Ceduna Multi-Client 3D Marine Seismic Survey

Environment Plan Summary

November 2014

PGS Australia Pty Ltd

Rev 3

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1 INTRODUCTION

The geophysical company Petroleum Geo-Services (PGS) proposes to acquire a multi-client three-dimensional (MC3D) marine seismic survey (MSS) in the Great Australian Bight (GAB), known as the Ceduna MC3D MSS.

This summary of the Environment Plan (EP) for the Ceduna MC3D MSS has been submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), to comply with Regulations 11(3) and 11(4) of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*.

1.1 Location of the Activity

Data acquisition will occur within the survey area, which covers approximately 13,800 km^2 (Figure 1-1). The survey area is defined as the area within which data acquisition occurs. Associated vessel operations (line run-ins and run-outs, soft-starts and line turns) may occur within 15 km of the 3D survey polygon. The survey area covers Petroleum Exploration Permits (EPP) 37, 38 and 43, and a small amount of adjacent open acreage areas. The survey area is located solely in Commonwealth waters adjacent to South Australia; however, the vessel may enter or operate within Commonwealth waters adjacent to Western Australia while undertaking associated operations as outlined above.

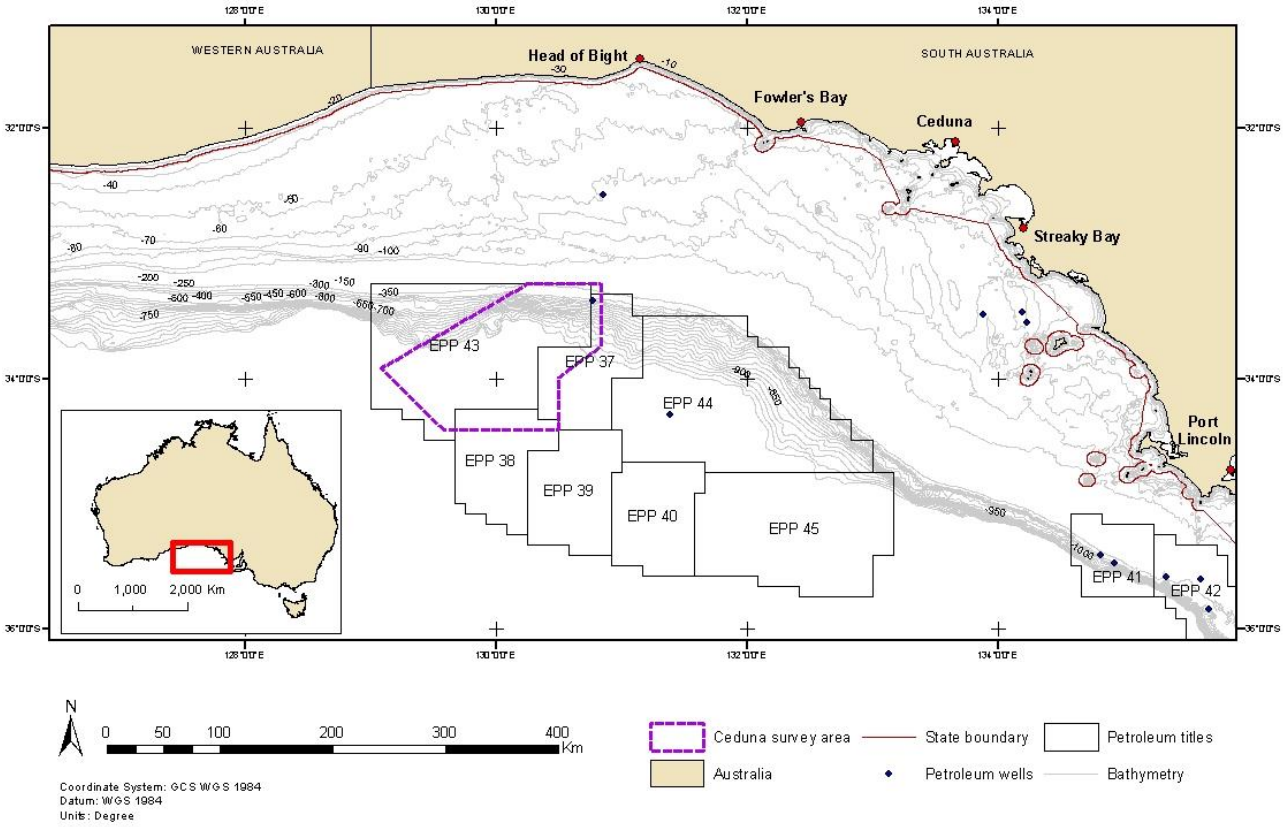
Boundary coordinates for the 13,800 km² survey area are shown in Table 1-1. The survey area is located 180 km from the nearest land (mainland South Australia), 475 km west of Port Lincoln and 295 km south west of Ceduna, the closest township. The water depths in the survey area are in the range of ~100 to 3,000 m with the shallowest water depths located along the northern and north eastern boundaries of the survey area.

Table 1-1: Co-ordinates of the proposed survey area

Longitude	Latitude
130.834741	-33.248623
130.834749	-33.748627
130.501423	-33.998632
130.50143	-34.415302
129.584771	-34.415313
129.084767	-33.915315
130.251413	-33.24863
130.834741	-33.248623

Datum: WGS84

Figure 1-1: Location of the survey permit area



1.2 Timing and Duration of the Activity

The survey will take approximately 5 months to acquire, occurring within the acquisition window of November 2014 to May 2015 (inclusive). This acquisition window is chosen to avoid adverse weather conditions which occur throughout the winter months and may pose additional, avoidable risks and excessive downtime, prolonging the overall duration of the survey.

2 DESCRIPTION OF THE ENVIRONMENT

This section describes the environmental values and sensitivities considered relevant to the planned activities scheduled to occur within the survey area boundaries (as outlined in Section 1.1), and those occurring in the 'wider environment' (the area potentially impacted by planned or unplanned events outside of the survey area). When describing the environmental values and sensitivities of the wider environment, a 65 km buffer around the survey area was determined to include the worst credible scenario for additional impacts outside the survey area.

The proposed survey area lies entirely in Commonwealth marine waters of the South West Marine Region (SWMR) in the Bight Basin (Ceduna and Polda sub-basins) covering water depths between approximately ~100 to 3,000 m.

2.1 Climate, Currents and Upwelling

The oceanography of the GAB is typified by a high energy, swell dominated wave regime and a coastline exposed to a persistent south-west swell (Environment Australia, 1996). The GAB experiences some of the world's highest and most persistent waves (Chelton *et al*., 1981). Tides along the western Eyre coast are microtidal in range and are predominantly semi-diurnal, with a mean tidal range of between 0.8 m and 1.2 m (Edyvane, 1998).

Open seawater temperatures in the GAB vary from a mean summer sea surface temperature of 18°C to a mean winter sea surface temperature of 14°C (decreasing to 11-12°C under the influence of upwellings). Generally, high salinities are a feature of the GAB, with levels of 35.7% being recorded at 100 m depths (Rochford, 1980).

A seasonal, atmospheric cyclonic cycle maintains a high pressure ridge over the South Australian Basin in summer, resulting in predominantly south-easterly winds. Average wind speeds of 14.72 knots (7.57 m/s), and maximum wind speed of 44 knots (22.6 m/s) per annum have been recorded in the GAB (BP, 2013a).

The GAB is dominated by a high south-west swell, generated by the west to east-moving low pressure cyclones south of the mainland. This south-west to westerly swell ranges from less than 2 m for 50% of the year, to 2-4 m for 30-45% of the year and exceeding 4 m approximately 10% of the year.

Four major water masses or currents influence the oceanography of the GAB (Edyvane, 1998), these are:

- Leeuwin Current;
- Central Bight water mass;
- West Wind Drift cold water mass; and
- Surface-flowing Flinders Current.

The circulation on the Southern Shelf is mainly wind driven, where current speed is almost non-existent within the GAB (DSEWPAC, 2008). Generally, in winter the flow is towards the east, and in summer towards the west.

The Bonney Coast circulation leads to classical upwelling plumes (the Bonney upwelling) which extend poleward to the wide shelf southeast of Kangaroo Island (Lewis, 1981; Schahinger, 1987). The western coast of the Eyre Peninsula is responsible for a second important area of summer upwelling (during October and November). These upwellings are sites of significant productivity, as they bring deep, cool, nutrient rich water to the surface, triggering high productivity with phytoplankton blooms, the production

of zooplankton blooms and krill swarms, which are important food sources for fish, foraging seabirds and marine mammals (DSEWPAC, 2008).

2.2 Geomorphology and Sedimentology

The GAB forms part of the Southern Shelf of Australia, which is the northern boundary of the South Australian Basin of the South East Indian Ocean. Along the Southern Shelf of the GAB and the Bonney Coast, in particular south of the Eyre Peninsula, 25 large and steep canyons connect the continental slope and the abyssal plain (Bye, 1998). The continental shelf is almost featureless, forming a gentle sloping plain out to the shelf break at 125-165 m depth (Edyvane, 1998). The outline of the continental slope is broken by a major terrace (Ceduna Terrace) and two minor terraces (Eyre and Beachport Terrace) (Willcox *et al*., 1988).

2.3 Biological Productivity

The rich marine biodiversity and high levels of endemism of this region are, in part, due to the long east-west extent of the southern coastline and the long period of geological isolation. Biological productivity in this bioregion is driven mainly through pulses of mixed water that irregularly wash through the system from the west. Highly mobile, higher order predators (such as tuna, school sharks, dolphins and seabirds) appear to track the food chains associated with these pulses of productivity as they move through the bioregion.

An ecologically important hotspot of productivity occurs on the inner shelf at the Head of Bight (DSEWPaC, 2012). Satellite images show higher concentrations of chlorophyll in this area and anecdotal observations indicate higher concentrations of a number of species, which appear to use the relatively sheltered area of mixed seagrass, sand and limestone reef as nursery and feeding grounds. These include juvenile Australian salmon, school shark, Australian sea lion, dolphins and southern right whales.

2.4 Benthic Habitats

Results of benthic habitat surveys suggest the mid-outer shelf (120 - 220 m depth, greater than 80 km offshore) has the most highly productive and diverse zone in terms of sediments, with many hundreds of species of bryozoans, foraminifera and ostracods. The upper slope area, at water depths below storm wave-base, is predominantly inhabited by low-growing bryozoans and a few sponges and other biota (Bone and James, 1998).

The majority of the survey area occurs in water depths deeper than the shelf (>200 m). While high biodiversity has been observed at water depths similar to the shallowest section of the survey area (e.g. the outer shelf region), such biodiversity is less evident at greater depths (Currie and Sorokin, 2011).

2.5 Marine Bioregions, Protected Areas and Key Ecological Features

2.5.1 Marine Bioregions

The survey area lies within the Southwest Marine Region (SWMR). The area potentially impacted by planned and unplanned events during the activity covers two bioregions; the Great Australian Bight Shelf and the Southern Province (DSEWPAC, 2008).

2.5.2 Marine Reserves

The survey area overlaps with the GAB Commonwealth Marine Reserve. The GAB Commonwealth Marine Reserve encompasses the former GAB Marine Park which is split into two designations; the Marine Mammal Protection Zone and the Benthic Protection Zone. Only the Benthic Protection Zone occurs within the survey area or the wider environment as defined by the 65 km buffer. These reserves were extended and combined in November 2012 to form the GAB Commonwealth Marine Reserve covering 45,926 km^2 with a depth range of 15 to 6,000 m.

Under transitional arrangements the GAB Marine Park is managed under the existing management plan. Under these plans, seismic activities are allowable within the Benthic Protection Zone with an approval or permit issued form the Director of National Parks. An application for a permit, under the EPBC Act, is being prepared in parallel with this EP and no activities will be carried out within the GAB Benthic Protection Zone without a permit.

2.5.3 Key Ecological features

The survey area and wider environment overlaps with one Key Ecological Feature (KEF), the Ancient Coastline at 90-120 m isobaths.

2.6 Marine Fauna

2.6.1 Pelagic Fish Species

Pelagic fish are known to concentrate along the shelf break in the GAB. Commercial fish landings taken from the shelf break and the upper and mid-slope include the southern bluefin tuna (SBT), school sharks, deep-water flathead, Bight redfish and orange roughy. Mid-water and pelagic fish are generally widespread and migratory, with species visiting cooler southern waters during summer (DSEWPAC, 2008).

2.6.1.1 Southern Bluefin Tuna

The SBT is a temperate water fish of the South Pacific Ocean. The IUCN lists the conservation status of this species as 'Critically Endangered' and SBT stocks are recognised as being 'Severely Depleted'. The SBT ranges from inshore areas adjacent to rocky foreshores, out to the mid-ocean deeps, well beyond the edge of the continental shelf. Spawning is believed to take place in tropical waters south of Timor and Java, off the Australian North West Shelf during the summer months. The GAB appears to be an important feeding and nursery ground during the summer. Juvenile SBT are suggested to congregate at seamounts, lumps and reefs in the GAB where prey species also congregate within shallow coastal waters. Juvenile SBT migrate east from the southern Indian Ocean arriving in the GAB between October and February where they aggregate in the eastern and northerly areas of the GAB predating on small pelagic fish, squid, krill and salps. Although the exact migratory patterns are unknown, tagging studies have revealed that juvenile SBT occur between 30 and 50°S in the Indian Ocean with lack of specific, or narrowly defined, migration routes (Basson *et al.*, 2012). The GAB is the only area in the world where young SBT (1-5 year old fish) are known to surface consistently (DSEWPAC, 2008).

2.6.2 Protected Species

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 7th June

2014 for the survey area polygon described by the boundary coordinates provided in Table 1-1. An additional search including a 65 km buffer to account for the wider environment was also conducted, which identified a further two threatened species. Further details of the Protected Matters search, indicating species likely to occur within, or adjacent to, the search area (the survey area or the wider environment as defined by the 65 km buffer) are provided in Table 2-1 (DoE, 2014a).

The majority of the marine species identified are likely to transit through the area, and it is unlikely that the habitats within the survey area are critical to the survival of these species. Biologically Important Areas (BIAs) as identified by the Conservation Values Atlas (DoE, 2014b) which overlap with, or are in proximity to, the search area, are highlighted in Table 2-1. There are no known nesting and breeding areas for these listed species within the search area. Similarly, there are no EPBC Act-listed Threatened Ecological Communities in the vicinity of the search area.

Beaked whales

While not listed as threatened or migratory under the EPBC Act, beaked whales, which belong to a family of toothed whales (Ziphiidae), have been identified as 'flagship' species for the SWMR. Six species of beaked whale were identified as possibly occurring within the survey area: the Andrew's, Blainville's, Gray's, strap-toothed, True's and Curvier's beaked whale.

Beaked whales have an oceanic distribution with preference for deep waters beyond the shelf edge. A recent study indicates that waters south-west of Australia may be important areas for beaked whales (MacLeod and Mitchell, 2006). In particular, areas of upwelling provide foraging habitat for these species.

Given the low number of reported beaked whale sightings in the region and the lack of upwelling within the survey area, the relatively low abundance of these species reduces the likelihood of a significant number of individuals being encountered during the survey.

Table 2-1: EPBC Act Protected Species that may occur in, or relate to, the survey area and the wider environment

Scientific name	Common name	Status	Likelihood of presence	Biologically Important Areas in proximity to survey area	
				Survey area	Wider environment
Cetaceans					
Balaenoptera musculus	Blue whale	Endangered, Migratory	Foraging, feeding or related behaviour may occur in area (peak activity November – May) but is more common in areas of upwelling which are absent from the survey area. Individuals may migrate through the area (November – May).	BIA for migration and possible foraging overlaps	
Caperea marginata	Pygmy right whale	Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	
Eubalaena australis	Southern right whale	Endangered, Migratory	Breed between May and October along the south coast of Australia with the Head of Bight being a particularly important calving area. Individuals may traverse the survey area on migration to breeding sites, however the general anti clockwise migration, lack of defined migration pathways and anecdotal observations indicate that large numbers of individuals are unlikely to be encountered.	BIA for breeding located ~160 km north	BIA for breeding located ~95 km north
Lagenorhynchus obscurus	Dusky dolphin	Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	
Megaptera novaeangliae	Humpback whale	Vulnerable, Migratory	Survey area does not contain any known feeding or resting habitat and does not lie within the migration pathway. Transient individuals may be encountered, but large numbers are not expected.	BIA for migrating humpback whale located > 400 km west	
Balaenoptera bonaerensis	Antarctic minke whale	Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	
Balaenoptera edeni	Bryde's whale	Migratory		None	
Orcinus orca	Killer whale	Migratory		None	

Scientific name	Common name	Status	Likelihood of presence	Biologically Important Areas in proximity to survey area	
				Survey area	Wider environment
Physeter macrocephalus	Sperm whale	Migratory	Foraging, feeding or related behaviour may occur in area (peak activity August – September but can occur year round) but is more common in areas of upwelling which are absent from the survey area. Individuals may migrate through the area.	Possible foraging BIA overlap	
Balaenoptera borealis	Sei whale[1]	Vulnerable	Survey area does not contain any known significant feeding habitat. Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	
Balaenoptera physalus	Fin whale[1]	Vulnerable, Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	
Pinnipeds					
Neophoca cinerea	Australian sea lion	Vulnerable	Individuals may occur in the survey area. However, since foraging trips are typically within 20 to 30 km of the coast, and at the closest point the survey area is located ~180 km to land, the likelihood of encountering foraging Australian sea lions within the survey area is expected to be low.	Male foraging BIA overlaps	Male and female foraging BIA overlaps
Sharks (Fish)					
Carcharodon carcharias	White shark	Vulnerable, Migratory	Likely to pass through the survey area. Foraging may occur; however, given the low abundance of preferred prey species (pinnipeds) large numbers of foraging individuals are not expected to occur.	Foraging BIA 77 km north	Foraging BIA 11 km north
Isurus oxyrinchus	Shortfin mako, mako shark	Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers.	None	

[1] May occur in the wider environment, unlikely to occur in the survey area

Scientific name	Common name	Status	Likelihood of presence	Biologically Important Areas in proximity to survey area	
				Survey area	Wider environment
Lamna nasus	Porbeagle, mackerel shark	Migratory		None	
Marine Reptiles					
Caretta caretta	Loggerhead turtle	Endangered; Migratory	Transient individuals may pass through the area but are unlikely to be encountered in large numbers. No significant breeding/nesting sites known to occur in the region. Areas of important foraging habitat not known to occur in the survey area.	None	
Chelonia mydas	Green turtle	Vulnerable; Migratory		None	
Dermochelys coriacea	Leatherback turtle	Endangered; Migratory		None	
Birds					
Diomedea antipodensis	Antipodean albatross	Vulnerable; Migratory	No nesting areas known to occur in proximity of survey area. Given these species large, pelagic distribution, individuals may fly over the area in transit or while foraging.	None	
Diomedea dabbenena	Tristan albatross	Endangered; Migratory		None	
Diomedea epomophora (sensu stricto)	Southern royal albatross	Vulnerable; migratory		None	
Diomedea sanfordi	Northern royal albatross	Endangered; Migratory		None	
Diomedea exulans (sensu lato)	Wandering albatross	Vulnerable; Migratory		None	
Macronectes giganteus	Southern giant petrel	Endangered; Migratory		None	
Macronectes halli	Northern giant-petrel	Vulnerable; Migratory		None	
Phoebetria fusca	Sooty albatross	Vulnerable; Migratory		None	
Puffinus carneipes	Flesh-footed shearwater	Migratory		Two breeding site BIAs: > 400 km east and >500 km west	
				Foraging BIA ~320 km west	Foraging BIA ~200 km west

Scientific name	Common name	Status	Likelihood of presence	Biologically Important Areas in proximity to survey area	
				Survey area	Wider environment
Thalassarche cauta cauta	Shy albatross ,Tasmanian shy albatross	Vulnerable; Migratory		None	
Thalassarche melanophris	Black-browed albatross	Vulnerable; Migratory		None	
Thalassarche impavida	Campbell albatross	Vulnerable; Migratory		None	
Thalassarche steadi	White-capped albatross	Vulnerable; Migratory		None	
Halobaena caerulea	Blue petrel	Vulnerable		None	
Pterodroma mollis	Soft plumaged petrel	Vulnerable		Foraging BIA located >600 km west	

Source: DoE (2014a) Protected Matters Search Tool, 7th June 2014; DoE (2014b) Conservation Values Atlas, 8th June 2014.

2.7 Socioeconomic Environment

The survey area is located approximately 475 km west of Port Lincoln and 295 km south west of Ceduna, the closest township. Socioeconomic activities that may occur within the survey area and surrounds include commercial fishing and shipping; and to a lesser extent, recreational fishing and tourism.

2.7.1 Commercial Fisheries

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

2.7.1.1 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 survey area has the potential to overlap an area encompassing several Commonwealth managed fisheries:

- Small Pelagic Fishery: Western sub-area zone;
- Southern and Eastern Scalefish and Shark Fishery;
- Southern Bluefin Tuna Fishery;
- Southern Squid Jig Fishery;
- Western Skipjack Fishery; and
- Western Tuna and Billfish Fishery.

The most economically important Commonwealth fishery in the GAB is the Southern Bluefin Tuna Fishery (SBTF). A summary description of this fishery is provided below.

Southern Bluefin Tuna Fishery

The SBT is one of the most highly valued fish species, and is targeted by fishing fleets from a number of nations, both on the high seas and within the Exclusive Economic Zones of Australia, New Zealand, Indonesia and South Africa (DAFF, 2012). Surface-schooling juveniles are found seasonally in the continental shelf region of southern Australia, with 2–3 year old SBT targeted in the GAB by Australian fishers using purse-seine gear. This catch is transferred to aquaculture farming operations off Port Lincoln in South Australia, where the fish are grown to a larger size to achieve higher market prices. Throughout the rest of its range, SBT are targeted by pelagic longliners, including domestic longliners operating along Australia's east coast.

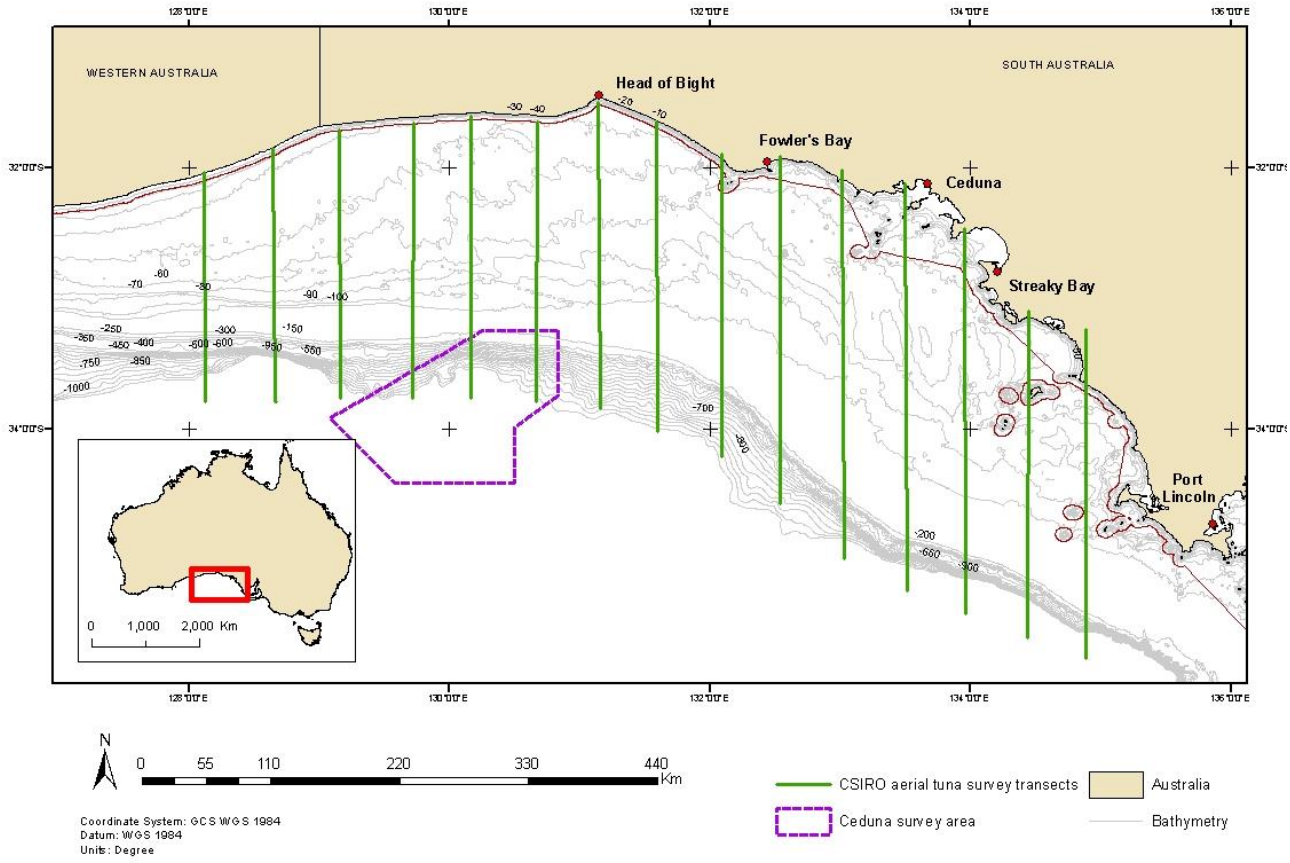
The gross value of production (GVP) in 2010–11 from the Southern Bluefin Tuna Fishery (SBTF) was estimated to be $30.5 million. For most fish caught in the SBTF, this value reflects the value of fish at the point of transfer to pens for farming. The value of wild-caught SBT in 2010–11 was significantly lower in real terms than in previous years, although higher than in 2009–10 ($25 million). The farmed value of SBT production in 2010–11 (after ranching and grow-out) was $115.3 million.

The survey area overlaps with the SBTF. High fishing effort is focused within the 200 m isobath, depths of the proposed survey are ~100 m to 3,000 m and the typical routes taken by fishermen in transferring the

catch from the catch location to aquaculture farming facilities occur to the east of the proposed survey area.

Every year between 1st January and 31st March, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) undertake aerial surveys in the GAB in order to carry out stock assessments for the SBT. The SBTF is managed through a system of output controls in the form of individually transferable quotas which are allocated as statutory fishing rights (SFRs) under the SBT Plan. The quotas are informed by the CSIRO aerial surveys and so any factor impacting these surveys may have indirect impacts on the SBT fishery. The location of the aerial survey transects are provided in Figure 2-1, and overlap with the northern section of the survey area.

Figure 2-1: Positioning of the CSIRO aerial tuna surveys in relation to the proposed survey area



2.7.1.2 State Fisheries

State fisheries are managed by the Primary Industries and Regions South Australia (PIRSA) Fisheries and Aquaculture in South Australia and the Department of Fisheries in Western Australia. The proposed survey area has the potential to overlap the following State fishing zones in waters adjacent to South Australia:

- Abalone Fishery: Western Zone;
- Charter Boat Fishery;
- Marine Scalefish Fishery;
- Miscellaneous Fishery: The Giant Crab Fishery;

- Prawn Fishery, Gulf St Vincent;
- Prawn Fishery, Spencer Gulf and West Coast;
- Rock Lobster Fishery: Northern Zone; and
- Sardine Fishery.

And the following fisheries within waters adjacent to Western Australia:

- Greenlip/Brownlip Abalone Fishery (Area 1);
- Specimen Shell Fishery;
- Marine Aquarium Fishery;
- South Coast Purse Seine Fishery (Zone 4);
- South Coast Demersal Scalefish Fishery;
- South Coast Trawl Fishery;
- Octopus Fishery; and
- Esperance Rock Lobster Fishery.

2.7.2 Petroleum Exploration and Production

Exploration permits EPP 37, 38 and 43 and adjacent open acreage areas have been subject to a relatively low level of petroleum exploration activities (seismic survey and exploration drilling) over the past 30 years. Two wells have been previously drilled in and within the vicinity the survey area; Potoroo 1 exploration well in EPP 44 (1975) and Gnarlyknots-1 exploration well also in EPP 44 (2003); however, these wells were abandoned and no activity is currently associated with them.

2.7.3 Commercial Shipping

Commercial shipping activity in the GAB has national and international significance, with the majority of vessels mainly passaging between Adelaide and Cape Leeuwin. Vessel traffic is greatest south of exploration permits EPP 43, 37 and 38, where the survey area occurs, although some lighter vessel traffic may occur within the survey area.

2.7.4 Tourism and Recreation

Recreational fishing may be undertaken in the area, but given the distance from the nearest shoreline (approximately 180 km) disturbance is unlikely. Similarly, given the distance of the survey area from the nearest population centre (approximately 295 km away at Ceduna), interference with tourism-based activities is unlikely to occur.

2.7.5 Defence Activities

The Commonwealth Department of Defence (DoD) training areas do not extend into any offshore waters of the GAB.

2.7.6 Heritage

Within the survey area or wider environment, there are no known:

- Indigenous cultural heritage values;
- Current or pending Native Title Determinations for the waters and seabed within and immediately adjacent to the survey area;
- Historic shipwreck sites;
- World Heritage Properties; or
- National Heritage Places.

3 DESCRIPTION OF THE ACTIVITY

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.

During the proposed activities, a survey vessel will traverse a series of pre-determined sail lines within the survey area at a speed of approximately 8-9 km/hr. As the vessel travels 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 (known in the industry as streamers) towed behind the survey vessel. 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.

Given the type of geology and depth of targets of interest, it is considered that the most suitable operating pressure of the seismic energy source will be approximately 2,000 pounds per square inch (psi) with the source deployed in two arrays firing alternatively, each with an intended volume of 4,130 cubic inch (cui).

PGS has designed the 4,130 cui source array to meet several criteria regarding operational stability, predictable behaviour, and fit-for-purpose subsurface seismic imaging (vertical focus). The size of the source volume is dependent on the depth below the seabed the geological targets occur. However, it is important to note that the energy produced is not proportional to total array volume. Several years of careful numerical modelling and acoustic source description have culminated in a configuration that can be accurately modelled and described across all frequencies of interest; from the perspective of both exploration requirements and for transparent environmental management. The three-dimensional acoustic output is predictable, it is measurably accurate, and therefore the operational towing depths and sub-array separation can be robustly customized for the relevant objectives of any survey location.

From the exploration perspective, the total array volume is optimized for the depth ranges of likely hydrocarbon targets. 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.

The seismic receiver array is intended to comprise approximately 12 streamers, with a length of approximately 8.1 km each. The streamers are towed side by side with a spacing of 120 m between each streamer at the front, and growing to approximately 150 m at the rear. Streamer depth will be approximately 15 m. A summary of the seismic survey parameters are provided in the table below.

Table 3-1- Intended survey acquisition parameters

Parameter	Value
No. of streamers	12
Streamers length	8.1 km
Streamers spacing	120 m front / ~150 m rear

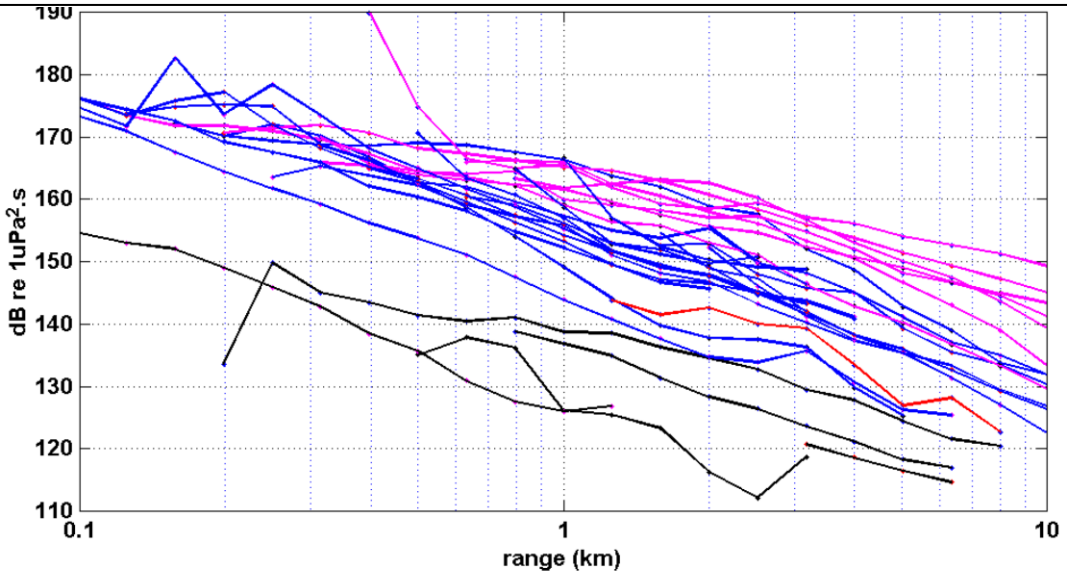
Streamer depth	Nominal 15 m
Intended size of seismic energy source array	4,130 cui
Operating pressure	2000 psi
Theoretical sound exposure level (SEL)	~229 dB re 1 µPa^2.s
Frequency range	~ 1- 200 Hz

Unpublished empirical measurements of a number of seismic sources in western and southern Australian waters show that sound exposure levels produced from arrays between 3,000 and 4,000 cui, are reduced to at least 150 dB re 1µPa^2.s within 10 km (Figure 3-1).

Figure 3-1: Sound exposure level (SEL) decay curves for a number of different seismic sources in western and southern Australian waters

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: Dr Rob McCauley, CMST Curtin University, June 2009. pers. comm., June 2009



In addition, a 4,130 cui array was modelled by Curtin University Centre for Marine Science and Technology (CMST) on behalf of BP's Ceduna seismic survey, producing a sound exposure level of 229 dB re 1µPa^2.s (at approximately 1 m from the source (BP, 2011)) at frequencies extending up to approximately 200 Hz.

The decay 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. Low frequency sound waves (such as those produced during seismic surveys) are more easily absorbed by both water and sediment in comparison to high frequency sound waves. As such, variation in water depths may influence the propagation of seismic signals, but to a much lesser degree than sound waves with higher frequencies (OGP, 2008) e.g. from shallow geophysical surveys. While sound is absorbed by seawater such that sound intensity decreases

exponentially with distance (Clay and Medwin, 1977), seawater properties such as temperature, salinity and acidity greatly influence this relationship (OGP, 2008). Furthermore, due to the ability of low frequency sound waves to travel through sediment (see below), in shallow water the sound emitted during a seismic survey is absorbed by the sediment resulting in an observed decay rate that is similar to that which would be observed in deeper water (OGP, 2008). This suggests that when comparing noise decay rates, these seawater properties are more important to consider than water depth.

Sediment or substrate type will influence the level of propagation or absorption of sound, but this will vary depending on the frequency of the sound wave. Generally, soft, sandy sediments have a significantly lower propagation speed when compared to consolidated sediments and rock (Buckingham, 2001), reducing the noise levels reflected back into the water column. However, low frequency sound waves (such as those discharged during seismic surveys) have a greater tendency to travel through the rock beneath the sea, and since the purpose of seismic surveys is to map the sedimentary structure under the sea, seismic signals are intended to penetrate well into the sea floor. As such, variations in sea floor conditions will not have a significant impact on sound propagation (in the marine environment) from seismic surveys (OGP, 2008).

SEL decay rates presented in the CMST modelling (BP, 2011) are used as indicative decay rates when assessing potential impacts of acoustic disturbance of this survey. The CMST study modelled three locations, the closest of which to the proposed survey was located ~ 17 km west at approximately 130.5°E and 33.5°S and approximately 200 km from the coast (BP, 2011). Estimated SELs from this location (at the 200 m and 1000 m isobaths) were the highest of the three locations modelled, and given the proximity of this location to the proposed survey area, were used in the risk assessment (Section 4). Results of the noise modelling showed that the seismic signal was strongly attenuated (reduced) by propagation towards the coast from the source locations close to the proposed survey area (leading to declining acoustic levels with decreasing distance to the coast) (BP, 2011). The maximum sound exposure level (SEL_{max}) was plotted against distance from the source location closest to shore to provide an estimate of noise decay. Results suggest that SEL_{max} is reduced to ambient (120 dB re 1 µPa2.s (APPEA, 2013)) at around 50 km, below 140 dB re 1 µPa2.s at approximately 30 km, and below 150 dB re 1 µPa2.s at approximately 5 km, which is similar to results presented in Figure 3-1. It is important to note that these are the maximum SEL levels which, due to the bathymetry of the seafloor, lead to attenuation and propagation towards the coast, occur south of the source location in open ocean, and are much higher than those recorded at similar distance north of the source location, closer to the coast.

Since locations used in this modelling are found in close proximity to the proposed survey area, benthic habitats, geomorphology, oceanography and metocean features of the survey area are likely to be similar to those parameterised in the model. Furthermore, it is anticipated that the proposed survey will be acquired using similar parameters used in the BP survey and as such, these SEL decay rates are considered comparable to those expected during the survey.

3.2 Vessels

A purpose-built seismic survey vessel from PGS's fleet, the Ramform Sovereign, will be used throughout the survey. The Ramform Sovereign will have all necessary certification/registration and will be fully compliant with all relevant MARPOL and SOLAS convention requirements for a vessel of this size and purpose.

Two support vessels will accompany the survey vessel with at least one support vessel being present with the seismic survey vessel at all times to maintain a safe distance between the survey array and other

vessels and manage interactions with shipping and fishing activities if required. Support vessels will also re-supply the seismic survey vessel; however, refuelling at-sea is not planned.

3.2.1 Cumulative impacts of two simultaneously operating seismic vessels

PGS is aware of an additional survey being carried out within permit blocks EPP 44 and 45. At the closest point, the two survey areas occur approximately 45 km from one another. Taking into account line run outs, the closest the two operating seismic vessels may occur will be > 30 km. Simultaneous operation of the two survey vessels may provide potential for cumulative impacts of emissions (including noise), discharges and physical presence of two survey vessels. Potential cumulative impacts were considered in the risk assessment outlined in Section 4.

4 ASSESSMENT OF THE RISKS AND IMPACTS

This section briefly describes the potential risks and impacts that could occur as a result of the proposed activity. Section 6 details the risk assessment and the controls that will be in place to minimise impacts to receptors described herein.

4.1 Disturbance to Marine Fauna

4.1.1 Discharge of Underwater Seismic Pulses

The source level of a sound is calculated assuming it arises from an "ideal point source." An ideal point source assumes all the sound energy is emanating from one focal point. It is important to understand that seismic source arrays are not point sources. The sound producing components of the array are spread over large areas (approximately 14 x 20 m), so even an animal directly beneath the array would not be exposed to energy as high as its theoretical maximum sound exposure level. For these types of sound sources, the sound exposure level (SEL) is a useful theoretical calculation to help determine likely received SEL at greater distances from the array, but it will not accurately describe the sound energy near the array.

Disturbance to Benthic Invertebrates

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). The limited acoustic sensitivity of decapods is also related to their lack of any gas-filled spaces such as those associated with pressure detection in fishes.

Extensive reviews (Moriyasu *et* al., 2004) of experiments conducted on invertebrates concluded that "very limited numbers of experiments were scientifically and reasonably conducted" but the results of nine quantitative studies showed five cases of immediate (lethal or physical) impacts of seismic sources on invertebrate species and four cases of no impacts. One study showed physiological impacts and another showed no physiological impact, three cases showed behavioural impacts and one study showed no impact on behaviour (Moriyasu *et al*., 2004).

A number of studies have examined the potential effects of seismic surveys on catch levels in fisheries targeting benthic crustaceans such as prawns and rock lobster. Andriguetto-Filho *et al*. (2005) investigated the effect of seismic surveys on prawn fisheries in relatively shallow waters (2-15 m) in Camamu Bay, north-western Brazil. Catch rates of various shrimp species were measured before and after use of a four component array with a source peak pressure of 196 dB re 1 µPa at 1 m, with catch rates found to be unaffected. It is also noted that the authors carried out histopathological studies on gonadal and hepatopancreatic tissue and reported that there was no damage that could be associated with exposure. This study did not detect any significant deleterious impacts of seismic sources on various penaeid species, suggesting that prawn stocks are resilient to the disturbance by a seismic source under the experimental conditions applied.

Parry and Gason (2006) investigated the effect of seismic source discharges on southern rock lobster (*Jasus edwardsii*) 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. However, most seismic surveys occurred in deep water, where impacts would be expected to be minimal.

Disturbance to Planktonic Organisms

Except for fish eggs, larvae (see 'Disturbance to Fish' below) 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). Various studies indicate the range of pathological effect on fish eggs and larvae is likely to be restricted to less than ~2 m. Calculations show that less than 0.02% of plankton in the area would be effected[2]. Any effect of the seismic operation on planktonic organisms is insignificant compared with the size of the planktonic population in a survey area or natural mortality rates for planktonic organisms.

Disturbance to Fish

Sound is perceived by fish through the ears and the lateral line which is sensitive to vibration. Direct physical damage may occur to fish if they approach within a few metres of an active seismic source component (Gausland, 2000; McCauley *et al*., 2003). 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 µPa (rms) and active avoidance at around 168 dB re 1 µPa (rms) (McCauley *et al*., 2000). Such behavioural changes present only temporary, short range, displacement of pelagic or migratory fish populations and are unlikely to have significant repercussions at the population level (McCauley, 1994). The potential effects of marine seismic surveys have been summarised as part of a detailed environmental assessment of geophysical exploration for mineral resources on the Gulf of Mexico outer continental shelf (MMS, 2004). This assessment concluded that negligible to potentially adverse effects on fish may occur from seismic surveys. These effects were not, however, considered to be biologically significant due to the following factors:

- Seismic survey noise may disturb fish and may produce temporary or permanent hearing impairment in some individuals, but it is unlikely to cause death or life-threatening injury;
- Seismic surveys are not expected to cause long term or permanent displacement of any listed species from critical/preferred habitat; and
- Seismic surveys are not expected to result in destruction or adverse modification of critical or essential fish habitat.

In summary, short term behavioural responses of fish may be observed at >140 dB re 1 µPa.s and a startle response at 160 dB re 1 µPa.s.

Disturbance to Southern Bluefin Tuna

While no specific research conducted on the impacts of seismic emissions on SBT are available, one study investigating the impacts of boat noise on caged northern Bluefin tuna (NBT) has been conducted (Sara *et al*., 2007). This study showed that semi-captive caged NBT changed swimming speed and increased vertical

[2] This assumes; plankton is uniformly distributed, single gun array, 18.75 m shot point interval, maximum range of pathological effect 2 m.

movement in response to boat noise. While the impact of passing boats resulted in a significant effect on the position of NBT in the exposure phase compared to the control, there was no difference in the position of NBT between the pre and post phases indicating that the behavioural responses were short term only (i.e. during exposure to boat noise only) correlating with the current status of research on behavioural responses by fish from seismic arrays.

While this study provides useful data on the behaviour of NBT in response to boat noise, the applicability to SBT is unknown. While NBT and SBT are anatomically similar and the species occupy similar niches, making direct comparisons between the two species should be done with caution. Indeed, fishing vessels involved in catching and towing SBT in the GAB are likely to operate within distances investigated in the Sara *et al* (2007) study. Presumably, if detrimental effects to the penned tuna were observed, different methods of relocating the catch to aquaculture would be employed by the industry. Furthermore, the use of caged tuna presents some limitations when applying to wild tuna. Although the authors conclude that NBT became habituated to the cage and did not show signs of stress, it remains plausible that any response to external stimuli could be exaggerated under such conditions. The temporary behavioural responses to the passing vessels observed suggests that in an uncaged scenario, individuals would respond with increased swimming or movement away from the source until noise levels have reduced, when normal behaviours are resumed. This conclusion is in line with that provided by McCauley (1994) outlined in 'Disturbance to Fish' above.

As highlighted above, no studies investigating the impact of noise on SBT have been undertaken. However, observations made by MFOs during past seismic activities in the GAB observed SBT from the survey vessel during operations undertaking normal behaviours including foraging and surface activity within 10 – 1000 m of the seismic vessel. These behaviours were similar to those made when the seismic source was shut down on line changes. While anecdotal, these are useful data as it is specific to the location (GAB), species (SBT) and activity (MSS) under discussion. This means the data is highly relevant and the observations are more likely to realistically reflect behaviours observed during the proposed MSS.

Additionally, the seismic source will not be discharged continuously during the survey with planned shut downs every 8 hours (for ~3.5 hours) for the purpose of line changes, which accounts for ~ 43% of the overall survey duration. This is in addition to the shutdown periods that will occur when the vessel returns to port for scheduled crew changes and refuelling, which occur every 5 weeks over ~6 days adding an additional 17% of planned down time. Further unplanned shut downs may occur due to poor weather conditions or cetacean sightings. Although these cannot be predicted, combined with the planned downtime outline above, it is reasonable to presume that the seismic source will be operating for less than 50% of the total survey duration. Being obligate ram ventilators, SBT are continually moving with high speeds of ~70 km/hr reported (Wardle *et al*. 1989). At this speed, individuals are able to travel >200 km over the course of line change (~3.5 hours), and further still during longer periods of downtime. This means that any individuals in the vicinity of the survey area will likely be out of range of any elevated noise as a result of the seismic source recommencing.

In assessing the above information, PGS does not consider it likely that the MSS will have negative impacts on SBT behaviour or migration.

Disturbance to Marine Turtles

Electro-physical studies have indicated that the best hearing range for marine turtles is in the range 100 to 700 Hz, which overlaps with the frequency range of maximum energy in the horizontally propagating

component of a seismic array 'pulse' (McCauley, 1994). It has been speculated that migrating turtles may use various acoustic cues and that acoustic disturbances might interfere with their navigational ability (McCauley, 1994). The auditory sensitivity of marine turtles is reported to be centred in the 400 to 1,000 Hz range, with a rapid drop-off in noise perception on either side of this range (Richardson *et al.*, 1995). This auditory range matches their weak vocalisation abilities, which are also in the low frequency range (100 to 700 Hz).

From seismic source exposure tests on a caged green turtle and a loggerhead turtle, that were extrapolated to response levels for a typical seismic source operating in 100 m water depth, McCauley *et al.* (2003) concluded that turtles would, in general, show behavioural responses at two kilometres (at ~166 dB re 1 µPa (rms)) and avoidance behaviour at one kilometre (at ~166 dB re 1 µPa (rms)) from such operations. However, they also noted that such rules of thumb for acoustic sources with frequencies within the range of turtle hearing (<1 kHz), cannot be reliably applied to shallow coastal waters near reefs, islands and

Marine turtles may possibly be exposed to noise levels sufficient to cause temporary threshold shift (TTS) should a seismic source start suddenly with turtles nearby (less than 30 m). In circumstances where seismic sources are already operating, (i.e. as a vessel moves along a pre-determined survey line), individuals would be expected to implement avoidance measures before entering ranges at which physical damage might take place.

Disturbance to Cetaceans

Marine mammals are sensitive to sound in the marine environment. Their extensive use of sound for communication, prey capture, predator avoidance and possibly navigation, and the possession of large gas-filled organs make them vulnerable to both disturbance and physiological damage from underwater sound of sufficient magnitude. Identifying these effects and the levels of sound which may induce them has been the subject of considerable research.

Baleen whales

Baleen whales produce a rich and complex range of underwater sounds ranging from about 12 Hz to 8 kHz but with the most common frequencies below 1 kHz (McCauley, 1994). This combined with studies of their hearing apparatus suggests that their hearing is also best adapted for low frequency sound (McCauley, 1994; Richardson *et al.*, 1995).

Richardson *et al.* (1995) summarised published baleen whale sound characteristics and Table 4-1 lists the estimated source levels, frequency ranges and dominant frequencies of baleen whale calls for species that may be encountered during the proposed survey. It can be seen that some species produce quite high sound levels. Likewise, McCauley *et al.* (2003) report humpback and southern right whale song components reaching 192 dB re 1 μPa^2 (pk-pk) as well as levels of 180 to 190 dB re 1 μPa^2 (pk-pk) for humpback flipper slapping and breaching sounds.

Physical damage to the auditory system of cetaceans may occur at noise levels of about 230 to 240 dB re 1µPa (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).

Table 4-1: Sounds produced by baleen whales that may be encountered during the proposed survey

Species	Frequency range (Hz)	Dominant frequency of vocalisations (Hz)	Estimated source sound pressure level (dB re 1µPa.m)
Blue	12-31,000	16-25, 6,000–8,000 (depending upon type of vocalisation)	130–188
Humpback	25–8,200	25–4,000	144–192
Minke	60-20,000	60-12,000	151-175
Bryde's	70–950	700-900	152-174
Fin	14-28,000	15,000 – 28,000	155-186
Sei	1500-3500	Sweep	-
Pygmy Right	To 300+	135-60	165-179
Southern Right	30-2200	50-500	172-186

Source: Richardson *et al.* (1995).

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). The level of sound at which response is elicited varies between species and even between individuals within a species (Richardson *et al.*, 1995).

A comprehensive study carried out by McCauley *et al.* (2003) monitored the effects of seismic survey sounds on humpback whales in the Exmouth Gulf region of Western Australia. The following conclusions were drawn from this research:

- Only localised avoidance was seen by migrating whales during the seismic operation, indicating that the 'risk factor' associated with the seismic survey was confined to a comparatively short period and small range displacement.
- Coupled with the fact that humpback whales were seen to be actively utilising the 'sound shadow' near the surface, then it is unlikely that animals will be at any physiological risk unless at very short range from a large seismic source array,.
- Upper levels of sound at 1.5 km from the seismic survey array are in the order of 182 dB re 1µPa^2, which is still well below the source levels of the highest components of humpback whale song (192 dB re 1µPa^2). Thus at 1.5 km the received seismic source signal is still well within the range which humpback whales would be expected to cope with physiologically, since it would be difficult to argue that humpback whale song can cause physiological problems to the animals (McCauley *et al.*, 2003).

While it is known that baleen whales will avoid operating seismic vessels, the distance over which the avoidance occurs seems to be highly variable between species and even within species (Richardson *et al.*, 1995; McCauley *et al.*, 1998), depending upon the activity of the individual. For example, 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 µPa rms). Some males have been recorded approaching seismic survey vessels to within 1 to 2 km, apparently to investigate the acoustic source (McCauley *et al.*, 2000). 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)

Toothed whales produce a wide range of whistles, clicks, pulsed sounds and echolocation clicks. 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 µPa (Richardson *et al.*, 1995).

For toothed whales exposed to single short pulses, the TTS threshold appears to be a function of the energy content of the pulse (Finneran *et al*., 2002). In their review, Gordon *et al.* (2004) considered the potential for TTS and concluded that the threshold for TTS was ~195 dB re 1 µPa. This is consistent with the review and calculations contained with Richardson and Moulton (2006) who considered the TTS threshold to be 192 to 202 dB re 1 µPa. Seismic pulses with received levels of 186 dB re 1 µPa or more are usually restricted to a radius of no more than about 300 m around a seismic airgun array, therefore the potential for TTS is extremely low as it would be necessary for the whale to be less than one kilometre from the airgun array and remain within this range as the vessel traversed a distance of four to five kilometres.

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) tagged sperm whales were exposed to a maximum received level of 148 dB re 1µPa. There was no indication that the whales showed horizontal avoidance of the seismic vessel nor was there any detected change in feeding rates.

Smaller toothed cetaceans have poor hearing in the low frequency range of airgun array noise (10 to 300 Hz) and seismic operators sometimes report dolphins and other small toothed whales near operating seismic source arrays. However, there is a component of seismic pulses in the higher spectrum and in general most toothed whales do show some limited avoidance of operating seismic vessels. Goold (1996) studied the effects of 3D seismic surveys on common dolphins (*Delphinus delphis*) in the Irish Sea. The results indicated that there was a local displacement of dolphins around the seismic operation. This observation is consistent with data compiled by Stone (2003) from marine mammal observers aboard seismic vessels in the North Sea that shows small toothed whale species tend to move away from operating compressed air seismic sources.

Disturbance to Pinnipeds

There is a lack of information on the effects of seismic operations on pinnipeds, especially in Australian waters (Pidcock *et al.*, 2003). Australian sea lions make underwater sounds including barks, whinnies and buzzing associated with social interactions. It has been measured that the projected sea lion energy for these sounds is between 250 Hz and 2 kHz frequency (Richardson *et al.*, 1995), and their hearing range is approximately between 0 – 4 Hz (Pidcock *et al.,* 2003), in comparison to the seismic array which may go up to 200 Hz. It has also been measured that pinnipeds have a high tolerance to strong sound pulses from nearby seismic vessels. For instance, during seismic survey operations it was observed that there was partial avoidance zone of Arctic seals from the vessel under 150 m, with the seals not moving farther than 250 m (Harris *et al.*, 2001).

4.1.2 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.

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 survey area. However, since the closest major breeding sites are over 400 km away and there are no emergent features within or near the survey area for potential seabird resting, it is not anticipated that the light emission as a result of the survey will have a significant impact.

The potential impacts of light emissions to fish from seismic vessels are expected to be restricted to localised attraction, temporary disorientation and increased predation. Since the seismic vessel will be continuously moving, any impacts arising from light emissions will be temporary only and are considered to be minor and restricted to a small proportion of the population. While spawning may occur in the survey area there is no known significant spawning or aggregating habitat for any of the fish species identified, and it is unlikely that these species would use this area for any significant period of time.

Light pollution reaching turtle nesting beaches is widely considered detrimental owing to its ability to alter important nocturnal activities including choice of nesting sites and orientation/navigation to the sea by post-nesting females and hatchlings (Witherington and Martin, 2003). Within the GAB there are no recorded mating, nesting and feeding associated aggregations, and individual turtles at most have infrequently been recorded in SA waters (Limpus, 2002), including northern Spencer Gulf waters and north-west of Kangaroo Island over 300 km east. As a result of the low abundance of adult turtles expected to be encountered during the survey, impacts from light emissions are considered unlikely.

Consequently, artificial light from survey operations is unlikely to significantly affect the population of any species in the GAB. Given the vessel will be constantly moving the light disturbance is only expected to be temporary and the potential for attraction and disorientation is likely to be low. Furthermore, lighting associated with the vessel is no different to that associated with other commercial vessels using the GAB.

4.1.3 Vessel Movements

Survey and support vessels working within the survey 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.

The impact from vessel interactions with marine fauna can be as minimal as temporary behavioural changes by the marine fauna to severe impacts such as mortality resulting from vessel strikes. Vessel collisions contribute to the mortality of marine fauna, notably large cetaceans (Knowlton and Kraus, 2001; Laist *et al*., 2001; Jensen and Silber, 2003). Vessel traffic has severely affected North Atlantic right whales (*Eubalaena glacialis*), for which collisions have been identified as a major source of mortality (Knowlton and Kraus, 2001). Due to the timing and location of the survey, southern right whales and blue whales may be encountered during the seismic survey. However, as a result of their size, distribution, the use of at least two MFOs on-board the survey vessel, a cetacean-vessel collision is considered unlikely.

Stranding records for Queensland, indicate that 14% of dead sea turtles had been struck by vessels (Hazel *et al*., 2007). These records are largely from populated areas of the state and comprise an unknown proportion of the total mortality. The study also showed that at moderate and high speeds (11 and 19 km/h respectively), turtles are less likely to flee an approaching vessel. The survey vessel will travel at 8-9

km/h. Given the lack of important dolphin and turtle habitat in the area, interactions with dolphins and marine turtles are considered unlikely.

The survey will involve a survey vessel and two support vessels travelling at slow speed (around 8-9 km/h) along defined paths, in deep offshore waters. At such speeds, any marine fauna present will likely take avoidance action before a collision. Since the survey area does not contain critical habitat for any faunal species, the density of marine fauna is likely to be low and as such the probability of vessel-fauna interactions is also low.

4.2 Disturbance to Benthic Habitats

Previous benthic surveys suggest there is a relatively high level of species richness within the GAB in comparison to other temperate environments (Poore *et al.*, 1994). Woodside (2002) completed benthic surveys within shallower depths on the Lincoln Shelf, south-east of the Head of the Bight. The results of both the Eucla and Lincoln Shelf benthic surveys (Woodside, 2002) suggest the mid-outer shelf (120-220 m depth, greater than 80 km offshore) has the most highly productive and diverse zone in terms of sediments, with many species of bryozoans, foraminifera and ostracods. The upper slope area, at water depths below storm wave-base, is predominantly inhabited by low-growing bryozoans and a few sponges and other biota (Bone and James, 1998).

This high level of species richness in the GAB was measured in shallower depths (<220 m) with comparatively high levels of light penetration. The survey area water depths range from 100 to 3,000 m and so the shallower part of the survey will fall within this range with the potential for an impact. At the deeper depths it can be assumed that there will be lower levels of species richness as a result of lower light infiltration to the seabed, resulting in a sandy and sparse benthic habitat.

4.2.1 Anchoring

The potential impacts to benthic habitats through anchoring include:

- Mortality of benthic fauna; and
- Indirect disturbance to benthic habitats and associated marine fauna by sedimentation through increased turbidity of the near-seabed water column.

The potential and significance of impacts caused by anchoring is dependent on the type of receiving environment, the size of the anchor and chain and the frequency of anchoring. Soft sediment benthic habitats of the survey area are relatively devoid of sensitive habitats (coral reefs, seagrass meadows). Anchoring typically causes minimal disruption to soft sediment and, given the widely distributed benthic inflora and fauna found within these areas, would have a minimal impact to the benthic fauna and inflora communities. Furthermore, anchoring would only impact a highly localised area of seabed.

With respect to routine operations during the proposed survey, impacts are unlikely to occur since anchoring within the survey area is not planned. Anchoring would only occur in emergency circumstances and the seismic and support vessels are fitted with highly sophisticated position fixing equipment.

4.2.2 Vessel Grounding

The potential for the survey and support vessel(s) to become grounded while working within the survey area is limited due to the absence of any emergent features or shallow water within or immediately adjacent to the area. The survey vessel will be operating in water depths of ~100 – 3,000 m.

Vessel impact and grounding has the potential to cause damage and mortality to flora and fauna, fracturing, reef rock displacement, smothering and disturbance of benthic habitat and sediment mobilisation and turbidity. These may be caused by vessel contact with the ocean bottom, by prop wash and cable dragging during attempts by operators and/or salvagers to refloat the vessels, and by subsequent movement of destabilised substrates (Gittings *et al*., 1993).

Vessel grounding also has the potential to result in the loss of containment of hydrocarbons such as fuels and oils from vessels that may also adversely affect aquatic marine life (see Section 4.6.3 for further hydrocarbon impact description).

4.2.3 Equipment Dragging or Loss

In the unlikely event of damage to or loss of a solid seismic streamer, potential environmental effects will be limited to physical impacts on benthic communities arising from the cable and associated equipment sinking to the seabed. 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. As the equipment sinks it passes a certain water depth (hydrostatic pressure equivalent to ~40 m depth) at which point the buoys inflate (compressed CO_2 gas cartridge) and bring the equipment back to the surface where it can be retrieved by the seismic or support vessel.

Dragging of streamers along the seabed may result in localized physical disturbance of substrates, benthic habitats and communities. However, given the water depth range in which the survey vessel will be operating with towed streamers within the survey area (~100 – 3,000 m), and the absence of any emergent features within or immediately adjacent to the area, the risk of significant impacts resulting from equipment dragging or loss is considered to be low.

4.3 Reduced Air Quality from Atmospheric Emissions

4.3.1 Operation of Machinery and Vessels

Atmospheric emissions from the proposed survey include greenhouse gases (GHG), NOx (nitrogen oxide), SOx (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 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. Incineration of waste is not expected to generate any significant atmospheric emissions, due to

the infrequent nature of the activity and the small volumes of material being burnt during each disposal episode.

4.4 Introduction of Invasive Marine Species

Invasive Marine Species (IMS) can be introduced to the marine environment via biological fouling on vessel hulls or equipment, and through ballast water exchange. 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.

4.4.1 Ballast Water

IMS can be introduced through ballast water discharges from vessels arriving from international waters. The Department of Agriculture (DoA, formerly the Australian Quarantine Inspection Service (AQIS)) is the lead agency for management of ballast water from international vessels. DoA has introduced the mandatory Australian Ballast Water Management Requirements (AQIS, 2008) that are enforced under the *Quarantine Act 1908*. Under these arrangements all vessels that have travelled from international waters are obligated to assess and manage their ballast water in accordance with the DoA requirements. 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.

4.4.2 Biofouling

Biofouling on vessel hulls and other external niche areas, biofouling on internal niches and biofouling on equipment routinely immersed in water all pose a potential risk of introducing IMS into Australia. 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.

The potential biofouling risk presented by the survey and support vessels selected to acquire the survey will relate to the length of time that these vessels have already been operating in Australian waters or, if they have been operating outside Australian waters, the location/s of the surveys they has been undertaking, the length of time spent at these location/s, and whether the vessels have undergone hull inspections, cleaning and application of new anti-foulant coating prior to returning to operate in Australia.

4.5 Marine Pollution from Routine Discharges

4.5.1 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.

4.5.2 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.

4.6 Marine Pollution from Accidental Discharges

4.6.1 Solid wastes

The vessels will produce a variety of solid wastes, including packaging and domestic wastes, such as aluminium cans, bottles, paper and cardboard.

Should these materials be accidentally discharged, they could potentially impact the marine environment if released in significant quantities resulting in physical impacts on marine fauna, for example marine fauna can ingest or become entangled in waste plastics.

4.6.2 Hazardous Materials

The vessels will store and use a variety of hazardous materials such as lubricating oils, cleaning chemicals and batteries.

These materials have the potential to adversely impact the marine environment if accidentally released in significant quantities. The potential effects include a reduction in water quality and toxic effects on marine flora and fauna. Chemicals e.g. solvents and detergents will typically be stored in small containers of 5-25 litre capacity and stored / used in internal areas where any leak or spill would be retained on board and cleaned up in accordance with the Shipboard Oil Pollution Emergency Plan (SOPEP) and associated spill clean-up procedures. Some spills may occur when small containers of chemicals are being used in open areas, where there is a risk of some entering the sea if spilled. The realistic worst case volume would be 25 litres.

4.6.3 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 (~120 L per seismic cable section);
- On-deck leak or spill of small quantities (up to 50 litres) of hydraulic oil or lubricating oil; or

- Larger volume (up to 865 m^3) loss of diesel from a ruptured fuel storage tank, resulting from vessel collision or grounding.

Since no at-sea refuelling is proposed, fuel spills associated with refuelling activities will not occur.

The potential environmental impact as a result of a significant vessel collision could cause chronic/acute toxicity effects on marine organisms from a hydrocarbon spill. 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.

The fuel that will be used by the survey and support vessels will be marine diesel. The marine diesel tanks within the vessels will most likely be located in the interior of the vessel, and are separated from the hull by tanks for other fluids (fresh water, grey/black water, bilge water, ballast water, sludge etc.).

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 in the order of 865 m^3. Note that this would require a total loss of inventory from the tank, a highly unlikely event given that the tank is unlikely to be full, and hydrostatic pressure from a below-sea-level rupture would reduce flow.

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 865 m^3.

It is possible that two survey vessels may be operating simultaneously in the region during the same time frame. Given that the minimum distance of 30 km will be maintained between the two vessels at all times, a collision between the two survey vessels is not considered a credible scenario.

An assessment of the relative speed of physical dispersion and evaporation of a surface slick of diesel under the expected environmental conditions offshore in the GAB during summer (proposed operational period) has been conducted using the ADIOS2 (Automated Data Inquiry for Oil Spills) oil weathering model. All diesel is expected to have evaporated or dispersed within 37 hours of the spill occurring, in which time it could travel ~32 km. Since the nearest shoreline and State waters boundary are located ~180 km and ~175 km from the survey area respectively, no shoreline contact is predicted, nor is the diesel slick expected to enter State waters.

The potential effects of a hydrocarbon spill on the marine environment varies greatly depending on factors such as the weather and sea state at the time of release, response measures, and the sensitivities of the habitats and species potentially affected.

Shoreline contact is not expected, greatly reducing the potential to impact sensitive habitats surrounding the South Australian coastline, such as mangroves, coral reefs and sandy beaches. As outlined above, the marine diesel could travel ~20 km within 24 hours (where 4% of the diesel will remain) and to 32 km within 37 hours, by which point all of the diesel will have dispersed and evaporated.

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.

4.7 Oil Spill Response

Oil spill response activities that may be implemented in the event of a loss of diesel to the marine environment can incur environmental impacts which can devalue the measures designed to mitigate the impact of the spill on the environment. Impacts may include additional vessel traffic and associated emissions, exhaust gases, noise and light, generation of waste contaminated with diesel, and inappropriate management of oil contaminated flora, fauna and surfaces.

Given the offshore location of the survey, and the relatively small amounts (4%) of diesel likely to remain after 24 hours, and the very low persistence of this fuel type which will disperse naturally and readily evaporate, the response strategy of monitor and evaluate would be most suitable – i.e. to allow spills to disperse naturally, and to monitor the position and trajectory of any surface slicks. Should monitoring and evaluation indicate that significant numbers of marine fauna individuals are likely to be impacted, oiled wildlife response strategies, such as cleaning and/or hazing, may be considered. All response strategies identified would be managed by AMSA as the appropriate Combat Agency. The responsibility of assessing the appropriateness of any response strategy outlined above, and its implementation, also lies with AMSA as Combat Agency.

4.8 Disturbance to Social, Community and Conservation Values

The vessel(s) will be operating 24 hours a day, seven days a week for the duration of the proposed survey. The physical presence of vessels in the survey area is a potential hazard to other marine users including commercial fisheries, shipping, defence and existing oil and gas activities.

Given the lack of defence activities in the area, disturbance to defence activities is not considered a credible risk and is not discussed further. Furthermore, while the survey area overlaps with three exploration permits, no facilities are present within the area. Should other vessels or rigs may be present (depending on planned activities of the titleholders); these will be identified during the pre-survey consultation. In order to acquire data within a permit block, PGS will require ingress agreement from the titleholder; should PGS's activities be considered a source of possible disturbance, ingress would not be granted. As such, impacts to existing oil and gas activity are not considered credible and are not assessed further.

4.8.1 Commercial Fisheries

There is a range of commercial fishery activity in the area of the proposed survey.

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

- Direct effects of underwater sound on target fish populations (e.g. spawning or migration)
- Interference with quota setting surveys
- Disruption to fishing operations
- 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.

The majority of fisheries identified (6 Commonwealth fisheries and 16 state fisheries) which may be potentially impacted which show limited fishing activity within the survey area and therefore impacts are considered minimal. However, the southern Bluefin tuna (SBT) fishery is the most active and has the greatest potential to be affected. Points outlined above most relevant to the SBT fishery include a) disruption to fishing operations (fishing vessels and towed pontoons), b) interference with quota setting (CSIRO aerial survey), and c) effects of underwater sound on SBT behaviour and migration.

a) Disruption to fishing operations

As described in Section 2.7.1, the SBT fishery targets juvenile SBT that aggregate in the GAB each year between October and March. Once caught, the catch is transferred to aquaculture close to Port Lincoln by towing pontoons at slow speed. The proposed survey has the potential to interfere with operations including catching and towing of SBT. It is also possible that any behavioural response of SBT due to the seismic source will result in injury to individuals given the limited space available within the pontoons. However, fishing locations are generally found to the east of the survey area and as such, fishing vessels are unlikely to be encountered. Nevertheless, additional mitigation measures (e.g. the vessel will not operate within 10 km of vessel towing a pontoon; Table 5-4) reduce this risk further.

b) Interference with quota setting

The fishery is operated on a quota system, with quotas set using a variety of indices, including abundance estimates obtained from aerial surveys conducted by CSIRO. Results of the aerial survey in 2012 were statistically below trend compared to years before and after. This aerial survey season overlapped with the 2011-2012 BP Ceduna MSS and concerns have been raised that the seismic activity lead to the below trend results.

PGS acknowledges that the 2012 result was statistically below trend but does not find evidence to suggest a direct link between the survey result and the BP MSS. The biomass per nm estimate will be influenced by a number of factors, those which may affect fish biology and behaviour, and also those affecting their detection by the surveyors. Some of these factors may be known and are recordable, for instance SST, wind speed, swell height, sea shadow and haze, while others may be known but cannot be reliably recorded, and others still may be complete unknowns. It was noted in Eveson *et al*. (2012) that the level of sea shadow and haze were notably higher than the average in 2012. Results of the GAM (Generalised Additive Model) show that the number of sightings per nm (SpM) decreases with increasing sea shadow and haze, an effect that is highly significant. It is possible that the environmental conditions of 2012 were not conducive to observing SBT by aerial methods, resulting in a low number of observations and subsequent biomass per nm estimates. Given the number of potential factors at play, being able to statistically isolate effects of individual variables is not possible and therefore the results can be confounded. Therefore, it is not possible to attribute the low estimate in 2012 to any one factor, including the presence of seismic activity.

In addition, changes in the strength of the Leeuwin Current can lead to potential changes in habitat utilization by SBT, and it is possible that the faster movement of SBT schools through the GAB (and therefore being unavailable to be observed during the CSIRO aerial survey area) is related to the unusually strong flow of the Leeuwin Current over 2011 – 2013. Given the unusual weather and oceanographic conditions also experienced in this season, and their potential to effect SBT distribution and detectability by aerial observers, the low biomass result cannot reasonably be attributed solely to seismic activity. Indeed, in information provided to PGS by ASBTIA it stated that *"The degree of cause and effect of the seismic*

survey in addition to unusual weather events suggest the degree of the impact of the seismic survey is unknown."

The potential for behvioural impacts to SBT resulting from the survey are described in Section 4.1.1 which suggest that seismic activities may lead to temporary and localised behavioural responses. Given the temporary nature of the response, and the minimal overlap of the seismic survey with the aerial survey, it is not expected that the seismic survey will significantly impact the aerial survey results or the resulting quotas.

c) Effects of underwater sound on SBT behaviour and migration

Research suggests that juvenile SBT move in a broad area between 30-50°S in the Indian Ocean, an area over 1,000 km; there do not appear to be specific or narrowly defined migration routes. As described in Section 4.1.1, a behavioural response may be exhibited by fish species at >140 dB re 1 µPa.s, but wild SBT have also been observed to continue normal behaviour 10-1000 m from an operating seismic vessel. For conservatism, a 50 km buffer around the survey vessel is assumed to assess potential impacts on SBT behaviour, this is highly conservative given the noise levels at 50 km are expected to be less than 140 dB re 1 µPa.s, well below the 156 dB re 1 µPa.s reported in McCauley *et al.* (2000).

Although anecdotal evidence suggests SBT do not show behavioural responses to seismic vessels, NBT have been observed exhibiting short term behavioural changes to boat noise. Therefore, should a response arise, it is likely to be temporary occurring only during exposure to elevated noise levels. Since the survey vessel is continually moving, normal behaviours are expected to resume once the vessel has passed, allowing SBT to continue on their migration. By assuming a conservative behavioural impacts buffer of 50 km around the survey vessel, this represents a maximum footprint of 100 km of a migration route of over 1,000 km, approximately 10%, which is considered unlikely to impede migrating SBT from entering the GAB.

In addition, taking into account shutdowns and returns to port, the total time the seismic source will be operating is less than 50% of the total survey duration, with shutdown periods of ~3.5 hours occurring every ~8 hours as described in Section 4.1.1. Being obligate ram ventilators, SBT are continually moving with high speeds of ~70 km/hr reported (Wardle et al. 1989). At this speed, individuals are able to travel >200 km over the course of line change (~3.5 hours), and further still during longer periods of downtime. This means that any individuals in the vicinity of the survey area will likely be out of range of any elevated noise as a result of the seismic source recommencing.

In assessing the potential impacts of the MSS on SBT migratory behaviour in light of the above information, PGS does not consider it likely that the MSS will have negative impacts on SBT migration or the subsequent results of the CSIRO aerial survey.

4.8.2 Shipping

Commercial shipping activity in the GAB has national and international significance, with the majority of vessels mainly passaging between Adelaide and Cape Leeuwin. Moderate shipping traffic may also be encountered from Thevenard, South Australia, to the west and south towards Port Lincoln and on to Victoria. Vessel traffic is greatest outside the survey area, although some lighter vessel traffic may occur within the survey 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.

The survey vessel and towed array represent a potential navigational hazard and other vessels will need to avoid the seismic vessel to prevent collisions, entanglement of streamers, and other incidents. Loss of equipment may interfere with shipping activity.

4.8.3 Heritage and Conservation Values

It is highly unlikely that the proposed survey will impact on any heritage listed places, given the location of the survey area. There are no heritage places within or adjacent to the survey area. The nearest World Heritage area is the Australian Fossil Mammal Sites (Naracoorte), located onshore approximately >800 km east of the proposed survey (DoE, 2013a). The nearest National Heritage site is the Whale Bone Area and the Point Fowler Structure, Fowlers Bay Conservation Reserve (designated places of archaeological significance), located approximately >200 km north-east of the survey area (DoE, 2013c).

The survey area overlaps two protected areas; the former GAB Marine Park, and the GAB CMR. The activities associated with the proposed activity within and in proximity of these protected areas may lead to impacts on the values of the areas; potential impacts of the activities on individual values are assessed in the sections above.

5 ENVIRONMENTAL RISK ASSESSMENT

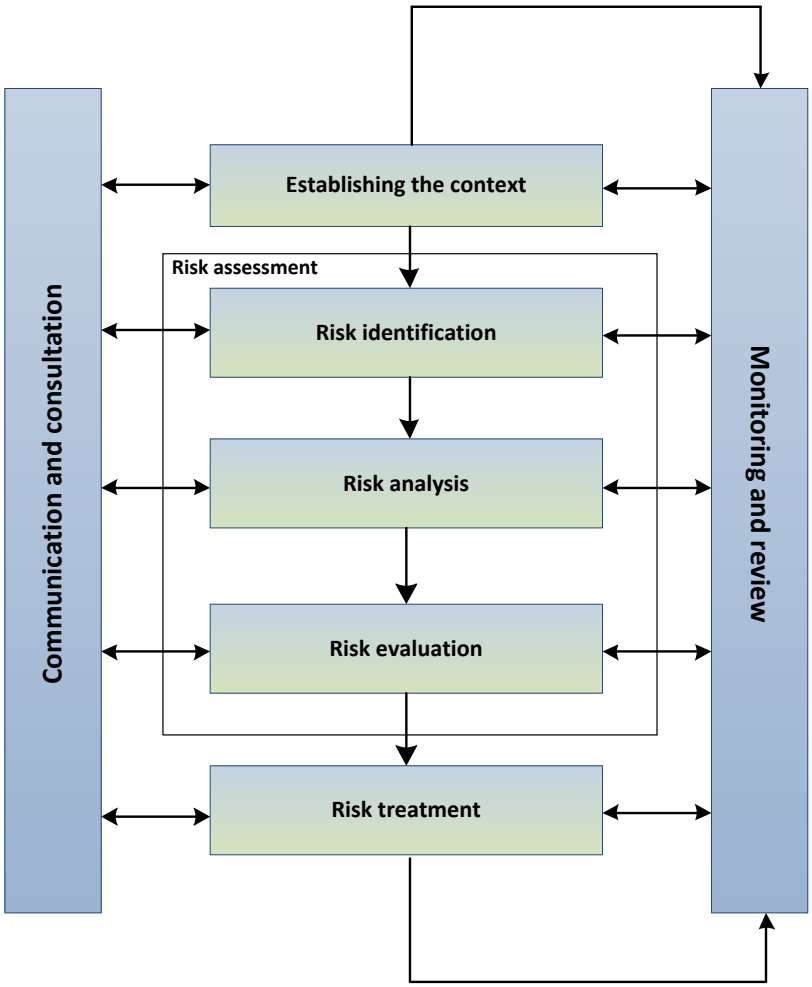
An environmental risk assessment has been undertaken to understand and manage the environmental risks associated with the proposed survey to a level that minimises impacts on the environment and meets the objectives of the survey.

5.1 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 key steps used for the risk assessment are shown in Figure 5-1 below.

Figure 5-1: Key steps used for risk assessment



Source: modified from *AS/NZS ISO 31000:2009 Risk management*

The environmental risks associated with the proposed seismic survey operations have been assessed by a methodology (Figure 5-1) that:

- Identifies the activities and the environmental aspects associated with them;
- Identifies the values/attributes at risk within the survey area and wider environment;
- 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.

The likelihood of occurrence for the key potential environmental impacts from the survey has been estimated based on industry incident reporting (Table 5-1). Table 5-1 also includes a qualitative description of environmental effects assigned to each category of consequence.

Table 5-1: 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.

Table 5-2 shows the overall environmental risk assessment matrix that compares the likelihood and consequences of potential environmental impacts arising from the survey and assigns a level of risk.

Table 5-2: 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.

5.1.1 Demonstrating ALARP and Acceptability

Determination that an impact or risk is reduced to ALARP is a process which factors in a range of environmental and operational considerations. The key stages in determining ALARP are as follows:

- Application of design and construction codes and standards and good industry practice;
- Early identification of hazards and implementation of the recommendations to eliminate risk through design, procedures and practices;
- Identification of the key risk drivers qualitatively or quantitatively;
- Identification of all possible risk reduction (control) measures; and
- Assessment of the practicability and cost benefit of each risk reduction measure (see below).

To demonstrate that an ALARP assessment has been undertaken for each of the environmental hazards identified, the 'Hierarchy of Control', commonly used in safety systems, has been adopted. In descending order of effectiveness, the hierarchy of control criteria is:

- Eliminate – remove the risk;
- Substitute – change the risk for a lower risk;
- Engineering – engineer out the risk;
- Isolation – isolate people or the environment from the risk ;
- Administrative – provide instructions or training to people to lower the risk; and
- Protective – use of protective equipment.

5.1.2 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 timing 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 benefits of implementation. Should the benefits outweigh the negatives, the control measure is implemented.

5.1.3 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 considered.

5.2 Summary of Pre-Mitigated Risk Assessment

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.

A summary of the aspects and hazards relating to the proposed activity, the potential impacts they pose and the pre-mitigated risk assessment is provided in Table 5-3.

Table 5-3: Summary of the environmental hazards, aspects, environmental impacts and pre-mitigated risk assessment

Hazard	Environmental aspect	Potential environmental impacts	Pre-mitigated risk assessment		
			Consequence of impact	Likelihood of the identified consequence	Inherent risk level
Disturbance to marine fauna	Discharge of underwater seismic pulses	Behavioural and physiological effects on cetaceans, turtles and fish	Slight	Possible	**Low**
		Physiological effects on benthic invertebrates and plankton	Slight	Possible	**Low**
	Light generation from vessels	Behavioural effects on dolphins, turtles, fish and seabirds	Slight	Possible	**Low**
	Vessel movements	Behavioural and physical effects (i.e. injury or mortality) on cetaceans, dolphins and turtles	Minor	Possible	**Low**
Disturbance to benthic habitats	Deployment and retrieval of anchors	Localised physical damage to benthic habitats	Slight	Possible	**Low**
	Vessel grounding		Minor	Unlikely	**Low**
	Equipment damage, dragging or loss		Slight	Possible	**Low**
Atmospheric emissions	Operation of machinery and vessels powered by internal combustion engines	Localised reduction air quality Greenhouse gas emissions	Slight	Likely	**Low**
Invasive marine species	Discharge of ballast water from vessels	Introduction and establishment of IMS and displacement of native marine species	Moderate	Unlikely	**Medium**
	Biofouling of vessel hulls, other niches and immersible equipment		Moderate	Unlikely	**Medium**

Hazard	Environmental aspect	Potential environmental impacts	Pre-mitigated risk assessment		
			Consequence of impact	Likelihood of the identified consequence	Inherent risk level
Marine pollution from routine discharges	Discharge of sewage, grey water and putrescible wastes	Localised reduction in water quality due to nutrient enrichment	Slight	Routine	**Low**
	Discharge of bilge water	Toxicity effects on marine fauna and flora Localised reduction in water quality	Slight	Possible	**Low**
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 Physical impacts on marine fauna i.e. from plastics	Minor	Possible	**Low**
	Hazardous materials		Minor	Possible	**Low**
	Fuel and oil spills		Moderate	Possible	**Medium**
	Oil spill response		Minor	Possible	**Low**
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**
	Interaction with shipping	Disruption to shipping activities	Slight	Possible	**Low**
	Operation of vessels within protected areas and heritage places	Disturbance to heritage and conservation values	Slight	Possible	**Low**

5.3 Summary of Control Measures and Residual Risk Assessment

Table 5-4 provides a summary of the hazards and aspects identified and the control measures assessed as practicable. Additional conditions assessed as not practicable are also provided, along with justification. Controls considered practicable and implemented are considered to reduce the potential risks and impacts to ALARP and to an acceptable level.

Table 5-4: Summary of control and mitigation measures and the residual risk assessment following implementation of these measures

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
Disturbance to marine fauna	Discharge of underwater seismic pulses	• EPBC Act Policy Statement 2.1 – Part A Standard Management Procedures: ➢ Continuous observations ➢ Precautionary zones: a. observation zone: 3 km+ b. low power zone: 2 km c. shutdown zone: 500 m ➢ Use of soft starts on every occasion ➢ Recommencement procedures ➢ Low visibility / night time restrictions • EPBC Act Policy Statement 2.1 – Part B Additional Management Procedures: ➢ Use of two Marine Fauna Observers (MFO) • Recording of all marine fauna sightings including tuna • Reporting of all marine fauna sightings including tuna • Use of smallest possible source size to meet geophysical objectives of survey • Simultaneous operating survey vessels will not occur	Use of PAM (passive acoustic monitoring)	PAM has limited application for detecting baleen whales such as blue whales, due to the type of vocalisations made by these whales in addition to the ability of the PAM system to detect the vocalisations above the seismic source emissions. As such, PAM is not considered to provide any environmental benefits to baleen whales and is not discussed further. PAM is able to detect toothed whales (odontoceti) such as sperm whales which produce click-like vocalisations. However PAM relies on whales vocalising and in general marine mammals do not continually vocalise. For sperm whales, studies have observed that individuals during rest periods (>1hr) at the surface or just below surface, with surfacing intervals typically less than 15 minutes, do not produce regular clicks, (Gannier et al, 2002; Hastie et al, 2003). In addition, female sperm whales and their young occupying temperate waters have been observed to spend several hours a day resting or socialising and rarely producing clicks (Hastie et al, 2003). Whilst PAM can potentially detect sperm whale vocalisations, current equipment available has limited ability to estimate the distance, depth or abundance of the individual(s) from the hydrophone. PAM sensitivity is also reliant on the sea state conditions (interference), acoustic signals generated from the	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		within 30 km of one another • Environmental induction for appropriate crew including MFOs, marine, deck and bridge crew • Acquisition of survey between November and May (inclusive) to avoid excessive downtime and minimise duration • Seismic source will only be discharged for ~50% of total survey duration • Adaptive night time and low visibility procedures: ➢ Should three or more blue, sperm or southern right whale instigated shutdowns occur per day (24 hour period) for three consecutive days, data acquisition will not occur during low visibility/night-time ➢ Operations during night or low visibility can resume following a 24 hour period, which included seismic operations during good visibility, in which no blue, sperm of southern right whale instigated shutdowns occurred • Adaptive precautionary zones and recommencement procedures: ➢ Should a blue or sperm whales be observed exhibiting foraging behaviour within the observation zone (3 km), the source will be shutdown		towing vessel (interference) and surrounding bathymetry (transmission losses). This results in a geographical variation in PAM sensitivity and reliability. There is limited data on the reliability of PAM during operations; however, recent operations in the Great Australian Bight, where the Ceduna MSS is proposed, provide some data. During this survey, a total of 23 sperm whales (on five separate sighting occasions) were visually detected by the MFOs during the survey, but none were detected acoustically with the PAM system. The observed individual's behaviour was categorised as milling, blowing, normal swimming, diving or no movement. The behaviours noted do not indicate foraging behaviour and that they were not detected by PAM suggests a lack of foraging dives (on which they would be expected to vocalise). The observed behaviours and a lack of vocalisations suggesting that foraging was not being undertaken indicates that this area of the GAB does not include critical foraging habitat for sperm whales. Sperm whales are usually found foraging in areas of upwelling, where nutrients found in deeper, cooler waters are brought to the surface increasing biological productivity and attracting higher order predators. Areas of significant upwelling occur at the Albany Canyons and in the canyons surrounding Kangaroo Island. Significant areas of upwelling are not known to occur in the survey area and therefore sperm whale foraging habitat is unlikely to be present in the survey	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		➢ The observation period during good visibility specified in the recommencement procedures described in the EP will be increased to 1 hour following a feeding blue or sperm instigated shutdown (restrictions on recommencement during poor visibility still apply as described in the EP)		area. As described above, PAM has reliability limitations in terms of detecting individuals and also in the operation of the PAM system itself. Should the system fail, PGS will be unable to comply with mitigation measure until the system is restored. Furthermore, the cost of contracting the PAM system and at least two operators at all times on the survey vessel increases the overall costs of the survey. Given the low numbers of foraging sperm whales potentially encountered (due to a lack of upwelling and associated productivity, as described above), which is corroborated by the observations made during previous surveys, combined with the low detection rate and potential unreliability in detection, PGS does not consider the additional potential costs are outweighed by the potential benefits. As such, the implementation of PAM is not considered practicable.	
			Use of additional MFOs	Additional costs to survey programme for 2 additional MFOs is approximately $285k. Unlikely to increase detection of cetaceans and therefore would not significantly reduce impacts to cetaceans.	
			Noise loggers at sensitive locations	Unable to provide adaptive management due to limitation in relaying the data back to the survey vessel in real time to implement mitigation measures. Therefore, would not decrease potential environmental impacts.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
			Use of spotter vessels/aircraft	Additional costs to survey programme for single spotter plane would be approximately $700k and refuelling and weather would limit effective time. Cost for additional vessel would be approximately $2,250k. Marine fauna may have moved away from the area by the time the operating survey vessel arrives, or other marine fauna entered the area rendering the pre survey check invalid. The uncertainty of the viability of spotter planes/vessels and the added environmental impacts from increased noise and air emissions, and increase in safety risks (e.g. vessel collision) are grossly disproportionate to the minimal environmental benefit of identifying marine fauna ahead of the survey vessel	
			Increased precautionary zones	Ability to detect cetaceans at distances greater than 3 km is low, especially in seas where swell can be significant (such as the GAB). Increasing the low power zone to 3 km is unlikely to lead to decreased disturbance to cetaceans since behavioural responses are observed at 1 – 2 km (see Section 4.1.1). Potential to increase number of shut downs extending the duration of the survey.	
			Use of smaller seismic energy source	Due to the water depth of the survey area (up to 5000 m), and the sub seabed depths of geophysical targets, a smaller energy source would be unable to meet the geophysical objectives of the survey. PGS would be unable to meet seismic data delivery requirements of clients.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	**Justification**	
			Use of quieter technologies; silenced air guns, marine vibrators, DTAGS	These unproven technologies are unavailable on a commercial basis to PGS. Geophysical objectives of the survey may not be met resulting in large gaps of data. PGS would be unable to meet seismic data delivery requirements of survey and may result in prolonging of total survey duration.	
			Acquisition of survey outside southern right whale aggregation and calving period, blue whale feeding period or sperm whale feeding period	Given the calving and foraging periods of these species, and the available weather window for safe seismic acquisition in the area, PGS would be unable to meet seismic data delivery requirements of clients. Minor benefit in terms of reduced risk to southern right, blue and sperm whales, given distance and sound exposure level decay to peak aggregating locations and also the low numbers of individuals expected to be encountered within the survey area.	
			Acquisition of survey outside fish spawning periods	PGS would be unable to meet seismic data delivery requirements of clients. Data acquisition would not be possible given the year-round nature of spawning periods in the region. Would also result in little benefit to fish populations given the low impacts expected.	
			Avoidance of CSIRO survey transects during January - March	Would prevent acquisition of data between January and March leading to three months of downtime mid survey, incurring large additional costs (~$36m). Sail lines are required to be orientated NW-SE as the environmental conditions (in particular the swell) makes SW-NE orientation impractical and would lead	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
				to increased down time and poor data quality. The survey is planned to be acquired from north to south to reduce the amount of overlap with the CSIRO surveys. The largest amount of overlap would occur prior to January 1st, the start of the CSIRO survey season. Conducting the survey from south to north would result in a greater amount of overlap compared to the proposed plan. The only available option to completely avoid all overlap with the CSIRO surveys would require acquisition of as much of the northern section as possible prior to January 1st then moving to an area outside the CSIRO survey area until March 31st before returning to infill the data gaps. This option would prolong the length of the survey, and could potentially lead to gaps in data that are unable to be acquired before the favourable weather window closes. To account for this, further data may be required in a following season, incurring substantial additional costs to PGS and increasing the presence of the operating seismic vessel in the area. In preparing the EP, PGS consulted with CSIRO and questioned whether it would be possible to co-ordinate the two operations in order to reduce potential overlap. For example, if CSIRO could traverse transect lines overlapping the survey area when the survey vessel has returned to port for refuelling/crew changes. However, it is not possible to predict or plan the dates and times for when CSIRO are able to fly the transect lines, as this is dependent	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
				upon weather conditions and available resources. Furthermore, CSIRO aim to survey each line multiple times throughout the season. PGS has also committed to conducting the survey in the direction preferred by ASBTIA (see 'disturbance to commercial fisheries below) Since ASBTIA's primary concerns are the SBT stock health and quota, it can be assumed that the requests of CSIRO and ASBTIA will be aligned.	
			Acquisition of survey outside SBT migratory periods	Would prevent acquisition of data between November and February, allowing only 3 months for a 5 month survey. PGS would be unable to meet seismic data delivery requirements of clients. Cost of remobilising and re-deploying for a following season would amount to approximately $8-16m depending on distance to remobilise.	
			Increased distance between two simultaneously operating seismic vessels within different survey areas	PGS may be unable to meet seismic data delivery requirements of clients. Given the lack of cumulative impacts assessed above, increasing the distance between operating seismic vessel would not result in a lower potential environmental impact.	
	Light generation from vessels	• Minimisation of survey and support vessel external lighting to levels required for navigation, vessel safety and safety of deck operations	Reduction of vessel lighting below levels required for	No additional cost, but introduces unacceptable safety risks to personnel and vessels. Little benefit given low numbers of turtles and seabirds in survey area and surrounding waters.	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		• Simultaneous operating survey vessels will not occur within 30 km of one another as determined through pre-consultation • Environmental induction for appropriate survey vessel crew including MFOs, marine, deck and bridge crew	navigation, vessel safety and safety of deck operations		
			Use of lighting wavelengths that are less intrusive to marine fauna	Not regarded as practicable given the range of marine fauna that may be present, and the different wavelengths that may affect behaviours of different species. Would result in little benefit given low level of impacts expected.	
			Acquisition of survey outside fish spawning /aggregation periods	PGS would be unable to meet seismic data delivery requirements of clients. Given the length of fish spawning / aggregation periods, available acquisition time would be insufficient for the duration of the survey. Would result in little benefit to fish populations given the low impacts expected and lack of significant spawning or aggregation sites within the survey area.	
	Vessel movements	• Australian National Guidelines for Whale and Dolphin Watching (DEH 2005b) (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 • Simultaneous operating survey vessels will not occur within 30 km of one another as determined through	Reduction in survey vessel speed during seismic acquisition	Substantial additional cost of approximately $12m if still acquired in the one season and would compromise the ability to collect seismic data while managing safety of equipment and within correct parameters. Survey would take longer to acquire, introducing additional environmental risk. Little benefit given low numbers of cetaceans in survey area and surrounding waters.	**Low**
			Observation and avoidance action for	The implementation of control measures and performance standards specifically for the observation and avoidance of other fauna such as dolphins and	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	**Justification**	
		pre-consultation • Environmental induction for appropriate survey vessel crew including MFOs, marine, deck and bridge crew	dolphins and turtles	turtles is not considered practicable, in light of the low likelihood of encountering such fauna at the survey location; this low likelihood combined with the slow speed of the vessel, enabling avoidance action by the fauna if encountered, is considered to reduce the potential risk to an acceptable level without further measures.	
			Use of additional MFOs	Additional costs to survey programme of approximately $285k. Unlikely to increase detection of marine fauna and therefore would not significantly reduce impacts.	
			Acquisition of survey outside southern right whale aggregation and calving period, peak blue whale feeding period and peak sperm whale feeding period	Given the calving and foraging periods of these species, and the available weather window for safe seismic acquisition in the area, PGS would be unable to meet seismic data delivery requirements of clients. Minor benefit in terms of reduced risk to southern right, blue and sperm whales, given distance and noise decay to peak aggregating locations and also the low numbers of individuals expected to be encountered within the survey area.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
			Seismic acquisition will only occur during daylight hours	Substantial additional cost of approximately $60m due to doubling of survey duration. PGS would be unable to meet seismic data delivery requirements of clients. Should equipment be required to be retrieved and redeployed daily, acquisition would be impossible given the time taken for deployment would be greater than the number of daylight hours.	
Disturbance to benthic habitats	Deployment and retrieval of anchors	• No anchoring within survey area, except in emergency situations	No anchoring in emergency situations	Very substantial additional cost if this leads to vessel grounding likely exceeding $20m for damage or $200m for loss. Introduces unacceptable safety risks to personnel and vessels.	**Low**
	Vessel grounding	• Survey and support vessels may use navigation systems such as: ECDIS, AIS, radar, GPS, and depth sounders • Standard maritime safety / navigation procedures	Pre-survey bathymetric/ geohazard survey of survey area to identify shallow water hazards	Substantial additional cost of approximately $450k assuming 30 day survey. Existing Admiralty charts and other survey data indicates that water depths in survey area are > 100 – 3,000 m, with no shallow water hazards.	**Low**
	Equipment damage, dragging or loss	• 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 <100 m	Cessation of seismic acquisition until all lost equipment is located / recovered	Substantial additional cost of approximately $1.2m per instance assuming 3 days downtime over and above value of equipment lost. Little benefit given water depths and sparse distribution of sensitive benthic habitats in survey area.	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
Atmospheric emissions	Operation of machinery and vessels powered by internal combustion engines	• 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 operating survey vessels will not occur within 30 km of one another as determined through pre-consultation • Implementation of a preventive maintenance system (PMS)	Sourcing of low sulphur fuel, even if not available in local port	Substantial additional cost of around $1.2m – support vessel would have to source low sulphur from other ports or primary vessel would have to steam to other port. Potential increase in survey duration due to increased transit times for support vessel. Little benefit given frequency/scale of emissions and lack of sensitive receptors in the survey area.	**Low**
			No incineration on vessels	Incineration of wastes on vessels using MARPOL-certified equipment and procedures is an accepted practice which avoids potentially greater environmental impact through transport, treatment and disposal onshore. Incineration also saves space on board and may prevent health hazards created by long term storage of wastes pending onshore disposal.	
			Routine shutdown of non-essential machinery on survey and support vessels	Little benefit given frequency/scale of emissions, lack of sensitive receptors and remoteness of the survey area. Build-up of burnable wastes aboard survey vessel, creating storage issues, increased chance of wastes being accidently discharged to sea, transfer of burnable wastes to shore creates additional environmental impacts and risks.	
Invasive marine species	Discharge of ballast water from vessels	• Ballast water will be discharged in line with a Vessel Ballast Management Plan, for example: ➢ Discharge will not occur in water depths <200	No routine discharge of ballast water from survey or support vessels	Due to water depths in the survey area, ballast water is required to be discharged to control the position of the vessel in the water.	**Medium**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	**Justification**	
		m ➢ No discharge of high risk ballast water within 12nm of Australian territorial areas • Australian/Vessel Ballast Water Management Requirements (if/when required)	Transfer of ballast water to separate vessel for discharge outside survey area	Substantial additional cost. Potential acquisition downtime, and increase in survey duration as seismic operations would have to cease during ballast water transfer. Little benefit given lack of sensitive habitats (shallow water habitats etc.), and potential translocation vectors (static vessels) in survey area. Introduction of additional safety risks to personnel during VTVT (vessel to vessel transfer) operations.	
	Biofouling of vessel hulls, other niches and immersible equipment	• Prior to survey commencing, both survey and support vessels have all necessary DoA clearances to operate unrestricted anywhere in Australian waters • National biofouling management guidance for the petroleum production and exploration industry is adhered to including: ➢ Vessel risk assessment conducted for all vessels (international or domestic) to determine risk level of vessel – if moderate/uncertain outcome further mitigation required: a. In-water inspection b. Hull cleaning carried out if inspection discovers invasive/non-native species c. Antifoulant paint reapplied in line with manufacturers specifications • Reporting of known or suspected introduced species	Application of new anti-foulant coating to survey and support vessels prior to survey commencement	Substantial additional cost of over $1.2m potential delay to survey commencement. Little benefit given recent anti-fouling treatment history for both survey and support vessels.	**Medium**
			Hull cleaning on every occasion	Additional cost of over $1.2m and potential delay to survey commencement, little benefit since hulls will be inspected and cleaned if required.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		to FishWatch			
Marine pollution from routine discharges	Discharge of sewage, grey water and putrescible wastes	• 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 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 operating survey vessels will not occur within 30 km of one another as determined through pre-consultation	Survey and support vessels can only discharge sewage and putrescible wastes outside the survey area	Substantial additional cost of over $2.4m due to acquisition downtime, and increase in survey duration as seismic operations would have to cease during transit and discharge outside survey area. Little benefit given lack of sensitive habitats (shallow water habitats etc.), within survey area.	**Low**
			Untreated sewage and putrescible wastes have to be transferred to shore for onshore treatment / disposal	Substantial additional cost of over $2.4m due to costs associated with onshore treatment and disposal, acquisition downtime, and increase in survey duration as seismic operations would have to cease during transfer of wastes to support vessel. Increase in fuel consumption for support vessel, given additional transits required. Risk of spills/leaks during transfer operations. Introduction of additional safety risks to personnel during VTVT operations.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		• 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	• 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 operating survey vessels will not occur within 30 km of one another as determined through pre-consultation	Survey and support vessels have to discharge bilge water contaminated with hydrocarbons with oil content < 15 ppm, or chemicals with low toxicity, to approved waste management provider onshore	Substantial additional cost of over $2.4m due to acquisition downtime, and increase in survey duration as seismic operations would have to cease during transit and discharge outside survey area. Little benefit given lack of sensitive receptors within survey area.	**Low**
			All contaminated bilge water from survey and support vessels have to be	Substantial additional cost of over $2.4m due to costs associated with onshore treatment and disposal, acquisition downtime, increase in survey duration as seismic operations would have to cease during transfer of contaminated bilge water to support vessel. Increase in fuel consumption for support	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
			transferred onshore for treatment/disposal, regardless of oil content or chemical toxicity	vessel, given additional transits required. Risk of spills/leaks during transfer operations.. Additional safety risks to personnel during VTVT operations.	
Marine pollution from accidental discharges	Discharge of solid wastes i.e. garbage	• 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 • Simultaneous operating survey vessels will not occur within 30 km of one another as determined through pre-consultation	No wastes will be incinerated offshore within or adjacent to the survey area – all burnable garbage will be transferred onshore for treatment and disposal	Substantial additional cost of over $1.2m associated with onshore treatment and disposal, acquisition downtime, and increase in survey duration as seismic operations would have to cease during transfer of burnable garbage to support vessel. Increase in fuel consumption for support vessel, given additional transits required to/from Thevenard port. Risk of loss to sea during transfer operations. Introduction of additional safety risks to personnel during VTVT operations.	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		• 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	• 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	No hazardous materials will be used aboard either the survey or support vessels	Hazardous materials (e.g. hydraulic fluid, lubricating oils, cleaning chemicals, paints, solvents, batteries etc.) are required routinely for safe and efficient operation of the survey and support vessels. Potential introduction of additional safety risks to personnel (e.g. inability to clean up spills, maintain vessels in good working order etc.). Suitable cost effective non-hazardous alternatives are not known to be available	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		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	• 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 • Refuelling will not occur at sea • The only fuel used will be marine diesel (no heavy fuel oil which is more persistent in the event of a spill)	Seismic acquisition will only occur during daylight hours	Substantial additional cost of approximately $60m due to doubling of survey duration. PGS would be unable to meet seismic data delivery requirements of clients.	**Medium**
			Seismic acquisition will only occur outside areas with substantial vessel movements (e.g. recognised core fishing grounds, shipping routes)	Large gaps in survey data coverage. Substantial additional costs likely exceeding $5m in filling these gaps. Large amounts of infill acquisition required.	
			Seismic acquisition will only occur outside protected areas (e.g. GAB and Western Eyre Commonwealth	Large gaps in survey data coverage which could not be acquired at any time. PGS would be unable to meet seismic data delivery requirements of clients. No environmental gain likely (based on the assessment of potential impacts on sensitive receptors in this EP).	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		• Crew preparedness, awareness and training	Marine Reserves)		
			Use of vessels with smaller tank sizes	May lead to delay in contracting survey vessel leading to delays in data acquisition. May also result in a smaller vessel only capable of towing a smaller array size which would be unable to meet the efficiency requirements of the survey. PGS would be unable to meet seismic data delivery requirements of clients. More refuelling would be needed, introducing additional risk.	
	Oil spill response	• 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 • Assessment of implementation of SOPEP, AMSA NATPLAN • Stakeholder consultation • Insurance policies to cover costs of environmental monitoring or clean up post spill	Implementation of OPEP independent of AMSA	Substantial additional cost that would be likely to exceed $5m and additional lead time of approximately 6 months in planning and implementation with no additional benefit since AMSA have suitable arrangements in place to respond to a vessel-based spill from this activity.	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
Disturbance to social and community values	Interaction with commercial fisheries	• 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 fisheries 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 • 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 • Recreational fishing from the survey and support	Seismic acquisition will only occur outside any fishing grounds	The survey area and adjacent waters are not core fishing grounds, with other fishing grounds adjacent to the survey area. Would create large gaps in survey data coverage. Very substantial additional costs likely exceeding $5m in filling these gaps. Large amounts of infill acquisition required. PGS would be unable to meet seismic data delivery requirements of clients.	**Low**
			Avoidance of CSIRO survey transects during January - March	Would prevent acquisition of data between January and March leading to three months of downtime mid survey, incurring large additional costs (~$36m) (see row for 'Disturbance to Marine Fauna' for more details).	
			Payment of compensation to fishermen for loss of catch	Difficulty of proving cause/effect relationship between seismic acquisition and any real/perceived loss of catch.	
			Seismic acquisition will only occur outside key fishing seasons	Not possible given that there is no closed season for the fisheries highlighted in the GAB which operates year round.	
			Delay start date to 2016 (Oct or Jan)	Large potential additional costs to PGS due to vessel idle time and in being unable to meet data requirements of clients. Clients may also face penalties. No expected benefit to SBT industry given lack of impacts expected.	

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		vessels will be prohibited • Observations of tuna by MFOs with sightings reported to ASBTIA to provide information to fishers on likely tuna school locations • Survey will be acquired in direction preferred by ASBTIA • Survey will commence after the 1st November 2014 • SBT fishery representatives invited on board vessel during operations • Efforts made to employ one MFO per swing from the SBT industry • Efforts to source alternative work between November and December undertaken • Survey vessel will divert course and/or shutdown should a towed pontoon enter within 10 km of survey vessel	Delay start to Dec/Jan 2015	Delaying by two months or more would incur large additional costs. Given the lack of evidence that seismic activity will directly impact SBT behaviour and migration patterns, these costs are not considered to be outweighed by the benefits of acquiescing to ASBTIA requests, particularly given the lack of evidence suggesting detrimental impacts of seismic activity to the SBT migration (see Section 4.8.1. for further details).	
	Interaction with shipping	• Adherence to the requirements of the *Navigation Act 2012*, and specifically *Marine Orders - Part 30: Prevention of collisions* • Adherence to the requirements of COLREGS	Seismic acquisition will only occur outside areas with substantial vessel	This would create large gaps in survey data coverage. Very substantial additional costs likely exceeding $5m in filling these gaps. Large amounts of infill acquisition required.	**Low**

Hazard	Environmental aspect	Control and mitigation measures implemented	Control measures not implemented and justification		Residual risk level
			Control measure	Justification	
		• Consultation with AMSA prior to the survey commencing to determine the level of commercial shipping in the vicinity of the survey area	movements (e.g. recognised shipping routes)		
		• 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 • In-water equipment lost will be recovered (where possible). Detailed records will be maintained of equipment lost overboard	Seismic acquisition will only occur during daylight hours	Substantial additional cost of approximately $60m due to doubling of survey duration. PGS would be unable to meet seismic data delivery requirements of clients. Should equipment be required to be retrieved and redeployed daily, acquisition would be impossible given the time taken for deployment would be greater than the number of daylight hours.	
	Operation of vessels within protected areas and heritage places	• 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	Survey and support vessels cannot enter or traverse waters within Commonwealth Marine Reserves or Marine Parks	Would create large gaps in survey data coverage. Very substantial additional costs in filling these gaps likely exceeding $5m. Large amounts of infill acquisition required. PGS would be unable to meet seismic data delivery requirements of clients. Limited benefit, as routine activities associated with the survey poses little risk to values and sensitivities of the proposed marine reserve.	**Low**

6 IMPLEMENTATION STRATEGY

PGS will implement an Environmental Management System (EMS) for this EP consistent with the Australian/New Zealand Standard AS/NZS ISO 14001 Environmental Management Systems – Requirements with guidance for use.

Table 6-1: Description of EMS elements

Environmental policy	HSE&Q Commitment Statement and Environment Policy
Planning	Environmental aspects associated with the survey have been identified and potential impacts assessed and evaluated
	Control measures, including performance standards and measurement criteria, to reduce impacts and risk have been identified
	Legislation relevant to the survey has been identified
Implementation and Operation	Roles and responsibility to ensure compliance with environmental commitments have been outlined
	Competence and training requirements have been identified
	Information to be monitored and recorded during the survey have been identified
	Emergency preparedness and response arrangements (including OPEP) have been identified
Checking	PGS undertakes scheduled audit/s of the activity to ensure: • Relevant control measures are in place • Opportunities for improvement and suggested remedial actions are provided • Non-conformances are effectively acted upon and closed out Environmental commitments, detailed in this environmental plan, are used as the basis to the audit.
	Arrangements detailed in Emergency Response plans will be tested at intervals commensurate with the nature and scale of the activity
Management review	Post-Survey Environmental Report will review environmental performance and determine whether environmental performance outcomes for the survey have been met
	Any identified actions and lessons learnt will be included in the environmental management of the on-going activity as soon as practicable via a formal Management of Change process, and their application considered for other PGS activities

Environmental performance of the survey is evaluated and reviewed in a number of ways. These reviews are undertaken to:

- Ensure all significant environmental aspects of the activity are covered (and continue to be covered) by the EP;
- Ensure that environmental management measures to achieve environmental performance outcomes and standards are being implemented, reviewed and where necessary amended;
- Identify potential non-conformances and opportunities for continuous improvement;
- Ensure that all EPO and EPS have been met in carrying out the activity; and
- Determine whether all environmental commitments outlined in the EP have been fulfilled

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; and
- A summary of the key information, commitments, environmental performance outcomes and standards, and measurement criteria for the activity will be distributed aboard the survey vessel.

Should any inadequacies or opportunities for 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 and of an acceptable level.

Management of changes to scope (e.g. timing, location or operational details described in this EP) are the responsibility of the PGS Vessel Manager. A risk assessment will be undertaken for all changes in scope to assess potential impacts of the change. If the 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. Any management of changes to scope will be in accordance with the PGS Management of Change procedures (1031GEN00 & 926VES00).

Notification to other government authorities, where required, will be undertaken by the PGS Vessel Manager. Notifications will include details of the change and procedures that will be put in place for managing or mitigating the additional or modified risks.

In addition, testing of the Oil Spill Emergency Plan (OPEP) (see Section 7.1), including the vessel SOPEP, will be conducted to assess the effectiveness of the OPEP arrangements, taking into account the nature and scale of the risk of a hydrocarbon spill. Specifically the tests will ensure the following:

- Roles and responsibilities of those involved are clear and understood;
- Communication sequence from PGS offshore personnel to PGS onshore personnel and the Combat Agency, including notification of the RCC, is adequate and includes all relevant responders;
- Equipment and procedures intended for source control on board the vessel are adequate for use and effective as outlined in the vessel SOPEP; and
- Should any inadequacies or improvements to the arrangements be found, the OPEP will be amended via a Management of Change under the responsibility of the PGS Vessel Manager.

The OPEP will be tested on the following occasions:

- Prior to the survey commencing;
- No later than 12 months since the last test. Since the survey duration is estimated at 5 months, it is not anticipated that the EP will be in force for a period of over 12 months;
- At a minimum of three monthly intervals throughout the survey; and
- Following any significant amendment of the arrangements.

7 EMERGENCY RESPONSE

A survey-specific Emergency Response Plan (ERP) will be prepared. The ERP will contain instructions for vessel emergency, medical emergency, search and rescue, reportable incidents, incident notification and contact information. In the event of an emergency of any type the Vessel Master will assume overall 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. Emergency response support can also be provided by PGS, if requested by the ERC.

7.1 Oil Pollution Emergency Plan

The Oil Pollution Emergency Plan (OPEP) for the survey 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 together form 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; and
- 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.

The survey vessel SOPEP, which has been prepared in accordance with the IMO guidelines for the development of shipboard oil pollution emergency plans, includes emergency response arrangements and provisions for testing the OSCP (oil pollution drills), as required under Regulations 14(8AA) and 14(8A) of the OPGGS(E) Regulations.

Priority actions in the event of a fuel or oil spill are to make the area safe and to stop the leak and ensure that further spillage is not possible. Deployment of small absorbent booms and other materials will be undertaken so as to maximise recovery of spilled material. All deck spills aboard the survey vessel will be cleaned-up immediately, using appropriate equipment from the onboard spill response kits (e.g. absorbent materials etc.) to minimise any likelihood of discharge of spilt hydrocarbons or chemicals to the sea.

For Commonwealth waters, initial actions will be undertaken by the survey vessel with subsequent actions determined in consultation with the regulatory authorities (AMSA) under NATPLAN. AMSA is the designated Combat Agency for oil spills from vessels within the Commonwealth jurisdiction. Upon notification of an incident, AMSA will assume control of the incident (AMSA, 2012). The assessment of appropriateness of response strategies, and their implementation, also lies with AMSA as Combat Agency.

Costs will be recovered by AMSA for any services they provide in responding to a hydrocarbon spill. PGS has insurance in place for sudden and accidental pollution, and the monitoring and clean-up that may be required.

8 STAKEHOLDER CONSULTATION

8.1 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 the EP. A full list of stakeholders contacted is provided in Table 8-1. Selected stakeholders were identified as 'highly relevant', that is, those considered to have the greatest potential interest in, or interests affected by the activity, for example, fishing bodies with potential activities in the survey area (indicated in Table 8-1 in italics). It was considered that these stakeholders would likely merit a greater level of consultation than the provision of information (i.e. a letter) on which they could comment.

On the 9th April 2014 all stakeholders were issued with the stakeholder consultation letter providing details of a 5 year survey programme, which covered much larger area that the survey area now defined by the EP. Since the issue of these letters, the scope of the survey programme has changed to cover a smaller area over a single season (as described in Section 1). The revised survey area is situated entirely within the original, larger area and falls within the same acquisition window (November to May) as the original survey programme.

Table 8-1: List of stakeholders considered relevant and contacted in the preparatory consultation (* *Italics indicate stakeholders considered 'highly relevant')*

Fisheries		Government		Conservation	Other
Australian Fisheries Management Association	South Australia Rock Lobster Advisory Council Inc	Department of Agriculture (DoA)	Parliament of Australia	Australian Conservation Foundation	Flinders Ports Pty Ltd
Australian Fishing Enterprises Pty Ltd	South Australia Sardine Industry Association	Australian Government Department of Resources, Energy and Tourism	**South Australia Department of Environment Water and Natural Resources*	Australian Marine Conservation Society	Port Lincoln Aboriginal Community Council
Australian Seafood Industry Council	South Australian Recreational Fishing Advisory Council	**Australian Marine Safety Authority*	**South Australia Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) - Petroleum*	Blue Whale Study	Ports South Australia
**Australian Southern Bluefin Tuna Aquaculture Industry Association*	South East Trawl Fishing Industry Association	Boating Industry Association of SA	**South Australia Department of Transport, Energy & Infrastructure*	Cetacean Ecology, Behaviour and Evolution Lab, Flinders University	Shipping Australia Limited
Commonwealth Fisheries Association	Southern Shark Industry Alliance Inc	City of Port Lincoln	South Australia Government - Department of the Premier and Cabinet	Conservation Council of South Australia	The South Australian Museum
Commonwealth Scientific and Industrial Research Organisation	Southern Squid Jig Fishery	Defence Science and Technology Organisation	South Australia Minister for Agriculture Fisheries and Forest	Conservation Council of Western Australia	Tourism South Australia
DI Fishing Eden Pty Ltd	Sustainable Shark Fishing Inc	Department of Defence - Air Command HQ	South Australia Minister for Mineral Resources & Energy	Deakin Whale Ecology Group	Yalata Aboriginal Community, Ceduna
Emily Kristina (Australia) Pty Ltd	The Rock Lobster Advisory Council	Department of Defence - Australia Hydrographic Office	South Australia Minister for Regional Development	Flinders University Cetacean Ecology, Behaviour and Evolution Lab (CEBEL)	

Fisheries		Government		Conservation	Other
**Great Australian Bight Fishing Industry Association*	Tony's Tuna International Pty Ltd	Department of Defence - Directorate of Property Acquisition, Mining and Native Title	South Australia Minister for Sustainability, Environment & Conservation	International Fund for Animal Welfare	
Lakes Entrance Fishermen's Co-operative Society Ltd (LEFCOL)	Tuna Boat Operators Association SA	Department of Environment	South Australia Research and Development Institute	Pew Environmental Group	
Markane Seafoods Pty Ltd	Tuna Farmers Pty Ltd	District Council of Ceduna	South Australian Chamber of Mines and Energy	The Lukin Group	
National Seafood Industry Alliance	Valente Holdings Pty Ltd	District Council of Lower Eyre Peninsula	State Member for Finniss	The Nature Conservancy	
Primary Industries and Regions South Australia	**Western Australia Department of Fisheries*	Eyre Regional Development Board	State Member for Flinders	Whale & Dolphin Conservation Society	
Raptis Fishing Licences Pty Ltd	Western Australia Fisheries Licence holders	Federal Member for Grey	State Member for Goyder		
RecFish South Australia	Western Australia Fishing Industry Council	Federal Member for Mayo	Western Australia Department of Mines and Petroleum		
Recfishwest	Wildcatch Fisheries South Australia	Geoscience Australia	Western Australia Department of Transport		
South Australia Aquaculture Council Inc	Marine Fishers Association of South Australia	National Native Tribunal			

8.2 Updated Consultation

For stakeholders identified as highly relevant (indicated in Table 8-1 in italics), and for which no response to the original consultation was received after four weeks, the consultation was followed up with a secondary email or phone call.

By the 14th May, PGS had received 20 responses from stakeholders. Each piece of feedback was reviewed in detail and the merits evaluated and taken into consideration in the preparation of the EP (Section 8.5). Following evaluation of feedback and further consultation with stakeholders, commitments were made to ensure the activity was carried out in a way that reduces potential impacts and risks to stakeholders where applicable. These commitments are provided in Section 8.4.

Since the revised scope of the proposed activity includes a smaller area and shorter duration it was not considered that any additional stakeholder comments would arise due to the change in scope. As such, for stakeholders that were previously closed out, a general notification was provided detailing the change in scope. For stakeholders who provided feedback yet to be closed out, a more detailed letter was provided outlining the change in scope or a meeting was held in which a presentation was provided that outlined the change in scope.

8.3 Ongoing Consultation

Where appropriate, consultation with stakeholders will be ongoing during the survey (Section 8.4). 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. If the feedback results in a change in operations or procedures, but is not considered to result in significant new or increase impact or risk, a Management of Change will be undertaken to ensure that any impacts of the survey on stakeholder's activities or interests are continually reduced to ALARP, in line with the Environmental Management System.

8.4 Future Consultation and Commitments

In response to stakeholder feedback, additional commitments to either future consultation or operations were agreed with stakeholders, these include:

- Both AMSA and the Hydrographic Office will be notified 2 weeks prior to activity commencement;
- DMP will be notified following the cessation of a stage of the survey;
- WA Department of Fisheries will be consulted at least one month prior to any acquisition occurring;
- Port Lincoln City Council will be provided with updates regarding the survey start date once dates have been confirmed;
- PGS will provide ASBTIA will updates regarding the survey commencement date once dates have been finalised, and on survey progress during the activity;
- Correspondence with ASBTIA will be ongoing in order to identify and prepare an available SBT fishery representative to go on board the seismic vessel during operations and SBT fishery personnel to work as an MFO during the activity ;
- A further meeting between PGS and ASBTIA occurred on the 1st October 2014;

- PGS also commits that:
  - The survey will start on or after the 1st November 2014; and
  - The survey will be acquired in the direction preferred by ASBTIA (subject to this being identified by ASBTIA during further consultation).

8.5 Evaluation of Merits of Feedback

The following sections provide details of the key themes of feedback received and PGS's response to this feedback. Where appropriate, PGS has made commitments regarding further consultation or operations as detailed in Section 8.4.

8.5.1 Maritime Safety

Summary of feedback received	Evaluation of feedback
AMSA notes that the southern section of the survey area has significant national and international commercial shipping traffic that follow the traffic route from Port Lincoln and other South Australian ports to all westward destinations via the South West Western Australia coast. Moderate shipping traffic will be encountered from Thevenard, South Australia, to the west and south towards Port Lincoln and on to Victoria. Given the length of tow a guard/support vessel in cooperation with the survey vessel will need to be active and maintain exceptional communications with all commercial shipping 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. 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. 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 and hence it is highly recommended that survey lines are planned to minimise this interaction with commercial shipping. AMSA request that the RCC is contacted for AUSCOAST warning broadcasts before operations commence. Additionally, the Australian Hydrographic Service must be contacted (no less than 2 working weeks) for the promulgation of related Notices To Mariners.	PGS notes the areas of increased activity, which is described in Section 2.7.3 and impacts assessed in Section 4. Control measures including communication and navigational aids are included in Section 4 and are considered to reduce the potential impacts to ALARP. Major shipping routes will be avoided where practicable. Where avoidance is not possible (i.e. would prevent survey objectivity) design of the sail lines to reduce time spent in shipping routes will be considered and implemented were practicable (Section 4). The Australian Hydrographic Office and AMSA were included in original consultation (see above). Both AMSA and the Hydrographic Office will be notified 2 weeks prior to activity commencement in order for Notice to Mariners and AUSCOAST warnings to be issued (Section 4).
Shipping Australia advises that the seismic vessels towing 8 km streamers to a width of 1.7 km will impact on the path of routine trading vessels. These ships will rely on the promulgation of more detailed and localised information in notices to mariners published by the Australian Hydrographic Service and broadcast of NAVAREA and AUSCOAST warnings by AMSA to maintain their awareness of these operations.	The Australian Hydrographic Office and AMSA were included in original consultation, and will be notified 2 weeks prior to activity commencement in order for Notice to Mariners, NAVAREA and AUSTCOAST warnings to be issued.
All areas lie within Commonwealth waters and DPTI assume that the Federal Hydrographer would publish a Nation Notice	Notice to Mariners will be issued by the Federal government. Given that the activity will not occur

Summary of feedback received	Evaluation of feedback
to Mariners although DPTI will also publish State Notice to Mariners if requested.	within State waters, PGS does not consider it necessary or appropriate for State issued Notice to Mariners to be issued.

8.5.2 Marine Fauna

Summary of feedback received	Evaluation of feedback
IFAW believes further seismic surveys in the GAB are inappropriate and note that PGS is not a titleholder and that most titleholders have already acquired or have existing proposals to acquire in the region.	Through application of a Special Prospecting Authority (SPA), PGS will assume the role of titleholder. An SPA will only be granted by titleholders of an exploration permit, should they require seismic data to be acquired. Since an SPA has been granted (in order to submit this EP), PGS considers that there is a need for further surveys and that these are appropriate.
IFAW raised concern that the survey may impact on feeding blue and sperm whales, migrating southern right whales and Australian sea lions. IFAW indicate that research in the eastern GAB confirmed importance of the area for whales and beaked whales.	PGS acknowledges the evidence for the eastern GAB upwelling providing feeding habitat for several cetacean species including the blue, sperm and beaked whales. However, the survey area does not overlap with this area of upwelling (which lies ~300 km to the east) and the lack of upwelling within the survey area suggests that critical foraging habitat does not occur. While southern right whales may traverse the survey area on migration to and from calving grounds along the coast, the lack of distinct migration pathways, the general anticlockwise migration pattern with individuals moving along the coast, and the lack of observations of southern right whales during other seismic surveys in the area over similar time frames, all suggest that potential impacts to this species are not expected.
IFAW requested to receive more specific information before an EP is submitted including sufficient information about:	
The specific areas being targeted for the seismic survey;	An update was provided of the revised survey area (as outlined in Section 1.1), and confirmation that the survey will occur between October 2014 (timing since changed to November 2014) and May 2015.
The specific mitigation measures PGS is proposing to protect cetaceans from acoustic disturbance; the estimated risk reduction for these measures;	PGS provided a summary of mitigation measures as outlined in Section 4.
Whether PGS intends to gather any baseline data to plug the current significant gaps on knowledge around cetacean presence, abundance, diversity and habitat use in the GAB, before proceeding with the seismic survey;	A robust environmental impact assessment will be conducted in order to obtain federal government approval of the proposed activity, including the development of suitable mitigation measures. With this in place it is not considered necessary to collect additional baseline data. However, MFOs on board the vessels will collect observational cetacean data which will help develop the baseline information which will be publicly available via the government's cetacean observation database.
What consideration PGS has given to encountering beaked whales (and other	While not listed as threatened or migratory, beaked whales were described in the EP and included in the risk assessment. Occurrence

Summary of feedback received	Evaluation of feedback
deep-diving species);	of beaked whales is most common in areas of upwelling, which do not occur in the survey area. As such, presence of large numbers of beaked whales within the survey is considered unlikely. Should individuals be present, avoidance behaviour or temporary altered behavioural states may occur and would likely cause low level, temporary impacts at an individual level only.
What measures will be taken to detect beaked whales (and other deep-diving species), or whales during night-time, to protect them from noise pollution generated by the survey;	One method of detecting cetaceans at night, during poor visibility or when diving, is through Passive Acoustic Monitoring (PAM). An assessment of why PAM would not be an efficient or cost effective method of detecting cetaceans during night time or poor visibility is provided in Table 5-4. As such, the implementation of PAM is not considered practicable. Mitigation measures outlined in Section 4, including adaptive management, are considered able to reduce risks to ALARP and of an acceptable level.
What considerations have been given to the use of quieter, alternative technologies to airguns to reduce the amount of noise input into the marine environment	Consideration of the available technology concluded that only seismic testing using airgun arrays would achieve the geophysical objectives of the survey.
What consideration has been given to the cumulative impact of PGS's planned activities on top of other proposed offshore petroleum?	Given the distance between the proposed survey and those known to be proposed over a similar time frame (>30 km), the assessment of potential for cumulative impacts on sensitive receptors concluded that cumulative impacts were unlikely.
DoE are currently drafting guidance for industry on where DoE are relevant for consultation. General policy and guidance that should be considered by proponents in developing EPs, referring to NOPSEMA's Information paper (N04750-IP1382).	NOPSEMA's Information paper (N04750-IP1382) identifies the consideration of the relevant values and sensitivities of matters protected as well as all other values and sensitivities that exist in the environment to be included in the plan. The specific EPBC Act matters protected relevant to the Program include World Heritage values of a declared World Heritage property, National Heritage values of a declared National Heritage place, the ecological character of a declared Ramsar wetland, listed threatened species and ecological communities, listed migratory species and Commonwealth marine areas. These matters are described in Section 2.
DEWNR encourage PGS to complete activities before the migration period of the southern right whale at the start of May.	PGS note DEWNR's preference that the survey be completed prior to May 2015 in order to avoid the southern right whale (SRW) migration period. While the survey may overlap the start of the SRW migration period, it is not expected that a significant number of SRWs will be encounter during the survey, due to the general anticlockwise migratory pathway of individuals, meaning that the majority of individuals will be to the east of the survey area and are less likely to traverse the survey area. Indeed, no SRWs were observed during previous seismic surveys which were carried out within a similar area within May in 2012 and 2014, supporting this expectation of low numbers. Furthermore, adaptive management controls (Section 4) will ensure that should any migrating individuals be observed, measures will be taken to reduce impacts to individuals and the population overall.

8.5.3 Commercial Fisheries

Summary of feedback received	Evaluation of feedback
Feedback received from fishery related stakeholders largely regarded the SBTF. Key points raised include:	
Vessels towing SBT pontoons have limited manoeuvrability, meaning they are unable to avoid seismic vessels. Furthermore, disturbance and stress to the SBT in the pontoons can lead to damage and reduced value of the catch.	PGS has acknowledged these issues (Section 4.8.1) and agreed to remain 10 km from the towing vessels, shutting down or moving away if necessary (Section 4).
The 2012 CSIRO results were 'dimensionally' below trend and fishing catches were unusual in that they occurred to the east of the CSIRO aerial survey area. These observations coincided with a 2011/2012 MSS conducted by BP.	PGS acknowledges that the 2012 result was statistically below trend but does not find evidence to suggest a direct link between the survey result and the BP MSS, as described in Section 4.8.1. PGS consulted with CSIRO during the preparation of the EP to investigate potential for co-ordinating the two surveys so that operations do not overlap. For example, transects overlapping the MSS area to be surveyed while the seismic vessel is off prospect for crew change or refuelling. However, given that favourable weather conditions are required for the aerial survey it is not possible to for CSIRO to 'miss out' transects for later surveying (see Table 5-4). In further attempts to reduce potential or perceived impacts of the MSS on the CSIRO aerial survey result, PGS has committed to acquiring the survey in the direction preferred by ASBTIA (see Table 5-4).
ASBTIA believes that the MSS will impede the migration of SBT into the GAB, preventing them from being present in the CSIRO aerial survey area and, therefore, adversely affecting the survey results.	In assessing the potential impacts of the MSS on SBT migratory behaviour in light of the information provided in Sections 4.1.1 and 4.8.1, PGS does not consider it likely that the MSS will have negative impacts on SBT migration or the subsequent results of the CSIRO aerial survey given that: • Using a conservative 50 km buffer around the survey vessel, only ~10% of the SBT migratory pathway is likely to experience noise levels leading to a behavioural response at any one time • Evidence suggests that any behavioural responses will be short term only and unlikely to lead to long term changes in behaviour. • Anecdotal evidence of SBT behaviour within 10 – 1000 m of the survey vessel indicates no 'abnormal' behaviours were observed. • Taking into account planned and unplanned shutdowns, the seismic source will only be discharged for ~50 % of the survey duration, with regular shut downs of 3.5 hours occurring every 8 hours for line changes. • SBT are continually moving at high speeds of ~70 km/hr enabling individuals to travel over 200 km during a line change shutdown.

Summary of feedback received	Evaluation of feedback
ASBTIA request that the survey starts later January 2015 or late January 2016	PGS understand that the basis of this request is to prevent the survey from overlapping with the juvenile SBT migration into the GAB. The survey duration is estimated at 5 months; however, this is a conservative estimate and assumes that activities can be completed during favourable weather conditions between October and May. In commencing the survey in late January, only 4 months of suitable conditions would be available in which to complete a 5 month survey. The weather conditions from June onwards, in particular the large swell which can be encountered, are impractical for data acquisition. Deploying equipment in large swells could lead to damage of the equipment and potential loss of the streamers. This is not only a cost to PGS, but can also lead to avoidable environmental impacts, interference with other sea users and damage to their equipment. The resulting data would unlikely be usable requiring resurveying of the same area in the future. Operating under these conditions also increases the H&S risks to personnel to an unacceptable level. In addition, delaying acquisition until late January would prevent acquisition of data in December and much of January when weather conditions are most favourable and when weather instigated shutdowns are expected to be fewer. By actively avoiding these months, the risk of delays is increased, potentially prolonging the total duration of the survey. As a result of a later start date and prolonged survey duration, PGS may be unable to complete the survey in one year resulting in a second season the following year. This would not only increase the costs (in the order of hundreds of millions AUD) to PGS, but would also expose the environment and other users of the sea to additional survey presence. PGS are aware that ASBTIA has negotiated with the proponents of the last two proposed surveys for the GAB to adjust survey timing to reduce impact to the tuna industry. However, in the case of Bight Petroleum, the survey is intended to last approximately 70 days (Bight Petroleum, 2012), three months shorter than PGS's proposed survey. Such shorter survey duration provides considerably more flexibility in survey timing. Even starting in March, Bight Petroleum has sufficient time to acquire the entire survey prior to June when weather conditions are unfavourable. For TGS's survey, given the timing of the acreage award, it would not have been practical to mobilise earlier than late December for the early 2014 season. It is also specified in ASBTIA's letter that the second phase of TGS's survey is set to commence in October 2014. Combined with the assessment of impacts in Section 4.8.1, and summarised above, the survey is considered unlikely to have negative impacts on SBT migration or the subsequent results of the CSIRO aerial survey.
ASBTIA request that PGS postpone the survey until later 2016 (October).	PGS understand that this request is based on the perceived effect of seismic surveys on the results of the CSIRO survey and consequences on the 2015 – 2017 quotas. While PGS acknowledge the low biomass per nm estimate resulting

Summary of feedback received	Evaluation of feedback
	from the 2012 aerial survey, we are unaware of any evidence that attributes the result to seismic activity. As described in Section 4.8.1, unusual weather conditions recorded during the 2012 aerial survey could potentially impact the ability of aerial surveyors to detect SBT. Furthermore, changes in the Leeuwin Current during this time have potential to change SBT habitat utilisation, altering their distribution in the GAB potentially moving them outside the aerial survey area (and therefore being unavailable to be observed during the aerial survey). Operationally, delaying the survey until late 2016 would incur great additional costs to PGS. The vessel to be used in the survey has already been decided and scheduled. Changing the plans at this stage could potentially lead to large costs (tens of millions of AUD) should vessel arrangements be changed. It should be noted that in the planning of the survey, PGS believed they were working in good faith by commencing as early as possible in order to clear the CSIRO survey transects as quickly as possible, and reduce overlap with the aerial surveys based on advice previously provided by ASBTIA (ASBTIA, 2012). Furthermore, due to conditions of the exploration permit, delaying the survey to 2016/17 would result in penalties to the permit holders (the sponsors of the survey) and potentially losing the permit licence. This may delay development of oil and gas activity in the GAB and the potentially lucrative economic benefits to Port Lincoln.
ASBTIA are concerned that another 'poor' (i.e. low biomass estimate) CSIRO survey result (in addition to the low 2012 result) within the 5 year average used to set the quotas may trigger the meta rule which may result in the tentative set quota being reduced.	While PGS acknowledges the potential implications of a 'poor' CSIRO survey result on the SBT quota and industry, assessment of the available evidence does not suggest that the MSS is likely to impact the results of the CSIRO survey, as described above and in more detail in Section 4.8.1, and therefore is unlikely to impact the SBT quotas and industry.
The South Australian Sardine Industry Association commented that the sardine fishery is completely dependent on a sustainable and stable SBT industry. SASIA quote the previous response from ASBTIA and highlight that given the dependence of the Sardine fishery on the SBT industry, SASIA's main concern would be driven by any potential negative impacts generated by the survey on the normal migration pattern of SBT during the catching window of Jan – March 2015. Whilst the majority of the harvest takes place in Lower Spencer Gulf (outside the survey area), the health of the GAB is important in the long term sustainability of the sardine fishery. SASIA supports the advice or submissions by ASBTIA regarding the survey.	Given the sardine fishery's concerns are that of the potential impacts of the survey on the SBT fishery, the issues and concerns raised have been previously addressed in responding to ASBTIA above and in the EP. PGS has assessed the concerns raised by ASBTIA and do not believe the proposed survey will negatively impact SBT migration or the subsequent quotas, as described above.

8.6 Additional Outcomes of Stakeholder Consultation

In addition to amendments to the proposed activity as appropriate, through consultation the following actions by PGS were identified as providing a positive impact on stakeholders and will be implemented during the survey.

8.6.1 SBT Industry Representatives

PGS has provided an invitation to members of the SBT industry to spend time on the survey vessel during operations. This will provide firsthand experience of seismic operations providing a better understanding of how the activity is conducted.

8.6.2 Employing Local MFOs

PGS has committed to providing two MFOs on the survey vessel at all times. One of these MFOs will be experienced with at least 6 months experience in an MFO role in Australian waters. The second MFO will be appropriately trained prior to the survey commencing, but if possible will be recruited from the SBT industry in Port Lincoln. This not only provides a member of the fishing industry with additional skills and potential employment opportunities, but also provides some economic benefit to the Port Lincoln community.

8.6.3 Environmental Monitoring

The survey and support vessels will be operating in areas rarely visited by research vessels. This provides a unique opportunity to collect environmental data in relatively poorly understood areas of the GAB. PGS has engaged with SARDI and IMOS to pursue environmental data collection opportunities.

Arrangements are in place for PGS to provide raw data collected from the survey vessel's EA600 echo-sounder to contribute to the IMOS Bio-Acoustic Ships of Opportunity Program (BASOOP). The program provides baseline acoustic data that will enable characterisation of open-ocean fish communities associated with different water masses through time. These communities regulate primary production and are forage for top predators (e.g. bottom fish/sharks, tuna, seals, birds). The necessary systems have been set up on the seismic survey vessel and will collect data on its voyage from Norway to Australia prior to mobilisation, and throughout the survey. PGS will also supply IMOS with the temperature and salinity data routinely collected from the survey vessel on a weekly basis throughout the survey.

Additional discussions are underway with SARDI investigating the potential for undertaking pelagic sampling from the support vessel as it travels from Port Lincoln to the survey area during operations. Detailed arrangements are under discussion regarding the route to be taken and the potential this has for providing a robust dataset of environmental data.

These data will provide additional information on the physical and biological conditions in an area of the GAB. The data will add to the current understanding of ecological processes which may influence SBT life history and behaviour, including migration patterns. Such information could be useful in better understanding and informing future management of the fishery.

9 DETAILS OF NOMINATED LIAISON PERSON

For further information about the proposed Ceduna MC3D MSS, please contact:

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10 REFERENCES

AMSA (2012) Advisory note for offshore petroleum industry consultation with respect to Oil Spill Contingency Plans http://www.amsa.gov.au/navigation/shipping-management/offshore-activities/documents/guidance-to-offshore-industry-oscp.pdf

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

ASBTIA (2012) Response to Bight Petroleum Pty Ltd/Exploration (mineral, oil and gas - marine)/Bight Basin/Commonwealth Marine/Lightning 3D Marine Seismic Survey (EPP-41 & EPP-42), Bight Basin, SA

Bone, Y. and James, N.P. (1998). Biota and sediments on the Great Australian Bight: their interdependence, deposition and potential for accumulation [Abstract]. In: Proceedings of the South East Indian Ocean and Great Australian Bight USA / Australia Bilateral Workshop, Flinders Institute for Atmospheric and Marine Sciences, Flinders University of South Australia.

BP (2011) EPBC referral 2011/5969: BP Exploration (Alpha) Ltd/Exploration (mineral, oil and gas - marine)/Approx 400km west of Port Lincoln /SA/Ceduna 3D Marine Seismic Survey, Great Australian Bight

BP (2013) Environment Plan Summary Great Australian Bight Site Investigation Programme. February 2013.

Chelton, D.B., Hussey, K.J. and Parke, M.E. (1981). Global satellite measurements of water vapour, wind speed and wave height. Nature, 294: 529-532.

Clay C.S, Medwin H. Acoustical Oceanography. New York: Wiley; 1977. 544 pp.

Commonwealth of Australia (2009) National Biofouling Management Guidance for the Petroleum Production and Exploration Industry.

Currie, D R, and S J Sorokin (2011). A preliminary assessment of the deepwater benthic communities of the Great Australian Bight Marine Park. Report to the South Australian Department of Environment and Natural Resources and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities. South Australian Research and Development Institute (Aquatic Sciences) Adelaide. SARDI Publication No F201/000526-1. SARDI Research Report Series No 592. 61 pp.

DAFF (2012) Department of Agriculture, Fisheries and Forestry. Fishery status reports 2011. Research by the Australian Bureau of Agricultural and Resource Economics and Sciences, published 2012.

DNV (2011). Assessment of the Risk of Pollution from Marine Oil Spills in Australian Ports and Water. Final Report for the Australian Maritime Safety Authority. Det Norske Veritas, Report No. PP002916. 50 pp.

DoE (2014a). EPBC Online Protected Matters Database accessed on 2nd January 2014 at http://www.environment.gov.au/epbc/pmst/index.html

DoE (2014b). Conservation Values Atlas accessed on 2nd January 2014 at http://www.environment.gov.au/topics/marine/marine-bioregional-plans/conservation-values-atlas

DoE (2014c). National Heritage Listing downloaded on 14th May 2014 at http://www.environment.gov.au/heritage/places/national/index.html

DSEWPAC (2008) South-west Marine Bioregional Plan. A description of the ecosystems, conservations and uses of the southwest marine region

DSEWPaC (2012). The South-West Marine Bioregional Plan, Bioregional Plan. A description of the ecosystems, conservations and users of the south-west marine region. Department of Sustainability, Environment, Water, Population and Communities (now Department of Environment).

Edyvane, K. 1998. Great Australian Bight Marine Park Management Plan, Part B, Resource Information. Department for Environment, Heritage and Aboriginal Affairs, South Australia.

Environment Australia (1996). Assessment of the Conservation Values of the Commonwealth Waters of the Great Australian Bight Region. Report prepared by the Biodiversity Group of Environment Australia, December 1996.

Eveson, Farley and Bravington (2012) The aerial survey index of abundance: updated analysis methods and results for the 2011/12 fishing season. CSBT-ESC/1208/16, 17th Meeting of the Scientific Committee, Commissionfor the Conservation of Soutehrn Bluefin Tuna, 27 – 31 August 2012, Tokyo, Japan.

Finneran, JJ, Schlundt, CE, Dear, R, Carder, CA, and Ridgway, SH (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America, 111 (6): 2929-2940.

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.

Gittings, SR, Bright, TJ and Hagman, DK (1993). The M/V Wellwood and other large vessel groundings: coral reef damage and recovery, pp. 174–180. In: Global Aspects of Coral Reefs: Health, Hazards, and History. Rosenstiel School of Marine and Atmospheric Science, Univ. of Miami. 420 pp.

Goold, JC (1996). Acoustic assessment of populations of common dolphin Delphinus delphis in conjunction with seismic surveying. Journal of the Marine Biological Association UK, 76: 811-820.

Harris, R. E., G. W. Miller and W. J. Richardson (2001). Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4): 795-812.

Hastie, Swift, Gordon, Slesser and Turrell (2003) Sperm whale distribution and seasonal density in the Faroe Shet;and Channel. Journal of Cetacean Research Management, 5 (3): 247 0 252

Hazel, J Lawler, IR Marsh, H Robson, S (2007). Vessel speed increases collision risk for the green turtle Chelonia mydas, Endangered Species Research, 3: 105–113

Jensen, AS and Silber, GK (2003). Large whale ship strike database. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. Technical Memorandum NMFS-OPR-25. 37 pp.

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.

Knowlton, AR and Kraus, SD (2001). Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. Journal of Cetacean Research and Management Special Issue, 2: 193-208.

Laist, DW, Knowlton, AR, Mead, JG, Collet, AS and Podesta, M (2001). Collision between ships and whales. Marine Mammal Science, 17: 35-75.

Lewis, R.K. (1981). Seasonal upwelling along the south-eastern coastline of South Australia. Australian Journal of Marine and Freshwater Research, 32: 843-854.

Limpus, C.J. (2002). Australian Marine Turtle Review. A study commissioned by Western Australian Department of Conservation and Land Management, October 2002.

MacLeod and Mitchell (2006) MacLeod, C.D., and Mitchell, G., 2006, 'Key Areas for Beaked Whales Worldwide', Journal of Cetacean Research Vol 7, Part 3.

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, 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, 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.

MMS (2004) Geological and Geophysical Exploration for Mineral Resources on the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment. U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region.

Moriyasu, M, Allain, R, Benhalima, K, and Claytor, R (2004). Effects of seismic and marine noise on invertebrates: A literature Review. Canadian Science Advisory Secretariat research document; 2004/126. Fisheries and Oceans Canada. 50 pp.

OGP (2008) Fundamentals of underwater sound. Report No 406. International Association of Oil and Gas Producers

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.

Pidcock. S, Burton. C and Lunney. M (2003). The potential sensitivity of marine mammals to mining and exploration in the Great Australian Bight Marine Park Marine Mammal Protection Zone. An independent review and risk assessment report to Environment Australia. Natural Heritage Trust.

Poore, G.C.B., Just, J. and Cohen, B.F. (1994). Composition and diversity of crustacea isopoda of the southeastern Australian continental slope. Deep-Sea Research, 41: 677-693.

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

Rochford, D.J. (1980). Nutrient status of the oceans around Australia. Report 1977-1979. CSIRO Division of Fisheries and Oceanography, Hobart.

Sara G., Dean, J.M., D'Amato, D., Buscaino, G., Oliveri, A., Genovese, S., Ferro, S., Buffa, G., Lo Martire, M., Mazzola, S. (2007) Effect of boat noise on behaviour of Bluefin tuna Thunnus thynnus in the Mediterranean Sea. Marine Ecology Progress Series 331:243-253

Schahinger, R.B. (1987). Structure of coastal upwelling events observed off the south-east coast of South Australia during February 1983-April 1984. Australian Journal of Marine and Freshwater Research, 38: 439-459.

Stone, C (2003). The effects of seismic activity on marine mammals in UK waters, 1998 -2000. Joint Nature Conservation Committee Report No. 323. January 2003. 78 pp.

Wardle, C. S., Videler, J. J., Arimoto, T., Franco, J. M. and He, P. (1989). The muscle twitch and the maximum swimming speed of giant bluefin tuna, Thunnus thynnus L. Journal of Fish Biology. 35, 129-137.

Watwood, Miller, Johnson, Madsen and Tyack (2006) Deep-diving foraging behaviour of sperm whales (Physeter macrocephalus). Journal of Animal Ecology. 75: 814-825.

Willcox, J.B. Stagg, H.M.J. and Davies, H.L. (1988). Rig Seismic research cruises 10 and 11: structure, stratigraphy and tectonic development of the Great Australian Bight region – preliminary report. Bureau of Mineral Resources, Australia: Report No. 88/13.

Witherington, BE and Martin, RE (2003). Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Third Edition. Florida Marine Research Institute (FMRI) Technical Report TR-2: 73. Florida Department of Environmental Protection.

Woodside (2002). Gnarlyknots-1 Exploration Well, EPP-29 Summary EP. ENV-627 (DRIMS-no.150034)