth on the edge of the operational area and information included in EP Section 5.5.4 Fish. EP Section 7.1.5.3 assesses seismic noise impacts to these species. From this assessment and the implementation of additional controls such as reducing the seismic sound source, impacts we assesses as acceptable and ALARP. EP Section 7.1.5.4 assess impacts to whale sharks and sharks in relation to seismic noise impacts and with the implementation of appropriate controls such as the application of EPBC Policy Statement 2.1 Part A and B.6 Adaptive management to whale sharks, potential impacts were assessed as ALARP and acceptable. EP Section 7.1.5.3 assesses seismic noise impacts to fish including mortality impacts (potentially caused by barotrauma) and temporary threshold shift. A cautionary approach to assessing impacts has been applied and with the appropriate controls will be implemented including reduction of the noise source and a loss of catch payment to commercial fishers if impacts eventuate, to reduce impacts to ALARP and an acceptable level. Santos, along with ConocoPhillips is a member of the APPEA Marine Environmental Science Program which recently commissioned the Centre for Marine Science and Technology to undertake a review of seismic survey research to identify gaps. Santos advises the next stage is to work with collaborative partners to undertake targeted research. Santos states, as previously raised, the Department should first look at the existing data to identify any short or long term impacts from previous seismic surveys undertaken in the area as well as the proposed Bethany survey. If confidentiality agreements can be obtained, Santos has already offered to assist in this analysis.
Timor Reef and Demersal Relevant	TRD-70	5/05/2017	[redacted] email to Santos stating that he has spoken to relevant parties and near term compensation calculations in relation to the Timor Reef and Demersal fisheries for loss of catch are contained in table within email. Welcomes suggestions from Santos. States lump sum calculation is to determine a risk factor and belief that if commercial catch rates are impacted, so is biomass. States the risk factor is accounting for a possible reduced value in an asset because total catch may need to be reduced if biomass reduces. States that based on a 50% drop in commercial catch rates, have used a factor of 30%.	Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] from the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Timor Reef and Demersal Relevant	TRD-69	2/05/2017	Santos email confirming Santos awaits their advice on the Lump Sum elements of the formula discussed at Saturday meeting in Darwin. Also await their advice on where and when we can meet to workshop further questions they may have on the EP. Further request to send any comments and questions on the EP to Santos.	Follow-up email.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-38 Part 1	1/05/2017	Santos email: Further response to [redacted] email from 28.04.2017 (record NTDPIRF-35). Santos asked for: Any firm data of pipefish/clam claims. Location coordinates or shape files of trawling trial in the TRF so Santos could map against survey area and advice on when the trial finish's [you said 3 to 4 months ï can you be more exact?]. Also advised that the Saturday meeting with the commercial fishermen had made some progress, and that they had described the trawl trial as being certain to become permanent. Santos asked what was the process around the trial becoming permanent, and when would it take place? Santos also advised it had reviewed the ConocoPhillips EP and did not identify a reference to "deafeningòor "deathòzone. Santos advised that as part of the impacts assessment undertaken for seismic surveys and documented in the applicable EPs, potential impacts to fish had been identified as mortality (including injury leading to death), recoverable injury (including injuries unlikely to result in mortality) and temporary threshold shift. Santos advised that in 2015, the Working Group on the Effects of Sound on Fish and Turtles undertook a review of experimental findings of sound on fishes and its American National Standards Institute (ANSI) accredited report presented sound exposure criteria for different levels of effects for different groups of species. In the Bethany EP, modelling of the seismic sound source was undertaken to determine the area where these threshold criteria were predicted to be exceeded, and this is detailed in Section 7.1.6 of the Bethany EP. Santos advised that an assessment of the controls/mitigations for seismic noise is detailed in Table 7-13, and displacement of fishing activity is detailed in Table 7-21. Santos advised a summary of the controls/mitigations was provided to the Dept's [redacted] and [redacted] on the 20 April 2017 and compromised 1. survey undertaken outside commercial fish main spawning period of October to May 2.commencement of survey in commercial fishing low activity period from mid-June to August 3. no financial loss to fishers from fish displacement impact due to the Bethany seismic survey through make-good payment to fishers where they can show reduced catch, from same effort, due to the Bethany seismic survey 4. no financial loss to fishers from having to fish in another area due to the Bethany seismic survey through make-good payment to fishers where they can show additional operating costs associated with having to fish in another area due to the Bethany seismic survey.	Information provide in response to NTDPIRF-35 28/4/2017. Trawl trial map provided on 8/5/17 (NTDPIRF). Information requested but not yet received: When trawl trial would finish. Process for trial becoming permanent and when would this occur. Further information provided on pipefish (one pipefish recorded) see NTDPIRF-42. No further information has been provided in regards to clam claims.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-38 Part 2	1/05/2017	Santos email: Further response to [redacted] email from 28.04.2017 (record NTDPIRF-35). Santos advised habitat information was detailed in Section 5.5.1 of the Bethany EP. Information on habitat information was provided to [redacted] and [redacted] on the 20 April 2017, and that Santos had assessed two surveys within the Oceanic Shoals Marine Reserve that had been undertaken in similar areas to the seismic survey area. These were 2009 - Four areas in the eastern sector of the Oceanic Shoals CMR were surveyed to obtained detailed geological (sedimentological, geochemical, geophysical) and biological data (macro-benthic and infaunal diversity, community structure) for the banks, channels and plains (Heap et al 2010); and 2010 - Survey to build on the earlier survey in 2009 to extend the biophysical maps and information of the complex seabed environment of the Van Diemen Rise and identify potential geo-hazards and unique, sensitive environments that relate to offshore infrastructure (Anderson et al 2011). Santos advised that a review of these survey reports did not identify the presence of giant clams (Tridacna maxima or gigas). A study by AIMS in 2015 of shoals in the area noted the lack of giant clams with only two noted in their surveys of Evans Shoal and Tassie Shoal. Based on this information, it is unlikely giant clams would be present in the survey area where the seismic source is operational. Heap, A.D., Przeslawski, R., Radke, L., Trafford, J., Battershill, C. & Shipboard Party, 2010. Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia. SOL4934 ï Post-survey Report. Geoscience Australia, Record 2010/09, 78pp. Anderson, T.J., Nichol, S., Radke, L., Heap, A.D., Battershill, C., Hughes, M., Siwabessy, P.J., Barrie, V., Alvarez de Glasby, B., Tran, M., Daniell, J. & Shipboard Party, 2011. Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia: GA0325/Sol5117 - Post-Survey Report. Geoscience Australia, Record 2011/08, 59pp. Based on these studies, engagement with your department, the NTSC and individual fishers, Santos has not identified any fish ȉhotspotsȉ within the survey area. As detailed in the EP Figure 5-11, Tassie Shoal is ~ 23 km and Goodrich Bank is ~ 25 km from the operational area where the seismic vessel will be present and ~ 33 km and ~ 35 km, respectively, from the survey area where the seismic acquisition will be undertaken. We look forward to your replies to the questions above and any information you can provide on fisheries catch by species within the Bethany survey area, as promised. Also, of course, please donȉt hesitate to ask if you require further information/queries in relation to the Bethany survey.	Information provide in response to NTDPIRF-35 28/4/2017.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-37	29/04/2017	NTDPIRF email: Acknowledging email and confirming that Santos' summary sounds right.	For information.
Timor Reef and Demersal Relevant	TRD-68 and attachment R	29/04/2017	[redacted] sends Santos the meeting minutes from 29.04.2017.	Meeting minutes.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-35	28/04/2017	NTDPIRF email: [redacted] asking if the EP has been submitted to NOPSEMA, if so can he have a copy? Said he felt some concerns not addressed, mainly through acknowledgement in previous EP by Conoco Phillips that there was a ȉrisk of deafeningȉ zone surrounding the array for fish. Given the potential impacts on fish behaviour (e.g. on feeding and predator avoidance), [redacted] wanted to look at the mitigation methods in the Santos EP, in particular any habitat information that would indicate fish ȉhotspotsȉ within survey area. Department noted quite a few bathymetric features on the nautical charts. [redacted] also advised that the Department would plot the fisheries catch by species within the survey area to show provide potential impact. Said he would try to get done next week and could do it without breaching confidentiality.	Santos response to request for EP and concerns raised is detailed in NTDPIRF-36. NTDPIRF offer to plot fisheries catch by species within the survey area to show potential impact.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-36 and Santos Bethany 3D Seismic Survey EP Rev 0	28/04/2017	Meeting: Santos meets with [redacted] in Darwin and provides follow-up email thanking the Department for the meeting and summarises the discussion points: In reference to [redacted] email of 20 April (NTDPIRF-33 and Santos reply NTDPIRF-34), Santos had relied on published information and couldn't see that pipefish species and giant clams were in the survey area (though [redacted] said they had now been observed in the survey area). Santos advised [redacted] it had replied to [redacted] on 20 April, asking for more information but had not had a reply - [redacted] advised he was now on 7 weeks holiday [emails attached]. [redacted] confirmed that this was anecdotal evidence flowing from the trawl fishing trial in the TR fishery which had been running for two years and had about 3 or 4 months to go. In reference to Dept's [redacted] email of 28 April (NTDPIRF-35) and his statement that COP had cited a 'risk of deafening' zone in its previous EP, Santos advised that it couldn't find one in the COP EP. [redacted] said he thought it could be 'death zone.' Santos' [redacted] spoke about temporary threshold shift and the research pointing to fish moving away. Santos expressed its delight that [redacted] was going to "plot the fisheries catch by species within the area of the survey to provide an indication of potential impact, without breaching confidentiality" and that this is the sort of information it had been seeking from the Dept. for some time. Santos asked about Oyster Pearl fishery, having recently been advised by [redacted] that it was an NT fishery, and inquired why the Department hadn't sent through the details of the licence holders of this fishery in October 2016, as it had the other NT fisheries. [redacted] phoned his office and confirmed its NT fishery status and described it as "sporadic" and as involving "dive activity near the western banks off Bathurst Island." [redacted] said there was anecdotal evidence that seismic destroyed the oyster pearl tissue. We agreed the best way of managing this fishery was through good communications leading up to, and during, the seismic program. On the issue of make-good discussions with the commercial fishers, Santos said it was genuine in its desire to reach a make-good agreement because it recognised there would be an impact on their operations. Santos advised [redacted] it had had proposed a make-good formula based on the formula agreed with the same fishers in 2006-07 but the fishers believed it was no longer relevant/outdated by technology. Santos advised [redacted] the make-good discussions had started in December, and were ongoing, and that Santos was meeting with them again tomorrow. [redacted] confirmed that Department fish catch data was more or less up to date (a few months lag). Santos attached a copy of the EP, as requested by [redacted] to the [redacted] meeting summary email and also confirmed that the EP had been submitted, as previously advised to [redacted] (email of this advice attached). Santos said it looked forward to receiving the fish catch by species plotting from [redacted]	Information provide in response to NTDPIRF emails NTDPIRF-33 20/4/2017 and NTDPIRF-35 28/4/2017. EP Section 5.6.3.2 Timor Reef Fishery updated with information about the trawl trial. EP Section 4.1 Ongoing Consultation includes ongoing consultation with the Pearl Producers Association EP Table 7.13 Seismic Noise Risk Assessment includes control in regards to safe diving near seismic surveys as per DMAC Safe Diving Distance from Seismic Surveying Operations. EP Section 7.1.5.3 Fish assesses the potential impact of mortality and temporary threshold shift on fish from the seismic source. A cautionary approach to assessing impacts has been applied and with the appropriate controls will be implemented including reduction of the noise source and a loss of catch payment to commercial fishers if impacts eventuate, to reduce impacts to ALARP and an acceptable level.
Timor Reef and Demersal Relevant	TRD-67 and attachment P	27/04/2017	Santos responds to [redacted] email and letter sent on 24.04.2017. Santos attaches a response letter (attachment P). Santos also notes in the mail that [redacted] didn't copy [redacted] into his email, and asks if [redacted] will forward this correspondence to him.	Response to letter detailed in TRD-66.
Timor Reef and Demersal Relevant	TRD-66 and attachment O	24/04/2017	[redacted] email to Santos with letter attached. Email states EP does not meet legislative requirements and cannot be accepted by the regulator, with reasons in attached correspondence. Email states letter also contains process which allows for timely acceptance and looks forward to urgent response to better understand the risks to fisher operations.	Response detailed in TRD-67.
Timor Reef and Demersal Relevant	TRD-65	21/04/2017	[redacted] emails Santos, advising keen to meet to discuss the calculation of compensation payment. Also states CPUE is covered in the 2nd formula provided by fishers, and will explain why 2006 formula does not make-good the losses they would incur. Agreed to meet on Saturday 29.4.17.	Meeting minutes (TRD-68).
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-33 (refers to attachment L)	20/04/2017	NTDPIRF email: [redacted] responds to Santos's email on 11.04.2017 (NTDPIRF-32) and provides comments on attachment L In section 2.2.1, first para, we can now inform you that there have been a number of pipefish species observed by Fisheries staff in the survey area over the past year during trials of trawl gears in the TRF. Also it is very likely that there are Giant Clams resident in the survey area. Additionally, we believe the uncertainty surrounding the long-term impacts of seismic testing on sustainability of fish and marine aquatic life raised previously by the department are still relevant. We note that the timing of the work is planned for periods of least impacts to everyday fishing activities in the proposed survey area.	Responses to NTDPIRF issues raised are documented in NTDPIRF-34 20/4/2017.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-34 Part a	20/04/2017	Santos email: Relating to email sent on 20.04.2017 (NTDPIRF-34) Santos response Based on the Department of Sustainability, Environment, Water, Population and Communities Marine Bioregional Plan for the North Marine Region, we had identified that seahorses and pipefish occur in water depths < 20 m deep. The water depths within the area of the survey range from 40 to 140 m and hence was assessed as being outside the range for seahorses and pipefish. Would you be able to provide us some more detailed information as to the water depths and locations as to where the pipefish species have been observed as part of the trawl gear trials in the TRF? If you have location data we would be able to map this over the survey area to gain an understanding of preferred habitat. Would you be able to provide us with some more information as to why you believe that giant clams may be present in the survey area? We assessed that it was unlikely that they would be in the survey area based on the following information: Two surveys within the Oceanic Shoals Marine Reserve have been undertaken in similar areas to the seismic survey area. These are: Å2009 - Four areas in the eastern sector of the Oceanic Shoals CMR were surveyed to obtained detailed geological (sedimentological, geochemical, geophysical) and biological data (macro-benthic and infaunal diversity, community structure) for the banks, channels and plains (Heap et al 2010). Å2010 - Survey to build on the earlier survey in 2009 to extend the biophysical maps and information of the complex seabed environment of the Van Diemen Rise and identify potential geo-hazards and unique, sensitive environments that relate to offshore infrastructure (Anderson et al 2011). A review of these survey reports did not identify the presence of giant clams (Tridacna maxima or gigas). A study by AIMS in 2015 of shoals in the area noted the lack of giant clams with only two noted in their surveys of Evans Shoal and Tassie Shoal. Based on this information it is unlikely that giant clams (Tridacna maxima or gigas) would be present in the survey area where the seismic source is operational. Heap, A.D., Przeslawski, R., Radke, L., Trafford, J., Battershill, C. & Shipboard Party, 2010. Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia. SOL4934 ï Post-survey Report. Geoscience Australia, Record 2010/09, 78pp. Anderson, T.J., Nichol, S., Radke, L., Heap, A.D., Battershill, C., Hughes, M., Siwabessy, P.J., Barrie, V., Alvarez de Glasby, B., Tran, M., Daniell, J. & Shipboard Party, 2011. Seabed Environments of the Eastern Joseph Bonaparte Gulf, Northern Australia: GA0325/Sol5117 - Post-Survey Report. Geoscience Australia, Record 2011/08, 59pp.	Responses to NTDPIRF issues raised are documented in NTDPIRF-33 20/4/2017. Email sent (NTDPIRF-54) acknowledges that the NMR bioregional plan had been incorrectly interpreted and that there is a potential for syngnathid species (pipefishes, seahorses and pipehorses) to occur in the survey area and the EP has been updated to reflect this see Section 5.5.4 Fish and Section 7.1.5.3 assesses seismic noise impacts to these species. From this assessment and the implementation of additional controls such as reducing the seismic sound source, impacts we assesses as acceptable and ALARP.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-34 Part b	20/04/2017	Santos acknowledges the Departmentõs concern in regards to long-term impacts of seismic on the sustainability of fish and marine aquatic life. As per the information provided to you, drawn from the Environment Plan, we have assessed these impacts and developed appropriate control measures including: ÅSurvey undertaken outside commercial fish main spawning period of October to May. ÅCommencement of survey in commercial fishing low activity period from mid-June to August. ÅNo financial loss to fishers from fish displacement impact due to the Bethany seismic survey through make-good payment to fishers where they can show reduced catch, from same effort, due to the Bethany seismic survey. ÅNo financial loss to fishers from having to fish in another area due to the Bethany seismic survey through make-good payment to fishers where they can show additional operating costs associated with having to fish in another area due to the Bethany seismic survey. The Department has communicated to Santos (letters May 2015 and Oct 2016) that commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic surveys. Santos has replied to those letters and tried to obtain further information in regards to catch data to be able to gain a more detailed understanding of this impact and recovery times to be able to better inform its impact assessment. To date we have not been able to obtain this information. Please let me know if you would like any further information.	Responses to NTDPIRF issues raised are documented in NTDPIRF-33 20/4/2017.
Timor Reef and Demersal Relevant	TRD-60	20/04/2017	[redacted] email to Santos, saying Santos email of 19.04.17 is the first time we have been provided "any of the material in the EP". Says this is inconsistent with NOPSEMA guidelines/ legislation and can Santos provide timeline for fishers' comment. Then says he is "well aware" any compensation "limited to a range of hundreds of thousands," and says wrongly assumed that Santos commitment to a make-good agreement that leaves fishers no worse off meant there was more funds available. [redacted] said losses likely to be far higher and "while you stated that we would have a strong arguments to request more funds at a later date I have no confidence in such a process." Said it was his "opinion that no formula can meet your stated aim of mitigating our losses if funds are capped so low." Said he would meet with [redacted] today and provide engagement summary feedback that day.	As per previous and subsequent records, engagement and provision of information has been ongoing with fishers and has ensured they have sufficient information and time to be consulted about heir interests and that Santos includes the outcome of that consultation in the EP where relevant. Information from EP relevant to their interests provided 5/4/17 (TRD-40). Response detailed in TRD-64.

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Timor Reef and Demersal Relevant	TRD-61	20/04/2017	[redacted] email to Santos stating that stakeholder engagement record is incomplete on issues raised throughout this process and some Santos responses not included. Asks that it be updated. Also asks purpose of document and its legal requirement.	Summary records of engagement with fishers provided with EP (TRD-58). Copies of email records provided 20.4.17 (TRD-64). Also advised in TRD-64 that it is a requirement to submit, with the EP, a summary of the responses made by a relevant person and our assessment of that response as well as the full text of any response by a relevant person.
Timor Reef and Demersal Relevant	TRD-62	20/04/2017	[redacted] email to Santos asking to clarify understanding of fish mortality risk, including injury leading to death. Says based on the noise modelling, the area where the sound source levels exceed the mortality and potential mortality injury threshold for fish with a swim bladder is restricted to a distance of <210 m from the seismic source when at full power ><210m from the seismic source. This would represent an area of approx. 44,100 m2 for each and every firing during the survey. Asks, is Santos claiming that despite recognising real risk, it is unlikely as no one has seen a dead fish? Says with risks identified this way, it is up to Santos to prove it's not happening. Says Santos recognises risk of injury leading to death but fish will swim away, and asks which fish species and size will swim away, noting that seismic vessel is moving twice as fast as trawler, so believes avoidance unlikely. Asks, are fish movements predicted as one-offs out of an area or multiple movements? Santos emails [redacted] responding to his questions: Q: Mortality - Is it correct that you are claiming that despite recognising this as a real risk it is unlikely as no one has seen a dead fish? Generally with risks identified in this way it would be your responsibility to prove its not happening. A: As detailed in EP Section 7.1.6.1.1 - No studies to date have demonstrated direct mortality of adult fish in response to airgun emissions, even when fired at close proximity (within 1ï 7 m) (DFO 2004; Boeger et al. 2006, as cited in NSW DPI 2014; Popper et al. 2016; Carroll et al. 2017). Q: Injury Leading to death - You recognise risk but claim unlikely as the fish would move away. Could you outline which species and sizes of fish you suggest could make such a migration. I would note your vessel is moving twice as fast as a trawler so such avoidance seem a little unlikely. Also, these fish movements are they predicted as one-offs out of the area completely or multiple movements just avoiding these sound levels? A: As detailed in EP Section 7.1.6.1.1 - Mortality, including injury leading to death - potential fish mortality, potential mortality injury and recoverable injury to fish are unlikely, for fish that are not site attached or reef fish, with impacts more likely to be behavioural including avoiding or moving away from the area for the period of the survey. The EP does not detail each potential fish species but groups them based on if they are free-swimming and able to move away from the area and those that are site attached and unlikely to move away from the area. The implementation of ŝoft startò procedures where the acoustic source is sequentially ramped up is employed to enable animals to move away from the vessel. As detailed in EP Section 7.1.6.1.3 Behavioural Changes - behavioural responses from fish to the seismic source is likely within a relatively localised area (hundreds to thousands of metres) and would be of short term duration as the seismic source passes (minutes to hours).	Response provided as per this record (TRD-62). EP Section 7.1.5.3.1 Seismic Noise Fish Mortality assesses impacts to pelagic fish and site attached fish. Based on data from the NTDPIRF the area of potential mortality impacts is within the area of the Timor Reef Fishery where 5 ï 12% of their catch has been caught based on data from 2011 to 2016 (Table 7 9). For the Demersal fishery the % catch for the much larger operating area is 0.04% thus the % catch from the potential area of impact would be significantly < 0.04% (Table 5 16). A conservative approach was used to identify the area where the sound source levels exceed the mortality and potential mortality injury thresholds as the furthest distance of 210 m was used. The area of potential impact is based a larger seismic source (3480 cuin) than the final seismic source (2380 cuin) which showed a reduction in the distances that the sound source levels exceed the mortality or mortal injury threshold for fish with a swim bladder of between 5 ï 45 m depending on the modelling location. With the appropriate controls in place, including a Catch Loss Payment should impacts to fish and catch rates eventuate, impacts to the fishers and fishery can be managed to an acceptable level.
Timor Reef and Demersal Relevant	TRD-63	20/04/2017	Santos email to [redacted] noting surprise at [redacted] claim that this is the first time provided any EP material. Santos advises it started with the Information Sheets, the first in October requesting feedback from stakeholders, and more recently the 5 April document (which contained the excerpts from the EP for seismic noise impacts to fish and catch rates and also for marine interactions, areas relevant to your activities). Santos repeats request for advice on when a good time to meet with trio to discuss a make-good agreement.	For information.
Timor Reef and Demersal Relevant	TRD-64 and attachment N	20/04/2017	Santos emails [redacted] in response to [redacted] email of 20.04.17, advising that stakeholder summary is complete to our knowledge, and asks him to identify where it is deficient? To assist, Santos attaches PDF of actual copies of exchanges, as provided to NOPSEMA. In response to [redacted] question, Santos also advises that it is a requirement to submit, with the EP, a summary of the responses made by a relevant person and our assessment of that response as well as the full text of any response by a relevant person.	Response to email TRD-60.
Timor Reef and Demersal Relevant	TRD-56	19/04/2017	[redacted] responds to Santos email of 18.04.2017, saying he is awaiting a revision to Santos information (provided on 5 April) based on his feedback. Advised he had contacted NOPSEMA about EP lodgement being made before he had seen revision, and he was not clear on what guidelines or process Santos was following. Requested a time from Santos on when he needed to provide feedback to revision of 5 April information.	Copy of Bethany EP provided (TRD-58) which included feedback from fishers to information provided on 5/4/17 (TRD-40). A workshop on the EP was held on 12 May and that consultation has been continuing since then to ensure the fishers have sufficient information and time to be consulted about the potential affect on their interests.

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Timor Reef and Demersal Relevant	TRD-57	19/04/2017	[redacted] email to Santos seeking EP copy asap. Flags he may be out of the loop on make-good discussions because believed "very little funds" were available from Santos and therefore formula "obsolete" (sic). Expresses hope this has changed because of impact of previous surveys.	Copy of Bethany EP provided (TRD-58). Santos has shown it committed to a make-good agreement by continued ongoing engagement to determine a formula. Santos has also proposed a make good payment model in the EP in the event that an agreement cannot be reached. Santos has engaged an independent expert whose preliminary view on the model is that it is industry standard and reasonable, and based on information which is feasible to obtain.
Timor Reef and Demersal Relevant	TRD-58 (attached submitted EP) and attachment N	19/04/2017	Santos email to [redacted] with EP and relevant engagement summary attached. Also attached is email to [redacted] (and [redacted] of 08.03.17 indicating a make-good budget in the range of hundreds of thousands of dollars. Also repeats commitment to [redacted] [redacted] (as representatives of [redacted] and [redacted] and [redacted] of desire to reach agreement on a make-good formula that is defensible, drawing on previous and future catch data and recognising effort. Repeat desire to meet at a convenient time in next fortnight, please offer some dates/locations.	Provision of EP.
Timor Reef and Demersal Relevant	TRD-59 (attached submitted EP) and attachment N	19/04/2017	Santos email response to [redacted] email of 18.04.17. Advise Santos belief that two formulas proposed by fishers (copied in this email) do not consider a displacement effect due to seismic unless they also accommodate both CPUE and location of catch, as was captured and assessed for the 06/07 model. Santos also can't see why 06/07 formula (copied in this email) could not accurately reflect current fishing in the TR & D fisheries. Please explain what you mean by this? Repeat desire to meet and discuss make-good model and reach agreement before the start of the program. Is there a time in the next fortnight?	Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] rom the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Amateur Fishermenȇs Association of the NT (AFANT)	AFANT-20	18/04/2017	Santos advises AFANT that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September.	For information.
Aquarium Fishery	AQ-18	18/04/2017	Santos advises [redacted] as both the Chair of the NTSC and as the Aquarium Fishery representative on the NTSC Board, that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September. We will keep you informed of its progress. [redacted] acknowledges email on 19.04.2017	EP Section 4.1 Ongoing Consultation includes AFANT.
ConocoPhillips	CoP-7	18/04/2017	Santos email: Please be advised we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September.	Provision of Information
Northern Prawn Fishery	NPF-26	18/04/2017	Santos email: Advising NPF that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September.	Provision of Information
Northern Territory Seafood Council	NTSC-15	18/04/2017	Santos email: Advises [redacted] as both the Chair of the NTSC and as the Aquarium Fishery representative on the NTSC Board, that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Confirm current planning is for the survey to commence in July and finish by the end of September. We will keep you informed of its progress. NTSC email: [redacted] acknowledges email.	EP Section 4.1 Ongoing Consultation updated to include NTSC.

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NT Department of Primary Industry and Resources	NTDPIR-7	18/04/2017	Santos email: Advises Department that we have submitted the Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Based on feedback, including from the department, the EP states: ÅThe operational window for the survey (which will take up to 75 days) is May to end of September. Current planning is for the survey to commence in July and finish by the end of Sept. These dates are based on initial advice from fishers to us that this was the period of least activity (June, July, August), and avoids a peak spawning period (October). ÅAs the survey area overlaps a number of fisheries (Demersal and Timor Reef immediately spring to mind), we acknowledge that there is the potential to impact commercial fishers via displacement of activities and therefore Santos has committed in the EP to a ĩCommercial Agreement for Displacementà We have been in discussions with key, relevant commercial fishermen about this for some time, and whilst not yet resolved, we are exercising best endeavours to reach a resolution before seismic activity begins.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-32	18/04/2017	Santos email: Advises Department that we have submitted the Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Based on feedback, including from the department, the EP states: ÅThe operational window for the survey (which will take up to 75 days) is May to end of September. Current planning is for the survey to commence in July and finish by the end of Sept. These dates are based on initial advice from fishers to us that this was the period of least activity (June, July, August), and avoids a peak spawning period (October). ÅAs the survey area overlaps a number of fisheries (Demersal and Timor Reef immediately spring to mind), we acknowledge that there is the potential to impact commercial fishers via displacement of activities and therefore Santos has committed in the EP to a ĩCommercial Agreement for Displacementà We have been in discussions with key, relevant commercial fishermen about this for some time, and whilst not yet resolved, we are exercising best endeavours to reach a resolution before seismic activity begins. NTDPIRF email: [redacted] acknowledges email on 19.04.2017.	For information.
Pearl Producers Association	PPA-12	18/04/2017	Santos advises PPA that they have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September. We will keep you informed of its progress. [redacted] acknowledges email with a thanks 18.04.2017	For information.
Spanish Mackerel	NTFSM-15	18/04/2017	Santos advises that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September. We will keep you informed of its progress.	For information.
Spanish Mackerel	SMF-12	18/04/2017	Santos advises SMF that we have submitted our Environment Plan to NOPSEMA for the Bethany seismic survey (over NTP85 and NTP82) in the Bonaparte Basin. Just to confirm, current planning is for the survey to commence in July and finish by the end of September.	For information.
Timor Reef and Demersal Relevant	TRD-54	18/04/2017	Santos responds to [redacted] enquiry of 13.04.2017. Advises there are two seismic/sound wave sources (15m x 15m), each made up of several elements of various sizes (ranging from 45 cubic inches to 290 cubic inches) which cumulatively total 3480 cubic inches. Each seismic/sound wave source operates alternately, and is designed to simulate a point source, such that the focus of energy emanates from the centre of the array. The modelling is done from the centre of the array. Also confirms that the EP has been submitted and will send a copy tomorrow, along with engagement history. Also repeats previous requests to provide a convenient date and location to meet and discuss make-good formula/arrangement aimed at leaving fishers no worse off from our activity. Also advises queries or requests for info via email so there is a clear record.	Response to request for further seismic source information (TRD-51). Modelled parameters for seismic source is detailed in Section 4 Jasco Noise Modelling Report sent to fishers 16/5/17 (TRD-79).
Timor Reef and Demersal Relevant	TRD-55	18/04/2017	[redacted] emails Santos saying he has been informed that the EP was lodged on Thursday and can he have a copy. [redacted] states commitment to compensation solution but COP seismic program has severely impacted catch rates, which have not recovered (in 9 months). Therefore disagrees with relevant EP entry on COP impact and cannot accept STO proposed compensation formula, used in 06-07 with fishers, because does not reflect current fishing in TR & D fisheries. [redacted] says fishers' proposed formulas have sufficient detail and accounts for effort. Concludes by saying COP impact has caused ongoing severe financial impact, and they remain concerned about Bethany's short and long term impact.	EP sent to fishers (see TRD-58). Information of 9 months recovery after CoP seismic survey is new information since EP submission. Despite requests no data to support claims of CoP seismic impacts to catch rates has been made available by fishers of the NTDPIFR. In regards to make-good agreement the 06-07 formula was based on catch effort and if applied today would take into account current fishing methods.
Timor Reef and Demersal Relevant	TRD	13/04/2017	Stakeholder engagement post EP submission on 13th April 2017.	

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Timor Reef and Demersal Relevant	TRD-51	13/04/2017	Santos reply to email 12/4/2017 requesting information on seismic source. [redacted] requested further information.	Further information sent - see TRD-54.
Timor Reef and Demersal Relevant	TRD-52	13/04/2017	Santos reply to email 12/4/2017 indicating that impacts to catch rates may occur and that CoP survey impact was referenced in information provided. The link to the CoP survey was not clear and this has been amended. Reiterated desire to strike make good arrangement before the start of the survey in good faith. And request for time to meet and discuss.	Information sent clarifying that information provided by fishers in regards to impacts from CoP survey was referenced in the EP information given on 5/4/17 (TRD-40). EP Section 7.1.6.1.4 Commercial Catch Rate Fish updated to clearly show catch rate impacts information is from CoP seismic survey.
Timor Reef and Demersal Relevant	TRD-53	13/04/2017	Santos email to [redacted] apologising for not getting back to him and will send information request on seismic source on Tuesday 18.04.2017.	For information
AMOSC	AMOSC-2 and attachment M	12/04/2017	AMOSC replies with consultation letter and one recommendation which is to include mention of the provision of ‰trained oiled wildlife personnelòfrom WA DPaW through AMOSC. They have a pool of trained staff as well who would be available to support if required. Santos replies 12.04.2017 Thank you for your timely response. I have updated the Bethany OPEP to included your recommendation. Once/if the EP is accepted by NOPSEMA I will send a final version of the Bethany OPEP to AMOSC for your records.	OPEP updated to include AMOSC's recommendation. EP Section 4.1 Ongoing Consultation includes requirement to send OPEP once accepted.
ConocoPhillips	CoP-6	12/04/2017	CoP email: Response to Santos email Thank you for the updated information (received via email and fact sheet on 3 April 2017) on the revised operational area for the Bethany Seismic Survey. Your email: ÅNoted that ConocoPhillips had previously provided advice (via emails on 12 and 14 October 2016) when the survey was confined to the NT/P85 permit area; ÅAdvised that survey area has now been extended to also cover the NT/P82 permit area; and ÅAsked whether ConocoPhillips will be undertaking any petroleum activity in, or in the vicinity of, the revised Bethany operational area, as detailed. Please be advised that ConocoPhillips is likely to be conducting all or part of the following petroleum activity in the vicinity of your operational area during part of your proposed June to August 2017 activity window: Drilling of the second well in our current appraisal drilling campaign in the NT/RL5 permit area (currently anticipated for completion during July). In addition, we may also be undertaking marine surveys, including environmental and/or geophysical scopes between the NT/RL5 permit area and Darwin (currently anticipated to occur over 2-3 weeks during July/August). Extension of the Bethany survey to cover the NT/P82 permit area will require communication in advance between our companies to ensure any potential SIMOPS are appropriately planned and managed. We are happy to work through our normal communication channels and protocols in this regard. Please contact myself in the first instance and I will ensure the appropriate personnel are involved.	EP Section 4.3 Ongoing Consultation updated to include ConocoPhillips.
Timor Reef and Demersal Relevant	TRD-49	12/04/2017	Email from [redacted] to Santos requesting phone call to clarify what is meant by seismic source in information provided.	Santos response - see TRD-51 and TRD-54.

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Timor Reef and Demersal Relevant	TRD-50	12/04/2017	Email from [redacted] expressing concern of direction or process did not want to waste time on a process that does not achieve a result for both parties. Talked about trust, impact of CoP survey on catch not referenced in our draft, advice that if total compensation package is less than 1M fisherman will lose money and at a time when still recovering from last survey. Challenged 2006/07 formula as not realistically reflecting commercial fishing operations in the two fisheries, saying that for trawl simplest effort calculation is time in the water. Also challenged using data going back to 2000 as average catch rates have no correlation to old data because of technology and better vessels. Happy to meet but concerned no real funds are available and issue of long term impact.	The impact to fishers catch from CoP survey was provided in the EP information sent to the fishers on 5/4/17 (TRD-40), however, it was a generic statement rather than specifically referencing the CoP survey. EP Section 7.1.6.1.4 Commercial Catch Rate Fish has been updated to reflect information is in regards to CoP survey and include new information from [redacted] that catch rates have not recovered after 9 months (TRD-55). Despite requests no data to support claims of CoP seismic impacts to catch rates has been made available by fishers or the NTDPIFR. Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted] rom the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-19	11/04/2017	Santos summarises phone conversation with AFANT Executive Officer, [redacted], at 11.08am on 11 April 2017. [redacted] said: ÅThe Bethany survey will have some impact on these charter operators but there was no clear position on when was the best or worst time. ÅThe NT Guided Fishers were the best placed to steer but not actively engaged ÅOK for us to rely on previous advice from AFANT that June-August would be the period of least disruption to recreational fishermen ([redacted] email of 16 Nov 2016). ÅWould like to be kept informed of surveyꞌs progress to share with members. I said I would provide updates through [redacted]	EP Section 5.6.4 Recreational Activities updated to include time period of least disruption. EP Section 4.1 Ongoing Consultation updated to include AFANT.
Northern Prawn Fishery	NPF-25	11/04/2017	Santos email: Follow-up of emails 20/3/017 and 4/4/17.	Follow-up - no response to date.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-31 and Attachment L	11/04/2017	Santos email: sent information for the EP provided to relevant TRF and Demersal Fishers, which based on responses from licensees are [redacted] and [redacted] Discussions have been ongoing with the three and we are hopefully that we can reach a make-good agreement. Advised hoping to submit EP at end of week. Please advise if any issues.	NTDPIRF provide further information in response to the information provided. See NTDPIRF-33.
Offshore Net and Line	ONLF-21 and attachment E	11/04/2017	A final follow-up on my email to you/Offshore Net & Line Fishery representative on the NT Seafood Council. Please let me know as soon as you can if you or your members have any issues or concerns to the proposed survey.	Follow-up on provision of information. A number of attempts to obtain a response from the ONLF including via NTSC (NTSC-12, NTSC-13, NTSC-14). No further engagement required.

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Pearl Producers Association	PPA-11 (PPA's referred to study site within record)	11/04/2017	Santos follows up on the email sent on 06.04.2017 have just left just left a message on your mobile phone (along with this email) chasing up a response to the questions asked below. Are you able to reply? [redacted] replies on 11.04.2017 As discussed very briefly in our last call. This map is just an indicative map compiled from By the Dept. of Fisheries WA, for the purposes of showing the locations of Pinctada maxima fisheries for the Marine Stewardship Council Assessment. It has recorded The Northern Fisheries as historic fisheries. This is not correct. The Pinctada maxima fisheries in the Northern Territory (which are managed and administered by the NT and not WA) are current fisheries. The Northern Territory Fisheries have also had the fisheries assessed against the Marine Stewardship Council standard in the assessment as WA (the Industry is the client in this assessment). Below is an 'indicative map' of the main NT fisheries. As explained previously, oysters from these areas are not abundantly distributed, and so in order to maintain the sustainability of the stock, they are harvested sparingly by hand (not intensively). Intensive harvesting would upset the sustainability of patches. As explained most of the harvesting activity is located in the south west (see 'study site 'in the map below) due to higher abundance. With respect to the Western Grounds (in the northern part of Melville) where distribution is less abundant and were the population can support fewer removals.	EP Sections EP Section 5.6.3 Northern Territory Managed Fisheries updated with information provided. No objectives or concerns raised in regards to the seismic survey and pearl oyster shell fishery.
Timor Reef and Demersal Relevant	TRD-46	11/04/2017	Email from [redacted] to Santos, expressing concern at short notice and out of concern for probable impacts on marine life, having put family break on hold and stating that canꞌt get industry answers to simple requests, information provided is inconsistent and citing non-published reports. Seeking advice on a more reasonable timeframe.	Non published report was a WA Dept. of Fishery Seismic Noise literature review that is in draft. A review of research of seismic impacts on fish by the WA DoF (2016), detailed that observations from the literature indicated 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 m from a high energy sound source (McCauley and Kent 2012). As detailed in response to [redacted] (TRD-47) statement and reference removed from the EP. Engagement has been ongoing and responses being timely where information required and EP being updated where new information has been provided. See ongoing TRD records.
Timor Reef and Demersal Relevant	TRD-47 (map included in record)	11/04/2017	Email from Santos to [redacted] addressing marine reserve claim (confusion over terminology between reserve and proposed park), the unpublished report (we agreed to remove statements and propositions from this report), advising that the phone call wasnꞌt recorded but noting he had not objected to the summary, and asking if further thought had been given to discussing a make-good agreement.	Information sent to address comments regarding Commonwealth reserve (TRD-45).
Timor Reef and Demersal Relevant	TRD-48	11/04/2017	Email from [redacted] asking Santos if the call was not recorded, were notes taken or others party to the call? Also, that he had not had time to review the draft summary except to note it was a selective record. Also questioned Santos understanding of marine reserve system. Seeking a timeframe for response.	For information.
ConocoPhillips	CoP-5	10/04/2017	CoP email: Requests when they need to respond by. Can you please give me a date that you need to have response by. Santos Email: Responds on 11.04.2017 with ASAP we are aiming to submit by cob Thursday.	Santos responded with request for response by 13.4.17
TGS	TGS-9	10/04/2017	TGS update that our EP North OMR response has been pushed back a month. Response was originally due in today, but weꞌve have an extension granted, so resubmission will now be on/before 10-May.	Provision of information.
AMOSC	AMOSC-1	9/04/2017	Santos sends email to AMOSC to review and provide comment on the Bethany OPEP.	For information.
Timor Reef and Demersal Relevant	TRD-44	7/04/2017	Email from [redacted] thanking Santos for responses but advising it would take time to adequately cover the material. Could you suggest a timeframe for the response. Good you send me transcript or sound file of the phone call.	Summary of phone call, with Santos response, provided (TRD-43).
Timor Reef and Demersal Relevant	TRD-45 (map included in record)	7/04/2017	Email from [redacted] to Santos re survey and its operation within a Commonwealth reserve, and asked why Santos thought the survey was some distance from the reserve.	Information sent - see record TRD-47.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-18	6/04/2017	Santos left message on office phone and mobile phone to follow up on phone call 27/3/17.	Follow-up of provision of information.

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Pearl Producers Association	PPA-10	6/04/2017	Santos emails - Thanks for this. But again I need to get further information from you, and as quickly as possible. The level of the intensity of [redacted] fishing activity in the seismic survey area is not clear. Can you/[redacted] show us where [redacted] has previously hand-harvested so we can see what level of impact our survey would have? The map we have below from the WA Dept. of Fisheries (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, 316pp) in regards to the fishery looks like it is an historic fishery, and not an active one. Also, is the fishing for the shells, meat or pearls?	Follow-up to obtain more information in regards to the Pearl Oyster Fishery activity in the survey area.
Timor Reef and Demersal Relevant	TRD-43	6/04/2017	Email from Santos to [redacted] with draft summary of the telephone conversation of 5 April (asking that it be corrected if considered inaccurate), along with Santos responses where appropriate (including agreeing to provide more information on resident fish) and attached updated document including the Santos risk table. Santos acknowledged potential for impact via temporary threshold shift and behavioural changes in the short term and that had potential to impact catch rates. Based on our consultation. Santos used an approach where catch rates could be affected by up to 50% and recovery to pre-seismic levels take 3 ï 4 months. Santos proposed control measure of no financial loss to fishers from fish displacement impact and impact of having to operate elsewhere. Santos email also highlighted that, based on the information available, was possible the survey could displace DF fishers from an area of approximately 3% of the DF fishery for up to 75 days, and TRF fishers from an area of approximately 30% of the TRF fishery for area up to 75 days. Santos also responded that research referenced was from well-respected scientists also confirmed that survey was within multi use Marine Reserve and 40km from proposed marine park. [redacted] advised that he would email with comments.	EP Section 5.5.4 and 7.1.5.3 Seismic Noise Fish updated to provide more information and assess impacts to resident fish. EP updated to remove reference to WA Dept. of Fishery Seismic Noise literature review that is in draft. EP Section 7.1.5.3 Seismic Noise Fish includes assessment of mortality and TTS impacts to fish. These sections have been updated based on feedback that mortally and TTS that leads to mortality could have a long term (> 12 months) impact on fish and fish populations. EP Section 7.1.5.3.4 Seismic Noise Fish Catch Rates updated based on feedback that impacts to catch rates could have a long term (> 12 months) impact to fishers.
Pearl Producers Association	PPA-8	5/04/2017	Santos replies to email Thank for this. But naturally it raises more questions, that urgently need answering. Can you/[redacted] please advise: 1. What is a sea plot? 2. Can you provide a description of what activities take place here i.e. trawling, hand harvesting, pots, farming? 3. Are the activities seasonal? We need to understand what activities take place and when they take place. 4. Is there a water depth restriction to activities? 5. Can we get coordinates of the area so we can map up against the Bethany survey area? We require this information ASAP as we are planning to submit the Environment Plan prior to Easter ï Thurs 13th April. Once we have this information, we can then see what the overlap is and determine potential impacts. If there is overlap, we are going to need to discuss directly with [redacted] and very quickly, to look at how we manage any potential impacts. And thanks for your review and amendments to the notes from our phone conversation yesterday. [redacted] replies that he will get back to Santos ASAP.	Follow-up to obtain more information in regards to the Pearl Oyster Fishery activity in the survey area.

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Pearl Producers Association	PPA-9	5/04/2017	1. What is a sea plot? Sea plot is a computerised chart display plotting system used by vessel skippers which provides skippers and fleet managers locational and spatial fishing information. It plots the position of tows or drifts geo-spatially by vessel and target etc. In essence it acts as a repository of a fishers fishing spots, and as such it is highly confidential data and not data that is shareable. It also provide a means of displaying vessel routes between various locations. 2. Can you provide a description of what activities take place here i.e. trawling, hand harvesting, pots, farming? Hand-harvesting (by drift divers) of Individual Pinctada maxima oysters. Pearl Culture type oysters are harvested ï and larger brood-stock oysters are left behind so that they spawn. Cannot harvest any other way or it would endanger the sustainability of the patch. Oysters in this area are not distributed abundantly (rather they have patchy distribution) 3. Are the activities seasonal? We need to understand what activities take place and when they take place. Oyster Fishing is seasonal ï In the NT, fishing can occur between the months of April and October. Areas are randomly fished dependent on annual requirements, patch size and the need for regeneration of natural stocks for a sustainable industry (brood stock being able to spawn). 4. Is there a water depth restriction to activities? Yes. Oyster Harvesting does not occur in water deeper than 35m. These deeper oysters are relied on as broodstock. Given that P. maxima are broadcast spawners and sessile in nature, it is important that there is abundant broodstock to sustain the population. 5. Can we get coordinates of the area so we can map up against the Bethany survey area? Co-ordinates for the smaller box on the map: 12.07.929 S 129.05.519E 12.24.240S 129.05.734E 12.07.717S 129.31.581E 12.24.240S 129.32.012E Co-ordinates for the larger area: 10.52.410S 128.44.411E 10.30.467S 129.31.689E 11.02.413S 129.52.582E 11.11.773S 129.36.859E 11.28.460S 129.47.951E 11.46.933S 129.16.181E As discussed, the PPA represents its members in matters that affect our members broadly, this includes the interactions between seismic surveys and Pinctada maxima stocks.	EP updated with information provided and assessment undertaken on noise impacts to Pearl Oysters and divers and displacement of fishery during period of survey. See EP Sections EP Section 5.6.3 Northern Territory Managed Fisheries, Section 7.1.5.2.3 Seismic Underwater Noise - Molluscs and Section 7.1.5.7 Seismic Underwater Noise - Pearl Oyster Divers.
Timor Reef and Demersal Relevant	TRD-40 and attachment L	5/04/2017	Email to [redacted] and [redacted] with attached information from EP relevant to their interests (or the licence-holders you represent). Once feedback received will update log and send back before EP is submitted. Advised it was a draft and was seeking feedback and clarification. Also asked if further considered make good formula, and request to meet.	Provision of information

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Timor Reef and Demersal Relevant	TRD-41	5/04/2017	Phone conversation with [redacted] with Santos. Expressed variety of concerns with information provided earlier in the day as well as the short notice in which expected to respond citing NOPSEMA guideline on reasonable time. Described content as ñrubbishô and referenced one example where mortality was a possibility for fish exposed to an airgun. He said for all those fish within 250m of either side of the 6km streamers, over 75 days, driving at 4.5 knots and firing a sound wave every 8 seconds it was like each fish getting hit 20 times. Challenged fish catch data (drawn NTG publications). Expressed noted usual assumption about fish swimming away but would be surprised if a Pipefish swam 500m in its life. We needed to put on the table possibility of mortality rate didn't want a war zone situation we had not provided our risk assessment matrix. Wanted to continue to make good discussions but higher level of risk meant it would involve more than just make good. He rejected the science saying it needed to be broader and reviewed by an independent scientist. He said there was not enough information to determine if there would be an impact across an area of the size of the survey. He also questioned the impact on the marine reserve.	Santos response in TRD-43. EP Section 7.1.5.3 Seismic Noise Fish assessing potential mortality impacts to pelagic and site attached fish including pipefish. Section 7.1.5 Seismic Noise Evaluation of Impacts assessing impacts to conservation values within the marine reserve such as corals, fish, turtles, seasnakes, rays. sharks and cetaceans. NTDIPRF provide more recent data which showed shows that total catch for 2011 to 2016 within the survey area, with the inclusion of a 3.6 km buffer which is the maximum noise impact area, ranges from 8% - 16% of the total TRF catch with an average of 11% (Section 7.1.5.3 Seismic Noise Fish). Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries [redacted] rom the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Timor Reef and Demersal Relevant	TRD-42	5/04/2017	Email from [redacted] to Santos saying working on previous email should be ready to send tomorrow.	No information received.
Northern Prawn Fishery	NPF-24 (map within record)	4/04/2017	NPF email: Confirmed closest NPF activity to the Bethany survey area (red area) is between 23 ï 47 km away from it. Santos email: 05.04.2017, acknowledging [redacted] eply and wanted to check if have any other comments/feedback?	For the EP assessment Santos has used ~ 19 km as the distance between the closest NPF activity to the survey area.
Pearl Producers Association	PPA-7 (within record includes [redacted] feedback) and attachment I	4/04/2017	Santos email: Summary of call for [redacted] to review as regulator requires engagement records, hence the reason for keeping account of our exchanges. You can see, if you follow the email chain, information in relation to NT/P85 was first provided to you on 11 October last year. [redacted] response to email on 05.04.2017 with his feedback to the phone call summary Attaches map from [redacted] You will see it indicates that there is Pinctada maxima fishing data within and in proximity to the proposed Santos area.	Map used to overlay with Bethany survey and operational area and shows that pearl oyster fishing area within both operational and survey area see EP Section 5.6.3 Northern Territory Managed Fisheries Figure 5-24.

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ConocoPhillips	CoP-4 and attachment E	3/04/2017	Santos email: Clarify if COP will be undertaking any petroleum activity in or in the vicinity of the revised Bethany operational area, as detailed in Information Sheet 2. You have previously provide advice on the NT/P85 permit area but the Bethany survey area has been extended to cover NT/P82.	Response received CoP-6.
Pearl Producers Association	PPA-6	31/03/2017	Santos calls and left phone message to see how he was going on his advice on Monday that he would send me something indicative on sea-pot data relevant to the Bethany survey by the end of this week. The message included a request to call or send through the information as soon as he was able.	Follow-up to obtain more information in regards to the Pearl Oyster Fishery activity in the survey area.
Inpex	IN-2	30/03/2017	Santos email: Follows up. Inpex reply advising that they have no activity planned in the Masela Permit during May to October 2017.	Section 5.6.5 Oil and Gas Activities updated to include information in regards to Inpex not undertaking any activities in Masela Permit.
Offshore Net and Line	ONLF-20 and attachment E	29/03/2017	Santos following up my previous correspondence (further below) to [redacted] as the representative of the Offshore Net & Line Fishery on the NT Seafood Council, in relation to a seismic survey (called Bethany) we are proposing to undertake in the Bonaparte Gulf later this year. After some months of communications with [redacted] he advised he has stepped down as that representative and been replaced by you. Attached Information Sheet#2 relating to Bethany. This information has been provided directly to the Offshore Net & Line Fishery licence-holders identified by the NT Department of Primary Industry & Resources. I have not had any feedback, other than from [redacted] saying he doesnӴ fish in the area. [redacted] has not provided any other advice. Could you please let me know if you or your members have any questions or concerns about the survey? I have assumed that the absence of comment means the survey area is not relevant to your members or there are no concerns, but assumptions can be risky.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-14	29/03/2017	Confirmation receipt of correspondence, desire to be kept informed of program.	EP Section 4.1 Ongoing Consultation update to include keeping the Spanish Mackerel Licensee up to date with regard to information for the Bethany survey.
Northern Territory Seafood Council	NTSC-13	28/03/2017	Phone: Attempt to contact [redacted] for the new Offshore Net Line & Fishery representative, but we received an out of office. She will not be back in the office until 8th May.	Santos follow-up with NTSC Chair (NTSC-14).
Northern Territory Seafood Council	NTSC-14	28/03/2017	Santos email: To [redacted] in his capacity in his role as the NT Seafood Chair in [redacted] absence. Santos summaries the direction it has been given with which NT Fisheries it needs to engage with and the responses we have received to date. Santos would like to know if there are any other concerns from NTSC and if he can provide contact details for [redacted] from Offshore Net Line & Fishery representative. NTSC email: Stating that be believes everyone has been covered and Santos has given ample opportunity for feedback. [redacted] also ask [redacted] for [redacted] details. Santos email: Thanks [redacted] for the response and confirms they have received [redacted] details.	Santos contacted [redacted] from Offshore Net Line & Fishery representative directly as per ONLF-20 and ONLF-21.
NT Department of Aboriginal Affairs	NTDoAA-4	28/03/2017	Santos emails to give an update on their stakeholder engagement and who they have consulted with. ÅNT Department of Primary Industry and Resources (including the Department of Fisheries) ÅTiwi Land Council ÅNT Seafood Council Undertaken searches of the: ÅNorthern Territory Governmentӳ Heritage register which did not identify any registered heritage sites within the survey area. ÅSacred sites protected by the Aboriginal Areas Protection Authority under the Northern Territory Aboriginal Sacred Sites Act 1989 which did not identify any sites to be present within the survey area. Å Australian Heritage Database which did not identify any heritage sites within the survey area. Emma replies on 28.03.17 thanking Santos for following up.	EP Section 5.7 Indigenous and European Heritage updated with information from searches undertaken. EP Table 4-2 Bethany Survey Assessment of Stakeholders updated with customary fishers assessed as not a relevant stakeholder based on information supplied from the NTDPIRF (NTDPIRF-31).
Offshore Net and Line	ONLF-19	28/03/2017	Santos called NTSC to follow-up email 20/3/17. Message on long service leave until 8 May.	Follow-up on provision of information.

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Timor Reef and Demersal Relevant	TRD-39	28/03/2017	Email from Santos to [redacted] advising of Santos response to latest fishersô proposed approach. Main concern was that did not take into account catch effort. Santos also suggested using catch data going back to 2000 as long-term data provided a more reliable, robust assessment. Reiterated desire to minimise impact but needed a formula that stood up to internal audit. Appreciate the effort involved, but the 2006-07 formula did this. Advised that Santos would provide relevant information from the EP before it was submitted in April. Also inquired whether available to meet in next fortnight.	Information relevant to fishers from the EP in regards to noise impact to fish and catch rates and displacement from the survey area was sent to fishers on 5/4/2017. Ongoing discussions in regards to make-good formula.
Tiwi Land Council	TI-3	28/03/2017	Santos follows up on discussion regarding the seismic survey information sent late January. If there are any questions the Tiwi Land Council has in regards to that program, please do not hesitate to let me know what they may be and we can address any queries associated with the program. Tiwi Land Council replies on 28.03.2017 - great and good to catch up with you again too...as discussed, the TLC are keen to be kept informed of any developments with the program.	No issues or concerns raised. EP Section 4.1 Ongoing Consultation updated to include Tiwi Land Council. Tiwi council were not engage on change of survey area as impact assessment to Tiwi Islands does not change as survey area is still within the Operational Area.
Amateur Fishermenö Association of the NT (AFANT)	AFANT-16	27/03/2017	AFANT informs Santos that [redacted] NTGFIA) has spoken to [redacted] and as advised previously AFANT will let us know if there are any issues. Santos replies acknowledging email and states they will not bother [redacted] again and will rely on AFANT advice.	EP Section 4.0 Consultation updated to note that the NT Guided Fishing Industry Association to be engaged via AFANT.
Amateur Fishermenö Association of the NT (AFANT)	AFANT-17	27/03/2017	Santos phone AFANT to follow-up from phone conversation 20/3/17. [redacted] hadn't had time to obtain feedback. Confirmed that the NTGFIA had an interest but not the expertise to respond so AFANT would be doing that on their behalf. Still working through a backlog of work. Was continuing to seek advice on our proposal but he wasnö expecting anything new. But he wanted to satisfy himself as the fish species were new to him. Wanted to check the survey window we were aiming for as he thought this was a good time for amateur fishers to be fishing Santos had been engaging with AFANT for many months but appreciated his being new to the role. Asked if 6 April was long enough and he said he had space in his diary next week and 6 April would be enough time.	Consultation records AFANT-11 and AFANT-19 confirm June-August would be the time period with the least disruption to recreational fishermen.
Pearl Producers Association	PPA-5	27/03/2017	Santos calls. [redacted] advised that he had ñsent the [Bethany] info out to a few guysò and ñC-pot data from [redacted] shows that they fish in a part of the survey area.ò He said most of their fishing effort was elsewhere but there was fishing in the south-west of the survey area. Asked how to get more information on where and when they fish and he said to best come through him (rather than [redacted] and that he will send me something indicative (ñI only have C-pot dataò) by the end of this week. I said I would call if I hadnö received anything.	Identification of Pearl Oyster Fishery ([redacted] as a relevant stakeholder (see EP Table 4-2 Bethany Survey Assessment of Stakeholders). Consultation continues to obtain more information about the fishery.
Demersal Fishery	NTFTRF-14 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details. No response. No further consultation required.
Inpex	IN-1	23/03/2017	Santos email: Asking if Inpex if they have any activities in their Masela Permit during May to October 2017. Inpex reply saying they will look into it.	Provision of Information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-57	23/03/2017	Santos email: Hi [redacted] I am working with [redacted] and we met once in Darwin. I was hoping you could let me know if the following reports are the most recent as this is what I can find on the Departmentö website: Fishery Status Report 2012 Status of Key NT Fish Stocks 2014 If you have more recent reports that are public could you send through. NTDPIRF email: Hi [redacted] has asked me to respond. Here is the link to our latest public reports: https://dpir.nt.gov.au/__data/assets/pdf_file/0019/233326/fr114.pdf and the national report; http://fish.gov.au/Jurisdiction/Northern-Territory Hope these help.	For information - confirming with the NTDPIRF the latest reports in the public domain.

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Offshore Net and Line	NTFONL-10 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-4 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-5 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-6 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-7 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-8 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Offshore Net and Line	NTFONL-9 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received after 3 attempts. No further consultation required.
Spanish Mackerel	NTFSM-10 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-11 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-12 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-13 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-7 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-8 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-9 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Timor Reef	NTFTRF-6 and attachment E	23/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	No response after five attempts - phone and four letters. No further consolation required.
Demersal Fishery	NTFDF-13 and attachment E	22/03/2017	Letter following up on letter sent on 23 January relating to seismic survey.	No response to four letters (NTFDF-1, NTFDF-2, NTFDF-3) and a number of phone calls. No further consultation required.

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Spanish Mackerel	NTFSM-4 and attachment E	22/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-5 and attachment E	22/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	NTFSM-6 and attachment E	22/03/2017	Letter via post Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Timor Reef and Demersal Relevant	TRD-38	22/03/2017	Email from [redacted] to Santos proposing a different make-good formula involving lump sum, up-front payment, catch disposal records, average per fishing day calculated for each species group (Goldband, Red Snapper, Grouped), price per kg agreed for each species group with an allowance for additional operational/displacement costs and catch disposal records provided to Santos for 3 years from start of survey. The shortfall (actual catch less average catch per fish day multiplied by Agreed price per kg) paid monthly to fisherman. Believed 2006/07 formula way over the top and the result would be the same under this formula. Stated that complicated formula with vast variables achieved only ľconfusion, mistrust and work for the boys.ò Also asked as to status of EP and when draft copy would be available.	Information relevant to fishers from the EP in regards to noise impacts to fish and catch rates and displacement from the survey area was sent to fishers on 5/4/2017 (TRD-40). Full EP was sent to fishers 19/4/17 (TRD-58). Ongoing discussions in regards to compensation package. Most recent state and summary detailed at TRD-94 24/5/17. In the event that a commercial agreement cannot be reached, Santos proposes to ensure that the potential impacts and risks on commercial fishing operators are reduced to as low as reasonably practicable and to an acceptable level by including a model for payments to commercial fishing operators in any event (see EP Table 7-16 Seismic Noise Risk Assessment control Loss of Catch Payment and EP Table 7-24 Marine User Interaction Risk Assessment Control Relocation Expenses Payment). Santos has based this model on what it understands to be industry standard for an appropriately evidence based compensation model. Santos has engaged an independent expert marine resource economist specialising in bioeconomic models for fisheries, [redacted]rom the CSIRO to advise on the acceptability of this payment model. His preliminary view (final report in prep) is that The proposed methodology is consistent with other models used to quantify and compensate for activities that have had a disruption impact on fisheries, catch rates are an appropriate mechanism to understand any impact, and the operational relocation expense makes perfect sense to cover additional cost.
Aquarium Fishery	AQ-16	21/03/2017	Aquarium Fishery's confirmed that the listed stakeholders do not operate in the proposed survey area and most don't operate at all. Santos replies acknowledging advice.	Based on AF information that no other Aquarium Fishery licensees operate in the proposed Bethany area, the licensees sent Information Sheet #1 were not sent Information Sheet #2 with the updated NT/P85 and NT/P82 areas. There was no response from the Aquarium Fishery licensees sent Information Sheet #1. EP Table 5-17 NT Managed Fisheries updated with information that only one aquarium fishery operator in the area.
Aquarium Fishery	AQ-17 (attachment included in email record)	21/03/2017	Santos sends the Aquarium Fishery Information for Santos Bethany Seismic Survey to [redacted] [redacted] for review. Aquarium Fishery emails on 24.03.2017 - thanking Santos for the information and mentions that it is very concise.	Information provided was based on concerns raised by AFANT in regards to potential impacts to divers in the water, small reef fish and corals and clams.
Demersal Fishery	NTFDF-12	21/03/2017	Santos at 10.25am on 21 March, phone call rang out.	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details.
NT Guided Fishing Association (NTGFA)	NTGFA-9	21/03/2017	Email from NTGFA saying have spoken to [redacted] and as advised previously AFANT will let us know if any issues. Santos replied thanks - wont bother you again and will rely on AFANT advise.	EP Section 4.0 Consultation updated to note that the NT Guided Fishing Industry Association to be engaged via AFANT.
TGS	TGS-7	21/03/2017	Santos replies thanking TGS for the update and agreed that STO and TGS should keep each other updated. Santos advises that they will be in contact around the 10th April to get an update.	For information

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TGS	TGS-8	21/03/2017	TGS replied informing Santos TGS's EP North shape/outline is actually under review and it is quite certain that we are going to reduce the size by excluding the NT waters from it. Thus, if Santos proceed with the proposed Bethany survey in NT/P85 and 82, there would be no spatial clash between operations. TGS planning to submit EP North to NOPSEMA on/before 10-April.	Section 5.6.5 Oil and Gas Activities updated to include information in regard to TGS North West Shelf Renaissance North Multi Client Marine Seismic Survey restricted to WA waters which is at a minimum is ~ 55 km from survey area and ~ 80 km from the survey acquisition area.
Timor Reef and Demersal Relevant	TRD-37	21/03/2017	[redacted] sent email acknowledging that he would will email Santos regarding recent telephone conversation (TRD-23) as soon as possible.	No information received.
Amateur Fishermen's Association of the NT (AFANT)	AFANT-15	20/03/2017	Santos phoned AFANT to follow up on email from 2.03.17. [redacted] new EO. Santos detailed the Bethany survey and previous emails to AFANT stretching back many months. [redacted] still catching up as EO role unfilled for a number of months, and he didn't know much about our program. Santos asked if AFANT was still representing the Northern Territory Guided Fishing Industry Association (NTGFIA), as advised by its executive director [redacted] in 2015. [redacted] said to check with them [after phoning and emailing NTGFIA on 20 March, I received an email from [redacted] on March 21 confirming that AFANT would advise the NTGFIA]. [redacted] asked when planning to undertake the survey. Based on feedback from commercial fishermen the period of least impact least was June, July and August, and we had scheduled our survey accordingly. [redacted] said he was surprised by this as it was during the non-cyclone period and therefore likely to be better for fishing. I said the fishermen had advised that it was least impact on fish breeding but not fishing activities as they fished all year round. [redacted] couldn't see why our survey would be a problem with his members, particularly being about 70km north-west of Melville Island, but wanted to touch base with his Committee and President ([redacted] He said he would let me know within a week.	EP Section 5.6.4 Recreational Activities updated to include that due to the distance offshore recreational activities would be limited.
Aquarium Fishery	AQ-15 (highlighted stakeholder list is included in record)	20/03/2017	Santos asks to [redacted] to confirm if the highlighted Aquarium Fishery stakeholders listed also operate in the region of our proposed seismic survey. [redacted] had already confirmed that Monsoon Aquatics are the only ones, however the NT Department of Primary Industry and Resources suggests there are others.	For information.
Arafura Bluewater Charters	ARA-4 and attachment E	20/03/2017	Phone call to follow-up on information sent. [redacted] confirmed he had received the information. All good.	No further consultation required.
Northern Prawn Fishery	NPF-23	20/03/2017	NPF email: Requesting the shapefiles for the Bethany areas so they can have a look at the fishing activity. Santos sends the shape files for Bethany area and the NPF area we have mapped. Please let me know if you need anything else.	Santos sent shape files for Bethany operational and survey area and the NPF area we have mapped.
Northern Territory Seafood Council	NTSC-12	20/03/2017	Santos email: Trying to contact [redacted] Chair ONLF) and [redacted] (Licensee ONLF) to close out this line of inquiry or respond to any concerns but despite my best efforts and the exchange of emails with [redacted] over a number of weeks, I cannot get clarity on the position of Offshore Net and Line fishers. If [redacted] is no longer the representative, could you please provide me with the contact details of the person who is ([redacted] I assume)?	To date no through ongoing engagement with ONLF no issues or concerns raised in regards to the Bethany survey. See OFNL records.
NT Guided Fishing Association (NTGFA)	NTGFA-8	20/03/2017	Santos emails to confirm left a message NT Guided Fishing Industry Association website phone number. Following up on Information Sheet #2 sent in Jan 2017. Spoken to the new AFANT Executive Officer [redacted] who said it was best for us to liaise directly with you on our seismic program (as I have continued to do) rather than defer to AFANT, despite your advice to me on 19 August 2015 (see in email chain below). Santos asks if [redacted] or any of this members have any issues with our program?	For information - no response.

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Offshore Net and Line	ONLF-18	20/03/2017	Santos emails NTSC as not having heard from [redacted] and noting that on the NTSC website [redacted] is still the representative of the Offshore Net and Line Fishery. Santos would like to close out the line of inquiry or respond to any concerns, however is unable to get any clarification on the position of Offshore Net and Line Fishers. Santos asks if NTSC can provide contact details of the new representative.	Follow-up on provision of information.
Pearl Producers Association	PPA-4 and attachment E	20/03/2017	Santos phones: Remembered emails but asked how far from Melville Island was the operational area (70km north-west of Melville Island) and he asked what depth (45m to 110m of water). He said there could be some overlap as there was some fishing in the south-west. He said he send the information off to one of his members just to make sure, and get back to me asap (I said I would call in a week if I hadnt heard from him).	Follow-up on provision of information.
Northern Prawn Fishery	NPF-22 and attachment J	19/03/2017	Santos email: Acknowledges NPF email of lack resources. Santos sends NPF information from Bethany Seismic Survey Environment Plan Rev 1 for comments and feedback. Santos also requests NPF to confirm that the 1 August to 1 December season is predominately when tiger prawns are caught and there is not likely to be significant activity near the Bethany survey as this area is predominately a banana and endeavour prawns area.	Sent information from the EP in relation to NPF's activities and potential impacts will be available.
Offshore Net and Line	ONLF-17	19/03/2017	Santos acknowledges email.	For information.
Northern Prawn Fishery	NPF-20	17/03/2017	Santos email: Remind NPF that we are currently collating information for the Bethany survey (NT/P85 and NT/P82) to send to NPF, similar to what Santos did for the Fishburn survey (WA-459-P), Santos' aim is to get it to NPF next week for comments.	Update on when information from the EP in relation to NPF's activities and potential impacts will be available.
Northern Prawn Fishery	NPF-21	17/03/2017	NPF confirms receipt of email, however notes that they are very busy at the moment so a quick turnaround on anything will be a challenge.	For information.
TGS	TGS-6	17/03/2017	Santos emails to ascertain who maybe undertaking seismic surveys in the area at the same time. Santos notes that they have sent TGS the Information Sheet #2, but would now like to clarify if your North West Shelf Renaissance North Multi Client Marine Seismic Survey will be undertaken within the area of our Bethany survey during June to 1 October 2017. Santos has received information from the Timor Reef and Demersal fisheries that there are two other surveys that will take place in the area, Santos would like to know who they are.	Provision of information.
Timor Reef and Demersal Relevant	TRD-35	17/03/2017	Phone conversation with [redacted] as in his capacity as the representative of the Demersal Fishery on the NT Seafood Council. Santos states commitment to making 'make-good payments' to [redacted] and [redacted] for the impact of seismic survey. But payments need a robust formula based on data that it is defensible to senior management and joint venture partners. Santos believed best formula was one detailed in 19 January email and employed in 2006-07. [redacted] expressed concern about two more (multi-client) surveys proposed over the Bonaparte during the next five years. Santos knows of one (TGS) in the same area - still trying to ascertain intended timing. Santos again requests support for formula and consents to access fish catch data. Look forward to hearing from you [redacted] or [redacted]	Section 7.1.5.6 Seismic Noise Cumulative Impacts assess the potential impacts from previous and simultaneous seismic surveys in the Bethany area. Based on the consultation undertaken with the permit holders in the area of the Bethany survey and multi-client seismic operators with Environment Plans being assessed by NOPSEMA (see Section 4), no seismic surveys were identified as likely to be acquired during or close to the same time period as the Bethany survey, within the survey area or in adjacent waters. The assessment of cumulative impacts was included in the EP sent to fishers 19/4/17 (TRD-58).
Timor Reef and Demersal Relevant	TRD-36	17/03/2017	Santos emails [redacted] draft summary of phone conversation.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-30	16/03/2017	NTDPIRF email: [redacted] replies to Santos stating that he is back from holidays and follows up to find out where the Department is at with addressing Santos' enquiries. Santos email (17.03.2017): Stating that [redacted] was able to help, however we are still outstanding is request in regards to charter and customary fishing: 1. Charter fishing (I have emailed [redacted] from Arafura Bluewater Charters a number of times, and had no response) 2. Customary fishing in or near the survey area (the WA DoF was helpful with a similar inquiry around our WA-459-P permit survey)? NTDPIRF email: [redacted] replies on 27.03.2017 confirming [redacted] is the only charter operator in the area and that there is no customary fishing reported.	1. Arafura Bluewater Charters ([redacted] included as relevant stakeholder (EP Table 4-2). See Stakeholder Records for Arafura Bluewater Charters (AFA). 2. EP Table 4-2 Bethany Survey Assessment of Stakeholders updated with customary fishers assessed as not a relevant stakeholder based on information supplied from the NTDPIRF.
Demersal Fishery	NTFDF-11	15/03/2017	Santos received phone message at 12.02pm on 14 March 2017 advising that [redacted] would call later. No call received.	For information

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Demersal Fishery	NTFDF-10	14/03/2017	Santos called [redacted] at 9.35am on 14 March 2017. I left a message to call me with his pager service.	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details.
Department of Defence	DoD-7	10/03/2017	DoD confirms it has reviewed the change of area of the Santos Bethany survey and has no objections.	No objections. Ongoing consultation as per: EP Section 4.1 Ongoing Consultation updated to include requirement notify DoD prior to commencement of the survey. EP Section 4.1 Ongoing Consultation updated to include requirement to notify AHS a minimum of 3 weeks prior to commencement of activities.
Demersal Fishery	NTFDF-4	8/03/2017	Santos called [redacted] [redacted] at 12.15pm on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. The phone rang out, with the Telstra (?) message saying currently available please try again later.	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details.
Demersal Fishery	NTFDF-5	8/03/2017	Santos called [redacted] from [redacted] at 12.05pm on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. Phone call summary: Santos was calling in follow up to the emails sent relating to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. We have had a response from your so we are checking to see if you have any issues, whether you need further information or have an ongoing interest? [redacted] responded with that he has been away, had been under the pump and struggling to what he had to do, and then asked ñwhere is it again?ò I referred him to Information Sheet #2 which described the location as being approximately 70km north-west of Melville Island and 250km north-west of Darwin, whereupon he said ñno dramas there for me.ò Santos confirmed that we wouldn't bother him again.	No further consultation required.
Demersal Fishery	NTFDF-6	8/03/2017	Santos called [redacted] at 12.09pm on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. Santos left a message following up emails sent to you in relation to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. I havenõt had a response from you so I am just checking if you have any issues, whether you need further information or have an ongoing interest. If you wish to discuss, please call. [redacted] called back at 12.19pm, he confirmed that "we don't work in the Bonaparte so it won't worry us". Santos confirmed that we wouldn't bother him again.	No further consultation required.
Demersal Fishery	NTFDF-7	8/03/2017	Santos called [redacted] at 12.12pm on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. Phone call summary: Santos was calling in follow up to the emails sent relating to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. We have had a response from your so we are checking to see if you have any issues, whether you need further information or have an ongoing interest? [redacted] responded that he had sold-on his interests to [redacted] and they now had his offshore licences. Santos responded saying that they are already speaking to their representative and thank him for the advice. Santos confirmed that we wouldn't bother him again.	No further consultation required.
Demersal Fishery	NTFDF-8	8/03/2017	Santos called [redacted] [redacted] at 12.15pm on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. The phone rang out, with the Telstra (?) message saying currently available please try again later.	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details.
Demersal Fishery	NTFDF-9	8/03/2017	Santos called [redacted] from Northern Wildcatch Seafood at 12.03pm on 08/03/2017, as he was an identified stakeholder from the Department. There was no answer so Santos left a message: Hi [redacted], my name is [redacted] I am from Santos and I am following up emails sent to you in relation to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. I havenõt had a response from you so I am just checking if you have any issues, whether you need further information or have an ongoing interest. If you wish to discuss, please call me [redacted]	No response to three letters (NTFDF-1, NTFDF-2, NTFDF-3. Using alternative contact details.
NT Department of Primary Industry and	NTDPIRF-29	8/03/2017	Santos email: To inform the Department that we have either emailed and sent postal letter to the licensees provided by the Dept. on three occasions with getting no response.	For information.

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Resources - Fisheries			Santos confirms they have called all licensees that the Dept. provided numbers for and either spoke or left a message with them.	
Timor Reef	NTFTRF-4	8/03/2017	Santos called [redacted] at 11.59am on 8/03/17, as he was an identified stakeholder from the NT Department of Primary Industry and Resources. Santos left a message following up emails sent to you in relation to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. I havenꞌt had a response from you so I am just checking if you have any issues, whether you need further information or have an ongoing interest. If you wish to discuss, please call. [redacted] returned call to inform Santos that he had received the information, but didn't know he had to respond. [redacted] has confirmed that he has 'no problem in this side" with the survey. Santos confirmed that we wouldn't bother him again.	No further consolation required.
Timor Reef	NTFTRF-5	8/03/2017	Santos called [redacted] from Northern Wildcatch Seafood at 12.03pm on 08/03/2017, as he was an identified stakeholder from the Department. No answer so Santos left a message: Hi [redacted], my name is [redacted] I am from Santos and I am following up emails sent to you in relation to the Bethany seismic survey in the Bonaparte Basin that we are aiming to start in July. I havenꞌt had a response from you so I am just checking if you have any issues, whether you need further information or have an ongoing interest. If you wish to discuss, please call me on [redacted]	No response.
Timor Reef and Demersal Relevant	TRD-34	8/03/2017	Santos email to [redacted] recognising his concern about CA and agreeing to proceed without one. Advised the next steps are to agree a make good formula and get respective consents for release of fish catch data from the NT Department of Primary Industry & Resources. Santos reiterated its support for make-good formula detailed in 19 January email, being the same approach adopted in 2006-07. Also advised that the gross make-good funds the Santos-led operations in NT/P-85 & NT/P-82 had set aside was is in the range of hundreds of thousands of dollars.	Santos could not obtain confidentiality agreements and therefore could not obtain commercial sensitive information i.e. fish catch data from the NTDPIRF. Progressed with further discussions on make-good payment.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-28	6/03/2017	NTDPIRF email: [redacted] replied stating they have sent the requests to [redacted] from [redacted] department. NTDPIRF email: Information on licence holders below not including the licences you already know of. Who owns the data once they have sold their licences is a little bit trickier but a case can be put to our director. Legally, the data remains with the person who actually supplied the data however, the Director may release information after considering the merits of a request on a case by case basis (similar to the above case). Timor Reef > > 3. [redacted] = still current? Yes. Best contact # [redacted] > 8. NORTHERN WILDCATCH SEAFOOD AUSTRALIA = Best contact - [redacted] > > Demersal > > 1. [redacted] PTY LTD = Best contact - [redacted] > 5. BARAMEDA FISHERIES (FNQ) PTY LTD = Best contact - [redacted] > 6. [redacted] = still current? = Yes. Best contact # [redacted] > 12. NORTHERN WILDCATCH SEAFOOD AUSTRALIA = Best contact - [redacted] > 13. [redacted] = still current? Yes. Best contact # [redacted]	Licence holder information provided by NTDPIRF. Contact made with licence holders not already engaged with. See Timor Reef Licence Holder and Demersal Fishery Licence Holder engagement records. Licence holders already engaged with are [redacted] and [redacted] see Timor Reef and Demersal engagement records. In October 2016, [redacted] Senior Licensing Officer, Department of Primary Industry and Resources, Northern Territory Government, provided me with a list of the NT fishery licensees. The names of some of the licence-holders in Timor Reef and Demersal fisheries are mostly corporate entities, so I asked the Department for further advice as to who were the people behind the corporate entities holding the licences. They responded with names and contact details. Most licences belonged to corporate entities owned by [redacted] I then made contact or attempted to contact (using two different forms of contact if provided e.g. email and postal address or email and phone call) all the individuals with whom we had not already made contact (we had already contacted [redacted] and [redacted] By linking the corporate entities with their owner, it became apparent that there are 4 different licence-holders in the Timor Reef Fishery and 7 in the Demersal Fishery, one of whom ([redacted] said he didnꞌt work in the Bonaparte (see note of phone conversation 080317) and another of whom ([redacted] said he had sold his interests to [redacted] (see note of phone conversation 080317).

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-27	5/03/2017	Santos email: Sent [redacted] from the Department as [redacted] out of office. Santos asks if [redacted] could help link the company names with the relevant individuals and queries over charter and customary fishing.	NTDPIRF replied on 16/3/2017 (NTDPIRF-31) in response to queries over charter and customary fishing. NTDPIRF replied on 6/3/2017 (NTDPIRF-28) with details of Timor Reef Fishery and Demersal Fishery licence-holders relevant individual names to the companies.
Offshore Net and Line	ONLF-15	4/03/2017	Offshore Net and Line Fishery acknowledges phone call summary with Santos, however, notes that he can't guarantee the new representative from ONLF [redacted] will get in contact with Santos.	For information.
Offshore Net and Line	ONLF-16	4/03/2017	[redacted] from OFNL restates that he is no longer the Chair and confirms he will pass this information to the new Chair. [redacted] also asks the question, wouldn't these responses be better aggregated through NT Seafood Council?	NTSC (NTSC-9) recommended engagement with all licence holders. Responses from fisheries groups was requested from NTSC with no response (NTSC-10).
Offshore Net and Line	ONLF-15	3/03/2017	Summary of phone conversation. Santos sends notes to [redacted] ÅWhilst you are still on the NTSC website as the representative of the Offshore Net and Line Fishery, it is not accurate and the NTSC website has yet to be updated ÅYour replacement is a gentleman called [redacted] a southern shark fisher with interests in WA and Victoria ÅYou havenô yet spoken to him about our proposed Bethany seismic survey but you will provide him with the details ÅI said we were getting closer to the start of the proposed survey and we were keen to know if there were any issues or concerns about the survey for Offshore Net and Line Fishery licence-holders. ÅYou said you would get [redacted] to make contact with me if there were any issues.	Follow-up on provision of information.
Spanish Mackerel	SMF-11	3/03/2017	Summary of phone conversation. Santos sent notes to [redacted] ÅFollowing up my previous emails, the most recent being yesterday, about whether the proposed Bethany seismic survey would impact the activities of the licence-holders of the Spanish Mackerel Fishery which you represent on the NT Seafood Council ÅYou said it wasnô clear. Mackerel were and ñtop and bottomò (habitat) fish. The trapping and drop-lining fishers were more likely to be concerned ÅYou said mackerel tended to aggregate in areas of shallow reef and shoals ÅYou said noise wasnô a great thing but you kind of had to live with it. It had been done before and you got through it ÅI asked whether you needed more information to that already supplied in Information Sheet # 2 (description of environment, receptors and risks) and you said you had what you needed ÅI asked if you wanted to be kept updated and you said yes. ÅYou said if there were any issues that arose, you would let me know.	EP Section 4.1 Ongoing Consultation update to include keeping the Spanish Mackerel Spanish Mackerel Licensee Committee Chair up to date with regard to information for the Bethany survey. Information provided in regards to Spanish mackerel tended to aggregate in areas of shallow reef and shoals. No objections or claims raised.
Amateur Fishermenôs Association of the NT (AFANT)	AFANT-14 and attachment E	2/03/2017	Santos resumes contact and re-checks AFANT's comment that the President will only be in contact if he has any concerns with the related proposed survey. Reattached is information sheet #2. Santos has not received any contact so can we assume there are no concerns? Santos also attached an email exchange with [redacted] of the NT Guided Fishing Industry Association for information and asks AFANT to advise if they continue to represent the NTGFIA on this matter (as per the email exchange).	Provision of information
Department of Defence	DoD-6 and attachment E	2/03/2017	Santos sent follow-up email on proposed Bethany survey (from 24.01.2017) and reattached information sheet #2. Santos would like to know if there are any ongoing interest to the Defence and if the Defence has any objections. Concerns about the potential impact of the proposed survey.	Provision of information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-26	2/03/2017	Santos email: Follow up on email (23/1/2017 NTDPIRF-23) referring to the Bethany survey noted in Information Sheet #2. Santos also notes engaging with the Department on fish catch data and awaiting fisher consent. Santos seeking confirmation on the licence-holders in Timor Reef Fishery and Demersal Fishery as trying to link the relevant individual names to the companies (list noted in the email). Santos asks if there are any charter fishing other than [redacted] from Arafura Bluewater Charter and if there are any customary fishing in or near survey area? NTDPIRF email: 02.03.2017 - Received an out of office for [redacted] from 3 Jan to 22 Jan. For urgent matter to contact Fisheries Reception on 8999 2144.	NTDPIRF replied on 16/3/2017 (NTDPIRF-31) in response to queries over charter and customary fishing. NTDPIRF replied on 6/3/2017 (NTDPIRF-28) with details of Timor Reef Fishery and Demersal Fishery licence-holders relevant individual names to the companies.
Offshore Net and Line	ONLF-13	2/03/2017	Santos follows up on email sent on 24/01/2017 and reattaches the Information Sheet #2. Santos also notes that on the NT Seafood Council website the Offshore Net and Line Fishery representative is still [redacted]	Follow-up on provision of information.
Offshore Net and Line	ONLF-14	2/03/2017	[redacted] replies that NT Seafood Council are yet to update their website.	For information.

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Pearl Producers Association	PPA-3 and attachment E	2/03/2017	Santos email: Follow up on email sent on 24/01/2017 and reattaches the information sheet #2. Santos notes that the survey is approximately 250km north-west of Darwin, 70km north-west of Melville Island, in 45m to 110m of water.	Provision of information. No response.
Spanish Mackerel	SMF-10	2/03/2017	Santos sent follow-up email on proposed Bethany survey seeking a response and noting if there are any concerns in [redacted] role as the representative of the Spanish Mackerel Fishery on the NT Seafood Council.	Follow-up on provision of information.
Timor Reef and Demersal Relevant	TRD-32	2/03/2017	Email from Santos to [redacted] following-up on email of 24/02/2017.	For information.
Timor Reef and Demersal Relevant	TRD-33	2/03/2017	Email from [redacted] reiterating concern about CA after further legal advice.	If Santos could not obtain confidentiality agreements, could not obtain commercial sensitive information i.e. fish catch data from the NTDPIRF.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-25	28/02/2017	NTDPIRF email: The Department replies stating the data has been aggregated because of confidentiality issues, there are far fewer licences operating in the TRF than in 2006. Have you progressed any discussions with licence holders to get permission to receive confidential data.	Consent from commercial fishermen to access confidential fish catch data has not yet been obtained and is part of ongoing discussions with relevant TRF and Demersal fishers. See relevant stakeholder records.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-25	28/02/2017	Santos email: Replies informing the Department that discussions with the Fishers are ongoing and we are hoping to have their consent for access to the confidential data soon. Santos wanted to ensure that the Department has the right data when the consents have been obtained. The comment relating to fewer licences in the TRF fishery, Santos asks how many there are now and what about Demersal fishery?	Consent from commercial fishermen to access confidential fish catch data has not yet been obtained and is part of ongoing discussions with relevant TRF and Demersal fishers. See relevant stakeholder records.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-25	28/02/2017	NTDPIRF email: The Department replies that they will have to check on licences numbers as cant report fine-scale information with less than five in area. Confirms once Santos has consent the Department will find GPS location data by month.	Consent from commercial fishermen to access confidential fish catch data has not yet been obtained and is part of ongoing discussions with relevant TRF and Demersal fishers. See relevant stakeholder records.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-25	27/02/2017	Santos email: Have reviewed the received data, but notes that it has been aggregated so unable to look at any detailed trend analysis. Santos asks if this data could be provided in the same format and level of detailed as received by the Department for the 2006 Santos seismic programs? This data included, catch by vessel, by fishing technique (trap, line, trawl), by shot/trap, by time and day, by kg gold ban snapper and kg of other fish caught and by location of activity. This will enable us to undertake a detailed analysis over both vessel, effort, time and location, which trending can then be normalised to identify any displacement affect from our operations. Santos attached example copies of log sheets that fishers complete to give the Department an idea of the information already collected.	Santos request for data that allows for trend analysis.
Timor Reef and Demersal Relevant	TRD-30	24/02/2017	Email from [redacted] to Santos forwarding Northern Seafood's ôsolicitor advice that CA not standard practice in this context.	For information.
Timor Reef and Demersal Relevant	TRD-31	24/02/2017	Email from Santos to [redacted] advice on why CA is appropriate because want to protect sensitive fish catch data.	If Santos could not obtain confidentiality agreements, could not obtain commercial sensitive information i.e. fish catch data from the NTDPIRF.

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Aquarium Fishery	AQ-14	23/02/2017	Phone call with [redacted] with follow-up email to confirm details. [redacted] confirmed he is the new Chair of the NT Seafood Council. Re NTP/82 & 85 permits, recapped first spoken in 2015 when looking to do a survey in NT/P85 only, in 2016. Was delayed and more recently NT/P82 added, proposed for 2017 (as advised in Information Sheet #2). Advised it will be about 2 to 3 weeks before Santos can provide [redacted] with information. Survey area is within the Oceanic Shoals Marine Reserve multi-purpose zone and Santos asked if there was any impacts to the aquarium fishery from the proposed changes to zoning in this reserve [redacted] said the new zoning did not really affect his aquarium fishery because it was deep water but he would like to have the nautical coordinates to be more confident. Santo to provide map. [redacted] said the aquarium fishery operated in was less than 30 metres, like around Evans Shoal and Blackwood Shoal, though in the future they planned to investigate deeper water opportunities. Santos asked [redacted] wearing his NTSC Chair hat, to confirm that [redacted] and [redacted] were the right people to be talking to in relation to the area we want to survey? [redacted] confirmed they were, and also that the least impact period of June, July and August and coincided with least impact period for aquarium fishery. Santos asked about tourist fishing operators like Arafura Bluewater Charters ([redacted] and [redacted] said they were to only other stakeholder he could think of who might have a view and he was surprised we hadnt heard from him. Santos advised sent numerous emails to him and had no reply. Santos asked if there were others, and [redacted] said [redacted] was on the Fishing Tours Operating Committee and would have advised others. [redacted] said he didnt think the area was of relevance to the Northern Prawn Fishery Discussed the opportunity to protect the giant clams. [redacted] to provide Santos with more detail. [redacted] advised giant clams typically in water depths of 18m to 25m. Santos advised the depths of the area of our survey ranged from 45m to 110m. Santos emailed [redacted] with a nautical map showing the proposed Oceanic Shoals Marine Reserve zoning.	Areas where the Aquarium Fishery fish are within the AMBA but not the operational or survey area. Likely habitat or water depths for Tridacna gigas where not identified within operational or survey area. EP Section 5.6.3 NT Fisheries updated with information about the fishery including June, July, Aug period least impact period for aquarium fishery, operate in less than 30 m, like around Evans Shoal and Blackwood Shoal, though in the future they planned to investigate deeper water opportunities. Information was provided to [redacted] on 21/3/2017 (AQ-17) in regards to potential impacts to divers in the water, small reef fish and corals and clams. Arafura Bluewater Charters ([redacted] noted as stakeholder - see engagement records.
Timor Reef and Demersal Relevant	TRD-29	21/02/2017	Santos email in response to telephone conversation with [redacted] about the signing of a CA covering discussions leading to an agreement.	For information.
Timor Reef and Demersal Relevant	TRD-28	16/02/2017	Santos send a draft Confidentiality Agreement for review.	For information.
Australian Fisheries Management Authority (AFMA)	AFMA-11 (record includes map of the new North West Slope Trawl Fishery boundary)	15/02/2017	STO follows up on some information on the North West Slope Trawl Fishery as there has been changes to the fishery area. STO asks for confirmation on the map below (from AFMA website) which notes the new boundary changes, if it doesn't could AFMA please send a may with the fishery boundary.	Email follow-up with phone to confirm that map on AFMA website is the latest North West Slope Trawl Fishery boundaries. Fishery is a significant distance from survey area and therefore not included in the EP.
Timor Reef and Demersal Relevant	TRD-27	14/02/2017	Email from Santos on entering standard CA before start discussions around potential make-good quantum involving release of fish catch data.	For information.
Offshore Net and Line	ONLF-11	30/01/2017	STO acknowledges the change of chair person and requests that pervious emails relating to the Bonaparte seismic program are sent to the successor.	For information.
Offshore Net and Line	ONLF-12	30/01/2017	[redacted] acknowledges that he will pass on these details.	For information.
Offshore Net and Line	ONLF-10	29/01/2017	Offshore Net and Line Fishery informs Santos that [redacted] is stepping down as chair and will put you in touch with new Chair.	For information.
TGS	TGS-5	27/01/2017	Santos emails noting TGS's comment from email of 31 October of a potential 2D in the Bonaparte Basin possibly crossing the WA-459-P permit area, do you have any greater clarity? The timing of our program in 459 is mid-June to August this year. TGS replies we have modified our proposed Q2 acquisition and have no plans to ingress WA-459-P. Santos emails 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 currently not got anything planed within 100km of WA-459-P during June and August.	Potential 2 D in the Bonaparte Basin that cross WA-459-P - not relevant to Bethany survey.
Timor Reef and Demersal Relevant	TRD-22	27/01/2017	Email from [redacted] noting telephone conversation on 25 January, confirming [redacted] will provide a submission to Santos regarding concerns and effects of the survey seismic. Expect next week.	No submission received.

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Timor Reef and Demersal Relevant	TRD-23	27/01/2017	Santos sends [redacted] draft summary of telephone conversation of 25 January. Notes were reviewed by [redacted] and updated after removal of some confidential information. After review of Information Sheet #2 stated he believed the impact of the survey would be devastating, denying access to 124 x 23 (nautical miles), area in which he had traps. Typically spread out and to move gear a logistical nightmare. He would put together an email confirming scale, catches in recent seasons and options. Didn't want to lose good skipper. Rotates to different areas to allow restock and had planned to fish this year where our program is planned.	To date have not received information from [redacted] s a trap fisher in the TRF. Based on data received from the NTDPIRF ~ 29% of the total catch for the TRF is within the operational area (data based on 2013-2015). For the period that the trawl trail has been undertaken (2015-2016) data shows that trap fishing has at a maximum been between 1% (2016) and 5% (2015) within the Bethany survey area of potential noise impact (survey area plus 3.6 km buffer). EP Section 7.9 Marine Users Interactions details the area of overlap and controls to minimise impacts to fishers including a Relocation Expenses Payment. Ongoing discussion and information (see TRD records) has been provided to [redacted] directly and via his representative [redacted] in regards to potential scale of impacts and proposed controls to manage impacts to an acceptable level.
Timor Reef and Demersal Relevant	TRD-24	27/01/2017	Email from Santos to [redacted] of draft summary notes of telephone conversation on 25 Jan. Rejected Santos formula. Also, didnȇt want to spend time going down this path if the make-good sum was in the order of [redacted] It was a major program impacting all fish stocks. The displacement was one thing but the ongoing impact was the biggest concern. If it was over sand, the impact might be 3 months. But over a breeding area, it could be two to three years. Discussion around impact research from other areas could never be completely applicable because of different fish types, other variables. What Santos wanting to do was great, but if fishers view was accurate there would be nothing in the area for 2 years. Asked for Santos to come back with compensation numbers we considered reasonable for a program of this size. Asked about timing of EP, Santos said March, and start of program, Santos said aiming for July.	Santos acknowledge that research to date has identified effects and no effects from seismic surveys on catch rates and abundance and that this is likely due to the importance of the context of exposure. Santos has adopted a conservation approach assuming that potential impacts on catchability of commercial species is possible and included proposed control measures to minimise impacts to commercial fishers including a Loss of Catch Payment in the event the catch rate were impacted. EP Section 7.1.5.3 Seismic Noise Fish assesses the level of impact based on data from the NTDPIRF (EP Section 5.6.3.2 TRF) shows that total catch for 2011 to 2016 within the survey area, with the inclusion of a 3.6 km buffer which is the maximum noise impact area, ranges from 8% - 16% of the total TRF catch with an average of 11%. In 2016, the trap % catch dropped to 1% while the trawl % increased to 14%. Information from the EP sent to the fishers (TRD-40 5/4/17) and EP sent to fishers (TRD-58 19/4/17) provided information on the assessment of potential impacts. Santos has not been able to locate any evidence, or been provided with any, that impacts from seismic could be 2 - 3 years on commercial catch rates. However, based on fishers feedback the EP Section EP Section 7.1.5.3 Seismic Noise Fish assesses has been updated to acknowledge that potential impacts could occur over a period greater than 12 months (long-term).
Timor Reef and Demersal Relevant	TRD-25	27/01/2017	Email from [redacted] to Santos making changes to phone summary. Concern that the compensation levels Santos is talking is not relevant to the actual cost borne by the fisherman. On Santos formula for calculating impact, [redacted] corrected draft to say he could not understand the approachȇs complexity. Is it make-good for the displacing of the fishing opportunity or for the fish? Believed it should be for the fish, therefore effort not relevant.	Santos notes fishers view on "effort" as part of compensation formula. Discussions on formula ongoing.
Timor Reef and Demersal Relevant	TRD-26	27/01/2017	Email from Santos to [redacted] with final amendments to [redacted] revision of phone summary.	For information.
Aquarium Fishery	AQ-13	25/01/2017	Acknowledgement of email from 24.01.17, would like to catch up on 9th Feb - 25.01.2017 Correspondence relating to scheduling a meeting in Darwin 25.01.2017 and 31.01.2017. Santos informs [redacted] that won't be in Darwin the next week, but can make contact before the next trip to Darwin alternatively can have a teleconference 01.02.2017 [redacted] suggests a teleconference that day, however STO replies stating that hasn't had time, but has suggested the 13th Feb from 11.00 Darwin time onwards 06.02.2017.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-24	25/01/2017	NTDPIRF email: Acknowledged email, advised passed email on to the Fishery Manager and will get back to you with any comments or concerns.	For information.
Tiwi Land Council	TI-1	25/01/2017	Santos: I wanted to let you know about a seismic survey Santos has been planning to do in offshore petroleum permit NT/P85, which is about 120km north-west of the Tiwi Islands. The survey has recently been expanded to include NT/P82, which is closer to the Tiwi Islands (approximately 70 km) and we therefore want to check to see if you have any issues or concerns with it. The attached Information Sheet #2 identifies the expanded area and also includes detail on the environment of the area, and the potential risks, impacts and controls. The survey will take a maximum of 75 days and we are planning to undertake the survey during the period of July ï September 2017. I have attached [redacted] and [redacted] contact details as they are best placed to answer all questions, but please let me know if you have any questions or concerns about the survey.	Provision of information.

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Tiwi Land Council	TI-2	25/01/2017	Will discuss with Chairman and TLC at our meeting in early February and let you know if there are any issues or further info requested, thanks for letting us know.	No issues or concerns raised.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-13	24/01/2017	Email from AFANT: I have forwarded that on to the AFANT President to have a look at. He will contact you only if he has any concerns with the proposed survey.	For information
Aquarium Fishery	AQ-12 and attachment E	24/01/2017	Email notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 attached. Santos wanting to meet or have phone hook-up.	Provision of information.
Offshore Net and Line	ONLF-9 and Attachment E	24/01/2017	Email notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.
PGS	PGS-3 and attachment E	24/01/2017	Santos emails notifying PGS of change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached. PGS replies on 25.01.17 acknowledged email and noted the comments sent on 12/10/17 remain the same.	Provision of information.
TGS	TGS-4 and attachment E	24/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-12 and attachment E	23/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached. An Out of office reply from AFANT noting to forward information to this address: [redacted]afant.com.au.Santos email forwarded to this email.	Provision of information
Aquarium Fishery	NTFAF-3 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Licensee details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Aquarium Fishery	NTFAF-4 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Licensee details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Arafura Bluewater Charters	ARA-3 and attachment E	23/01/2017	Email notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.
Australian Fisheries Management Authority (AFMA)	AFMA-10 and attachment E	23/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	For information. No response.
Commonwealth Fisheries Association	CFA-10 and attachment E	23/01/2017	Email notifying stakeholder of change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 attached	Provision of information. No response received. Further consultation not required as CFA is involved in policy and strategy rather than providing feedback on individual activities.
Demersal Fishery	NTFDF-3 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet #2 with details of our proposed surveys.	For information. licensee details provided by NTDPIRF (see NTDPIRF-20). No response from licensees further follow-up undertaken for those licensee that had alternative contact details.
Department of Defence	DoD-5 and attachment E	23/01/2017	Email notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.
Northern Prawn Fishery	NPF-19 and attachment E	23/01/2017	Santos email: Notify stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information Sheet #2. Please let me know if you or your members have any questions or concerns about the new survey area.	Provision of information
Northern Territory Seafood Council	NTSC-11 and attachment E	23/01/2017	Santos email: Notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 attached. Have advised [redacted] [redacted] and [redacted] (via [redacted] and am contacting the licence holders using the contact details provided by the Dept. Please let me know if you or your members have any questions or concerns about the new survey area.	No feedback obtained from NTSC in regards to Information Sheet #2.
NT Department of Primary Industry and Resources	NTDPIR-5 and Attachment E	23/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.

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NT Department of Primary Industry and Resources	NTDPIR-6	23/01/2017	The Energy Directorate has no issues with the proposed changes.	No issues raised by NTDPIR.
NT Guided Fishing Association (NTGFA)	NTGFA-7 and attachment D	23/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	For information - no response.
Offshore Net and Line	NTFONL-3 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information. No response received.
Pearl Producers Association	PPA-2 and attachment E	23/01/2017	Santos email: Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information. No response.
Spanish Mackerel	NTFSM-3 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Follow-up on provision of information.
Spanish Mackerel	SMF-9	23/01/2017	Email notifying stakeholder of that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information sheet #2 also attached.	Provision of information.
Timor Reef	NTFTRF-3 and attachment E	23/01/2017	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	For information
Timor Reef and Demersal Relevant	TRD-20 Attachment E	23/01/2017	Santos email confirming that [redacted] represented [redacted] in discussions over the survey, and formally notifying of a change to the survey area (now covering two permit areas - NTP85 and NTP82). Information Sheet #2 attached, including detail on the environment of the area, and the potential risks, impacts and controls, and seeking feedback/concerns.	Provision of information.
Timor Reef and Demersal Relevant	TRD-21 Attachment E	23/01/2017	Santos email formally notifying of a change to the survey area (now covering two permit areas - NTP85 and NTP82). Information Sheet #2 attached, including detail on the environment of the area, and the potential risks, impacts and controls, and seeking feedback/concerns.	Provision of information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-23 and attachment Q	20/01/2017	NTDPIRF email: Please see data extracted with notes on missing data. Fishing effort in this fishery has been fairly inconsistent given the development of new gear e.g. moving from line to trap and more recently from trap to trawl. Consequently, there is no good strong time series of CPUE data available to assess abundance of the fish harvested and any potential factors that influence this (e.g. seismic, illegal fishing and even the target fishing by the fishery operators). Santos email 23.01.17: Thanks for providing some catch data. Have forwarded to environment manager, and I await advice from her. In the meantime, as I advised [redacted] we are having ongoing discussions with the commercial fishermen about how we can mitigate the potential impact of our program. Email notifying stakeholder that there has been a change to the Bethany survey area, it is now proposed that the survey cover two offshore permit areas - NTP85 and NTP82. Information Sheet #2 sent detailing the new area and providing details of the environment of the area, potential risks, impacts and controls. Let me know if any questions or concerns.	Fish catch data reviewed and comment provided on 27/2/17 (NTDPIRF-25).
Timor Reef and Demersal Relevant	TRD-19	20/01/2017	Santos email to [redacted] providing contact details of seismic contractor and previous vessel specifications for support vessels.	As per meeting in May 2015 where fishers raised potential for commercial opportunities Santos provided contractor details for fishers to determine if vessels could be utilised by the survey contractor.
Timor Reef and Demersal Relevant	TRD-17	19/01/2017	Email from Santos to [redacted] (cc [redacted] advising that the effect of the fisher formula was for Santos to pay the fishers to stay in port. Santos appreciated the size of the survey but keen for a formula that supports ongoing fishing, recognising operational expenses and displacement costs. Santos then proposed formula that, for displacement calculations, compared catch per unit effort data (grouped by fish type) for 3 years before survey, the alternative area and for the 6 month period following the survey, similar approach to 2006-2007. Formula provided. Please advise thoughts.	Santos questions formula provided by fishers and proposes alternative based on formula used in 2006/7.
Timor Reef and Demersal Relevant	TRD-18	19/01/2017	Email from [redacted] to Santos, confirming receipt of email with Santos formula and would review with [redacted] and [redacted] Offered use o[redacted]s a support vessel for survey, and asked for who best to contact.	As per meeting in May 2015 where fishers raised potential for commercial opportunities Santos provided contractor details for fishers to determine if vessels could be utilised by the survey contractor.

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Timor Reef and Demersal Relevant	TRD-16	17/01/2017	Email from Santos to [redacted] advising company would get back on fishersôproposed formula, and that information sheet on extended seismic survey would be issued to stakeholders shortly.	For information.
Timor Reef and Demersal Relevant	TRD-15	16/01/2017	Email from [redacted] to Santos advising that keen to reach compensation agreement but did not see modelling based on effort as a real consideration given fish stocks either killed or displaced during seismic, and the only real discussion is the extent of the impact. Proposed calculation based on the quota units held. Formula provided.	Santos response in TRD-17.
Timor Reef and Demersal Relevant	TRD-14	10/01/2017	Email from Santos to [redacted] (after Santos received phone call from [redacted] asking about progress) following-up fisher make-good formula options.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-22	20/12/2016	Santos email: Following up on request for fish catch data (email requesting data on 19/10/16 NTDPIRF-19 and 31/10/16 NTDPIRF-21). NTDPIRF email: 28/12/2016 Have requested [redacted] to talk to you about the request. He is on leave but said he will call you.	NTDPIRF sent fish catch data 20/1/2017 (NTDPIRF-23).
Timor Reef and Demersal Relevant	TRD-13	16/12/2016	Email from Santos to [redacted] on 16/012/16 summarising key points from meeting held on 13/12/2016 in Melbourne. Discussion included advice from Santos that survey area could be extended to include adjoining permit, NT/P82 (held 100% by Magellan with 3D obligation. Clarification from [redacted] that June to August was a period of least impact on fish breeding but not fishing activities. Fishers confirmed position that seismic impacted fish presence/mortality. [redacted] said took years to recover from the 2006-2007 program. Expressed concern that extended survey effectively ruled out ability to fish in TR fishery, that 6km distance at which CoP said no sound impact meant there was nowhere to fish, risk of losing good crew, licence restricted to operating only in fishery, recent research on scallops and lobsters would make any activity in the marine reserve difficult. Fishers raised need for 3M to 5M by a mass study which would help concerns about long term impact. Could there be an industry co-investment (CoP had offered money towards such research). This would help address long term impacts of seismic. Santos advised support for development of a mechanism to make-good the displacement impact of seismic programs, similar to approach agreed and employed in 2006-2007. Fish catch data - before, during and after - would be needed to calculate impact. Fishers advised they provide Santos with formula options to consider. [redacted] would consider best form of longer term research, Santos would contact the NT Dept. of Fisheries to access the fish catch data. Santos said it aiming to submit the EP in Feb/March.	The survey timing was planned to try align with the period of least fishing activity June to mid-August and to avoid peaking spawning in October. This was based on information from the NT DPIFR (records NTDPIFR-2, NTPIRF-4). Fishers advised at meeting in May 2015 (NTSC-2 14/5/2015) that September to May is the sensitive time for fishing and seismic during this period should be avoided. This was independently supported by advice from the Department. Much later, the fishers said they fished all year round, so this was a reference to fish breeding and not fishing activities September to May is the sensitive time for fishing and seismic during this period should be avoided. Fishers clarified (TRD-13 16/12/16) that June to August was a period of least impact on fish breeding but not fishing activities. Further clarification was provided on 9/5/17 (TRD-74) that fishing activity is not seasonal. Tropical fish breed throughout the year but this is thought to intensify September to May and therefore this period was to be of least impact to fish breeding, not current fishing activities. Based on this information EP Section 5.5.3 Plankton and Section 7.1.5.1 Seismic Noise Plankton has been updated to include that peak spawning is from Sept to May. Section 7.9.5 Marine Users Interactions has been updated to reflect that the TRF operate all year round. EP Table 7-16 Seismic Noise Risk Assessment: assessment of controls was updated to include that the main fisheries in the area (TRF and Demersal) do not have a closed season and peak spawning occurs from Sept to May. The survey was planned on original information that period of least intensity (June ï mid August) and prior to the start of spawning in October. Impacts to fishers and spawning have been assessed based on these timings from the fishers within the EP Section 7.1.5.1 Seismic Noise Plankton, Section 7.1.5.3 Seismic Noise Fish, Section 7.9.5 Marine Users Interactions and with the appropriate controls in place impacts to the fishers and fishery can be managed to an acceptable level.
ConocoPhillips	CoP-3	13/12/2016	CoP email: Sent Fact Sheet in regards to their Barossa Appraisal Drilling Program. Commencing Barossa 5 well January 2017 and is anticipated to take about 100 days in permit NT/RL5.	Provision of Information
Timor Reef and Demersal Relevant	NA	13/12/2016	Meeting held in Melbourne with [redacted] (representing himself), [redacted] (representing [redacted] (representing [redacted] & [redacted] and Santos representatives.	Meeting
Eni Australia Limited	ENI-3	12/12/2016	Santos email: Further follow-up on email 11.10.16 and 31.10.16.	Follow-up.
Eni Australia Limited	ENI-4	12/12/2016	Eni email: Eni Exploration 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 5.6.5 Oil and Gas Activities updated to include information in regards to Eni not undertaking any activates in NT/RL8 which is ~ 20 km from survey area. Other permits are > 100 km from the survey area.
Northern Prawn Fishery	NPF-18 and attachment H	28/11/2016	Email from [redacted] with NPF fishing effort distribution in the JBG for the years 2010 ï 2016 as requested. It would be appreciated if you could please send me the billing details Santos for provision of this data so I can invoice accordingly.	Data used to map up a boundary to show area of effort (EP Figure 5-21) as NPF asked to keep catch data locations confidential.

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Timor Reef and Demersal Relevant	TRD-12	25/11/2016	Email from Santos to [redacted] stating agreement with objectives, and desire to involve the other key licence holders ([redacted] and [redacted] and meet to discuss.	Discussions have been ongoing with the fishers (see further records for TRD) as to achieving agreed objectives: minimal impact to the environment, minimise the disruption that seismic surveys have on the fishing industry/business and develop methods for financial assistance/compensation to fishing businesses who are adversely impacted by a seismic survey.
Department of Defence	DoD-4	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: Åreporting the location and type of UXO that may be in the areas of interest to Santos; Åidentifying or removing any UXO; or Åany 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 4.1 Ongoing Consultation updated to include requirement notify DoD prior to commencement of the survey. EP Section 4.1 Ongoing Consultation updated to include requirement to notify AHS a minimum of 3 weeks prior to commencement of activities.
Northern Prawn Fishery	NPF-17	21/11/2016	Phone conversation with follow-up email [redacted] replies in red NPFI advised that you can provide catch data maps going back to 2010. Santos agrees to pay for collation of data. Santos said they would collate the outstanding questions asked over a couple of email exchanges and include them in this email (see below). Collated questions and answers from NPFI 1. Are you able to tell me what factors are common to the areas where your members fish i.e. water depth, sea floor type (sandy, muddy, corals?)é ? Please refer to areas of fishing activity when we send through. 2. Whilst we are aiming to start the WA-459-P (Fishburn) survey in mid-June (based on your advice as to when would be the least disruptive time), what would be the impact if we began it in May? As previously advised, NPF operators would prefer that the seismic testing takes place outside of fishing seasons to avoid any interactions between the users. The concern about impacts of seismic on prawns has exacerbated as a result of two low catch years in the JBG(including 2016), and also in respond to the recently released report on impacts of seismic on scallops and lobsters. Our members are understandably nervous about whether seismic is impacting the area of the JBG given the large concentration of seismic activities over the past few years. 3. Is it best if we engage with you (as CEO of the NPF), rather than directly with your members, and then you can distribute our information to all of those fishers of yours who are relevant? Yes ï its fine to engage directly with NPFI ï we will need to discuss a fee structure for providing the liaison service with our members.	Information provided to NPFI on recently released report on impacts of seismic on scallops and lobsters apart of information pack for Fishburn Seismic Survey and also for Bethany see NPF-25. NPF going to collate catch data so can plot against survey and operational area to identify any overlap and potential impacts.
Timor Reef and Demersal Relevant	TRD-11	21/11/2016	Email from [redacted] to Santos indicating did not want to undertake process to merely obtain environmental plan with ñno impact on reality.òReiterated that impacted by CoP survey. Outlined key objectives for both parties to be complete seismic survey with minimal impact to the environment, minimise the disruption that seismic surveys have on the fishing industry/business and develop methods for financial assistance/compensation to fishing businesses who are adversely impacted by a seismic survey.	Discussions have been ongoing with the fishers (see further records for TRD) as to achieving agreed objectives: minimal impact to the environment, minimise the disruption that seismic surveys have on the fishing industry/business and develop methods for financial assistance/compensation to fishing businesses who are adversely impacted by a seismic survey.
Aquarium Fishery	NTFAF-2 and attachment D	18/11/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Licensee details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Demersal Fishery	NTFDF-2 and attachment D	18/11/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet #1 with details of our proposed surveys.	For information. licensee details provided by NTDPIRF (see NTDPIRF-20)

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Northern Prawn Fishery	NPF-16	18/11/2016	Follow-up of 3 November.	Follow-up on information requested.
Offshore Net and Line	NTFONL-2 and attachment D	18/11/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Provision of information. No response received.
Spanish Mackerel	NTFSM-2 and attachment D	18/11/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Follow-up on provision of information.
Timor Reef	NTFTRF-2 and attachment D	18/11/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	For information
Timor Reef and Demersal Relevant	TRD-10	16/11/2016	Email from Santos to [redacted] apologising if draft summary led to a misunderstanding; opportunity to correct was always clear. Advised Santos was keen to find an acceptable solution but also achieve regulatory approval.	Santos and fishers are aligned in finding an acceptable solution.
Timor Reef and Demersal Relevant	TRD-9	15/11/2016	Email from [redacted] to Santos expressing disappointment at accuracy of email and concern that it was ëengagementô for regulatory approval rather than ëconsultationô to address issues. Corrections included metrics around COP survey impact including reduced catches by 50% from just after survey started, with rates reducing from [redacted] per day reducing to [redacted] per day and costing over [redacted] per trip (2 weeks), and that, with survey having finished on 11 October 2016, advice was that may be seeing some improvement but still too early. Advised that had heard a fisherman in another fishery saw improvement in 3 to 4 months but not qualified and needed to be discussed with [redacted] As for proposed timing, [redacted] said he wasnít sure how it been determined (perhaps vessels slipped during the dry) but fishing days were consistent across all months.	EP Section 7.1.6.1.4 Commercial Catch Rate Fish: updated to included information about impacts to catch rates from CoP seismic survey. Santos provided information in TRD-43 (6/4/17) and TRD-52 (13/4/17) that it used the provided information in regards to catch rates could be affected by up to 50% and recovery to pre-seismic levels take 3 ï 4 months for the EP assessment on catch rates. The survey timing was planned to try align with the period of least fishing activity June to mid-August and to avoid peaking spawning in October. This was based on information from the NT DPIFR (records NTDPIFR-2, NTPIRF-4). Fishers advised at meeting in May 2015 (NTSC-2 14/5/2015) that September to May is the sensitive time for fishing and seismic during this period should be avoided. This was independently supported by advice from the Department. Much later, the fishers said they fished all year round, so this was a reference to fish breeding and not fishing activities September to May is the sensitive time for fishing and seismic during this period should be avoided. Fishers clarified (TRD-13 16/12/16) that June to August was a period of least impact on fish breeding but not fishing activities. Further clarification was provided on 9/5/17 (TRD-74) that fishing activity is not seasonal. Tropical fish breed throughout the year but this is thought to intensify September to May and therefore this period was to be of least impact to fish breeding, not current fishing activities. Based on this information EP Section 5.5.3 Plankton and Section 7.1.5.1 Seismic Noise Plankton has been updated to include that peak spawning is from Sept to May. Section 7.9.5 Marine Users Interactions has been updated to reflect that the TRF operate all year round. EP Table 7-16 Seismic Noise Risk Assessment: assessment of controls was updated to include that the main fisheries in the area (TRF and Demersal) do not have a closed season and peak spawning occurs from Sept to May. The survey was planned on original information that period of least intensity (June ï mid August) and prior to the start of spawning in October. Impacts to fishers and spawning have been assessed based on these timings from the fishers within the EP Section 7.1.5.1 Seismic Noise Plankton, Section 7.1.5.3 Seismic Noise Fish, Section 7.9.5 Marine Users Interactions and with the appropriate controls in place impacts to the fishers and fishery can be managed to an acceptable level.
Amateur Fishermenís Association of the NT (AFANT)	AFANT-11	14/11/2016	AFANT responded that the Bethany survey will have some impact on these charter operators but similar to the commercial fleet June-August would be the time period with the least disruption to recreational fishermen.	EP Section 5.6.4 Recreational Activities updated to include time period of least disruption. Survey timing planned for June - Sept.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
Offshore Net and Line	ONLF-8	12/11/2016	Chair email: I havenꞌt had any specific feedback but importantly I am not in a position to say that this doesnꞌt mean that individual licences/business do not have ongoing issues. I am very happy to get the information. I do however know that there has been concern on the impacts on the resource following recent FRDC reports that indicates that seismic operations have impacted on marine life?	Assessment of seismic noise impacts on marine life detailed in EP Section 7.1. Data from recent FRDC research included in EP Section 7.1.5.2.2 Seismic Underwater Noise - Prawns and Section 7.1.5.2.3 Seismic Underwater Noise.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-10 and attachment record AFANT-8	11/11/2016	Email from AFANT [redacted] notifying stakeholders that he has resigned from his position as Executive Officer of AFANT, and has been appointed as a Ministerial Adviser for the Hon. Ken Vowles, the Minister for Primary Industries and Resources. Santos replies to email on 11.11.2016: Congratulations on your appointment. But before you go was wondering whether you had had time to consider the attached (record AFANT-8)? And who should we engage with once you leave?	Follow-up of provision of information.
Timor Reef and Demersal Relevant	TRD-8	11/11/2016	Email from Santos to [redacted] with draft summary of 08/11/2016 phone conversation and encouraging amendment if not accurate. Draft Summary included [redacted] statements on impact of recent COP survey on catch, precautionary principle, querying how we had nominated June, July and August as the least disruptive period to commercial fishers (advice from May 2015 meeting), [redacted] happy for [redacted] to represent him. Santos statements aware of potential impact and desire to talk about how we could minimise impact and reach some form of a make-good arrangement.	EP Section 7.1.6.1.4 Commercial Catch Rate - Fish updated to include information on feedback in regards to impacts to catch rates from CoP seismic survey. EP Section 7.1.6.1.4 Commercial Catch Rate - Fish: applies cautious approach consistent with the precautionary principle in acknowledging that potential impacts on catchability of commercial species is possible and have included control measure of a Loss of Catch Payment. Information from the EP sent to the fishers (TRD-40 5/4/17) and EP sent to fishers (TRD-58 19/4/17). Both these documents included information in regards to a make-good payment for displacement (loss of catch) and for operating cost associated with having to fish in another area. Since this information was provided further consultation has been ongoing with fishers and the controls in the EP updated to more clearly reflect the structure of payment. This information was sent to the fishers on 22/5/17 (TRD-87)
Timor Reef and Demersal Relevant	Phone call	8/11/2016	Telephone call and conversation with [redacted] representing [redacted] See TRD-8 for summary record of phone call.	See TRD-8 for summary record of Santos response.
Northern Prawn Fishery	NPF-15	3/11/2016	Phone conversation with follow-up email. NPFI advised that you can provide catch data maps going back to 2010. Santos agrees to pay for collation of data. Santos said they would collate the outstanding questions asked over a couple of email exchanges and include them in this email (see below). Collated questions and answers from NPFI 1. Are you able to tell me what factors are common to the areas where your members fish i.e. water depth, sea floor type (sandy, muddy, corals?)é ? 2. Whilst we are aiming to start the WA-459-P (Fishburn) survey in mid-June (based on your advice as to when would be the least disruptive time), what would be the impact if we began it in May? 3. Is it best if we engage with you (as CEO of the NPF), rather than directly with your members, and then you can distribute our information to all of those fishers of yours who are relevant?	Follow-up on information requested.
Aquarium Fishery	AQ-11	2/11/2016	Santos acknowledges email and areas of concern. Inform [redacted] that just undertaking our assessment of noise impacts, including reviewing the scallop report. Once we have this information we will get back to [redacted] to discuss. Santos notes that [redacted] mentioned the clams when we spoke over the phone last year; and would like to talk more about it, particularly around what part you think we could play. Santos also would like to catch up for a meeting in Darwin.	Information was provided to [redacted] on 21/3/2017 (AQ-17) in regards to potential impacts to divers in the water, small reef fish and corals and clams.
Aquarium Fishery	AQ-10	1/11/2016	[redacted] nforms Santos that email is the best way to receive information. Concerns are for the reef areas with localised fish and giant clam populations that cannot leave the reef to escape the surveying. Recently saw article on scallop die off after seismic testing and is concerned about the few remaining tridacna gigas on Evans and Blackwood Shoals. [redacted] would really like to work with Santos if possible to remove the few remaining clams from the reef and breed them on land for subsequent restocking and sale.	Information was provided to [redacted] on 21/3/2017 (AQ-17) in regards to potential impacts to divers in the water, small reef fish and corals and clams.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-9 and attachment D	31/10/2016	From Santos to AFANT, following up on email from 11 October advising Santos' plans to undertake seismic surveys over WA-459-P and NT/P85 in the Bonaparte Gulf in 2017. Also attached it information sheet 1. If the proposed surveys are of interest, could you please advise me how you would like to be consulted in the future. Also, could you please advise of any areas of concern you may have and the type of additional information you would like to receive. Any guidance you have on the NTGFIA and charter boat industry, as per my email below, would also be gratefully received.	Follow-up of provision of information.

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Arafura Bluewater Charters	ARA-2	31/10/2016	Santos sends a follow up email and also notes that if the proposed surveys are of interest, could you please advise them how you would like to be consulted in the future (e.g. email? Over the phone? In person?).	Follow-up on provision of information.
Australian Fisheries Management Authority (AFMA)	AFMA-9	31/10/2016	Follow up on email sent on 11th October 2016.	Follow-up email. No response.
Eni Australia Limited	ENI-2	31/10/2016	Santos email: Follow-up on email 11.10.16.	Follow-up.
Northern Prawn Fishery	NPF-14	31/10/2016	Santos ask are you able to send through data summary maps for NT/P85 (including operational area ï the coordinates are in the Information Sheet)? Follow-up on additional questions asked 21/10/16 email.	Follow-up on information requested.
Northern Territory Seafood Council	NTSC-10	31/10/2016	Santos email: Asking if any feedback from licensee in relation to the NTSC sending out Information Sheet #1? No replies have been obtained from [redacted] or [redacted] Have copied you into follow-up emails to [redacted] and [redacted] Confirmed that Santos sent information to license holders using contact details provided by the Dept. NTSC email: Will respond next week (14/11).	No feedback obtained from NTSC in regards to Information Sheet #1.
NT Department of Primary Industry and Resources	NTDPIR-3	31/10/2016	Follow-up on email 30.9.16 and 11.10.16.	Follow-up provision of information.
NT Department of Primary Industry and Resources	NTDPIR-4	31/10/2016	Reviewed Information Sheet and the Energy Directorate in DPIR has no concerns with the proposal. As the Joint Authority for offshore title administration, I wish to stay informed of current and proposed activities. Email communication as is in place is appropriate. Understand you have contacted NT Department of Primary Industry and Resources - Fisheries to seek comments on fisheries aspects. As now one department, perhaps it would be more appropriate to for Santos to receive a combined comment from this Department. If you have concerns about the suggested approach, please let me know, otherwise I will discuss with the Director Fisheries and Aquaculture to see how best to effect this.	Section 4.1 Ongoing Consultation updated to include requirement to notify NT Department of Primary Industry and Resources of start and cessation of activities.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-21	31/10/2016	Santos email: Have received licensee lists for fisheries and immediately sent out letters and emails to the people/entities on the list. Santos also follows up in regards to the fish catch data (email requesting data on 19/10/16 NTDPIRF-19) NTDPIRF email: Will chase this up again and apologises for the delay.	Santos sent letters and emails to all licensees provided by the NTDPIRF (see individual stakeholder records). NTDPIRF sent fish catch data 20/1/2017 (NTDPIRF-23).
NT Guided Fishing Association (NTGFA)	NTGFA-6	31/10/2016	If the proposed surveys are of interest, could you please advise me how you would like to be consulted in the future (e.g. email? Over the phone? In person?). Also, could you please advise of any areas of concern you may have and the type of additional information you would like to receive. I look forward to hearing from you (I can be contacted by return of this email or phone on 08 [redacted] Please let me know if you would prefer I phone you ï if so, you will need to provide me with your phone number).	For information - no response.
Offshore Net and Line	ONLF-7	31/10/2016	Santos Email to Chair: Did you receive any feedback from your members? Are you OK to continue receiving information from me via email?	Follow-up on provision of information.
Spanish Mackerel	SMF-8	31/10/2016	If the proposed surveys are of interest, could you please advise me how you would like to be consulted in the future (e.g. email? Over the phone? In person?). Also, could you please advise of any areas of concern you may have and the type of additional information you would like to receive. I look forward to hearing from you (I can be contacted by return of this email or phone on 08 [redacted] Please let me know if you would prefer I phone you ï if so, you will need to provide me with your phone number).	Follow-up on provision of information.
TGS	TGS-3 (attachment included in record)	31/10/2016	TGS replied informing Santos 'Though Iôm sure youôre probably aware we have our ôEP Northô presently in with NOPSEMA, under assessment (https://www.nopsema.gov.au/environmental-management/activity-status-and-summaries/details/353).' TGS responds that have a potential 2D in the Bonaparte Basin with the majority of the data being in the Vulcan Sub Basin. Map 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.	Potential 2 D in the Bonaparte Basin that cross WA-459-P - not relevant to Bethany survey.
Timor Reef and Demersal Relevant	TRD-7	31/10/2016	Email from Santos following-up email of 11/10/2016 seeking advice on any areas of concern, now that had time to consider Information Sheet#1. Also seeking advice on convenient time to meet/phone conversation to discuss any areas of concern, and how to minimise any potential disruption.	Provision of information. No feedback obtained.

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TGS	TGS-2 and attachment D	28/10/2016	Santos email: We are working up plans for NTP85 and WA459P, Origin NT84P and Magellan at NT82P. Actually, I sent [redacted] from your shop the attached email on 85 & 459 but havenôt heard anything. Is she still there? Can you help? TGS response on 28.10.2016 Copying [redacted] on this reply, am sure sheôll get back to you soon. Though lôm sure youôre probably aware we have our ôEP Northô presently in with NOPSEMA, under assessment (https://www.nopsema.gov.au/environmental-management/activity-status-and-summaries/details/353).	Follow-up.
Aquarium Fishery	NTFAF-1 and attachment D	24/10/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Licence details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Demersal Fishery	NTFDF-1 and attachment D	24/10/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet #1 with details of our proposed surveys.	For information. licensee details provided by NTDPIRF (see NTDPIRF-20)
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-20 and attachment F	24/10/2016	NTDPIRF email: The Department sent the Licensee lists for Fisheries that may work within the specified area. Included Aquarium Fish/Display licensees who may collect fish in this area.	NTDPIRF sent through Licensee information for fisheries that may work within the survey area. In October 2016 [redacted] Senior Licensing Officer, Department of Primary Industry and Resources, Northern Territory Government, provided me with a list of the NT fishery licensees. The names of some of the licence-holders in Timor Reef and Demersal fisheries are mostly corporate entities, so I asked the Department for further advice as to who were the people behind the corporate entities holding the licences. They responded with names and contact details. Most licences belonged to corporate entities owned by [redacted] I then made contact or attempted to contact (using two different forms of contact if provided e.g. email and postal address or email and phone call) all the individuals with whom we had not already made contact (we had already contacted [redacted] and [redacted] By linking the corporate entities with their owner, it became apparent that there are 4 different licence-holders in the Timor Reef Fishery and 7 in the Demersal Fishery, one of whom ([redacted] said he didnôt work in the Bonaparte (see note of phone conversation 080317) and another of whom ([redacted] said he had sold his interests to [redacted] (see note of phone conversation 080317).
Offshore Net and Line	NTFONL-1 and attachment D	24/10/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet #1 with details of our proposed surveys.	Licensee details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Spanish Mackerel	NTFSM-1 and attachment D	24/10/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	Licensee details provided by NTDPIRF (see NTDPIRF-20). Provision of information. No response received.
Timor Reef	NTFTR-1 and attachment D	24/10/2016	Email or postal letter depending on which contact details provided Notification that Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, also attached the Information Sheet with details of our proposed surveys.	For information
Northern Prawn Fishery	NPF-12	21/10/2016	Email from [redacted] with attachment NPF Data Summary (maps relate WA-459-P)	Not relevant - maps for WA-459-P permit.
Northern Prawn Fishery	NPF-13	21/10/2016	Additional questions have been asked to [redacted] ÅThe 2014 and 2015 fishing activity maps seem to display a pattern of sorts. Are you able to tell me what factors are common to the areas where your members fish i.e. water depth, sea floor type (sandy, muddy, corals?)é ? ÅIs there any chance of getting this fishing activity data over a longer period, say 5 to 10 years, to show trends? ÅLike to plot our ôoperationalô area on these maps (not just the permit area). Are you able to do this or alternatively, provide your shape files for us to do?	Clarification questions to further understand the areas where the NPF fish.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-18	19/10/2016	Santos email: Follow up on email 13/10/2016 (NTDPIRF-15) in relation to obtaining details of the licensees in the Demersal Fishery and the Timor Reef Fishery to be able to alert all licence-holders to our plans. Santos acknowledges letter responding to Information Sheet #1 sent by the Dept. Santos notes comment that the effects of seismic surveys on the sustainability of fish stocks have not been adequately determined or understood and the desire for a research project (involving all users of the Commonwealth waters off the NT) . One way of getting a better appreciation would be to compare fish catch data over the past 10 years, during which time there have been a number of seismic campaigns. I flagged our proposed seismic program with [redacted] on Friday and the role fish catch data would play in determining impact. Is this data available in the region over the past 10 years?	NTDPIRF sent through Licensee information for fisheries that may work within the survey area (NTDPIRF-20 24/10/16). Ongoing dialogue with NTDPIRF in relation to obtaining fish catch data (NTDPIRF-19, NTDPIRF-21) to be able to look at determining impacts from seismic surveys. NTDPIRF sent fish catch data 20/1/2017 (NTDPIRF-23).
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-19	19/10/2016	NTDPIRF email: Will chase it up and see what the delay is...sorry about that. We will also respond to your data question.	NTDPIRF sent through Licensee information for fisheries that may work within the survey area (NTDPIRF-20 24/10/16). NTDPIRF sent fish catch data 20/1/2017 (NTDPIRF-23).
Northern Prawn Fishery	NPF-11	18/10/2016	Reply from [redacted] answering questions raised by TB. Specific comments to your questions below: With that in mind, could you also please confirm your advice (provided in an email on 10 December last year) that it is best if we engage with you (as CEO of the NPF), rather than directly with your members, and that you would distribute our information to all your relevant fishers to save doubling up. Q1: Is this still the case? Without knowing who is on your contact list I would suggest its best to continue working through NPFI. We can distribute the information you provide and work on preparing a combined response to on proposals. On Thursday, you also said you would send through a map showing the 2015 activity of your members (similar to the Google map [redacted] sent through late last year). Please send through when you can. I will forward through separately. Please note that the fishing effort in the JBG was much lower and NOT typical of effort patterns over time. A couple of reasons ï one being that prawn production was unusually high (the highest since 1998) in the Gulf of Carpentaria in 2015. As such, the boats went where they could maximise the catch which resulted in very little fishing effort in the JBG ï the second is concern about seismic . Itõs notable that the catches in JBG are quite low again this year ï which has exacerbated concerns about seismic impacts! I need to talk more to the boys about this closer to the end of the season but I suspect the topic will be high on the agenda. I have been engaging with our exploration team to assist in their contracting of s seismic vessel contractor, and they have advised that while they are aiming for operations in the ówindowsô that your members are not fishing (15 June to 1 August, and 1 December to 1 April), there is the risk that early or late completion of the preceding survey may result in the seismic vessel arriving earlier or later than planned. Q2: Could you please therefore advise what the issues and impact would be if the seismic program started in the first half of June or even May? Now this has been rescheduled for June 2017 - should be ok Q3: Could you please also advise what the issues and impact would be if the seismic program did not finish until into August? That shouldnõt be too much of a problem as long as the survey doesnõt run over for too long and depending on where the boats are ï they will probably start in JBG in ate August, early Sept	Clarification that information for licensees within the NPF should come through NPFI. Noted that current low fishing effort in JBG could change. Further clarification to understand timing of fishing and potential impacts.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-16	17/10/2016	NTDPIRF letter: In reply to Information Sheet #1 sent 11.10.16 1. Operators in the Timor Reef, Demersal and Offshore Net and Line fisheries, along with Fishing Tour Operators, all actively utilise the proposed survey area, with the main target species being offshore demersal fish such as goldband snappers and red snappers. 2. Operators have reported past experiences with similar 3D marine seismic surveys that indicate surveying may affect the catchability (and economics) of offshore demersal fish for significant periods of time (i.e. during and post survey). For this reason, the Department of Primary Industry and Resources (DPIR) believes there is a potential risk of this seismic survey to these fisheries, particularly if conducted during periods of peak fishing activity between October and March if the planned survey is delayed for any reason. 3. Note you have discussed the proposed survey with the commercial fishers in the NT to reduce this risk, as well as the issue of physical displacement. Your confirmation that, based on these discussions, the acquisition if marine seismic data is planned to occur during the period of least activity for the most relevant commercial fishery, the Timor Reef Fishery, is welcomed. 4. The NT has responsibility for the management of all fish and other aquatic life resources in waters relevant to the NT. It is the DPIR's ongoing concern that the short and long-term cumulative effects of seismic surveys on fish stocks have still not been adequately determined or the longer-term effects of the sustainability of fish stocks well understood. 5. There is evidence that indicates that 3D marine seismic surveys can cause hearing impairment of fish up to several kilometres away from the array and DPIR is concerned that hearing impaired fish may suffer mortality through predation which therefore represents an unquantified risk to these stocks. 6. As well as the potential lethal impacts there is the potential for sub lethal impacts such as disrupting spawning aggregations. 7. DPIR believes that serious consideration should be given to the development of targeted research project that examines the physical impacts of seismic surveys on catchability of tropical fish species. A project of this nature should involve all stakeholders utilising the Commonwealth waters off the NT (and potentially WA and QLD). 8. I hope this information assists with the development of appropriate mitigation measures in the EP and I look forward to reviewing the EP when it becomes available.	1. Timor Reef, Demersal, Spanish mackerel and Offshore Net and Line fisheries included as potential relevant stakeholder (EP Table 4-2). See stakeholder engagement records. Letter (NTDPIRF-6) informs NTDPIRF that Santos has commenced engagement with individual fishers to identify any issues they may have in regards to the proposed survey. Consultation with NTDPIRF (NTDPIRF-1) and AFANT only identified Arafura Bluewater Charters as fishing tour operator likely near the survey area. Arafura Bluewater Charters ([redacted] included as potential relevant stakeholder (EP Table 4-2). See Stakeholder Records for Arafura Bluewater Charters (AFA). 2. Survey planned to be undertaken between July to end Sept (EP window is broader May to end Sept) outside the peak period of fishing activity between October and March. Ongoing requests to NTDPIRF (NTDPIRF-5, NTDPIRF-6, NTDPIRF-18) to provide data to support statements in regards to 3D marine seismic surveys may affect the catchability (and economics) of offshore demersal fish for significant periods of time (i.e. during and post survey). 3. Confirmation from NTDPIRF that the proposed survey timing (July to end-Sept) is planned to occur during the period of least activity for the most relevant commercial fishery, the Timor Reef Fishery. 4. Santos has requested (NTDPIRF-5, NTDPIRF-6, NTDPIRF-18) data from NTDPIRF to be able to identify and assess any impacts in regards to short and long-term cumulative effects of seismic surveys on fish stocks. This data is not available without confidentiality agreements with the licensees. 5. EP Section 7.1.6.1.2 Seismic Noise - Fish Temporary threshold shift addresses this potential impact and how it may impact the sustainability of fish stocks. 6. EP Section 7.1.5.1 Seismic Noise - Plankton addresses potential impacts to plankton including fish eggs and larvae. Survey has been planned to end at the end of September to avoid peak fish spawning season (Oct - May) as advised by NTDPIRF (NTDPIRF-4). 7. Santos requested more information in regards to research and data (NTDPIRF-18). Santos and NTDPIRF have had ongoing discussions in regard to research (NTDPIRF-41, NTDPIRF-42, NTDPIRF-43, NTDPIRF-44) and agreed this was a broader industry issue requiring collaborative arrangements. Santos would keep the NTDPIRF up to date of upcoming research opportunities being coordinated by the APPEA Marine Environmental Science Program (MESP) via the Bonaparte Fishing Group. 8. Santos provided exerts from the EP in regards to impacts to fish and catch rates to NTDPIRF on 11 April 2017 and the EP Rev 0 on the 29 April 2017.
Offshore Net and Line	ONLF-6	17/10/2016	[redacted] will pass on [redacted] details to members. [redacted] Acknowledged [redacted] email noting that [redacted] will pass on details once he get them.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-17	14/10/2016	NTDPIRF email: [redacted] will send through NT Fishery contact details.	NTDPIRF sent through Licensee information for fisheries that may work within the survey area (NTDPIRF-20 24/10/16).
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-15	13/10/2016	Santos email: Santos informs Dept. it had requested from NTSC for the names of the licensees in the Demersal Fishery (NT Fishery Joint Authority) and the Timor Reef Fishery (NT Fishery Joint Authority) and they have pointed to the Department to obtain. Request to Dept. to obtain licensee names. Have emailed [redacted] new chair of the Offshore Net and Line Fishery, and Spanish Mackerel Fishery Chair [redacted] asking if there are licensees amongst their fisheries who would be interested in our proposed activities. If the Department is able to advise on Demersal and Timor Reef licensees, would also be good to confirm Offshore Net and Spanish Mackerel ones as well.	NTDPIRF sent through Licensee information for fisheries that may work within the survey area (NTDPIRF-20 24/10/16).
Aquarium Fishery	AQ-9	12/10/2016	[redacted] email: They are the only aquarium operator in that area -12.10.2016 Santos acknowledges response that [redacted] is the only aquarium operator in the area. STO asks if [redacted] is happy to receive information via email and if there are any areas of concern and the type of additional information you would like to receive. 31.10.2016.	EP Table 4-2 Assessment of Stakeholder updated to include AFANT and Monsoon Aquatic as a relevant stakeholders. Engagement with Monsoon Aquatic is via [redacted] via the Aquarium Fishery. Section 4.1 Ongoing consultation updated to include Aquarium Fishery Chair of the Licensee Committee.
Commonwealth Fisheries Association	CFA-9	12/10/2016	CFA acknowledges email "Yes, all good with me" and asks for confirmation that the following stakeholders have been contacted NTSC, WAFIC and NPFI? Santos confirms have contacted NTSC, WAFIC and NPF 12.10.2016.	For information.

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ConocoPhillips	CoP-2	12/10/2016	CoP email: As an initial response and advise currently seeking acceptance of an EP from NOPSEMA for an appraisal drilling campaign in Retention Lease Permit NT/RL5. Campaign will involve the drilling, evaluation and potential production testing of up to three appraisal wells between 2016 and 2018. Drilling of the initial well is scheduled to commence in Q4 2016. Fact information sheet was provided in link. CoP email: Replies to Santos on 14.10.2016 see no issues arising if our activities occur simultaneously at some stage of next year. Will check to let you know if there will be any environmental survey work so you have a full picture of any other activity/traffic that might occur.	EP Section 5.6.5 Oil and Gas Activities updated to include ConocoPhillips appraisal drilling and assess likelihood of cumulative impacts.
Northern Territory Seafood Council	NTSC-9	12/10/2016	NTSC email: Have forwarded the Information Sheet #1 to those member's go have email (Timor Reef, Demersal, Aquarium, Spanish Mackerel, Offshore Net and Line, Prawn operators/licence holders). Noting that page 7 & 8 has the proposed timeframe for consultation and submitting of EP. Other members details (postal) can be obtained from NT Fisheries and NTSC encourages Santos to write to all licence holders in the fisheries that overlap this exploration area. Provided [redacted] email address. Santos email: Didn’t ask [redacted] or [redacted] in my email to them but are there any other licence holders in the Demersal Fishery - NT Fishery Joint Authority? Similarly, didn’t ask [redacted] re the Timor Reef Fishery - NT Fishery Joint Authority. Are there any other licence holders? NTSC email: Yes, there are other operators in all the fisheries ï best to get the list from Fisheries and do a post out/email out with their information. Santos email: Will follow up with the Department. Please let me know of any responses you get to your email below.	Santos obtained licensee details from the NTDPIRF (NTDPIRF-20). Santos sent Information Sheet #1 and #2 to all licensee's in the following fisheries: Aquarium, Spanish mackerel, Offshore Net and Line, Timor Reef, Demersal, Northern Prawn Fishery. See individual stakeholder records. Santos informed NTSC that Information Sheet #1 sent to license holders using contact details provided by the Dept.
NT Department of Aboriginal Affairs	NTDoAA-3	12/10/2016	Email from DoAA: Seismic program is outside of the NT’s coastal waters albeit the NT Minister for Primary Industry and Resources and Department of Primary Industry and Fisheries have roles as part of the joint authority with the Commonwealth Government. You may wish to make contact with the Aboriginal Areas Protection Authority in relation to possible sacred site issues, the Heritage Branch in the Department of Environment and Natural Resources in relation to any possible heritage (maritime or historical archaeological) issues, the Department of Primary Industry and Fisheries in relation to any possible fishing issues/interests, the Tiwi Land Council and the NT Seafood Council to provide notification of the activities and seek feedback in relation to any possible impacts.	Response to NTDoAA provided 28/2/2017 NTDoAA-4
Offshore Net and Line	ONLF-5 and Attachment D	12/10/2016	Introductory email that we have previously liaised with [redacted] Please find attached an Information Sheet#1relating to a proposed seismic survey in NT/P85, most relevant to you and your members, and one we propose to do earlier, 200km to the south-west, at WA-459-P. If you require any additional information, have any questions or feedback, please don’t hesitate to contact me.	Provision of information.
PGS	PGS-2	12/10/2016	PGS replies to Santos' email with the below: ÅThe 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 ÅPGS has been in discussions with another operator about potential Multi Client work near the proposed Bethany survey area, but no substantial progress has been made and no firm plans are currently in place. PGS will advise Santos should this situation change, and will consider Santosôplans in any related EP submission. Santos acknowledges advice.	Section 5.6.5 Oil and Gas Activities updated to include information in regards to PGS Rollo Multi Client 3D Seismic Survey which is restricted to WA waters which is at a minimum is ~ 55 km from survey area and ~ 80 km from the survey acquisition area.
Shell Australia	SA-2	12/10/2016	We have no activities planned that would be affected by your survey.	Section 5.6.5 Oil and Gas Activities update to include information in regards to Shell not undertaking any activities in NT/RL7 in 2017.
Amateur Fishermen’s Association of the NT (AFANT)	AFANT-8 and attachment D	11/10/2016	Resumed contact to inform AFANT that proposed seismic program will be going ahead. Sent Information Sheet #1 relating to the two seismic surveys previously discussed, one in NT/Commonwealth waters, the other in WA/Commonwealth waters, now aiming for mid-2017.	Provision of information
Aquarium Fishery	AQ-8 and attachment D	11/10/2016	Santos email: Reinitiate contact as Santosô2017 seismic program planned for mid 2017. Information Sheet #1 provided covering previously discussed surveys, one in NT/Commonwealth waters, the other in WA/Commonwealth waters. Santos asks if any other operators in the aquarium fishery that should be contacted.	For information.
Arafura Bluewater Charters	ARA-1 and attachment D	11/10/2016	Santos informs Arafura Bluewater Charters that they are planning to undertake two seismic surveys in the Bonaparte Basin next year, one over WA-459-P in WA/commonwealth waters followed by a survey over NT/P85 in NT/Commonwealth waters. Please see attached an Information Sheet #1 with details of the proposed surveys.	Provision of information.
Australian Fisheries Management	AFMA-8 and attachment D	11/10/2016	Sent AFMA Information Sheet #1 relating to the two seismic surveys proposed for the Bonaparte Gulf in 2017. We understand the only Commonwealth fishery in the WA-459-P and NT/P85 permit areas is the Northern Prawn Fishery.	For information. No response.

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Authority (AFMA)				
Commonwealth Fisheries Association	CFA-8 and attachment D	11/10/2016	Email reinitiating contact in regards to the seismic surveys and sent Information Sheet #1 relating to the two seismic surveys previously discussed, one in NT/Commonwealth waters, the other in WA/Commonwealth waters, now aiming for mid-2017.	Provision of information.
ConocoPhillips	CoP-1 and attachment D	11/10/2016	Santos email: Planning to undertake a seismic survey over NT/P85 in 2017, and want to check ConocoPhillipsô interests in NT/RL5 and NT/RL6 would not be affected by the proposed survey. Information Sheet #1 attached.	Response received CoP-2.
Department of Defence	DoD-3 Attachment D	11/10/2016	Sent Information Sheet #1 relating to two 3D seismic surveys Santos is planning to undertake next year (from mid-June) in the Bonaparte Gulf.	Provision of information.
Eni Australia Limited	ENI-1	11/10/2016	Santos email: Sent Information Sheet#1 with details of proposed seismic surveys to check if Eni's activities in the Bonaparte (WA-34-R, WA-69-R, WA-33-L, NT/RL8 and NT/P68) would be affected and if any drilling or seismic activity in these permits. If you require any additional information, have any questions or feedback, please donõt hesitate to contact me.	Provision of Information.
Northern Prawn Fishery	NPF-10 and attachment D & J	11/10/2016	Planning for Santosô 2017 seismic program has now resumed. Information Sheet #1 included and letter from Santosô Vice President of Exploration expressing his goal to undertake the seismic program with the minimum disruption to your membersô business. Follow-up on answers/information from you over questions raised 21 June.	Provision of information.
Northern Territory Seafood Council	NTSC-8 and attachment D	11/10/2016	Santos email: Planning for Santosô 2017 seismic program is underway again, so please find attached an Information Sheet #1 relating to the proposed seismic survey in NT/P85, most relevant to you and your members, and an earlier survey, 200km to the south-west, at WA-459-P. If you require any additional information, have any questions or feedback, please don't hesitate to contact me.	Provision of Information.
NT Department of Aboriginal Affairs	NTDoAA-2 and Attachment D	11/10/2016	Email with Information Sheet#1 relating to the proposed seismic activity.	Provision of information.
NT Department of Primary Industry and Resources	NTDPIR-2 and Attachment D	11/10/2016	Follow-up on email 30.9.16 and included Information Sheet#1	Provision of information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-14 and attachment D	11/10/2016	Santos email: Resumption of planning for Santosô 2017 seismic program. Provided Information Sheet #1 relating to two seismic surveys we are proposing to undertake in the Bonaparte, starting in June next year. If require additional information, have any questions or feedback please contact me.	NTDPIRF sent letter of reply to Information Sheet #1 (NTDPIRF-16).
NT Guided Fishing Association (NTGFA)	NTGFA-5 and attachment D	11/10/2016	The program, originally scheduled for 2016, was delayed and we are now aiming for the middle of next year. Please find attached an Information Sheet #1 relating to two seismic surveys we are planning to undertake in the Bonaparte Basin, one in NT/Commonwealth waters (which I have raised previously below), the other in WA/Commonwealth waters.	For information - no response.
Pearl Producers Association	PPA-1 and attachment D	11/10/2016	Santos email: Introductory email with map and coordinates to establish if fish in area and/or interested in seismic survey.	Provision of information. No response.
PGS	PGS-1 and attachment D	11/10/2016	Notification email to PGS that Santos is planning to undertake seismic surveys over WA-459 and NT/P85 in 2017, Santos would like to check PGS activities in the Bonaparte would not be affected by the proposed surveys and if PGS is planning any seismic activity in the area next year. It is noted if PGS are Santos will need to note this information in the development of its EP. Attached is information sheet #1	Provision of information.
Shell Australia	SA-1	11/10/2016	Sent Information Sheet#1 with details of proposed seismic surveys to check if Shell's interests in the Bonaparte (NT/RL7) would be affected and if any drilling or seismic activity in these permits. Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017. Please see attached an Information Sheet with details of our proposed surveys. If you require any additional information, have any questions or feedback, please donõt hesitate to contact me.	Provision of information.
Spanish Mackerel	SMF-7	11/10/2016	Planning for Santosô 2017 seismic program is underway again, so, as promised in my March email (below), I am resuming contact. Please find attached an Information Sheet relating to two seismic surveys we are planning to undertake next year in the Bonaparte Basin, one in NT/Commonwealth waters (which I have raised previously below), the other in WA/Commonwealth waters.	Provision of information.
TGS	TGS-1 and attachment D	11/10/2016	Santos email: Santos is planning to undertake seismic surveys over WA-459-P and NT/P85 in 2017, and to check that TGSõs activities in the Bonaparte would not be affected by the proposed surveys. Information Sheet #1 attached with details of the proposed surveys. If you require any additional information, have any questions or feedback, please donõt hesitate to contact me.	Provision of information.

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Timor Reef and Demersal Relevant	TRD-6 and attachment D and Attachment k	11/10/2016	Email from Santos advising that planning for NT/P85 survey had resumed. Attached Information Sheet #1 detailing key aspects of proposed survey and a request for advice on how survey could be undertaken with minimum impact on interests/activities. Also attached letter from Santos VP seeking opportunity for senior manager to meet and discuss concerns.	Provision of information. No feedback obtained.
Northern Territory Seafood Council	NTSC-7	4/10/2016	Santos email: Good to get your thoughts on engagement. Going to send out Information Sheet and letter to from Exploration VP to [redacted] and [redacted] Could you check email addresses as have sent email to these addresses with no replies. Will also send Information Sheet to you, Aquarium Fishery, Spanish mackerel and Offshore Net and Line- can you think of any other of your members. NTSC email: Confirms fisheries and contacts including NPF and best to send information sheet to all licence holders in each fishery to cover your bases.	Santos sent Information Sheet #1 main contacts in the following fisheries: Aquarium, Spanish mackerel, Offshore Net and Line, Timor Reef, Demersal, Northern Prawn Fishery. See individual stakeholder records. As per NTSC-9 consequently Santos sent Information Sheet #1 sent to all license holders from the Aquarium, Spanish mackerel, Offshore Net and Line, Timor Reef, Demersal, Northern Prawn Fishery using contact details provided by the Dept.
Department of Defence	DoD-2	30/09/2016	Confirmed that the Property Acquisition, Mining and Native Title Property Management Branch via the offshore petroleum inbox was appropriate for oil and gas consultation.	For information.
NT Department of Aboriginal Affairs	NTDoAA-1	30/09/2016	Introductory email with map to determine if any customary fishing or cultural heritage areas of Traditional Owner groups in the region.	Provision of information.
NT Department of Primary Industry and Resources	NTDPIR-1	30/09/2016	Contact to determine who, within the Department, we should be consulting with in regards to the OPGGS Env Regulations say the Department of the relevant Minister is a relevant person.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-13	30/09/2016	Santos email: Information that within the next 10 days or so, we are aiming to resume our consultation for the proposed seismic program at NT/P85 , which is now scheduled for next year (2017). Will send you an Information Sheet and we can go from there. Do you know if there is anyone other Monsoon Aquatics/[redacted] with an Aquarium Fishery licence within the vicinity of the proposed survey area (Bethany).	Information Sheet #1 sent to NTDPIRF (NTDPIRF-13). NTDPIRF sent through Licensee information for fisheries that may work within the survey area (NTDPIRF-20 24/10/16). Licensee information included Aquarium Fishery/Display licensees.
Australian Fisheries Management Authority (AFMA)	AFMA-7 and attachment A	29/09/2016	Email to determine if Southern Bluefin Tuna Fishery, Western Tuna and Billfish Fishery or Western Skipjack Fishery fish in or near permit area AFMA replied that only Cth fishery in area is NPF 30.09.2016	AFMA licensing confirmed that only Northern Prawn Fishery (NPF) operate in area. EP Section 5.6.2 updated with information that NPF only Commonwealth fishery in the area of Bethany survey.
Department of Defence	DoD-1	2/09/2016	Confirm that the Property Acquisition, Mining and Native Title Property Management Branch which [redacted]s 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.	For information.
Australian Fisheries Management Authority (AFMA)	AFMA-6	15/03/2016	Email acknowledging our email sent on 140316 and thanking us for our efforts to avoid impacts on the commercial fishing industry.	For information.
Amateur Fishermenꞌs Association of the NT (AFANT)	AFANT-7	14/03/2016	Email to AFANT to let them know seismic survey has been delayed for permits NT/P85 and 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. AFANT acknowledged email.	For information
Aquarium Fishery	AQ-7	14/03/2016	Santos email: Inform seismic survey delayed for permits NT/P85 and WA-459-P - due to contracting issues. Delays mean that we have missed the preferred timeline window so it will be postponed to 2017.	For information.
Australian Fisheries Management Authority (AFMA)	AFMA-5	14/03/2016	Email to AFMA let them know that the seismic survey has been delayed for permits NT/P85 and 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.	For information.
Commonwealth Fisheries Association	CFA-7	14/03/2016	Email to CFA to let them know that the seismic survey has been delayed for permits NT/P85 and 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. FCFA acknowledged email.	For information.
Northern Territory Seafood Council	NTSC-6	14/03/2016	Santos email: To let them know that the NT/P85 seismic survey has been delayed - due to contracting issues. Delays mean that we have missed the preferred timeline window so it will be postponed by a year. NTSC email: Acknowledging Santos' email.	Provision of Information.

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NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-11	14/03/2016	Santos email: Confirm meeting discussion with regard to proposed ómake-goodôscheme. Santos will formally write to the Dept. outlining the proposal. Advised that the seismic survey has been delayed for permit NT/P85 - due to contracting issues meaning that we have missed the preferred timeline window so it will be postponed by a year.	This discussion was around a broader industry make-good scheme modelled on other mechanisms implemented by titleholders and the fishing industry. Discussions were held with NTSC in relation to a make-good agreement as detailed in NTSC-2.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-12	14/03/2016	NTDPIRF email: Acknowledgement that Santos has postponed the survey dates.	For information.
NT Guided Fishing Association (NTGFA)	NTGFA-4	14/03/2016	Email to let them know seismic survey has been delayed for permit NT/P85 - due to contracting issues. Delays mean that we have missed the preferred timeline window so it will be postponed by a year.	For information - no response.
Spanish Mackerel	SMF-6	14/03/2016	Email let them know that the seismic survey has been delayed for permit NT/P85 - due to contracting issues. Delays mean that we have missed the preferred timeline window so it will be postponed by a year.	For information.
Timor Reef and Demersal Relevant	TRD-5	14/03/2016	Email from Santos advising seismic survey delayed due to contracting issues, and wouldnôt now hit fishers preferred window so will be postponed to 2017.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-10	28/01/2016	Meeting: Meeting with [redacted] in Darwin to discuss proposed ómake-goodôscheme. [redacted] was supportive of proposal and said it was not dissimilar to mechanism Dept. had implemented to deal with closing off of areas to free fishers in 2015 (chaired by [redacted]). He said ôthe principle had been establishedô and suggested Santos speak to NTSC and Santos lawyers, then formally write to the Dept. outlining proposal.	This discussion was around a broader industry make-good scheme modelled on other mechanisms implemented by titleholders and the fishing industry. Discussions were held with NTSC in relation to a make-good agreement as detailed in NTSC-2.
Northern Territory Seafood Council	NTSC-5	11/01/2016	Santos send: Apologising for delay in response. If all goes well submit EP at end March/early April.	Provision of Information.
Amateur Fishermenôs Association of the NT (AFANT)	AFANT-6	21/12/2015	Email to let AFANT letting them know that the contract for seismic vessel has gone out and will be in contact in Feb 2016 with more information and clarify what bluewater fishing is. AFANT replied (21.12.15) another type of fishing like estuary fishing, sport fishing, fly fishing etc.	For information
Aquarium Fishery	AQ-6	20/12/2015	Santos email: Provide update on Bonaparte surveys - contract out for tender and would update in new year.	For information.
Commonwealth Fisheries Association	CFA-6	20/12/2015	Sent email on update of Bonaparte survey - contract out for tender and would update in new year.	For information.
Northern Territory Seafood Council	NTSC-4	20/12/2015	Santos email: Update of Bonaparte survey - contract out for tender and would update in new year. Hopefully meet in Feb 2016 when we can have a more informed discussion around the proposed activities and minimising any impact. Continuing to work up the make-good mechanism. NTSC email: Asking when the EP will be submitted.	Date for EP submission provided on 11/1/2016 (NTSC-4)
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-9	20/12/2015	Santos email: Update of Bonaparte survey - contract out for tender and would update in hopefully February. Keen to discuss idea of independent "make-good "mechanism for assessing fisher impact claims.	Meeting undertaken with NTDPIRF (NTDPIRF-10) to discuss proposed ómake-goodôscheme.
Spanish Mackerel	SMF-5	20/12/2015	Sent email on update of Bonaparte survey - contract out for tender and would update in new year.	For information.
Timor Reef and Demersal Relevant	TRD-4	20/12/2015	Email from Santos advising that seismic tender contract only just been released and we will update status in the new year.	For information.
Australian Fisheries Management Authority (AFMA)	AFMA - 3	1/12/2015	AFMA replied. 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 with him you can obtain names and addresses from AFMA Licensing.	AFMA licensing confirmed that only Northern Prawn Fishery operate in area (AFMA-7 29.9.16).

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Australian Fisheries Management Authority (AFMA)	AFMA-4	1/12/2015	AFMA confirmed that the Northern Prawn Fishery (NPF) and Western Tuna and Billfish Fishery (WTBF) appear to overlap the permit area.	AFMA licensing confirmed that only Northern Prawn Fishery operate in area (AFMA-7 29.9.16).
Aquarium Fishery	AQ-5	15/11/2015	Santos email: Notification of WA-459-P survey and notes STO will be in contact when a contractor has been secured for the NT/P-85 survey.	For information.
Commonwealth Fisheries Association	CFA-5	15/11/2015	Follow-up from meeting at Seafood Directions. Providing update on surveys.	For information.
Northern Territory Seafood Council	NTSC-3 and attachment B	15/11/2015	Santos email: Request to meet to discuss various issues including proposed seismic survey in NT/P85 permit. Sent information in regards to WA-459-P seismic survey.	Provision of Information.
Northern Prawn Fishery	NPF-8	13/11/2015	[redacted] reply: The times youǿve suggested would be during fishing seasons for the NPF guys. The seasons go from 1 April ï 15 June and 1 August ï 1 December and some of the fleet will start either or both seasons in the JBG and spend a good part of the season there, particularly the first season. Attached is an image with fishing activity in the JBG for 2014, which all occurred south east of the 459 box.	Santos obtaining information to understand timing of NPF and scheduling of Fishburn (WA-459-P) and NT/P85 survey.
Northern Prawn Fishery	NPF-9	13/11/2015	As current non participants in the NT fin fish fishery, I would assume that you are communicating with the Northern Territory Seafood Council on this? I appreciate the information stream but unless we have an interest I will take a back seat on any response. [redacted] will provide the response from the NPF.	Further engagement not required as responses will be provided by NPF
Northern Prawn Fishery	NPF-7	12/11/2015	Email in regards to understanding the restrictions around timing. Santos aiming to commence 459 (Fishburn survey) in the June 15 to July 15 window discussed at our meeting in Perth. Want to understand flexibility around said window, specifically, what are the issues/impacts around both: 1. starting the program earlier (say in May?) 2. if, due to a later start, it goes into August. Why are these periods either side of the window going to have greater impact on your activities?	Santos obtaining information to understand timing of NPF and scheduling of Fishburn (WA-459-P) and NT/P85 survey.
Northern Prawn Fishery	NPF-6	4/11/2015	[redacted] confirms and agrees with [redacted] response to you so wonǿ elaborate further other than to express appreciation for including the coordinates in the docs and to reiterate that the best timing for the surveys is during our closed seasons, preferably in December.	Noted that NPF has two seasons with best time for survey being December. However, this time does not align with other fisheries in the area.
Northern Prawn Fishery	NPF-5	3/11/2015	[redacted] responds to Santos' email, his comments are in red. As mentioned, Santos is now planning for two seismic programs in the Bonaparte Basin next year, one in WA-459-P and the other in NT/P85 ï please see the following attachments to assist with the location of these permits: Â Santos permit map (we took your advice on the latitudes and longitudes!) Thanks this is a great help now and into the future if they could keep doing Â WA-459-P map with coordinates Â NT/P 85 map with coordinates Could you please confirm from our discussion that: Â NT/P85 is not within the Northern Prawn Fishery but it is within the Timor Reef and Demersal fisheries, the period of lowest impact for seismic in this permit area being June, July and August. This area is still within the NPF but we do not work that area. Â WA-459-P is within the NPF and there are two windows when they are not fishing - June 15th to July 15th, and then Dec to February And yes these are the best dates for the for any part of our fishery as we have closures in place for these period and there would be little interacting with the fleet. Our reasons for closures are for breeding cycles so not to sure how it will play out on that.	NT/P85 is within the NPF but is not worked by the NPF. Further data obtained by NPF which shows they have catch effort near to the survey area. See EP Section 5.6.2.1
Northern Prawn Fishery	NPF-4 (attachment A and map in record)	2/11/2015	Follow-up from meeting on 28/10/15 with maps and coordinates of permit and information about seismic survey. Â Santos permit map (we took your advice on the latitudes and longitudes!) Â WA-459-P map with coordinates Â NT/P 85 map with coordinates Could you please confirm from our discussion that: Â NT/P85 is not within the Northern Prawn Fishery but it is within the Timor Reef and Demersal fisheries, the period of lowest impact for seismic in this permit area being June, July and August. Â WA-459-P is within the NPF and there are two windows when they are not fishing - June 15th to July 15th, and then Dec to February.	Provision of information.
Commonwealth Fisheries Association	CFA-4	28/10/2015	Met CEO at Seafood Directions Conference in Perth to introduce ourselves and discuss planned seismic surveys. CEO confirmed CFA was more to do with policy and strategy rather than providing feedback on individual activities. CFA does not send out information to its members or provide members details. Details can	For information.

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			be obtained from AFMA. Ongoing engagement with CFA on broader industry/fisheries issues via APPEA industry/fisheries round table.	
Northern Prawn Fishery	NPF-3 (meeting record form within NPF-3)	27/10/2015	Meeting at Seafood Directions Conference in Perth to introduce Santos and seismic survey in NTP/85 and WA-459-P.	For information.
Amateur Fishermenõs Association of the NT (AFANT)	AFANT-5	12/10/2015	AFANT advises it is comfortable with the proposed survey, please provide more information as it becomes available.	EP Table 4-2 Assessment of Stakeholder updated to include AFANT as a relevant stakeholder. EP Section 4.1 Ongoing consultation updated to include AFANT.
Commonwealth Fisheries Association	CFA-3	24/09/2015	Sent follow-up email to arrange to meet CEO at Seafood Directions In Perth in Oct.	For information.
Amateur Fishermenõs Association of the NT (AFANT)	AFANT-4 and attachment A, B and C	17/09/2015	Email to [redacted] requesting the maps that had been shown at the meeting. [redacted] commented that he had a few questions on the issue this week from his members and wanted to run the issue past our committee.	Maps sent as requested.
Amateur Fishermenõs Association of the NT (AFANT)	AFANT-3	24/08/2015	Met in Darwin in August. No specific concerns with survey. ñMinimal disruption to amateur fisherman as graze edge on north-west block. 4 to 6 weeks [seismic program] is a short timeframe. Their main season is the Dry season, mainly [from end of May]ò	Consultation records AFANT-11 and AFANT-19 confirm June-August would be the time period with the least disruption to recreational fishermen. EP Section 5.6.4. Recreational Activities updated with this information.
Aquarium Fishery	AQ-4	20/08/2015	Phone meeting to discuss NTP/85 seismic survey and to understand what the Aquarium Fishery do and where they operate. Santos provided information as to the survey timing, area and water depths. Fishery provided information that scuba dive to a maximum of 30m. Dive all year round. Go to Evan Shoal, east of Lyndoch Shoals, Blackwood Shoal and Money Shoal in Arafura. Also take fish from Timor Reef Fishery Area. Concerns were impact of seismic to divers in the water, small reef fish and corals and clams. Giant clams (Tridacna maxima and gigas) seen at Evans and Lyndoch shoals. Committed to send information on seismic and site attached fish and any work on clams.	EP Section 5.6.3 NT Managed Fisheries updated to include information in regards to fishery. EP Section 5.5.1 detail that the closest shoal to the operational area is Tassie Shoals (23 km). Areas where the Aquarium Fishery fish are within the AMBA but not the operational or survey area. DMAC12 Safe Diving Distances from Seismic Surveying Operations identifies as minimum safe distance of 10 km. Information was provided to [redacted] on 23/3/2017 in regards to potential impacts to divers in the water, small reef fish and corals and clams.
NT Guided Fishing Association (NTGFA)	NTGFA-3	19/08/2015	Response from [redacted] indicating that he would be away and suggested catching up with AFANT - [redacted] Response to [redacted] that meeting had been arranged with [redacted] for Monday 24/8/15.	Meeting arranged with AFANT (See AFANT-3).
Offshore Net and Line	ONLF-4	11/08/2015	[redacted] replied that though a license holder in the NT is not an active participant in any fisheries in the NT. [redacted] responded that wont bother him with further information about the program.	No further consultation required.
Spanish Mackerel	SMF-4	11/08/2015	[redacted] requested to catch up when in Darwin.	For information
Timor Reef and Demersal Relevant	TRD-3	11/08/2015	Separate emails sent to [redacted] informing them that the Santos proposed seismic program for next year - in petroleum permit NT/P85, in the Bonaparte Basin - has not progressed very far since our discussions in May. Indeed, we have yet to secure a seismic contractor and are unlikely to do so until the last quarter of this year. We will keep you inform on any progress. Santos also included in emails the 14.05.2015 email to [redacted] which summarised the May meeting, and ask "is that a correct summary and have I missed anything?".	Provision of information See NTSC-2 for meeting record and Santos responses. No reply from NTSC in regards to meeting minutes.
Aquarium Fishery	AQ-3	10/08/2015	Santos email: Follow-up on email 5/6/2015. Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Phone meeting held 20/8/2015 (AQ-3).
Commonwealth Fisheries Association	CFA-2	10/08/2015	Santos sent email see if CFA would be at the forthcoming NT Seafood Industry Awards in Darwin or Australian Seafood Industry Awards in Perth, to discuss the seismic survey in NT/P85. Details of the survey location are included in the email.	Provision of information.
NT Guided Fishing Association (NTGFA)	NTGFA-2	10/08/2015	Follow-up email as no response. Initial contact to inform about survey and to arrange to meet when in Darwin in August.	For information - no response.
Offshore Net and Line	ONLF-3	10/08/2015	Follow-up email - Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Request to meet to discuss survey.

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Spanish Mackerel	SMF-3	10/08/2015	Follow-up email - Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Request to meet to discuss survey.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-8	8/08/2015	NTDPIRF email: Advised next Offshore Snapper Fishery Advisory Committee had not been confirmed and he would put seismic issue and industry interaction on the agenda and advise Santos of any outcomes.	Santos was not advised of any outcomes or concerns from the Offshore Snapper Fishery Advisory Committee.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-7 (no record of meeting summary)	7/08/2015	Meeting: Meeting held in Darwin with [redacted] A meeting summary was not taken. Aim of meeting was to discuss Santos plans for the Bethany seismic survey, introduce the Santos Offshore Environment Manager, Public Affairs Manager and Offshore Exploration Manager, and gain an understanding of the NT fisheries activities in the survey area.	For information.
Northern Prawn Fishery	NPF-2	4/08/2015	Initial contact to inform about survey and to arrange to meet when in Darwin in August.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-6	3/07/2015	Santos letter: Letter in response to NTDPIRF letter (5/6/2015) and Santos email (16/6/15). Informs NTDPIRF that Santos has commenced engagement with individual fishers to identify any issues they may have in regards to the proposed survey. Request to share data in relation to the observation that Commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic exploration activity. Santos interested to obtain catch data or similar for past 20 years to allow identification of any long term impacts from previous seismic surveys undertaken in the area (last to our knowledge was 2006/2007) and help establish a baseline. The need for adequately funded, target research to examine the impact of noise on tropical fish. A significant amount of research has already been undertaken on the impact of seismic on marine life including tropical fish species showing little or no impact, so hoping you might be able to suggest what form of targeted research you had in mind.	Santos has requested (NTDPIRF-5, NTDPIRF-6, NTDPIRF-18) data from NTDPIRF to be able to identify and assess short and long-term cumulative effects of seismic surveys on fish stocks. NTDPIRF sent fish catch data 20/1/2017 (NTDPIRF-23). Santos has asked (NTDPIRF-5, NTDPIRF-6) if NTDPIRF had any thoughts on what ongoing monitoring and targeted research would entail.
Australian Fisheries Management Authority (AFMA)	AFMA-2	25/06/2015	Summary of meeting with AFMA on Thursday 25 June 2015. Discussion points as to information about the following fisheries. - NT/P85 Seismic Survey Specific Information - Western Skipjack Tuna - Northern Prawn Fishery - Western Tuna and Billfish	Information obtained from AFMA was used to further identified potential commercial fisheries in the survey area.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-3	25/06/2015	Santos email: Follow-up to NTDPIRF in regards to providing seasonality and the relative importance of area to the fisheries. Enquiry as to any tourist/fishing business operating at this distance (120km from shore). Asking to confirm if Arafura Bluewater Charters operate in area.	Letter received from NTDPIRF (NTDPIRF-4) providing seasonality and relative importance of area to the fisheries
Australian Fisheries Management Authority (AFMA)	AFMA - 1 Attachment A & B	23/06/2015	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.	Request for information Commonwealth fisheries within survey area.
Amateur Fishermenȃs Association of the NT (AFANT)	AFANT-1	18/06/2015	[redacted] (Insight Fly Fishing) passed on email from Santos to AFANT [redacted] Executive Officer, Amateur Fishermen's Association NT. AFANT is the peak representative body for the Northern Territories 32,000 recreational fishermen and we would very much like to discuss this project with you as it has the potential to have significant impacts on recreational fishing. Please forward me the maps of the proposed survey area.	Maps of proposed survey area sent (AFANT-2). Consultation undertaken to further understand the potential of the survey to have significant impacts on recreational fishing. From further consultation it was identified that survey would have minimal disruption to amateur fishers (AFANT-3)
Amateur Fishermenȃs Association of the NT (AFANT)	AFANT-2 and attachment A and B	18/06/2015	Sent map as per email request from [redacted]	Provision of information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-5	16/06/2015	Santos email: In response to NTDPIF letter (5/6/2015) requesting more information in regards to: If NTDPIRF could share data in relation to the observation that Commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic exploration activity. If NTDPIRF had any thoughts on what ongoing monitoring and targeted research would entail.	No response - request for data and thoughts on ongoing monitoring and targeted research followed-up on 3/7/15 (NTDPIRF-6).
NT Guided Fishing	NTGFA-1	9/06/2015	Initial contact to inform about survey and to arrange to meet when in Darwin in August. [redacted] passed on email to [redacted] Executive Officer, Amateur Fishermen's Association NT.	For information.

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Association (NTGFA)				
Aquarium Fishery	AQ-2 and attachment A	5/06/2015	Santos email: Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Phone meeting held 20/8/2015 (AQ-3).
Northern Prawn Fishery	NPF-1	5/06/2015	Santos email: Initial contact to inform about survey and to arrange to meet when in Darwin in August.	For information.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-4	5/06/2015	NTDPIRF letter: 1. The Timor Reef, Demersal, Spanish mackerel and Offshore Net and Line fisheries all actively utilise the proposed survey area. 2. Commercial experience has shown that viable catch levels from these fisheries only occur in a few geographical areas (including the survey areas depicted in the Santos proposal). 3. There are also guided fishing activities undertaken by Fishing Tour Operators in this area which could also be potentially affected. 4. As you may be aware past seismic surveys have been reported by the commercial fishing industry to affect the catchability of offshore demersal fish for significant periods of time. 5. Therefore there is a potential risk to the fishery, particularly if conducted during the peak spawning time of October to May. 6. Graph of TRF catch by month shows the period of late June to mid-August is the usually the period of least activity. It is suggested you try and target the survey to this period, but I also suggest you confirm with industry regarding the timing. 7. The actual effects of 3D seismic surveys on the catchability of demersal fish species are poorly understood. Commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic exploration activity. These observations suggest the ongoing need for monitoring to determine if an adverse reaction to noise and vibrations is experienced by tropical snappers, cods emperor and prey species which may reduce the productivity of the commercial fisheries in the area. 8. The aquatic resources of Territory waters are not homogenously distributed and any commercial operator displaced from an area undergoing and recovering from the impacts of seismic survey work may not have the ability to transfer effort to an equivalently productive, or an economically similar, fishing area. 9. There is therefore potential for the proposed actions by Santos in the Commonwealth Marine Environment to produce a significant adverse impact on the fishery in both the short and long term and I would encourage you to consider this information critically in your decision-making processes. 10. Further, as this is a question which arises regularly it is considered that an adequately funded, targeted research project, which examined the impact of noise on tropical fisheries, would best inform future decision making. To this end I encourage your company to consider initiating work on determining the effects of seismic surveys on catchability of tropical snappers and emperors. Noting direct effects on prey species, spawning, recruitment and long-term ecosystem impacts are also poorly understood. 11. As the NT has responsibility for the management of all fish and other aquatic life resources in waters relevant to the NT (including the adjacent areas), there is concern that there is an increasing number of similar surveys by exploration companies in surrounding areas when the full effects of previous seismic surveys on the sustainability of fish stocks have not been determined.	In addition to the below, need to address that you have considered the information as critical (their point 9) and also how you have responses re the research project (their point 10)1. Timor Reef, Demersal, Spanish mackerel and Offshore Net and Line fisheries included as relevant stakeholder (EP Table 4-2). See stakeholder engagement records. Letter (NTDPIRF-6) informs NTDPIRF that Santos has commenced engagement with individual fishers to identify any issues they may have in regards to the proposed survey. 2. There is limited (one report for TRF from 2009) public information in relation to georeferenced catch data to be able to identify these geographical areas with viable catch levels. Ongoing consultation with the Department and relevant fishers (TRF and Demersal) had not been able to validate where these geographical areas with viable catch levels are. Data was received from the NTDPIRF on 18/5/17 (see NTDPIRF-49). 3. Consultation with NTDPIRF (NTDPIRF-1) and AFANT only identified Arafura Bluewater Charters as fishing tour operator likely near the survey area. Arafura Bluewater Charters ([redacted] included as relevant stakeholder (EP Table 4-2). See Stakeholder Records for Arafura Bluewater Charters (AFA). 4. Email sent to NTDPIRF (NTDPIRF-5, NTDPIRF-6, NTDPIRF-34) asking if NTDPIRF could share data in relation to the observation that commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic exploration activity. No data or information to support seismic activity impact catchability of offshore demersal fish for a significant time has been made available. 5. Survey planned to be undertaken between July to end Sept (EP window is broader (May to end Sept) to avoid peak spawning period. 6. Survey planned to be undertaken between July to end Sept (EP window is broader (May to end Sept) to coincide with period of least activity based on information provided by NTDPIRF (NTDPIRF-4, NTDPIRF-16). Ongoing consultation with fishers have not been able to confirm if there is a period of least activity. 7. Email sent to NTDPIRF (NTDPIRF-5, NTDPIRF-6) asking if NTDPIRF could share data in relation to the observation that Commercial fishers have indicated that catch rates appear to remain depressed for months after 3D seismic exploration activity. To date no data has been provided by NTDPIRF or the fishers to support these observations. 8. There is limited (one report for TRF from 2009) public information in relation to georeferenced catch data to be able to identify these geographical areas with viable catch levels. Ongoing consultation with the Department and relevant fishers (TRF and Demersal) had not been able to validate where these geographical areas with viable catch levels are. Data was received from the NTDPIRF on 18/5/17 (see NTDPIRF-49). 9. Santos has considered the concerns from the NTDPIRF and fishers that seismic surveys have the potential to have a significant impact on the fishery in both the short and long term. EP Section 7.1.6 assesses the potential impacts and risk of seismic noise all receptors within the Commonwealth Marine Environment, including fish and catch rates. To date no data has been provided by the NTDPIRF or fishers to show that there has been a significant impact to the fishery from previous seismic surveys. 10. Emails sent to NTDPIRF (NTDPIRF-5, NTDPIRF-6) asking if NTDPIRF had any thoughts on what ongoing monitoring and targeted research would entail. Santos and NTDPIRF have had ongoing discussions in regard to research (NTDPIRF-41, NTDPIRF-42, NTDPIRF-43, NTDPIRF-44) and agreed this was a broader industry issue requiring collaborative arrangements. Santos would keep the NTDPIRF up to date of upcoming research opportunities being coordinated by

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
				the APPEA Marine Environmental Science Program (MESP) via the Bonaparte Fishing Group. 11. EP Section 7.1.11 Seismic Noise Cumulative Impacts assesses cumulative impacts from previous and planned seismic surveys within the area of the Bethany survey. As per dot point 4 Santos has requested if the Dept. could share data in relation seismic survey impacts on catch rates.
Offshore Net and Line	ONLF-2	5/06/2015	Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Request to meet to discuss survey.
Spanish Mackerel	SMF-2	5/06/2015	Initial contact to inform about survey and to arrange to meet when in Darwin in August.	Request to meet to discuss survey.
Northern Territory Seafood Council	NTSC-2	15/05/2015	NTSC email: Confirmed was an individual from Demersal fishery that did not want to engage. Provided contact details for Aquarium Fishery, Spanish Mackerel Fishery and Offshore Net and Line Fishery. Mentioned research opportunities with the Aquarium Fishery in regards to mapping coral reef beds.	Aquarium, Spanish mackerel and Offshore Net and Line fisheries included as relevant stakeholder (EP Table 4-2). See stakeholder engagement records.
Northern Territory Seafood Council	NTSC-2	14/05/2015	Santos email: Follow-up email after meeting to confirm key points discussed: The purpose of this email is to confirm the key points discussed, and to get contact addresses for [redacted] and [redacted] so as to continue discussions with them directly, as you recommended. Please let me know if I have misinterpreted any of the points below. 1. An overarching agreement should be struck with the individual fishermen ([redacted] as Santos had previously done, covering management of issues/relationship (I am checking with [redacted] to obtain previous example) 2. The NT Seafood Council/[redacted] want to see the science around fish movements, particularly on why there isn't the risk of "boxing in" the fish 3. The NT Seafood Council/[redacted] would welcome support (investment) in research opportunities like genetic testing 4. September to May is the sensitive time for fishing and seismic during this period should be avoided 5. The NT Seafood Council/[redacted] will need access to timely operational information – Santos needs to provide contacts on logistics, how information will be communicated etc. 6. Commercial opportunities were discussed with the fishers and Santos provide details of seismic contractor to discuss use of fishing vessel for support vessels (See to provide support for the seismic program (engage directly with individual fishermen) 7. The NT Seafood Council/[redacted] would welcome support for the NT Seafood Council where we can (as mentioned, Santos is sponsoring an award at this year's gala dinner and, through its partner, GDF SUEZ, has supported the two previous awards' nights). Is that a correct summary and have I missed anything? Finally, I am also keen to get the contact names and details of the representatives of fisheries that weren't at last week's meeting, specifically: • Aquarium Fishery • Spanish Mackerel Fishery • Offshore Net and Line Fishery [redacted] mentioned one fishery was not interested in engaging with Santos, which is fine. I just need to test that directly (at some point, the regulator will want to see that we have made a real effort to engage). Are there any other relevant fisheries I need to liaise with? Please let me know if I have missed anything and I look forward to hearing from you soon.	Confirmation on meeting notes was not received from NTSC. 1. Santos and the TRD fisheries are in the process of negotiating an agreement to ensure the TRD fisheries are no better or worse off as a result of the survey. If no agreement is able to be finalised, Santos proposes to make payments to the commercial fishing operators in any event, as per Table 7-13 (loss of catch payment) and 7-21 (relocation expenses payment). Santos has engaged an independent expert to review the payment model as set out in Table 7-13 and 7-21, the expert's preliminary view is that the payment models are industry standard and reasonable, and based on information which is feasible to obtain. 2. EP Section 7.1.5.3 Fish assessing impacts from seismic noise to fish including catch rates. Impacts and risk were assessed as acceptable and ALARP. 3. Discussion with fishers undertaken on research (TRD-13) which recognised needs an industry co-investment solution. 4. Survey planned to be undertaken between July to end Sept (EP window is broader May to end Sept) based on this information. 5. During the survey Santos will implement a daily communication process with relevant stakeholders. This is detailed in EP Table7-21 and in EP Section 4.1 Ongoing Consultation. 6. Santos provided information to the TRD in regards to using fishing vessels as support vessels. (TRD-18 and TRD-19) 7.Santos has sponsored the NTSC Fish and Chip award for 2015, 2016 and 2017.
Timor Reef and Demersal Relevant	TRD-2	14/05/2015	Email from Santos to NTSC Chairman [redacted] containing summary of key points from Darwin meeting from 08.05.2015 (as described above) and seeking [redacted] advice as to whether a correct summary or if anything missing.	See NTSC-2 for meeting record and Santos responses. No reply from NTSC in regards to meeting minutes.
Commonwealth Fisheries Association	CFA-1	12/05/2015	Sent introductory email to new CEO to initiate catch-up in Melbourne.	For information.

Stakeholder	Record # relating to document (doc #)	Date	Summary of Consultation/Response	Assessment of Merit of Feedback/Actions (Where not incorporated in the Summary)
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-2	8/05/2015	NTDPIRF email: Confirming that fishing activity in the permit area is lowest in June/ July. Also avoids potentially impacting on spawning aggregations.	Survey timing planned to overlap with period of lowest activity June/July and spawning period.
Timor Reef and Demersal Relevant	TRD - 1 Meeting record NTSC-2	8/05/2015	Meeting in Darwin with Timor Reef & Demersal Chairman, [redacted] Timor Reef Vice Chairman [redacted] Demersal Vice Chairman [redacted] and NTSC Chairman [redacted] where proposed survey over NT/P85 was discussed. Discussion points included their desire for agreement to be struck with individual fishermen to cover issues with each fisher, desire to see science around fish movements, desire to see more research like genetic testing, advice that September to May is the sensitive time for fishing and seismic during this period should be avoided, desire for timely operational information, desire for commercial opportunities to support seismic survey and desire to support NTSC.	See NTSC-2 for meeting record and Santos responses.
NT Department of Primary Industry and Resources - Fisheries	NTDPIRF-1	7/05/2015	Meeting: Met to discuss seismic survey and to identify who fishes in the area. Santos to provide coordinates of the permit to the Dept. The Dept. will respond with seasonality and relative importance of the area to the fishery. Dept. also flagged that there was one tourist/fishing operator at these distances from shore - Arafura Bluewater Charters ([redacted] - and they would investigate whether this business runs charters across the permit area. Santos email (8.5.15): sent meeting notes and NTP/85 permit coordinates. NTDPIRF email (8.5.15): requested GIS shapefile of permit area. Santos email (11.5.15): sent GIS shapefile of permit area.	Arafura Bluewater Charters ([redacted] included as a relevant stakeholder (EP Table 4-2). See Stakeholder Records for Arafura Bluewater Charters (AFA). Santos sent NTDPIRF map of permit with coordinates and GIS shapefile.
Spanish Mackerel	SMF-1	1/05/2015	Email from NTSC CEO to fishers to arrange meeting with [redacted] to discuss NT/P85 seismic survey.	Request to meet to discuss survey.
Aquarium Fishery	AQ-1	30/04/2015	Email from NTSC CEO to fishers including Aquarium Fishery to arrange meeting with Santos to discuss NT/P85 seismic survey.	Aquarium Fishery CEO could not attend meeting. Phone meeting held 20/8/2015 (AQ-3).
Northern Territory Seafood Council	NTSC-1 (map included in record)	30/04/2015	NTSC Email: To Timor Reef and Demersal fishers to arrange meeting with Santos to discuss NT/P85 seismic survey.	Meeting held with Timor Reef & Demersal Chairman, [redacted] Timor Reef Vice Chairman [redacted] Demersal Vice Chairman [redacted] and NTSC Chairman [redacted] 8/5/15 (TRD-1)
Offshore Net and Line	ONLF-1	30/04/2015	Email from NTSC CEO to fishers to arrange meeting with Santos to discuss NT/P85 seismic survey.	Request to meet to discuss survey.
Northern Territory Seafood Council	NTSC-1 (map included in record)	23/04/2015	NTSC Email: To advise that Demersal, Timor Reef, Aquarium, Spanish Mackerel and Offshore Net and Line fisheries access the NT/P85 area, and recommending we meet Timor Reef & Demersal Chairman, [redacted] Timor Reef Vice Chairman [redacted] and Demersal Vice Chairman [redacted]	Demersal, Timor Reef, Aquarium, Spanish Mackerel and Offshore Net and Line fisheries included as relevant stakeholder (EP Table 4-2). See stakeholder engagement records. Meeting held with Timor Reef & Demersal Chairman, [redacted] Timor Reef Vice Chairman [redacted] Demersal Vice Chairman [redacted] and NTSC Chairman [redacted] 8/5/15 (TRD-1)

Appendix 3: JASCO Acoustic Modelling Report

Bethany 3-D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

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Disclaimer:

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

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Contents

Figures

Tables

Executive Summary

Sound models were used to assess underwater noise levels during the proposed Bethany 3-D Marine Seismic Survey (MSS) by Santos Offshore Limited. The modelling approach considered source directivity and range-dependent environmental properties in the area, and accounted for the acoustic emission characteristics of a 2380 in^3 seismic airgun array, a surrogate for the maximum airgun array size considered for operation during the survey. These results are required to assess effects of noise exposure on marine mammals, fish, turtles, and plankton in and around the proposed survey acquisition area. Sound levels due to pressure are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL).

The modelling study for the Bethany 3-D MSS assessed

- Four single-impulse sites for water column SPL, PK, PK-PK, and per-pulse SEL;
- Five single-impulse sites for seafloor PK, PK-PK and seafloor per-pulse SEL; and
- One scenario for accumulated SEL over 24 hours (SEL_{24h}).

The analysis considered several effects criteria, the results which are summarised below for the representative single-impulse sites and accumulated SEL scenarios:

Mammals

- EPBC Act Policy Statement 2.1 (DEWHA 2008): Airgun sounds exceeded the unweighted per-pulse SEL criterion for the 1 km low-power zone of 160 dB re 1 µPa^2·s within 2.24 to 3.01 km of the airgun array ($R_{95\%}$ distances, Sites 2 and 3).
- United States National Marine Fisheries Service (NMFS 2013) acoustic threshold for behavioural effects in cetaceans: Airgun sounds exceeded the SPL threshold of 160 dB re 1 µPa for behavioural effects on marine mammals within 4.68 to 7.24 km of the airgun array (R_{max} distances, Sites 2 and 4).
- NMFS (2016) marine mammal injury criteria: The results considered both metrics within the criteria for Permanent Threshold Shift (PTS; PK and SEL_{24h}). The farthest distance associated with either metric is required to be applied. The maximum distances along with the relevant metric and the location of the results are summarised in Table 1.

Table 1. Summary of permanent threshold shift (PTS) onset distances for marine mammals.

Relevant hearing group	Metric for PTS onset	Distance R_{max} (km)
Low-frequency cetaceans	SEL_{24h}	2.4
Mid-frequency cetaceans	PK	<0.02
High-frequency cetaceans	PK	0.29

Turtle Behaviour

- United States NMFS criterion for behavioural effects in turtles: Airgun sounds exceeded the 166 dB re 1 µPa (SPL) threshold for behavioural effects within 3 to 4.5 km of the airgun array (R_{max} distances, Sites 2 and 3).

Fish, Turtle Injury, Fish Eggs, and Fish Larvae

The distance to PK levels relevant to fish at the seafloor is site specific, with no consistent pattern between site depth and distance to isopleth. Considering both per-pulse modelling sites and the associated SEL_{24h} scenario:

- Sound levels associated with either a) mortality and potential mortal injury or b) recoverable injury to fish, based on Popper et al. (2014) using the SEL_{24h} metric, are predicted to occur at ranges shorter than those predicted using the PK metric. In line with the conditions of the criteria, the PK metric therefore should be used to assess these impacts.

- Similarly, for turtles, fish eggs, and fish larvae and sound levels associated with either mortality or potential mortal injury, the PK metric should also be used to assess potential impacts.
- Therefore, applying the Popper et al. (2014) criteria:
  - For mortality and potential mortal injury or recoverable injury, the relevant sound level for the most sensitive fish groups is 207 dB re 1 µPa PK, and the associated maximum distance is 165 m (65 m depth).
    - This sound level and distance are also associated in the criteria with mortality and potential mortal injury to turtles, fish eggs, and fish larvae.
  - The relevant sound level for the least sensitive fish group (fishes without a swim bladder, sharks), is 213 dB re 1 µPa PK, and the associated maximum distance is 72 m (35 m depth).
- Considering the defined 24 h period of exposure, fish (including sharks) could experience temporary threshold shift (TTS) from the proposed seismic survey. It is predicted that this will occur within 3.4 km of the airgun array, considering the maximum from either the seafloor or maximum-over-depth ranges.

Plankton

- For comparison to the level reported in McCauley et al. (2017) for potential effects on plankton, the distance to 178 dB re 1 µPa PK-PK in the water column was assessed. The range to this sound level is predicted to be a maximum of 6.2 km.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the Bethany 3-D Marine Seismic Survey (MSS) proposed by Santos Offshore Limited (Santos). The acoustic modelling was commissioned to help assess any possible effects of sounds from the proposed seismic survey on marine fauna. Modelled sound levels are for a 2380 in^3 airgun array towed at 6.0 m depth. The report presents metrics to assess sound exposure effects primarily on cetaceans, turtles and fish, but also includes metrics for plankton.

JASCO's specialised Airgun Array Source Model (AASM), predicted the underwater acoustic signature of the array. AASM accounts for individual airgun volumes and array geometry. Complementary underwater acoustic propagation models were used in conjunction with the modelled array signature to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at defined locations, and accumulated sound exposure fields were predicted for one likely scenario of survey operations over 24 h. A conservative sound speed profile that is most supportive of sound propagation conditions for the period of the survey was defined, and applied at each of the modelling locations. The modelling methodology (Section 3) considered source directivity and range-dependent environmental properties in each of the areas assessed.

Sound levels due to pressure are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK), and either single-impulse (i.e., per-pulse) (Section 4.2) or accumulated sound exposure levels (SEL) (Section 4.3) as appropriate.

JASCO defined the general locations of the modelling sites in consultation with Santos, who also specified the acquisition pattern and the planned tow direction for the survey. Table 2 lists the site-specific site locations, which are also shown in Figure 1. An additional five sites, Sites A through E, with depths from 35–75 m, were assessed for seafloor PK, PK-PK and per-pulse SEL, these are also listed in Table 2. These Sites do not have a specific location, but rather are representative of a specific water depth, as the geoacoustic and sound speed profiles are consistent across the survey region.

Table 2. Location details for the site-specific modelled sites.

Site	Latitude	Longitude	UTM (WGS84) Zone 52 S		Water depth (m)	Representative tow direction
			X (m)	*Y* (m)		
1	10° 53' 58.9419" S	128° 42' 52.2412" E	468801.5	8795095	40.9	56.9°
2	10° 48' 13.5824" S	128° 56' 17.3804" E	493240.1	8805717	84	236.9°
3	10° 45' 05.5799" S	128° 56' 36.9464" E	493833.1	8811491	60.5	56.9°
4	10° 35' 21.1436" S	129° 59' 15.7382" E	608052.4	8829270	43.9	241.2°
A	Not applicable, not site specific				35	Not relevant
B					45	
C					55	
D					65	
E					75	

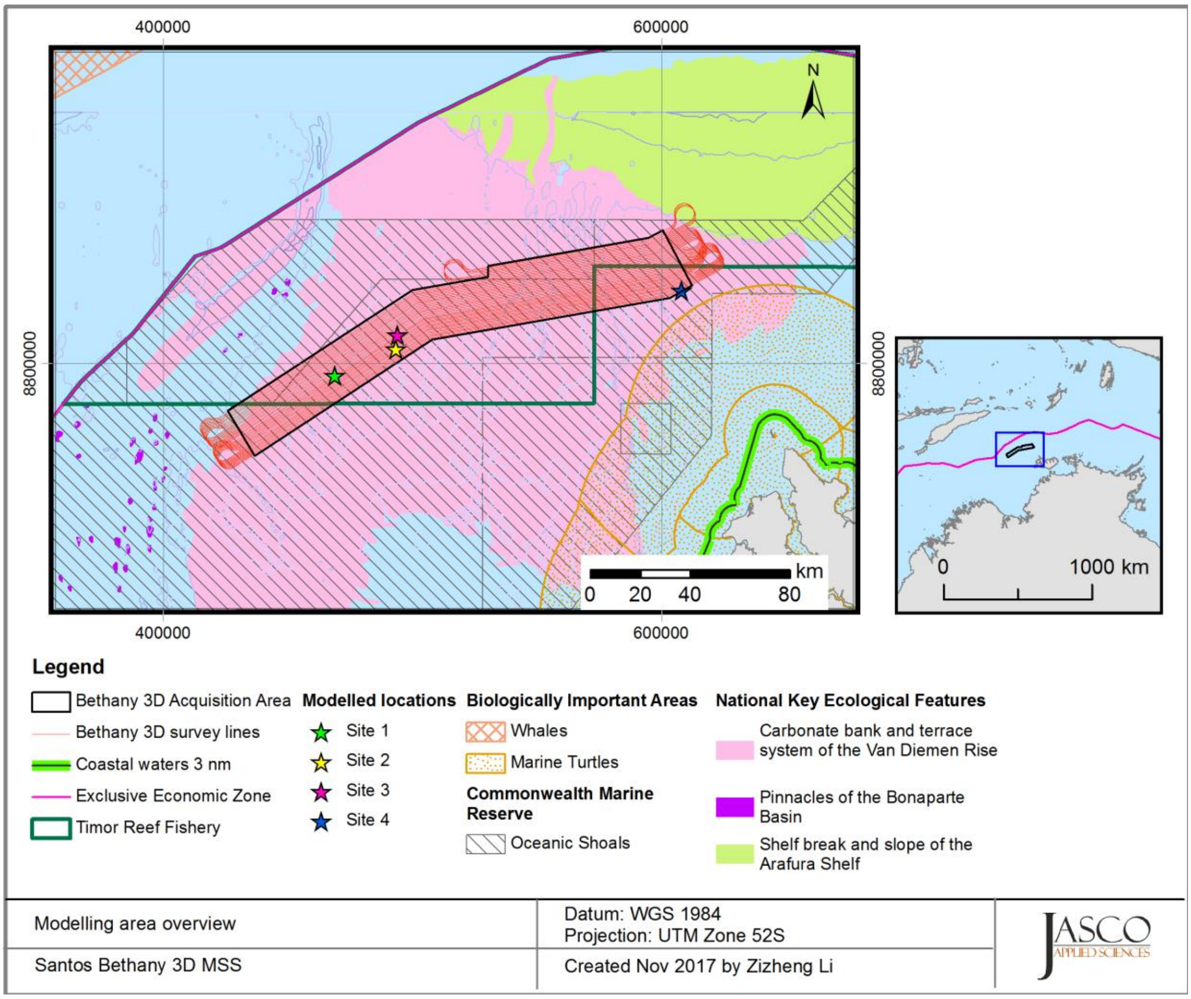

Figure 1. Modelling site locations and features for the Bethany 3-D MSS acoustic modelling.

2. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a “per pulse” assessment or over 24 h. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI-ASA S1.1 (R2013) and ISO/DIS 18405.2:2017 (2016).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have investigated an SEL-based assessment approach for injury, with a handful of key papers published on the topic. The number of studies that investigated the level of disturbance to marine animals by underwater noise has also increased substantially.

We chose the following noise criteria for this study because they include standard thresholds and thresholds suggested by the best available science (Sections 2.1–2.2 and Appendix A):

1. Single-impulse threshold for cetaceans (unweighted per-pulse SEL of 160 dB re 1 µPa^2·s) outlined in the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008).
2. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2016) for the onset of Permanent Threshold Shift (PTS) in marine mammals.
3. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) criterion (NMFS 2013) for marine mammals of 160 dB re 1 µPa SPL for impulsive sound sources.
4. Sound exposure guidelines for fish, fish eggs and larvae, and turtles (Popper et al. 2014).
5. Threshold for turtle behavioural response (NSF 2011), 166 dB re 1 µPa (SPL), applied by the U.S. NMFS.
6. 178 dB re 1 µPa PK-PK in the water column, reported for comparison to McCauley et al. (2017) and potential effects on plankton.

2.1. Marine Mammals

The criteria applied in this study to assess possible effects of airgun noise on marine mammals are summarised in Table 3 and detailed in Sections 2.1.1 and 2.1.2, with frequency weighting explained in Appendix A.3.

Table 3. The unweighted per-pulse SPL, SEL, SEL_{24h} and PK thresholds for acoustic effects on marine mammals.

Hearing group	DEWHA (2008)	NMFS (2013)	NMFS (2016)			
	Unweighted per-pulse SEL (dB re 1 µPa²·s)	Behaviour	Injury (PTS)		(TTS)	
		SPL (dB re 1 µPa)	Weighted SEL_{24h} (dB re 1 µPa²·s)	PK (dB re 1 µPa)	Weighted SEL_{24h} (dB re 1 µPa²·s)	PK (dB re 1 µPa)
Low-frequency cetaceans	160	160	183	219	168	213
Mid-frequency cetaceans			185	230	170	224
High-frequency cetaceans			155	202	140	196

2.1.1. Behavioural response

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds. They found that most marine mammals exhibited varying responses between 140 and 180 dB re 1 µPa SPL, but inconsistent results between studies makes choosing a single behavioural threshold difficult. Studies varied in their lack of control groups, imprecise measurements, inconsistent metrics, and that animal responses depended on study context, which included the animal's activity state. To create meaningful quantitative data from the collected information, Southall et al. (2007) proposed a severity scale that increased with increasing sound levels.

NMFS has historically used a relatively simple sound level criterion for potentially disturbing a marine mammal. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for cetaceans (NMFS 2013). This threshold has been applied for this report.

2.1.2. Injury and hearing sensitivity changes

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

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). The Policy Statement states that the application of this threshold minimises the likelihood of TTS in mysticetes and large odontocetes. The Policy Statement does not apply to smaller dolphins and porpoises as DEWHA assessed these cetaceans as having peak hearing sensitivities at higher frequency ranges than those that seismic arrays typically produce.

To assist in assessing the potential for injuries to marine mammals in addition to the application of EPBC Act Policy Statement 2.1, this report applies the criteria recommended by NMFS (2016) as outlined in Appendix A.2, considering both PTS and TTS.

2.2. Fish, Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a NOAA panel two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

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

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. These effects are not assessed in this report. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

Table 4 lists relevant effects thresholds from Popper et al. (2014). In general, any adverse effects of seismic sound on fish behaviour depends on the species, the state of the individual exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a single-impulse of a maximum received level of either 231 dB re 1 μPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. This is done for marine mammals in the Southall et al. (2007) criteria, where it is 24 h or the duration of the activity, whichever longer. Popper et al. (2014) recommend a standard period should be applied, where this is either defined as a justified fixed period or the duration of the activity; however, the publication also includes caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. In the discussion of the criteria, Popper et al. (2014) discuss the complications in determining a relevant period of mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source, and that in reality a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be near a sound source (i.e., overlap in space and time between the source and receiver). For example, the accumulation time for fast moving (relative to the receiver) mobile sound sources is driven primarily by the characteristics of source (i.e., speed, duty cycle) (NMFS 2016).

Guidelines for TTS in Popper et al. (2014) are based upon data from Popper et al. (2005) for exposure of several riverine species to a seismic airgun array. In all cases, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 h has been applied in this study for SEL, which is similar to that applied for marine mammals in Southall et al. (2007) and NMFS (2016).

Table 4. Criteria for seismic noise exposure for fish and turtles, adapted from Popper et al. (2014).

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

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

2.2.1. Turtle behavioural response

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. McCauley et al. (2000) observed the behavioural response of caged turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural disturbance response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011). At that time, and in the absence of any data from which to determine the sound levels that could injure an animal, TTS or PTS onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011). Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa^2·s (SEL_{24h}) (Table 4). Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of meters) from the airgun. Both the NMFS criteria for behavioural disturbance (SPL of 166 dB re 1 µPa) and the Popper et al. (2014) injury criteria were included in this analysis, although the analysis did not consider the ranges at which an animal could suffer impairment, as defined by Popper et al. (2014).

3. Methods

This section details the methodology for predicting the source levels, modelling the sound propagation, and assessing distances to the selected impact criteria.

3.1. Acoustic Source Model

The source levels and directivity of the airgun array were predicted with JASCO's AASM, which considers:

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

Details of the model are described in Appendix B, and the array was modelled over AASM's full frequency range, up to 25 kHz.

3.2. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the airgun array for frequencies of 5 Hz to 25 kHz:

- Combined range-dependent parabolic equation JASCO's Marine Operations Noise Model (MONM), and Gaussian beam acoustic ray-trace model (BELLHOP)(MONM-BELLHOP).
- Full Waveform Range-dependent Acoustic Model (FWRAM).
- Wavenumber integration model (VSTACK).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK and PK-PK. Appendix C details each model.

3.3. Parameter Overview

The specifications of the airgun array source modelled at all sites and the environmental parameters used in the propagation models, such as bathymetry, sound speed profile and geoacoustics, are described in detail in Appendix D.

The airgun array under consideration for the proposed Bethany 3-D MSS is a 11.2 × 15 m 2380 in^3 seismic array consisting of three strings towed at a 6 m depth (Figure D-4, Table D-2). The firing pressure will be 2000 psi. As described in Section 3.4.2, the modelling is based on 12.5 m shot point interval (based on triple source mode), and a 600 m line space interval.

A single sound speed profile that provided the greatest propagation is applied, which occurs during July.

3.4. Accumulated SEL

3.4.1. Method overview

During a seismic survey, a new portion of sound energy is introduced into the environment with each pulse from the airgun array. While some impact criteria are based on per-pulse energy released, others, such as the marine mammal and fish SEL criteria used in this report (Sections 2.1 and 2.2) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 h. An accurate assessment of the cumulative acoustic field depends not only on the parameters of each impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses.

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

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

3.4.2. Scenario definition

The assessment has considered a single 24 h period of seismic operation, along two sequential lines in the acquisition pattern to assess a conservative scenario in terms of 24 h SEL. The two sequential acquisition line sections assessed are 85 and 84.9 km long, and 4.5 km apart. The seismic vessel is assumed to start at the eastern end of the northern line, and traverse the survey lines at ~4.5 knots, with an impulse interval of 12.5 m. The survey has been modelled considering a triple source array, with a source separation of 37.5 m, with each being source is activated individually according to a set sequence. The modelling accounts for the location of the active source for each seismic impulse. In total, 13592 impulses are accounted for in the scenario.

Because modelling the thousands of impulses needed to represent 24 h of seismic operation is time consuming, we estimated the acoustic fields based on single-impulse model sites from representative source locations which formed the library of representative footprints. As the geoacoustics are the same throughout the region, only the bathymetry needs to be considered when determining the location of the representative source locations. An analysis of the bathymetry along the acquisition lines in the modelled scenario determined that consideration of three representative sites would provide a sufficient representation. The three single-impulse sites selected encompass the shallower flatter sections of the lines (Site 1), the shallower sections of the canyon features (Site 2), and the bottom of the canyon features (Site 3). The survey lines within the 24 h exposure calculation were segmented by classifying impulse points to one of the three representative sites based on geographic similarity (Figure 2).

To produce maps of cumulative received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level and level at the seafloor are calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse are then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 50 m. The contours and threshold ranges are calculated from these flat Cartesian projections of the modelled acoustic fields.

The single-impulse SEL fields are computed over model grids ~150 km × 150 km in range, which encompass the full area of the cumulative grid (the entire survey area). The unweighted (fish) and frequency-weighted SEL_{24h} results are rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the airgun array are rendered.

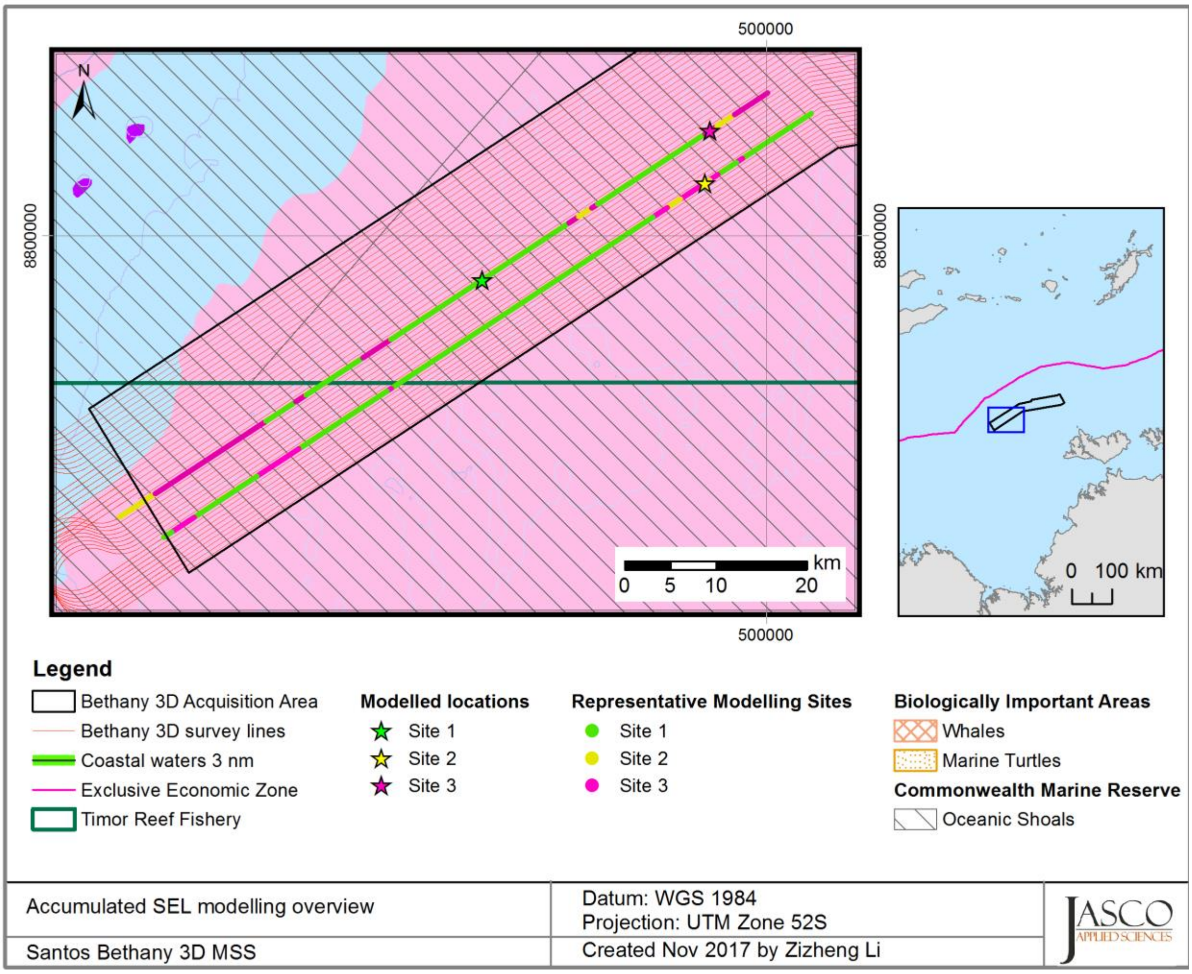

Figure 2. Acquisition lines considered for SEL_{24h} calculations. The representative sites are colour-coded to indicate the model scenario classification scheme used to define the noise footprint for each airgun impulse point.

3.5. Geometry and Modelled Regions

Using MONM, the sound field is modelled up to distances of 100 km from the source, with a horizontal separation of 40 m between receiver points along the modelled radials. Sound fields are modelled with a horizontal angular resolution of $\Delta\theta = 2.5°$ for a total of $N = 144$ radial planes. Receiver depths are chosen to span the entire water column over the modelled areas, from 1 m to 600 m, with step sizes that increase with depth. To supplement the MONM results, high-frequency results for propagation loss are modelled using Bellhop for frequencies from 1 to 25 kHz. The MONM and Bellhop results are combined to produce results for the full frequency range of interest.

FWRAM transects out to 140 km with a horizontal range step of 40 m from McPherson and Li (2017) are used, and supplemented with additional higher resolution runs out to 20 km considering the 2380 in^3 source with a frequency dependent horizontal range step applied. This ranges from 50 m at lower frequencies to 10 m above 800 Hz. These additional transects are completed along only four radials (broadside and endfire directions) for computational efficiency, from 10 Hz to 1 kHz in 0.5 Hz steps. This is done to compute SEL-to-SPL conversions (Appendix D.2).

VSTACK is used to model PK, PK-PK, and per-pulse SEL at the seafloor. The maximum modelled range for VSTACK is 1000 m. Because VSTACK assumes constant bathymetry, radials are only run in four directions (fore and aft endfire, port and starboard broadside). Received levels were computed for receivers at seafloor.

4. Results

This section presents the model results in formats that include tables of maximum (R_{max}) and 95% ($R_{95\%}$) distances to sound level thresholds and sound field contour maps, which show predicted sound levels at the sites and the various sound level threshold contours.

4.1. Acoustic Source Levels and Directivity

The pressure signatures of the individual airguns and the composite 1/3-octave-band point source equivalent directional levels of the array were modelled with AASM (Section 3.1). Although AASM accounts for notional pressure signatures of each airgun array with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

The horizontal and vertical overpressure signatures and corresponding power spectrum levels, along with the horizontal directivity plots for the 2380 in^3 airgun array, are provided in Appendix B.2.

Table 5 shows the PK and per-pulse SEL source levels for the airgun array in the endfire, broadside, and vertical directions. The vertical source level that accounts for the surface ghost is also presented to make it easier to compare the output of other airgun array source models.

Table 5. Source level specifications in the horizontal plane for the 2380 in^3 array, for a 6 m tow depth. Source levels are per-pulse and unweighted.

Direction	Peak pressure level (dB re 1 µPa @ 1 m)	SEL (dB re 1 µPa2·s @ 1 m)	
		10–2000 Hz	2000–25000 Hz
Broadside	248.0	223.2	182.7
Endfire	245.9	223.1	187.4
Vertical (no ghost)	254.6	227.8	194.4
Vertical (with ghost)	254.6	230.5	197.4

4.2. Per-pulse Sound Fields

Per-pulse results for the proposed Bethany 3-D MSS are presented at four modelling sites for maximum-over-depth SPL and SEL (see Table 2 for locations, depths, and tow directions). Additionally, five depths (Sites A-E) were assessed for seafloor PK, PK-PK, and per-pulse SEL.

4.2.1. Tabulated results

4.2.1.1. Maximum-over-depth results

Tables 6–10 show the estimated ranges for the various applicable per-pulse effects criteria and isopleths of interest as maximum-over-depth for the 2380 in^3 airgun array towed at 6 m.

Table 6. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2380 in^3 array to modelled maximum-over-depth DEWHA (2008) criterion and applied marine mammal and turtle behavioural response thresholds.

Threshold	Site 1 (40.9 m)		Site 2 (84 m)		Site 3 (60.5 m)		Site 4 (43.9 m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
DEWHA (2008), Unweighted per-pulse SEL: 160 dB re 1 µPa^2·s	2.7	2.5	2.4	2.2	3.3	3.0	3.2	2.7
NMFS (2013) Marine mammal behaviour, SPL: 160 dB re 1 µPa	7.1	6.0	4.7	4.0	6.5	5.8	7.2	6.1
Turtle behaviour, SPL: 166 dB re 1 µPa (NSF 2011)	3.6	3.2	3.0	2.8	4.5	4.0	4.1	3.6

Table 7. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2380 in^3 array to modelled maximum-over-depth per-pulse SEL isopleths. A dash indicates the threshold is not reached.

Per-pulse SEL (dB re 1 µPa^2·s)	Site 1 (40.9 m)		Site 2 (84 m)		Site 3 (60.5 m)		Site 4 (43.9 m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
200	–	–	–	–	–	–	–	–
190	0.06	0.06	0.04	0.04	0.04	0.04	0.04	0.04
180	0.18	0.18	0.22	0.22	0.20	0.18	0.20	0.18
170	1.01	0.95	0.88	0.79	0.97	0.89	1.12	1.00
160	2.74	2.47	2.43	2.24	3.27	3.01	3.15	2.73
150	7.61	6.75	5.46	4.33	7.11	6.19	8.53	6.85
140	23.50	19.50	12.20	9.78	17.20	13.70	25.30	19.30
130	66.30	47.40	31.30	21.80	45.60	34.50	64.70	49.10
120	104.00	85.80	76.30	57.10	102.00	76.60	113.00	95.20
110	141.00	118.00	135.00	111.00	140.00	114.00	139.00	111.00

Table 8. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2380 in^3 array to modelled maximum-over-depth SPL isopleths. A dash indicates the threshold is not reached.

SPL (dB re 1 µPa)	Site 1 (40.9 m)		Site 2 (84 m)		Site 3 (60.5 m)		Site 4 (43.9 m)	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
200	0.04	0.04	-	-	-	-	0.04	0.04
190	0.17	0.17	0.20	0.20	0.18	0.18	0.18	0.17
180	0.89	0.84	0.77	0.69	0.84	0.78	1.01	0.89
170	2.46	2.24	2.32	2.06	2.99	2.61	2.87	2.54
160	7.07	6.02	4.68	3.99	6.50	5.85	7.24	6.11
150	20.90	17.60	11.30	9.22	15.90	12.50	23.60	17.50
140	53.90	44.50	28.70	19.50	41.30	32.20	57.40	45.70
130	103.00	82.70	69.70	49.70	93.60	71.90	110.00	93.90
120	141.00	116.00	125.00	104.00	140.00	110.00	138.00	109.00

Table 9. Maximum (R_{max}) horizontal distances (in m) from the 2380 in^3 array to PTS and TTS PK levels for marine mammals at the shallowest (Site 1) and deepest (Site 2) sites.

Hearing group	PTS			TTS		
	PK Threshold (dB re 1 µPa)	Distance R_{max} (m)		PK Threshold (dB re 1 µPa)	Distance R_{max} (m)	
		Site 1 (40.9 m)	Site 2 (84 m)		Site 1 (40.9 m)	Site 2 (84 m)
Low-frequency cetaceans	219	20	20	213	40	40
Mid-frequency cetaceans	230	< 20	< 20	224	< 20	< 20
High-frequency cetaceans	202	290	160	196	490	500

Table 10. Maximum (R_{max}) horizontal distances (in km) from the 2380 in^3 array to modelled maximum-over-depth PK-PK relevant for plankton, assessed along the four FWRAM modelling transects at the shallowest (Site 1) and deepest (Site 2) sites.

PK-PK (dB re 1 µPa)	Distance R_{max} (km)	
	Site 1 (40.9 m)	Site 2 (84 m)
178	6.2	4.2

4.2.1.2. Seafloor results

The estimated ranges for the various applicable per-pulse effects criteria and isopleths of interest at the seafloor for the 2380 in^3 airgun array towed at 6 m are shown in Tables 11–13.

Table 11. Maximum (R_{max}) horizontal distances (in m) from the 2380 in^3 array to modelled seafloor PK levels from four transects.

Peak pressure level (dB re 1 µPa)	Distance R_{max} (m)				
	A (35 m depth)	B (45 m depth)	C (55 m depth)	D (65 m depth)	E (75 m depth)
230	-	-	-	-	-
225	9	< 1	-	-	-
220	29	22	18	13	5
215	53	58	53	46	39
213†	57	67	72	68	61
210	110	77	85	94	100
207‡	143	153	160	165	116
205	159	175	188	196	202
200	367	375	385	286	302
195	524	578	634	619	644

Defined in Popper et al. (2014) as being associated with mortality and potential mortal injury and recoverable injury:
† Fish: No swim bladder
‡ Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing, Turtles, fish eggs, and larvae

Table 12. Maximum (R_{max}) horizontal distances (in m) from the 2380 in^3 array to modelled seafloor PK-PK levels from four transects.

PK-PK (dB re 1 µPa)	Distance R_{max} (m)				
	A (35 m depth)	B (45 m depth)	C (55 m depth)	D (65 m depth)	E (75 m depth)
230	8	-	-	-	-
225	27	22	19	14	7
220	49	51	49	46	42
215	112	77	81	87	90
210	156	172	183	194	202
205	385	339	360	282	298
202	476	522	449	449	465
200	545	582	638	651	621

Table 13. Maximum (R_{max}) horizontal distances (in m) from the 2380 in^3 array to modelled seafloor SEL per-pulse levels from four transects.

SEL (dB re 1 µPa^2·s)	Distance R_{max} (m)				
	A (35 m depth)	B (45 m depth)	C (55 m depth)	D (65 m depth)	E (75 m depth)
205	-	-	-	-	-
200	16	6	-	-	-
195	35	35	32	26	16
190	59	61	63	63	63
185	122	128	112	113	112
180	227	198	207	216	221
175	505	474	449	421	431

4.2.2. Maps and graphs

Figures 3–10 show maps of the estimated sound fields, threshold contours and isopleths of interest for the per-pulse SEL and SPL results for the proposed Bethany 3-D MSS at the four modelling sites (see Table 2 for a list of locations, depths, and tow directions).

Figures 11–16 present plots of the vertical slices of the estimated sound fields for per-pulse SEL and SPL at Sites 1, 2, and 4. Figure 17 shows seafloor PK and PK-PK plots for each site.

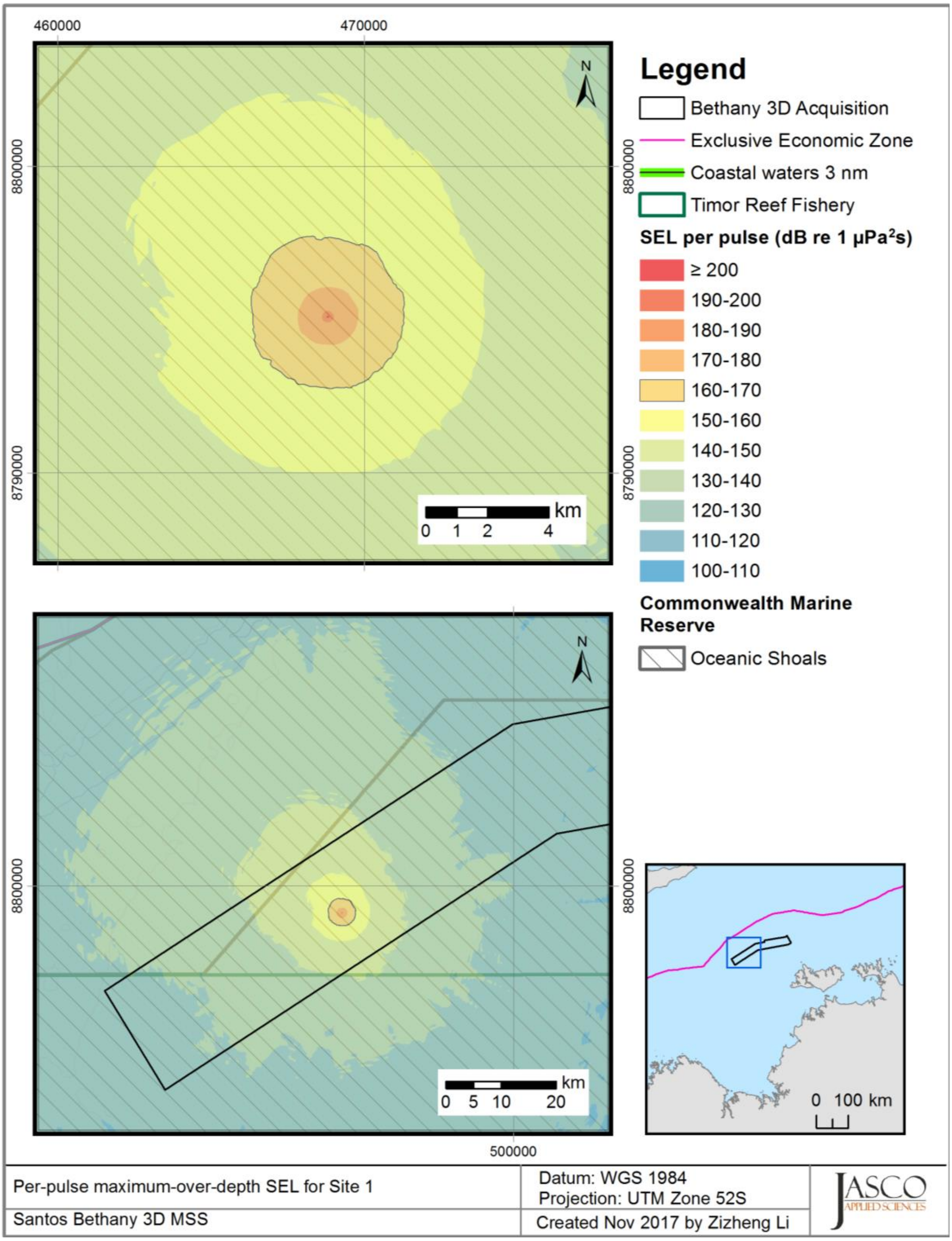

Figure 3. Site 1: Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 2380 in^3 array.

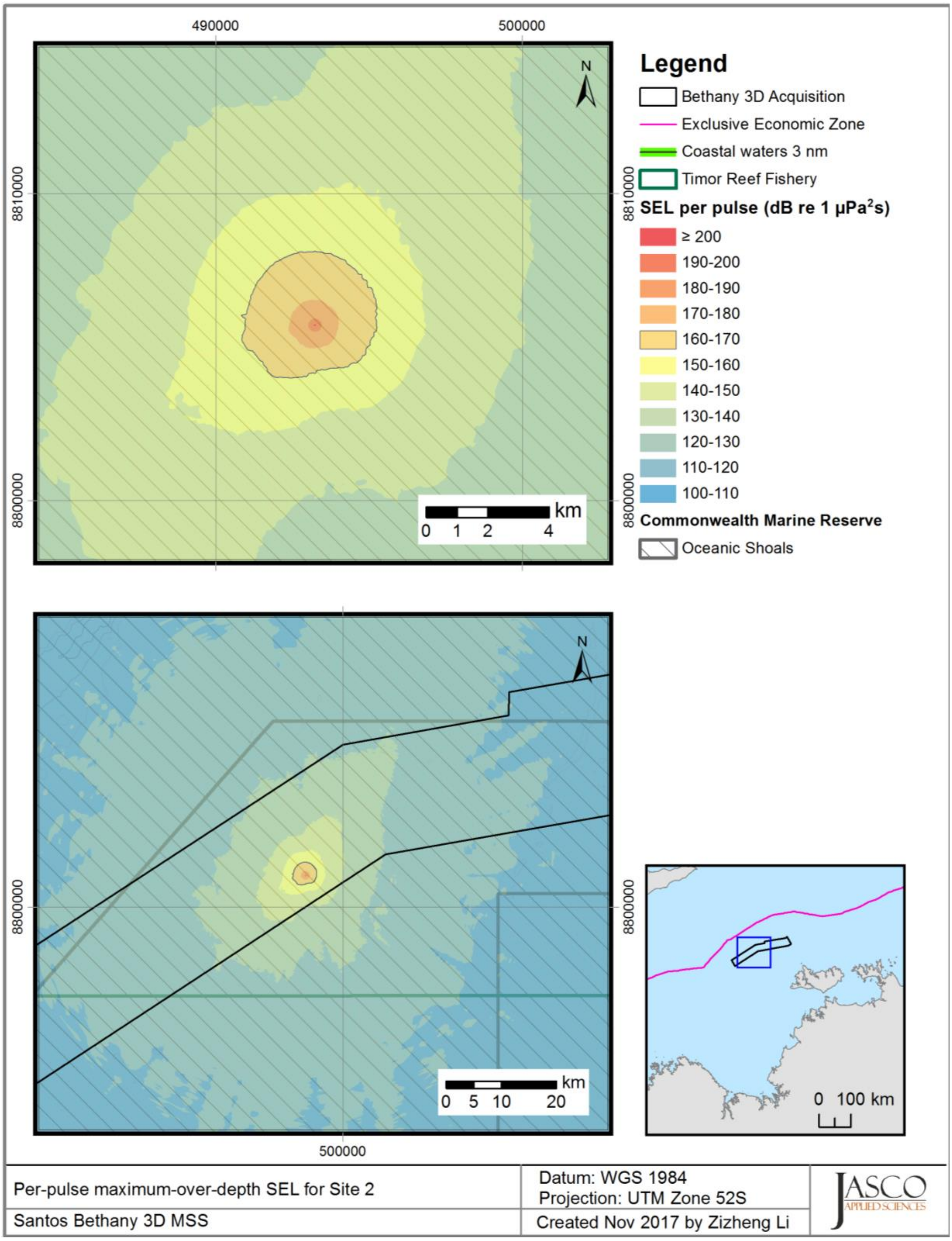

Figure 4. Site 2: Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 2380 in^3 array.

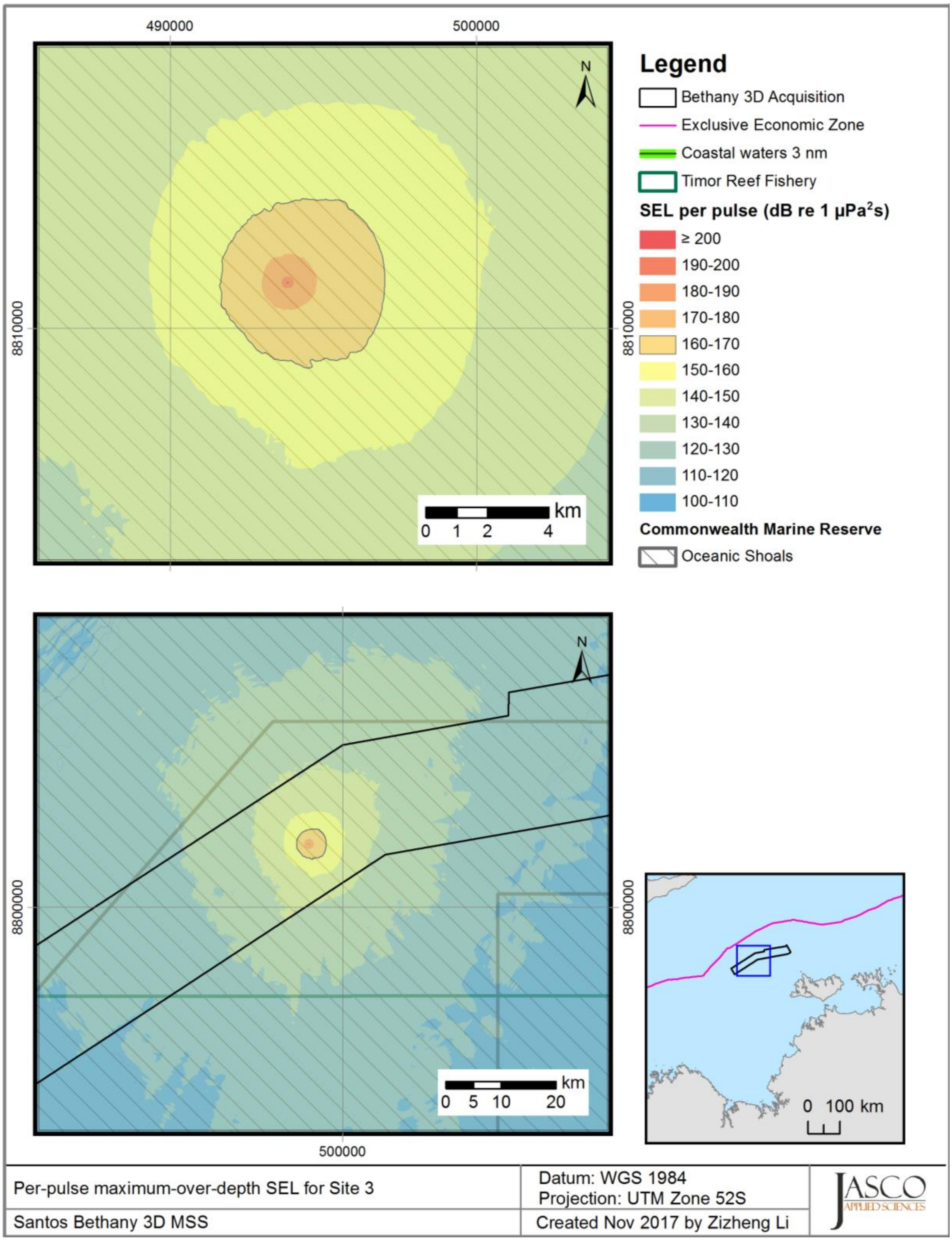

Figure 5. Site 3: Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 2380 in^3 array.

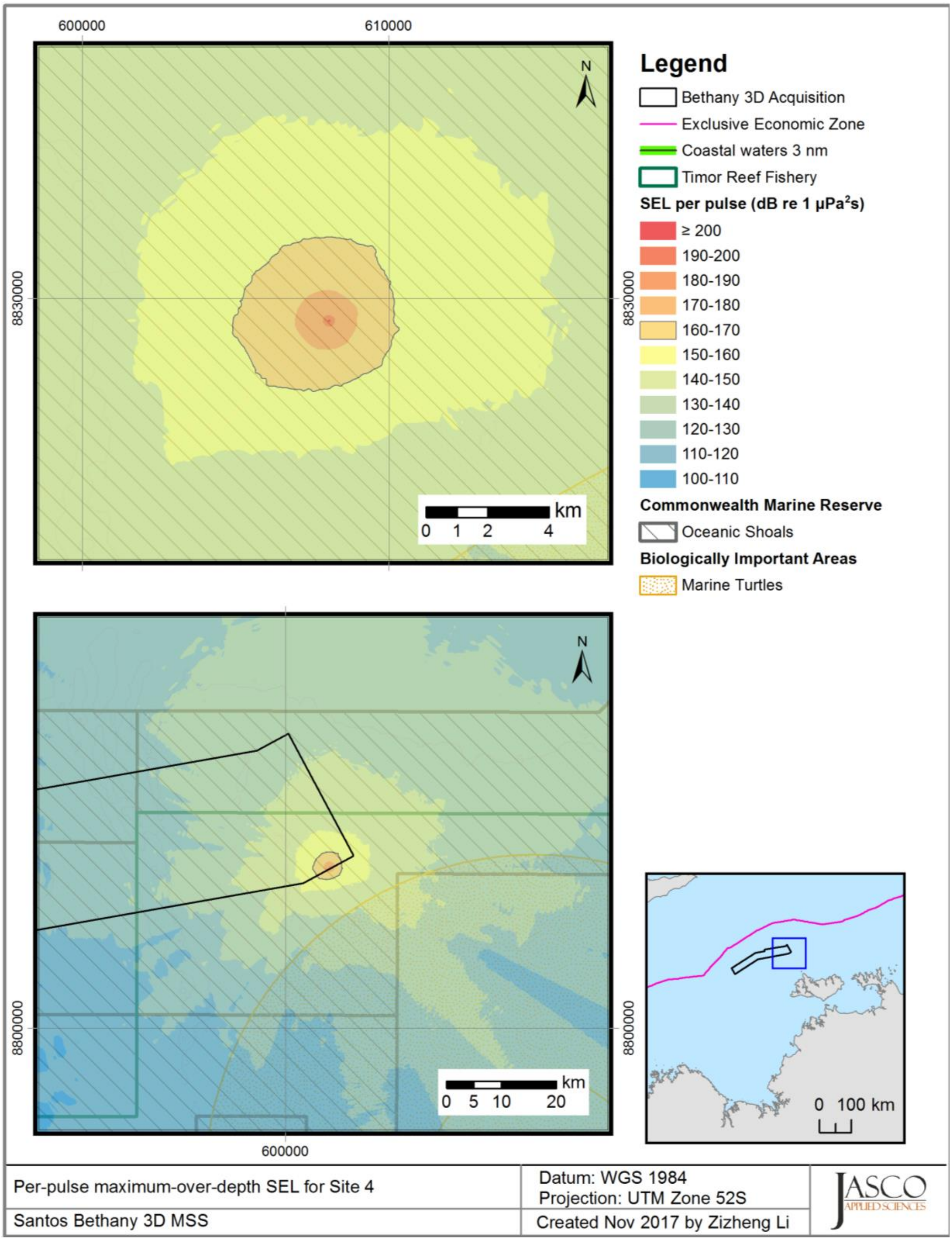

Figure 6. Site 4: Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 2380 in^3 array.

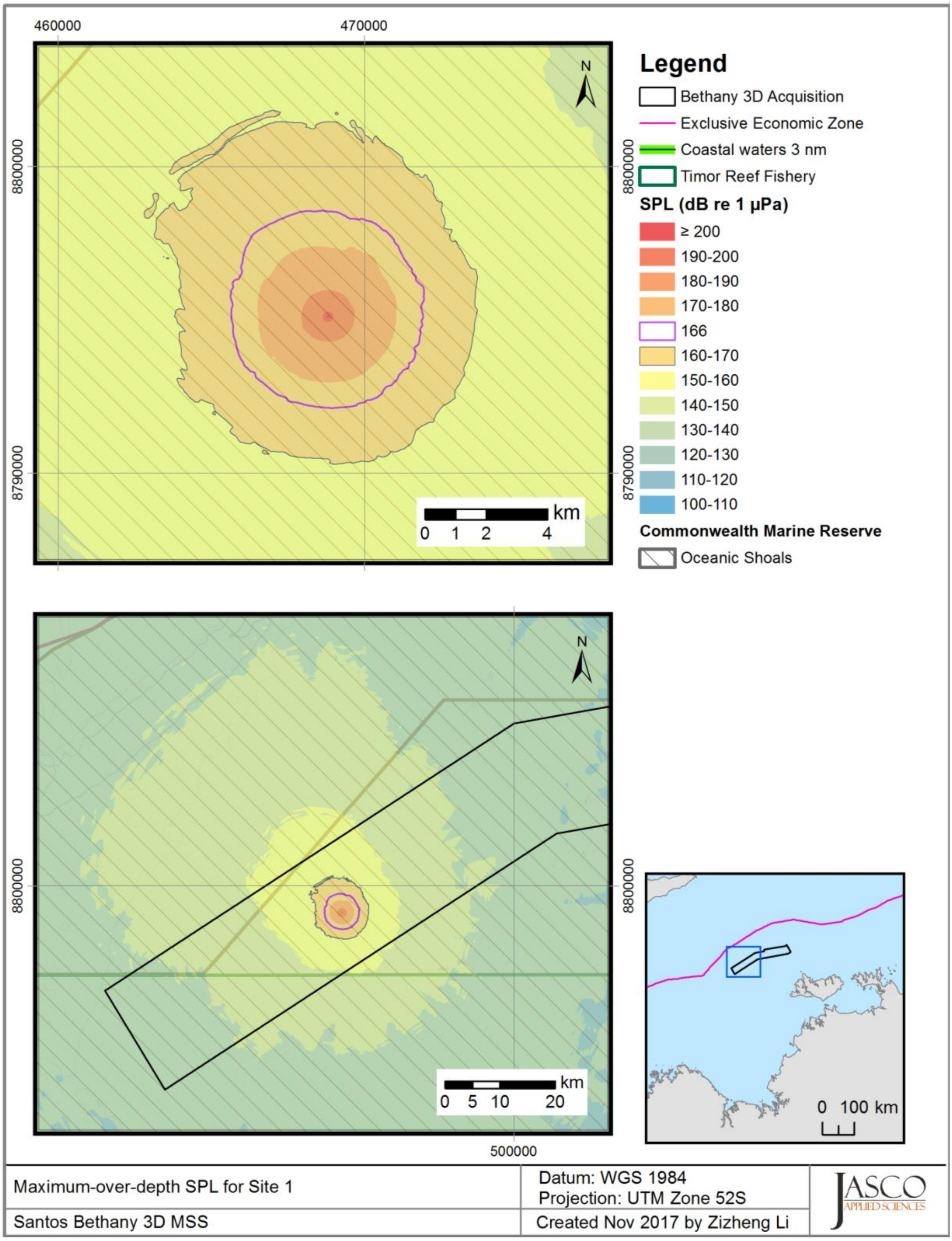

Figure 7. Site 1: Sound level contour map showing unweighted maximum-over-depth SPL results for the 2380 in^3 array. Isopleths for turtle (166 dB re 1 µPa) and marine mammal (160 dB re 1 µPa) behavioural criteria are shown.

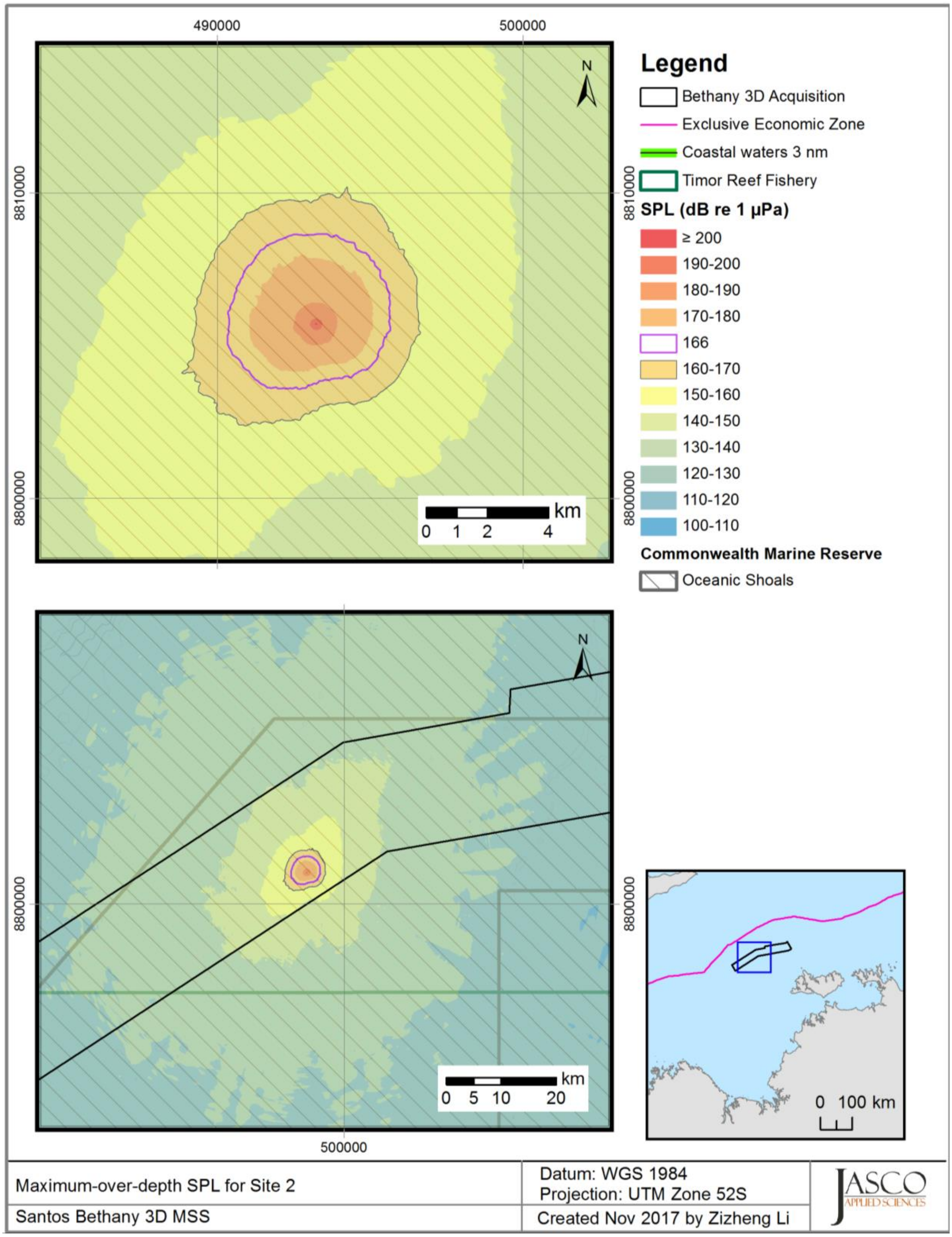

Figure 8. Site 2: Sound level contour map showing unweighted maximum-over-depth SPL results for the 2380 in^3 array. Isopleths for turtle (166 dB re 1 µPa) and marine mammal (160 dB re 1 µPa) behavioural criteria are shown.

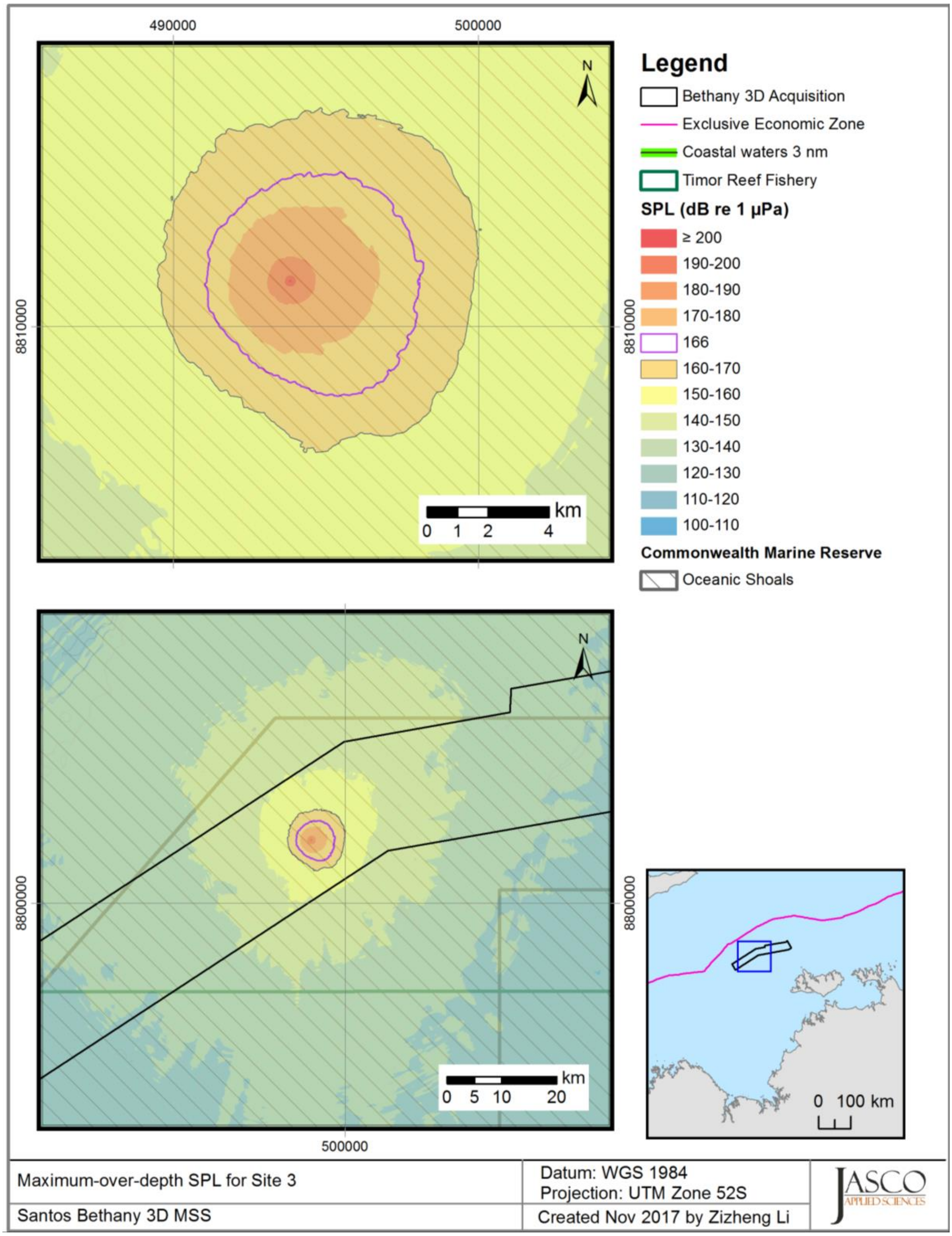

Figure 9. Site 3: Sound level contour map showing unweighted maximum-over-depth SPL results for the 2380 in^3 array. Isopleths for turtle (166 dB re 1 µPa) and marine mammal (160 dB re 1 µPa) behavioural criteria are shown.

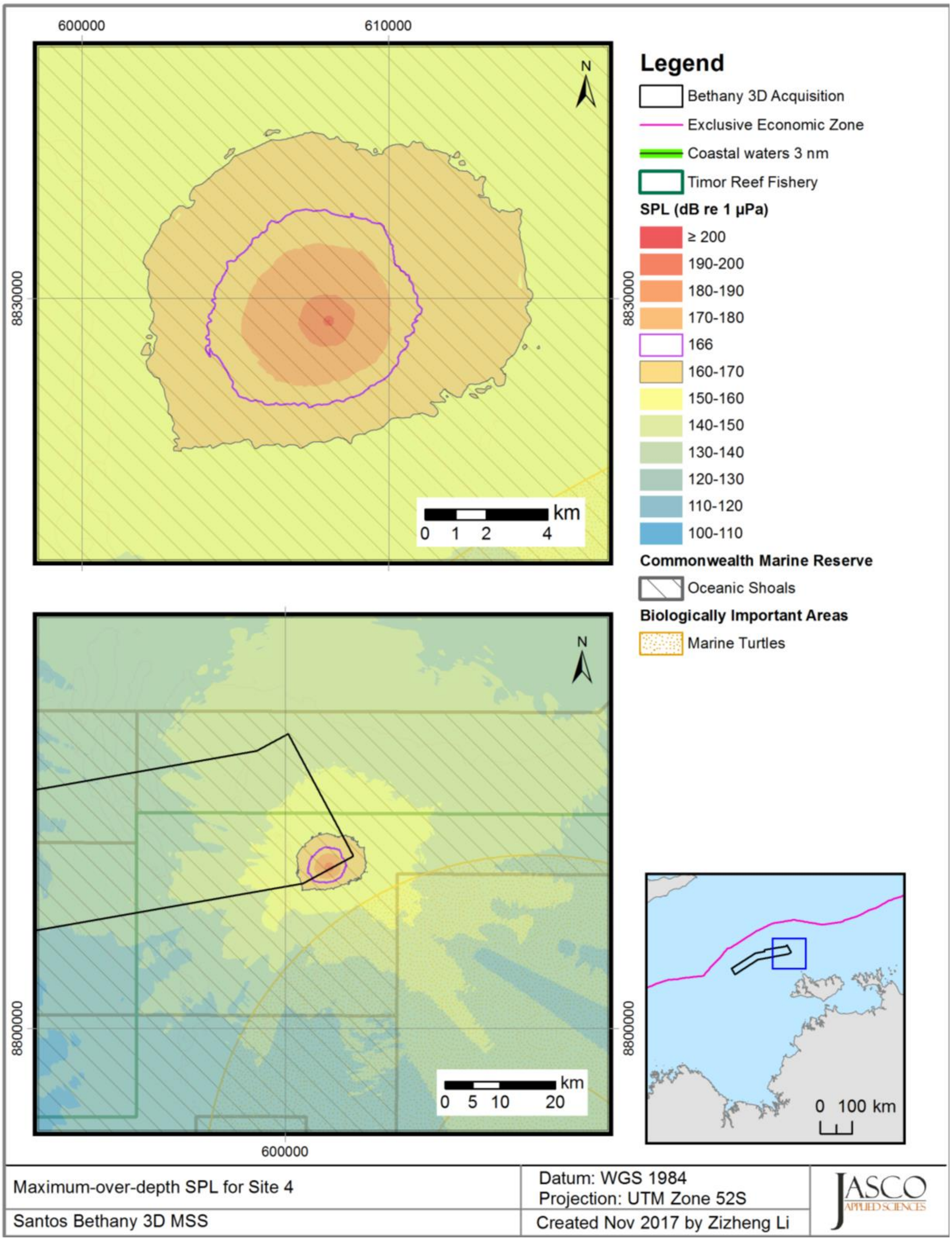

Figure 10. Site 4: Sound level contour map showing unweighted maximum-over-depth SPL results for the 2380 in^3 array. Isopleths for turtle (166 dB re 1 µPa) and marine mammal (160 dB re 1 µPa) behavioural criteria are shown.

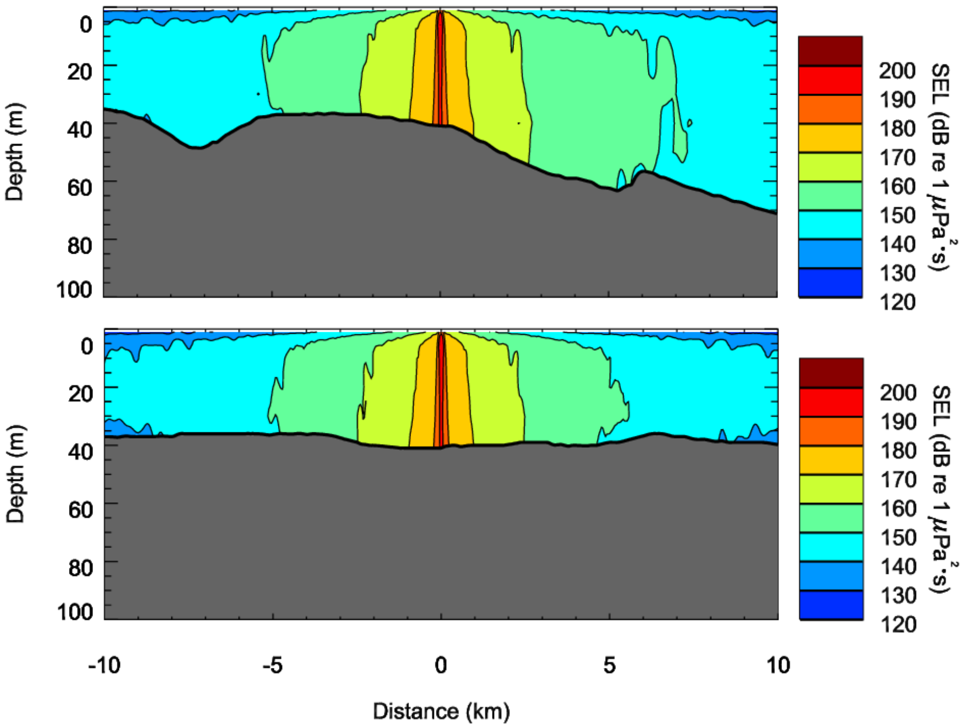

Figure 11. Site 1: Predicted unweighted per-pulse SEL for the 2380 in³ array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

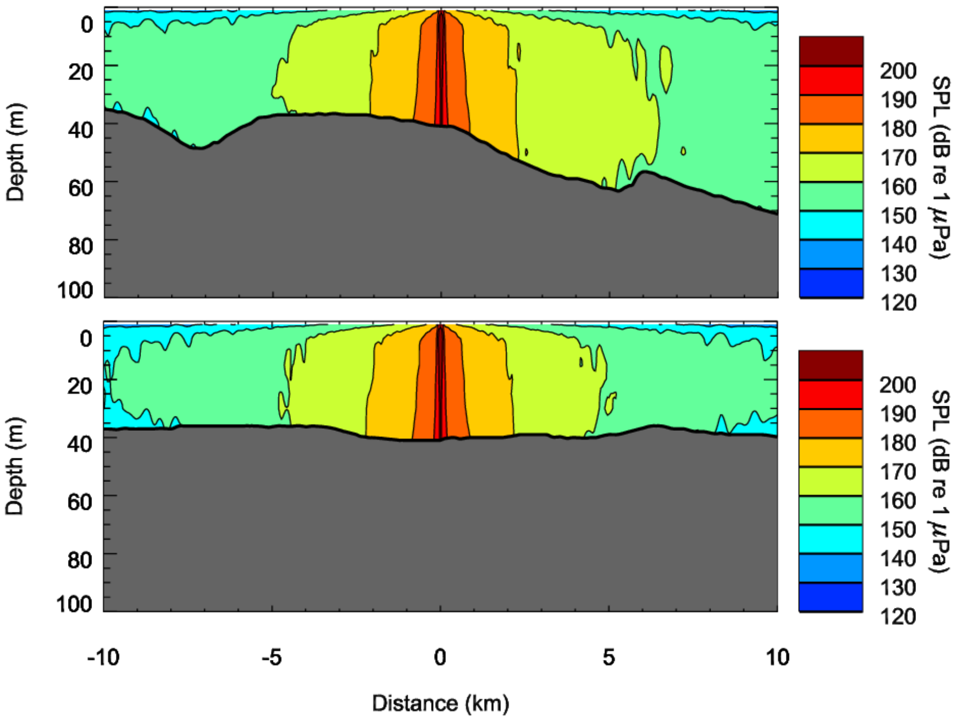

Figure 12. Site 1: Predicted unweighted SPL for the 2380 in³ array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

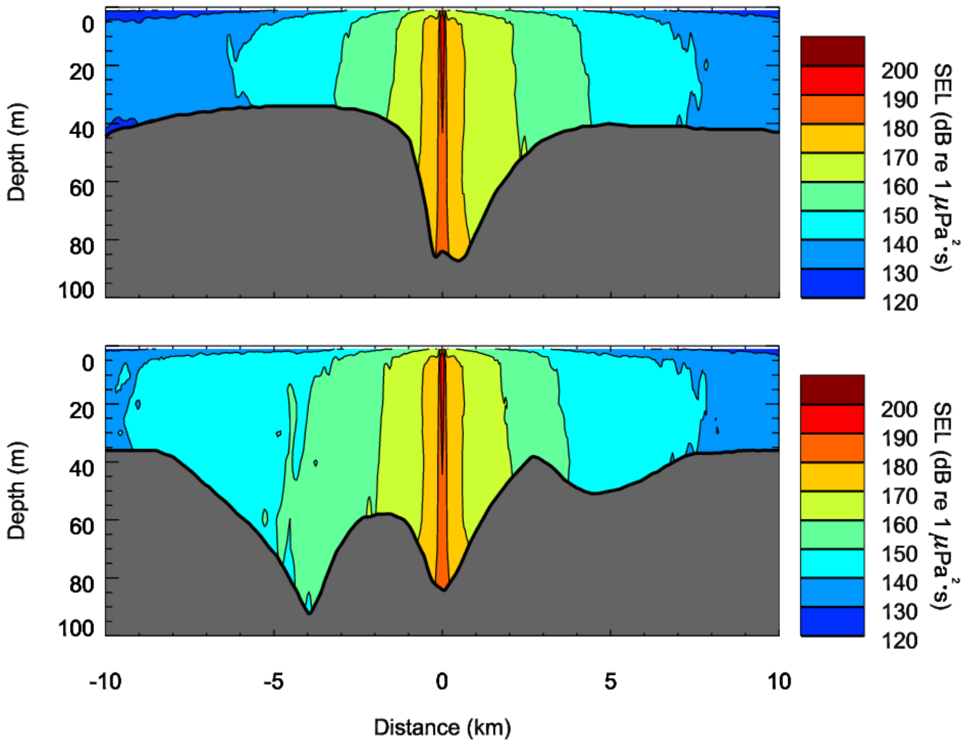

Figure 13. Site 2: Predicted unweighted per-pulse SEL for the 2380 in^3 array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

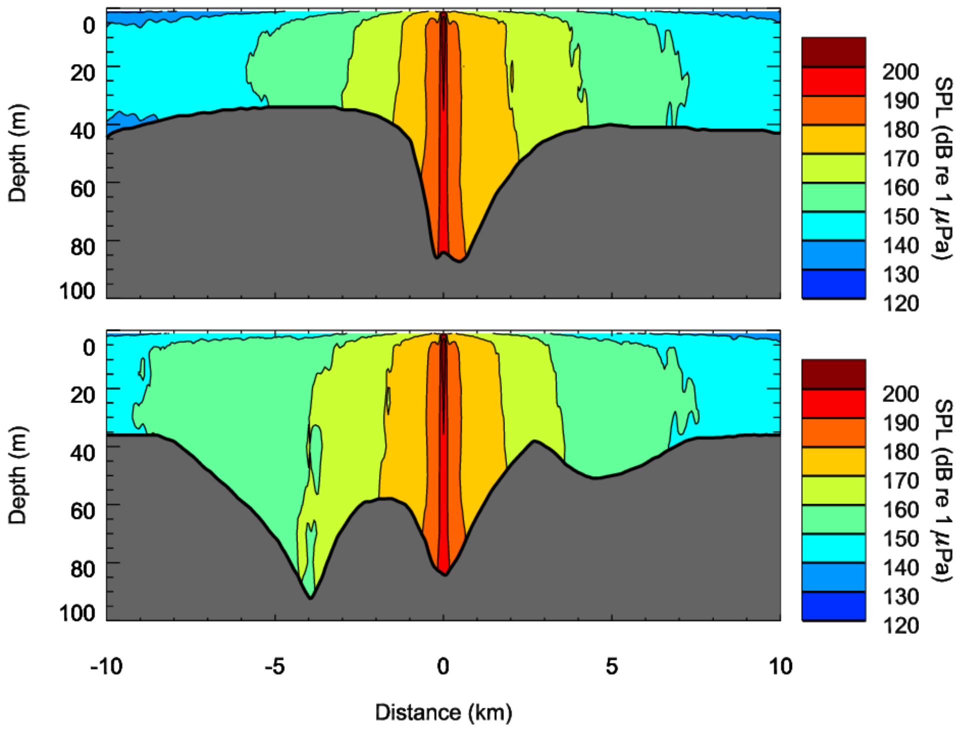

Figure 14. Site 2: Predicted unweighted SPL for the 2380 in^3 array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

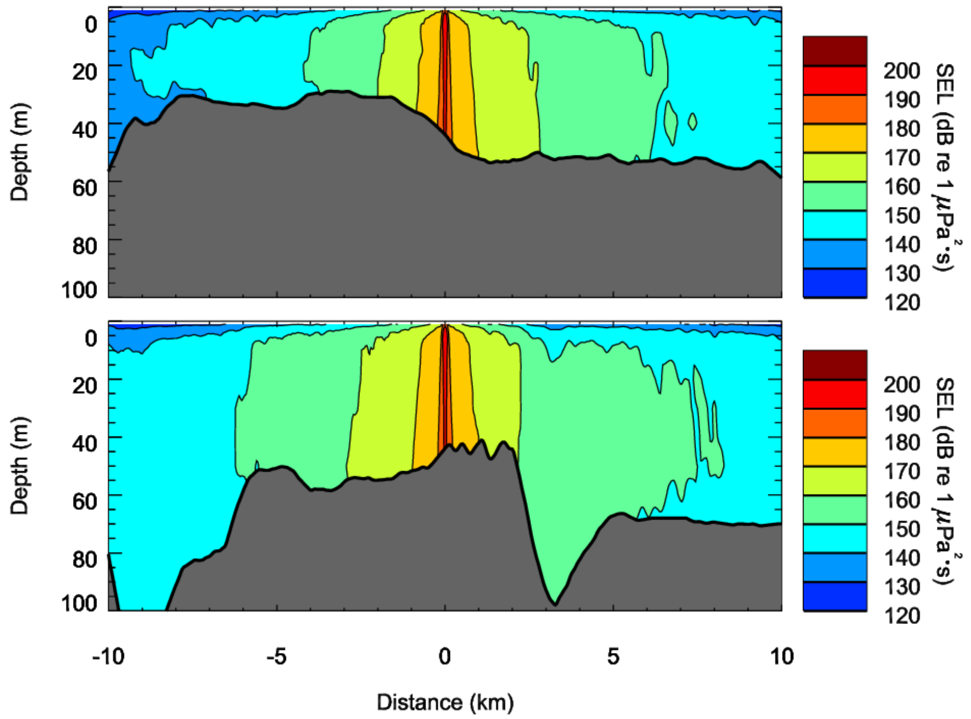

Figure 15. Site 4: Predicted unweighted per-pulse SEL for the 2380 in³ array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

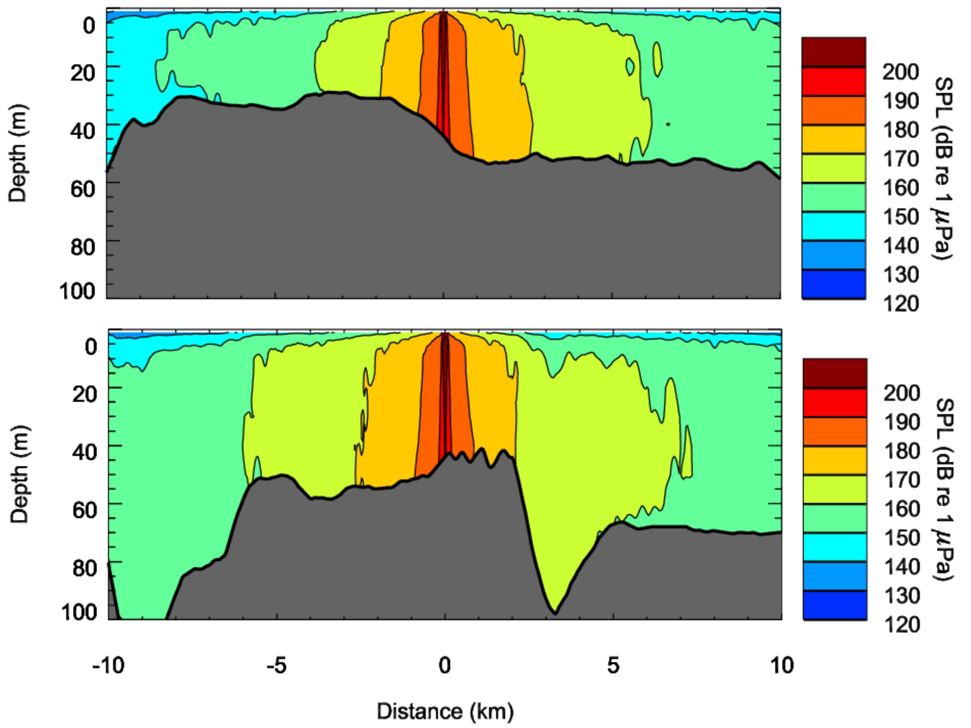

Figure 16. Site 4: Predicted unweighted SPL for the 2380 in³ array as vertical slices. Levels are shown along a single transect from broadside (top) and endfire (bottom). The source depth is 6 m.

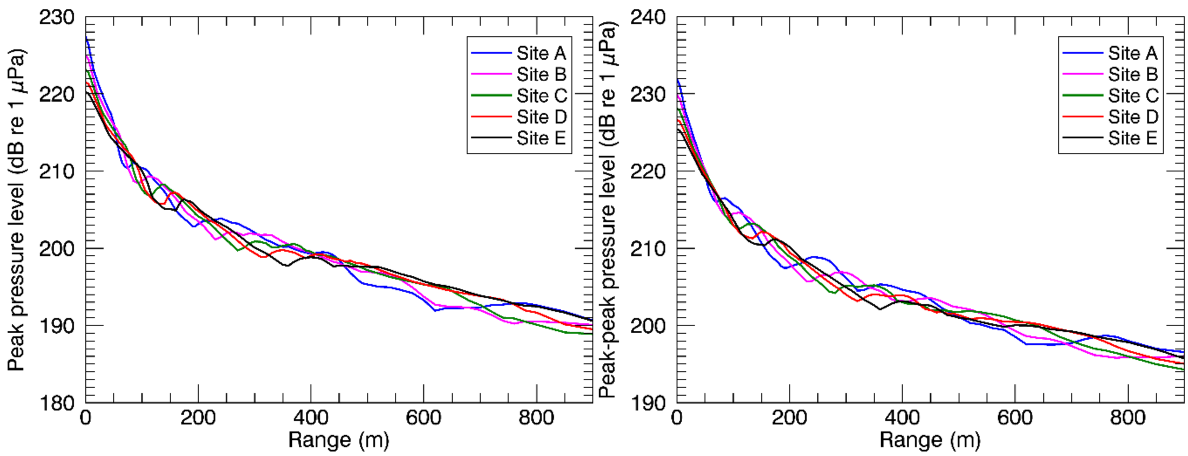

Figure 17. Peak pressure level (left) and peak-peak pressure level (right) as a function of range, for receivers at the seafloor. Maximum levels are shown for each of four transects, assessing broadside and endfire directions. The source depth is 6 m.

4.3. Multiple Pulse Sound Fields

The SEL_{24h} results for the proposed Bethany 3-D MSS are presented for one possible operational scenario, described in Section 3.4.2. Tables 14 and 15 show estimated ranges to the appropriate cumulative exposure criterion contour for the marine fauna groups considered. The radii in this section represent the perpendicular distance from to the closest survey line to the relevant isopleth.

Table 14. Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds NMFS (2016) for the considered scenario within the Bethany 3-D MSS acquisition area. A dash indicates the threshold is not reached.

Hearing group	PTS			TTS		
	Threshold for SEL_{24h} (dB re 1 µPa²·s)	R_{max} (km)	Area (km²)	Threshold for SEL_{24h} (dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	2.4	720	168	43.6	6395
Mid-frequency cetaceans	185	-	-	170	0.05	1.8
High-frequency cetaceans	155	0.08	19.4	140	0.20	51.4

Table 15. Distances (in km) to maximum-over-depth and seafloor SEL_{24h} based fish and turtle criteria for the considered scenario within the Bethany 3-D MSS acquisition area. Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing. A dash indicates the threshold is not reached.

Marine animal group	Threshold for SEL_{24h} (dB re 1 µPa²·s)	Maximum-over-depth		Seafloor	
		R_{max} (km)	Area (km²)	R_{max} (km)	Area (km²)
Fish mortality and potential mortal injury					
I	219	0.08	24.4	-	-
II Fish eggs and larvae	210	0.10	24.9	-	-
III	207	0.10	24.9	-	-
Fish recoverable injury					
I	216	0.08	24.5	-	-
II, III	203	0.10	24.9	0.05	6.10
Fish TTS					
I, II, III	186	3.40	878	2.90	790
Turtle mortality and potential mortal injury					
Turtles	210	0.10	24.9	-	-

The sound level contour map is presented in Figure 18. The contours for marine mammal injury thresholds shown in the maps represent weighted metrics for low-frequency cetaceans and as such do not numerically match the SEL contour bands that are unweighted.

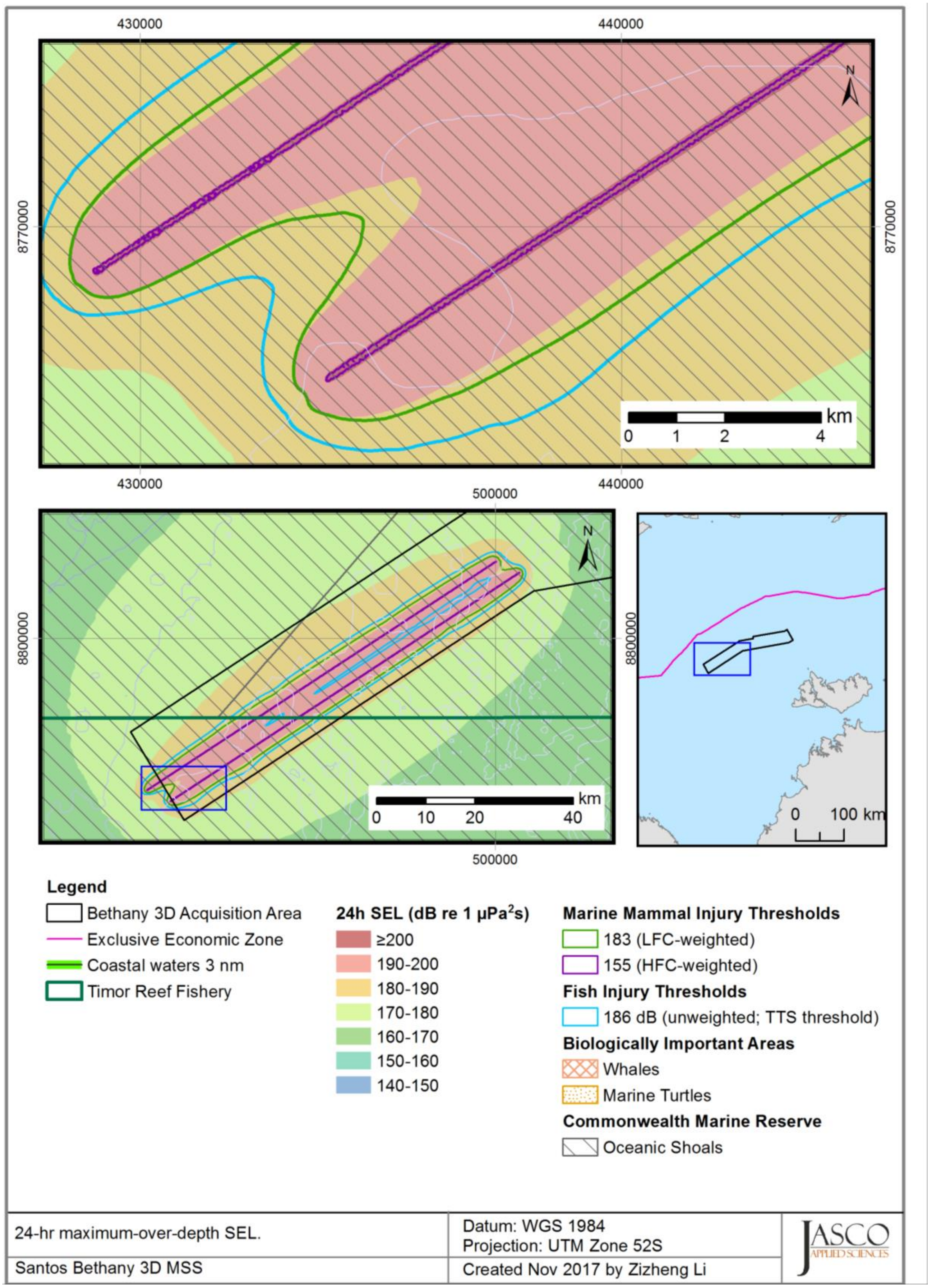

Figure 18. Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results for the 2380 in^3 array.

5. Discussion

5.1. Overview and sound source levels

This modelling study predicted underwater sound levels associated with the Santos proposed Bethany 3-D MSS. The underwater sound field was modelled for operating a 2380 in^3 airgun array as the maximum source (Appendix D.4) with water column sound speed profiles for July. Analysed sound speed profiles (Appendix D.3.2) indicated that this month had the greatest noise transmission, making it the most conducive month for sound propagation, and as such it was selected for modelling to ensure we did not underestimate distances to received sound level thresholds over the entire survey period. The modelling also accounted for site-specific bathymetric variations (Appendix D.3.1) and local geoacoustic properties (Appendix D.3.3).

This report focuses on PK levels at the seafloor that are relevant to fish. These levels are highly dependent upon the depth of the water at close range. The first reflection is the sound from the sea surface, followed by a reflection from the seafloor, these two reflections then interact with each other prior to subsequent reflections. As the distance from the source increases beyond approximately three water depths, a complex pattern of destructive surface reflection and constructive critical angle bottom reflections dominate over sounds due to any direct path transmission. Consequently, the PK level compared with range does not follow a simple relationship with water depth (see results in Table 11).

While the results from modelling PK levels to assess mortality and potential mortal injury to fish, turtles, fish eggs, and larvae are presented in terms of horizontal distances to the sound level at the seafloor, given the distribution of sound within the water column for the locations assessed, these distances will also predominantly represent the maximum-over-depth distance.

Most acoustic energy from the airgun array is output at lower frequencies, in the tens to hundreds of hertz. Although there was little difference in the broadband source levels in the endfire and broadside directions, some directivity below a few hundred hertz led to slightly higher emissions in the broadside direction at those frequencies. Because the survey will be in shallow water, the low-frequency components associated with the highest spectral levels for the source attenuated rapidly compared to those at higher frequencies. The overall broadband (10–2000 Hz) unweighted per-pulse SEL source level of the 2380 in^3 airgun array operating at 6 m were 223.2 dB re 1 µPa^2·s @ 1 m in the broadside direction and 223.1 dB re 1 µPa^2·s @ 1 m in the endfire direction. The peak pressure levels in the same directions were 248.0 and 245.9 dB re 1 µPa, respectively. Table 5 presents these results.

5.2. Per-pulse sound fields

The 2380 in^3 airgun array is does not exhibit strong directionality (Appendix B.2), which combined with the shallow water depth, resulted in footprints with directionality determined more by bathymetry than by the airgun array itself. The ranges to the per-pulse SEL isopleths were similar across all four sites for levels higher than 160 dB re 1 µPa^2·s. For lower sound levels, the distances to isopleths were greatest at the two shallowest modelled sites (Sites 1 and 4, with depths of 40.9 and 43.9 m respectively), and shortest at the deepest site, Site 2 (84 m). This is partly due to the bathymetry surrounding the modelling sites, with the canyon feature at Site 2 influencing the wider area propagation, while at Sites 1 and 4 the sound propagates towards the deeper offshore water in an environment that gradually becomes deeper. These predictions demonstrate the influence of site-specific bathymetry along the survey transects.

The distances to the SPL-based criteria for marine mammal and turtle behaviour were assessed at all sites within the operational area. The greatest distance to the isopleth associated with the NMFS (2013) marine mammal behavioural response criterion of 160 dB re 1 µPa was 7.24 km (R_{max} distance) at Site 4, while the shortest was 4.68 km at Site 2. The greatest distance to the isopleth associated with the U.S. NMFS criterion for behavioural effects in turtles (166 dB re 1 µPa) was 4.5 km (R_{max} distance) at Site 3, while the shortest was 3 km at Site 2.

Marine mammals could experience a permanent auditory threshold shift (PTS) based on the criteria applied (NMFS 2016). This is a dual metric criterion, requiring consideration of both PK and accumulated SEL, with the maximum distance from either metric being the one required to be applied. The peak pressure criteria were exceeded at a maximum horizontal distance of 20 m for low-frequency cetaceans, within 20 m for mid-frequency cetaceans, and 290 m for high-frequency cetaceans (Table 9); the maximum distances for all three hearing groups are predicted to occur at Site 1. Distances are from the centre of the array, but as the array is not a point source (11.2 × 15 m), and the actual ranges from the edge of the airgun array are negligible for all but high-frequency cetaceans. TTS is predicted to occur in the three cetacean hearing groups, with the maximum distances being 40, < 20, and 500 m for low, mid and high-frequency cetaceans, respectively.

The distance to PK levels relevant to fish at the seafloor is site specific, with no consistent pattern between site depth and distance to isopleth (Table 11, Figure 17). This is related to the complex pattern of destructive surface reflection and constructive critical angle bottom reflections that singularly affect sound propagation in shallow water. As demonstrated, the distances can be greater for depths even slightly shallower or deeper. Considering the PK-based potential injury criteria associated with fish from Popper et al. (2014) for fish without a swim bladder, the maximum distance was 72 m at Site C (55 m depth), while for those fish with swim bladders not involved in hearing, as well as turtles, fish eggs, and larvae, the maximum distance was 165 m at Site D (65 m depth) (Table 11).

5.3. Multiple Pulse Sound Fields

The accumulated SEL scenario considers 24 h of seismic operation along two specified acquisition lines. The model measured the accumulated effects of noise, accounting for the change in location and the azimuth of the source at each impulse point. These accumulated SEL results which were used to assess possible PTS and TTS in marine mammals, along with SEL_{24h}-based fish and turtle criteria.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 h, based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The radii that correspond to SEL_{24h} typically represent an unlikely worst case scenario for SEL-based exposure since, more realistically, marine fauna (mammals or fish) would not stay in the same location or at the same range for 24 h. Therefore, a reported radius of SEL_{24h} criteria does not mean that any animal travelling within this radius of the source will be injured, but rather that it could be injured if it remained in that range for 24 h. The reported radii represent the perpendicular distance from to the closest survey line to the relevant isopleth.

The assessed survey lines are ~4.5 km apart and in total comprise 13592 single impulses. At receiver locations close to the survey lines the, modelled noise level was dominated by those shots nearest to them with little to no influence from the other line where the nearest shot was within a few kilometres of the receiver. The greater propagation in the offshore direction seen in the single shot results was reflected here, as again the ranges to isopleths at lower levels were greater in this direction, which is because propagation towards the north encountered the gradual increase in depth. This was even apparent in the 180 dB re 1 µPa²·s isopleth. For levels above 183 dB re 1 µPa²·s, the isopleths were evenly distributed around the track lines, with only a slight extension of ranges in the broadside direction (Figure 18).

The SEL_{24h} PTS criteria for marine mammals (NMFS 2016) was not exceeded for mid-frequency cetaceans, but it was exceeded for low- and high-frequency cetaceans, which could be effected at distances of up to 2.4 or 0.08 km (Table 14). The distance for low-frequency cetaceans was greater for the SEL_{24h} metric than the PK metric, but the opposite was the case for high-frequency cetaceans.

The criteria for either possible mortality and potential mortal injury in fish, turtles, fish eggs, and fish larvae was not reached at the seafloor using the SEL_{24h} metric based on Popper et al. (2014) (Table 15). Recoverable injury in fish, turtles, fish eggs, and fish larvae could occur within 50 m; however, this distance was less than that predicted considering the PK metric. Temporary impairment of fish auditory systems (TTS) could occur within 3.4 km of the airgun array for fish in the water column, or within 2.9 km for seafloor fish, based on the estimated R_{max} radii (Table 15).

5.4. Summary

5.4.1. Marine mammal injury

For comparison to the EPBC Act Policy Statement 2.1 (DEWHA 2008), the $R_{95\%}$ 160 dB re 1 µPa^2·s single-impulse SEL distances for the survey were greater than 1 km, being between 3.27 and 2.43 km (Sites 3 and 4, respectively).

The results for the NMFS (2016) criteria applied for marine mammal PTS consider both metrics within the criteria (PK and SEL_{24h}). The farthest distance associated with either metric is required to be applied. The maximum distances along with the relevant metric and the location of the results are summarised in Table 16.

Table 16. Summary of marine mammal PTS onset distances.

Relevant hearing group	Metric associated with greatest distance to PTS onset	Distance R_{max} (km)	Result location
Low-frequency cetaceans	SEL_{24h}	2.4	Table 14
Mid-frequency cetaceans	PK	< 0.02	Table 9
High-frequency cetaceans	PK	0.29	Table 9

5.4.2. Marine mammal behaviour

The maximum distance at which the NMFS (2013) marine mammal behavioural response criterion of 160 dB re 1 µPa could be exceeded was 7.24 km (Site 2, Table 6).

5.4.3. Fish, turtles, fish eggs, and fish larvae

In addition to presenting detailed results for seafloor PK, PK-PK, and per-pulse SEL for comparison to literature, the modelling study assessed the ranges for quantitative criteria from Popper et al. (2014) associated with mortality and potential mortal injury and impairment in:

- Fish without a swim bladder (also appropriate for sharks in the absence of other information)
- Fish with a swim bladder not used for hearing
- Fish that use their swim bladders for hearing
- Turtles
- Fish eggs, and fish larvae

The distance to PK levels relevant to fish at the seafloor is site specific, with no consistent pattern between site depth and distance to isopleth.

Sound levels associated with either mortality and potential mortal injury or recoverable injury to fish, based on Popper et al. (2014), using the SEL_{24h} metric, are predicted to occur at ranges shorter than those predicted using the PK metric. In line with the conditions of the criteria, the PK metric therefore should be used to assess these impacts. A similar scenario exists for sound levels associated with either mortality and potential mortal injury to turtles, fish eggs, and fish larvae.

Therefore, applying the Popper et al. (2014) criteria:

- For mortality and potential mortal injury or recoverable injury, the relevant sound level for the most sensitive fish groups is 207 dB re 1 µPa PK, and the associated maximum distance is 165 m (65 m depth).
    - This sound level and distance are also associated in the criteria with mortality and potential mortal injury to turtles, fish eggs, and fish larvae.

- The relevant sound level for the least sensitive fish group (fishes without a swim bladder, sharks), is 213 dB re 1 µPa PK, and the associated maximum distance is 72 m (55 m depth).

Considering the defined 24h period of exposure, fish (including sharks) could experience TTS within 3.4 km of the airgun array anywhere in the water column, or within 2.9 km of the array on the seafloor.

Behavioural effects in turtles were also considered. The maximum distance to the isopleth associated with the U.S. NMFS criterion for behavioural effects in turtles (166 dB re 1 µPa) was 4.5 km (R_{max} distance, Site 3).

5.4.4. Plankton

For comparison to the level reported in McCauley et al. (2017) for potential effects on plankton, the distance to 178 dB re 1 µPa PK-PK in the water column was assessed. The range to this sound level is predicted to be a maximum of 6.2 km (Site 1, 40.9 m depth, Table 10).

Glossary

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands comprise a one octave-band. One-third-octave-bands become wider with increasing frequency. Also see octave.

90% time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% sound pressure level (SPL(T_{90}))
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

audiogram
A graph of hearing threshold level (sound pressure levels) as a function of frequency, which describes the hearing sensitivity of an animal over its hearing range.

auditory weighting function (frequency-weighting function)
Auditory weighting functions account for marine mammal hearing sensitivity. They are applied to sound measurements to emphasise frequencies that an animal hears well and de-emphasise frequencies they hear less well or not at all (Southall et al. 2007, Finneran and Jenkins 2012, NOAA 2013).

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

bar
Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to $10^{6\ \mathrm{Pa}}$ or $10^{11\ \mu\mathrm{Pa}}$.

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

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

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

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

endfire direction
Parallel to the travel direction of a source. Also see broadside direction.

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

functional hearing group
Grouping of marine mammal species with similar estimated hearing ranges. Southall et al. (2007) proposed the following functional hearing groups: low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seafloor.

hearing threshold
The sound pressure level that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

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

high-frequency cetacean
The functional hearing group that represents odontocetes specialised for using high frequencies.

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

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

maximum-over-depth (MOD)
The maximum value over all modelled depths above the seafloor.

mid-frequency cetacean
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

M-weighting
The process of band-pass filtering loud sounds to reduce the importance of inaudible or less-audible frequencies for broad classes of marine mammals. “Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds” (Southall et al. 2007).

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the grey whale (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI/ASA S3.20-1995 R2008). Marine vessels, aircraft, machinery, construction, and vibratory pile driving are examples.

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterises these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

parabolic equation method
A computationally-efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak sound pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: dB re 1 µPa

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

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

power spectrum density
The acoustic signal power per unit frequency as measured at a single frequency. Unit: $\mu Pa^2/Hz$, or $\mu Pa^2 \cdot s$.

power spectrum density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 $\mu Pa^2/Hz$.

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

pulsed sound
Discrete sounds with durations less than a few seconds. Sounds with longer durations are called continuous sounds.

received level
The sound level measured at a receiver.

signature
Pressure signal generated by a source.

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

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

sound exposure level (SEL)
A measure related to the sound energy in one or more pulses. Unit: dB re 1 µPa^2·s.

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

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa:

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

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level Unit: dB re 1 µPa.

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

source level (SL)
The sound pressure level or sound exposure level measured 1 metre from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 µPa @ 1 m or dB re 1 µPa^2·s.

spectrum
An acoustic signal represented in terms of its power (or energy) distribution versus frequency.

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

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

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

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level (PK; dB re 1 μPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

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

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

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

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

The sound pressure level (SPL; dB re 1 μPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

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

where $g(t)$ is an optional time weighting function. The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL.

In studies of impulsive noise, the time window function $g(t)$ is often a decaying exponential that emphasises more recent pressure signals to mimic the leaky integration of the mammalian hearing system. For example, human-based fast time weighting applies an exponential function with time constant 125 ms. Other approaches for evaluating L_p of impulsive signals include setting g(t) to 1 and T to the “90% time window” (T_{90}; the period over which cumulative square pressure function passes between 5% and 95% of its full per-pulse value) or to a constant value (e.g., T_{fix} = 125 ms).

The sound exposure level (SEL, dB re 1 µPa²·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

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

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

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

Because the SPL(T_{90}) and SEL are both computed from the integral of square pressure, these metrics are related by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T), \quad \text{(A-6)}$$

$$L_{p90} = L_E - 10\log_{10}(T_{90}) - 0.458, \quad \text{(A-7)}$$

where the 0.458 dB factor accounts for the 10% of SEL missing from the SPL(T_{90}) integration time window.

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

A.2. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury) and disturbance (Section 2.1.1). The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.2.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: Low-, Mid- and

High-Frequency Cetaceans (LFC, MFC, and HFC respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

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

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

Table A-1. Marine mammal injury (PTS onset) thresholds based on NMFS (2016).

Hearing group	Impulsive source		Non-impulsive source
	PK	Weighted SEL (24 h)	Weighted SEL (24 h)
Low-frequency cetaceans	219	183	199
Mid-frequency cetaceans	230	185	198
High-frequency cetaceans	202	155	173
Phocid pinnipeds in water	218	185	201
Otariid pinnipeds in water	232	203	219

A.3. Marine Mammal Frequency Weighting

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

A.3.1. Marine mammal frequency weighting functions

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

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-8)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016). Table A-2 lists the frequency-weighting parameters for each hearing group; Figure A-1 shows the resulting frequency-weighting curves.

Table A-2. Parameters for the auditory weighting functions recommended by NMFS (2016).

Hearing group	*a*	*b*	f_{lo} (Hz)	f_{hi} (Hz)	*K* (dB)
Low-frequency cetaceans	1.0	2	200	19,000	0.13
Mid-frequency cetaceans	1.6	2	8,800	110,000	1.20
High-frequency cetaceans	1.8	2	12,000	140,000	1.36
Phocid pinnipeds in water	1.0	2	1,900	30,000	0.75
Otariid pinnipeds in water	2.0	2	940	25,000	0.64

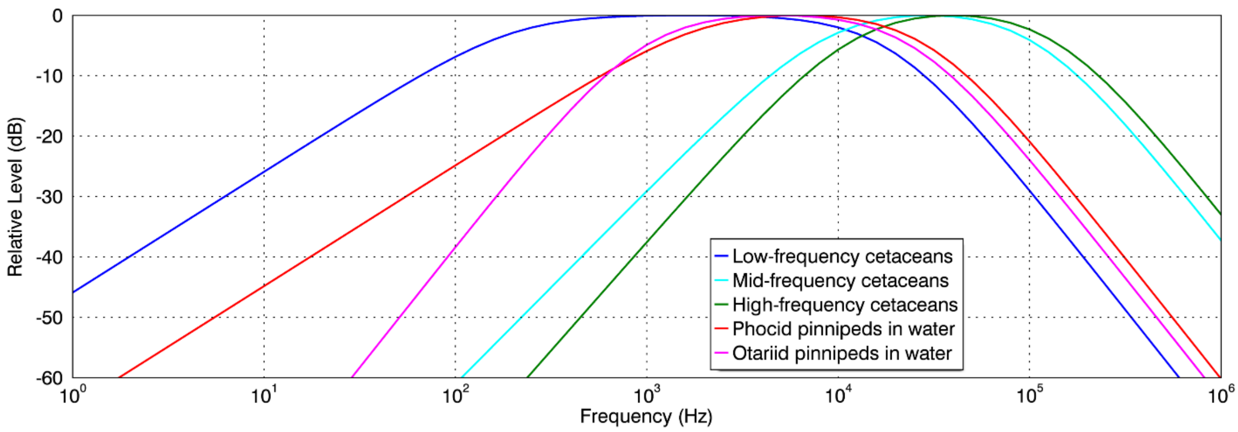


Figure A-1. Auditory weighting functions for functional marine mammal hearing groups as recommended by NMFS (2016).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model (AASM)

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the airgun array spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

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

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

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

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered a directional point source in the far field.

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

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda}, \qquad \text{(B-1)}$$

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

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

B.2. Array Source Levels and Directivity

Figure B-1 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signature and corresponding power spectrum levels for the 2380 in^3 array. The signatures consist of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 500 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the array, and correspond with the volumes and relative locations of the airguns to each other.

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-2); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.1.

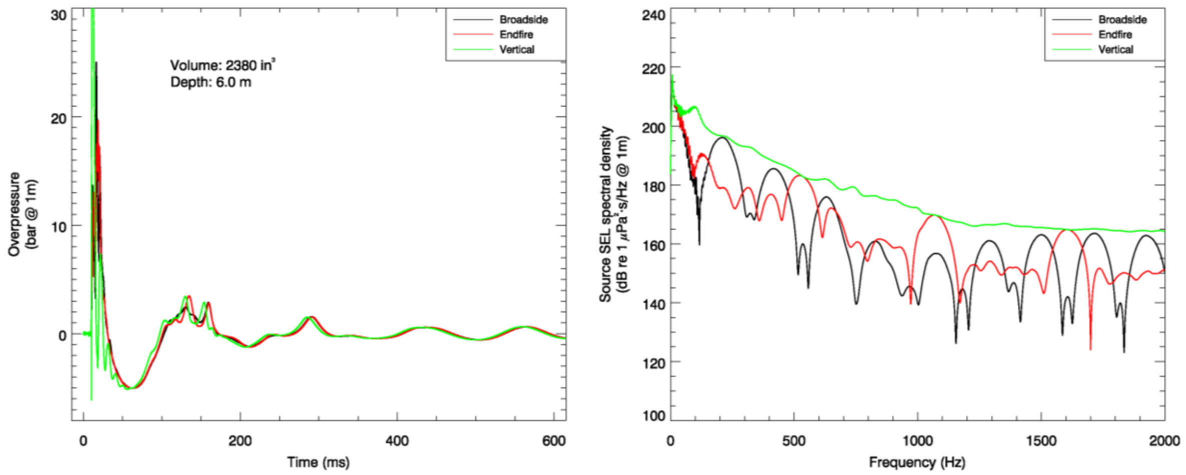


Figure B-1. Predicted source level details for the 2380 in^3 array towed at a depth of 6 m. (Left) the overpressure signature and (right) the power spectrum for broadside (perpendicular to tow direction) and endfire (directly aft of the array) directions, and for vertically down.

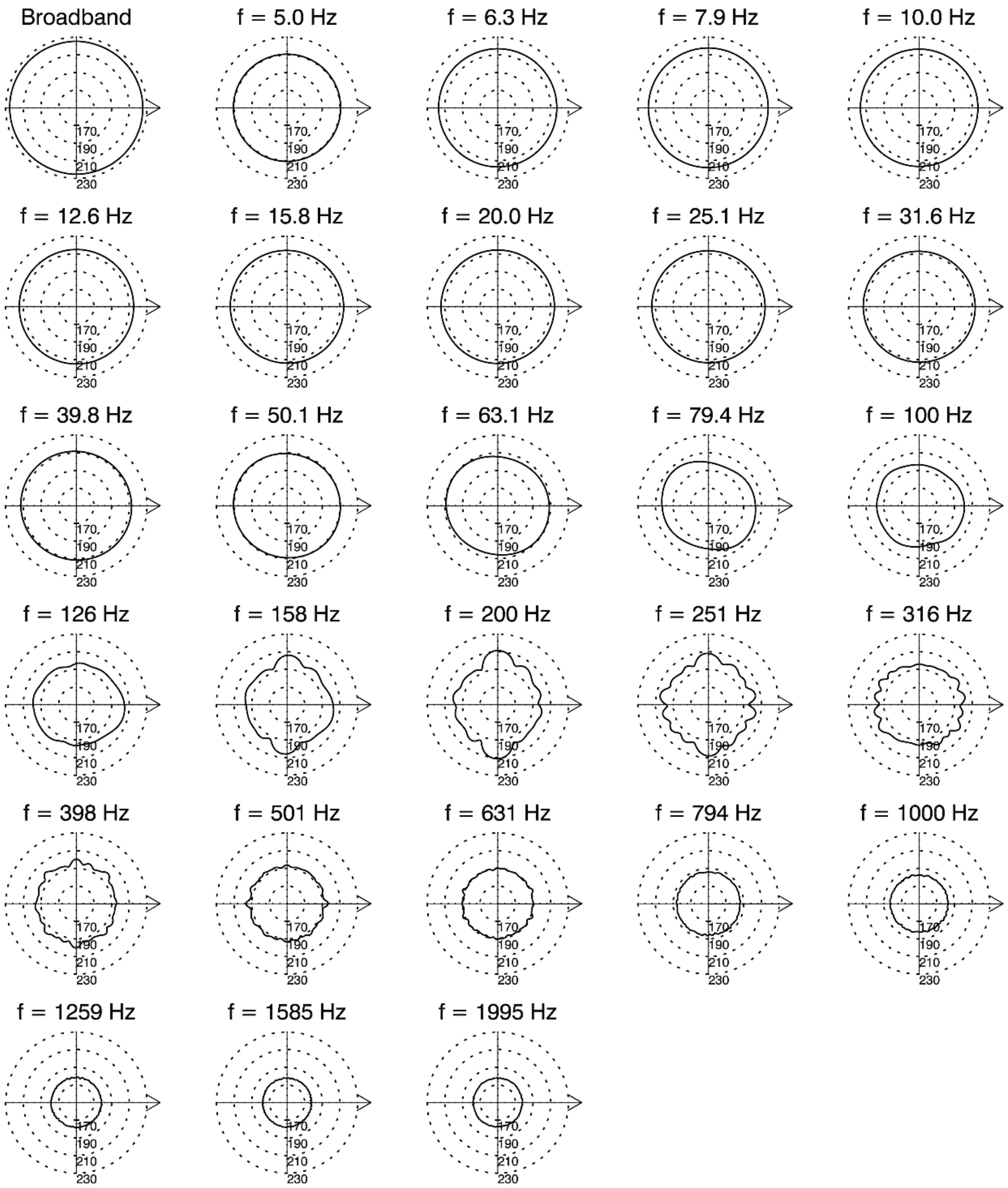


Figure B-2. Directionality of the predicted horizontal source levels for the 2380 in^3 array, 5 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. Tow depth is 6 m (see Figure B-1).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed, but is well suited for effective longer range estimation. This model computes sound propagation at frequencies of 5 Hz to 1.25 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies >1.25 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

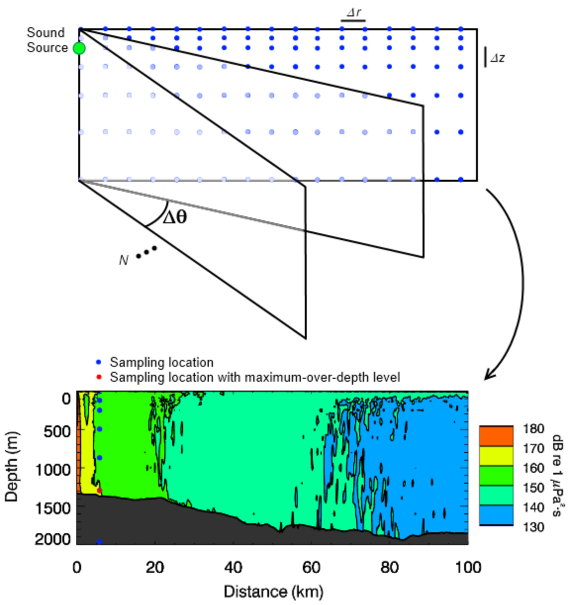


Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received 1/3-octave-band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SELs are presented as colour contours around the source.

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

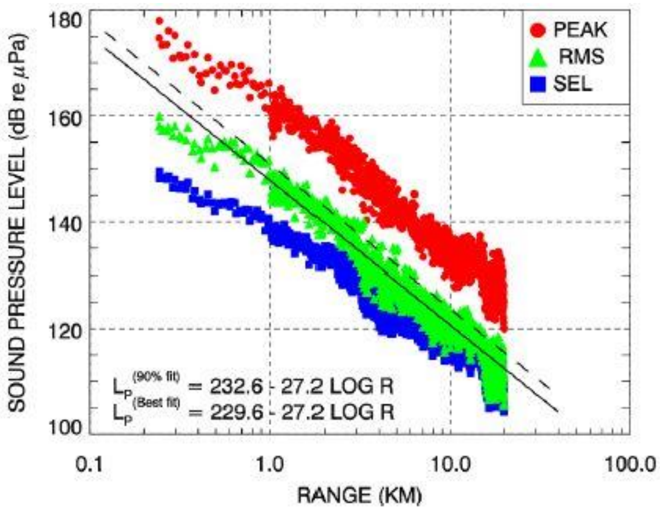


Figure C-2. Peak and SPL and per-pulse SEL versus range from a 20 in^3 airgun array. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

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

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

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

C.3. Wavenumber Integration Model

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

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

Appendix D. Methods and Parameters

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

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the seafloor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

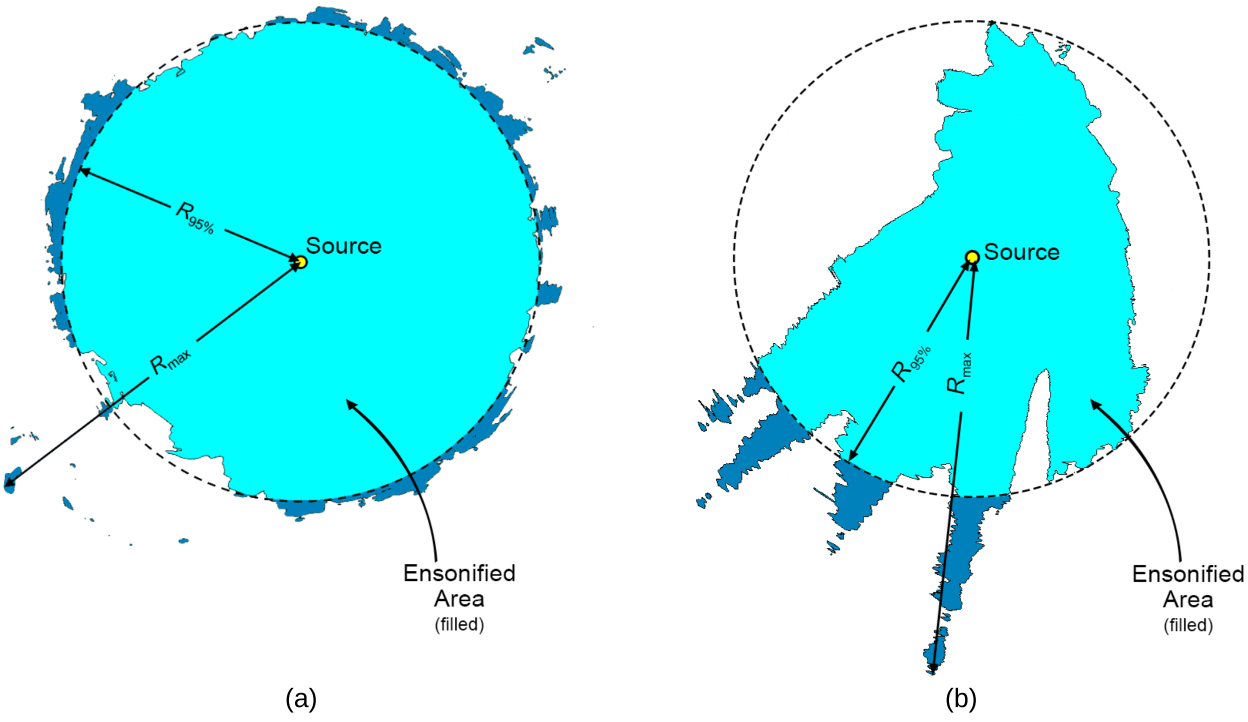


Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified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

D.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over the pulse's entire duration. The pulse SPL on the other hand is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms) (Appendix A), as implemented in Martin et al. (2017). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 5–2000 Hz. This was performed along broadside and endfire radials towards the deeper water depths to be conservative. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL -to-SPL offsets were averaged in 1 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range- dependent conversion function was applied to predicted per-pulse SEL results from MONM to model SPL values. Figure D-2 shows the conversion offsets for the two sites; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source.

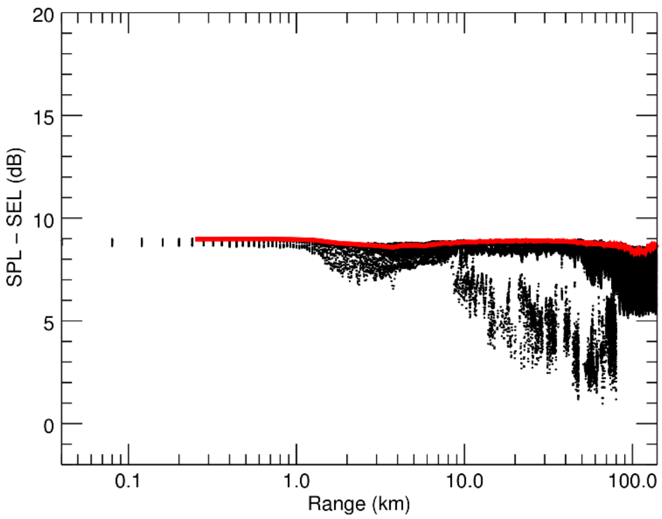


Figure D-2. Range-and-depth-dependent conversion offset for converting SEL to SPL for seismic pulses along the transects in the broadside and endfire directions toward deeper water. Slices are shown for the 3090 in^3 array modelled in McPherson and Li (2017) at Site 6. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid (~280 × 280 m at the studied latitude) rendered for Australian waters (Whiteway 2009) (Figure 1). Bathymetry data were extracted and re-gridded onto a Universal

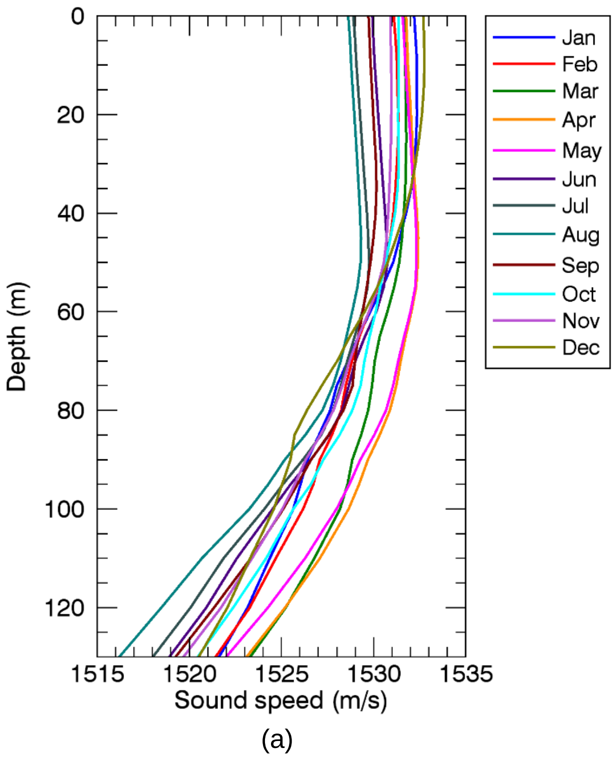
Transverse Mercator (UTM) coordinate projection (Zone 52 S) with a regular grid spacing of 100 × 100 m.

D.3.2. Sound speed profiles

The sound speed profile (SSP) for the modelled site was derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The temperature-salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles (Figure D-3). The July sound speed profile is expected to be most favourable to longer-range sound propagation, due to the increase in sound speed over depth. As such, this month was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds.

Because sound will propagate into the deeper waters near each site, additional GDEM profiles were also considered to ensure full water column coverage over the modelled region. The profiles used for modelling were taken from GDEM grid points in deeper portions of the modelled area, after checking that the alternate profiles agreed with the profiles at the source locations for the depths where the profiles overlap. The resulting profile used as input to the sound propagation modelling is shown in Figure D-3 b.



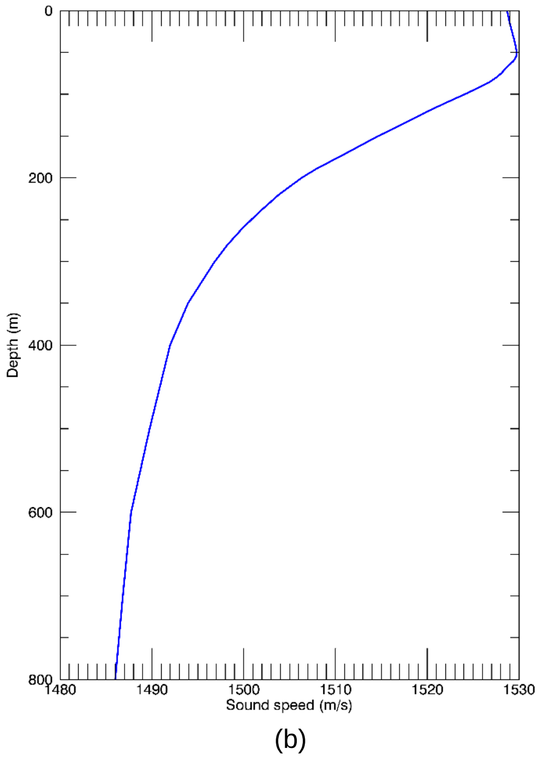


Figure D-3. (a) Monthly sound speed profiles for the survey region, (b) the July sound speed profile used for the modelling. Results are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

The modelling sites are located in the North West Marine Region of Australia (Baker et al. 2008), more specifically the middle shelf region, which is dominated by calcareous sand; the sand content of the sites is ≥80% for the survey area (Baker et al. 2008). Grain size distributions are spatially variable in the area. Overall sediment thicknesses are over 1 km (Whittaker et al. 2013). To provide precautionary estimates of underwater sound levels in the spatially heterogeneous environment, a simplified profile was constructed assuming increasingly consolidated sediment (Table D-1). Geoacoustic parameters were estimated from the sediment model of Buckingham (2005).

Table D-1. Geoacoustic profile used in the acoustic propagation models for Bethany survey area.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–10	Medium sand	1.96	1730–1933	0.60–1.20	350	3.65
10–20		1.97	1933–2042	1.20–1.45		
20–50		1.97–1.98	2042–2244	1.45–1.82		
50–100		1.98–2.00	2244–2456	1.82–2.10		
100–200		2.00–2.03	2456–2740	2.10–2.37		
200–500		2.03–2.10	2740–3254	2.37–2.70		
>500		2.10	3254	2.70		

D.4. Acoustic Source

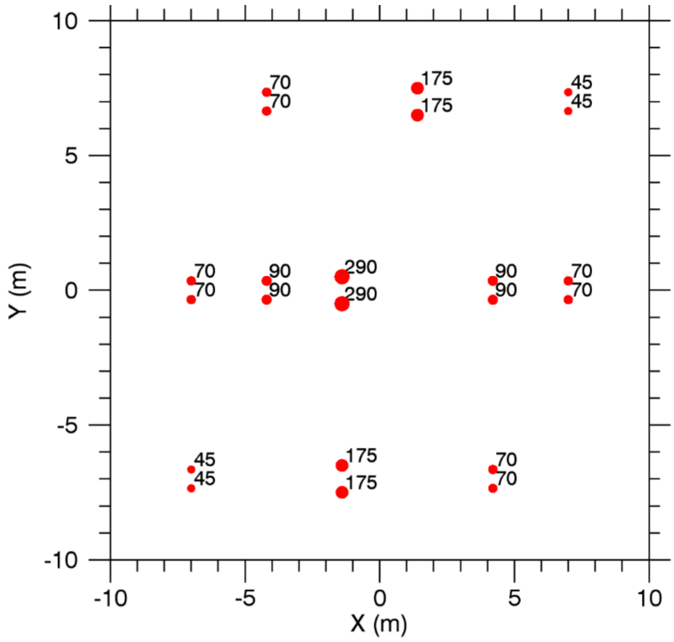


Figure D-4. Layout of the 2380 in^3 modelled airgun array. Tow depth is 6 m and dimensions are 11.2 × 15 m. The labels indicate the firing volume (in cubic inches) for each airgun. The tow direction is assumed to be in the positive *x* direction. Also see Table D-2.

Table D-2. Layout of the modelled 2380 in^3 airgun array. Tow depth is 6 m. Firing pressure for all guns is 2000 psi. The tow direction is assumed to be in the positive *x* direction. Also see Figure D-4.

Gun	*x* (m)	*y* (m)	Volume (in^3)	Gun	*x* (m)	*y* (m)	Volume (in^3)	Gun	*x* (m)	*y* (m)	Volume (in^3)
1	−4.2	7.35	70	7	−7	0.35	70	17	−7	−6.65	45
2	−4.2	6.65	70	8	−7	−0.35	70	18	−7	−7.35	45
3	1.4	7.5	175	9	−4.2	0.35	90	19	−1.4	−6.5	175
4	1.4	6.5	175	10	−4.2	−0.35	90	20	−1.4	−7.5	175
5	7	7.35	45	11	−1.4	0.5	290	21	4.2	−6.65	70
6	7	6.65	45	12	−1.4	−0.5	290	22	4.2	−7.35	70
-	-	-	-	13	4.2	0.35	90	-	-	-	-
-	-	-	-	14	4.2	−0.35	90	-	-	-	-
-	-	-	-	15	7	0.35	70	-	-	-	-
-	-	-	-	16	7	−0.35	70	-	-	-	-

D.5. Model Validation

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017). In addition, JASCO has conducted many seismic surveys, which have been internally validated (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016).

Appendix 4: Independent Peer Review Report

Potential for Impact of Cumulative Sound Exposure on Fishes During a Seismic Survey

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Environmental BioAcoustics, LLC
Silver Spring, Maryland, USA
February 24, 2018

Environmental BioAcoustics LLC was commissioned by Environmental Resources Management (ERM) to conduct an independent, expert peer review of aspects relating to concerns raised by stakeholders regarding impacts of cumulative seismic noise from the proposed Santos Bethany 3D seismic survey on fish, including TTS effects, and length of time for recovery and the applicability of an SEL_{24h} metric.

Inputs:

- seismic noise and fish impact assessment section from the Bethany Environment Plan;
- underwater noise modeling report and additional data extraction/analysis from JASCO; and
- the findings of relevant peer-reviewed scientific literature.

The review is based upon the best available science, with a focus on peer-reviewed scientific literature.[1]

As background, I (the author) have been working on various aspects of fish hearing and bioacoustics for over 50 years, (over 250 peer-reviewed publications) and has been investigating the effects of man-made sound on fishes and other aquatic life since the early 1990's. My laboratory at the University of Maryland (College Park, MD, USA - www.popperlab.umd.edu) has done a number of formative studies on effects of various sounds on fishes, including several studies on effects of seismic air guns (e.g., Popper et al. 2005; Popper et al. 2016b) and another loud impulsive source, pile driving (e.g., Halvorsen et al. 2012b; Halvorsen et al. 2012a; Casper et al. 2013a; Casper et al. 2017). I have also been involved in developing current guidelines for effects of man-made sound on fishes and turtles (Popper et al. 2014) and I am co-founder and organizer of a series of international meetings on effects of man-made sound on aquatic life (see www.an-2019.org) (Popper and Hawkins 2012; Popper and Hawkins 2016). I have consulted in the US and internationally on various aspects of sound and fishes. I am co-founder and editor of the Springer Handbook of Auditory Research (SHAR), a series of books (now close to 70) on various aspects of hearing. Finally, I am editor of *Acoustics Today* (www.acousticstoday.org), a scientific magazine of the Acoustical Society of America, the foremost scholarly group in the world for the study of all aspects of acoustics.

[1] Focus is on peer reviewed material since, as pointed out clearly by Popper and Hastings (2009), much of the non-peer reviewed literature on effects of sound on fishes lacks appropriate statistical analysis and/or controls. Thus, all such information needs to be carefully evaluated before use in any review or analysis.

Statement of Issue

Concern has been expressed that exposure to the sounds from a seismic source during offshore exploration for oil and gas may result in impairment of fishes, including (though not stated directly) temporary hearing loss in fishes that are in the region of the exploration.

Clearly, there is reason for interest in the potential impact of sound on fishes (Popper et al. 2014). However, as discussed in this document, the degree and duration of effects associated with seismic exploration is not likely to be of sufficient magnitude to result in the most serious concern for animals – a long-term decrease in fitness, and thus a decrease in survival and/or ability to reproduce. Moreover, the only likely effect of cumulative sound exposure (e.g., a level of TTS) may not, as a result of seismic exposure, even be detectable were it measured experimentally in the exposed fishes. Indeed, when one considers that most (if not all) fish species exposed to the sounds have relatively poor hearing (compared to fishes with hearing specializations, the majority of which appear to be found in fresh waters), and it takes sound intensities substantially above hearing threshold to start to induce TTS, the likelihood of there being detectable (and behaviorally significant) TTS, is probably low.

Should SEL be Accumulated over 24 Hours for the Bethany Survey?

One of the major concerns and discussion points raised by stakeholders has been the duration of time over which sound exposure should be accumulated in order to determine the total sound exposure level (SEL) that may result in impact on fishes. Their perspective appears to be that the population of animals is exposed to the high level of seismic sounds and so are constantly accumulating sound – therefore requiring modeling and assessment of SEL_{cum} of over 24 hours (and perhaps for the duration of the survey).

A much more appropriate perspective, however, is to consider every fish in the population, but individually, and ask about the signal received by each animal. In this case, what becomes apparent is that each individual is exposed to relatively "loud" sounds for a much shorter period of time and the exposure is only at levels that might lead to potential effects if the fish is relatively close to the sound source for an extended period of time.

This becomes apparent from an analysis of the JASCO modeling data, and the methodology of the Bethany 3D seismic survey (Figures 1 and 2). From these data, it is clear that the actual SEL_{cum}, in what we might call a worst case situation (the fish stays in one spot for the duration of an exposure), is for a period much less than 24 hours and requires an understanding of how SEL_{ss} accumulates to give the SEL_{cum}.

More specifically, if we assume a "worst case" scenario where a fish is 100 m from a line, the maximum SEL_{ss}, on closest approach of a vessel, is modeled to be about 188 dB re $1\mu Pa^2 \cdot s$ (Figure 1). When the vessel is at greater distances (both approaching and leaving the fish), the SEL_{ss} is considerably less (Figure 1, orange line). Since SEL_{ss} is added logarithmically to get the SEL_{cum}, as the number of sounds increases, the SEL_{cum} increases, but the level of increase will be small. Thus, the maximum contribution to the SEL_{cum} will be for the sounds at or near the closest point to the fish, and the sounds from greater distances will contribute far less to the SEL_{cum} (see blue line in Figure 1).

In the "worst case" scenario, it is clear that once maximum exposure is reached, subsequent exposure adds almost nothing to the cumulative SEL and that recovery from any impact is likely to start. From the perspective of the fish, the amount of sound added beyond the point of maximum exposure is at such a low level that it would not likely add to any effect.

The next exposure of the fish to a sound will be at least 3.5 hours later (after the seismic vessel has turned to a new line) and at a distance of about 5 km. Figure 2 shows that the SEL_{ss} for this exposure will be about 153 dB re 1$\mu Pa^2 \cdot s$ and the maximum SEL_{cum} about 177 dB re 1$\mu Pa^2 \cdot s$, which is well below the level suggested to be for onset of TTS by Popper et al. (2014) and below the level that resulted in TTS in Popper et al. (2005). Moreover, this is far below the level that results in onset of any tissue damage in fishes from an impulsive source (Halvorsen et al. 2012b).

Finally, if one assumes that the fish continues to remain stationary, then the next closest pass to the fish will be at least 48 hours later, but about 500 m further distance away from the stationary animal. Modeling suggests that the maximum SEL_{cum} in this case will be about 5 dB lower than the initial pass. However, by this time the fish would certainly have recovered from any effect, and any effect on hearing (TTS) would be considerably less than for the closest pass, and for even shorter duration.

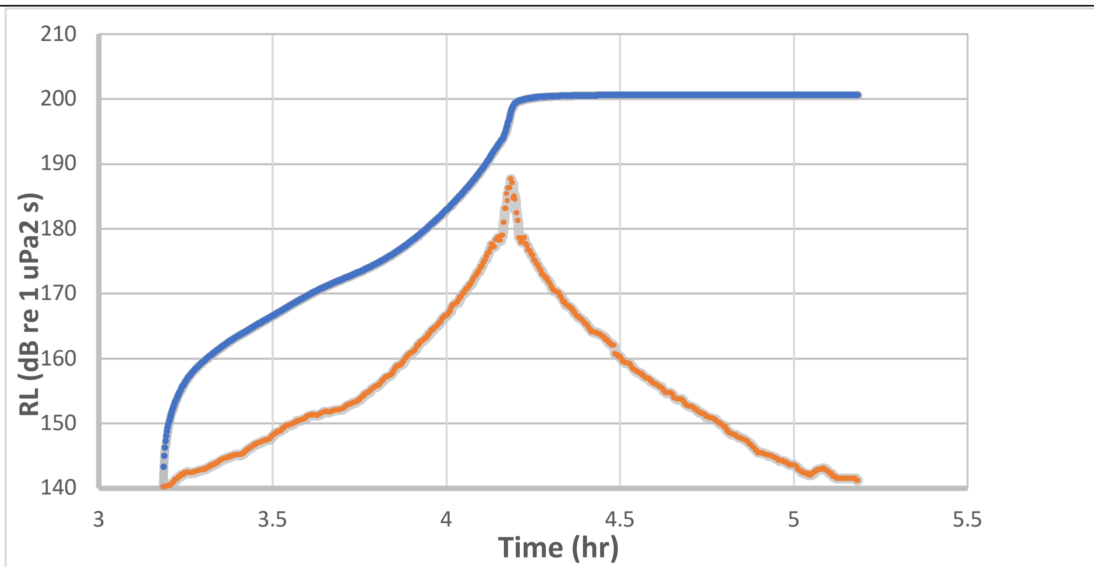

Figure 1: SEL_{ss} (orange) and SEL_{cum} (blue) to which a stationary fish would be exposed at a distance of 100 m from a seismic line over a period of two hours (one hour on either side of closest approach). The maximum SEL_{cum} does not increase once the seismic vessel has passed due to the additional exposure. Since the SELss declines by about 50 dB within an hour after maximum exposure, it is reasonable to assume that recovery from TTS is already underway. (Data provided by JASCO Feb. 19, 2018).

Of course, it must be recognized the previous situation is not likely unless a fish is restricted to a particular spot for behavioral reasons. A far more likely scenario recognizes that many fish species of interest move around, some over large distances. If one assumes that the fish can hear the sound of the seismic source (or the vessel towing it), it is reasonable to think that if the sound becomes too loud, the fish will move away from the source since they are able to determine the direction of a sound source (called sound source localization), just as can humans. If the sound gets loud and the fish moves away, the amount of energy to which it is exposed is likely to be one or a few seismic pulses, and these would not likely be loud enough to result in any effect since the fish would move away at a much lower level signal than could cause harm.

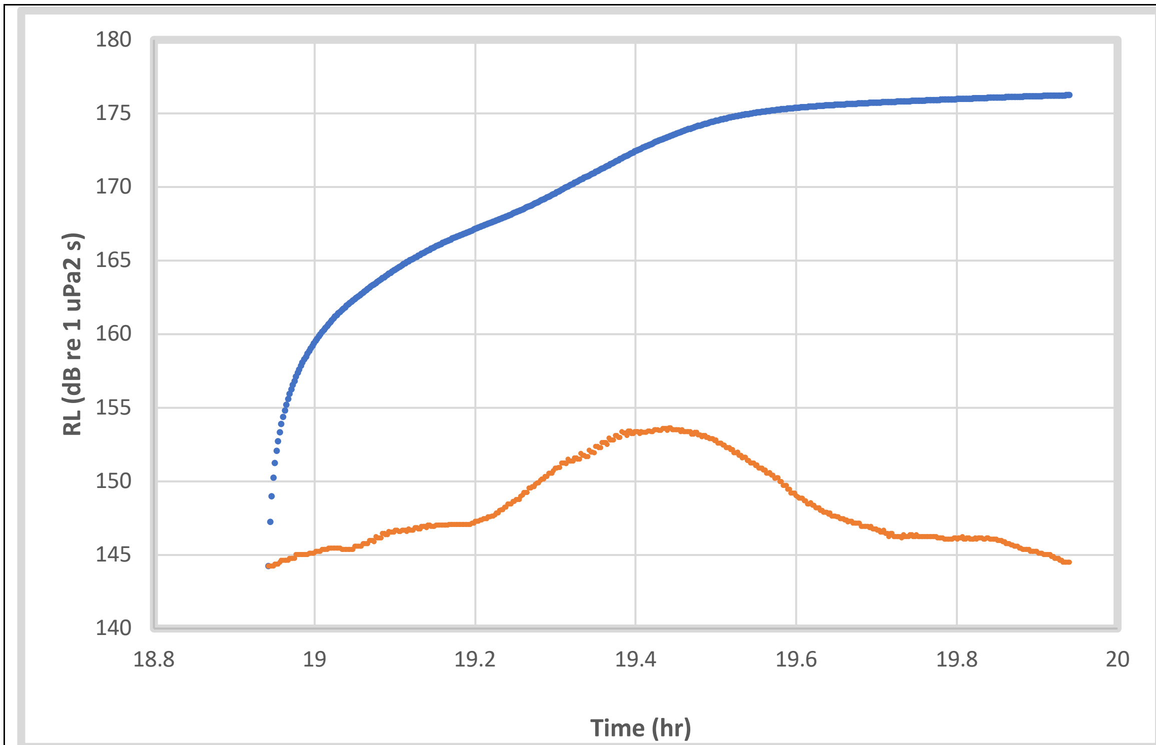

Figure 2: SEL_{ss} (orange) and SEL_{cum} (blue) to which a stationary fish would be exposed at a distance of 5 km (a second pass) from a seismic line over a period of 60 minutes (30 minutes on either side of closest approach). The SEL_{cum} assumes that there has been complete recovery from the first pass which would have been at 100 m from the seismic line. In this scenario, the SEL_{cum} would not exceed the guidelines for seismic exposure to produce TTS. (Data provided by JASCO Feb. 19, 2018).

Temporary Threshold Shift – One Potential Effect on Fishes

Of the potential impacts on fishes from exposure to sound, one of the most commonly discussed and most likely, is Temporary Threshold Shift (TTS), which is a temporary decrease in hearing sensitivity (Popper et al. 2014). TTS is generally thought to be a consequence of exposure to a loud sound and/or to a long-duration sound (e.g., Finneran 2015; Liberman 2016).[2]

[2] In contrast, Permanent Threshold Shift (PTS) is a permanent loss of hearing sensitivity. While PTS is common in humans and other mammals, often as a result of aging or exposure to loud sounds (or both), it has not been demonstrated in fishes. The basis of PTS is death of the sensory hair cells of the inner ear. While most animals, when they lose sensory hair cells, never get them repaired or replaced, fishes (and to a lesser degree amphibians and young birds) can regrow these important cells. Thus, if a fish loses sensory hair cells due to a loud sound, the cells are replaced within a few days and hearing returns to normal (e.g., Smith and Monroe 2016).

TTS has been most widely studied in mammals (including humans), and it has also been shown to take place in other vertebrates including birds (e.g., Saunders and Salvi 2008; Dooling et al. 2015) and fishes (e.g., Scholik and Yan 2002; Smith and Monroe 2016). During TTS, sounds have to be louder than normal to be detected. The consequences of TTS for fishes is that it has a potential to result in temporary poorer detection of biologically relevant sounds including the sounds of potential mates, predators, prey, etc. In all cases, TTS appears to be the result of temporary damage to the sensory hair cells of the inner ear or to the innervating nerves that carry the signals from the ear to the brain (e.g., Smith et al. 2006; Dooling et al. 2008; Liberman 2016).

The relationship between sound duration and sound intensity and the degree and duration of TTS varies considerably and may depend on the hearing sensitivity of the listener, the frequency of the sound, whether the sound is continuous or intermittent, and many other factors (For futher consideration see, for example, Finneran 2015; Ryan et al. 2016). In general, a louder sound may result in more TTS (sensitivity change and/or duration) than would exposure to a less intense version of the same sound. Similarly, there may be more TTS as a result of longer exposure than to a shorter exposure of the same sound. If a TTS-producing sound is intermittent (as is the pulse from a seismic survey), then there may be recovery from TTS between exposures so that the effects of multiple exposures to the same sound might be less when there are long vs. short gaps (assuming time for exposure to the actual sound is the same) (e.g., Finneran et al. 2010; Kastelein et al. 2016).

Much less is known about TTS in fishes since only a few studies have been done, and these have been on just a very few species (see Smith and Monroe 2016 for an excellent comprehensive review). While extrapolation of the general findings to other fish species must be made with the greatest of caution, there is evidence, based on limited data, that TTS will not start to show up in fishes until the intensity of the sound is well above the fish's hearing threshold (the lowest sound level that can be detected at a particular frequency), and perhaps even above the sound level where some physical or physiological effects take place (Casper et al. 2013b). Thus, a fish with poor hearing sensitivity (e.g., a salmonid) may not show TTS until a sound is far louder that it would need to be to induce TTS in a fish with better hearing sensitivity (e.g., goldfish or catfish).

How Much TTS Might be Expected for Bethany Fishes?

An important question is whether TTS will even occur in fishes as a result of the Bethany 3D survey. Data on TTS for fishes are very limited. The first study on effects of seismic sounds on fish hearing, and the only one to look at recovery, was done by Popper et al. (2005). In that study, three species were exposed to seismic shots. The fact that this was done in a river with caged animals, and not during a 3D seismic survey, is not, for the purposes of this analysis, of consequence.[3] Indeed, had the fishes studied been free-swimming, it is likely that there would

[3] The stakeholders raised the issue that one cannot extrapolate from the 1.9 m deep river (Popper et al. 2005 study) to greater depths in the Bethany survey area. In fact, that is an incorrect assumption in terms of acoustic exposure since the riverine study looked at the received level of signal at the fish. The received level has nothing to do with water depth or anything else – it is the level to which the fish is exposed!

have been no effect whatsoever since they are likely to have moved away from the source as it started to approach them (much as is likely to be the case for fishes in the Bethany survey area that normally move around).

Of the three species tested by Popper et al. (2005), the lake chub (*Couesius plumbeus*), a fish with excellent hearing, showed most TTS. A salmonid, the broad whitefish (*Coregonus nasus*), showed no TTS. The data showed TTS for adult, *but not juvenile*, northern pike (*Esox lucius*). When we did this study we were perplexed by the adult northern pike data since this is a species that does not hear as well as the lake chub and has no specializations that could be expected to enhance hearing (Mann et al. 2007), and the results remain unexplained.

The other study that looked at TTS post seismic exposure was done on several reef species following seismic exposure (in cages) at Scott Reef (Australia) (Hastings et al. 2008; Hastings and Miksis-Olds 2012). The investigators reported no TTS in any species, including several that had hearing specializations, even when the cumulative SEL was as high as 190 dB re $1\mu Pa^2 \cdot s$.

Studies with other types of sounds, none of which were impulsive, primarily showed TTS in species with hearing specializations, although a few studies also show a small level of TTS in fishes without specializations (reviewed in Smith and Monroe 2016). However, since the sound spectrum and duration of all of these studies were different from impulsive stimuli, extrapolation in terms of recovery is not possible.

Moreover, since each TTS study was done differently in most every way (e.g., sound source, how sound presented, duration, intensity, species) it is not possible, at this stage of our knowledge, to generalize about likely TTS in any species. What is possibly true is that fishes with hearing specializations, such as lake chub and goldfish, are much more likely to show TTS at lower sound exposure levels than fishes without specializations. This suggestion is based on the findings of Smith and colleagues (Smith et al. 2006; Smith et al. 2011) that suggests that the amount of TTS (and even whether it occurs) depends upon the level of the exposure sound above the hearing threshold of the species. Thus, if the exposure level is 200 dB and the threshold 140 dB, it is more likely to cause TTS than if the threshold of the fish is only 30 dB below the seismic signal e.g., 170 dB).

The point is that even if one is concerned about TTS in fishes in the Bethany survey area (or other marine fishes) as a result of seismic exploration, the preponderance of the data (albeit limited) leads to the suggestion that TTS is not likely to occur since the signal will not be very much above threshold for the bulk of fishes since they have no hearing specializations. And, even if there is TTS, the amount of TTS is likely to be limited.

Indeed, a very critical issue to consider is *how much* TTS might result in temporary effects on some aspect of fish behavior. One problem in determining this is that there is normal variation in hearing sensitivity in all animals over even short periods of time. Recognizing this, in developing guidelines for potential effects of sound on fishes, it was agreed that a minimum of 6 dB change would be required to suggest that TTS may have taken place (Popper et al. 2014). However, this is a very conservative value, and current standards for TTS in humans in the US state that there must be a change in sensitivity of at least 10 dB to suggest any hearing substantive hearing changes (Ryan et al. 2016).

Thus, even if it were shown that fishes within the Bethany 3D survey area had a change in hearing sensitivity, unless the change were very substantial, it would be impossible to know if the change is normal variation (including due to the experimental paradigm measuring hearing) or actually a result of seismic exposure.

Evidence from Other Impulsive Sources

An additional potentially instructive study is work done in my laboratory on the effects of another very intense impulsive sound source – pile driving. While the signals from seismic air guns and pile driving are not identical, they are similar enough to allow (cautious) comparison. Our study (Casper et al. 2013b) examined the effects on the ear of 960 replicated pile strikes presented at a SEL_{cum} of 210, 213, or 216 dB re $1\mu Pa^2\cdot s$. The results showed damage to sensory hair cells of the inner ear, something that is strongly correlated with the presence of TTS (Smith et al. 2006; Smith et al. 2011), only at the highest SEL_{cum} in hybrid striped bass, and there was no inner ear damage in tilapia (neither species is thought to have any specializations that enhances hearing). Significantly, both species showed damage to other body tissues at the lower sound exposure levels.

These results, which come from exposure to 960 strikes in 8 minutes (one strike every 1.5 seconds) is roughly equivalent to the exposure that fish exposed to seismic activity would receive in two hours at about 12.5 second intervals (Figure 1, 988 pulses). The results suggest (again, being very cautious since the sources are somewhat different) that TTS, in at least the two species studied, would not occur until the cumulative sound exposure level is substantially higher than any fish would encounter in the Bethany survey area, even if there is no recovery from TTS.

Effects of Seismic Exposure on Marine Mammals

Equally instructive may be a study of TTS to bottlenose dolphins (*Tursiops truncatus*) subject to signals from a seismic airgun (Finneran et al. 2015). In this investigation, three animals were subject to 10 impulses with an SEL_{cum} of 193 to 195 dB re $1\mu Pa^2\cdot s$ and no TTS was found.[4] While the overall ear structure of dolphins is different from that of fishes, the same sensory structure, the sensory hair cell, is present in both and TTS is correlated with damage to these sensory cells (as discussed above). Thus, while the mechanism by which signals get to the sensory hair cells differ substantially, the fact that the hair cells in dolphins are not impacted by seismic impulses suggests that the same might be the case in fishes.

Potential for Physical Effects

While highly unlikely, there is the potential for concern that exposure to seismic sounds may result in physical or physiological effects on fishes. This could potentially result in mortality

[4] Due to animal welfare considerations, greater exposure would not be allowed.

either directly or over some period of time after exposure. There are, however, no peer-reviewed data that demonstrates such effects though one can hypothesize that a fish very close (a few meters, perhaps) of a source could be harmed since, as the JASCO report shows, source levels are very high (though there are no such data). At the same time, several studies that have examined fishes physically after exposure to seismic sources have not shown tissue damage (Popper et al. 2005; Song et al. 2008; McCauley and Kent 2012; Popper et al. 2016a), though one study, that has not been replicated, showed inner ear damage (McCauley et al. 2003) and another is suggestive of some ear damage, but with few, and not statistically acceptable, data (McCauley and Kent 2012).

At the same time, there is some evidence that the sound levels to which fishes will be exposed in the Bethany 3D study are well below those that would result in physical damage to fishes. These data are from studies on the effects of pile driving on five morphologically different fish species (e.g., Halvorsen et al. 2012b; Halvorsen et al. 2012a; Casper et al. 2013a; Casper et al. 2013b; Casper et al. 2017). While the signals from pile driving and seismic air guns have some differences, they are similar in that both are short, impulsive, have rapid rise times, and are primarily low frequency.

The pile driving studies exposed fishes to either 960 or 1920 strikes (equivalent to the name number of seismic pulses) with SEL_{ss} that equals or exceeds the highest levels a fish would encounter in the Bethany survey unless it was very close to the source. The results show that there was no onset of physical damage until the SEL_{cum} was 207 to 210 dB re $1\mu Pa^2 \cdot s$ (depending on the species) and these were all recoverable injuries (e.g., mild hematoma) and it was not until the SEL_{cum} was 6-9 dB greater that potential mortal injuries showed up. In the pile driving studies, the SEL_{ss} for individual strikes were generally higher than in the proposed seismic study, and the strikes were presented at about 1.5 sec. intervals as compared to 12.5 sec. in the seismic survey. This means that not only would there be recovery from any physical injury (if it occurred) after the cessation of the loudest sound in the seismic study, but that there likely be enough time between pulses to result in some recovery, unlike in the pile driving work.

Conclusions

- The time over which energy should be accumulated in each individual fish in the survey area should be limited to the time over which fishes get maximum exposure. Thus, 24 hours is likely far too long a period for calculation of accumulation of energy in determining potential harm (e.g., damage or TTS). There is no scientific basis for longer periods than 24 hours!
- It is highly unlikely that there would be physical damage to fishes as a result of the survey unless the animals are very close to the source (perhaps within a few meters).
- The most likely effect (if any) to fishes resulting from cumulative sound exposure is temporary threshold shift (TTS). However:
    - Most fishes in the Bethany region, being species that do not have hearing specializations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey.

- If TTS does take place, the duration of exposure to the most intense sounds that could result in TTS will be over just a few hours. Thus, accumulation of energy over longer periods than a few hours is probably not appropriate.
- If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity.
- Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.

- Nothing is known about the behavioral implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of its having a significant impact on fish fitness is very low.

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