



Forge Multi-Client 3D Marine Seismic Survey

Environment Plan Summary

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PGS Australia Pty Ltd

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## 1 INTRODUCTION

### 1.1 Scope

The scope of this Environment Plan (EP) covers 3D seismic data acquisition activities within a defined operational area, known as the Forge Multi-Client 3D Marine Seismic Survey (MSS) (the 'survey') to be undertaken by PGS Australia Ltd (PGS). Activities include full fold data acquisition and ancillary activities including line run ins/outs, soft start procedures and line turns. Data acquisition will occur in phases over a 10 month period between 1<sup>st</sup> November 2015 and 31<sup>st</sup> December 2016. This EP does not cover transfer of the survey or support vessels to and from the operational area as they will fall under normal maritime requirements.

This EP, as accepted by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), is a legally binding document between NOPSEMA, as the Regulator under the Environment Regulations, and PGS, setting out the performance outcomes, standards and criteria against which compliance and environmental performance will be monitored.

## 2 DESCRIPTION OF THE ACTIVITY

### 2.1 Location of the Activity

Data acquisition will occur within the operational area, which covers approximately 58,166 km<sup>2</sup> (Figure 2-1). The operational area is defined as the area within which data acquisition and associated vessel operations (line run-ins and run-outs, soft-starts and line turns) may occur. For the purpose of this survey PGS will obtain the relevant special prospecting authority (SPA) and Authority Access (AAs) to enable PGS to assume the role of the titleholder for the survey. The operational area is located solely in Commonwealth waters adjacent to Western Australia.

At its closest point, the survey area is 6 km from the nearest land (Browse and Cartier Islands), 40 km from the nearest mainland shoreline on the West Australian (WA) coast, 160 km north of Cape Leveque and 253 km north of Derby. Water depths in the survey area are in the range of -5 to 461 m.

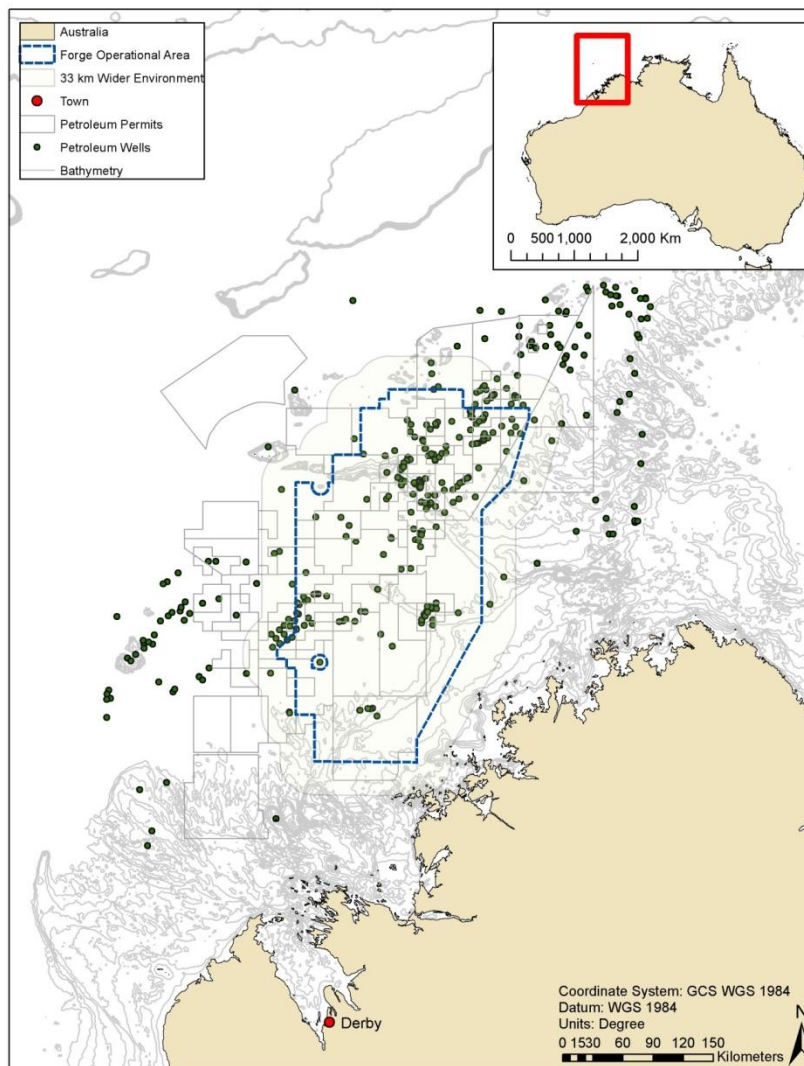


Figure 2-1: Location of the operational area



## 2.2 Timing and Duration of the Activity

The survey will occur in two seasons totalling 10 months over a period between 1<sup>st</sup> November 2015 and 31<sup>st</sup> December 2016. The first season will run from November 1<sup>st</sup> 2015 to June 30<sup>th</sup> 2016, and the second season will run from November 1<sup>st</sup> 2016 to December 31<sup>st</sup> 2016. Seismic acquisition will not be occurring throughout the entire seasonal periods as it is dependent on PGS' client requirements and optimal weather windows. Additional temporal exclusion zones will apply as described in section 2.1.

## 2.3 Seismic Programme

### 2.3.1 Survey Parameters

The marine seismic survey proposed is a conventional 3D survey similar to most others conducted in Australian waters in terms of technical methods and procedures. No unique or unusual equipment or operations are proposed. The survey will be conducted using a purpose built seismic vessel.

Up to two survey vessels will traverse a series of pre-determined sail lines within the operational area at a speed of approximately 8-9 km/hr. As the vessels travel along the sail lines a series of sound pulses (approximately every 10 seconds) will be directed down through the water column and seabed. The sound is attenuated and reflected at geological boundaries and the reflected signals are detected using sensitive pressure and velocity sensors arranged along a number of cables (streamers) towed behind the survey vessels. The reflected sound is then processed to provide information about the structure and composition of geological formations below the seabed in an attempt to identify potential hydrocarbon reservoirs.

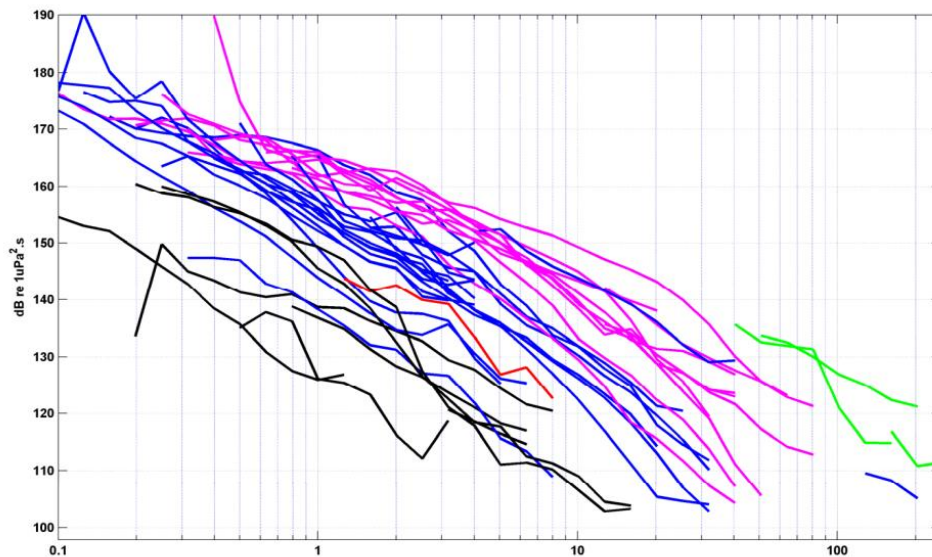
PGS has designed the 4,130 cui source array to meet several criteria regarding operational stability, predictable behavior, and fit-for-purpose subsurface seismic imaging (vertical focus). In contrast to some historically much larger arrays, the 4,130 cui array is able to use only three sub-arrays to yield acoustic output that is close to being azimuthally symmetric (resulting in low horizontal power output), minimizes bubble energy, and minimizes in-sea maintenance and handling risks.

Table 2-1: Intended survey acquisition parameters

Parameter	Value
No. of streamers	14-16
Streamers length	8.5 km
Streamers spacing	75 – 120 m
Streamer depth	15 - 25 m
Intended size of seismic energy source array	4,130 cui
Operating pressure	2000 psi
Shotpoint interval	18.75 m
Theoretical sound exposure level (SEL)	~229 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
Frequency range	~ 1- 210 Hz

A 4,130 cubic inch (cui) array has been modelled by Curtin University Centre for Marine Science and Technology (CMST) to produce a sound energy level of 229dB re 1 $\mu$ Pa<sup>2</sup>.s @ 1m (the maximum sound exposure level (SEL) expected for the proposed Forge 3D MSS) (BP, 2011) at frequencies extending up to approximately 200 Hz. These sound pulses decrease to levels in the order of 200 dB re 1 $\mu$ Pa (SPL) within 1 km of the source and approximately 150 dB re 1 $\mu$ Pa (SPL) within 10 km, dependent on the sound propagation characteristics of the area. Empirical measurements of a number of seismic sources in western and southern Australian waters that are indicative of the proposed survey parameters show that sound exposure levels produced from arrays between 3,000 and 4,000 cui, are reduced to at least 150 dB re 1 $\mu$ Pa<sup>2</sup>.s within 10 km (Figure 2-2).

The attenuation rate of a sound wave is dependent on both its frequency and the local conditions such as water temperature, water depth and sea bottom sediments. .



All air gun measures where received levels for a given survey have been averaged in log spaced range bins and presented as the mean value/bin +95% confidence limit. The black curves are arrays or single components of <1,000 cui capacity; the red curve is array of 1,000-2,000 cui; the blue curves 2,000-3,000 cui and the magenta curves 3,000-4,000 cui. Source: CMST Curtin University, CMST (2013) report

Figure 2-2: Sound exposure level (SEL) decay curves for a number of different seismic sources in western and southern Australian waters

## 2.4 Vessels

### 2.4.1 Seismic survey vessels

Up to two purpose built seismic survey vessels from PGS's fleet will be used throughout the survey, possibly simultaneously. Since the exact vessels to be used have not yet been confirmed at the time of submission of the EP, the largest vessel (with the largest tank size) of the fleet, the Ramform Titan, has been used in the risk assessment (Section 5) on the basis that any other vessel selected will have lesser impacts, thus providing a conservative worst case assessment basis.





## 2.4.2 Support vessels

One or more vessels will accompany each survey vessel to maintain a safe distance between the seismic array and other vessels and manage interactions with shipping and fishing activities if required. The support vessels are yet to be confirmed, however, they will use marine diesel only and will be of smaller size compared to the proposed survey vessels.

## 2.4.3 Cumulative impacts of two simultaneously operating seismic vessels

The simultaneous operation of more than one seismic vessel in the area or the repeated use of seismic airguns over the same location, may lead to increased cumulative noise energy that could increase risk of impacts to marine fauna, particularly from underwater noise.

Given the size of the operational area and intended survey period, two survey vessels may be used at various times to allow for efficient data acquisition in optimum periods. PGS is also aware of another seismic survey proposed within the Forge survey area and timeframe. To avoid cumulative noise impacts to the environment and noise interference and data corruption due to two simultaneously operating seismic sources, a minimum separation buffer zone of 30 km will be maintained to reduce sound exposure levels to below levels that could cause physical or behavioral impacts to sensitive marine receptors.

## 2.5 Survey Logistics

Depending on the duration of possible survey phases, the survey vessel(s) may need to be refueled at sea using the support vessel either within or immediately adjacent to the operational area.

Support vessels will be used to provide the survey vessel with logistical supplies. It is intended to use helicopters for crew changes, but support vessels may also be used. Support vessels and helicopters may also be required to assist in HSE and operational emergencies as required.

### 3 DESCRIPTION OF THE ENVIRONMENT

The proposed operational area lies entirely in Commonwealth marine waters of the North West Marine Region (NWMR) in the Browse Basin covering water depths between approximately 5 m to 461 m; however acquisition will only occur in greater than 39 m chart depth.

Sensitive receptors of the wider environment may be impacted by planned and unplanned events within and outside the operational area. Planned events include elevated noise levels from seismic discharges and unplanned events include a worst case hydrocarbon spill scenario: a marine diesel spill as a result of a fuel tank rupture.

The maximum credible extent of a surface slick was modelled for a potential unmitigated hydrocarbon spill caused by a fuel tank rupture and was estimated to extend a maximum of 33 km outside the operational area boundary (Section 5.6.3).

Underwater sound exposure levels from the source array are expected to reduce to below levels that may cause behavioural disturbance to marine fauna of 160 dB re 1 $\mu$ Pa<sup>2</sup>.s (DEWHA 2008) within 10 km. Since the area potentially being impacted by a spill (33 km) is greater than the area that noise emissions may potentially cause behavioural disturbance (DEWHA 2008), when describing the environmental values and sensitivities of the 'wider environment', a 33 km buffer around the operational area was employed.

#### 3.1 Physical Environment

##### 3.1.1 Climate and Meteorology

The surface waters of the bioregion are tropical year-round, with summer sea surface temperatures around 30°C, and winter temperatures around 25°C. South-east trade winds are prevalent from April to September. From May to August the winds average 3 to 8 m/s; however winds stronger than 8 m/s are not uncommon.

The North-west or West Monsoons prevail from December to March and are associated with prominent cloud, rain and thunderstorm activity. Cyclones may occur between December and April. Typically, cyclones move south-west across the Arafura and Timor Seas. Gale to hurricane force winds are liable to be encountered over an area between about 32 and 240 km wide. The Kimberley system is subject to episodic offshore cyclonic activity. Cyclones tend to generate offshore and move south, rarely crossing the coast until they reach the Pilbara region. They can contribute to mixing of water layers as well as play an important role in the dispersal of sediments and species (DEWHA, 2007).

##### 3.1.2 Oceanography

Average swell heights are low, around 0.4–0.6 m in all months. The greatest exposure to swells is from the west (SSE, 1993). Tropical cyclones have generated significant swell heights of up to 5 m in this area, although the predicted frequency of swells exceeding 2 m is less than 5% (WNI, 1996).

Four major water masses or currents influence the oceanography of the NWMR (DEWHA, 2007), these are:

- South Equatorial Current;
- The Indonesian Throughflow (ITF);
- Eastern Gyral Current; and

- Leeuwin Current.

Data from the region shows that currents have historical prevailing directional trends that are summarised in Table 3-1 below (APASA 2012).

Table 3-1: Predicted general prevailing current trends within the operational area

Month	Assumed Prevailing Current Heading
Jan	NE
Feb	NE
Mar	SW
Apr	SW
May	SW
Jun	SW/SSW
Jul	SW/SSW
Aug	SW/SSW
Sep	Variable
Oct	Variable
Nov	Variable
Dec	NE

*Note that seasons and months are as defined by the BOM (2015). Assumed prevailing currents are from APASA (2012).*

### 3.1.3 Geomorphology and Sedimentology

The regional sedimentology is dominated by marine carbonates as a result of the NWMR receiving little terrigenous input throughout its evolution. On average, 60% of the sediments in the Region are carbonate derived. The highest carbonate contents occur on the shelf, including areas associated with reefs and algal banks. The deepest areas of the abyssal plain/deep ocean are muddy, and any potential particulate carbonate content would have been removed through dissolution as it sank beneath the carbonate compensation depth (DEWHA, 2007).

There a number of reefs and islands in the Kimberley system of the NWMR within and adjacent to the Forge 3D MSS operational area:

- Scott Reef and Seringapatam Reef located ~127 km and ~124 km west of the operational area, respectively. These reefs occur on the upper continental slope in water depths of 500–1,500 m. These reefs are designated as Key Ecological Features (KEF) of the NWMR.

- Adele Island, located ~67 km south-west of the operational area. Adele Island is built on a coralline platform reef, and extensive coral reefs surround the island. It is also an important seabird nesting and roosting location.
- Browse Island, located within the south-east of the operational area. Browse Island is an important green turtle and seabird nesting site. It is surrounded by extensive coral reefs. The island is a WA Class 'C' Nature Reserve vested with the Conservation Commission and managed by the WA Department of Environment and Conservation (DEC), and an International Union for Conservation of Nature (IUCN) Category 1A protected area.
- Cartier Island, located within the operational area boundary in the North West, is an unvegetated 44.5 hectare (ha) sand cay surrounded by a wide platform and fringing coral reef, located 350 km off Western Australia's Kimberley coast. Cartier Island Marine Nature Reserve comprises a reef system and its surrounding waters and covers an area within a four nautical mile radius of the centre of the island. The reserve is categorised as an IUCN Category 1A protected area and designated as a KEF for the NWMR.
- Ashmore Reef located ~30 km North West of the operational area. The reef covers an area of 150 km<sup>2</sup> containing lagoons, intertidal flats, sandbanks and limestone platform and vegetated sandy cays. The reef is declared a National Nature Reserve based on its significance as a major province of Western Australia coral reef. It also provides an important habitat for migratory seabirds, and a feeding and breeding habitat for marine turtles. Listed KEF for the NWMR.
- A number of shallow submerged features (shoals) are present in the north east of the operational area. Others may be present in the area but have not yet been identified in published literature. The shoals present within the survey area rise steeply from the seabed to shallow depths (~16 m or more). As such these shoals all have the potential to support photosynthetic organisms and primary production due to water clarity and adequate light penetration at the depths of the shoal plateaus (Heyward et al., 2011). Depth profiles of the shoals are provided in Figure 3-1 and are further discussed in section 3.3.

## 3.2 Biological Environment

### 3.2.1 Biological Productivity

The operational area lies within the NWMR. The area potentially impacted by planned and unplanned events during the activity covers four bioregions; the Northwest Shelf Province, the Northwest Transition, the Northwest Shelf Transition and The Timor Province.

Overall, the region is thought to have low productivity, with increased productivity associated with ephemeral events, such as topographically induced water movement around geomorphic features (i.e. coral reefs, canyon heads), therefore causing some mixing of the water column. The islands and reefs are a key biodiversity focal point in this region.

### 3.2.2 Key Ecological Features and Protected Areas

A summary of the Commonwealth Marine Reserves (CMR), Marine Parks and KEFs overlapping with the operational area and the wider environment potentially impacted by unplanned events is given in Table 3-2 below.

Table 3-2: Summary of Protected Areas and KEFs of the operational area and the nearby region



Feature	Survey area	Wider environment
Commonwealth Marine Reserves (CMR)	<ul style="list-style-type: none"> <li>• Kimberley                             <ul style="list-style-type: none"> <li>➤ IUCN VI Multiple Use Zone</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Ashmore Reef (~25 km NW)                             <ul style="list-style-type: none"> <li>➤ IUCN II Recreational Use Zone</li> <li>➤ IUCN IA Sanctuary Zone</li> </ul> </li> <li>• Cartier Island (Overlap)                             <ul style="list-style-type: none"> <li>➤ IUCN IA Sanctuary Zone</li> </ul> </li> <li>• Kimberley (Overlap)                             <ul style="list-style-type: none"> <li>➤ IUCN II Marine National Park Zone</li> <li>➤ IUCN VI Multiple Use Zone</li> </ul> </li> </ul>
State Marine Parks	<ul style="list-style-type: none"> <li>• None</li> </ul>	<ul style="list-style-type: none"> <li>• Camden Sound (Lalang-garram) Marine Park (Overlap)</li> </ul>
Key Ecological Features (KEFs)	<ul style="list-style-type: none"> <li>• Ancient coastline at 125 m depth contour</li> <li>• Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters</li> <li>• Carbonate bank and terrace system of the Sahul Shelf</li> <li>• Continental Slope and Demersal Fish Communities</li> </ul>	<ul style="list-style-type: none"> <li>• Ancient coastline at 125 m depth contour</li> <li>• Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters</li> <li>• Carbonate bank and terrace system of the Sahul Shelf</li> <li>• Continental Slope and Demersal Fish Communities</li> </ul>

### 3.2.2.1 Marine Reserves

Management objectives of the marine reserves and how they are met are provided below in Table 3-3.

Table 3-3: Management Objectives of Relevant Commonwealth Marine Reserves

Commonwealth Marine Reserve	IUCN Zone	Management Objective	How Survey Meets Requirement
Ashmore Reef	IUCN II Recreational Use Zone	Protected and managed to preserve its natural condition	Vessel will not enter reserve. CMR outside operational area therefore no operations will occur in CMR.
	IUCN IA Sanctuary Zone	Managed primarily for scientific research or environmental	Vessel will not enter reserve. CMR outside operational area therefore no

		monitoring	operations will occur in CMR.
Cartier Island	IUCN IA Sanctuary Zone	Managed primarily for scientific research or environmental monitoring	Vessel will not enter or approach within 1 km of reserve therefore no operations will occur within 1 km of CMR.
Kimberley	IUCN II Marine National Park Zone	Protected and managed to preserve its natural condition	CMR outside operational area therefore no operations will occur in CMR.
	IUCN VI Multiple Use Zone	Managed to ensure long-term protection and maintenance of biological diversity with a sustainable flow of natural products and services to meet community needs	Mining (including exploration, development and other activities) is an allowed activity

### 3.3 Benthic Habitats and Shallow Reefs

#### 3.3.1 Shoals

Studies on shoals show that coral growth is limited to depths less than 50 m as the quality of light changes rapidly with depth, both in intensity and composition.

Previous Australian Institute of Marine Science (AIMS) research on the Timor Sea shoals indicated that habitats in less than 60 m were most likely to support diverse communities associated with benthic primary producer habitat (Heyward *et al.* 2013) and indicate high fish abundance and species richness around the shoal rims which are ~25 - 40 m deep on a horizontal plateau (Heyward *et al.*, 2011). Figure 3-1 demonstrates that the 60 m depth is found on the steep sides of the shoals, relatively close to the plateau present at the top. The studies indicate the majority of the habitat found around the shallower slope edges out to the 60 m contour are “sparse mixed biota”, while the hard corals are dominant towards the centre of the shoal plateaus (Heyward *et al.* 2011).

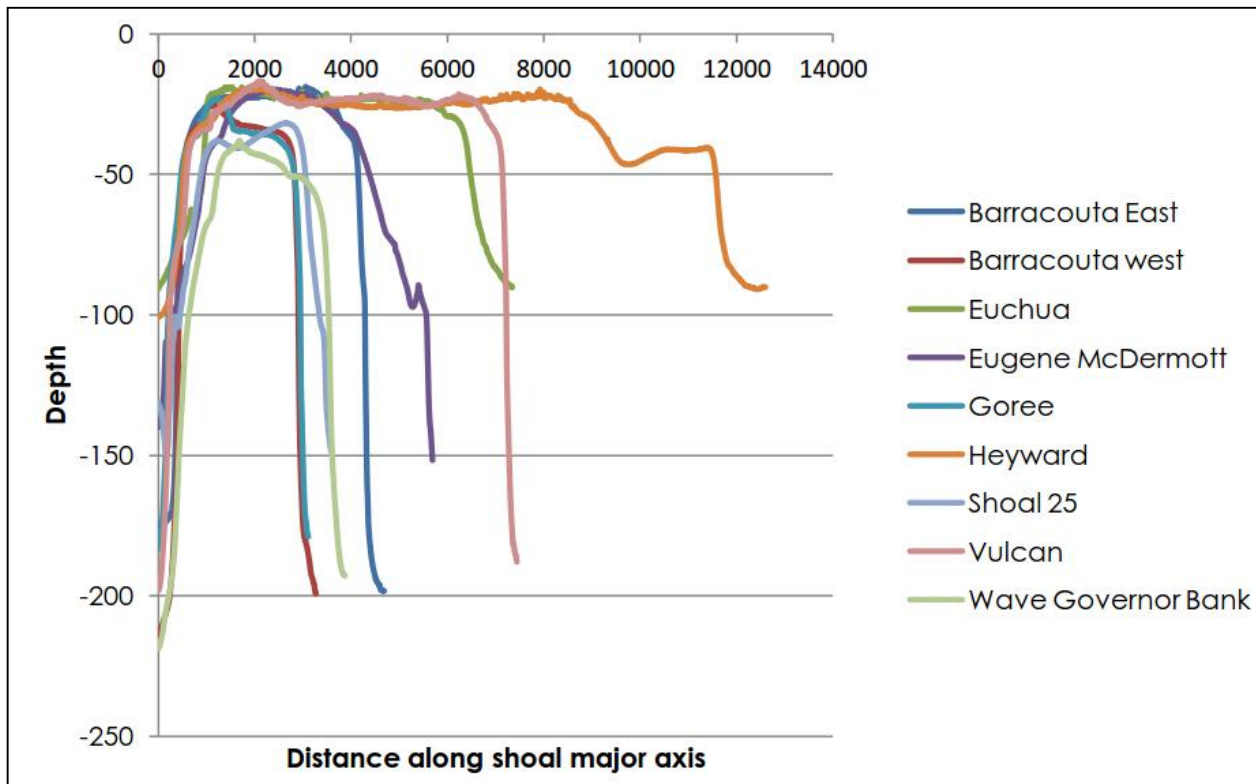


Figure 3-1 Cross section of shoal depth profiles in the Timor Sea from a multibeam transect across the long axis of each shoal

Source: Heyward et al 2011

The seabed on the flat, plateau-like areas of the shoal tops are dominated by benthic primary producers, including varying amounts of algae and hard corals, interspersed with sand and rubble patches. Both benthic communities and fish faunas of the shoals are diverse and varied within and between shoals. The biota on these shoals are typical of shallow tropical reef systems elsewhere. Attached (benthic) biota include many coral and algal species and are likely to mirror regional coral reef diversity. A multivariate analysis of the community structure recognised six assemblages of fishes among the shoals, principally determined by depth, the amount of reefal substrata and the size (area) of the shoal plateau (Heyward et al., 2011)

### Browse Island and Cartier Island

The reef fronts of the area are punctuated with spur and groove formations and have a high diversity of robust corals. The reef crests are algal dominated with the reef flats striated with lines of coral rubble. The sand flats are extensive and mobile, comprising carbonate sands (Commonwealth of Australia, 2002). General morphological characteristics of the reefs are that the reef front and crest is comprised of hard and soft corals, gorgonians, sponges and a range of encrusting organisms. It provides habitat also for a number of fish, crustaceans and echinoderms.

The reef flats have areas of sea grass, which provide critical habitat for a number of species. Areas of the sandflats that do not dry at low tide also have a sparse cover of soft corals and various algae. The lagoon habitat supports a wide range of fish, and predators such as sharks and sea snakes. The lagoons associated

with Cartier Island also support corals, sponges and a range of holothurians, echinoderms and polychaetes on and beneath the substrate.

### 3.4 Marine Fauna

#### 3.4.1 Non-listed Species

The operational area overlaps the Key Ecological Feature of the Continental Slope Demersal Fish Communities.

During consultation with the WA Department of Fisheries (section 6.4) the following fish were identified as key commercial species in the area:

Table 3-4: Peak spawning / aggregation times for key commercial fish species in the North Coast Bioregion

Bioregion	Key Fish Species Within Zone	Spawning / Aggregation Times
North Coast	Blacktip Shark ( <i>Carcharhinus tilstoni</i> & <i>C. limbatus</i> )	Nov – Dec
	Goldband Snapper ( <i>Pristipomoides multidens</i> )	Jan – April
	Rankin Cod ( <i>Epinephelus multiinotatus</i> )	Aug – Oct
	Red Emperor ( <i>Lutjanus sebae</i> )	Jan – Mar
	Pink Snapper ( <i>Pagrus auratus</i> ) (rare)	May – Jul
	Sandbar Shark ( <i>Carcharhinus plumbeus</i> )	Oct – Jan
	Spanish Mackerel ( <i>Scomberomorus commerson</i> )	Aug - Nov

#### 3.4.2 Protected Species and Biologically Important Areas

A review of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) database (Protected Matters search tool) held by the Department of Environment (DoE) was conducted on 5<sup>th</sup> June 2015 for the operational area.

An additional search including a 33 km buffer to account for the wider environment was also conducted, which identified a further eleven threatened species. Further details of the Protected Matters search, indicating species likely to occur within, or adjacent to, the search area are provided below in Table 3-5 (DoE, 2014a).



Table 3-5: EPBC Act Protected Species that may occur in, or relate to, the operational area and the wider environment.

Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
Cetaceans								
<i>Balaenoptera bonaerensis</i>	Antarctic minke whale	Migratory	✓	Species or species habitat may occur within area	×	Species or species habitat may occur within area	None	None
<i>Balaenoptera edeni</i>	Bryde's whale	Migratory	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	None	None
<i>Balaenoptera musculus</i>	Blue whale	Endangered; Migratory	✓	Migration route known to occur within area	✓	Migration route known to occur within area	BIA for migration overlaps	BIA for migration overlaps
<i>Megaptera novaeangliae</i>	Humpback whale	Vulnerable, Migratory	✓	Breeding known to occur within area	✓	Breeding known to occur within area	BIA for migrating and calving overlaps	BIA for migrating and calving overlaps
<i>Orcaella brevirostris</i>	Irrawaddy dolphin	Migratory	✓	Species or species habitat may occur within area	✓	Species or species habitat known to occur within area	None	None
<i>Orcinus orca</i>	Killer whale	Migratory	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	None	None
<i>Physeter macrocephalus</i>	Sperm whale	Migratory	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	None	None
<i>Sousa chinensis</i>	Indo-Pacific humpback dolphin	Migratory	x	n/a	✓	Breeding known to occur within area	None	BIA for foraging (high density prey)
<i>Tersiops</i>	Spotted	Migratory	✓	Species or species	✓	Species or species habitat	None	BIA for



Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
<i>aduncus</i>	bottlenose dolphin			habitat likely to occur within area		likely to occur within area		foraging (high density prey)
Sirenians								
<i>Dugong dugon</i>	Dugong	Migratory	✓	Species or species habitat may occur within area	✓	Breeding known to occur within area	BIA for foraging ~150 km SSW of operational area	BIA for foraging ~114 km SSW of area that may be affected by unplanned events
Sharks/Rays (Fish)								
<i>Rhincodon typus</i>	Whale shark	Vulnerable, Migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Foraging, feeding or related behavior known to occur within area	BIA for foraging overlaps area	BIA for foraging overlaps area
<i>Isurus oxyrinchus</i>	Shortfin mako, mako shark	Migratory	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	None	None
<i>Isurus Paucus</i>	Longfin mako	Migratory		Species or species habitat likely to occur within area		Species or species habitat likely to occur within area	None	None
<i>Manta birostris</i>	Giant manta ray	Migratory	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	None	None
<i>Carcharodon carcharias</i>	White shark	Vulnerable, Migratory	✓	Species or species habitat may occur within area	✓	Species or species habitat may occur within area	None	None
<i>Glyphis garricki</i>	Northern river shark	Endangered	x	n/a	✓	Species or species habitat may occur within area	None	None



Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
<i>Pristis pristis</i>	Large-tooth sawfish	Vulnerable	x	n/a	✓	Species or species habitat likely to occur within area	None	None
<i>Pristis clavata</i>	Dwarf Sawfish	Vulnerable	x	n/a	✓	Foraging, feeding or related behavior known to occur within area	None	None
<i>Pristis zijsron</i>	Green sawfish	Vulnerable	x	n/a	✓	Species or species habitat known to occur within area	None	None
Marine Reptiles								
<i>Caretta caretta</i>	Loggerhead turtle	Endangered; Migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Foraging, feeding or related behavior known to occur within area	None	None
<i>Chelonia mydas</i>	Green turtle	Vulnerable; Migratory	✓	Breeding known to occur within area	✓	Breeding known to occur within area	BIA for interesting overlaps (Cartier Island)	BIA for interesting overlaps
<i>Crocodylus porosus</i>	Salt-water Crocodile	Migratory	✓	Species or species habitat likely to occur within area	✓	Species or species habitat likely to occur within area	None	None
<i>Dermochelys coriacea</i>	Leatherback turtle	Endangered; Migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Breeding likely to occur within area	None	None
<i>Eretmochelys imbricate</i>	Hawksbill turtle	Vulnerable, migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Foraging, feeding or related behavior known to occur within area	BIA for foraging ~16 km west of operational area	BIA for interesting overlaps



Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
<i>Lepidochelys olivacea</i>	Olive Ridley turtle	Endangered, migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Foraging, feeding or related behavior known to occur within area	None	BIA for foraging ~54 km east of wider environment
<i>Natator depressus</i>	Flatback turtle	Vulnerable, migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Breeding known to occur within area	None	None
<i>Aipysurus apraefrontalis</i>	Short-nosed seasnake	Critically endangered	✓	Species or species habitat likely to occur within area	✓	Species or species habitat known to occur within area	None	None
<i>Aipysurus foliosquarman</i>	Leaf-scaled seasnake	Critically endangered	✓	Species or species habitat likely to occur within area	✓	Species or species habitat known to occur within area	None	None
Birds								
<i>Anous tenuirostris melanops</i>	Australian lesser noddy	Vulnerable	✓	Foraging, feeding or related behavior known to occur within area	✓	Breeding known to occur within area	None	None
<i>Calonectris leucomelas</i>	Streaked shearwater	Migratory	x		✓	Species or species habitat may occur within area	None	None
<i>Fregata ariel</i>	Lesser frigatebird	Migratory	✓	Foraging, feeding or related behavior known to occur within area	✓	Breeding known to occur within area	BIA for breeding and foraging overlaps	BIA for breeding and foraging overlaps
<i>Fregata minor</i>	Great frigatebird	Migratory	✓	Foraging, feeding or related behavior likely to occur within area	✓	Breeding known to occur within area	BIA for breeding and foraging overlaps	BIA for breeding and foraging overlaps



Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
<i>Phaethon lepturus</i>	White-tailed tropicbird	Migratory	✓	Foraging, feeding or related behavior likely to occur within area	✓	Breeding known to occur within area	BIA for breeding and foraging overlaps in north west	BIA for breeding and foraging overlaps in north west
<i>Puffinus Pacificus</i>	Wedge-tailed shearwater	Migratory	x	n/a	✓	Breeding known to occur within area	BIA for breeding and foraging overlaps in north west	BIA for breeding and foraging overlaps in north west
<i>Sterna albifrons</i>	Little tern	Migratory	X	n/a	✓	Breeding known to occur within area	BIA for breeding ~30 km north west of operational area	BIA for breeding overlaps
<i>Sterna bengalensis</i>	Lesser crested tern	Migratory	X	n/a	✓	Breeding known to occur within area	BIA for breeding ~30 km north west of operational area	BIA for breeding overlaps
<i>Sterna dougallii</i>	Roseate tern	Migratory	x	n/a	✓	Breeding known to occur within area	BIA for breeding ~30 km north west of operational area	BIA for breeding overlaps
<i>Sula</i>	Brown booby	Migratory	✓	Breeding known to	✓	Breeding known to occur	BIA for	BIA for



Scientific name	Common name	Status	Presence				Biologically Important Areas in proximity to operational area	
			Operational area	Type of presence	Wider Environment	Type of presence	Survey area	Wider environment
<i>leucogaster</i>				occur within area		within area	breeding and foraging overlaps in north west	breeding and foraging overlaps in north west
<i>Sula sula</i>	Red-footed booby	Migratory	✓	Breeding known to occur within area	✓	Breeding known to occur within area	BIA for breeding and foraging overlaps in west	BIA for breeding and foraging overlaps in west
<i>Apus pacificus</i>	Fork tailed swift	Migratory	×	n/a	✓	Species or species habitat likely to occur within area	None	None
<i>Pandion cristatus</i>	Eastern Osprey	Migratory	✓	Species or species habitat may occur within area	✓	Breeding known to occur within area	None	None
<i>Ardea alba</i>	Great Egret	Migratory	X	n/a	✓	Species or species habitat may occur within area	None	None
<i>Charadrius veredus</i>	Oriental Plover	Migratory	X	n/a	✓	Species or species habitat may occur within area	None	None

Source: DoE (2015) Protected Matters Search Tool, 5th June 2015; DoE (2014a) Conservation Values Atlas, 15<sup>th</sup> May 2015 (DoE 2014b).

### 3.4.2.1 Marine Mammals

#### Blue whale

In the NWMR pygmy blue whales migrate along the 500 m to 1,000 m depth contour on the edge of the slope and are likely to be feeding on ephemeral krill aggregations (DEWHA, 2007). The northward component of this migration takes place from May to mid-August, with a peak in July-August, and the southward component occurs from late October to November-December, with a few isolated individuals moving south in January (Dr Rob McCauley, Curtin University CMST, pers. comm., June 2009). Blue whales reportedly move between Scott Reef and Browse Island during July (northern migration) and again during October–November as part of their southern migration (DEWHA 2008). Recent acoustic evidence suggests that blue whales move in the area between Scott Reef and Browse Island during July (moving north) and again in October/November (moving south) (DEWHA, 2007).

The operational area overlaps a BIA for migration in the North West. Consequently, migrating blue whales may be encountered in the operational area during the May to December northward migration period. However this would likely be limited to individuals and significant numbers are not expected.

#### Humpback whale

The west coast Australian humpback population migrates from Southern Ocean feeding grounds to breeding grounds in coastal waters of the Kimberley. Recent satellite tagging of southbound humpback whales indicate that whales generally migrated close to the coastline, within a few tens of kilometres of shore and in a corridor frequently less than 100 km (Double *et al.* 2010). Aerial surveys and noise logger recordings undertaken for Chevron's Wheatstone Project indicated that the main distribution of humpback whales were sighted at an average distance of 50 km from the mainland during the northern migration and 35 km during the southbound migration (RPS 2010). Therefore low numbers of humpback whales may be present in the operational area considering the distance from the mainland of 40 km.

Between June and early August the northward migration moves along the Western Australian coast from Albany to Camden Sound. The southbound migration moves down the coast between late August and November, although females with calves have been documented leaving the calving areas last, with a later peak in abundance observed from mid-August to mid-September (Jenner *et al.* 2001, 2010).

Given the importance of the area to resting, calving and migration of humpback whales in the area, BIAs have been designated for these activities. The south east corner of the operational area overlaps with BIAs for resting, calving and migration of the humpback whale.

#### Dugong

Dugongs are seagrass specialists and known to be associated with seagrass meadows. In north-west WA populations are known at Shark Bay, Ningaloo Marine Park and Exmouth Gulf and Exmouth Gulf to De Grey River; all of which are nearshore and coastal marine habitats (Marsh *et al.*, 2002). They are generally solitary, travel in pairs, or associate only in small groups (three to six individuals). While dugongs have been known to travel long sporadic distances, they are not expected to aggregate in large numbers in the offshore waters. Therefore, significant numbers are not expected to be encountered during the survey, although some individuals may transit through the operational areas. No BIAs for dugongs are present within the operational area or wider environment.

### 3.4.2.2 Marine Reptiles

#### Loggerhead turtle

Major nesting locations include the Muiron Islands, the Ningaloo Coast south to Carnarvon and the islands around Shark Bay, which includes Dirk Hartog Island, one of the principal nesting and inter-nesting sites in WA (Limpus 2008). Given the distances of these areas from the operational area, nesting or internesting loggerhead turtles are not expected to be encountered during the survey. Transient individuals may pass through the area on migration or foraging.

#### Green turtle

Green turtles present within the survey area may be of a genetically discrete breeding unit associated with the Ashmore stock (Moritz *et al.*, 2002).

Green turtle nesting abundance and timing fluctuates significantly from year to year depending on environmental variables, locality, and food availability (Pendoley Environmental 2011). While peak breeding is expected in January and February, it is possible that breeding may occur as early as 1st November through to the end of February (Pendoley 2014, pers comm).

BIAs for internesting green turtles overlap the operational area at Cartier Island in the North West and the wider environment at Ashmore reef ~ 30 km North West and Cassini island ~72 km east of the operational area. Browse Island, while not a BIA, is also a rookery area for green turtles (DEWHA, 2008b; Limpus, 2008).

#### Leatherback turtle

There are no critical habitats identified in WA identified for leatherback turtles (DSEWPaC 2012b, Environment Australia 2003), therefore significant numbers of the species are not expected to be encountered.

#### Hawksbill turtle

BIAs for internesting occur within the wider environment at Ashmore reef (30 km NW of operational area). Hawksbill turtles are unlikely to spend significant time within offshore waters as it is too deep to act as a feeding ground. However it is likely they may migrate through those areas and may transit through the operational area to reach foraging sites at shoals and shallow or emergent (Browse and Cartier Islands) features within the operational area. Therefore while individuals may be encountered within the operational area, significant numbers are not expected.

#### Olive Ridley turtle

A BIA for foraging is designated ~80 km to the east of the operational area outside the area that may be impacted by unplanned events. Therefore while transient individuals may be encountered within the operational area, significant numbers are not expected.

#### Flatback turtle

A BIA for foraging is designated ~80 km to the east of the operational area outside an area that may be impacted by unplanned events. Therefore while transient individuals may be encountered within the operational area, significant numbers are not expected. Browse Island, while not a designated BIA, is a known nesting site for flatback turtles (DEWHA, 2008; Limpus, 2008).



### Saltwater crocodile

While transient individuals could possibly be present in the operational area, encounters offshore are not expected. The species may be present in the wider environment of the Kimberley shoreline. No BIA's are in place for the saltwater crocodile.

### Short nosed sea snake

The short-nosed seasnake was relatively common in reef surveys from 1994–1998 but has become scarce at Ashmore Reef (30 km north west of operational area) and has not been recorded there since the late 1990s despite a fivefold increase in survey effort (DEWHA 2007; Guinea 2006, 2007a; Lukoschek *et al.* 2013). Guinea and Whiting (2005) reported that very few short-nosed seasnakes moved even as far as 50 m away from the reef flat. Therefore while individuals may be encountered it is anticipated that the shallowest operational depth of 39 m will be a limiting factor so significant numbers are not expected.

### Leaf scaled sea snake

At Ashmore Reef, the leaf-scaled seasnake occurs on the reef flat during both high and low tides. It is found in exposed tidal pools during low tide, and has behavioural adaptations that enable it to tolerate the high water temperatures in pools (Guinea & Whiting 2005). While individuals may be encountered it is anticipated that the shallowest operational depth of 39 m will be a limiting factor so significant numbers are not expected.

## 3.4.2.3 Fish

### White shark

White sharks may be present within the operational area. However, due to their highly migratory and solitary nature, and the low probability of presence of a key prey species (e.g. pinnipeds), individuals are likely to be transient only and the likelihood of encountering this species is considered low.

### Whale shark

Detailed and informal surveys carried out in both 1991 and 1992 demonstrated that whale sharks congregate off Ningaloo Reef (Western Australia) from March to July, possibly to coincide with mass spawning of coral (DoE 2014). Estimates of the size of the population participating in the Ningaloo aggregation are between 300 and 500 individuals (Meekan *et al.* 2006).

Research on the migration patterns of whale sharks in the western Indian Ocean, and isolated and infrequent observations of individuals, indicate that a small number of the WA population migrate through the NWS. Wilson *et al.* (2006) tagged 19 whale sharks in 2003 and 2004, with long term movements patterns successfully recorded from six individuals. All travelled northeast into the Indian Ocean after departing Ningaloo Reef, with one tracked to Ashmore Reef and another to Scott Reef suggesting lower numbers within the operational area.

It is possible that relatively low numbers of individuals may be encountered throughout the operational area and area that may be affected by unplanned events, particularly as a BIA for foraging overlaps the south and east of both areas, however significant numbers are not expected.

### Northern river shark

The range of this species means that it is not expected to be encountered in the operational area. However it may be present in very low numbers within the area that could be impacted by unplanned events.

### Giant manta ray

Since the species is migratory it is possible that individuals may be encountered in the operational area, however, given that they generally don't aggregate in large groups, high numbers are not expected to be encountered during the survey.

### Large-tooth/Freshwater sawfish

Important foraging and pupping areas south of the operational area have been designated as BIAs for this species. However, the range of this species means that it is not expected to be encountered within the operational area; however it may inhabit inshore areas potentially impacted by unplanned events.

### Green sawfish

Important foraging and pupping areas south of the operational area have been designated as BIAs for this species. However, the range of this species means that it is not expected to be encountered within the operational area; however it may inhabit inshore areas potentially impacted by unplanned events.

#### 3.4.2.4 Birds

The EPBC protected matters search highlighted a total of 13 threatened and/or migratory bird species that may occur within and surrounding the proposed operational area.

- Australian lesser noddy: vulnerable;
- Lesser frigatebird: migratory;
- Great frigatebird: migratory;
- White tailed tropicbird: migratory;
- Wedge tailed shearwater: migratory;
- Little tern: migratory;
- Lesser crested tern: migratory;
- Roseate tern, migratory;
- Brown booby: migratory;
- Red footed booby: migratory
- Eastern Osprey: migratory
- Great Egret: migratory
- Oriental Plover: migratory

Ashmore reef is recognized as an important breeding area for seabirds. The operational area is located ~40km from the nearest mainland coastline where the distributions of many common seabirds overlap the

southern Browse Basin and are expected to occur in the operational area and surrounding waters. Migratory shorebirds are likely to be present in the region between July and October and again between March and April as the operational area is located within the East Asian-Australasian Flyway.

### 3.5 Socioeconomic Environment

The operational area is located approximately 161 km north of Cape Leveque and 256 km north of Derby, the closest township. Socio-economic activities that may occur within the operational area and surrounds include commercial fishing and shipping, petroleum activities, and to a lesser extent recreational fishing and tourism.

#### 3.5.1 Commercial Fisheries

The proposed operational area has the potential to interact with several Commonwealth and State managed fisheries.

##### 3.5.1.1 Commonwealth Fisheries

Commonwealth fisheries are managed by the Australian Fisheries Management Association (AFMA), with Commonwealth fisheries operating from 3 nm of baseline out to 200 nm (the extent of the Australian Fishing Zone, AFZ). The operational area has the potential to overlap an area encompassing several Commonwealth managed fisheries.

PGS has undertaken extensive consultation with these fisheries through the relevant representing associations to ensure that any impacts to their activities are minimized (see section 6.4). A summary of these fisheries is provided below in Table 3-6.

Table 3-6: Summary of Commonwealth Fisheries operating within the operational area and wider environment

Fishery	Extent	Fishing Method	Potential for interaction
North West Slope Trawl Fishery	The NWSTF operates off north-western Australia from 114°E to 125°E, roughly between the 200 m isobath and the outer boundary of the Australian Fishing Zone	Trawl	Only one active vessel in 2012. Australian scampi has been the main target of the fishery typically at depths of 350–600 m on the continental slope. This depth range is beyond the maximum of the operational area and so significant impacts are not expected.
Southern Bluefin Tuna Fishery	Fishing activity occurs in the Great Australian Bight off South Australia. Spawning of the species occurs in North-Western Australia.	Longline, Purse seine	Direct impacts to fishing activity will not occur due to the great distance of fishing activity from the operational area. However the wider environment of the operational area potentially overlaps spawning sites for the Bluefin Tuna. Therefore while impacts are possible, they are not expected.
Western Tuna and Billfish Fishery	Activity historically focused south of Abrolhos Islands (~2000 km from operational area).	Pelagic Longline, Purse seining, Pelagic hook and line	Activity not expected north of Abrolhos islands so no impacts expected.

Fishery	Extent	Fishing Method	Potential for interaction
Western Skipjack Fishery	Activity historically focused south of Abrolhos Islands (~2000 km from operational area).	Purse seine	Activity not expected north of Abrolhos islands so no impacts expected.

### 3.5.1.2 State Fisheries

State fisheries are managed by the Western Australia Department of Fisheries. The proposed operational area has the potential to overlap a number of State fishing zones as summarized in Table 3-7.

PGS has undertaken extensive consultation with these fisheries through the relevant representing associations to ensure that any impacts to their activities are minimized (see section 6.4).

Table 3-7: Summary of State Fisheries operating within the operational area and wider environment

Fishery	Extent	Fishing Method	Potential for interaction
Abalone Managed Fishery (zone 4)	All Western Australian coastal waters.	Hookah or Scuba	Operational Area and wider environment overlaps Northern Zone (Greenough Rivermouth to NT Border). However this area is closed until further notice so interaction not expected.
Broome Prawn Managed Fishery (North Coast Prawn Managed Fishery)	All Western Australian waters of the Indian Ocean lying east of 120° east longitude and west of 123°45' east longitude on the landward side of the 200 m isobath	Trawl	Within south east of operational area and wider environment. Limited effort (29 nights in 2012) reduces chance of impacts.
Kimberley Prawn Managed Fishery (North Coast Prawn Managed Fishery)	All Western Australian waters of the Indian Ocean lying east of 123°45' east longitude and west of 126°58' east longitude	Trawl	Overlap with operational area and wider environment. 15 boats fished for 362 days in 2012 which suggests potential for interaction.
Joint Authority Northern Shark Fishery	Comprises two fisheries: The WA NCSF extends from longitude 114°06' E (North West Cape) to 123°45' E (Koolan Island) (Closed since 2005), and the JA (Joint Authority) NSF from longitude 123°45' E to the WA/NT border	Longline and Gillnet	Operational area overlaps fishery but no effort in recent years suggests no significant impacts.
Kimberley Developing Mud Crab Fishery	King Sound to Northern Territory border	Trap	Only three commercial operators present in wider environment only. Average number of traplifts suggest moderate activity and potential interaction during unplanned events.

Fishery	Extent	Fishing Method	Potential for interaction
Kimberley Gillnet and Barramundi Managed Fishery	Nearshore and estuarine zones from the WA/NT border (129°E) to the top end of Eighty Mile Beach, south of Broome (19°S)	Any (net size limits)	511 block days effort in 2011. Activity occurs throughout the inshore area of the Kimberley but does not overlap the wider environment so impacts to the fishery are not expected.
Mackerel Managed Fishery	West Coast Bioregion to the Western Australian/Northern Territory border, with most effort and catches recorded north of Geraldton and particularly in the Kimberley region (area 1)	Near surface trolling and jig.	Effort concentrated throughout Kimberley region and overlap with operational area so potential interaction exists.
North Coast Demersal Scalefish Managed Fishery	Northwest coast of Western Australia in the waters east of 120° E longitude	Trap, handline, dropline	Distance offshore of the majority of the operational area reduces chance of encounter with recreational fishers. Only 11 licence holders fishing the area means that while interference is possible it is not expected to be significant.
WA Marine Aquarium Fishery	Throughout survey area but very localized around population centers and low level.	Dive based with hand held nets.	Although there is overlap with the operational area, these are low volume catches unlikely to operate in operational water depths of the survey area (<39 m).
Pearl Oyster Fishery	Zone 3: West of longitude 125°20' E and north of latitude 18°14' S. Zone 4: East of longitude 125°20' E to the Western Australia/Northern Territory border	Drift dive	5 vessels operated in 2012 recording 17 396 hours dive time. During consultation Pearl Producers Association advised no anticipated impact on industry (section 6.4).
Specimen Shell Managed Fishery	All Western Australian waters between the high water mark and the 200 m isobath	Dive (hand)	While the 200m isobath extent incorporates the majority of the operational area, it is not considered an area of high effort so impacts are expected to be minimal.
West Coast Deep Crustacean Managed Fishery	The fishery operates year round North of latitude 34° 24' S (Cape Leeuwin) and west of the Northern Territory border on the seaward side of the 150m isobath out to the extent of the AFZ, mostly in 500 to 800 m of water	Pot (trap)	The area fished overlaps the operational area and wider environment and so the potential for interaction exists. However the large geographic range of the fishery and the predominant depth range of fishing effort in greater than 500 m (deeper than maximum operational area depth) suggests this will be limited.
Beche-de-mer Fishery	Exmouth Gulf to the Northern Territory border, however fishers do have access to all Western Australian waters	Diving / wading -hand harvest	The shallow depths required for the harvesting method are less than that of the operational minimum (39 m) in the survey area and so impacts are not expected.



### 3.5.2 Petroleum Exploration and Production

The following petroleum permits are overlapped by the operational area:

AC/L01	AC/P32	AC/P51	AC/RL01	W1423	WA 422P
AC/L02	AC/P34	AC/P53	AC/RL04	WA 044L	WA 424P
AC/L03	AC/P34	AC/P54	AC/RL05	WA 044L	WA 432P
AC/L06	AC/P34	AC/P55	AC14-1	WA 054R	WA 471P
AC/L08	AC/P36	AC/P57	AC14-2	WA 285P	WA 485P
AC/P04	AC/P36	AC/P64	AC14-3	WA 341P	WA 494P
AC/P04	AC/P37	AC/R L01	AC14-4	WA 342P	WA343P
AC/P21	AC/P41	AC/R L07	W12-05	WA 344P	WA421P
AC/P21	AC/P45	AC/R L09	W1402	WA 371P	
AC/P22	AC/P50	AC/R L09	W1403	WA 377P	

The Inpex Ichthys gas field development is a significant development in the area. Possible pipeline works and associated vessel presence may be associated with this development within the survey area. The Shell Prelude development is planned within the survey area, and subsea installation works associated with this may occur during the timeframe of this EP.

PGS is aware of another seismic survey currently proposed to take place over parts of the operational area and potentially within the timeframe of the Forge MSS and as such mitigations to ensure cumulative impacts are ALARP will be in place along with simultaneous operations procedures and pre-survey consultation.

### 3.5.3 Commercial Shipping

Commercial shipping activity in the North West has national and international significance, with the majority of vessels mainly utilizing Osborne Passage. The busiest areas of vessel activity within the operational area are to the North West of Browse Island and across a line running east to west, approximately 10 km south of Cartier Island. Other light vessel traffic might occur throughout the operational area. Due to the difference in vessel speed between the survey vessel and commercial fishing, the survey vessel has potential to lead to necessary avoidance action being taken by shipping vessels. Consultation with associated stakeholders, including AMSA and fishermen, is ongoing (see Section 6.4).



### 3.5.4 Tourism and Recreation

Given the distance from the nearest shoreline (approximately 40 km) and population centres (256 km at Derby) significant disturbance is not expected and would only be likely near the mainland shoreline within the wider environment. It is possible low levels of recreational fishing and tourism may occur around emergent features within the operational area however this would be expected to be low level given the distance to the mainland shoreline and nearest population centers.

### 3.5.5 Defence Activities

The Department of Defence (DoD) informed PGS that they have no objection to the survey. DoD advised that part of the survey area is underneath Restricted Airspace R811. DoD requires a minimum of 14 days notification should any aviation activities be contemplated in this area.

### 3.5.6 Heritage

There are no known indigenous cultural heritage values or issues for the waters and seabed within and immediately adjacent to the operational area. There are two current Native Title Determinations for the waters and seabed within and immediately adjacent to the operational area:

- Unguu Part A
- Dambimangari

Within the area that may be impacted by unplanned event related to the operational area (33 km buffer) there is:

- one national heritage place, the West Kimberley (listed place) ~ 40 km from operational area,
- one wetland of international importance, Ashmore reef national nature reserve (within Ramsar site) ~30 km from operational area,
- one Commonwealth heritage place, Ashmore reef national nature reserve (~30 km).



## 4 ENVIRONMENTAL RISK ASSESSMENT

An environmental risk assessment has been undertaken to understand and manage the environmental risks associated with the proposed survey to a level that minimises impacts on the environment and meets the objectives of the survey.

### 4.1 Environmental Risk Assessment Methodology

The risk assessment methodology applied is consistent with the Australian/New Zealand Standard AS/NZS ISO 31000:2009 Risk management - Principles and guidelines, Handbook HB 203:2012 Managing environment – related risk, and Handbook HB 89-2012 Risk management – Guidelines on risk assessment techniques. The risk assessment has been undertaken to identify the sources of risk (aspects) and potential environmental impacts associated with the activity and to assign a level of significance or risk to each impact. This subsequently assists in prioritising mitigation measures to ensure that the environmental impacts are managed to as low as reasonably practicable (ALARP). The risk has been measured in terms of likelihood and consequence, where consequence is defined as the outcome or impact of an event, and likelihood as a description of the probability or frequency of the identified consequence occurring. Following identification of practicable mitigation measures, the residual risk of each impact is reassigned and assessed for environmental acceptability.

The environmental risks associated with the proposed seismic survey operations have been assessed by a methodology that:

- Identifies the activities and the environmental aspects associated with them;
- Identifies the values/attributes at risk within and adjacent to the operational area;
- Defines the potential environmental effects of the activities;
- Identifies the likelihood of occurrence and potential consequences; and
- Determines overall environmental risk levels using a likelihood and consequence matrix.

### 4.2 Assessment of Likelihood of Occurrence and Environmental Impact

The likelihood of occurrence for the key potential environmental impacts from the survey has been estimated based on industry incident reporting (Table 4-1). Table 4-1 also includes a qualitative description of environmental effects assigned to each category of consequence.

Table 4-1: Definitions for qualitative assessment of likelihood and environmental effects

Likelihood	Qualitative description of likelihood
Unlikely	Impact has not occurred in the past and there is a low probability that it will occur in exceptional circumstances.
Possible	Impact may have occurred in the past and there is a moderate probability that it will occur at some time.
Likely	Impact has occurred in the past and there is a high probability that it will occur at some time.
Highly Likely	Impact has been a common problem in the past and there is a high probability that it will occur in most circumstances.
Routine	Impact will occur, is currently a problem in the area or is expected to occur in almost all circumstances.





Consequence	Qualitative description of environmental effects
Slight	Possible incidental impacts to flora and fauna in a locally affected environmental setting. No ecological consequences.
Minor	Reduction of the abundance/biomass of flora and fauna in the affected environmental setting. No changes to biodiversity or ecological system.
Moderate	Reduction of abundance/biomass in the affected environmental setting. Limited impact to local biodiversity without loss of pre-incident conditions.
Severe	Substantial reduction of abundance/biomass in the affected environmental setting. Significant impact to biodiversity and ecological functioning. Eventual recovery of ecological systems possible, but not necessarily to the same pre-incident conditions.
Catastrophic	Irreversible and irrecoverable changes to abundance/biomass in the affected environmental setting. Loss of biodiversity on a regional scale. Loss of ecological functioning with little prospect of recovery to pre-incident conditions.

### 4.3 Overall Environmental Risk Assessment

Table 4-2 shows the overall environmental risk assessment matrix (also referred to as an event potential matrix) that compares the likelihood and consequences of potential environmental impacts arising from the survey and assigns a level of risk.

Table 4-2: Generic environmental risk assessment matrix

CONSEQUENCE	LIKELIHOOD					
	Unlikely	Possible	Likely	Highly Likely	Routine	
Catastrophic	High	High	High	High	High	High Risk Level: Apply strict precautionary principle, and industry best practice to reduce to ALARP.
Severe	Medium	Medium	Medium	High	High	
Moderate	Medium	Medium	Medium	Medium	Medium	Medium Risk level: Apply standard cost-benefit approach to reduce risk to ALARP.
Minor	Low	Low	Medium	Medium	Medium	
Slight	Low	Low	Low	Low	Low	Low Risk level: Apply normal business management practice to avoid impact.



### 4.3.1 Demonstrating ALARP and Acceptability

### 4.3.2 Practicability Assessment

While reducing potential impacts associated with a particular risk, implementation of a specific control measure may require additional costs or effort, may lead to temporal or operational restraints, or potentially pose different risks to another aspect of the environment. In assessing practicability of control measures, these negative aspects (cost, effort, timing/ operational restrictions and additional environmental risks) are weighed against the environmental benefit of implementing the control measure. Should the benefit outweigh the negatives, the control measure is implemented.

### 4.3.3 Demonstrating Acceptability

Following assessment of control measures for practicability, the risk will be ALARP and assigned a residual risk ranking. The residual risk is then assessed to determine whether it is at an environmentally acceptable level. In determining acceptability, factors such as stakeholder interest / concern, industry standards, laws and PGS's company policies and practices are also considered.

## 4.4 Summary of Environmental Risk Assessment Results

The environmental risks and potential environmental impacts of the proposed survey have been determined on the basis of PGS's previous seismic survey experience in Australian waters and the outcomes of a risk assessment presented in Table 4-2. The risk assessment indicates that the potential impacts arising for the proposed survey can be categorised as having Low to Medium risk levels. No risks were assessed as High.

Table 4-2 also summarises the control measures to be implemented during the survey to ensure impacts and reduced to ALARP and acceptable.

Table 4-3: Summary of the environmental risk assessment and control measures

Hazard	Environmental aspect	Potential environmental impacts	Consequence of impact	Likelihood of the identified consequence	Residual risk level	Control Measures
Disturbance to marine fauna	Discharge of underwater seismic pulses	Behavioural and physiological effects on cetaceans, turtles and fish	Slight	Possible	Low	EPBC Act Policy Statement 2.1 – Part A Standard Management Procedures implemented for whales: <ul style="list-style-type: none"> <li>• Continuous observations</li> <li>• Precautionary zones:                             <ul style="list-style-type: none"> <li>➤ observation zone: 3 km+</li> <li>➤ low power zone: 2 km</li> <li>➤ shutdown zone: 500 m</li> </ul> </li> <li>• Use of soft starts on every occasion</li> <li>• Recommencement procedures</li> <li>• Low visibility / night time restrictions</li> </ul>
						EPBC Act Policy Statement 2.1 – Part B Additional Management Procedures implemented for whales : <ul style="list-style-type: none"> <li>• Use of two MFOs (per operating seismic survey vessel)</li> <li>• Adaptive Management</li> </ul> The vessel will move a minimum of 20km away from the area in the event that 3 whale instigated shut downs occur, and not return within 24 hours. 20km is considered conservative distance to reduce noise output to below levels expected to cause behavioural disturbance (as described in 5.1.1.1).



					<p>In addition to the whale interaction management measures the MFOs will conduct the following for whale sharks and turtles:</p> <ul style="list-style-type: none"> <li>• maintain continuous visual observations for within a 500 m horizontal radius of the survey vessel;</li> <li>• ensure that if whale sharks or turtles are sighted within 500 m horizontal radius of survey vessel, the acoustic source will be shut down; and</li> <li>• undertake visual observations for whale sharks and turtles for at least 10 minutes prior to the commencement of soft start, focusing on a 500 m horizontal radius of the survey vessel.</li> </ul>
					<p>Use of smallest possible source size to meet geophysical objectives of survey</p> <ul style="list-style-type: none"> <li>• Standard 4130 cui array when water depths/topography are greater than 55m chart depth/distance from source</li> <li>• Maximum of 3060 cui array between 55m and 39m chart depth/distance from source</li> <li>• No operations (discharge of seismic) in depths below 39m chart depth/distance from source</li> </ul>
					<p>Simultaneous operating survey vessels will not occur within 30 km of one another</p>
					<p>Environmental induction for appropriate crew including MFOs, marine, deck and bridge crew                  Unless an action is reasonably necessary to prevent a risk to human health or to deal with an emergency, helicopters will operate in accordance with Part 8 of EPBC Regulations (Aircraft).</p>
					<p>Acquisition within the blue whale BIA will not occur November (note the survey will not be taking place in July or October when blue whale migration is occurring)</p>



						Operations will not occur within 6 km of Browse or 7 km of Cartier Islands. No operations within 1 km of Cartier CMR.
						No discharge of seismic source within 20 km of Browse or Cartier Islands 1 Nov – 28 February
		Physiological effects on benthic invertebrates and plankton	Slight	Possible	Low	Data acquisition will not occur in waters less than 39m chart depth
	Noise generated from vessels and Helicopters	Behavioural and physiological effects on marine fauna	Slight	Possible	Low	
Light generation from vessels	Behavioural effects on dolphins, turtles, fish and seabirds	Slight	Possible	Low	Minimisation of survey and support vessel external lighting to levels required for navigation, vessel safety and safety of deck operations	
						Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed



						Environmental induction for appropriate survey vessel crew including MFOs, marine, deck and bridge crew
						Minimum of 6 km to browse Island and 7 km to Cartier Island at all times. 20 km buffer around Cartier and Browse Island during 1 <sup>st</sup> January to last day of February
	Vessel movements	Behavioural and physical effects (i.e. injury or mortality) on cetaceans and turtles	Minor	Possible	Low	Australian National Guidelines for Whale and Dolphin Watching (DEH 2005) (for the avoidance of whales)
Recording and reporting of any vessel interactions with marine fauna						
Specific vessel-whale interaction procedures for non-acoustic energy source operations						
Use of turtle guards on tail buoys if tail buoy design requires						
Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed						



						Environmental induction for appropriate survey vessel crew including MFOs, marine, deck and bridge crew
Disturbance to benthic habitats	Deployment and retrieval of anchors	Localised physical damage to benthic habitats	Slight	Possible	Low	No anchoring within operational area, except in emergency situations
	Vessel grounding		Minor	Unlikely	Low	Survey and support vessels may use navigation systems such as: ECDIS, AIS, radar, GPS, and depth sounders
						Standard maritime safety / navigation procedures
						Operations will not occur within 6 km of Browse or 7 km of Cartier Islands
						Operations will not occur in less than 39 m water depth
	Equipment damage, dragging or loss		Slight	Possible	Low	Lost in-water equipment will be recovered, where possible
						Cables will be self-inflating if lost.
						Recording / reporting of incidents involving loss of equipment (e.g. cable loss)
Survey vessel will not operate in water depths <39 m						

Atmospheric emissions	Operation of machinery, vessels and helicopters powered by internal combustion engines	Localised reduction air quality Greenhouse gas emissions	Slight	Likely	Low	Compliance with Protection of the Sea (Prevention of Pollution from Ships) Act (PSPPS Act) and Marine Orders - Part 97: Marine pollution prevention - air pollution
						Optimisation of fuel use to increase efficiency and minimise emissions
						Use of low sulphur fuel (if/when available)
						Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed
						Implementation of a preventive maintenance system (PMS)
Invasive marine species	Discharge of ballast water from vessels	Introduction and establishment of IMS and displacement of native marine species	Moderate	Unlikely	Medium	Ballast water will be discharged in line with a Vessel Ballast Management Plan, for example: <ul style="list-style-type: none"> <li>• Discharge will not occur in water depths &lt;200 m</li> <li>• No discharge of high risk ballast water within 12nm of Australian territorial areas</li> </ul>
	Biofouling of vessel hulls, other niches and immersible equipment					Australian/Vessel Ballast Water Management Requirements (if/when required)
						All necessary DoA clearances to operate unrestricted anywhere in Australian waters
						Hull/marine equipment inspection (and cleaning if required) prior to the vessel entering the operational area
Reporting of known or suspected introduced species to FishWatch by phone (1800 815 507).						
Marine pollution from routine	Discharge of sewage, grey water and	Localised reduction in water quality	Slight	Routine	Low	Sewage treated as per MARPOL Annex V requirements including: Sewage and putrescible wastes macerated prior to disposal Sewage and putrescible waste treatment systems and holding tanks fully survey



discharges	putrescible wastes	due to nutrient enrichment				prior to survey commencement Sewage discharged >3 nm from land for treated sewage; >12 nm from land for untreated sewage
						Adherence to Marine Orders – Part 96: discharge of sewage and putrescibles waste will be of short duration with high dispersion and biodegradability; all sewage and putrescible waste treatment systems and holding tanks are to be fully surveyed prior to survey commencement; and survey onboard sewage treatment plant approved by the International Maritime Organisation (IMO).
						Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed
						If support vessel is unable to treat/store grey water (i.e. wastewater from sinks and showers) biodegradable soaps and detergents will be used (where possible)
						Vessel Waste Log will be maintained to record waste management practices
Discharge of bilge water	Acute toxicity effects on marine fauna and flora Localised reduction in water quality	Slight	Possible	Low	Compliance with PSPPS Act and Marine Orders - Part 91: Marine Pollution Prevention - Oil	
					Containment and onshore disposal of bilge water contaminated with hydrocarbons, except if the oil content is < 15 ppm	
					Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed	
Marine pollution from accidental discharges	Discharge of solid wastes i.e. garbage	Toxic effects on marine fauna and flora Localised reduction in water quality Indirect effects on commercial fisheries Disturbance to marine fauna or habitats	Minor	Possible	Low	Compliance with PSPPS Act and Marine Orders - Part 95: Marine Pollution Prevention - Garbage
						No discharge of plastics or plastic products of any kind from survey and support vessels
						No discharge of domestic wastes or maintenance wastes from survey and support vessels
						All waste receptacles aboard survey and support vessels will be covered with tightly fitting, secure lids
						All solid, liquid and hazardous wastes (other than sewage, grey water and putrescible wastes) will be incinerated or compacted (if possible) and stored in designated areas and sent ashore for recycling, disposal or treatment
						Incinerators used are compliant with requirements of MARPOL and IMO



		Physical impacts on marine fauna i.e. from plastics				Simultaneous data acquisition will not occur within 30 km of other survey vessels as determined through survey planning and pre-survey consultation and SIMOPS procedures as developed	
						Incinerators will be operated in accordance with manufacturers specifications by train personnel	
						All storage facilities and handling equipment will be in good working order and designed in such a way as to prevent and contain any spillage as far as practicable	
						Vessel Waste Log will be maintained to record quantities of wastes transported onshore, and detailed records of waste accidentally discharged	
	Hazardous materials			Minor	Possible	Low	Compliance with PSPPS Act and Marine Orders – Part 94: Marine Pollution Prevention – Packaged Harmful Substances
							All chemical and hazardous wastes will be segregated into clearly marked containers prior to onshore disposal
							All storage facilities and handling equipment will be in good working order and designed in such a way as to prevent and contain any spillage
							Tested / implemented Shipboard Oil Pollution Emergency Plan (SOPEP) for both survey and support vessels
							Material Safety Data Sheet (MSDS) readily available for all hazardous substances aboard survey and support vessels
							Spill response bins/kits will be located in close proximity to hydrocarbon storage areas for prompt response in the event of a spill or leak. Kits checked for their adequacy and replenished as necessary. Personnel trained in use of this equipment
	Fuel and oil spills			Moderate	Possible	Medium	Adherence to the requirements of the Navigation Act 2012, and specifically Marine Orders – Part 30: Prevention of collisions
							Adherence to the requirements of COLREGS
							Compliance with AMSA administered marine safety regulations and marine notification requirements
							Survey and support vessels will use approved navigation systems and depth sounders
Standard maritime safety / navigation procedures							
Hydrocarbons located above deck will be stored with some form of secondary containment to contain leaks or spills							
The survey vessel has an implemented and tested SOPEP							
The only fuel used will be marine diesel (no heavy fuel oil which is more persistent)							



					Low	in the event of a spill)		
						Crew preparedness, awareness and training		
						Oil Pollution Emergency Plan and Emergency Response Plan in place		
						Refuelling at sea subject to PGS Marine Operations Offshore Bunkering Procedures and PGS Bunker Delivery – Quantity and Quality Control		
						Vessel will not approach within 33 km of emergent features in line with predicted seasonal current.		
	Oil spill response				Minor	Possible	Low	SOPEP in place
	Implementation of NATPLAN							
	Management of wastes in compliance with the NATPLAN document Management and Disposal of Oil Spill Debris;							
	Oil spill reports demonstrating reporting of spills to AMSA							
	Vessel records of oil spill drills carried out							
Disturbance to social and community values	Interaction with commercial fisheries	Disruption to commercial fishing vessels Potential noise impacts on target species Restriction of access to fishing grounds, loss/damage to gear Recreational take of finfish species Interaction with CSIRO surveys	Minor	Possible	Low	Adherence to the requirements of the Navigation Act 2012, and specifically Marine Orders - Part 30: Prevention of collisions		
						Adherence to the requirements of COLREGS		
						Notification of activity details to relevant stakeholders prior to survey commencement		
						Use of a support vessel to manage vessel interactions		
						Use of standard maritime safety procedures		
						Compliance with AMSA administered marine safety regulations and marine notification requirements		
						Consultation with relevant fisheries stakeholders		
						Consultation with titleholders within operational area		
						Fishermen and other mariners alerted of vessels presence and extent of towed array. Establishment of a vessel exclusion zone around the survey vessel and its towed equipment. Display of appropriate navigational beacons and lights, radar watch, radio contact		
						In-water equipment lost will be recovered (where possible). Detailed records will be maintained of equipment lost overboard		



	Interaction with shipping	Disruption to shipping activities	Slight	Possible	Low	Recreational fishing from the survey and support vessels will be prohibited
						Adherence to the requirements of the Navigation Act 2012, and specifically Marine Orders - Part 30: Prevention of collisions
						Adherence to the requirements of COLREGS
						Consultation with AMSA prior to the survey commencing to determine the level of commercial shipping in the vicinity of the operational area
						Access authority applications approved for ingress into permit areas where other activities are occurring
						Use of a support vessel to manage vessel interactions
						Use of standard maritime safety procedures
						Compliance with AMSA administered marine safety regulations and marine notification requirements
						Shipping alerted of vessels presence and extent of towed array. Establishment of a vessel exclusion zone around the survey vessel. Display of appropriate navigational beacons and lights, radar watch, radio contact
	Operation of vessels within protected areas and heritage places	Disturbance to heritage and conservation values	Slight	Possible	Low	Implementation of the performance outcomes, standards and measurement criteria described in this EP
						Ensuring that appropriate crew (including MFOs, marine, deck and bridge crew) are aware of and comply with the accepted EP
	Interaction with petroleum activities	Increased risk from cumulative to petroleum activities	Minor	Possible	Low	Adherence to the requirements of the Navigation Act 2012, and specifically Marine Orders - Part 30: Prevention of collisions
						Adherence to the requirements of COLREGS
						Consultation with AMSA prior to the survey commencing to determine the level of vessels in the vicinity of the operational area
						Use of a support vessel to manage vessel interactions
						Use of standard maritime safety procedures
						Compliance with AMSA administered marine safety regulations and marine notification requirements
	Proponents of identified activity alerted of vessels presence and extent of towed					



						array. Establishment of a vessel exclusion zone around the survey vessel. Display of appropriate navigational beacons and lights, radar watch, radio contact
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## 5 ASSESSMENT OF IMPACTS AND RISKS

### 5.1 Disturbance to Marine Fauna

#### 5.1.1 Underwater noise

##### *Noise from Vessel / Helicopter operations*

Noise emitted by project vessels and helicopters will be short in duration and is likely to be reduced to background levels within kilometres to tens of kilometres (APPEA, 2013b). As such, any potential related marine fauna behavioural are expected to be temporary and short ranged (i.e. nuisance factor) (McCauley, 1994). Therefore the aspect of underwater noise considered to have the greatest potential impact is noise emitted from the seismic source array and is discussed below.

##### *Noise from seismic source*

The sound levels of the Forge 3D MSS are expected to decrease to levels in the order of 200 dB re 1 $\mu$ Pa (SPL) within 1 km of the source and approximately 150 dB re 1 $\mu$ Pa (SPL) within 10 km, dependent on the sound propagation characteristics of the area. Sound will decay rapidly in shallow water environments and will transmit over greater distances in deeper environments. The sound exposure levels are greatest directly underneath the source with rapid decay horizontally from the source.

Underwater noise can affect marine fauna in three main ways:

- Injury to hearing or other organs. Hearing loss may be temporary (temporary threshold shift (TTS)) or permanent (permanent threshold shift (PTS)).
- Disturbance leading to behavioural changes or displacement of fauna. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation.
- Masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).

Sound level thresholds above which injury (TTS/PTS) or behavioral disturbance may occur vary widely between species and potentially between individuals of the same species.

##### 5.1.1.1 Disturbance to Marine Mammals

The threshold of 160dB re 1 $\mu$ Pa<sup>2</sup>.s has been adopted as the acoustic level whereby damage to whales may occur based upon EPBC Policy Guidelines 2.1 - Interaction between offshore seismic exploration and whales (DEWHA 2008). Based on modelling of predicted sound attenuation, sound exposure levels of 160 dB re 1 $\mu$ Pa<sup>2</sup>.s are not expected outside of 10 km from the source.

##### *Baleen whales*

Physical damage to the auditory system of cetaceans may occur at noise levels of about 230 to 240 dB re 1 $\mu$ Pa (Gausland, 2000), which is equivalent to a distance of about one to two metres from the energy source. Because of the good swimming abilities of marine mammals and their avoidance of either the vessel or the airgun array, it is highly unlikely that any marine mammals will be exposed to levels likely to cause pathological damage (McCauley, 1994).

Sound associated with seismic sources used during seismic surveys can cause significant behavioural changes in whales (McCauley, 1994). Behavioural responses to sound include swimming away from the source, rapid swimming on the surface and breaching (McCauley *et al.*, 2003).

McCauley *et al.* (2000) estimated that avoidance of seismic operations by humpback whales in key habitat (such as breeding, resting or feeding areas) would occur between 7 and 12 km of the survey vessel, whereas migrating individuals have been seen to adjust course and speed to enable an avoidance range of around 3 km (received sound level in the range of 157 to 164 dB re 1  $\mu$ Pa rms). It is considered that this avoidance behaviour represents only temporary and minor effect on either the individual or the species unless avoidance results in displacement of whales from breeding, resting or feeding areas.

### Toothed whales (including beaked whales)

The frequency range of toothed whale sounds excluding echo location clicks are mostly <20 kHz with most of the energy typically around 10 kHz, although some calls may be as low as 100 to 900 Hz, ranging from 100 to 180 dB re 1  $\mu$ Pa (Richardson *et al.*, 1995).

There is little systematic data on the behavioural response of toothed whales to seismic surveys. Richardson *et al.* (1995) reports that sperm whales appeared to react by moving away from surveys and ceasing to call even at great distances from a survey. However, in a recent study supported by the US Minerals Management Service (Jochens and Biggs, 2003) two controlled exposure experiments were carried out (including one with three simultaneously tagged whales) to monitor the response of sperm whales to seismic source. The whales were exposed to a maximum received level of 148 dB re 1  $\mu$ Pa. There was no indication that the whales showed horizontal avoidance of the seismic vessel nor was there any detected change in feeding rates of the tagged sperm whales.

### Dugong

Although there has been no documented evidence of marine seismic surveys being detrimental to populations of dugongs, there have also been no detailed studies (Gales *et al.*, 2003). Effects from seismic surveys may include interference with the animal's natural acoustic communication signals, damage to hearing systems and behavioral changes including disturbance reactions, ranging from brief alterations in behavior to short or long term effects on individuals and populations (Gales *et al.*, 2003).

### Overlap with Critical Marine Mammal Habitat and Peak Periods of Activity

The operational area marginally overlaps the blue whale BIA for migration in the North West of the operational area. Blue whales reportedly move between Scott Reef and Browse Island during July (northern migration) and again during October–November as part of their southern migration (DEWHA 2008). As operations will not occur in July or October due to the seasons of the survey timeframe, significant numbers are not expected to be encountered.

The operational area overlaps with the humpback whale BIA in the south east. Humpback whales migrate up the Western Australian coast in between May and November to calve, rest and mate. Due to survey timing and vessel availability PGS will not be operating between July 1<sup>st</sup> and October 31<sup>st</sup>, therefore data acquisition will not overlap with migration periods of the humpback whale. As such, humpback whales are not expected to be encountered in significant numbers.

As per the recovery plans for each of these species, PGS will assess and manage acoustic disturbance – 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” through adhering to EPBC Act Policy Statement 2.1.

Furthermore, PGS will apply adaptive management procedures throughout the operational area as detailed in Table 4-3 .

No BIAs for dugongs are present within the operational area or wider environment. The closest known aggregations of dugong occur within the Shark Bay Work Heritage Area, ~1500 km from the operational area.

#### 5.1.1.2 Disturbance to Marine Reptiles

McCauley *et al.* (2000) found that turtles showed behavioural responses to approaching seismic survey noise at approximately 166 dB re 1  $\mu$ Pa. Very little is understood about marine turtle hearing and what levels may cause permanent damage.

It is likely that the survey will encounter marine turtles that are travelling between rookeries or occupying shallow waters near nesting rookeries on Browse Island or Cartier Island. Peak nesting season for green turtles (most likely to occur in the operational area due to the nesting sites on Browse and Cartier islands) is in January and February when nesting turtles are most likely to be present, with seasonal variations seeing lower levels of breeding possible from as early as November.

Browse Island and Cartier Island may represent lower numbers of nesting turtles relative to principle rookeries outside of the operational area, however they do represent significant nesting locations and a possible genetically discrete breeding unit, and as such a 20 km exclusion zone will apply to Cartier Island and Browse Island during the entire recognised turtle nesting period of 1<sup>st</sup> November to last day of February (as identified in section 3.4.2.2), encompassing the peak period of January and February. During this time the vessel will not acquire data (discharge seismic pulses) within 20 km of the zero bathymetry contour (LAT as defined by AHO charts) of Cartier or Browse Island at any time. At this distance SELs are not expected to exceed 145 dB re 1  $\mu$ Pa @ 1 m<sup>2</sup>. This is considered to be a conservative buffer based upon expected behavioural responses above a threshold of 175 dB re 1  $\mu$ Pa @ 1 m<sup>2</sup>. Along with the use of soft starts, these measures ensure the survey meets the objectives of the marine turtle recovery plan and reduces the impacts to ALARP.

The short nosed seasnake is most commonly found in close proximity to coral reefs and the survey does not contain any habitat considered critical to the species. Individuals may occur around Browse Island and Cartier Island in shallow water habitats. The survey will not operate in water depths less than 39m and not within 6km of Browse or 7 km Cartier islands (1 km extra separation from Cartier CMR). High numbers of encounters of sea snake is not likely and no impact to the sea snake population in the area is expected.

#### 5.1.1.3 Disturbance to Fish

Studies indicate that fish (including sharks) may begin to show behavioural responses (e.g. increased swimming) to an approaching seismic array at received sound levels of approximately 156 dB re 1  $\mu$ Pa (rms) and active avoidance at around 168 dB re 1  $\mu$ Pa (rms) (McCauley *et al.*, 2000). This corresponds to behavioural changes at approximately 3 km to 5 km from the seismic array, and avoidance from approximately 1 km to 2 km in about 100 m of water (McCauley *et al.*, 2000). As such, fish are highly



unlikely to be in close enough proximity to the discharging seismic source for physiological damage to the ears and lateral line to occur.

Table 5-1 Exposure guidelines for sound levels from seismic airguns for mortality and impairment in fishes and turtles

Type of Animal	Mortality and potential mortal injury	Impairment	
		Recoverable injury	TTS
Fish: no swim bladder (particle motion detection)	>219 dB SEL <sub>cum</sub> or >213 dB peak	>216 dB SEL <sub>cum</sub> or >213 dB peak	> >186 dB SEL <sub>cum</sub>
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL <sub>cum</sub> or > 207 dB peak	203 dB SEL <sub>cum</sub> or > 207 dB peak	> >186 dB SEL <sub>cum</sub>
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL <sub>cum</sub> or >207 dB peak	203 dB SEL <sub>cum</sub> or >207 dB peak	186 dB SEL <sub>cum</sub>
Sea Turtles	210 dB SEL <sub>cum</sub> or >207 dB peak	-	-
Eggs and larvae	>210 dB SEL <sub>cum</sub> or >207 dB peak	-	-

Note: peak and rms sound pressure levels dB re 1 μPa; SEL dB re 1 μPa<sup>2</sup>.s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist.

Source: Popper *et al.*, 2014

#### Site attached fish (demersal or reefal)

A recent study of site-attached reef species (at Scott Reef in the NWMR) revealed no significant effect of a 3D seismic survey on overall abundance or the species richness within coral reef fish communities (Miller & Cripps, 2013).

In terms of behavioural response the following has been observed in fish (McCauley et. al 2003):

Low level behavioural effects:

- avoidance at >140 dB re 1 μPa<sup>2</sup>.s (pelagic species and the more nomadic demersal species), a distance of ~10 km from source;

- startle/alarm at  $>160$  dB re  $1 \mu\text{Pa}^2\cdot\text{s}$  (species with limited home ranges or site-attached and/or territorial strategies), a distance of 1-2 km from source.

High level behavioural effects:

- fright/flight at  $>180$  dB re  $1 \mu\text{Pa}^2\cdot\text{s}$  (species with limited home ranges or site-attached and/or territorial strategies) (Woodside, 2007), a distance of ~100 – 200 m from source.

Detailed studies conducted by Woodside (2007) indicated that the threshold received SELs that could result in various sub-lethal and/or physiological effects for site attached species:

- Onset of short term reversible loss in hearing sensitivity (temporary threshold shift - TTS) at  $>180$  dB re  $1 \mu\text{Pa}^2\cdot\text{s}$ , a threshold expected to be exceeded only within 100 m of the source
- Onset of longer term loss in hearing sensitivity (TTS/permanent threshold shift – PTS) at  $>187$  dB re  $1 \mu\text{Pa}^2\cdot\text{s}$ , a threshold expected to be exceeded only within 100 m of the source
- TTS onset but no injury to non-auditory tissues to ~ 1 kg sized fish at  $>200$  dB re  $1 \mu\text{Pa}^2\cdot\text{s}$  (Woodside, 2007), a figure that will only be experienced within 39/55 m of the source, a water depth that will be avoided.

Therefore the use of array volume will be depth dependant as per the following:

- Standard 4130 cui array when water depths are greater than 55m chart depth
- Maximum of 3060 cui array between 55m and 39m chart depth
- No data acquisition in depths below 39m chart depth

*Note that these depth dependant exclusion zones apply to the charted water depth (LAT) at the seismic source.*

### Cumulative Impacts to Site Attached Species

Where cumulative impacts are concerned, Popper *et al.*, (2014), used the equation  $\text{SEL}_{\text{cum}} = \text{SEL}_{\text{ss}} + 10\log_{10}(N)$ .  $\text{SEL}_{\text{ss}}$  refers to 'single strike' or a 'shot' when referring to seismic, and N is the number of shots (seismic discharges) that will exceed the  $\text{SEL}_{\text{ss}}$  threshold of 200 dB re  $1 \mu\text{Pa}^2$  at a fixed (site attached) point.

For this survey, an expected  $\text{SEL}_{\text{cum}}$  was calculated as 205.5 dB  $\text{SEL}_{\text{cum}}$ .

As is demonstrated by Table 5-1, a maximum value of 205.5 dB  $\text{SEL}_{\text{cum}}$  expected in the survey may result in TTS in site attached fish and is at the lowest end of the values (203-216 dB  $\text{SEL}_{\text{cum}}$ ) that may result in a recoverable injury, none of which are expected to result in mortality.

### Lateral impacts of underwater discharges

To mitigate for any lateral impacts to fish, further to the commitment of reducing the array in depths below 55 m and no survey in depths shallower than 39 m, PGS commit to surveying with a reduced array (dropped smallest array) within 55 m (chart depth) of receiving topography in any direction, and no discharge within 39 m (chart depth) of receiving topography in any direction. This will be achieved through planning the sail lines using the latest charts of the operational area.

The result of these controls is that the source will not be discharged:

- Above shoal tops shallower than 39 m
- Within 55m (full array) or 39 m (reduced array) of shoal edges
- Within threshold range of areas of predicted high site attached fish abundance

#### 5.1.1.4 Disturbance to Benthic Habitats

Few marine invertebrates have sensory organs that can perceive sound pressure, but many have organs or elaborate arrays of tactile 'hairs', called mechanoreceptors, that are sensitive to hydro-acoustic disturbances (McCauley, 1994). Close to a seismic source, the mechano-sensory system of many benthic crustaceans will perceive the 'sound' of compressed air pulses, but for most species such stimulation would only occur within the near-field or closer, perhaps within distances of several metres from the source (McCauley, 1994).

A number of studies have examined the potential effects of seismic surveys on catch levels in fisheries targeting benthic crustaceans. Parry and Gason (2006) investigated the effect of seismic source discharges on southern rock lobster catch rates in western Victoria between 1978 and 2004. There was no evidence that catch rates of rock lobsters in western Victoria were affected by seismic surveys in the weeks or years following the surveys.

To ensure that no area of seabed will be exposed to sound above relevant threshold levels PGS will commit to a 'survey corridor' so that the proposed activity will not occur within 39m chart depth or within 39 m of charted topographical features in any direction. Furthermore the following mitigations will apply:

Standard 4130 cui array when charted water depths / charted topographical feature distances are greater than 55m chart depth

Maximum of 3060 cui array between 55m and 39m chart depth / charted topographical feature

No operations (discharge of seismic) in less than 39m chart depth / distance to topographical feature

#### 5.1.1.5 Disturbance to Coral

It is speculated that sound emissions from seismic activity could remove polyps from the calcium carbonate skeleton or that vibrations from pressure pulses propagating through the skeleton could damage polyps, but neither have been reported in the literature. As the polyps do not contain voids or internal airspaces, it is thought that any vibration caused by pressure pulses from seismic emissions will not be significant enough to remove or damage polyps from the protection of the calcium carbonate skeleton.

There are areas where coral is likely to exist. However, the survey will not occur within less than 39m chart depth. In shallow water environments such as coral reef environment, sound will decay rapidly. It is unlikely that the activity will have any significant impacts on existing coral communities, significant mass spawning events or the planktonic life stages of coral species.

#### 5.1.1.6 Disturbance to Planktonic Organisms

Except for fish eggs, larvae and other minute planktonic organisms within a few metres of a compressed air seismic source, no planktonic organisms are likely to be affected significantly by seismic source discharges (McCauley, 1994). Studies indicate that the range of pathological effect on fish eggs and larvae is likely to be restricted to less than ~2 m. Any effect of the seismic operation on planktonic organisms is insignificant compared with the size of the planktonic population in an operational area or natural mortality rates for planktonic organisms.

### 5.1.1.7 Disturbance to Commonwealth Marine Reserves

The only CMR that overlaps the operational area is the Kimberley CMR IUCN zone VI. The general approval for the North-west Commonwealth Marine Reserves Network provides for mining activities (including seismic surveys) to be carried out within this zone of the Kimberley CMR.

The vessel will not acquire data within 1 km of Cartier Island Marine reserve at any time. As such SELs that may enter the reserve will not exceed 165 dB re 1  $\mu$ Pa @ 1 m<sup>2</sup>, below the level at which significant impacts to sensitive receptors are expected. Furthermore, a 20 km exclusion zone will apply to Cartier Island during the sensitive turtle nesting period of 1<sup>st</sup> January to last day of February.

### 5.1.2 Light Generation

Lighting on the survey and support vessels, is required for safe navigation and work practices at night, and has the potential to create artificial (unnatural) light. This may subsequently affect some marine species, primarily seabirds and turtles.

Artificial lighting has the potential to affect marine fauna, notably turtles, fish and seabirds. Behavioural responses to light can alter foraging and breeding activity in turtles, seabirds, fish and dolphins, conferring competitive advantage to some species and reducing reproductive success and/or survival in others.

It is possible that seabirds may fly over the operational area, particularly due to overlap with seabird BIAs for both foraging and breeding and the presence of emergent features within the operational area for potential seabird resting. However as the vessels will not approach within at least 6 km of emergent features and will not approach within 40 km of mainland shoreline during operations it is not anticipated that the light emission as a result of the survey will have a significant impact.

The introduction of light from the proposed survey is not expected to cause disturbance to marine turtles given the distance from emergent features where turtles nest. Furthermore during the peak of the nesting season for green turtles in the region (between 1 January and last day of February), there will be no seismic acquisition within 20 km of Browse Island.

### 5.1.3 Vessel Movements

Survey and support vessels working within the operational area may present a potential physical hazard (e.g. animal displacement or vessel strike) to marine fauna including whales and other fauna, such as dolphins and turtles. Due to the timing and location of the survey, a high number of whale encounters are not expected. Management controls including marine fauna observers (MFOs) and adherence to guidelines for interacting with whales and dolphins will minimize the risk of potential vessel collision to very low.

The survey will operate outside of 39m chart depth, within which turtles are expected to be most abundant therefore turtle encounters are not expected to be high and the risk of vessel collision is considered low. The survey will involve a survey vessel and two support vessels travelling at slow speed (around 8-9 km/h) along defined paths, in offshore waters of greater than 39 m depth. At such speeds, any marine fauna present will likely take avoidance action before a collision. The implementation of management controls, such as EPBC Policy Statement 2.1, are expected to reduce vessel-fauna interactions and the risk of vessel strike is considered low. The use of turtle guards on streamer tail buoys can further reduce the risk of turtle entrapment.

## 5.2 Physical Disturbance to Benthic Habitats

Impacts from anchoring are unlikely to occur since anchoring within the operational area is not planned. Anchoring would only occur in emergency circumstances and the seismic and support vessels are fitted with highly sophisticated dynamic position fixing equipment.

The potential for the survey and support vessel(s) to become grounded while working within the operational area is limited as operations will not occur in water depths less than 39 m. Equipment dragging is unlikely as seismic streamers are fitted with pressure-activated, self-inflating buoys that are designed to bring the equipment to the surface if lost accidentally during a survey.

## 5.3 Reduced Air Quality from Atmospheric Emissions

Atmospheric emissions from the proposed survey include greenhouse gases (GHG), NO<sub>x</sub> (nitrogen oxide), SO<sub>x</sub> (sulphur oxide), CO (carbon monoxide) and particulate matter (dark smoke) emissions from:

- use of survey and support vessel main engines for propulsion;
- use of survey and support vessel main and emergency power generation equipment;
- use of aviation fuel for transport of personnel using helicopters;
- use of marine diesel by the survey vessel workboat; and
- incineration of liquid and solid wastes aboard the survey vessel (note: this would only occur for a limited duration as waste incineration is an intermittent operation).

Potential environmental effects from these atmospheric emissions are a contribution to GHG emissions (albeit very minor) that may potentially influence climate change, and a localised reduction in air quality. Atmospheric emissions generated during the survey will result in a localised, temporary reduction in air quality.

## 5.4 Introduction of Invasive Marine Species

Invasive marine species (IMS) are marine plants, animals and algae that have been introduced into a region that is beyond their natural range but have the ability to survive, and possibly thrive. Some IMS pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports and tourism. Impacts of IMS can include:

- Over-predation of native flora and fauna;
- Out-competing of native flora and fauna for food;
- Human illness through released toxins;
- Depletion of viable fishing areas and aquaculture stock;
- Reduction of coastal aesthetics; and
- Damage to marine and industrial equipment and infrastructure.

### 5.4.1 Ballast Water

The Department of Agriculture (DoA) has introduced the mandatory Australian Ballast Water Management Requirements (AQIS, 2008) that are enforced under the *Quarantine Act 1908*. These arrangements prohibit the discharge of high-risk ballast water within Australian territorial seas (within 12 nautical miles of Australian territories) including Australian ports. It is also recommended by DoA that ballast exchanges be conducted as far as possible away from shore and in water at least 200 m deep. Any vessels used for the survey will be required to meet the ballast water management standards of DoA.

### 5.4.2 Biofouling

Under the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia, 2009) a risk assessment approach is recommended to manage biofouling. Any vessels used for the survey will be required to meet the biosecurity standards of DoA.

## 5.5 Marine Pollution from Routine Discharges

### 5.5.1 Sewage, Grey Water and Putrescible Wastes

During the survey, the survey and support vessels will routinely discharge sewage, grey water (comprising laundry, shower and sink water) and putrescible wastes (comprising of food scraps) to the ocean in accordance with the requirements of the MARPOL 73/78 Convention (as implemented in Commonwealth waters by the PSPPS Act).

Routine discharge of wastewater to the ocean will cause a negligible and localised increase in nutrient concentrations. The total nutrient loading from vessel operations during the survey will be insignificant in comparison to the natural daily nutrient flux that occurs within the region.

### 5.5.2 Bilge Water

Bilge tanks receive fluids from many parts of the vessel. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals. This can cause a localised reduction in water quality if not treated prior to discharge. All discharges will be comply with the Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (PSPPS Act) and Marine Orders - Part 91: Marine Pollution Prevention – Oil.

## 5.6 Marine Pollution from Accidental Discharges

### 5.6.1 Solid wastes

The vessels will produce a variety of other solid wastes, including packaging and domestic wastes, such as aluminium cans, bottles, paper and cardboard. These will be controlled in compliance with PSPPS Act and Marine Orders - Part 95: Marine Pollution Prevention – Garbage which requires containment onboard and no discharge to sea.

## 5.6.2 Hazardous Materials

The vessels will store and use a variety of hazardous materials such as lubricating oils, cleaning chemicals and batteries. These will be controlled in compliance with PSPPS Act and Marine Orders – Part 94: Marine Pollution Prevention – Packaged Harmful Substances.

## 5.6.3 Fuel and Oil Spills

The hazards associated with fuel and oil spills during the survey (that are considered most credible) are:

- Seismic streamer gel leak of (~200 ml per section due to viscosity of gel);
- On-deck leak or spill of small quantities (up to 50 litres) of hydraulic oil or lubricating oil;
- Up to 37.5 m<sup>3</sup> marine diesel spill during at sea refuelling; or
- Larger volume (up to 1062 m<sup>3</sup>) loss of marine diesel from a ruptured fuel storage tank, resulting from vessel collision or grounding.

The potential environmental impact as a result of a significant accidental release of marine diesel could cause chronic/acute toxicity effects on marine organisms, with the worst case arising from a vessel collision. However, it is highly unlikely that such a collision would occur during the survey, as the survey and support vessels will be required to adhere to standard maritime safety and navigational procedures, such as use of lights, beacons, notification of vessel presence via Notice To Mariners (NTM), radio contact and through use of the support vessel.

In the extremely unlikely event of a rupture and complete loss of the entire contents of the largest of the vessels fuel oil tanks, for example as a result of vessel collision, the maximum hydrocarbon spill from the survey vessel would be 1062 m<sup>3</sup>.

Other smaller hydrocarbon spills could include smaller diesel spills from machinery onboard the seismic survey vessel, diesel spills from the support vessels, however these spills are expected to be much smaller than a total volume of 1062 m<sup>3</sup>.

Marine diesel can be assumed to travel 100% of the current and 3% of the wind speed (ITOPF, undated). Assuming a wind speed of 8 m/s and a current speed of 0.1 m/s (average conditions expected in the permit area; Section 3.1), a marine diesel slick in Summer is expected to have evaporated or dispersed within 25 hours of the spill occurring in which time it could travel ~31 km, while a marine diesel slick in winter is expected to have evaporated or dispersed within 27 hours of the spill occurring, in which time it could travel ~ 33 km.

The nearest shorelines from the operational area are Browse and Cartier Islands (6 km and 7 km respectively) and the nearest mainland shoreline is 40 km away. Shoreline contact could be expected in ~ 3 hours at the islands within the operational area while no mainland shoreline contact would occur.

However, prevailing currents within the survey area are seasonal with predictable directional trends as demonstrated by Table 3-1. PGS will plan the survey schedule so that the timing of operations is such that the vessel(s) will operate in the predicted downward side (as assumed from Table 3-1) of emergent features within the operational area when approaching within the 33 km wider environment that may be impacted by an unplanned release. When a persistent prevailing current is predicted heading towards the emergent islands, operations will not occur within 33 km of the emergent features in line with currents. In the open ocean habitat, where the proposed survey will occur, any spilled diesel would be subject to rapid

dispersal, weathering, evaporative losses and dissipation throughout the water column. Potentially affected biota includes seabirds, cetaceans and turtles that may come into contact with a surface diesel slick in the period prior to disappearance of these slicks due to natural dispersion and evaporation.

## 5.7 Disturbance to Social, Community and Conservation Values

### 5.7.1 Commercial Fisheries

In general, disruption to commercial fisheries in the area could result from:

- Direct effects of underwater sound on target fish populations.
- Restriction of access to fishing grounds due to vessel movements and operations.
- Seismic equipment loss and subsequent interference with fishing gear (entanglement).
- Loss of fishing gear e.g. buoyed fish traps.
- Recreational take of finfish species from the survey and support vessels.

Fishing companies and individual license holders operating in the operational area and wider environment have been contacted by PGS directly and via the appropriate peak fishing industry organisations, and informed of the location and timing of the seismic survey. Any concerns have been considered in section 6.4.

Due to limited responses received from consultation, and the remoteness and distance offshore of the majority of the survey area, the risk of potential impacts to commercial fisheries from the survey are considered minimal.

### 5.7.2 Shipping

Consultation with AMSA has shown that vessel traffic is greatest outside the operational area, although other vessel traffic is likely to occur within the operational area. A Notice to Mariners will be issued to notify all marine users of the presence of the survey and support vessels prior to the commencement of each phase of operations. Vessel interactions will be managed by adherence to the requirements of the Navigation Act 2012, and specifically Marine Orders - Part 30: Prevention of collisions.

### 5.7.3 Heritage and Conservation Values

As they are not present within the operational area, it is not expected that the proposed survey will impact on any heritage listed places. As described in Section 3.5.6, within the wider environment that may be impacted by unplanned events, there is one listed heritage place, one internationally important wetland, and one commonwealth heritage place.

### 5.7.4 Petroleum Activity

PGS will manage overlapping petroleum activities through pre-survey consultation and simultaneous operating procedures. PGS will continue to monitor other proposed activities that overlap the Forge operational area and timeframe through ongoing consultation.



## 6 MONITORING OF ENVIRONMENTAL PERFORMANCE

### 6.1 Auditing

The following arrangements will be established to evaluate environmental performance of the activity:

- An inspection of the vessels will be carried out by the 3rd Party quality control (QC) before the activity to ensure that procedures and equipment for managing routine discharges and emissions are in place to enable compliance with the EP.
- An inspection of the vessels will be carried out by the 3rd Party QC on a monthly basis throughout the survey to ensure commitments outlined in the EP are complied with.
- A summary of the key information, commitments, environmental performance outcomes, standards and measurement criteria for the activity will be distributed aboard the survey vessel, and implementation of the environmental performance outcomes and commitments will be monitored on a regular basis by the 3rd Party QC.

Should any inadequacies or improvements be found, the EP will be amended via a Management of Change to ensure environmental impacts and risks of the activity are continually identified and reduced to a level that is ALARP.

### 6.2 Environment Plan Review

If any change represents a significant modification that is not provided for in the accepted EP in force for the activity, a revision of the EP will be conducted in accordance with Regulation 17 of the Environment Regulations. The revised EP will be submitted to NOPSEMA in accordance with the requirements of Regulation 17(2), and the proposed change to the activity will not commence until the revised EP has been accepted by NOPSEMA.

Should any comments or feedback be raised by stakeholders prior to or during the survey that were not previously identified in the preparation of the EP, the impacts and risks will be assessed and if a significant new or increased impact or risk be identified, the EP will be reviewed and if considered necessary, revised and resubmitted to NOPSEMA under Regulation 17.

In compliance with Regulation 14(8AA) the Oil Pollution Emergency Plan (OPEP) will be continuously reviewed and kept up-to-date to ensure new information or improved technology can be incorporated as specified in the SOPEP.

### 6.3 Emergency Response

#### 6.3.1 Emergency Response Preparation

The PGS Marine Emergency Response & Contingency Plan outlines responsibilities and duties for the recovery from any emergency situation that may occur on any of its operations and vessels (including support vessels) worldwide. In the event of an emergency of any type the survey vessel Master will assume overall onsite command and act as the Emergency Response Coordinator (ERC). All persons aboard the vessel(s) will be required to act under the ERC's directions.

### 6.3.2 Oil Pollution Emergency Plan

The Oil Pollution Emergency Plan (OPEP) for the survey, taking into account the nature and scale of the activity and the potential spill risks involved comprises components of the survey vessel SOPEP that manage the environmental impacts of a spill, supported as required by applicable established, statutory Oil Spill Contingency Plans (OSCPs). In summary, the following plans are in place as a contingency in the unlikely event of an oil spill, which as a whole, represent the OPEP for this activity:

- Survey vessel SOPEP - deals with spills which are either contained on the vessel or which can be dealt with from / by the vessel
- National Plan to Combat Pollution of the Sea by Oil (NATPLAN): Australian Maritime Safety Authority (AMSA) - deals with spills from the vessels which affect Commonwealth waters
- WestPlan-MOP and MOSCP: WA DoT will be notified of incidents immediately through the Oil Spill Response Coordinator (OSRC).

#### 6.3.2.1 Vessel SOPEP

The survey vessel SOPEP, which has been prepared in accordance with the IMO guidelines for the development of shipboard oil pollution emergency plans (resolution MEPC.54(32) as amended by resolution MEPC.86(44)), includes emergency response arrangements and provisions for testing the OSCP (oil pollution drills), as required under Regulations 14(8AA) and 14(8A) of the Environment Regulations.

#### 6.3.2.2 Type I Operational Monitoring

In the event of an incident that resulted in a release of diesel to the waters surrounding the survey or support vessels, surveillance and monitoring would be carried out by the Combat Agency. PGS are responsible for undertaking Type I operational monitoring which would have the primary objective of spill surveillance and tracking. This monitoring will be implemented to:

- determine the extent and character of a spill;
- track the movement and trajectory of surface diesel slicks;
- assess impact of spill response undertaken e.g. increased vessels in the area;
- identify areas/ resources potentially affected by surface slicks; and
- determine sea conditions/ other constraints.

This monitoring will enable the Vessel Master to provide the necessary information to the relevant Combat Agency (AMSA or DoT), via a POLREP form, to determine and plan appropriate response actions under NATPLAN or the WestPlan MOP / MOSCP (if either of these plans are actually activated). Operational monitoring and observation in the event of a spill will inform an adaptive spill response and scientific monitoring of relevant key sensitive receptors.

#### 6.3.2.3 Type II Scientific Monitoring

Type II scientific monitoring may also be implemented at the request of the Combat Agency or other authority (e.g. EPA/DPaW) in the event of a spill that could result in significant environmental impact such as vessel collision to understand the effects of the spill and any response activities on the marine

environment. Given the open waters in which the spill could occur, scientific monitoring may be implemented for seabirds, marine mammals and turtles. In the event of shoreline contact (which is not considered likely), scientific monitoring may be implemented for sandy beaches and tidal zones, mangroves, coral reefs and fish (including fisheries). Relevant stakeholders may be consulted for advisory support prior to or during scientific monitoring activities and may include government, specialist advisors, research organisations, operators and key marine users.

## 6.4 Stakeholder Consultation

### 6.4.1 Preparatory Consultation

Consultation with stakeholder groups, primarily within the commercial fishing industry, concerning the proposed survey has taken place prior to, and during, the preparation of this EP. Stakeholders were identified through the following mechanisms:

- Identification of marine user groups and interest groups active in the area (e.g., recreational and commercial fisheries, other oil and gas producers, merchant shipping etc.)
- Active participation in industry bodies (e.g., Australian Petroleum Production and Exploration Association [APPEA])
- AFMA's Guidelines for petroleum industry consultation, confirming that all applicable fishers had been consulted
- Records from previous consultation activities in the area

A full list of stakeholders contacted is provided in Table 6-1. All stakeholders were issued with the following information:

- On 20<sup>th</sup> August 2014, an initial letter detailing a 2 year survey program with an operational area covering 43,800 km<sup>2</sup> with approximately 20,000 km<sup>2</sup> of data acquisition.
- On 13<sup>th</sup> May 2015 a revised scope notification was sent out detailing a work scope consisting of a 5 year survey program covering 58,166km<sup>2</sup> with approximately 30,000 km<sup>2</sup> of data acquisition.
- On 27<sup>th</sup> July 2015 a further updated notification letter was sent out informing the same stakeholders of a revised start date of the 1<sup>st</sup> September 2015 and a reduced survey timeframe of 16 months, as provided for in this EP.

Where no response to the original consultation was received after four weeks, the consultation was followed up with a secondary email.

By 7<sup>th</sup> August 2015, PGS had received responses from 17 stakeholders. These are summarised in Table 6-2 . Each piece of feedback was reviewed in detail and the merits evaluated and taken into consideration in the preparation of this EP.

Table 6-1: List of stakeholders considered relevant and contacted in the preparatory consultation

Fisheries		Government	Other	Conservation
ASBTIA	Abalone Managed Fishery	Coastwatch	Coastwatch	Centre For Whale Research
A Raptis & Sons	Joint Authority Northern Shark Fishery	INPEX (Ichthys field)	INPEX (Ichthys field)	
Austral Fisheries	Kimberley Gillnet and Barramundi Limited Entry Fishery	Shell (Concerto and Prelude fields)	Shell (Concerto and Prelude fields)	
Australian Fisheries Management Authority	Mackerel Managed Fishery	National Native Title Tribunal	National Native Title Tribunal	
Commonwealth Fisheries Association	Marine Aquarium Fish Managed Fishery	Department of Defence (DPSG, RAAF, AIS)	CGG (Gravis Survey)	
WA Department of Fisheries	Northern Demersal Scalefish Managed Fishery	WA Department of Mines and Petroleum		
Kimberley Preoffessional Fishermans Association	Abalone Managed Fishery	Shire of Derby West Kimberley		
MG Kailis Northern Fishing Companies Association	Pearl Oyster Fishery Specimen Shell Managed Fishery	Shire of Broome NT Department of Transport		
Northern Prawn Fishery Industry Inc. (NRFI)	WA North Coast Shark Fishery	NT Department of Foreign Affairs and Trade		
Shark Bay Seafoods	North Coast Prawn Managed Fishery	NT Department of Primary Industry and Fisheries		
WA Fishing Industry Council	West Coast Deep Sea Crustacean Managed Fishery	NT Department of Mines and Energy		
Tunawest	North Coast Nearshore and Estuarine Fishery	Shire of Wyndham East Kimberley		
WA Seafood Exporters	North Coast Demersal Fishery (Kimberly sector)	Australian Hydrographic Service		
Westmore Seafoods	Beche-de-mer Fishery	Australian Maritime Safety Authority		
Recfishwest	North Coast Crab fishery	Border Protection Command		
Pearl Producers Association				

Table 6-2: Stakeholder submissions received

Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
AFMA	27/08/2014 Email	Recommended to contact fishermen in the area and requested to be informed of any changes	Sent updated notification on 13/05/2015 – no response received.
AMSA	25/08/2014, 14/05/2015 Emails	<p>Advised: Extra caution must be taken as the survey area overlaps Osborne Passage and the charted Preferred Route.</p> <p>Given the length of tow (~8,000m), the support vessel in cooperation with the survey vessel will need to be active and maintain exceptional communications with all commercial shipping, should they be encountered, in the survey area noting there will be a considerable speed difference between commercial shipping and the survey vessel whilst the latter is conducting operations.</p> <p>It is worth noting that any related avoiding action by commercial shipping, should it be necessary, should not increase and/or compound the navigational risk to other shipping in the vicinity. The seismic vessel must display appropriate day shapes, lights and streamers, reflective tail buoys, to indicate the vessel is towing and is therefore restricted in her ability to manoeuvre. Visual and radar watches must be maintained on the bridge at all times.</p> <p>Please ensure AMSA's RCC is contacted through <a href="mailto:rccaus@amsa.gov.au">rccaus@amsa.gov.au</a> for Auscoast warning broadcasts before operations commence. AMSA's RCC will require the vessels details and area of operation and need to be advised when the survey starts and ends. Additionally, the Australian</p>	<p>Sent updated notification on 13/05/2015 – sent updated traffic plot and informed same advice still stands.</p> <p>Sent updated notification on 27/07/2015 – sent updated traffic plot and reconfirmed previous advice and request for lessons learned.</p>

Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
		<p>Hydrographic Service must be contacted through <a href="mailto:hydro.ntm@defence.gov.au">hydro.ntm@defence.gov.au</a> well in advance (i.e. no less than 2 working weeks) for the promulgation of related Notices To Mariners (NTM).</p> <p>At the conclusion of the survey, please be in touch to comment on the operations and the interaction with commercial shipping at the time of the survey (i.e. any lessons learned).</p>	
ASBTIA	14/05/2015 Email	Informed of no objections	No further action required
Australian customs and border protection services	17/10/2014 Email	Acknowledged receipt and will forward to relevant area	No further action required
Australian Hydrographic Service	16/10/2014 Email	Requested to be 'Kept in loop on status of survey operations so that we can issue temp notices to cover'.	No further action required – further consultation notifications will suffice
	28/07/2015	Requested confirmation of details prior to survey	No further action required – further consultation notifications will suffice
Department of Defence	01/09/2014, 29/05/2015 Emails	Defence informed it has reviewed the survey program and has no objections. Made PGS aware of possibility of unexploded ordinance in the area (standard protocol) and restricted airspace above operational area.	No further action required
Department of Defence (RAAF)	10 <sup>th</sup> April 2014 Email	Advised that the email has been received and forwarded to appropriate areas for action/response as required	No further action required
Department of Environment	20/08/2014 Email	Advised the Department of the Environment is not a relevant agency for consultation under the OPGGS(E) Regulations, as the NOPSEMA authorisation process encompasses the functions, interests and activities of the Department.	No further action required

Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
<p>WA Department of Mines and Petroleum</p>	<p>08/09/2014 Email</p>	<p>DMP has reviewed the notification and does not require any further information at this time. DMP notes that prior to commencing any survey within the survey area, PGS will contact DMP to provide detailed information for the proposed activity including the size, location and geographical coordinates for the survey area, timing and duration, parameters for the towed seismic array, and details of the survey and support vessels. Subsequent to provision of the above information, DMP may raise specific concerns or issues with the proposed survey at that time.</p>	<p>Pre-survey notification detailing survey parameters</p>
	<p>05/08/2015</p>	<p>In relation to previous correspondence from DMP on 8/9/2014 , please subsequently provide refined details of timing, the area of acquisition and details of the survey and support vessels. Subsequent to provision of the above information, DMP may raise specific concerns or issues with the proposed survey at that time.</p>	
<p>WA Department of Parks and Wildlife</p>	<p>04/06/2015 Email</p>	<p>Informed that:</p> <p>To inform the assessment of the Forge Multi-client Marine Seismic Survey, Parks and Wildlife recommends that you clarify and interpret the following information to the satisfaction of the regulator:</p> <ul style="list-style-type: none"> <li>• maximum received SELs in adjacent areas of State waters that are reserved under the</li> </ul>	<p>All points are considered throughout the impact assessment within this EP and residual risks and impacts are assessed to be as low as reasonably practical by the regulator.</p>

Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
		<p>CALM Act, or are known to provide habitat for species that are specially protected or threatened wildlife under the WC Act;</p> <ul style="list-style-type: none"> <li>• a comparison between the received SELs, and levels likely to cause injury (including permanent or temporary threshold shift in hearing), or trigger the behavioural disturbance of specially protected or threatened species that may inhabit, migrate through, or use the area for nesting or calving during proposed survey periods;</li> <li>• survey design and operational management procedures that will be implemented in order to avoid, or minimise impacts on specially protected or threatened wildlife and reserve values, including marine turtles, and cetaceans noting the importance of humpback whale (<i>Megaptera novaenglie</i>) calving grounds in Lalang-garram/Camden Sound Marine Park, and humpback and pigmy blue whales (<i>Balaenoptera musculus brevicauda</i>) migration pathways.</li> <li>• the potential cumulative impacts of multiple seismic surveys conducted by PGS and other operators during peak periods for, and in the vicinity of, nesting turtles and migrating or calving cetaceans.</li> </ul>	
WA Department of Fisheries (DoF)	15/10/2014 Email	1. Requested consultation to consist of:	1. DoF have not yet responded to the survey updates sent on 13/05/2015 2. Fisheries incorporated into EP and consulted with





Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
		<ul style="list-style-type: none"> <li>• Specific start and finish dates</li> <li>• The spatial extent of proposed activities (including any exclusion zones) and;</li> <li>• Information on identified specific fishing interests, including previous consultation with individual licenced fishers</li> </ul> <p>2. Advised of active fisheries in the proposed area.</p> <p>3. Requested that the EP contain mitigation strategies to minimise the impacts of the survey on fish spawning</p> <p>4. Requested that reporting arrangements for biosecurity are forwarded to all vessel operators.</p>	<p>3. Mitigation strategies included in EP</p> <p>4. Biosecurity procedures for vessels will include reporting arrangements</p>
Goldband Nominees	14/05/2015 email	<p>Requested PGS liaise with fishing vessel to determine vessel and gear location. This also would apply to 2 other fishing companies that fish the same areas</p> <p>Informed that a daily call to their sat phone will update instantly to the location of our gear</p>	<p>PGS agreed to request</p> <p>PGS proposed a meeting to share information. Meeting will occur prior to any operations.</p>
	29/07/2015	Acknowledged receipt of update	
MG Kailis Group	16/10/2014 email	Advised of no impact to fishing operations	No further action required
National Native Title Group	29/05/2015 email	Advised of two overlapping Native Title Determinations	No further action required
Northern Territory Department of mines and Energy	16/10/2014 email	Advised it is not a relevant agency for consultation as NOPSEMA/NOPTA manage NT waters	No further action required
Pearl Producers	22/08/2014 email	Advised of no impact	No further action required



Stakeholder	Date and means of correspondence	Response / outcomes	Assessment / actions
Association			
Raptis	16/10/2014 email	Advised of no impact	No further action required

No other responses to this consultation have been received, and no other issues or concerns regarding the proposed activities have been raised by any other stakeholders contacted during this preparatory consultation.

### 6.4.2 Ongoing Consultation

PGS recognises the need for ongoing stakeholder consultation throughout the timeframe of the EP. As extensive and adequate consultation has been undertaken already, further notifications issued to stakeholders are not expected to raise any new or additional concerns.

However, should any comments or feedback be raised by stakeholders prior to or during the survey that were not previously identified in the preparation of the EP, the impacts and risks will be assessed and if a significant new or increased impact or risk is identified, the EP will be resubmitted to NOPSEMA under Regulation 17. If the feedback results in a change in operations, but is not considered to result in significant new or increased impact or risk, a Management of Change will be undertaken. This ensures that any impacts of the survey on stakeholder's activities or interests are continually reduced to ALARP.

### 6.4.3 Pre-survey Consultation

One month prior to the commencement of each phase of the survey PGS will send out a stakeholder notification to all stakeholders identified in Table 6-1, along with any identified through ongoing consultation.

In addition to any other pre-survey notifications identified in Table 6-2, prior to commencement of each phase of the survey PGS will consult a number of additional stakeholders, primarily within the offshore exploration and production industry. These consultations will include, as far as possible, other geophysical companies operating in Australian waters, plus titleholders of petroleum titles within the operational area. The primary objective of this consultation will be to ascertain if there are any other seismic surveys or other oilfield activities proposed for areas adjacent to the operational area, over the same time period.

Simultaneous operations (SIMOPS) plans will be prepared in conjunction with other title holders / operators as required. Concurrent surveys usually require a minimum separation distance of ~30 km between the two operating survey vessels to avoid noise interference with the received signals. If separation distances between the survey vessels could be closer than 30 km then the two proponents routinely work out procedures for simultaneous operations to eliminate or minimise the potential for noise interference and data corruption - for instance, a time-sharing arrangement where, over a 24 hour period each vessel will acquire for a period of 12 hours whilst the airgun arrays of the other vessel are shut down.

## 7 DETAILS OF THE TITLEHOLDER AND LIASON PERSON

	Titleholder	Nominated liaison person
<b>Name</b>	PGS Australia Pty Ltd (PGS)	Terry Visser
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<b>ACN number</b>	077 150 415	

## 8 REFERENCES

- APPEA (2013b) Seismic and the Marine Environment [http://www.appea.com.au/wp-content/uploads/2013/05/Seismic\\_and\\_the\\_Marine\\_Environment.pdf](http://www.appea.com.au/wp-content/uploads/2013/05/Seismic_and_the_Marine_Environment.pdf) [Accessed 1st July 2013]
- Buckingham M. J. (2001) Precision correlations between the Geoacoustic parameters of an unconsolidated sandy marine sediment. *Journal of Computational Acoustics*, Vol. 9, No. 1
- Commonwealth of Australia (2002) Ashmore Reef National Nature Reserve and Cartier Island Marine Reserve (Commonwealth Waters) Management Plans Environment Australia, Canberra.
- DEWHA (Department of the Environment, Water, Heritage and the Arts) (2007) A characterisation of the marine environment of the North-west Marine Region: Perth workshop report. A summary of an expert workshop convened in Perth, Western Australia. 5-6 September 2007, DEWHA, Hobart
- DEWHA (2008) EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales. Australian Government, Department of the Environment, Water Heritage and the Arts
- DoE (2014a). EPBC Online Protected Matters Database accessed on 5th June 2015 at <http://www.environment.gov.au/epbc/pmst/index.html>
- DoE (2014b). Conservation Values Atlas accessed on 15th May 2015 at <http://www.environment.gov.au/topics/marine/marine-bioregional-plans/conservation-values-atlas>
- Double, M.C., Gales, N., Jenner, K.C.S. and Jenner, M.-N. (2010) Satellite tracking of south-bound humpback whales in the Kimberley region of Western Australia. Report to the Western Australian Marine Science Institution.
- DSEWPaC (2012b) Marine bioregional plans (North West). Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT. Available at <http://www.environment.gov.au/coasts/marineplans/about.html>
- Environment Australia (2003) Recovery Plan for Marine Turtles in Australia. Prepared by the Marine Species Section, Approvals and Wildlife Division, Environment Australia, Canberra, ACT
- Gales, N., Hindell, M., Kirkwood, R. (2003) *Marine Mammals: Fisheries, Tourism and Management Issues*. Pub. CSIRO Publishing, Victoria, Australia.
- Garnett, S.T. & G.M. Crowley (2000). *The Action Plan for Australian Birds 2000*. [Online]. Canberra, ACT: Environment Australia and Birds Australia. Available from: <http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html>
- Gausland, I (2000). Impact of seismic survey on marine life. SPE 61127. SPE International Conference on Health, Safety and the Environment in Oil and Gas Exploration and Production. 26-28 June 2000. 4 pp.
- Guinea, M.L. (2006). Final Report Survey 2005: Sea snakes of Ashmore Reef, Hibernia Reef and Cartier Island. Consultant's report to the Department of the Environment and Water Resources, Canberra. [Online]. Canberra: Department of the Environment and Water Resources. Available from: [http://www.afma.gov.au/information/publications/fishery/baps/docs\\_reports/npf\\_final\\_2007.pdf](http://www.afma.gov.au/information/publications/fishery/baps/docs_reports/npf_final_2007.pdf).

Guinea, M.L. (2007a). Survey March 16 - April 2 2007: Sea snakes of Ashmore Reef, Hibernia Reef and Cartier Island with comments on Scott Reef. Final Report to the Department of the Environment and Water Resources, Canberra. Darwin: Charles Darwin University.

Heyward et al., (2011) Monitoring study S5 Banks and Shaols, Montara 2011 Offshore Banks Assessment Survey. Report for PTTEP Australasia (Ashmore Cartier) PTY. Ltd. Australian Institute of Marine Science, Townsville. (253 pp.).

Heyward *et al* (2013) Montara: Vulcan, Barracouta East and Goeree Shoals Survey 2013; Heyward *et al* 2013; Report for PTTEP Australasia (Ashmore Cartier) Pty Ltd. Australian Institute of Marine Science, Perth. (87pp.)

Jenner, KCS, Jenner, M-N & McCabe, KA, 2001 Geographical and temporal movements of humpback whales in Western Australian waters. APPEA Journal Vol 41(2001), pp 749—765

Jochens, AE, and Biggs, DC (2003). Sperm Whale Seismic Study in the Gulf of Mexico. US Minerals Management Service OCS Study 2003-069. Report published by US Department of Minerals Management Service OCS Region, New Orleans. 135 pp.

Limpus CJ (2008) A biological review of Australian marine turtle species. 2. Green turtle, *Chelonia mydas* (Linnaeus). The State of Queensland. Environmental Protection Agency, Brisbane, Queensland.

McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M-N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. In: Environmental implications of offshore oil and gas development in Australia: further research - A compilation of three scientific marine studies. pp. 364-521. Australian Petroleum Production and Exploration Association Limited, Canberra.

McCauley R. D., Fewtrell, J., Duncan, A., Jenner, C., Jenner M-N., Penrose, J. D., Prince, R. T., Adhitya, A., Murdoch, J. and McCabe, A. K. (2003). Marine seismic survey: analysis and propagation of source signals; and effects of exposure on humpback whales, sea turtles, fishes and squid. Curtin University Centre for Marine Science and Technology (CMST). Report R99-15 for the Australian Petroleum Production and Exploration Association (APPEA). Published in: Environmental Implications of Offshore Oil and Gas Developments in Australia: Further Research. APPEA, 2003: 520.

McCauley, RD (1994). The environmental implications of offshore oil and gas development in Australia – seismic survey. In: Swan, J.M., Neff, J.M. and Young, P.C. (eds.), Environmental Implications of Offshore Oil and Gas Development in Australia - The Findings of an Independent Scientific Review, pp. 123-207. Australian Petroleum Exploration Association, Sydney. pp. 19-21.

Meekan, M.G., C.J.A. Bradshaw, M. Press, C. McLean, A. Richards, S. Quasnichka & J.G. Taylor (2006). Population size and structure of whale sharks *Rhincodon typus* at Ningaloo Reef, Western Australia. Marine Ecology Progress Series. 319:275-85.

Miller, IR & Cripps, E 2013, 'Three dimensional marine seismic survey has no measurable effect on species richness or abundance of a coral reef associated fish community' Marine Pollution Bulletin, vol 77, no. 1-2, pp. 63-70

Moritz, C., D. Broderick, K. Dethmers, N. FitzSimmons & C. Limpus (2002). Population Genetics of Southeast Asian and Western Pacific Green Turtles, *Chelonia mydas*. *Unpublished Report to United Nations Environment Programme*. CMS, Bonn, Germany. Musick, J.A., Stevens, J.D., Baum, J.K., Bradai, M., Clò, S., Fergusson, I., Grubbs, R.D., Soldo, A., Vacchi, M. & Vooren, C.M. 2009. *Carcharhinus plumbeus*. The IUCN Red List of Threatened Species. Version 2015.2. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on 29 July 2015.

Parry, GD and Gason, A (2006). The effect of seismic survey on catch rates of rock lobsters in western Victoria, Australia. Fisheries Research, 79: 272–284.

Pendoley Environmental (2011) Varanus Island Marine Turtle Tagging Programme 2009 - 2010. Report to Apache Energy Ltd.

Popper et al., (2014) Sound Exposure Guidelines for Fishes and Sea Turtles : A Technical Report prepared by ANSI-Accredited Standard Committee S3/SC1 and registered with ANSI

Richardson, W. J., Greene, C. R., Maime, C. I. and Thomson, D. H. (1995). Marine Mammals and Noise. Academic Press, San Diego, California.

RPS (2010). Marine Mammals Technical Report. Wheatstone Protect Technical Appendix O12. Report prepared for Chevron Australia Pty Ltd. Perth, Western Australia.

Wilson, S Polovina, J Stewart, B & Meekan, M (2006) Movements of whale sharks (*Rhincodon typus*) tagged at Ningaloo Reef. Marine Biology, vol. 147, pp. 1157-1166.

Woodside (2007) Literature Review – Effects of seismic airguns and other sources of pulsed sound on marine fishes