NIGHTCAP MULTI-CLIENT MARINE SEISMIC SURVEYS

ENVIRONMENT PLAN – PUBLIC SUMMARY

Pathfinder Energy Pty Ltd

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1 INTRODUCTION

In the North-west Marine Region (NWMR) offshore from Western Australia (WA), the geophysical company Pathfinder Energy Pty Ltd (Pathfinder) proposes to acquire three-dimensional (3D) marine seismic surveys within the Nightcap operational area (Figure 1.1). In accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Environment Regulations), the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) accepted the Nightcap Multi-client Marine Seismic Surveys Environment Plan (EP) Revision 2 on 16 November 2016. The overall purpose of the EP was not only to comply with statutory requirements but also to ensure that the seismic acquisition is planned and conducted in accordance with Pathfinder environmental policies and standards. This EP will also serve as an environment management tool to implement targeted environmental control measures throughout the proposed seismic surveys. No survey activities will occur before 1 January 2017, and the entire EP will be valid for 24 months.

Thus, this EP Summary provides information included in the accepted EP, including the assessment of environmental impacts and risks, which will be managed to as low as reasonably practicable (ALARP) and acceptable levels through the implementation of control measures.

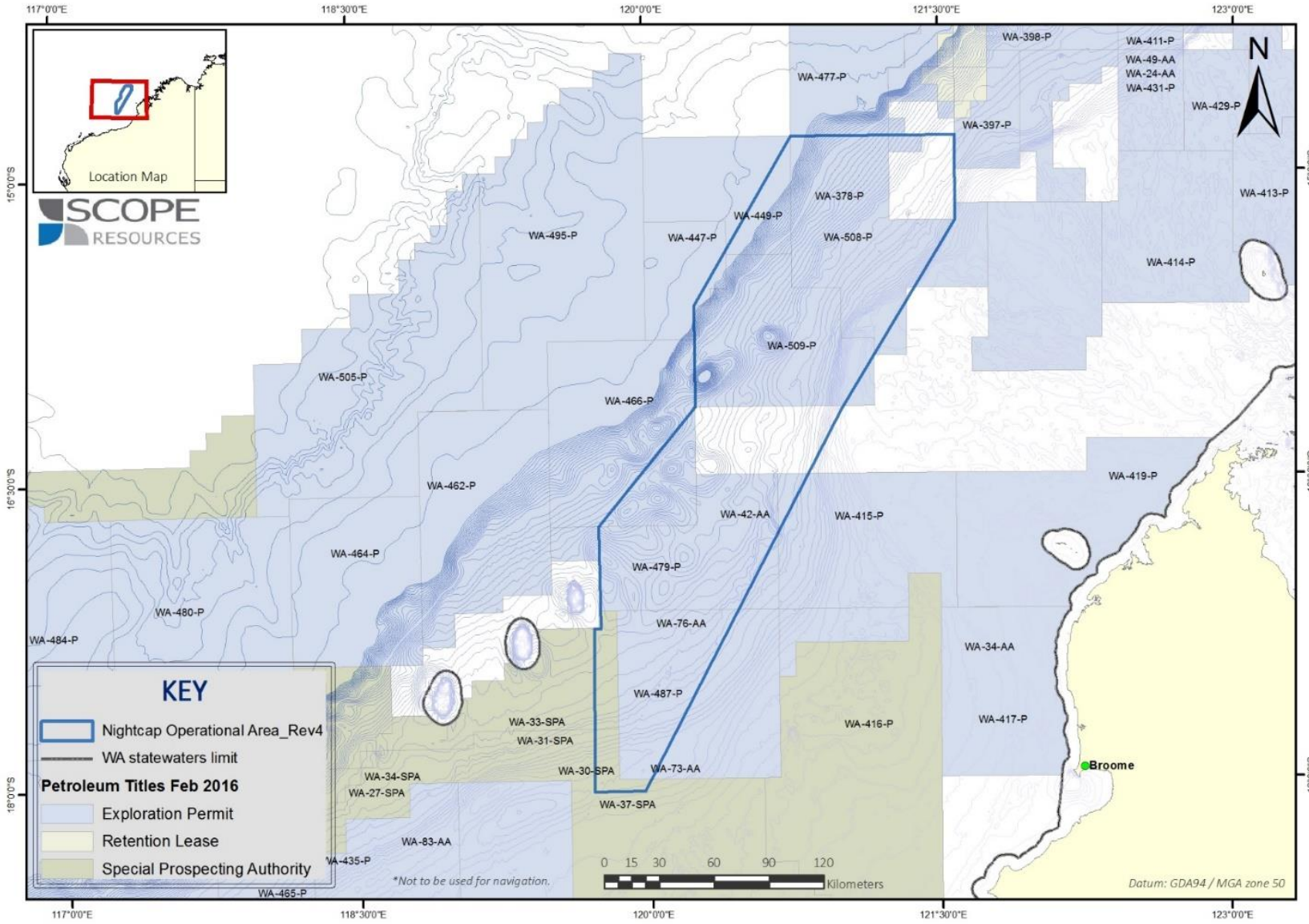


Figure 1.1 - Location of Pathfinder Nightcap MSS operational area

1.1 LOCATION OF THE ACTIVITY

The operational area lies entirely in Commonwealth waters within the NWMR and incorporates Exploration Permits WA-378-P, WA-397-P, WA-415-P, WA-443-P, WA-447-P, WA-449-P, WA-466-P, WA-479-P, WA-477-P, WA-487-P, WA-508-P and WA-509-P and adjacent open acreage areas (Figure 1.1). Pathfinder is the registered titleholder for WA-479-P, WA-487-P, WA-508-P and WA-509-P. Boundary coordinates for the ~30,940 km^2 operational area are listed in Table 1.1.

At the closest point, the operational area is located ~210 km west of Broome on the mainland coast. The southeast corner is located >190 km northwest of Eighty Mile Beach and >70 km south of Scott Reef. The survey area is in close proximity to the Mermaid Reef Commonwealth Marine Reserve (MRCMR) boundary (~4 km) and overlaps the multiple use zone of the proclaimed Kimberley CMR. Located in WA State waters, the boundary of Rowley Shoals Marine Park at Clerke Reef is >30 km to the west of the operational area.

Water depths across the survey area range from ~80–1,300 m, with the deepest water depths situated in the northern half of the survey area. However, seismic activities will not occur in water shallower than 100 m.

1.2 COORDINATES OF THE PROPOSED ACTIVITY

Boundary coordinates for the Nightcap MSS operational area are as follows:

Table 1.1 - Nightcap MSS operational area coordinates

Latitude (S) Decimal Degrees	Longitude (E) Decimal Degrees
-17.2541	119.7187
-17.2541	119.7526
-16.7491	119.7504
-16.2088	120.2136
-15.7262	120.2135
-14.8319	120.7513
-14.832	120.9997
-14.8291	121.5846
-15.2474	121.5846
-15.2486	121.5844
-16.1816	120.9999
-18.0566	119.9692
-18.0573	119.7091
-17.2541	119.7187

Datum: GCS_WGS84

1.3 SEISMIC PROGRAMME

1.3.1 Survey Parameters

In terms of technical methods and procedures, the proposed MSS is a typical 3D survey (Table 1.2) similar to most others conducted in Australian marine waters. No unique or unusual equipment or operations are proposed. No vessels or seismic equipment shall enter the MRCMR or Rowley Shoals Marine Park at any time.

As the vessel travels along the survey lines, the acoustic source will produce a series of noise pulses every 7–8 seconds. These pulses will be directed downward through the water column and seabed. The transmitted sound is attenuated and reflected at geological boundaries. The reflected signals are detected using sensitive microphones arranged along a number of hydrophone cables (i.e. streamers) that are towed behind the survey vessel. The reflected sound is then processed to provide accurate information about the structure and composition of geological formations below the seabed and to identify hydrocarbon reservoirs.

Table 1.2 - Nightcap MSS Acquisition Parameters

Parameter	Nightcap MSS
No. of streamers	12 (solid)
Streamer length	~8,100 m
Streamer spacing	~120 m
Streamer depth	18–25 m
Size of airgun array	~4,240 in^3
Operating pressure	~2,000 psi
Source interval	25 m
Source depth	8 m (+/-1 m)
Frequency range	1–200 Hz
Peak Source Levels (Broadside)	$SPL_{0\text{-}pk}$ 248 dB re 1 µPa $SEL_{per\text{-}pulse}$ 225.2 dB re 1 $\mu Pa^2 \cdot s$
Peak Source Levels (Vertical)	$SPL_{0\text{-}pk}$ 256.9 dB re 1 µPa $SEL_{per\text{-}pulse}$ 232.9 dB re 1 $\mu Pa^2 \cdot s$

1.3.2 Acoustic Source

The volume of the acoustic source was selected to provide a strong signal (i.e. peak amplitude), better signal to noise output, deeper penetration and hence improved data quality. Total energy source volumes vary from survey to survey and are designed to provide sufficient seismic energy to illuminate the geological objective of the survey, whilst minimising environmental disturbance. Recent studies determined that source volumes do not actually correspond linearly with source output levels, and the modelled or theoretical source levels often quoted for seismic source arrays are not directly predictive of the actual received sound levels at distance in the water column. As a reduction in source air volume has a relatively minimal influence on source level, there is minimal scope for reducing the source level of an acoustic array by modifying the operating pressure or the total air volume of the array.

1.3.3 Underwater Acoustic Modelling

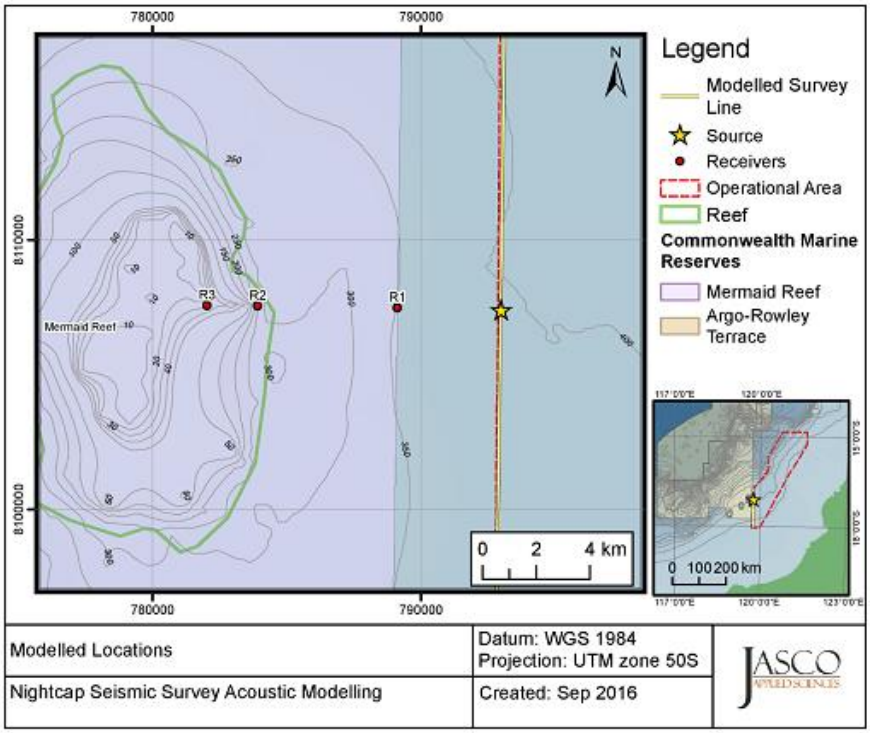
The sound fields associated with a representative airgun array were predicted from a location in the operational area closest to a sensitive habitat (i.e. Mermaid Reef Commonwealth Marine Reserve, MRCMR; McPherson *et al.* 2016). As the actual acoustic array configuration is not confirmed, acoustic modelling was undertaken for a representative 4,240 in^3 array. During the survey, the array configuration is likely to change depending on vessel contractor and equipment. However, to ensure compliance with the EP environmental risk assessment, Pathfinder will ensure that the overall broadband SPL (peak) level will not exceed the peak levels presented in the underwater acoustic modelling.

The array's underwater acoustic signature was predicted with a specialised computer model that accounted for individual airgun volumes and array geometry (McPherson *et al.* 2016). In conjunction with the modelled array signatures, underwater acoustic propagation models estimated sound levels at incremental distances from the source and at three receiver locations: at the CMR boundary (water depth of 398 m), the 250 m isobath and 30 m isobath (
Table 1.3, Figure 1.2).

Table 1.3 – Location details for the acoustic modelling sites

Modelling Site	Location Description	Water Depth (m)
Single-shot site	Inside operational area boundary	398
Start of survey line	Inside operational area boundary	160
End of survey line	Inside operational area boundary	513
Receiver Site 1	On MRCMR boundary; ~4 km from operational area	310
Receiver Site 2	On 250 m isobath; ~9 km from operational area	250
Receiver Site 3	On 30 m isobath; ~11 km from operational area	30

Source: McPherson *et al.* 2016



Source: McPherson *et al.* 2016

Figure 1.2 – Site location for the Pathfinder Nightcap MSS acoustic modelling.

The underwater acoustic modelling predicted the acoustic source levels, modelled the propagation of the sound and assessed distances to selected, impact threshold criteria (McPherson *et al.* 2016). An accurate assessment of the cumulative acoustic field depends not only on the parameters of each pulse, but also on the number of pulses delivered in a given time period and the relative position of the source.

1.3.4 Underwater Acoustic Modelling Results

Acoustic Source Levels

Acoustic propagation models estimated the sound pressure signatures of the individual airguns, and most energy was produced at frequencies below 700 Hz. The peak source levels were presented as zero-to-peak SPLs (i.e. peak pressure level), SPL (rms) and single-shot (i.e. per-pulse) SEL (Table 1.4). Broadside direction is perpendicular to the tow direction, while endfire direction is parallel to the tow direction.

Table 1.4 – Peal source levels in the horizontal plane for the 4,240 in^3 array at an 8 m tow depth

Direction	Peak Pressure Level $SPL_{0\text{-}pk}$ (dB re 1 µPa at 1 m)	SPL_{rms} (dB re 1 µPa at 1 m)	$SEL_{per\text{-}pulse}$ (dB re 1 µPa^2·s at 1 m)	
			10–2,000 Hz	2,000–25,000 Hz
Broadside	248.0	231.7	225.2	186.9
Endfire	247.8	231.9	225.2	189.1
Vertical	256.9	241.1	232.9	199.8

Source: McPherson *et al.* 2016

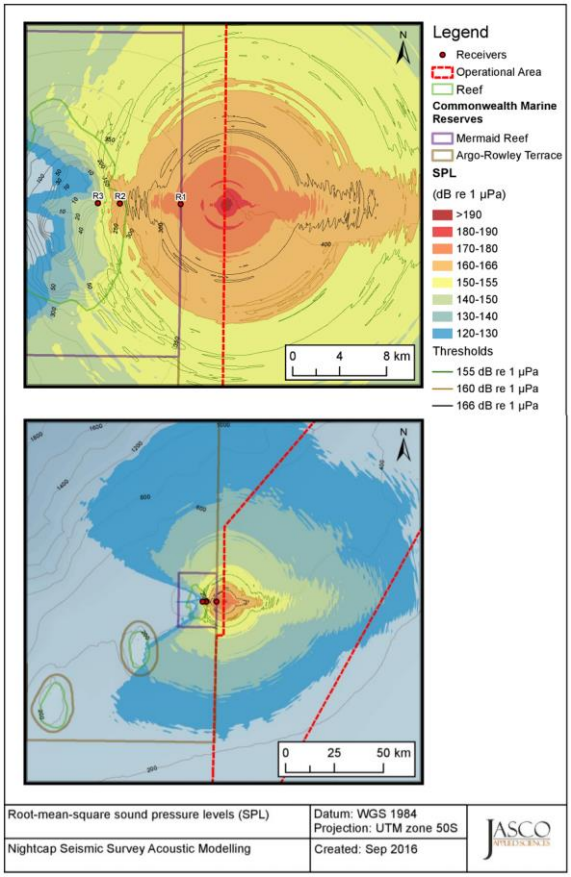
Per-pulse Sound Fields

Acoustic modelling demonstrated that the per-pulse sound fields propagated well at ranges beyond a few kilometres (Figure 1.3 and Figure 1.4). The predicted distances to specific levels were computed from the maximum-over-depth fields, with R95% predicted sound range encompassing at least 95% of the area (in the horizontal plane) that would be exposed to sound at or above that level (Table 1.5).

Table 1.5 – Horizontal distances from the acoustic source to modelled SPL and unweighted $SELp_{er\text{-}pulse}$ isopleths

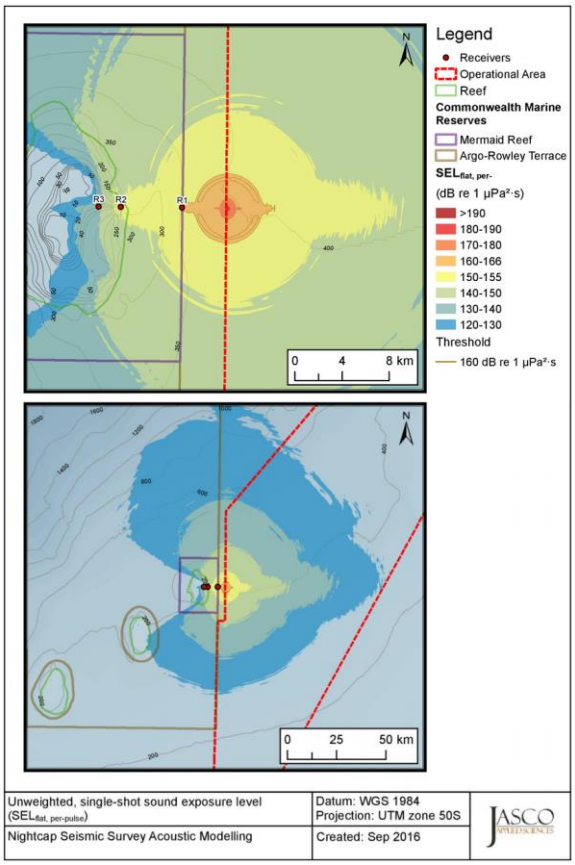
SEL_{flat} (dB re 1 µPa²·s)	Horizontal Distance ($R_{95\%}$ km)	SPL_{rms} (dB re 1 µPa)	Horizontal Distance ($R_{95\%}$ km)
200	0.02	200	0.16
190	0.06	190	0.58
180	0.20	180	2.1
170	0.90	170	6.0
160	3.0	160	15.0
150	10.7	150	26.9
140	24.2	140	46.2
130	43.6	130	66.0
120	78.7	120	95.0

Source: McPherson *et al.* 2016



Source: McPherson *et al.* 2016

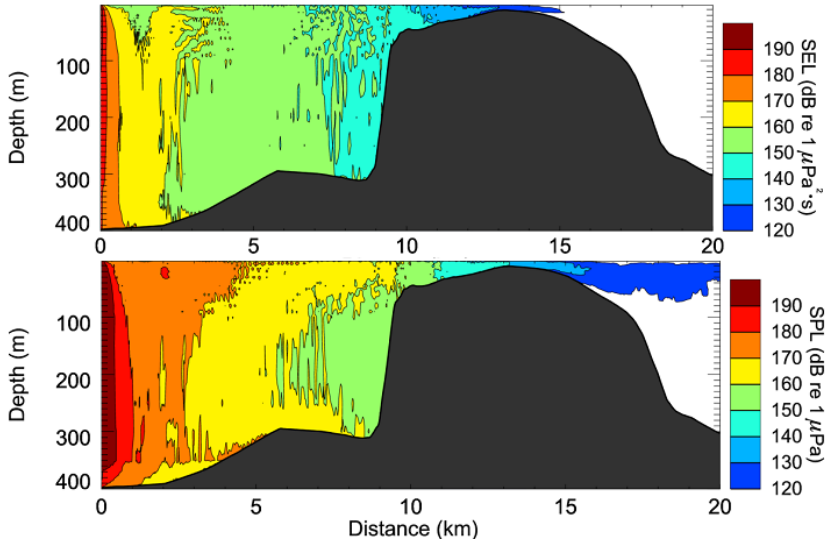
Figure 1.3 – Sound level contour map showing maximum-over-depth (in the water column) SPL results



Source: McPherson *et al.* 2016

Figure 1.4 – Sound level contour map showing maximum-over-depth (in the water column) SEL results

From the single-shot acoustic source, acoustic modelling predicted the long-range sound fields toward Mermaid Reef (Figure 1.5) and toward open water. These results demonstrated that sound transmission in both directions had different propagation characteristics, most notable of which was the effect caused by the seabed topography at Mermaid Reef, where the steep incline and depth change prevented most of the higher-intensity sound levels from entering the shallower waters of the inner reef and lagoons.



Source: McPherson *et al.* 2016

Figure 1.5 – Predicted unweighted per-pulse SEL (top) and SPL (bottom) for the 4,240 in^3 array as a vertical slice toward Mermaid Reef. Levels are show along the port broadside direction to illustrate the propagation paths and bathymetry effect.

Under the EPBC Act Policy Statement 2.1, the horizontal radius of the Low power zone is based on sound levels that whales are likely to hear (i.e. 160 dB re 1 $\mu Pa^2 \cdot s$ SEL). Acoustic modelling results predicted that the estimated distance to this threshold level was 3 km from the sound source. Therefore, based on the acoustic modelling results and as required by the *EPBC Act Policy Statement 2.1*, the following precaution zones will be applied for the Nightcap MSS operational area:

- Observation zone: 3+ km horizontal radius from the acoustic source
- Low power zone: 2 km horizontal radius from the acoustic source
- Shut-down zone: 500 m horizontal radius from the acoustic source.

Accumulated SEL over 24 Hours

The acoustic modelling estimated the accumulated SELs over 24 hours from a representative seismic survey line, which was 145 km long and at the closest location to the Mermaid Reef CMR (Table 1.6).

Table 1.6 – M-weighted (low, mid and high-frequency cetaceans) and unweighted (fish) SEL values predicted at each acoustic modelling receiver location and integrated over 24 hours of a representative survey line for the 4,240 in^3 array

Receiver Location	SEL_{LFC} (dB re 1 $\mu Pa^2 \cdot s$)		SEL_{MFC} (dB re 1 $\mu Pa^2 \cdot s$)		SEL_{HFC} (dB re 1 $\mu Pa^2 \cdot s$)		SEL_{flat} (dB re 1 $\mu Pa^2 \cdot s$)	
	Max over depth	At seafloor	Max over depth	At seafloor	Max over depth	At seafloor	Max over depth	At seafloor
Site 1 (MRCMR boundary)	184.2	180.5	176.4	171.6	174.6	169.6	184.7	181.0
Site 2 (250 m isobath)	177.4	173.5	171.4	165.9	169.7	164.2	177.8	174.1
Site 3 (30 m isobath)	166.5	166.2	161.0	159.4	159.7	157.8	166.8	166.6

Source: McPherson *et al.* 2016

1.4 VESSELS

1.4.1 Seismic Survey Vessels

Pathfinder will ensure that all vessels contracted for the Nightcap MSS will have valid certifications and registrations applicable for the proposed activity and operate in full compliance with relevant MARPOL and SOLAS convention requirements that are specific for the vessel's size and purpose. A purpose-built seismic survey vessel will be contracted to undertake the proposed MSS. The survey vessel may have an overall length of ~95 m and contain standard equipment and facilities required for 3D MSS operations. With the exception of emergency conditions, the survey vessel will not anchor at sea.

1.4.2 Support Vessel

A support vessel will be contracted to provide logistical and safety support throughout the proposed MSS. For example, the support vessel will maintain a safe distance between the acoustic array and other vessels and assist in managing interactions with shipping and fishing activities, as required. The support vessel may have a crew of ~15 personnel, and supply the survey vessel with fuel and/or other supplies. With the exception of emergency conditions, the support vessel will not anchor at sea.

1.5 SURVEY VESSEL REFUELLING

The Nightcap MSS is likely to require refuelling at sea using the support vessel within or immediately adjacent to the operational area. In accordance with the contract vessel's procedures, refuelling may occur at sea during daylight hours only and will not occur within a distance of 25 km from any emergent land or shallow water features (i.e. 30 m water depth).

2 DESCRIPTION OF THE RECEIVING ENVIRONMENT

In accordance with Regulation 13(2) of the Environment Regulations, a description of the existing environment that may potentially be affected by planned and unplanned activities relating to the Nightcap MSS is presented in this section. It includes a description of relevant natural, cultural and socio-economic aspects of the environment, as well as details of relevant values and sensitivities.

2.1 PHYSICAL SETTING

The Nightcap MSS operational area lies entirely within Commonwealth marine waters of the NWMR, which is composed primarily of continental slope and continental shelf. Other features (such as canyons, plateaux, terraces, ridges, reefs, banks and shoals) occupy less space in the region but have relatively high importance for productivity and biodiversity (DEWHA 2008a). Over half of the total area of banks and shoals across Australia's marine jurisdiction occur within the NWMR.

The NWMR is dominated by marine carbonates (on average 60%) with the highest carbonate contents occurring on the shelf, including areas associated with reefs and algal banks/shoals. Sediment transport on the shelf is largely influenced by tidal currents, while on the slope and abyssal plains, it is mostly influenced by large ocean currents and slope processes (Baker *et al.* 2008).

2.1.1 Key Ecological Features

Three Key Ecological Features (KEF) are located within the Nightcap MSS operational area: the Ancient Coastline at 125 m depth contour, Continental Slope Demersal Fish Communities and Mermaid Reef and Commonwealth waters surrounding Rowley Shoals (Table 2.1 and Figure 2.1).

Table 2.1 – Key Ecological Features within Nightcap MSS Operational Area

KEF	Overlap in Operational Area	Values	Description
Ancient Coastline at 125 m depth contour	• <10% KEF • water depth >100 m	Unique seafloor feature with ecological properties of regional significance	Parts of the ancient coastline, particularly where it exists as a rocky escarpment, provide biologically important habitats in areas otherwise dominated by soft sediments. The topographic complexity of these escarpments facilitate vertical mixing of the water column, providing relatively nutrient-rich local environments.
Continental slope demersal fish communities	• <50% KEF • water depth >200 m	High levels of endemism	The diversity of demersal fish assemblages on the continental slope in the Timor Province, the Northwest Transition and the Northwest Province is high compared to elsewhere along the continental slope.
Mermaid Reef and Commonwealth waters surrounding Rowley Shoals	• <1% KEF • water depth >300 m	High productivity and aggregations of marine life	The Rowley Shoals (including Mermaid Reef) are areas of enhanced productivity and high species richness, facilitated by mixing nutrients from deep water (500–700 m). The reef habitat with steep changes in slope attract migratory pelagic species such as dolphins, tuna, billfish and sharks.

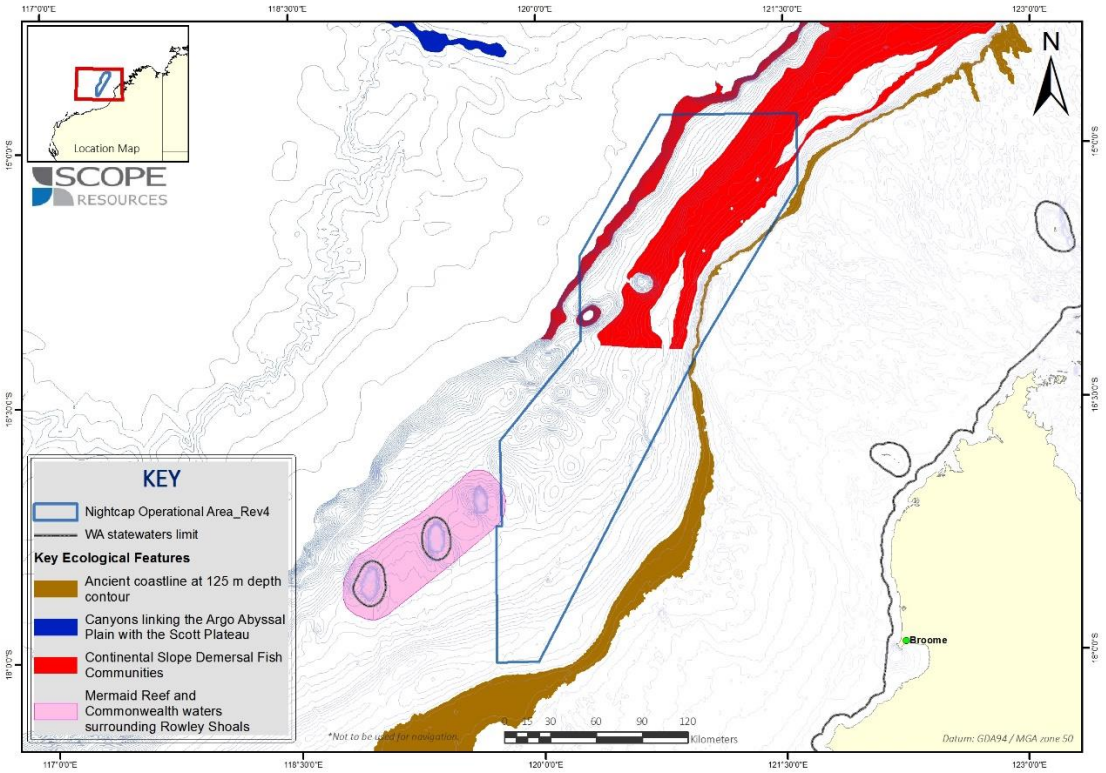


Figure 2.1 - Nightcap MSS Operational Area and Key Ecological Features

2.2 BIOLOGICAL ENVIRONMENT

2.2.1 Productivity and Plankton Communities

Seasonal changes in the region's oceanography are the primary drivers of biological productivity in the NWMR. These include: weakening of the Indonesian Throughflow and Leeuwin Current; the seasonal reversal in wind direction, which supports the development of currents such as the Ningaloo Current; conditions more favourable for upwelling on the NWS; and episodic events such as cyclones. As a result of the periodic nature of these changes, biological productivity follows sporadic and significant cycles that are geographically dispersed (DEWHA 2007). The offshore water of the NWMR are oligotrophic and planktonic abundances are likely to be low, and are characterised by high species diversity but relatively low endemicity. Bentho-pelagic fish (those that occur in water depths of ~200–1,000 m) are a vital link in the trophic systems of the Region (Brewer *et al.* 2007). As fish migrate vertically between the pelagic and benthic (seafloor) systems, they consume nutrients and aid in the transfer of the nutrients between the two systems.

2.2.2 Biological Communities

Most of the NWMR species are tropical and found in other parts of the Indian and western Pacific oceans. The NWMR has high species diversity, but with fewer endemic species than cooler and more temperate waters. The high species richness of the NWMR is associated with the diversity of habitats available, such as hard seafloor areas (e.g. limestone pavements on the NWS), submerged cliffs and coral reefs of the Kimberley, and atolls and reefs on the edge of the NWS. These habitats support a high diversity of benthic filter feeders and producers.

The NWMR supports internationally-important breeding and feeding grounds for a number of threatened and migratory marine species that transit through the bioregion, including humpback whales, which mate and give birth in the waters off the Kimberley coast. Significant turtle rookeries are found on coastal beaches and offshore islands and the surrounding waters provide important resting and internesting (i.e. in between egg laying periods) habitats (DEWHA 2007, 2008a). Most of the NWMR species are tropical and found in other parts of the Indian and western Pacific oceans. The NWMR has high species diversity, but with fewer endemic species than cooler and more temperate waters. The region contains more coastal and shelf fish species than anywhere else on the WA coast, particularly in the Kimberley and the NWS, and is home to globally-significant populations of

internationally threatened species. The region's high species richness partially reflects its strong biogeographic links with Indonesia and the west Pacific through the ITF (DEWHA 2012a).

The high species richness of the NWMR is said to be associated with the diversity of habitats available. These include hard seafloor areas (e.g. limestone pavements on the NWS), submerged cliffs and coral reefs of the Kimberley, and atolls and reefs on the edge of the NWS. These habitats support a high diversity of benthic filter feeders and producers. Fish spawning in summer/autumn in the Kimberley is thought to correspond with peaks in production and current movements. There is a strong delineation in demersal slope fish communities in the Kimberley in comparison to systems further south.

The NWMR supports internationally-important breeding and feeding grounds for a number of threatened and migratory marine species that transit through the bioregion, including humpback whales, which mate and give birth in the waters off the Kimberley coast. Significant turtle rookeries are found on coastal beaches and offshore islands and the surrounding waters provide important resting and internesting (i.e. in between egg laying periods) habitats (DEWHA 2007, 2008a).

2.2.2.1 Benthic Communities

Much of the NWMR's outer mid-shelf is covered by a relatively featureless, sandy-mud seabed with a sparse covering of sessile organisms dominated by filter-feeding heterotrophs such as gorgonians, sponges, soft corals, and detritus-feeding crabs and echinoderms. This is especially true of the non-trawled areas in the deeper water, and the soft-bottomed rises (Heyward *et al.* 1997). However, the many limestone banks are likely to be a key ecological feature of this region. They have a harder substrate and are likely to support a more diverse range of sessile benthos such as hard and soft corals, gorgonians, encrusting sponges and macroalgae; and consequently, a more reef-associated fish fauna. Although these waters may be relatively oligotrophic for part of the year, these communities probably rely on primary productivity from phytoplankton and commensal zooxanthellae within hard corals (Brewer *et al.* 2007).

Coral reef communities are naturally highly dynamic ecosystems, with especially high species diversity, and there is a distinct zonation in reef types. Coral communities, including patch or fringing reefs occur in shallow water, sub tidal environments of the NWMR, as well as around intertidal areas adjacent to islands and other emergent features (DEWHA 2007). Significant areas of coral reefs within the NWMR include the Rowley Shoals, of which Mermaid Reef is within close proximity to the Nightcap MSS operational area. The Rowley Shoals are a hotspot for biodiversity in this bioregion and contain intertidal and sub-tidal coral reefs. These reefs support a diverse marine fauna typical of oceanic coral reef communities of the Indo-west Pacific. The reefs are important stepping-stones in the maintenance of gene flow among the northwest Australian coral reefs.

The NWMR contains a high diversity of crustaceans across a range of habitats, from intertidal sites to the deeper waters of the slope and the abyss. Dominant species groups include prawns, scampi and crabs. In addition to providing a prey resource for large pelagic fish, crustaceans are also a significant food for cephalopods such as squid and octopus (DEWHA 2008a). The North West Slope Trawl Fishery (NWSTF) targets scampi in the NWMR. Data from the fishery suggested that muddy sediments support significant populations of crustaceans (Fletcher & Santoro 2015).

The NWMR supports a diverse assemblage of fish, particularly in shallow water near the mainland and around islands. Most fish have tropical distributions and are well-distributed throughout the Indo-west Pacific region. Pelagic fish are highly mobile and have a wide geographic distribution (DEWHA 2008a). The NWMR also supports large populations of cartilaginous fish such as sharks and rays, which are typically higher-order predators and perform an important ecological role of prey species regulation. Shark species abundance and diversity are considerable on the Rowley Shoals and Mermaid Reef, and fish species richness around atolls increases in a northerly direction and as reefs get closer to Indonesia, which is a centre for reef fish diversity. The Rowley Shoals have over 500 species of fish inhabitants, including many species not found on nearshore coral reefs. In relation to the proposed Nightcap MSS operational area, site-attached fish are only located around the reefs of the Rowley Shoals.

2.2.3 Protected Marine Species

The Nightcap operational area supports marine species that are listed as threatened and/or migratory under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). These protected species are listed in Table 2.2.

Table 2.2 – Species protected under the EPBC Act that may occur in the Nightcap MSS operational area.

Species	Common name	Protection status	Threatened status	Migratory status
Cetaceans (Whales and Dolphins)				
Balaenoptera bonaerensis	Antarctic Minke Whale	Cetacean	-	Migratory
Balaenoptera borealis	Sei Whale	Cetacean	Vulnerable	Migratory
Balaenoptera edeni	Bryde's Whale	Cetacean	-	Migratory
Balaenoptera musculus	Blue Whale	Cetacean	Endangered	Migratory
Balaenoptera physalus	Fin Whale	Cetacean	Vulnerable	Migratory
Delphinus delphis	Common Dolphin	Cetacean	-	-
Feresa attenuata	Pygmy Killer Whale	Cetacean	-	-
Globicephala macrorhynchus	Short-finned Pilot Whale	Cetacean	-	-
Grampus griseus	Risso's Dolphin	Cetacean	-	-
Kogia breviceps	Pygmy Sperm Whale	Cetacean	-	-
Kogia simus	Dwarf Sperm Whale	Cetacean	-	-
Lagenodelphis hosei	Fraser's Dolphin	Cetacean	-	-
Megaptera novaeangliae	Humpback Whale	Cetacean	Vulnerable	Migratory
Mesoplodon densirostris	Blainville's Beaked Whale	Cetacean	-	-
Orcinus orca	Killer Whale	Cetacean	-	Migratory
Peponocephala electra	Melon-headed Whale	Cetacean	-	-
Physeter macrocephalus	Sperm Whale	Cetacean	-	Migratory
Pseudorca crassidens	False Killer Whale	Cetacean	-	-
Stenella attenuata	Spotted Dolphin	Cetacean	-	-
Stenella coeruleoalba	Striped Dolphin	Cetacean	-	-
Stenella longirostris	Long-snouted Spinner Dolphin	Cetacean	-	-
Steno bredanensis	Rough-toothed Dolphin	Cetacean	-	-
Tursiops aduncus	Indian Ocean Bottlenose Dolphin	Cetacean	-	-
Tursiops aduncus	Spotted Bottlenose dolphin (Arafura / Timor Sea populations)	Cetacean	-	Migratory
Tursiops truncatus s. str.	Bottlenose Dolphin	Cetacean	-	-
Ziphius cavirostris	Cuvier's Beaked Whale	Cetacean	-	-
Marine Turtles				
Caretta caretta	Loggerhead Turtle	Listed	Endangered	Migratory
Chelonia mydas	Green Turtle	Listed	Vulnerable	Migratory
Dermochelys coriacea	Leatherback Turtle	Listed	Endangered	Migratory
Eretmochelys imbricata	Hawksbill Turtle	Listed	Vulnerable	Migratory
Lepidochelys olivacea	Olive Ridley Turtle	Listed	Endangered	Migratory
Natator depressus	Flatback Turtle	Listed	Vulnerable	Migratory
Sea Snakes				
Acalyptophis peronii	Horned Sea snake	Listed	-	-
Aipysurus duboisii	Dubois' Sea snake	Listed	-	-
Aipysurus eydouxii	Spine-tailed Sea snake	Listed	-	-
Aipysurus laevis	Olive Sea snake	Listed	-	-
Aipysurus tenuis	Brown-lined Sea snake	Listed	-	-
Astrotia stokesii	Stokes' Sea snake	Listed	-	-
Disteira kingii	Spectacled Sea snake	Listed	-	-
Disteira major	Olive-headed Sea snake	Listed	-	-
Emydocephalus annulatus	Turtle-headed Sea snake	Listed	-	-

Species	Common name	Protection status	Threatened status	Migratory status
Ephalophis greyi	North-western Mangrove Sea snake	Listed	-	-
Hydrophis elegans	Elegant Sea snake	Listed	-	-
Hydrophis mcdowelli	null	Listed	-	-
Hydrophis ornatus	Spotted Sea snake	Listed	-	-
Lapemis hardwickii	Spine-bellied Sea snake	Listed	-	-
Pelamis platurus	Yellow-bellied Sea snake	Listed	-	-
Sharks & Rays				
Carcharodon carcharias	Great White Shark	Listed	Vulnerable	Migratory
Isurus oxyrinchus	Shortfin Mako	Listed	-	Migratory
Isurus paucus	Longfin Mako	Listed	-	Migratory
Manta birostris	Giant Manta Ray	Listed	-	Migratory
Manta alfredi	Reef Manta Ray	Listed	-	Migratory
Pristis pristis	Largetooth Sawfish	Listed	Vulnerable	-
Pristis zijsron	Green Sawfish	Listed	Vulnerable	-
Rhincodon typus	Whale Shark	Listed	Vulnerable	Migratory
Ray-finned Fishes				
Bhanotia fasciolata	Corrugated Pipefish, Barbed Pipefish	Listed	-	-
Campichthys tricarinatus	Three-keel Pipefish	Listed	-	-
Choeroichthys brachysoma	Pacific Short-bodied Pipefish	Listed	-	-
Choeroichthys suillus	Pig-snouted Pipefish	Listed	-	-
Corythoichthys amplexus	Fijian Banded Pipefish	Listed	-	-
Corythoichthys flavofasciatus	Reticulate Pipefish	Listed	-	-
Corythoichthys intestinalis	Australian Messmate Pipefish	Listed	-	-
Corythoichthys schultzi	Schultz's Pipefish	Listed	-	-
Cosmocampus banneri	Roughridge Pipefish	Listed	-	-
Doryrhamphus dactyliophorus	Banded Pipefish	Listed	-	-
Doryrhamphus excisus	Bluestripe Pipefish	Listed	-	-
Doryrhamphus janssi	Cleaner Pipefish	Listed	-	-
Filicampus tigris	Tiger Pipefish	Listed	-	-
Halicampus brocki	Brock's Pipefish	Listed	-	-
Halicampus dunckeri	Red-hair Pipefish	Listed	-	-
Halicampus grayi	Mud Pipefish	Listed	-	-
Halicampus spinirostris	Spiny-snout Pipefish	Listed	-	-
Haliichthys taeniophorus	Ribboned Seadragon	Listed	-	-
Hippichthys penicillus	Beady Pipefish	Listed	-	-
Hippocampus angustus	Western Spiny Seahorse	Listed	-	-
Hippocampus histrix	Spiny Seahorse	Listed	-	-
Hippocampus kuda	Spotted Seahorse	Listed	-	-
Hippocampus spinosissimus	Hedgehog Seahorse	Listed	-	-
Micrognathus micronotopterus	Tidepool Pipefish	Listed	-	-
Solegnathus hardwickii	Pallid Pipehorse	Listed	-	-
Solegnathus lettiensis	Gunther's Pipefish	Listed	-	-
Solenostomus cyanopterus	Robust Ghost Pipefish	Listed	-	-
Solenostomus paegnius	Rough-snout Ghost Pipefish	Listed	-	-
Syngnathoides biaculeatus	Double-end Pipehorse	Listed	-	-
Trachyrhamphus bicoarctatus	Bentstick Pipefish	Listed	-	-
Trachyrhamphus longirostris	Straightstick Pipefish; Long-nosed Pipefish	Listed	-	-
Seabirds and Shorebirds				

Species	Common name	Protection status	Threatened status	Migratory status
Calidris ferruginea	Curlew Sandpiper	Listed	Critically Engangered	Migratory Wetland species
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Listed	Critically Engangered	Migratory Wetland species
Calonectris leucomelas	Streaked Shearwater	Listed	-	Migratory
Pandion haliaetus	Osprey	Listed	-	Migratory Wetland species
Phaethon lepturus	White-tailed Tropicbird	Listed	-	Migratory

Source: The Department of the Environment and Energy 2016a

The Nightcap MSS operational area does not overlap any habitat that is critical to the survival of a protected species. Similarly, there are no EPBC Act-listed threatened ecological communities in the operational area. However, within or adjacent to the Nightcap MSS operational area, a few of the protected marine fauna species have overlapping Biologically Important Areas (BIAs), such as breeding, nesting, foraging areas. The likelihood of a threatened species in the Nightcap MSS operational area and surrounding waters is summarised in the following sections.

2.2.3.1 Mysticetes (Baleen Whales)

Four mysticetes or baleen whale species are likely to occur within the operational area. However, only two of these species have a Threatened status under the EPBC Act: the blue whale (Endangered) and the humpback whale (Vulnerable). While there are no known foraging BIAs within the Nightcap operational area, the latter overlaps the known distribution and migration BIA for pygmy blue whales. During their annual migration along WA coastline, migrating pygmy blue whales may be encountered throughout the operational area. The Nightcap MSS operational area overlaps the pygmy blue whale distribution area, although less than half of the operational area intersects with the primary migratory pathway where the migration route is >250 km wide. The deepest waters of the operational area are ~1,300 m, and given that the pygmy blue whale migratory pathway is centred on the 500 m contour, individuals are likely to be encountered. Given the timing and progression of migration, and based on annual acoustic detections at Scott Reef (>190 km north; Department of the Environment and Energy 2016b), migrating pygmy blue whales are expected to travel through the Nightcap MSS operational area on their southbound migration from September–December. During their northern migration, they may be encountered in the deeper waters of the operational area from April–July, particularly as anecdotal sightings of pygmy blue whales have been documented at Mermaid Reef in June 2008 (Jenner *et al.* 2009).

While overlapping with known distribution area, the Nightcap operational area is located >70 km from the identified humpback whale migration corridor. Based on the operational area's substantial distance offshore (>150 km to the coast) and in deep water (up to 1,300 m), it is unlikely that significant numbers of migrating humpback whales will be encountered during proposed survey activities. While humpback whales are known to occur along the Ancient Coastline KEF, the overlap with the operational area comprises a small proportion (<10%) of the total KEF. However, as the Group D population abundance is increasing at remarkable rates (TSSC 2015a, Bejder *et al.* 2015, IWC 2011, Hedley *et al.* 2011), individual humpback whales are likely to be observed within the eastern portions of the operational area as they migrate to and from their known calving grounds in Camden Sound (>500 km away). Overall, the occurrence of humpback whales in the Nightcap operational area is expected to be temporary and low.

Other baleen whale species are likely to occur within the Nightcap operational area. These include sei whales, fin whales, Bryde's whales and the Antarctic minke whales). However, based on the deep, offshore waters of the operational area, significant numbers of these baleen whales species are not expected.

Eighteen species of odontocetes or toothed whales and dolphins are likely to occur within the Nightcap operational area. However, only three of these species are also protected with a Migratory status: the killer

whale, sperm whale and spotted bottlenose dolphin (Arafura/Timor Sea populations). With no critical habitats or BIAs overlapping the operational area, observations of odontocetes are likely to be rare and infrequent.

2.2.3.2 Sharks and Rays

Within the Nightcap operational area, several species of sharks, rays and sawfish may be encountered, including great white sharks, whale sharks, manta rays, largetooth sawfish and green sawfish. Based on their habitat preference of shallow, inshore waters of rivers and estuaries of northern Australia, it is unlikely that either the largetooth or green sawfish will be encountered in the offshore waters of the Nightcap MSS operational area. There are no known aggregation sites or critical habitats for great white sharks in the NWMR (DSEWPaC 2013), and observations of great white sharks are not expected within the Nightcap MSS operational area. A foraging BIA for whale sharks overlaps the northeast and southern edges of the Nightcap MSS operational area. During the whale shark migration period, it is likely that whale sharks may be encountered during the proposed survey activities. However, due to low population abundance estimates as well as unknown and irregular movements, it is not expected that whale sharks will be encountered in significant numbers in the operational area, and any observation of whale sharks are likely to be rare and infrequent.

2.2.3.3 Marine Turtles

Six marine turtle species may occur within or in the waters surrounding the Nightcap MSS operational area: green, hawksbill and flatback turtles (Vulnerable and Migratory); and the loggerhead, leatherback and olive ridley turtles (Endangered and Migratory). There are no breeding, nesting or foraging sites for marine turtles overlapping the operational area, and the closest marine reptile BIA is located >100 km away. While some marine turtles occur within the Rowley Shoals Marine Park (DEC 2007) and in and around Mermaid Reef (DNP 2013), these reefs are not considered critical habitats for marine reptiles, and there are no known significant breeding sites for marine turtles within the Rowley Shoals Marine Park (Environment Australia 2003). Thus, it is reasonable to conclude that low numbers of marine turtles may transit through the operational area and migrate along the continental shelf toward their foraging habitats. However, based on the remote distance offshore and the absence of critical habitats or BIAs, it is highly unlikely that significant numbers of the marine turtles will occur within the Nightcap MSS operational area, and their occurrence is expected to be rare and infrequent.

2.2.3.4 Sea Snakes

Fourteen species of sea snakes are protected under the EPBC Act as marine species and may occur within or adjacent to the operational area (Table 2.2). However, given the operational area's deep water depths (80–1,300 m) and substantial distance from shore, it is unlikely that large numbers of sea snakes will be encountered within the Nightcap MSS operational area, and any occurrence will likely be rare and infrequent.

2.2.3.5 Seabirds and Shorebirds

Four migratory bird species may occur within the Nightcap MSS operational: white-tailed tropicbird, little tern, streaked shearwater and osprey. The nearest emergent land features to the Nightcap MSS operational area are the Rowley Shoals, in which Bedwell Island (connected to Clerke Reef >30 km away) is recognised as a breeding and foraging BIA for a single pair of white-tailed tropicbirds (DSEWPaC 2012a). Although white-tailed tropicbirds may fly over the Nightcap MSS operational area, it is unlikely that significant numbers will be encountered, particularly since only a single pair is known to occur at the Rowley Shoals. Bedwell Island and Cunningham Island (connected to Imperieuse Reef) are also identified as a resting BIA for the little tern. While the little tern is classified as a non-breeding visitor, they utilise the offshore reefs and islands of the Rowley Shoals as resting areas. However, as the resting BIA does not overlap with the operational area, significant numbers of little terns are unlikely to be encountered during the survey, and observations would be limited to transient individuals during their migration between their breeding grounds and the offshore areas of the NWS.

While common in Australia, the osprey is found mostly in coastal areas and wetland habitats, with a preference for high cliffs and elevated islands, none of which occur within the operational area. Thus, while these birds are known to travel great distances to forage (DoE 2016b), the likelihood of encountering an osprey within the Nightcap MSS operational area is expected to be rare and infrequent. Therefore, although streaked shearwaters may occur offshore and forage in open waters, it is unlikely that significant numbers of this species will be encountered within the Nightcap MSS operational area, especially given their migratory presence mostly in the northern regions of Australia.

2.3 SOCIO-ECONOMIC ENVIRONMENT

2.3.1 Commercial Fisheries

The following WA state fisheries are administered by the Department of Fisheries and authorised to operate within the proposed Nightcap MSS operational area:

- Mackerel Managed Fishery
- Northern Demersal Scalefish Managed Fishery
- Pilbara Demersal Scalefish Fisheries
    - Pilbara Fish Trawl (Interim) Managed Fishery
    - Pilbara Trap Managed Fishery
    - Pilbara Line Fishery
- Pearl Oyster Managed Fishery
- North Coast Prawn Managed Fishery
    - Broome Prawn Managed Fishery
    - Onslow Prawn Managed Fishery
    - Nickol Bay Prawn Managed Fishery
- West Coast Deep Sea Crustacean Managed Fishery (WCDSCF).

Commercial Commonwealth fisheries managed by the Australian Fisheries Management Authority (AFMA) that can operate in the Nightcap MSS operational area include the following:

- North West Slope Trawl Fishery (NWSTF)
- Western Skipjack Tuna Fishery
- Western Tuna and Billfish Fishery.

However, commercial fisheries with current fishing effort that does not overlap the Nightcap MSS operational area have not been described in this EP.

2.3.2 Marine Parks and Reserves

The Nightcap MSS operational area overlaps two Commonwealth Marine Reserves (CMR) and is adjacent to a third CMR and one WA State marine parks (Figure 2.2):

- Argo-Rowley Terrace CMR - Multiple Use Zone, IUCN category VI
- Kimberley CMR – Multiple Use Zone, IUCN category VI
- Mermaid Reef CMR - Strict Nature Reserve, IUCN category Ia
- Rowley Shoals Marine Park.

Until management plans come into effect for the Argo-Rowley Terrace and Kimberley CMRs, transitional management arrangements apply, and there are no changes on the water for users of the new proposed reserves (i.e. seismic surveys are permitted to take place within any zone of the proposed CMR). Under these arrangements, CMRs are managed in a manner consistent with the arrangements that applied to the reserve area prior to the Proclamation of the current Network reserves (DoE 2015c). Therefore, the Mermaid Reef CMR is currently being managed under the former management plan, *Mermaid Reef Marine National Nature Reserve Plan of Management 2000-2007* (DNP 2000).

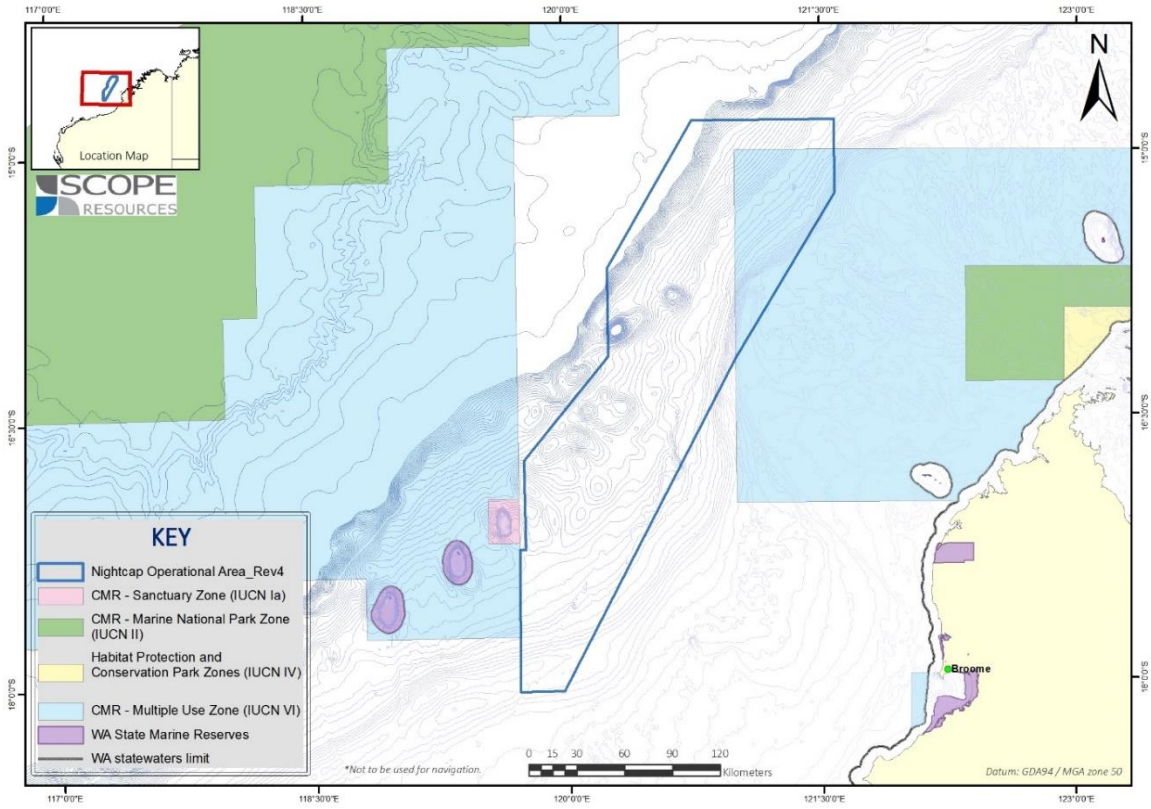


Figure 2.2 Commonwealth Marine Reserves and WA State Marine Parks in the vicinity of the Nightcap MSS

The Argo-Rowley Terrace CMR's IUCN category VI Multiple Use Zone overlaps the southwest portion of the operational area, and water depths in this zone are >230 m and not associated with any marine fauna BIA. This zone is managed for the ecologically sustainable use of natural ecosystems while ensuring long-term protection of the biological diversity and natural values. Several activity types are permitted within this multiple use zone, including mining and seismic exploration.

The Kimberley CMR's IUCN category VI zone overlaps the operational area and is not associated with any marine fauna BIA. This section of the KCMR intersects ~4,700 km^2 of the northeast corner of the Nightcap MSS operational area, representing a small portion (<7%) of the total Kimberley CMR. Minimum water depth in this overlap area is 80 m.

Although the Nightcap MSS operational area does not overlap or intersect with the Mermaid Reef CMR (Figure 2.3), Pathfinder recognises the values of the CMR and will make every effort to comply with strategic management objectives by not towing deployed equipment through or undertaking seismic acquisition activities within the MRCMR. Therefore, based on the proposed management controls and lack of overlapping areas, it is unlikely that the proposed survey activities will have a significant impact on the values and sensitive features of the MRCMR.

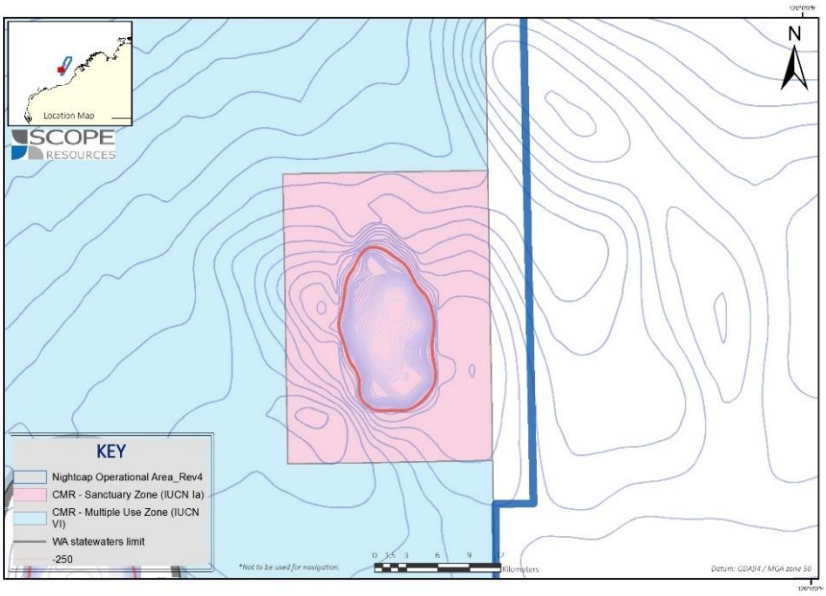


Figure 2.3 - Mermaid Reef CMR and the Nightcap MSS operational area boundary

2.3.2.1 WA State Marine Reserve

Rowley Shoals Marine Park

The Nightcap MSS operational area does not overlap the Rowley Shoals Marine Park, the boundary of which is >30 km away at Clerke Reef and >70 km away at Imperieuse Reef. The Rowley Shoals Marine Park (Figure 2.4) is characterised by intertidal and subtidal coral reefs, diverse marine fauna and high water quality. These attributes and the low level of use contribute to the Park's unique wilderness qualities, which are a significant attraction for visitors. Due to contrasting depths, the Rowley Shoals support a diverse marine invertebrate community, including a number of endemic species. Invertebrate species (excluding corals) at the Rowley Shoals include sponges, cnidarians (e.g. jellyfish, anemones), worms, bryozoans (e.g. sea mosses), crustaceans (e.g. crabs, lobsters, etc.), molluscs (e.g. cuttlefish, baler shells, giant clams, etc.), echinoderms (e.g. starfish, sea urchins) and sea squirts (DEC 2007). The remoteness of Rowley Shoals and low use ensured that the marine environment of the is in a near natural state, particularly relative to other reefs in the Indo-West Pacific region which are subject to intense, human pressures and destructive fishing practices.

Imperieuse Reef (Figure 2.4) is ~16 km x ~8 km and rises steeply from the surrounding ocean floor, which is 230 m deep. On the south-eastern edge of the reef, coral boulders rise ~3 m above the water mark. Large areas of the reef dry out at low water, and there are two lagoons that contain coral patches. Cunningham Islet is a small sand cay 3.7 m high and devoid of vegetation. It is located close within the northern extremity of the reef and is surrounded by a small lagoon, 93 m wide. Clerke Reef (Figure 2.4) lies ~23 km north-west of Imperieuse Reef and is ~15 km x ~6 km. It rises steeply from the surrounding ocean floor, which is 390 m deep. Near the northern end of the reef lies Bedwell Islet, a bare sand cay about 2 m high which is a nesting site for the red-tailed tropic bird (DEC 2007). On the eastern and western sides of the reef are a number of boulders which fall dry. A narrow passage leads to a lagoon with many detached coral patches within the reef.

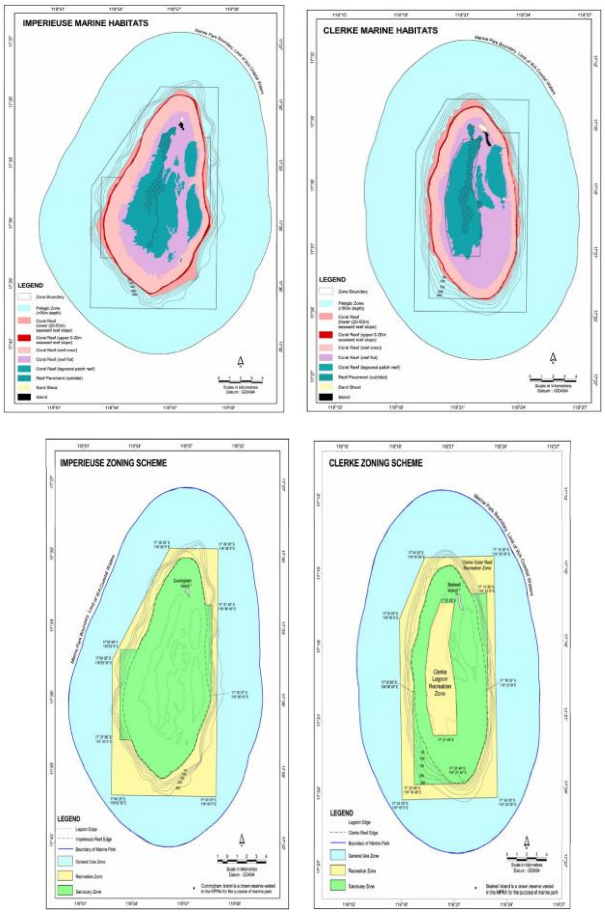
The major habitats of the area include intertidal and subtidal reefs that comprise the typical coral atoll formation and are home to many reef associated species. The Rowley Shoals contain 214 coral species and approximately 530 species of fishes (Gilmour *et al.* 2007 as cited in DEWHA 2008a), 264 species of molluscs and 82 species of echinoderms (Done *et al.* 1994, Gilmour *et al.* 2007 as cited in DEWHA 2008a). Many of these records were new to WA, reflecting the significant differences between the offshore Indo-Pacific fauna and inshore WA coastal fauna. Therefore, the faunal assemblages of the Rowley Shoals Marine Park are regionally significant, as they contain large numbers of species not found in the more turbid coastal environments of tropical WA (DEC 2007).

DPaW (formerly DEC) is responsible for the management of marine conservation reserves under provisions of the *Conservation and Land Management Act 1984* (DEC 2007). Management objectives and strategies promote conservation, science and education, public participation and recreational and commercial uses within and

external to the park. As such, management actions conserve the ecological and social values of the marine park, and designated zones maintain the environmental values and compatible activities and purposes of the park, including sanctuary, recreation, special purpose and general use zones. Seismic activities within each of these zones are assessed by relevant agencies (DEC 2007). It should be noted that, as outlined in the *Rowley Shoals Marine Park Management Plan 2007–2017* (DEC 2007), seismic activities could occur within all areas of the park, including sanctuary zones, if assessed accordingly under the *Environment Protection Act 1986*.

In relation to conservation, a strategic objective of the *Rowley Shoals Marine Park Management Plan* is to maintain the marine biodiversity of the Marine Park and to maintain its ecological integrity and social values. To help achieve this, the Park has been zoned based on a number of key principles including:

- the value of the Shoals as an international coral reef reference site
- recognition that a key value of the Shoals is wilderness and it relies on the area having a high degree of naturalness (e.g. presence of large fish).



Source DEC 2007

Figure 2.4 – Major Marine Habitats and Zoning Schemes of Imperieuse Reef (left) and Clerke Reef (right) in the Rowley Shoals Marine Park

The boundary of the Rowley Shoals Marine Park around Clerke Reef is >30 km from the Nightcap MSS operational area, while the sanctuary zone (i.e. inner reef lagoon) is >37 km from the operational area. The marine park boundary around Imperieuse Reef is >70 km away from the operational area, with the sanctuary zone a further 4 km beyond. As there is no overlap with the Rowley Shoals Marine Park, the proposed survey activities will not occur within the protected state waters.

Although the Nightcap MSS operational area does not overlap or intersect with the Rowley Shoals Marine Park, Pathfinder recognises the values of the marine park and will make every effort to achieve the park's management objectives by not towing deployed equipment through or undertaking seismic acquisition

activities within the marine park. Table 2.3 outlines management goals as described in the *Rowley Shoals Marine Park Management Plan* (DEC 2007), and Pathfinder's commitments to ensure that they are met. Pathfinder believe that any potential impact of the proposed survey activities will have minimal and temporary disturbance on individual species, populations or ecosystems, or social values. Therefore, based on the proposed management controls and lack of overlapping areas, it is unlikely that the proposed survey activities will have a significant impact on the values and sensitive features of the Rowley Shoals Marine Park.

Table 2.3 – Relevant Values and Management Objectives of the Rowley Shoals Marine Park (Source DEC 2007) and the Proposed Survey Commitments

Value	Management Objective	Target	Survey commitment
Geology and Geomorphology	To ensure the structural complexity of the Park's geomorphology is not significantly affected by human activities.	No change of seabed structural complexity as a result of human activity in the Park.	No anchoring within the Marine Park
Water Quality	To ensure that the water quality of the Marine Park is not significantly impacted by sewage discharge from boats.	No change in water quality of all Park waters from background levels as a result of human activity in the Park.	All discharges to be in accordance with MARPOL. No discharges within the Marine Park
Intertidal coral reef communities	To ensure species diversity and abundance of marine flora and fauna on the intertidal coral reef communities of the Park are not significantly impacted by reef-walking and collecting activities.	No loss of intertidal coral reef community diversity as a result of human activity in the Park. No loss of living intertidal coral reef community abundance* as a result of human activity in the Park.	No activities shall occur within the Marine Park
Subtidal coral reef communities	To reduce damage to coral communities caused by mooring and anchoring activities.	No loss of subtidal coral reef community diversity as a result of human activity in the Park. No loss of living subtidal coral community abundance* as a result of human activity in the Park.	No anchoring or mooring within the Marine Park
Invertebrates (excluding corals)	To ensure that invertebrate diversity and abundance are not significantly impacted by recreational fishing and from illegal fishing activities in the Park.	No loss of invertebrate species diversity as a result of human activity in the Park. No loss of protected invertebrate species abundance* as a result of human activity in the Park. Abundance and size composition of invertebrate species in sanctuary zones to be at natural** levels. Management targets for abundance of targeted invertebrate species in all other areas to be determined in consultation with DoF and peak bodies.	No activities, including fishing, within the Marine Park. Noise impacts within the Park where invertebrates will mostly occur (reef areas) will be below those that may cause mortality, permanent injury or TTS.
Finfish	To develop an understanding of the finfish diversity and abundance in the Park.	No loss of finfish species diversity as a result of human activity in the Park. No loss of protected finfish species abundance* as a result of human activity in the Park. Abundance and size composition of finfish species in sanctuary zones to be at natural# levels Management targets for abundance of targeted finfish species in all other areas to be determined in	No activities, including fishing, within the Marine Park. Noise impacts within the Park where site-attached fish occur will be below those that may cause mortality, permanent injury or TTS. Noise impacts within the general use area of the Park will be below those that may cause mortality and permanent injury. Pelagic fish can swim away

Value	Management Objective	Target	Survey commitment
		consultation with DoF and peak bodies.	from a sound source so TTS is not anticipated.
Turtles	To gain an increased understanding of the importance of habitats within the Park for turtles.	No loss of turtle diversity as a result of human activity in the Park. No loss in turtle abundance* as a result of human activity in the Park.	No activities within the Marine Park. Noise impacts within the Park where turtles will mostly occur (reef areas) will be below those that may cause mortality, permanent injury or TTS.
Seabirds	To ensure that breeding red–tailed tropic birds on Bedwell Island are not significantly disturbed by human activity.	No loss of seabird diversity as a result of human activity in the Park. No loss of seabird abundance* as a result of human activity in the Park.	No activities within the Marine Park.
Cetaceans	To gain an increased understanding of the use of the Park by cetaceans.	No loss of cetacean diversity as a result of human activity in Park. No loss of cetacean abundance* as a result of human activity in the Park.	No activities within the Marine Park.

*In this context a loss or change in "abundance" or "biomass" excludes losses of a minor, transient or accidental nature. This qualification does not apply to seabirds, turtles and cetaceans where minor or transient losses would be unacceptable (but does not apply to losses due to accidents)

**"Natural" in this case refers to the abundance that would occur in areas that are undisturbed and/or unexploited by human activities.

2.3.2.2 Other Protected Places

There are no World Heritage Properties or Ramsar Wetlands of International Importance located within the Nightcap MSS operational area (DoE 2016a). The nearest WHP is the Ningaloo Coast, which is located >650 km from the operational area, The nearest RAMSAR Wetlands are Roebuck Bay and Eighty Mile Beach on the WA coast, which are >220 km and >190 km away, respectively.

2.3.3 Exploration and Petroleum

An analysis of the Australian Marine Spatial Information System (AMSIS) confirmed that there are no petroleum production facilities or pipelines within the Nightcap MSS operational area (AMSIS 2016). Seven petroleum wells are located throughout the permit areas of the operational area (NOPTA 2016). Information regarding production facilities within or adjacent to a proposed survey within the Nightcap MSS operational area will be confirmed prior to commencement of the activity, and additional stakeholder consultation will be undertaken to identify recent concerns or developments of relevant persons. The seismic and support vessels operating on an individual survey will not enter a designated Petroleum Safety Zone (500 m radius) around any production facilities, as per Section 616(2) of the OPGGS Act.

2.3.4 Commercial Shipping

Major shipping routes in the vicinity of the Nightcap MSS operational area are associated with entry to the Port of Dampier, Port Hedland and Barrow Island, with less traffic through the Port of Broome (AMSA, pers. comm. 11 January 2016). Shipping within the NWMR includes:

- international bulk freighters/tankers arriving and departing from Dampier and Port Hedland, including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers
- domestic support/supply vessels servicing offshore facilities and Barrow Island development
- construction vessels/barges/dredges
- offshore survey vessels
- commercial fishing vessels.

2.3.5 Tourism and Recreation

The Rowley Shoals Marine Park have limited visitation, with the major activities in the area being nature-based tourism and recreational fishing, primarily by charter vessel and mostly occurring between September and December. Nature-based tourism is based on the Department of Parks and Wildlife (DPaW) licensed charter boat operators who take passengers to the Rowley Shoals on trips of up to 10 days in duration (DEC 2007). The

shallow, sheltered lagoons provide ideal conditions for snorkelling, while SCUBA divers can experience lagoon, channel, and wall dives. Recreational diving is depth-limited to 40 m.

Physical interaction of the survey activities with divers and dive boats is unlikely as the seismic vessels will not enter state waters and will be located a minimum of 4 km from the boundary of the Mermaid Reef Nature Reserve and a minimum of 11 km from any credible dive site. Furthermore, based on noise modelling, received SPL within the atolls will be minimal. At a location on the 250 m contour of Mermaid Reef (~9 km away), predicted seismic acoustic emissions are reduced to SPL of 157 dB re 1 µPa and 148 dB re 1 µPa at 11 km distance (Section 1.3.4). Reefs are known to be noisy places due to increased biotic activity, and noise from SCUBA diving equipment is known to emit higher sound levels than what is anticipated from the proposed seismic source at the reef (Anthony *et al.* 2009).

The Rowley Shoals have a relatively low level of fishing effort, primarily due to their isolation from major population centres. However, charter boat operators offer passengers an array of experiences such as SCUBA diving, snorkelling, fishing and other nature-based activities (DEC 2007). Therefore, considering the distance of the seismic vessels from the reefs, the predicted received sound levels and the low fishing effort, it is unlikely that significant levels of interactions will occur between marine-based tourism at Rowley Shoals and the proposed survey activities within the Nightcap MSS operational area.

Charter boats in the Rowley Shoals region visit primarily Clerke Reef, as it provides easy access into the lagoon and a protected mooring/anchorage site. Plus the lagoon and surrounding waters of Clerke Reef provide excellent opportunities for visitors to engage in all nature-based activities. Because of their remote location, most visitors go to the Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve by charter boat, and trips are generally a minimum of five days. Imperieuse and Clerke Reefs are the most visited sites. In the Pilbara area, there are 13 charter vessels, five of which have commercial fishing boat licenses and target demersal scalefish (Fletcher & Santoro 2015).

2.3.6 Cultural Heritage

There are no Native Title Determination Areas overlapping with or in the vicinity of the Nightcap MSS operational area. A search of the National Shipwrecks Database (Department of the Environment and Energy 2016c) indicated that there is one shipwreck located in the vicinity of the Nightcap MSS operational area. The *Lively* is a 240 t sailing vessel that wrecked near Mermaid Reef in 1810. It is located ~12 km from the western boundary of the Nightcap MSS operational area.

2.3.7 National Heritage

There are no Commonwealth Heritage Places or National Heritage Places within the Nightcap MSS operational area. Mermaid Reef is the only place listed on the Commonwealth Heritage List that is in close proximity to the Nightcap MSS operational area: Mermaid Reef - Rowley Shoals, ~4 km away, Listed Place (22/06/2004) Place ID 105255, Place File No 5/09/210/0033.

2.3.8 Defence Activities

There are no defence activities overlapping with the Nightcap MSS operational area (AMSIS 2015).

3 ENVIRONMENTAL RISK ASSESSMENT

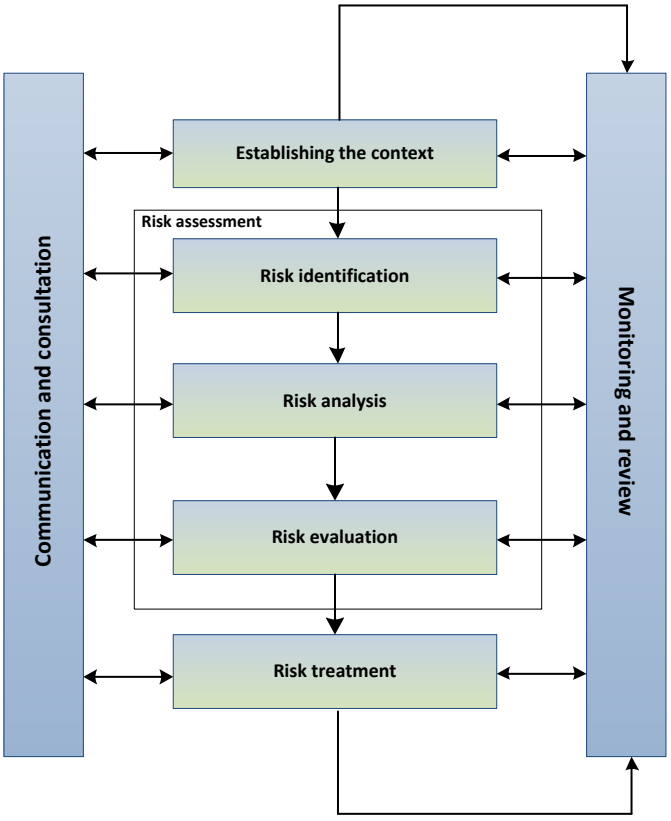
An Environmental Risk Assessment (ERA) was undertaken to understand and manage potential environmental impacts and risks associated with the proposed survey activities within the Nightcap MSS operational area. This ERA was designed to provide:

- details of the environmental impacts and risks associated with survey activities
- an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk
- details of the control measures that will be used to reduce the impacts and risks of the activity to as low as reasonably practicable (ALARP) and to an acceptable level.

3.1 RISK ASSESSMENT METHODOLOGY

The ERA 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 ERA identified sources of risk (i.e. aspects) and potential environmental impacts associated with the activity and assigned a level of significance or risk to each impact. The risk management methodology provided a framework to demonstrate that the identified impacts and risks are reduced to ALARP and that the acceptability of impacts and risks.

The risk was 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. The key steps used for the risk assessment are shown in Figure 3.1.



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

Figure 3.1 - Key steps used for risk assessment

The environmental risks associated with the proposed survey activities were assessed by a methodology that:

- identified the activities and the environmental aspects associated with them
- identified the values/attributes at risk within and adjacent to the polygon
- defined the potential environmental effects of the activities
- identified the likelihood of occurrence and potential consequences
- determined overall environmental risk levels using a likelihood and consequence matrix.

Risks were identified for both planned (e.g. routine and non-routine) and unplanned (e.g. accidents or incidents) activities. Potential environmental impacts were determined based on the stressor type. The ERA further developed an understanding of potential risk by defining the impacts and assessing appropriate controls. The analysis considered previous risk assessments for similar activities and reviewed relevant studies, past performance, external stakeholder consultation feedback and existing environment and key sensitivities/values. The following key steps were undertaken for each identified risk during the risk assessment:

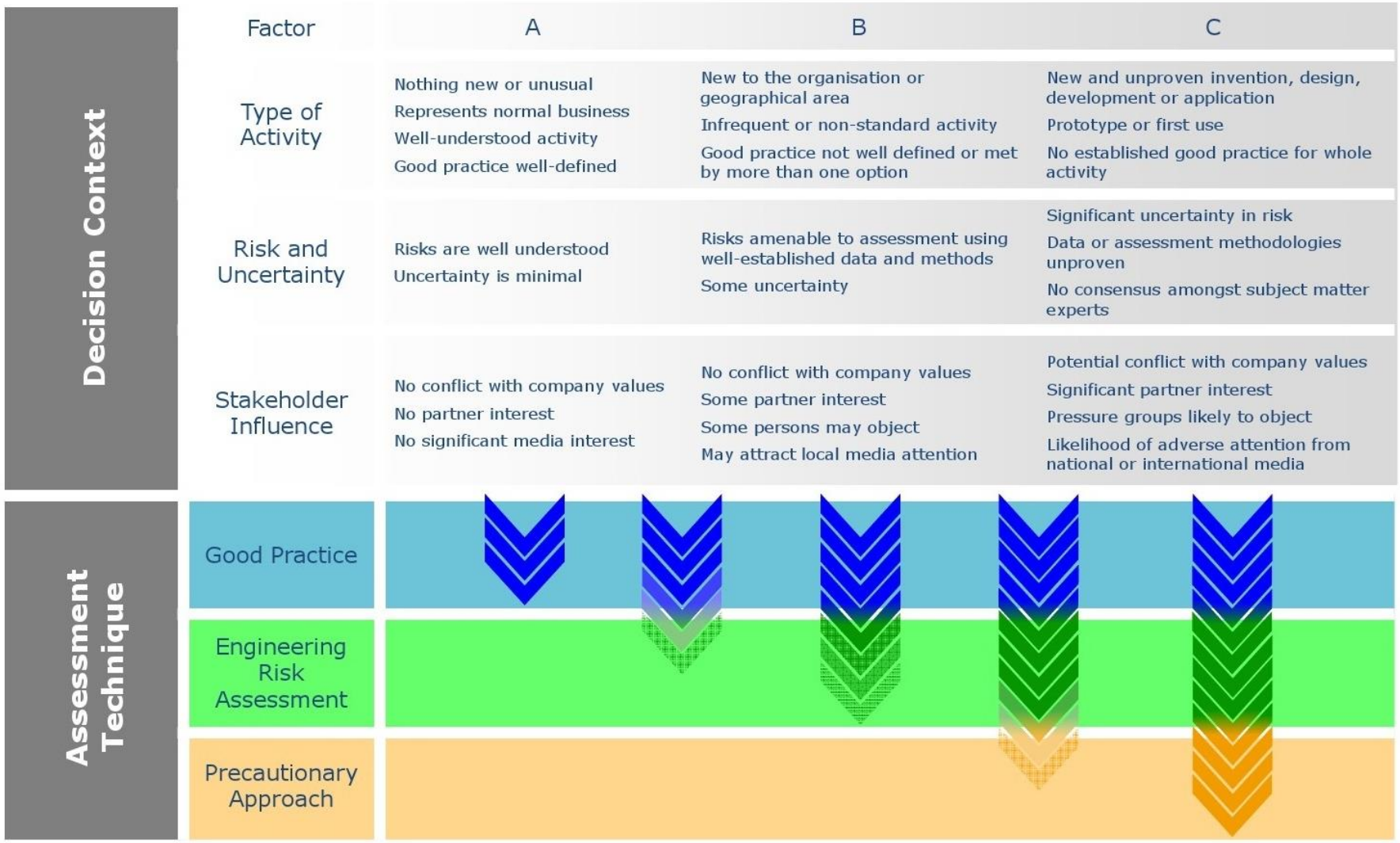
- identification of decision type in accordance with the decision support framework
- identification of appropriate control measures (preventative and mitigation) aligned with the decision type
- determination of the residual risk rating.

To support the risk assessment process, level of supporting evidence that may be required to draw sound conclusions regarding risk level and whether the risk is ALARP and acceptable was based on the *Guidance on Risk Related Decision Making* (Oil & Gas UK 2014), thus ensuring that:

- activities do not pose an unacceptable environmental risk
- appropriate focus is placed on activities where the risk is demonstrated to be ALARP and is anticipated to be acceptable
- appropriate effort is applied to the management of risks based on the uncertainty of the risk, the complexity and residual risk rating.

Determining whether risks were reduced to ALARP required an understanding of the nature and cause of the risk to be avoided, as well as the sacrifice (in terms of safety, time, effort and cost) involved in avoiding that risk. The hierarchy of decision tools used in this case (from lowest risk to highest risk) was adapted from the *Guidance on Risk Related Decision Making* (Oil & Gas UK 2014; see Figure 3.2). Within the context of a specific decision situation, the framework provided a means to:

- determine the relative importance of the various methods of assessing risk (e.g. by reference to standards, cost benefit analysis (CBA), or societal values)
- judge which of these methods is best placed to determine whether the risks are tolerable and ALARP.



Source: Oil & Gas UK (2014).

Figure 3.2 - Risk Related Decision Making Framework

The framework provided appropriate tools, commensurate to the level of uncertainty or novelty associated with the risk. The decision type was selected based on an informed decision around the uncertainty of the risk. This framework enabled an appropriate understanding of a risk and a determination if the risk can be demonstrated to be ALARP and acceptable.

3.1.1 Residual Risk Rating Process

The residual risk rating process assigned a level of risk to each impact as measured in terms of consequence and likelihood. The assigned risk level is the residual risk (i.e. risk with controls in place) and was therefore determined following the identification of the decision type and appropriate control measures. The risk rating process considered the environmental impacts and where applicable, the social and cultural impacts of the risk.

Table 3.1 - Operational likelihood categories

Categories	Likelihood Description		
	Definition	**Probability**	**Experience History of occurrence in Company or industry**
Remote	Almost impossible	Unheard of in the industry	Event occurs once in 10 years
Unlikely	Could occur but would not be expected	Has occurred once or twice in the industry	Event occurs once in five years
Possible	Might occur at some point	Has occurred many times in the industry but not within the Company	Event occurs once a year
Likely	Will probably occur at some point	Has occurred frequently within the Company	Event occurs once monthly
Highly Unlikely	Expected to occur in most circumstances	Has occurred at the Location	Event occurs weekly

3.1.1 Categorisation of Environmental Consequences

Environmental consequences arising from potential environmental aspects of the MSS were categorised from Slight to Catastrophic (Table 3.2).

3.1.1 Assessment of Likelihood of Occurrence

The next step in the risk analysis process identifies the likelihood of occurrence for the potential environmental impacts and risks according to the qualitative description in Table 3.1. The likelihood of occurrence (from Remote to Highly Likely) for the potential environmental impacts from the proposed survey activities have been estimated based on industry incident reporting, previous ERA and professional judgement.

Table 3.2 - Environmental consequence categories

Consequence Category	Biodiversity and Ecosystem Function			Environmental Quality			Social	
	Protected Species	Marine Primary Producer Habitat	Ecological Diversity	Water Quality	Sediment Quality	Air Quality	Protected Areas	Cultural
Catastrophic	Local population eradication and/or loss of critical habitats/activities	Permanent eradication at regional scale	Permanent effects at regional scale	Permanent reduction in water quality. Known biological effect on a regional scale	Permanent contamination with known biological on a regional scale	Continuous damage to the environment and/or human health	Significant permanent effects on one or more of protected areas values	Significant, permanent effects on aesthetic, economic or recreational values. Overall societal benefits do not outweigh impacts
Massive	Extensive population-level effects. Significant effect on critical habitats/activities	Large-scale, long term effects. Recovery >10 years, or effects permanent	Large-scale, long term effects. Recovery >10 years or effects permanent	Continuous or regular discharge. Known biological effect concentrations on large scale (1-100 km^2)	Long term contamination above background. Known biological effect concentrations on large scale	Sustained, exceedance over national/international air quality standards. Potential harm to the environment or human health	Significant long term effects on one or more of protected areas values	Significant long term effects on aesthetic, economic or recreational values. Overall societal benefits do not outweigh impacts
Major	Minor disruption to significant portion of population. Minor effects on critical habitats/activities. No threats to population viability	Localised but long term effects. Recovery >10 years, or effects permanent	Localised, long term effects. Community maintains ecological integrity with significant change in composition	Continuous or regular discharge. Known biological effect concentrations on medium scale (1-10 km^2)	Short to medium-term contamination above background. Known biological effect concentrations on large scale	Major and temporary exceedance over national/international air quality standards. Potential harm to the environment or human health	Minor but long term or permanent effects on one or more of protected areas values	Major effects on aesthetic, economic or recreational values. Overall societal benefits do not outweigh impacts
Moderate	Minor disruption to small portion of population. Minor, temporary effects on critical habitats/activities. No threat to population viability	Localised, medium-term effects. Recovery 5-10 years	Localised, medium-term effects. Ecological integrity maintained with insignificant change to species composition	Continuous or regular discharge. Known biological effect concentrations on small scale (<1 km^2)	Short to medium-term contamination above background. Known biological effect concentrations on medium scale	Moderate and temporary exceedance over national/international air quality standards. No harm to the environment or human health expected	Minor and medium-term effects on one or more of protected areas values. Full recovery expected	Moderate effects on aesthetic, economic or recreational values but overall societal benefits outweigh impacts
Minor	Minor and temporary disruption to small portion of population. No effects on critical habitats/activities	Localised, short term effects. Recovery in the timescale of months to <5 years	Localised, short to medium-term effects. Full recovery expected	Temporary discharge with contamination above background levels. Known biological effect concentrations on medium scale (<10 km^2)	Temporary contamination above background. Known biological effect concentrations on medium scale	Minor and temporary exceedance over national/international air quality standards. No harm to the environment or human health expected	Minor and short term effects on one or more of protected areas values. Full recovery expected	Minor and temporary effects on aesthetic, economic or recreational values

Consequence Category	Biodiversity and Ecosystem Function			Environmental Quality			Social	
	Protected Species	Marine Primary Producer Habitat	Ecological Diversity	Water Quality	Sediment Quality	Air Quality	Protected Areas	Cultural
Slight	Possible incidental effects to flora and fauna in a locally affected environmental setting	Localised, temporary effects. Recovery in the timescale of days to weeks	Localised, temporary effects. Slight impact on ecological integrity or species composition	Temporary discharge with contamination above background levels. Known biological effect concentrations on small scale (<1 km^2)	Temporary contamination above background. Known biological effect concentrations on small scale	Slight, temporary exceedance over national/international air quality standards. No harm to the environment or human health expected	Slight to negligible effects on any protected area values	Slight to negligible effects on aesthetic, economic or recreational values

Table 3.3 - Environmental event potential matrix

		LIKELIHOOD LEVEL					
		Remote	**Highly Unlikely**	**Unlikely**	**Possible**	**Likely**	**Highly Likely**
CONSEQUENCE LEVEL	**Catastrophic**	2	2	1	1	1	1
	Massive	3	2	2	1	1	1
	Major	3	3	2	2	1	1
	Moderate	4	3	3	2	2	1
	Minor	4	4	3	3	2	2
	Slight	4	4	4	3	3	2

Operational Risk Levels

Risk Level 1: **SEVERE** risk, apply strict Precautionary Principle.

Risk Level 2: **HIGH** risk, apply industry best practice to reduce to ALARP.

Risk Level 3: **MEDIUM** risk, apply standard cost-benefit approach to reduce risk to ALARP.

Risk Level 4: **LOW** risk, apply normal business management practice to avoid impact.

3.1.2 Demonstration of ALARP

As outlined in **Table 3.4**, impacts and risks are reduced to ALARP where:

- The residual risk is **LOW**:
  - good industry practice or comparable standards have been applied to control the risk, because any further effort towards risk reduction is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.
- The residual risk is **MEDIUM** or **HIGH**:
  - good industry practice is applied for the situation/ risk; or
  - alternatives have been identified and the control measures selected to reduce the impacts and risks to ALARP. This may require assessment of Company and industry benchmarking, review of local and international codes and standards, consultation with stakeholders, etc.

Table 3.4 - Residual risk levels and associated decision making tools and principles

Residual Risk Level	Environmental Threshold	Decision Making Tools	Environmental Decision Principles
LOW Broadly Acceptable Zone	No substantial risk (i.e. negligible risk) of harm to species or communities	Comparison to codes and standards, good oilfield practice and professional judgement are used to assess risk acceptability	If the environmental risk of the hazard has been found to be 'Broadly Acceptable' and the control measures are consistent with applicable standards and good industry practice then no further action is required to reduce the risk further. However, if a control measure that would further reduce the impact or risk is readily available, and the cost of implementation is not disproportionate to the benefit gained, then it is considered 'reasonably practicable' and should be implemented.
MEDIUM / HIGH ALARP Zone	Likely to cause, or substantial risk of causing serious harm to non-listed species or communities	Risk based analysis are used in addition to comparison to codes and standards, good oilfield practice and professional judgement to assess risk acceptability.	An iterative process to identify alternative / additional control mechanisms has been conducted to reduce the risk to the 'Broadly Acceptable' zone. However, if the risk cannot be reasonably reduced to the 'Broadly Acceptable' zone without grossly disproportionate sacrifice; then the mitigated environmental risk is considered to be ALARP.
SEVERE Intolerable Zone	Likely to cause, or substantial risk of causing significant impact to protected species or communities	All of above decision making tools apply plus consideration of company values and societal values	If the environmental impact or risk has been found to fall within this zone then the activity should not be carried out. Work to reduce the level of risk should be assessed against the Precautionary Principle with the burden of proof requiring demonstration that the risk has been reduced to the ALARP Zone before the activity can be commenced.

3.1.3 Demonstration of Acceptability

The following process has been applied to demonstrate acceptability (as illustrated in **Table 3.5**):

- **LOW** residual risks are 'Broadly Acceptable', if they meet legislative requirements, industry codes and standards, regulator expectations, the Pathfinder Environment Policy and industry guidelines.
- **MEDIUM** and **HIGH** residual risks are 'Broadly Acceptable' if ALARP can be demonstrated using good industry practice, risk based analysis, if societal concerns are accounted for and the alternative control measures are disproportionate to the benefit gained.
- **SEVERE** residual risks are 'Intolerable' and therefore 'Unacceptable'. Risks will require further investigation and mitigation to reduce the risk to a lower and more acceptable level. If after further investigation the risk remains in the severe category, the risk requires appropriate business sign-off to accept the risk.

A range of criteria have been considered when evaluating the acceptability of environmental impacts and risks associated with 3D MSS within the Nightcap MSS operational area. This evaluation works at several levels, as outlined in Table 3.5.

Table 3.5 - Acceptability criteria

Criteria	Question	Acceptability demonstrated
Policy compliance	Is the proposed management of the impact or risk aligned with the Pathfinder Environment Policy?	The impact or risk must be compliant with the objectives of the company policies.
Management System compliance	Is the proposed management of the impact or risk aligned with the Pathfinder HSE Management System?	Where specific Pathfinder procedures and work instructions are in place for management of the impact or risk in question, acceptability is demonstrated.
Social acceptability	Have stakeholders raised any concerns about activity impacts or risks, and if so, are measures in place to manage those concerns?	Stakeholder concerns must have been adequately addressed and closed out.
Laws and standards	Is the impact or risk being managed in accordance with existing Australian or international laws or standards, such as EPBC Policy Statements, MARPOL, AMSA Marine Orders, Marine Notices etc.	Compliance with specific laws or standards is demonstrated.

Criteria	Question	Acceptability demonstrated
Industry best practice	Is the impact or risk being managed in line with industry best practice, such as APPEA Code of Environmental Practice, IAGC guidelines etc.?	Management of the impact or risk complies with relevant industry best practice.
Environmental context	Is the impact or risk being managed pursuant to the nature of the receiving environment (e.g. sensitive or unique environmental features generally require more management measures to protect them than environments widely represented in a region)?	The proposed impact or risk controls, EPO and EPS must be consistent with the nature of the receiving environment.
Environmentally Sustainable Development (ESD) Principles	Does the proposed impact or risk comply with the APPEA Principles of Conduct (APPEA 2003), which includes that ESD principles be integrated into company decision-making.	Acquisition of 2D and 3D MSS within the Nightcap MSS operational area is consistent with the APPEA Principles of Conduct.
ALARP	Are there any further reasonable and practicable controls that can be implemented to further reduce the impact or risk?	There is a consensus that residual risk has been demonstrated to be ALARP.

3.1.4 Environmental Risk Evaluation

This section of the EP describes the results of the risk evaluation for proposed MSS within the Nightcap MSS operational area using the methodology described above. As required by the Environment Regulations, this evaluation demonstrates that the impacts and risks associated with proposed MSS within the Nightcap MSS operational area will be reduced to ALARP and will be of an acceptable level. The risks identified during the ERA process (including Decision Type, residual risk level and acceptability of residual risk; Table 3.2) have been divided into two broad categories: Planned (routine and non-routine) and Unplanned (accidents or incidents) activities. Both of these categories have then been further divided into impact assessment groupings based on stressor type, e.g. noise, equipment loss, etc.

3.1.4.1 Risk Evaluation Summary

The ERA for proposed MSS within the Nightcap operational area indicates that the residual environmental impacts and risks associated with the activities will be reduced to ALARP and are of an acceptable level. The ERA identified 11 credible sources of environmental risk, including five planned and five unplanned types, which are all assessed as having a Low or Medium residual risk following implementation of identified control measures. A summary of the risk evaluation for proposed MSS within the operational area is provided in Table 3.6, and the details of the risk evaluation are further described throughout this section.

3.1.4.2 Environmental Impacts/Risks Excluded from the Detailed Risk Evaluation

The ERA identified a number of environmental impacts and risks that were assessed as not being applicable (i.e. not credible) to normal acquisition operations within the Nightcap MSS operational area. These impacts and risks were not included in the detailed risk evaluation described in this section of the EP and are outlined below for information only. Both impacts and risks were determined to have a Low level of residual risk.

The Nightcap MSS operational area is located in a water depth range of ~80–1,300 m and at a distance of at least 9 km from any shallow water locations (i.e. the 250 m contour surrounding Mermaid Reef). There are no emergent or shallow water features within, or immediately adjacent to, the operational area. Consequently, risks associated with shallow water/near shore activities—vessel light emissions, vessel anchoring and vessel grounding—were determined to be not relevant to assess via the detailed risk evaluation. Therefore, general vessel activities have been excluded from the risk evaluation for this activity.

As outlined in Section 2.3.8, there are no defence activities overlapping the Nightcap MSS operational area or surrounding waters. Subsequently, potential impacts on defence activities are not included in the detailed risk evaluation that is described in this section of the EP.

Table 3.6 - Environmental risk evaluation summary for proposed MSS within the Nightcap MSS operational area

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	*Likelihood*	*Risk*		
PLANNED (ROUTINE AND NON-ROUTINE) ACTIVITIES							
Physical presence of survey vessel	Vessel noise emissions (excluding seismic acoustic emissions)	Short-term localised disturbance to marine fauna, such as alteration of behaviours and localised displacement	Slight	Unlikely	**Low**	• Interaction between the survey and support vessels (not including a vessel that it towing or retrieving/deploying a seismic array) and cetaceans within the operational areas will be consistent with EPBC Regulations 2000 - Part 8 Division 8.1 (Regulation 8.05 & 8.06) - Interacting with cetaceans and calves • Interaction between vessels and whale sharks within the operational area will be consistent with *Whale Shark Management Plan* (Program 57; DPaW 2013): vessels will not knowingly approach closer than 400 m of a whale shark. • Interaction between vessels (not including a vessel that is towing or retrieving/deploying a seismic array) and turtles within the operational area will be consistent with the vessel fauna interaction procedure that a vessel will not travel at speeds >6 knots within 300 m of a turtle. • Interaction between helicopters and cetaceans within the operational area will be consistent with EPBC Regulations 2000–Part 8 Division 8.1 (Regulation 8.07)–Interacting with cetaceans	Broadly Acceptable

	Interaction with commercial fisheries	• Disruption to fishing vessels
		• Potential direct and indirect noise impacts on target species
		• Restriction of access to fishing grounds, loss/damage to gear
		• Recreational take of finfish
			Minor	Possible	**Medium**	• Operations of the survey vessel must comply with the following:
						  ○ International Regulations for Preventing Collisions at Sea 1972 (COLREG)
						  ○ Standards of Training, Certification & Watchkeeping (STCW) Convention
						  ○ *Navigation Act 2012*
						  ○ standards for watchkeeping.
						• Operations of the survey vessel will be in accordance with Marine Notice 21/2013: Sound navigational practices; and with Marine Notice 4/2012: Safety of Fishing Vessels.
						• The survey vessel will have an AIS tracking device installed and operating to aid identification by other vessels.
						• Mariners will be alerted of survey and support vessels' presence and extent of towed array. This includes the display of navigational beacons and lights to indicate that the vessel has restricted manoeuvrability and the implementation of the survey vessel communications protocol.
						• Notification of activity details to relevant stakeholders four weeks prior to the survey commencing, including the offer of a 7–10 day forecast of operations and the promulgation of a survey fact sheet (minimum one week) prior to the survey commencing and containing specific information of the survey vessels and contact information.
						• Approximately every six months Pathfinder shall ensure:
						  ○ regular updates are provided to stakeholders
						  ○ identified stakeholders are still relevant and correct
						  ○ any new stakeholders are identified.
						• Use of a dedicated support vessel to manage interactions with stakeholders (including commercial fishing, charter and shipping vessels) during seismic acquisition operations including implementation of the SNA, which is likely to cover at least a 10-km radius from the survey vessel to account for the length of the towed streamer spread.
						• Tail buoys are visible to other mariners (e.g. reflective tape/strobes/radar reflector, etc.) so they are aware of the towed extent and vessels restricted manoeuvrability
						• In-water equipment lost will be recovered (where possible) and detailed records maintained of any loss of in-water equipment.
						• If equipment lost is irretrievable, maintain records of the circumstances that prohibited the equipment from being recovered.
						• To prevent further interactions with the survey activity and commercial fishing, recreational fishing from the survey and support vessels is prohibited.
							Acceptable if ALARP

	Interaction with commercial vessels/ shipping	Temporary disruption/ exclusion of shipping traffic					
	Interaction with tourism activities including recreational fishing	Temporary disruption/exclusion of marine tourism			**Low**	• MFO observation (as used for cetaceans, turtles and whale sharks) will include observations for diving and charter vessels, particularly with the aim of determining if there are divers or small boats in the water outside the reef. • If seismic operations occur between 1 September and 30 November and overlaps charter vessel operated dive/snorkelling tours within Mermaid Reef Commonwealth Marine Reserve, Pathfinder will undertake a joint risk assessment and, if required, jointly develop and implement a SIMOPS plan in consultation with dive and charter vessel operators. The SIMOPS plan will adopt the DMAC guidance, including stopping seismic acquisition immediately before and when divers are in the water, if requested by the charter operator. • DPaW will be provided a survey fact sheet ~1 week prior to activities commencing, and a daily 7–10 day forecast of operations to disseminate to charter boat operators (covering diving and fishing activities) and visitors to the Rowley Shoals. • The survey vessel is not permitted to transit the Mermaid Reef Commonwealth Marine Reserve of the Rowley Shoals Marine Park with the seismic equipment deployed.	

[1] Refer to relevant section for details.

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	***Likelihood***	***Risk***		
	Biofouling of vessel hull, other niches and immersible equipment	Introduction and establishment of IMS and displacement of native marine species	Slight	Highly Unlikely	**Low**	• Ballast water discharges for the survey and support vessels must comply with the requirements of the Australian Ballast Water Management Requirements (as enforced under the *Biosecurity Act 2015* and Quarantine Regulations 2000) • Vessels must have a Ballast Water Management Plan that complies with Regulation B-1 of the International Convention for the Control and Management of Ship's Ballast Water and Sediments 2004. • The Plan should have been prepared in accordance with the IMO *Guidelines for Ballast Water Management and the Development of Ballast Water Management Plans* (IMO Resolution MEPC.127(53). • Whilst in Australian waters, the survey and support vessels must operate in accordance with the conditions detailed in the "Approval to Berth" issued by Department of Agriculture (DoA), and submitted a Quarantine Pre-arrival Report (QPAR). • The risks of introducing IMS via biofouling into WA waters and ports must be managed in accordance with marine pest management guidelines (as enforced under the WA *Fish Resources Management Act 1994* and Fish Resources Management Regulations 1995) for the survey and support vessels. • Application of DoA guideline that full ballast, high risk exchanges are conducted as far as possible away from shore and in water at least 200 m deep. • Application of guidelines detailed in the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry, and the IMO Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species implemented for the survey and support vessels, including the use of a biofouling management plan and record book for the survey and support vessels. • The survey and support vessels will have a recent dry dock, IMS inspection or antifoulant application prior to mobilising to Australian waters. • If the survey and/or support vessels has to leave Australian waters before completion of the survey, it will be required to undergo a further IMS inspection and cleaning (if required), prior to re-entering Australian waters to complete the survey. • The survey vessel chosen for an individual survey will be assessed using the DoF Vessel Check tool: https://vesselcheck.fish.wa.gov.au.	Broadly Acceptable

Seismic acoustic emissions	Underwater noise emissions from discharge of airgun array, during standard operating periods	Disturbance to marine fauna, particularly whales, marine turtles and whale sharks, involving potential physiological and behavioural effects
		Disturbance to tourism activities, divers
			Slight	Unlikely	**Low**	• Use of the smallest possible seismic acoustic source (overall broadband SPL (peak) of 248 dB re 1 µPa at 1m horizontal)
						• **EPBC Act Policy Statement 2.1 - Part A - Standard Management Procedures**
						• As per the EPBC Act Policy Statement 2.1, the operation of the seismic source at all times during the survey must comply with the requirements of the Part A Standard Management Procedures of the EPBC Act Policy Statement 2.1 - Interactions between offshore seismic activities and whales (DEWHA 2008b) and will be implemented for all surveys within the Nightcap MSS operational area.
						• The following precaution zones will be implemented for all individual surveys within the Nightcap MSS operational area:
						  ○ *Observation* zone: 3+ km horizontal radius from the acoustic source
						  ○ *Low power* zone: 2 km horizontal radius from the acoustic source
						  ○ *Shut-down* zone: 500 m horizontal radius from the acoustic source
						• Detailed reports of all marine fauna sightings (cetaceans, whale sharks and turtles) and interactions will be recorded and reported, via the Annual Report (if relevant) and Post-survey Environmental Review Report.
						• Operation of the seismic source within the whale shark BIAs (as identified on the NCVA) during the peak period (July–November) must comply with all aspects of requirements of the EPBC Act Policy Statement 2.1 Part A Standard Management Procedures as defined above in EPS 31.
						• No discharge of the acoustic source outside Nightcap MSS operational area.
						• Survey and support vessel personnel (marine and seismic) provided with pre-survey induction on EPBC Act Policy Statement 2.1 requirements and protected fauna.
						• Only appropriately experienced MFOs (as determined by a review of their CVs in the project proposal submitted by the provider) will be contracted to undertake the proposed survey activities.
						• Detailed reports of all marine fauna sightings (e.g. cetaceans, whale sharks, turtles) and interactions will be recorded and reported, and all cetacean sightings will be recorded using the Cetacean Sightings Application (CSA - Version 3 - BETA; http://data.marinemammals.gov.au/csa/).
						• Vessels will not undertake full seismic acquisition activities within 50 km of another vessel also acquiring data.
						• Pathfinder shall search the NOPSEMA website and consult with geophysical companies and/or titleholders to determine the presence of other seismic operations overlapping the operational area.
						• Seismic source modelling software will be used during the pre-survey planning phase to determine the ideal array volume to be used.
						• Pathfinder will not undertake a seismic survey after a previous Pathfinder survey was undertaken over the same area.
						• Prior to individual surveys, Pathfinder will undertake pre-survey planning that will review and consider new information.
						• No seismic acquisition in water depths shallower than 100 m
						• If a marine turtle is observed within 500 m of the acoustic source during pre start-up visual observations, soft-start procedures will not commence for 30 minutes after sighting occurred.
							Broadly Acceptable

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	*Likelihood*	*Risk*		
Routine discharges	Underwater noise emissions from discharge of airgun array during sensitive periods	Disturbance to marine fauna, particularly whales, marine turtles and whale sharks, involving potential physiological and behavioural effects	Minor	Possible	**Medium**	• **<u>Pygmy blue whale specific</u>** Notwithstanding EPS 31 and 32 operation of the seismic source **during the peak periods** for pygmy blue whales from **1 April–31 July** and **1 September–31 December** must comply with the following EPBC Act Policy Statement 2.1 Part B Additional Management Procedure: ○ application of increased precaution zones (Observation zone: >3 km; Shut-down zone: 2 km) ○ application of an increased pre-start observation of 45 minutes, rather than 30 minutes ○ application of increased pre-start observation period allows for the possibility of longer dive times for whales, i.e. the time between surfacing events is longer for animals that are feeding ○ limiting initiation of soft start procedures to conditions that allow visual inspection of power-down/shut-down zone • **<u>EPBC Act Policy Statement 2.1 - Part B - Additional Management Procedures</u>** Notwithstanding EPS 31, operation of the seismic source within the operational area at all times must comply with the following EPBC Act Policy Statement 2.1 Part B Additional Management Procedures: • Two experienced and dedicated Marine Fauna Observers (MFOs) on the survey vessel for the entire duration of the survey will ensure accurate and reliable compliance, particularly if ○ survey located during peak migration times ○ Observed density of whales higher than expected from pre-survey planning. • At least one MFO on observation effort during all daylight hours for individual surveys. • Two MFOs alternate observation effort for applicable species within a BIA and during all daylight hours at peak periods (or as necessary). • **<u>All whales - Adaptive Management Procedures</u>** Notwithstanding EPS 31, 32 and 33: If three or more whale sightings within the power-down/shut-down zone occurred within preceding 24 hours (i.e. observed density of whales in the area is higher than expected), then one of the following procedures will be implemented: ○ survey vessel will relocate to another survey line >20 km from location of last whale sighting and will not return within 24 hours ○ no survey operations in current location for 24 hours. At this point, if less than three whale sightings in power-down/shut-down zone occurred within the preceding 24 hours, survey operations can re-commence in this location with start-up procedures as per EPBC Act Policy Statement 2.1.	Acceptable if ALARP
	Discharge of ballast water	Introduction and establishment of IMS and displacement of native marine species	Slight	Highly Unlikely	**Low**	• Sewage discharges from vessels must comply with the requirements of: ○ MARPOL Annex IV - Sewage ○ Protection of the Sea (Prevention of Pollution from Ships) Act 1983 - Section 26D ○ Marine Order 96 (Marine pollution prevention — sewage) 2013. • Sewage systems must be an IMO approved/MARPOL compliant sewage treatment plant. • Sewage and putrescible wastes must be passed through a grinder or comminuter and a disinfection system so that the final product is small enough to pass through a screen of less than 25 mm diameter prior to disposal to the sea. • Comminuted and disinfected sewage can be discharged if: ○ the vessel is >3 nmi from nearest land, Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park ○ sewage originating from holding tanks is discharged at a moderate rate (as defined in Marine Order 96) while the vessel is proceeding en-route at a speed not less than 4 knots. • Sewage that is not comminuted or disinfected can be discharged if: ○ the vessel is >12 nmi from nearest land, Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park ○ sewage originating from holding tanks is discharged at a moderate rate (as defined in Marine Order 96) while the vessel is proceeding en-route at a speed not less than 4 knots. • Food waste discharges from vessels must comply with the requirements of: ○ MARPOL Annex V - Garbage ○ Protection of the Sea (Prevention of Pollution from Ships) Act 1983 - Section 26F ○ Marine Order 95 (Marine pollution prevention - garbage) 2013. • Food wastes can be discharged from the survey and support vessel if: ○ it is comminuted or ground to a particle size <25 mm ○ the vessel is moving faster than 4 knots ○ the discharge takes place as far as practicable from the nearest land, but in any case, ≥3 nmi from the nearest land, Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park.	Broadly Acceptable
	Discharge of bilge water, sewage, grey water and food wastes	Localised eutrophication of the water column; and localised adverse effect to marine biota		Unlikely	**Low**		

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	***Likelihood***	***Risk***		
						• Food wastes that are not comminuted or ground can be discharged if: o the vessel is en-route o the discharge takes place as far as practicable from the nearest land, but in any case, ≥12 nmi from the nearest land, MRCMR and Rowley Shoals Marine Park. • Bilge water discharges (machinery space bilges) must comply with the requirements of: o MARPOL Annex I - Oil o Protection of the Sea (Prevention of Pollution from Ships) Act 1983 - Section 9. • Bilge water discharges can occur only if: o the vessel has a IMO approved/MARPOL compliant oily water separator (International Oil Pollution Prevention Certificate [IOPPC]) o the vessel is proceeding en-route (i.e. is not stationary) o oil content less than 15 parts per million (ppm) o oil discharge monitoring and control system and oil filtering equipment are operating. • If the above cannot be met, oil must be retained aboard for on-shore disposal. • Bilge water contaminated with chemicals must be contained and disposed of onshore, except if the chemical is demonstrated to have a low toxicity (as determined by the relevant Material Safety Data Sheet [MSDS]). • Discharges of bilge water will be recorded in the survey and support vessel engine room logs. • Incinerators will be operated in accordance with established operating procedures that align with manufacturers' specifications. • Incineration of any oil sludge on board, or disposal of any oil sludges/slops in port, must be recorded in the survey vessel Oil Record Book (a requirement under MARPOL 73/78).	
Routine atmospheric emissions	Emissions from fuel consumption and waste combustion	Localised reduction in air quality Greenhouse gas emissions	Slight	Highly Unlikely	**Low**	• Operations of the vessels will be in accordance with Marine Notice 6/2012: Revised Garbage Discharge Regulations for Ships. o Adherence to MARPOL 73/78 Annex VI (as implemented in Commonwealth waters by the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (PSPPS Act); and Marine Orders - Part 97: Marine pollution prevention - air pollution). o Quarterly reviews of SEEMP and energy performance (for vessels >400 GT). • Implementation of a Ship Energy Efficiency Management Plan (SEEMP) for the survey vessel (MARPOL 73/78 Annex VI requirement from 1 January 2012). • Vessel combustion equipment compliant with MARPOL 73/78 Annex VI requirements.	Broadly Acceptable
	UNPLANNED ACTIVITIES (ACCIDENTS/INCIDENTS)						
Physical presence of support vessel, survey vessel and towed array	Collision between vessels / towed array and marine fauna	Injury or fatality to protected marine fauna (cetaceans, marine turtles, whale sharks)	Minor	Highly Unlikely	**Low**	• Operations of the vessels will be in accordance with Marine Notice 6/2012: Revised Garbage Discharge Regulations for Ships. o Adherence to MARPOL 73/78 Annex VI (as implemented in Commonwealth waters by the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (PSPPS Act); and Marine Orders - Part 97: Marine pollution prevention - air pollution). o Quarterly reviews of SEEMP and energy performance (for vessels >400 GT). • Implementation of a Ship Energy Efficiency Management Plan (SEEMP) for the survey vessel (MARPOL 73/78 Annex VI requirement from 1 January 2012). • Vessel combustion equipment compliant with MARPOL 73/78 Annex VI requirements. • Any incidents of vessel or towed array collision with cetaceans, turtles or whale sharks must be reported as a reportable incidents for the activity, in accordance with Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 - Regulation 26. • Any incidents of vessel or towed array collision with whales must be reported to the Department of the Environment and Energy via the National Marine Mammal Data Portal, online national ship strike database and associated web-based questionnaire: https://data.marinemammals.gov.au/report/shipstrike. • Streamer tail buoys will be fitted with appropriate turtle guards or be of an improved design such as PartnerPlast.	Broadly Acceptable
	Vessel grounding	Localised physical damage to benthic habitats	Slight	Highly Unlikely	**Low**	Vessels will use approved navigation systems and depth sounders.	Broadly Acceptable
	Equipment dragging or loss	Localised physical damage to benthic habitats	Slight	Unlikely	**Low**	• Streamers equipped with pressure-activated, self-inflating buoys designed to bring the equipment to the surface if lost accidentally. • Streamers will be towed at a depth that will not allow them to be closer than 10 m from the seabed. • Use of solid streamers, rather than fluid-filled streamers. • Steamers and associated equipment shall be checked/inspected prior to use. • Anchoring will not occur within the Nightcap MSS operational area except in the event of an emergency. • Any incidents of vessel anchoring, vessel grounding or loss of streamer or associated equipment shall be reported to NOPSEMA. • Procedures will be developed and implemented for lifting activities and streamer deployment/retrieval.	Broadly Acceptable

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	***Likelihood***	***Risk***		
						• Equipment will be deployed during appropriate weather conditions only. • Appropriate storage of equipment on-board. • Streamers fitted with Streamer Recovery Devices (SRD). • All lifting undertaken on board the vessels to be load rated as appropriate for the working load.	

Waste management	Accidental release of hazardous or non-hazardous waste	Pollution and contamination of the environment and secondary impacts of marine fauna (e.g. ingestion, entanglement)	Slight	Unlikely	**Low**	• Handling of hazardous and non-hazardous materials on-board the survey and support vessels will comply with relevant legislation:
						  ○ MARPOL Annex III - Noxious Liquid Substances
						  ○ MARPOL Annex V - Garbage
						  ○ Navigation Act 2012
						  ○ Protection of the Sea (Prevention of Pollution from Ships) Act 1983
						• No discharge of plastics or plastic products of any kind.
						• No discharge of domestic wastes or maintenance wastes.
						• All waste receptacles covered with tightly fitting, secure lids to prevent any solid wastes from blowing overboard.
						• All solid, liquid and hazardous wastes (other than bilge water, sewage and food wastes) will be incinerated or compacted (if possible) and stored in designated areas and sent ashore for recycling, disposal or treatment.
						• Any hydrocarbon storage on deck must be designed and maintained to have at least one barrier (i.e. form of bunding) to contain and prevent deck spills entering the marine environment. This can include containment lips on deck (primary bunding) and/or secondary containment measures (e.g. bunding, containment pallet, transport packs, absorbent pad barriers) in place.
						• Correct segregation of solid and hazardous wastes.
						• Vessels >400 GRT must have an implemented and tested SOPEP in place that complies with the requirements of:
						  ○ Regulation 37 of MARPOL Annex I
						  ○ Marine Order 91 (Marine pollution prevention - oil) 2014.
						• All hazardous substances (as defined in NOHSC: 1008 [2004] - Approved Criteria for Classifying Hazardous Substances) will have MSDS that are readily available on-board.
							Broadly Acceptable

Non-routine/ accidental hydrocarbon release	Hydrocarbon release caused by topsides (vessel) loss of containment	Localised and temporary reduction in water quality due to hydrocarbon contamination	Slight	Unlikely	**Low**	• All vessels will have spill response bins/kits in close proximity to hydrocarbon storage areas for prompt response in the event of a spill or leak. The kits will be checked for their adequacy and replenished as necessary prior to the commencement of activities and on a regular basis thereafter.
						• Vessels <400 GRT that do not have a SOPEP will have an approved spill management plan or equivalent.
						• In the event of any fuel or oil spills to sea, SOPEP/OPEP procedures will be followed for notification and consultation with AMSA and WA Department of Transport (DoT) to ensure prompt and appropriate mobilisation of NATPLAN or WestPlan-MOP/WA DoT OSCP as appropriate.
						• The survey vessel must have a valid International Oil Pollution Prevention Certificate (IOPPC) applicable to vessel class.
						• Any hydrocarbon storage on deck of the vessel must be designed and maintained to have at least one barrier (i.e. form of bunding) to contain and prevent deck spills entering the marine environment. This may include containment lips on deck (primary bunding) and/or secondary containment measures (bunding, containment pallet, transport packs, absorbent pad barriers) in place.
						• Equipment located on deck and utilising hydrocarbons (e.g. cranes, winches or other hydraulic equipment) will:
						  ○ have as a minimum primary bunding (i.e. deck edge lips or up-stands) to prevent loss of hydrocarbons to the marine environment
						  ○ be maintained to reduce risk of loss of hydrocarbon containment to the marine environment.
						• Spill Response Readiness:
						  ○ Vessel SOPEPs will be in the prescribed format described in Guidelines for the Development of Shipboard Oil Pollution Emergency Plans, adopted by IMO as Resolution MEPC.54(32)
						  ○ An OPEP drill (Regulation 14(8C)), appropriate to the response arrangements and nature and scale of the activity, will be conducted in Australian waters prior to the commencement of the survey and tested as per the following:
						  ▪ when new response arrangements are introduced
						  ▪ if previous response arrangements are significantly amended
						  ▪ not later than 12 months after the most recent test
						  ▪ if a new location for the activity is added to the EP after the response arrangements have been tested and before the next test is conducted.
						• SOPEP drills will be undertaken as per the seismic vessel standard operating procedure.
						• Support vessels will test response arrangements prior to the commencement of the survey.
						• All drill tests will be reported as per MARPOL Annex I (Regulation 15) requirements and reviewed as part of the on-going monitoring and improvement of emergency control measures.
						• If a phase duration is greater than one year, survey and support vessels' HSE inspections will be undertaken no later than 12 months after the most recent inspection.
							Broadly Acceptable

Aspect	Source of Risk	Key Potential Environmental Impacts[1]	Risk Rating			Control Measures	Acceptability of Residual Risk
			Consequence	***Likelihood***	***Risk***		

						• Reporting:
						  ○ When a fuel/oil spill to sea occurs, the survey vessel master will inform the AMSA JRCC using a Marine Pollution Report (POLREP) form (AMSA 197 [MO 91/2]. AMSA JRCC will notify AMSA and/or WA DoT.
						  ○ Any diesel spills to sea >80 L will be reported to NOPSEMA as soon as practicable and with written notification within three days.
						  ○ A written record of the notification to NOPSEMA must be given to National Offshore Petroleum Titles Administrator (NOPTA) and the Department of the responsible State Ministers (DoT, Department of Mines and Petroleum (DMP), DPaW and/or DER) within seven days.
						• Reporting of any spills of hydrocarbons to the sea from the survey vessel must comply with requirements of Marine Order 91 (Marine pollution prevention - oil) 2014.	

	Hydrocarbon release caused by loss of structural integrity from vessel collision between survey vessel and third-party vessel	Toxic effects on marine fauna and flora
		Localised and temporary reduction in water quality.
		Direct and indirect effects on commercial and recreational fisheries
			Moderate	Highly Unlikely	**Medium**	• Refuelling at sea will be subject to vessel standard operating procedures, plus the following additional measures:
						  ○ AMSA will be notified prior to any refuelling taking place.
						  ○ At-sea refuelling will not take place within a distance of 25 km of any emergent land or shallow water features (30 m or less depth).
						  ○ Refuelling of vessels will be undertaken under favourable wind and sea conditions as determined by the vessel masters.
						  ○ Refuelling will take place during daylight hours only.
						  ○ Job Hazard Analysis (JHA) or equivalent in place and reviewed before each fuel transfer.
						  ○ All valves and flexible transfer hoses checked for integrity prior to use and certified.
						  ○ Dry break couplings (or similar) in place for all flexible hydrocarbon transfer hoses.
						• Only marine gas oil (MGO) will be used for survey activities within the operational area.
						• Pathfinder will not acquire data or undertake close proximity procedures between survey and support vessels within 40 km of the Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park boundaries during the months of September–November.
						• Immediate actions:
						  ○ In the event of a vessel-to-vessel collision, implementation of measures described in the vessel's emergency contingency plans and measures described in the OPEP.
						  ○ In Commonwealth waters, notify AMSA immediately (1 800 641 792 or 6230 6811)
						  ○ In WA State waters, contact DoT MEET immediately (9480 9924)
						  ○ Commence spill monitoring and supply real-time information to control agency as soon as it is safe and practicable to do so
						• Response strategy: The primary response strategy in the event of a diesel spill to sea from the survey vessel will be:
						  ○ Immediate notification to AMSA JRCC.
						  ○ Allow small diesel spills to disperse and evaporate naturally, and monitor position and trajectory of any surface slicks.
						  ○ Physical breakup by repeated transits through larger spills as directed by AMSA/DOT
						• Spill monitoring:
						  1. In the event of a major diesel spill from the survey vessel to the sea, Pathfinder will implement relevant Type I "Operational Monitoring" implemented for spill surveillance and tracking.
						  2. If there is a likelihood of a diesel spill impacting any protected areas (e.g. Mermaid Reef Commonwealth Marine Reserve or Rowley Shoals Marine Park), Pathfinder will:
						  a. notify DPaW and DoE.
						  b. implement the appropriate Type II "Scientific Monitoring" to understand the effects of the spill and any response activities on the marine environment.
						• Stakeholder consultation:
						  ○ Pre-survey consultation with AMSA and DoT to ensure agreement in place for SOPEP interface with NATPLAN, WestPlan-MOP and WA DoT OSCP
						  ○ Consultation in the event of a major diesel spill - relevant stakeholders (apart from Combat Agencies) will be contacted in the event of a large diesel spill occurring in the Nightcap MSS operational area.
						• During the pre-survey planning phase and prior to the commencement of individual surveys located near a sensitive area (e.g. Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park), Pathfinder will have an agreement in place with a third-party response provider to undertake scientific monitoring appropriate to the nature and scale of the spill prior to commencing activities
						• In collaboration with response provider, Type II Scientific Monitoring Plan will be developed and meet the monitoring guidelines and methodologies described in the AMSA Oil Spill Monitoring Handbook (AMSA 2003a) and Oil Spill Monitoring Background Paper (AMSA 2003b).
						• Insurances: Pathfinder has public liability insurance that covers any pollution that could result in environmental damage, specifically pollution emanating from their vessels. As such, this insurance would cover the cost of environmental monitoring or clean-up post spill.
							Acceptable if ALARP

3.2 PLANNED ACTIVITIES (ROUTINE AND NON-ROUTINE)

3.2.1 Vessel Noise Emissions

3.2.1.1 Description of Risk

The source of environmental risk discussed within this section is noise emitted from the survey vessel and support vessel (i.e. engines, propellers, hull flow noise - excluding noise generated by the seismic acoustic source) within the Nightcap MSS operational area causing potential short-term localised disturbance to marine fauna, such as alteration of behaviour and localised displacement.

3.2.1.2 Potential Environmental Impacts

During the survey, underwater noise will be generated from the survey and support vessels. Studies of underwater noise associated with petroleum operations have generally reported that the main source of noise relates to the use of thrusters to maintain vessel position, rather than cruising. Noise characteristics and levels vary considerably between vessel types and the particular activity being conducted.

The sound levels and frequency characteristics of underwater noise produced by vessels are related to vessel size and speed. When idle or moving between sites, vessels generally emit low-level noise. Tugboats, crew boats, supply ships and many research vessels in the 50–100 m size class typically have broadband source levels in the 165–180 dB re 1µPa range (Götz *et al.* 2009). In comparison, underwater noise levels generated by fishing trawlers can peak at around 175 dB re 1µPa, and large ships can produce levels exceeding 190 dB re 1µPa (Götz *et al.* 2009). These levels are significantly lower than the seismic source noise levels discussed in Section 1.3.2.

Underwater noise generated by the presence of the survey vessel may result in incidental changes in behaviour of marine fauna (primarily cetaceans, whale sharks and marine turtles), such as disturbance, avoidance or attraction. However, these impacts are likely to be localized and temporary. Furthermore, underwater noise from the survey vessel is transient, in that the vessel will be moving across large areas rather than concentrating activities in a small area, and the type of noise is no different to that emitted by the commercial shipping traffic and fishing vessels operating in these areas. Given the slow operating speed (generally 4-5 knots), and the low numbers of marine fauna anticipated to be in the area at the time of the survey, the probability of significant impacts from disturbance to marine fauna is assessed to be low.

The survey vessel will slow down within close distances (<300 m) of cetaceans and will generally be operating at slow operating speeds (generally 4–5 knots, unless in an emergency). In addition, the source data indicated that vessel noise emissions from routine operations do not have the intensity and characteristics likely to cause physiological damage to marine fauna. This is further supported by the fact that the noise emitted from seismic vessels is generally of a lower intensity in comparison to stationary vessels utilising night positioning.

3.2.2 Interaction with Other Mariners, including Commercial and Recreational Fisheries, Tourism and Shipping

3.2.2.1 Description of Risk

There are a number of commercial fisheries operating within the area of the Nightcap MSS operational area. Additionally, there is significant commercial shipping activity associated with entry to the Port of Dampier, Port Hedland and Barrow Island. The Rowley Shoals are a known tourist destination associated with diving, eco-tourism and fishing. There is the possibility that fishing, tourism and commercial activities will be disrupted by the physical presence of the seismic and support vessels.

3.2.2.2 Potential Environmental Impacts

Commercial Fisheries

Disruption to fisheries in the Nightcap MSS operational area could result from:

- direct effects of underwater noise disturbance on target fish populations
- indirect effects of underwater noise disturbance on fish prey species

- 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, cray pots
- recreational take of finfish species from the survey vessel and support vessels.

Although the management areas of various fisheries overlap the Nightcap MSS operational area, only five State-managed fisheries and two Commonwealth fisheries may physically overlap the operational area. Potential consequences to commercial fisheries are a temporary loss of access to fishing grounds when the survey vessel is in the operational area, which could result in reduced catches and income.

The MMF, NDSF, PLF, PTMF, WCDSCF and NWSTF may be actively fishing in or adjacent to the operational area. However, the potential for interaction is low, based on an analysis of the current fishery closures, depth range of activity, historical fishing effort data and fishing methods and based on consultation feedback, with proposed mitigation including on-going consultation.

Recreational Fisheries

Due to its distance offshore, recreational fishers in the area generally visit through charter boat operators offering live aboard packages. The main targeted species are marlin and sailfish, but also tuna, mackerel and trevally. The best fishing for most species is between August and March. Although charters may be available all year, the majority commence in September during the best fishing and weather periods. There is the possibility of interaction with charter operated fishing vessels. However, as the numbers will be limited and likely contained to the waters immediately around the Rowley Shoals, with proposed mitigation including on-going consultation, the potential for interaction is low.

Tourism Operations

Disruption to tourism operations in the Nightcap MSS operational area could result from:

- direct effects of underwater noise disturbance on divers
- disruption to 'wilderness character' of Mermaid Reef and therefore diver/snorkeler visual or auditory experience
- restriction of access to tourism locations due to vessel movements and operations.

The majority of vessels visiting the Rowley Shoals are charter boat operators supporting various activities, such as eco-tourism, diving and recreational fishing. Charter boat operators must work through DPaW as part of the licensing requirements, and if the general public wish to visit the Rowley Shoals, they are encouraged to contact DPaW particularly for booking moorings. As such, the DPaW are a main focal point for activities around the Rowley Shoals and thus the best avenue by which Pathfinder can inform stakeholders of the proposed activities. However, based on past consultation with Scope Resources and DPaW, Pathfinder have contact details for the main vessel operators and included them in the stakeholder consultation for this EP.

Vessels supporting activities such as diving, eco-tourism and recreational fishing will generally be limited to the waters around the three atolls of the Rowley Shoals, including MRCMR. As the proposed seismic activities will be limited to the waters outside of the Rowley Shoals Marine Park and the MRCMR, any interactions are likely to be limited to vessels transiting between the shoals and the mainland. As part of their observation duties, the MFO will observe for diving/charter vessels particularly with the aim of determining if there are divers or small boats in the water and outside the reef shoals of MRCMR and Rowley Shoals Marine Park. A survey support vessel will be used to manage all vessel interactions.

Diving

Divers exposed to high levels of underwater sound can suffer from dizziness, hearing damage or other injuries to other sensitive organs, depending on the frequency and intensity of the sound. The human auditory system is significantly less-sensitive underwater than in air and is further degraded if diving equipment obstructs the ears or face (e.g. diving with a hood or full facemask). Underwater auditory threshold curves indicate that the human auditory system is most sensitive to waterborne sound at frequencies between 400 Hz to 1 kHz (Parvin

et al. 1994 as cited in Anthony *et al*. 2009), and these frequencies have the greatest potential for damage. In general, within this frequency band, underwater hearing is 35–40 dB less sensitive than in air. There is some variation in acceptable received sound levels for divers (Ainslie 2008):

- thresholds for military divers (NATO Undersea Research Centre): 177 dB re 1µPa (<250 Hz)
- recreational divers (NATO Undersea Research Centre): 154 dB re 1µPa (600–2500 Hz)
- discomfort threshold non-hooded (DMAC commercial diver guidelines): 196 dB re 1µPa
- advised threshold (Parvin *et al*. 2002 as cited in Ainslie 2008): 155 dB re 1µPa (500–2500 Hz).

Diving and snorkelling is most likely to be undertaken in shallow water on the reef with the view of observing predominantly site-attached wildlife and experiencing the 'wilderness character' of Rowley Shoals. Recreational diving is conducted predominantly in shallow waters <40 m, which is the depth limit that standard recreational dive certification allows (www.padi.com). Predicted received SPL at a location on the 250 m contour at Mermaid Reef (~9 km from seismic source at its closet point) is 157 dB re 1µPa (Section 1.3.4), which is less than noise associated with many powerboats (165 dB re 1uPa; Anthony *et al*. 2009) and is well below safety levels recommended for military divers and DMAC guidelines. At a location on the 30-m contour surrounding Mermaid Reef (~11 km from the Nightcap MSS operational area), acoustic modelling predicted SPL 148 dB re 1µPa (Section 1.3.4), which does not exceed the standard thresholds for recreational divers.

To further contextualise the distance between potential dive/snorkelling locations and the survey vessel, it is worth noting that the maximum visual distance to the horizon on the water surface is approximately 5 km due to the curvature of the Earth. If a survey vessel is at the very edge of the operational area (the closest possible location) and on the boundary of the MRCMR, the proposed activity will be well beyond the limit of possible sight for divers. As such, it is unlikely that the proposed survey activities will significantly impact the visual experience of divers in the waters at Rowley Shoals.

Radford *et al.* (as cited in Anthony *et al.* 2009) measured the transmitted noise levels from three types of underwater breathing apparatus: a self-contained underwater breathing apparatus (SCUBA); semi-closed circuit re-breather (SCR); and a closed-circuit re-breather (CCR) systems. SCUBA produced the most noise, followed by SCR and CCR (161, 131 and 108 dB re 1 µP at 1m, respectively), with much of the noise occurring at low frequencies (<200 Hz). Consequently, recreational divers who will be utilising SCUBA equipment for diving on Mermaid Reef will be exposed to significantly greater noise intensities from the SCUBA equipment itself than from any residual seismic noise on the reef from the survey vessel ~9 km away. It should also be considered that the frequencies of biotic noise emanating from a noisy reef environment and the SCUBA equipment overlap seismic noise frequencies, and so it may be possible that faint remnant seismic emission noise at the reef cannot be distinguished from background (i.e. masked), even by snorkelers who may dive a few meters below the water surface. Nevertheless, in the event that snorkelling/diving is simultaneous with a proposed seismic activity within the Nightcap MSS operational area, the dive charter operators may request that seismic activity be stopped immediately before or during in-water activities.

The only way to dive at the Rowley Shoals is via live-aboard dive boats that are run by charter boat operators. An extensive search of diving tours offered to the Rowley Shoals indicated that all vessels are operated out of Broome and occur between mid-September and late November. Due to the distance from mainland (~260 km from Broome and 12 hours steaming time), the Rowley Shoals are not a heavily-frequented location, and vessels will be limited generally to charter vessels. Therefore, although it is possible that general visitors and charter boat operators may be encountered within or adjacent to the survey area, the numbers are not anticipated to be high. Pathfinder will liaise with DPaW (who manage licences for charter vessel operators) prior to survey activities commencing and to charter boat operators identified in the consultation process. Pathfinder will also ensure that a 7–10 day forecast of operations is circulated to the charter vessel operators and to the general public who wish to use the shoals' moorings and facilities. With Pathfinder's effort to engage with charter and dive operators before a survey commences, the risk of environmental impacts from the survey activities are expected to be low.

However, if pre-survey planning determines that that the proposed survey operations will overlap with specific charter and dive operator, then a final management measure (and only if required) will be to undertake a risk assessment and prepare SIMOPS plan jointly with individual operators. The Diving Medical Advisory Committee guidelines on Safe Diving Distance from Seismic Surveying Operations have been developed for commercial dive operations and suggest the use of underwater audio communications equipment, particularly if divers have the potential to come closer than 10 km of a seismic survey. Nevertheless, the guidelines will be adopted for recreational diving.

Section 3.2.4 details the potential environmental impacts of seismic underwater noise. Benthic invertebrates (such as coral) are keystone features of Mermaid Reef but are only sensitive to noise in the near field (i.e. 10–20 m). Thus, they are not expected to be sensitive to airgun emissions more than 10 km away. Similarly, the Maxima study on seismic noise on Scott Reef showed that received peak-to-peak SPLs >260 dB re 1 µPa induced injury for coral species and that exposure to SEL levels of 180, 187 and 200 dB re 1 $uPa^2 \cdot s$ did not result in any detectable effect on plate corals (Woodside 2007). The same study showed that the Maxima 3D MSS, which was undertaken inside the lagoon at Scott Reef, was unlikely to have any significant impacts on the health and hearing of tropical reef fish. Site-attached fish exhibited startle responses at noise levels >160 dB re $1\mu Pa^2 \cdot s$. For the proposed Nightcap MSS activities, the acoustic modelling results demonstrated that sound levels received at a location on the 250 m isobath at Mermaid Reef (~9 km away from operational area) were predicted to be 150 dB re $1\mu Pa^2 \cdot s$ (Section 1.3.4), and as such, no significant effect on behaviour in fish are expected. Furthermore, acoustic modelling results predicted that sound levels received at a location on the 30 m isobath at Mermaid Reef (~11 km away from operational area) would be reduced to 138.6 dB re $1\mu Pa^2 \cdot s$. The acoustic modelling results included a safety factor of 3 dB to the predicted received levels to provide cautionary results and to reflect the inherent variability of sound levels in the modelled area.

Therefore, based on the predicted sound levels, pre-survey planning and consultation, acceptable diving thresholds and the transient nature of the sound source, significant impacts are not anticipated on diver's or snorkeler's experience of the wilderness character of Rowley Shoals. Furthermore, if after all management measures have been implemented and the potential for interaction still remains, a final precautionary option to reduce impacts is to undertake a joint risk assessment with Pathfinder and the specific charter/dive operator. If required by that joint risk assessment, a SIMOPS plan may be developed cooperatively. Ultimately, the dive vessel may request that all seismic operations cease immediately before and during diving/snorkelling activities. Considering the above, Pathfinder believes that with these management controls and stakeholder engagement, potential interactions with marine tourism from proposed survey activities will be managed to ALARP and acceptable levels.

Shipping

Commercial and domestic vessels inbound and outbound from the Port of Dampier, Port Hedland and Barrow Island will be encountered in the Nightcap MSS operational area (AMSA 2015; Section 2.3.4). It is also likely that recreational vessels will transit through the operational area en route to the Rowley Shoals. Therefore, the survey vessel and towed array represent a potential navigational hazard that require avoidance to prevent vessel collisions, entanglement of and damage to the streamer and other components of the towed array, among other incidents. The highest potential risk will be during the slow-speed turning of the survey vessel during line changes or when it is moving perpendicular to the normal passage of commercial shipping.

As such, clear and effective communication will be maintained with all vessels within the vicinity of the survey activities and whilst the towed array is deployed. There may be a considerable speed difference between commercial shipping and the survey vessel whilst the latter is conducting operations. Any avoiding or diversionary action that may be required by a non-survey related commercial vessel will have to be taken without compromising navigational safety. Thus, the survey vessel master will establish communications early with any potential vessel that may be approaching. A Safe Navigation Area (SNA) will be in place for the duration of proposed survey activities. The extent of this SNA will be specific to the survey vessel and extent of the towed array, covering at least a 10-km radius from the survey vessel to account for the length of the towed streamer array (i.e. 8,100 m). A support vessel will implement the SNA if approaching vessels fail to heed navigational warnings (e.g. NAVAREA X warnings, Notices to Mariners [NTM], beacons, lights, radio contact, etc.).

Furthermore, based on consultation with AMSA (Table 9.2), Pathfinder will notify AMSA's Joint Rescue Coordination Centre (JRCC) for AUSCOAST warning broadcasts 24-48 hours before survey operations commence. AMSA's JRCC will require the vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone) and area of operation and need to be advised when the survey starts and ends. Additionally, the Australian Hydrographic Service (AHS) will be contacted no less than four working weeks before survey operations commence for the promulgation of related NTM. At the conclusion of the survey, Pathfinder will contact AMSA and provide comments on the survey operations and the interactions (if any) with commercial shipping during the survey (i.e. any lessons learned). This information will be communicated to AMSA via a marine traffic log, whereby any close encounters and communications are commented upon.

3.2.3 Biofouling of Vessel Hull, Other Niches and Immersible Equipment & Ballast Water Discharge

3.2.3.1 Description of Risk

Invasive Marine Species (IMS) are marine plants or animals that were introduced into a region beyond their natural range and have the ability to survive, reproduce and establish founder populations. Species of concern vary from one region to another depending on various environmental factors, such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities. IMS have been introduced and translocated around Australia by a variety of natural and human means, including discharge of ballast water, biofouling and aquaculture operations. In the case of Pathfinder's proposed survey activities, the key vectors requiring management attention include:

- discharge of high risk ballast water taken-up at international or domestic sources
- biofouling on vessel hulls and other external niches (e.g. propulsion units, steering gear and thruster tunnels)
- biofouling of vessel internal niches (e.g. sea chests, strainers, seawater pipe work, anchor cable lockers, bilge spaces, etc.)
- biofouling on equipment routinely immersed in water.

Once introduced, IMS may cause serious environmental, social and economic impacts through predation or displacement of native species. These direct or indirect impacts also have the potential to threaten a range of sectors including:

- commercial fisheries and aquaculture
- tourism industry
- human health
- shipping
- infrastructure.

Following their establishment, eradication of IMS populations is often impossible, limiting management options to on-going control or impact minimisation. For this reason, increased management requirements have been implemented in recent years by Commonwealth and State/Territory regulatory agencies, with further legislation currently under development. Reducing the risk of IMS introduction and establishment represents by far the most effective and cost-efficient means of managing the threat of IMS introduction.

3.2.3.2 Potential Environmental Impacts

Ballast Water

Ballast water which may potentially harbour invasive marine species can be released by survey and support vessels during marine seismic surveys. Once introduced, IMS can cause serious environmental, social and economic impacts through predation or displacement of native species. These direct or indirect impacts have the potential to threaten a range of sectors including commercial fisheries and aquaculture, the tourism industry, human health, shipping and infrastructure.

The DoA is the lead agency for management of ballast water from international vessels. The *Biosecurity Act 2015* (Biosecurity Act) replaced the *Quarantine Act 1908*, allowing for significant modernisation of the biosecurity system. The Biosecurity Act introduces new requirements that affect how the department manages the biosecurity risks associated with goods, people and conveyances entering Australia. Ballast water in international vessels has been regulated since 2001 under the *Quarantine Act 1908* and this will continue under the Biosecurity Act. The Act introduces, for the first time, regulation of ballast water on all domestic movements of vessels. Implementation of domestic ballast water regulations has been delayed until the International Maritime Organisations' (IMO) Convention for the Control and Management of Ballast Water and Sediments comes into force. Under the Biosecurity Act, it is an offence to discharge ballast water in Australian seas. The acceptable area for ballast water exchange defined in the declaration is waters that are at least 12 nmi from the nearest land, as defined by the International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 (BWM Convention).

Biofouling

Biofouling on vessel hulls and other external niche areas, on internal niches, and 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. As such, the potential biofouling risk presented by the survey and support vessels within the Nightcap MSS operational area will relate to the length of time that these vessels have already been operating in Australian waters or, if operating outside Australian waters, the location(s) of the surveys undertaken, the length of time spent at these location(s), and whether the vessels have undergone hull inspections, cleaning and application of new antifoulant coating prior to operating in Australian waters.

At this stage, the survey and support vessels that will be used for the proposed survey activities are not confirmed. Vessels may be contracted from companies operating either within or outside Australia. On this basis, Pathfinder shall ensure that all contracted vessels complete an IMS Risk assessment prior to arriving in Australia, and all of the necessary clearances to operate within Australia waters, as required. This includes meeting the biosecurity standards of Department of Agriculture and Food (DAF) and the DoF, who have significant powers to prevent the arrival and establishment of IMS of concern. Any vessel or marine infrastructure destined for WA waters is required to meet the aquatic biosecurity standards set out under the *Fisheries Resources Management Act 1994*, including a Marine Biosecurity Inspection for the presence of known and potential IMS to ensure compliance with Regulation 176. Target marine species of concern to Australian waters can be observed during the in-water inspection in order to ensure the vessel will be considered to pose a low risk of introducing any IMS of concern to Australian waters. Vessels will be coated in an appropriate antifouling system that is considered suitable for both coastal and deep-sea vessels and is compliant with the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (IMO document AFS/CONF/26).

3.2.4 Underwater Noise Emissions from Discharge of Source Array

3.2.4.1 Description of Risk

The proposed survey activities will utilise a seismic acoustic source with an overall broadband SPL (peak) of 248 dB re 1 µPa at 1m (horizontal) to generate acoustic pulses by periodically discharging compressed air into the water column at spatial intervals of ~25 m with frequencies extending up to 200 Hz (Section 1.3.4). The primary environmental risk from seismic surveys is the potential adverse impacts from sound emissions caused by the discharge of underwater seismic pulses. The level of impact to marine fauna depends on multiple factors, such as sound intensity and duration, distance from the source, fauna species and the mitigation measures employed. Potential impacts range from mortality or acute damage from close exposure to high sound levels, to various behavioural responses such as area avoidance (McCauley 1994). Section 1.3 provides an overview of the survey and acoustic source parameters.

Sound Source Justification

The size of the acoustic source will ensure that reservoir targets are imaged correctly and that the most meaningful data can be acquired. Target depths can only be understood once acquisition commences and data analysed. Given the absence of critical habitats, mitigation measures proposed, unknown target depths and

data requirements, disproportionate costs and additional safety risks associated with changing the sound source during surveys, the use of the smallest possible acoustic source (overall broadband SPL (peak) no greater than 248 dB re 1 µPa at 1m) within the Nightcap MSS operational area is considered ALARP and acceptable.

3.2.4.2 Potential Environmental Impacts

The assessment of environmental impacts and associated risks is based on a rigorous and robust interpretation of the currently available science. Whilst every effort has been made to source papers and reports that relate to the circumstances within the operational area, it is not always possible to find examples that directly apply to the specific acoustic source parameters and environmental conditions (e.g. water depth range, seabed geo-acoustical properties, etc.) for surveys conducted within the operational area. This process is further complicated by the uncertainties and shortcomings of the available literature, as outlined above. Studies relating to the environmental effect of marine seismic surveys focused largely on the potential effects to fish stocks and marine mammals from the sound waves associated with the seismic energy source. Concerns included:

- pathological effects (lethal and sub-lethal injuries) – immediate and delayed mortality and physiological effects to nearby marine organisms
- behavioural change to populations
- disruptions to feeding, mating, breeding or nursery activities of marine organisms in such a way as to affect the survival or abundance of populations
- disruptions to the abundance and behaviour of prey species for marine mammals, seabirds and fish
- changed behaviour or breeding patterns of commercially-targeted, marine species, either directly or indirectly and in such a way that commercial or recreational fishing activities are compromised.

The response of marine fauna to seismic survey sounds will range generally from no effect to various behavioural changes. Immediate chronic effects are likely to be restricted to very short ranges and high sound intensities and are unlikely to occur for the majority of species, as most free-swimming animals will avoid areas in which chronic effects may occur. Site-attached species associated with benthic communities may be at greater risk of negative impacts, although no site-attached species are known to occur within the operational area.

Temporary and Permanent Threshold Shifts

TTS occurs when an animal's hearing threshold is temporarily increased during and immediately after an exposure event to a loud sound source (Richardson *et al.* 1995). Permanent threshold shifts (PTS) occurs when an animal experiences a shift in their hearing threshold caused by prolonged or repeated exposure to high sound levels and resulting in permanent and irreversible damage (Richardson *et al.* 1995). Accurately measuring PTS is difficult and not always possible, and thus TTS measurements over time are used to predict likely occurrences of PTS. Figure 3.3 and Table 3.7 show the summary of the draft US weighted and un-weighted threshold levels for TTS and PTS onset for low-frequency (LF) cetaceans (baleen whales), mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales) and high-frequency (HF) cetaceans (true porpoises, pygmy and dwarf sperm whales, cephalorhynchid dolphins, Peale's dolphin and hourglass dolphin) for impulsive sources of noise such as seismic airgun arrays (NOAA 2016).

Functional marine mammal hearing groups, auditory bandwidth (estimated lower to upper frequency hearing cut-off), genera represented in each group, and group-specific (M) frequency-weightings

Functional hearing group	Estimated auditory bandwidth	Genera represented (Number species/subspecies)	Frequency-weighting network
Low-frequency cetaceans	7 Hz to 22 kHz	*Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera* (13 species/subspecies)	M_{lf} (lf: low-frequency cetacean)
Mid-frequency cetaceans	150 Hz to 160 kHz	*Steno, Sousa, Sotalia, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcaella, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Tasmacetus, Hyperoodon, Mesoplodon* (57 species/subspecies)	M_{mf} (mf: mid-frequency cetaceans)
High-frequency cetaceans	200 Hz to 180 kHz	*Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes, Pontoporia, Cephalorhynchus* (20 species/subspecies)	M_{hf} (hf: high-frequency cetaceans)

Source: modified from Southall *et al.* 2007

Figure 3.3 - M-weighting functions for the three groups

Table 3.7 - Summary of acoustic threshold levels for PTS onset for cetaceans

PTS Onset Threshold	Southall *et al.* 2007	Wood *et al.* 2012
SPL_{peak}	230	-
SEL_{cum} (Low-frequency cetaceans)	198	192
SEL_{cum} (Mid-frequency cetaceans)	198	198
SEL_{cum} (High-frequency cetaceans)	198	179

In comparison to Table 3.8, acoustic modelling predicted that the proposed survey activities will have a received cumulative $SEL_{flat,24h}$ of 177 dB re 1 $\mu Pa^2 \cdot s$ (Table 1.6) at a receiver location on the 250 m isobath at Mermaid Reef (i.e. closest sensitive marine habitat ~9 km away). This estimated received level is below the threshold level to induce TTS, PTS, serious injury or potential mortal in various fish, turtles and larvae (Table 3.8). At the receiver location on the 30 m isobath of Mermaid Reef, the acoustic modelling results predicted a further reduced, received cumulative $SEL_{flat,\ 24h}$ of 166.8 dB re 1 $\mu Pa^2 \cdot s$ (Table 1.6). By definition, hearing sensitivity recovers after TTS, and hearing loss from TTS is temporary and acceptable. The extent (i.e. how many dB of hearing loss) and the duration of the TTS may continue from minutes to days after the exposure. Based on the distance of the operational area from any areas of significant site-attached species, the results from acoustic modelling, as well as the transient nature of the sound source and implementation of management controls, adverse impacts from underwater noise is not likely to occur for marine fauna on the shoals and is therefore ALARP and acceptable.

Table 3.8 - Exposure guidelines sound levels for mortality and impairment in fishes and turtles

Source: modified from Popper *et al.* 2014

Type of animal	Mortality or potential mortal injury	Impairment	
		Recoverable injury	TTS
Fish: no swim bladder	>219 dB SEL_{cum} or >213 dB_{peak}	>216 dB SEL_{cum} or >213 dB_{peak}	>186 dB SEL_{cum}
Fish: swim bladder but not involved in hearing	>210 dB SEL_{cum} or >207 dB_{peak}	>203 dB SEL_{cum} or >207 dB_{peak}	>186 dB SEL_{cum}
Fish: swim bladder involved in hearing	>207 dB SEL_{cum} or >207 dB_{peak}	>203 dB SEL_{cum} or >207 dB_{peak}	>186 dB SEL_{cum}
Sea turtles	>210 dB SEL_{cum} or >207 dB_{peak}	-	-
Eggs and larvae	>210 dB SEL_{cum} or >207 dB_{peak}	-	-

Acoustic Impacts on Planktonic Organisms

Based on scientific literature and underwater acoustic modelling (McCauley 1994, McPherson *et al.* 2016), no planktonic organisms are likely to be affected significantly by acoustic source discharges except for fish eggs, larvae and other minute planktonic organisms within a few meters of an airgun. Data presented in Table 3.9 indicated that the range of chronic effects on fish eggs and larvae is likely to be restricted to less than 2 m. Calculations indicated that <0.02% of plankton in an area would be affected, assuming that plankton are distributed uniformly, a single gun array, 18.75-m shot-point intervals and a maximum range of pathological effect 2 m. Data presented in a paper by Popper *et al.* (2014) cite the references and studies outlined in Table 3.9 and determined that eggs and larvae in very close proximity (<5 m) are likely to suffer mortality and tissue damage. Even with this increased radius, the percentage of plankton affected would still be very minor, and the effects from the seismic discharge is insignificant compared with the size of the planktonic population in a survey area or natural mortality rates for planktonic organisms.

Sound exposure guidelines for eggs and larvae indicate that SPL >222 dB re 1 µPa may incur mortality or potential mortal injury while animals nearby have a moderate risk of recoverable injury or TTS (Table 3.9). These predictions are based on work by Bolle *et al.* (2012) on pile driving signals. The acoustic modelling results demonstrated that sound fields from a single shot of the acoustic source would exceed SPL 200 dB re 1µPa within 20 m of the array (Section 1.3.4). As these are the best available data in the scientific literature and based on the acoustic modelling results, it is reasonable to conclude that the predicted sound levels will be below levels that are known to induce mortality or serious injury to planktonic organisms, only within very close proximity to the airgun array.

Table 3.9 – Summary of seismic noise impacts on fish eggs and larvae

Species	Source	Source level (dB re 1 µPa @ 1 m)	Distance from source (m)	Exposure level (dB re 1 µPa)	Observed effect	Reference
Cod (larvae 5 days)	Single airgun	250	1	250	Delamination of the retina	Matishov (1992)
Cod (larvae 2-10 days)	Single airgun	222	1	222	No injuries detected	Dalen and Knutsen (1986)
			10	202	No injuries detected	
Fish eggs (Anchovy)	Single airgun	230 (estimated)	1	230	7.8% of eggs injured relative to control	Kostyvchenko (1973)
Fish eggs (Red Mullet)			10	210	No injuries detected	
			1	230	No injuries detected	
			10	210	No injuries detected	
Dungeness Crab (larvae)	Seven airgun array	244 (estimated)	1	233.5	No significant difference in survival rate relative to controls	Pearson *et al.* (1994)
			1	250	Delamination of the retina	
			1	222	No injuries detected	

Sætre & Ona (1996) calculated that under the 'worst case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population. For a number of fish species, natural mortality is estimated at 5–15% per day. As such, seismic related impacts are so low that it can be considered to have inconsequential risk on recruitment to the populations. Consequently, the potential impacts of seismic operations on fish eggs and larvae would be low to negligible when compared with the size of the planktonic population in the Nightcap MSS operational area, the duration of the survey (short-term), the transient nature of the acoustic source and the inherently-high, natural mortality rates for planktonic organisms.

Acoustic Impacts on Benthic Invertebrates

Based on the consideration of anatomical features related to hearing mechanisms and a review of available studies, McCauley (1994) postulated that the mechano-sensory system of many invertebrates may only perceive the sound of airgun 'shots' close to a seismic source (possibly <20 m from an array). These conclusions suggested that surveys must be run in very shallow water to have an effect. The study contained zones of effect for invertebrates as follows:

- Audible zone ~20 m from the source array
- Response zone ~10 m from the source array
- Pathological zone ~2 m from the source array.

Few marine invertebrates have sensory organs that can perceive sound pressure, but some have organs or elaborate arrays of tactile 'hairs' that are sensitive to hydro-acoustic disturbances (McCauley 1994). These sensory hairs or organs are collectively known as mechanoreceptors, and crustaceans are particularly well-endowed with them. Close to a seismic source, the mechano-sensory system of many benthic crustaceans will perceive the 'sound' of airgun 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).

Decapod crustaceans have a variety of external and internal sensory receptors that are potentially responsive to sound and vibration. Many of these resemble vertebrate receptors that respond to hydrodynamic stimulation, particle motion and possibly pressure. However, the exoskeleton and body plan of aquatic decapods are more capable of responding to particle displacement components of an impinging sound field than pressure changes. The limited acoustic sensitivity of decapods is also related to their lack of gas-filled spaces, such as those associated with pressure detection in fishes. Many decapods have extensive arrays of hair-like receptors, both on and inside their exoskeleton, that most probably respond to water or substrate-borne displacements. They also have many proprioceptive organs that may perceive vibrations (Christian *et al*. 2003).

In an extensive and thorough review, Moriyasu *et al*. (2004) provided a summary of impacts of seismic airguns on marine invertebrates based on literature reviews. They concluded that "very limited numbers of experiments were scientifically and reasonably conducted", but the results of nine quantitative studies showed five cases of immediate (i.e. lethal or physical) impacts of seismic airguns on invertebrate species and four cases of no impacts (Table 3.10). One study showed physiological impacts, whereas another showed no physiological impact. Three cases showed behavioural impacts, and one study showed no impact on behaviour. This review (Moriyasu *et al*. 2004) commented that the papers by La Bella *et al*. (1996), McCauley *et al*. (2003) and Christian *et al*. (2003) provided the most detailed and useful information on the possible impacts of seismic airguns on invertebrates among the documents they examined. Moriyasu *et al*. (2004) concluded that:

"*Squid (McCauley et al. 2000) and crab behaviour (Christian et al. 2003) have been studied by direct observation. Pre- and post-seismic airguns comparisons of catch rates were made by La Bella et al. (1996) and Christian et al. (2003) on various invertebrate species. The quantitative and anecdotal aspects of all other studies were inadequate for assessing the effects of ..... seismic airguns on invertebrates. In addition, in-depth analyses on physiological changes in animals exposed to seismic airguns are quasi-absent.*"

Table 3.10 – Summary of impacts of seismic acoustic source on various marine invertebrates

	Lethal/Physical	Physiological/Pathological	Behavioural	Catch Rate
Negative impacts observed	*Loligo vulgaris* *Chionoecetes opilio* (eggs) *Chlamys islandicus* Sea urchins *Architeuthis dux*	*Bolinus brandaris*	*Alloteuthis sublata* *Sepioteuthis australis* *A. dux*	*B. brandaris*
No impacts observed	*Chionoecetes opilio* *Mytilus edulis* *Gammarus locusta* *Crangon*	*C. opilio*	*C. opilio*	*C. crangon* *Penaeus blebejus* *Nephrops norvegicus* *Illes coindetti* *Squilla mantis* *Paphia aurea* *Anadara inaequivalvis*

La Bella *et al*. (1996; as cited in Moriyasu *et al*. 2004) reported that no apparent changes in trawl catches were found in short-finned squid (*I. coindetti*) nor in Norway lobster (*N. norvegicus*) in the area prospected one day before at sound source levels of 210 dB re 1µPa at 1 m (corresponding to levels of 149 dB re 1µPa at animal location). The same authors reported a lack of apparent catch reductions in mantis shrimp (*S. mantis*) caught by gill nets, and in golden carpet shell (*P. aurea*), inaequivalvis ark shell (*A. inaequivalvis*) and purple die murex (*B. brandaris*), all of which were caught by a hydraulic clam dredge in the area prospected one and two days before exposed to the same sound level mentioned above. However, purple die murex caught by gillnet showed a significant difference in catch rate. Based on the results of catch comparison of this species between hydraulic dredge and gill nets, the authors concluded that this is a change in behavioural reaction to seismic guns rather than immediate mortality (La Bella *et al.* 1996; as cited in Moriyasu *et al.* 2004).

Caged squid (*S. australis*) subjected to an individual operating airgun showed behavioural changes and avoidance (McCauley *et al*. 2003; cited in Moriyasu *et al*. 2004). They found an alarm response at 156–161 dB re 1µPa, and a strong startle response at 174 dB re 1µPa that involved ink ejection and rapid swimming. The caged squid also moved to the sound shadowed area of the cage. The authors suggested thresholds for affecting squid's behaviour were at 161–166 dB re 1 µPa.

After being exposed to sound levels of 197–237 dB from an airgun array, Christian *et al*. (2003; as cited in Moriyasu *et al.* 2004) did not detect effects on the behaviour of snow crab (*C. opilio*) placed in cages and put on the ocean bottom at a depth of 50 m. Additionally, this study found no effects on catch rate of snow crab by comparing pre and post-seismic testing. The catch rates were even higher in post-seismic fishing than pre-seismic fishing. The authors concluded that this was likely due to physical, biological or behavioural factors unrelated to the seismic source. The same study also examined a series of morphological and physiological characteristics, e.g. haemolymph, hepatopancreas, heart, heads (statocysts, green glands, and brains), gills and gonads. They did not find significant effects on the physiological components of tested animals, but noted that embryonic development of external eggs may be delayed after being exposed to seismic airguns (Christian *et al.* 2003; as cited in Moriyasu *et al*. 2004).

In the 2003 and 2004, the Canadian Department of Fisheries and Oceans (DFO) conducted a study on the effects of seismic surveys on snow crabs in conjunction with a seismic survey off the western coast of Cape Breton (DFO 2004). Crabs were caged at water depths of 63 and 73 m (experimental site) and 85 m (control site). The seismic survey involved 132 hours of survey time with a low volume (i.e. 1,310 cui) airgun array. Maximum SPL_{rms} received at the test and control sites were 174 dB re 1µPa and 118 dB re 1µPa, respectively. The caging experiment examined short (12 days) and medium-term (five months) differences in the morphology and physiology of snow crabs at test and control sites. Snow crabs from both groups were also observed under laboratory conditions for differences in mortality, morphology, physiology, feeding and orientation (i.e. turnover rate) over a five-month period. This seismic survey did not cause any acute or mid-term mortality of the crab, nor was there any evidence of changes to feeding in the laboratory. Survival of embryos being carried by female crabs and locomotion of the resulting larvae after hatch were unaffected by the seismic survey. In the short-term, gills, antennules and statocysts (i.e. balance organs) were soiled in the test group, but they were found to be completely cleaned of sediment when sampled five months later. In this study, there was indication of some slight histological differences in the control and test groups, but these differences were attributed to natural variability associated with the different oceanography/feeding regimes at the locations where the control and experimental animals were collected and held in the environment (DFO 2004).

Payne *et al*. (2007) reported on pilot studies conducted in the laboratory and field that investigated the potential for effects of exposure to seismic airgun noise on lobster health. A number of potential effects were assessed, including lobster survival, food consumption, turnover rate, leg loss and various serum parameters. A small histo-pathological study was also undertaken on lobsters used in one of the trials. Exposures of usually 20–50 shots were conducted with a 10 cui and a 40 cui sleeve gun in the laboratory and field, respectively. The lower-level exposures were carried out in a large aquarium, while the higher-level exposures were carried out in the field. Animals were caged during exposure, and after exposure, animals were maintained in aquaria for long-

term observation and sampling. Observations were made over a period of a few days to several months, depending on the specific trial. Sound measurements were conducted on three occasions in the laboratory to determine the received levels at the cage site. Peak-to-peak SPLs averaged ~202 dB re 1µPa with energy densities ranging from 144–169 dB re 1µ Pa^2/Hz. Three separate measurements were also carried-out in the field. The back calculation provided an average received peak-to-peak SPL of ~227 dB re 1µPa and an average peak energy density of 187 dB re 1µPa^2/Hz. Exposure of lobster to "low" (~202 dB re 1µPa peak-to-peak) and "high" (~227 dB re 1µPa peak-to-peak) SPLs had no effects on delayed mortality up to eight months post-exposure, mechanobalancing systems (as demonstrated by lack of effects in righting ability) or loss of appendages. However, sub-lethal effects were observed with respect to feeding and serum biochemistry, with statistically significant effects sometimes being observed weeks to months after low-level exposures. Feeding was generally characterized by an increase in food consumption. A histochemical change (i.e. elevated deposits of carbohydrate) was also noted in the hepatopancreas of animals exposed four-months previously.

A number of studies 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 airgun array with a source peak pressure of 196 dB re 1µPa at 1 m. Catch rates were found to be unaffected. The experiment was undertaken over a period of a few days, whereby immigration would not be a confounding factor. The authors also conducted histopathological studies on gonadal and hepatopancreatic tissue and reported no damage that could be associated with exposure. This study did not detect any significant deleterious impacts of seismic airgun noise on various penaeid species, suggesting that prawn stocks are resilient to the disturbance by airguns under the experimental conditions applied.

The study by Andriguetto-Filho *et al.* (2005) on the effect of seismic surveys on prawn fisheries in Brazil is supported by pilot observations carried out by the DFO on commercially important northern shrimp (*P. borealis*) where no "flight or fright" reactions were found in animals exposed to relatively high sound levels in the laboratory (DFO 2008). Although crustaceans can be expected to detect the particle motion component of sound as revealed by sensitive electrophysiological or other techniques, this did not mean that they would respond and subsequently move away from a seismic operation, thereby causing ramifications for catchability.

Between 1978 and 2004, Parry & Gason (2006) investigated the effect of seismic airgun discharges on southern rock lobster (*Jasus edwardsii*) via statistical analysis of the coincidence between seismic surveys and changes in commercial catch rates in western Victoria. 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. Furthermore, most seismic surveys occurred in deep water, where impacts were expected to be minimal. The apparent lack of impact of seismic surveys on catch rates of rock lobsters was consistent with the limited information available on the physiological effects of seismic surveys on invertebrates, including rock lobsters (Parry & Gason 2006).

From 2013–2015, a long-term study evaluated the acoustic impacts from seismic exposure on southern rock lobsters (*Jasus edwardsii*) in Australia (Day *et al.* 2016). The experimental field research maintained the lobsters in modified lobster pots while a vessel with the acoustic source passed within close proximity to the animals. Sea noise loggers measured maximum sound levels at SEL 189 dB re 1 µPa^2·s and SPL 211 dB re 1 µPa. The results contained no evidence of lobster mortality for any experiment, as well as no evidence of impact to lobster embryos, which were described as resilient to the acoustic exposure. However, reflex behaviours, sensory hairs and biochemistry levels indicated high levels of impairment and/or damage, all of which have the potential to compromise other behaviours and biological responses. These results need to be interpreted with caution, particularly as the lobsters were maintained in pots and prevented from swimming away to avoid the sound source. Also, these experiments were undertaken in shallower water (10–12 m) than the Nightcap operational area (>100 m deep). Furthermore, at a location within the Nightcap operational area in 398 m water depth, acoustic modelling results estimated that the received sound levels at the seafloor would be SPL ~200 dB re 1 µPa (McPherson *et al.* 2016), which is less than the SPL measured (~210 dB re 1 µPa) in the shallow-water, lobster experiments at ~20 m away (Day *et al.* 2016). Therefore, while the recent lobster field experiments provide the most robust and accurate data available, similar acoustic impacts are not likely to result from the survey activities

in the Nightcap operational area, which is in deep water and with lower estimated received sound levels. Nonetheless, Pathfinder will monitor any further scientific publications on this topic, evaluate the results and where warranted, review and modify control measures in this EP.

Based on the scientific data presented here, the majority of benthic crustaceans are likely to exhibit a behavioural response to airgun pulses at very close ranges, which means that only surveys occurring in very shallow water would have the observed impacts. A conservative figure for the minimum depth for a response would be 15 m from the array (McCauley 1994). For the Nightcap MSS operational area, seismic acquisition will not occur in water shallower than 100 m, and the operational area is ~4 km from the boundary of the MRCMR, closest point of which is in water 310 m deep. Regarding commercial fisheries, the WCDSCF and NWSTF operate mostly in deep water (i.e. 500–800 m and >200 m, respectively), and while their licence areas overlap the Nightcap operational area, high levels of fishing operations are unlikely in the operational area, based on the large size of the fisheries' license areas, the lack of sensitive or critical areas for these fisheries in the operational area, and the low current fishing effort and activity levels of these fisheries. Thus, any disturbance to benthic crustaceans immediately beneath an airgun array would be transmitted in deep-water (>100 m depth) and extremely short-lived, as they would be only exposed to one or two pulses before the source moves out of the potential range within which any disturbance may occur.

Bivalve molluscs

Little is known about sound detection in invertebrates. However, many species have mechano-sensory structures that have some resemblance to vertebrate ears. Many molluscs, including bivalves, possess statocysts, which are organs that assist the organism in maintaining balance and orientation in its immediate environment. Statocysts are fluid-filled, capsule-like sensory organs, usually including ciliated hair cells and containing a single dense body (statolith) or a number of smaller ones (statoconia). The statolith and/or statoconia interact with the cilia lining the capsule, probably (as has been shown in gastropods and cephalopods) conveying information about orientation to the organism. They may also enable the animals to detect low-frequency pressure waves in sediment, either in the pore-water or as vibrational signals associated with movements of sediment particles (Wethey & Woodin 2005). Additionally, proprioception (i.e. the sensing of movement of bodily tissue by acoustic energy) may be involved in the detection of sound in invertebrates, including bivalves (McCauley & Kent 2008).

It has been postulated that statocyst organs may be receptive to the particle acceleration component of a sound wave, possibly in the far-field (Hawkins & Myrberg 1983, as cited in McCauley 1994). Franzen (1995) showed that tellinid bivalves (*Macoma balthica*) are sensitive to frequencies in the range of 50–200 Hz, which corresponds to shear-wave vibrations that propagate along the sediment surface. A study on the ox-heart clam (*Glossus humanus*) demonstrated sensitivity to vibrations and hypothesized as related to sensing breaking waves on the incoming tide, allowing the clam to move with the tide (Frings 1964, as cited in McCauley & Kent 2008). *Donax variabilis*, a coquina clam, responded to pressure signals in the range of 20 Pa, or a sound pressure level of 140 dB (Ellers 1995). In at least one other bivalve species, response to sound was evident by changes in aggregations. Low frequency sound (30–130 Hz) was demonstrated as an effective control measure for zebra mussel fouling (Donskoy & Ludyanskiy 1996).

Although there are only a handful of studies that examined the potential effects of seismic airgun noise on bivalve molluscs (including Le Provost *et al.* 1986), it appears that several species of bivalves (including two oyster species) are remarkably resilient to the shock waves created by the detonation of high explosives underwater. It is difficult to determine at what distances from an airgun array would sub-lethal effects (such as morphological, biochemical and physiological changes being indicators of some level of stress in an animal) occur in bivalve molluscs, such as pearl oyster. La Bella *et al.* (1996) examined biochemical indicators of stress in bivalves exposed to seismic airgun noise and found that hydrocortisone, glucose and lactate levels between test and control animals were significantly different ($P > 0.05$) in the venerid clam *P. aurea*, showing an evidence of stress caused by underwater noise. This was at a minimum exposure range of 7.5 m.

In the past, commercial scallop fishermen expressed concerns about the potential impacts of seismic surveys on their catch levels. In a study off the Isle of Man, Brand and Wilson (1996) assessed the effects of seismic surveys in the field by comparing long-term, catch-per-unit-effort (CPUE) of commercial scallops with CPUE

following a seismic survey. They found no evidence that seismic surveys affected CPUE of scallops and attributed a decline in scallop CPUE coincident with two years of poor recruitment prior to the seismic survey. Similarly, in the Bass Strait, scallop fishermen expressed concern that seismic acquisition might kill scallops (*Pecten fumatus*), weaken their adductor muscles (indication of sub-lethal effects) or increase the mortality of larval scallops. In a study conducted by the Victorian Marine and Freshwater Research Institute (MAFRI), the effects of seismic airgun noise were measured by comparing both mortality and adductor muscle strength of scallops deployed in an area exposed to passes of a survey vessel towing an operating, 24-airgun array, with those in a control area 20 km away from the test area (Parry *et al.* 2002). The effects of seismic testing on plankton, including larval scallops, were measured by comparing plankton communities immediately behind the seismic vessel with those sampled before and at a 2-km distance from the seismic testing. This study found that both mortality rate and adductor muscle strength of scallops suspended in the water column and exposed to the operating airgun array at a minimum distance of 11.7 m were not significantly different from the controls. Similarly, there was no major difference in the abundance of plankton (including bivalve larvae) behind the seismic survey vessel from their abundance before the passage of the vessel or 2-km distance from the vessel. High levels of variability in plankton communities meant that only large changes would have been detected, but the available literature suggests that effects on plankton are confined to ranges within 5 m of airguns (Parry *et al.* 2002).

A study conducted by the Tasmanian Aquaculture and Fisheries Institute (TAFI) assessed the immediate impact of seismic surveys on adult commercial scallops (*P. fumatus*) in the Bass Strait (Harrington *et al.* 2010). As a response from concerned scallop fishermen, TAFI was commissioned by AFMA to undertake a 'before and after' study of the effects of the seismic survey on the target species. The study examined the short-term effects of seismic acquisition on health and abundance of adult scallops. The health parameters considered were gonad and meat condition to represent sub-lethal impacts and based on a three-month seismic acquisition programme using a 4,240 in^3 seismic source. The study found no change in the condition or abundance of live scallops in the impacted site compared to a control site, with gonad condition, meat size and meat texture remaining relatively unchanged. There was also no observable change in the size frequency distribution of scallops in the impacted and semi-impacted sites following the seismic survey. The conclusion was that no short-term (<two months) impacts on the survival of adult commercial scallops were detected after the seismic survey.

From 2013–2015, a long-term study evaluated the acoustic impacts from seismic exposure on scallops (*Pecten fumatus*) in Australia (Day *et al.* 2016). The experimental field research maintained the scallops in mesh enclosures while a vessel with the acoustic source passed within close proximity to the animals. Sea noise loggers measured maximum sound levels at SEL 189 dB re 1 $\mu Pa^2 \cdot s$ and SPL 211 dB re 1 µPa. The scallops did not result in mass mortality after acoustic exposure, but the mortality risk increased significantly with time, with the majority of mortality recorded 120 days post-exposure. However, potential impacts from repeated or prolonged exposure were not determined in this study. In addition, scallop behaviours, osmoregulation and biochemistry levels were impaired and affected significantly following acoustic exposure, and further investigation will be required to determine ecological and long-term impacts to the species and relevant commercial fisheries. Scallop larvae were not used in this experiment (i.e. adults only), and potential impacts to other life stages were not measured and remain unknown. The ecological implications of these impacts were not evaluated within the scope of these experiments. Also, these experiments were undertaken in much shallower water (10–12 m) than the Nightcap operational area (>100 m deep). Furthermore, at a location within the Nightcap operational area (i.e. 398 m deep), acoustic modelling estimated the received SPL of ~200 dB re 1 µPa within a horizontal distance <160 m from the source (McPherson *et al.* 2016). Therefore, while the recent scallop field experiments provide the most robust and accurate data available, similar acoustic impacts are not likely to result from the survey activities in the Nightcap operational area, which is in deep water and with estimated received sound levels.

Another recent study on the potential short-term impacts of marine seismic surveys on scallops in the Gippsland Basin was undertaken in response to stakeholder concerns from the fishing industry about an April 2015 seismic survey in the Gippsland Basin (Przeslawski *et al.* 2016). Sound monitoring was undertaken for the 2015 seismic survey using four calibrated acoustic recording units that were moored at varying seafloor depths (44–70 m) within the study area, including one control >25 km from seismic survey operations, with a dynamic range of

SPL up to 165 dB re 1 µPa. The highest SEL recorded by the hydrophones was 146 dB re 1 $\mu Pa^2 \cdot s$ at 51 m water depth, at a distance of 1.4 km from the airguns (Przeslawski *et al.* 2016). The authors concluded that these SELs did not cause mass mortalities two months after sound exposure, such as that observed previously in 2010. Scallop density was low, and long-term and sub-lethal effects remain unknown. Such mortality events are more likely due to other stressors (e.g. disease outbreaks, heat waves, etc.) or a combination of stressors of which noise exposure may be included. However, this theory warrants further research. At a location within the Nightcap operational area (i.e. 398 m deep), acoustic modelling results estimated that the received sound levels would be SPL ~150 dB re 1 µPa at horizontal distances ~25 km away (McPherson *et al.* 2016). Therefore, while these scallop field experiments provide the most robust and accurate data available, similar acoustic impacts are not likely to result from the survey activities in the Nightcap operational area, which is in deep water and with substantially lower estimated received sound levels. Nonetheless, Pathfinder will monitor any further scientific publications on this topic, evaluate the results and where warranted, review and modify control measures in this EP.

From studies to date, it seems that significant impacts on bivalve molluscs (such as the pearl oyster) from airgun noise emissions will only occur within short distances from the acoustic source. A conservative estimate for a minimum distance beyond which significant effects are unlikely is ~10 m, but this will depend on the source dynamics and propagation characteristics of the area. Benthic environments that may support bivalve molluscs are mostly limited to the shallow waters (<35 m) offshore of Eighty Mile Beach, which is >190 km away from the Nightcap MSS operational area boundary. Thus, significant impacts from underwater noise are not expected to occur within the distance known to cause effects (<10 m from the source) to bivalve molluscs. Furthermore, proposed survey activities will not occur in water depths <100 m, thereby reducing any likelihood for significant impacts from underwater noise on bivalve molluscs.

Acoustic Impacts on Fish

Fishes like other vertebrates have two inner ears within similar structure. The basic mechanism for transduction of sound into electrical signals is the sensory hair cell. High-intensity sounds are able to fatigue, damage or kill these cells resulting in temporary or permanent haring loss. Fish, however, unlike other tetrapods, are able to regenerate sensory hair cells throughout their lives. In addition, hair cells damaged as a result of exposure to sound may cause a temporary shift in auditory thresholds (i.e. TTS) and can subsequently be replaced (Popper & Hastings 2009).

The majority of fish species detect sounds from below 50 Hz and up to 500–1,500 Hz. A smaller number of species can detect sounds over 3 kHz, while very few species can detect sounds over 100 kHz. The critical issue for understanding whether an anthropogenic sound affects hearing sensitivity is whether the sound is within the hearing frequency range of a receptor fish and with enough acoustic intensity to be detected. For this risk assessment, a precautionary approach (i.e. worst case scenario) concludes that all fish have hearing within the 0–200 Hz frequency range and thus are able to detect the seismic source.

Potentially direct impacts on fish species related to the operation of survey airgun arrays include behavioural avoidance of seismic sound sources, TTS, PTS or mortality. Indirect effects may include reduced catches resulting from changes in feeding behaviour and vertical/horizontal distribution (Skalski *et al.* 1992). Behavioural responses to sounds are variable but include:

- leaving the area of the noise source/avoidance (Skalski *et al.* 1992, Wardle *et al.* 2001)
- startle/alarm responses (Pearson *et al.* 1992, Wardle *et al.* 2001)
- spatial changes in schooling behaviour/swimming patterns (Slotte *et al.* 2004, Woodside 2007)
- changes in depth/vertical distribution (Pearson *et al.* 1992, Slotte *et al.* 2004, Woodside 2007).

These effects are expected to be short-lived, with duration of effect less than or equal to the duration of exposure. The effects vary between species and individuals and are dependent on the properties of received sound (DFO 2004). The ecological significance of such effects is expected to be low, except where they influence reproductive activity. For some fish, strong 'startle' responses have been observed at SPLs of 200–205 dB re 1µPa, indicating that sounds at or above this level may cause fish to move away from the vessel. Except for areas

directly under a sound source, sound levels of this intensity are likely to occur ~100–200 m from an airgun array. Based on this, an approximate range of 200 m is given as the minimum distance at which fish may move away from an operating array and below which physical effects may occur (McCauley 1994). Additional studies (McCauley *et al.* 2003) found that active avoidance may occur in some fish species when exposed to sound levels with SPL ~161–168 dB re 1µPa, which corresponds to a horizontal distance of ~2–3 km from the acoustic source (Section 1.3.34). Therefore, compared to the predicted sound levels received within the 250 m depth contour at Mermaid and Clerke Reefs (SEL ~142 dB re 1µPa^2·s and SPL ~151 dB re 1µPa at ~9 km away from operational area), fish species are not likely to exhibit behavioural responses to the seismic acoustic source. These levels are aligned with published scientific results from a study at Scott Reef (Woodside 2007), in which the threshold of received SELs that could result in various behavioural effects in fish included:

- avoidance at >140 dB re 1µPa^2·s (pelagic species and the more nomadic demersal species)
- startle/alarm at >160 dB re 1µPa^2·s (species with limited home ranges or site-attached and/or territorial strategies)
- fright/flight at >180 dB re 1µPa^2·s (species with limited home ranges or site-attached and/or territorial strategies).

Available evidence suggested that behavioural changes for some fish species may be no more than a nuisance factor, and that within a few seconds, fish are likely to continue their previous activity. The temporary, short-range displacement of pelagic or migratory fish populations may have insignificant repercussions at a population level (McCauley 1994). For site-attached reef fish, spatial patterns of richness, abundance and diversity did not change after exposure to airgun noise emissions (Woodside 2007). A study of the fish community at Scott Reef was undertaken before and after the Maxima 3D seismic survey in 2007, and included small, site-attached demersal species belonging to the Family Pomacentridae (Miller & Cripps 2013). Data from underwater visual census were combined with a decade of historical data to assess the potential impacts from the seismic survey. Taking into account spatial, temporal and observer variability, statistical modelling showed no significant effect of the seismic survey on the overall abundance or species richness of Pomacentridae. Thus, no detectable effect of the seismic survey was found on the abundance of these fish species at Scott Reef. Similarly, Wardle *et al.* (2001 as cited in Popper & Hastings 2009) found that fish and invertebrates on a rocky reef in Scotland only showed minor behavioural responses to an airgun with a measured peak level of 210 dB re µPa at 16 m and 195 re µPa at 109 m. They also noted no permanent changes in the reef fish or invertebrate behaviours throughout the study, as no animals left the reef and no damage was observed.

Based on existing information, impacts on fish populations resulting from seismic survey noise are likely to be restricted to the following:

- surveys that take place over protracted periods close to areas important for the purposes of feeding, spawning or breeding
- surveys that take place over protracted periods close to areas that constitute narrow, restricted migratory paths
- populations that cannot move away from operating arrays (e.g. site-attached reef species that experience short ranges and high sound intensities).

At the population level, fish may be impacted if behavioural responses result in displacement from migration paths or disturbance of spawning, thereby affecting recruitment of fish stocks. The major performance measures for the fish stocks in the Pilbara demersal fisheries relate to breeding stock levels of the long-lived and short-lived finfish indicator species. The target spawning biomass is 40% of the level when catch was first recorded, and the limit level is 30% of the initial spawning biomass. An age-based stock assessment model for red emperor and Rankin cod (i.e. long-lived indicator species) was last run in 2009, and outcomes indicated that spawning biomass of both these species were >40%, indicating satisfactory breeding stock levels (Fletcher & Santoro 2015). Considering the distribution range of key species in this area, adequate spawning biomass levels and unrestricted migratory routes, the potential impact on fish populations from the proposed survey activities is considered to be low.

Short-term effects on commercial and recreational catches may occur within and around the operational area. Sound effects on fish catches are somewhat equivocal because of the lack of determination between natural movements and changes in fish. However, one comprehensive study by Engås *et al.* (1996) observed cod and haddock moving back within an area 3–5 days after seismic survey exposure. Similarly, Slotte *et al.* (2004) observed westward movement of large masses of blue whiting and herring towards and into the survey area 3–4 days after seismic shooting, indicating that migrations proceeded as normal soon after a seismic survey. Therefore, any disruptions would likely be short-term and during the course of the survey, with conditions returning to 'normal' levels soon after.

The level and duration of exposure that causes TTS varies widely and can be affected by factors such as repetition rate of the sound, pressure level, frequency, duration, health of the organisms, etc. By definition, hearing recovers after TTS. The extent (i.e. how many dB of hearing loss) and duration of the TTS may continue from minutes to days after the end of exposure. Based on various studies, including investigations on the effects of seismic sound exposure on fish at Scott Reef (Woodside 2007), the following threshold received SELs could result in various sub-lethal and/or physiological effects:

- onset of short-term reversible loss in hearing sensitivity (TTS) cumulative SEL at >180 dB re 1μPa^2·s
- onset of long-term loss in hearing sensitivity (TTS/PTS) cumulative SEL at >187 dB re 1μPa^2·s
- TTS onset but no injury to non-auditory tissues to ~1 kg sized fish at >200 dB re 1μPa^2·s.

Assessment of chronic effects of airgun sounds on fish species have usually involved exposure of captive or caged fish to nearby sound sources. Studies with caged fish (Kosheleva 1992, McCauley *et al.* 2003) showed that some caged fish were unable to swim away from the noise source and suffered physiological damage to eyes and hearing. Popper *et al.* (2014) proposed minimum levels that may result in recoverable injury and mortality or potential mortal injury:

- recoverable injury:
  - no swim bladder: >216 dB SEL_{cum} or >213 dB_{peak}
  - swim bladder not involved in hearing: >203 dB SEL_{cum} or >207 dB_{peak}
  - swim bladder used for hearing: >203 dB SEL_{cum} or >207 dB_{peak}
- mortality and potential mortal injury:
  - no swim bladder: >219 dB SEL_{cum} or >213 dB_{peak}
  - swim bladder not involved in hearing: >210 dB SEL_{cum} or >207 dB_{peak}
  - swim bladder used for hearing: >207 dB SEL_{cum} or >207 dB_{peak}.

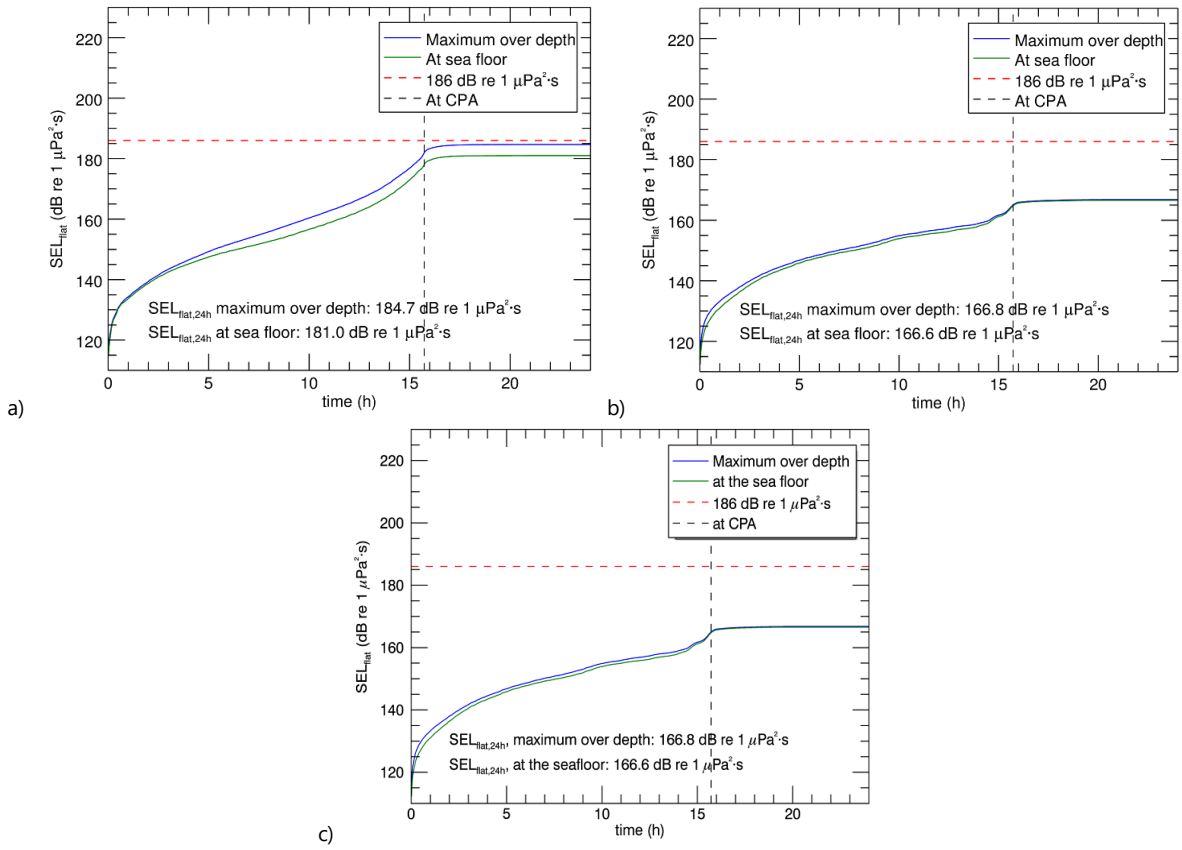
There are no documented cases of fish mortality from exposure to seismic airgun noise under field-operating conditions (DFO 2004). An experiment with river fish in cages 1.9 m deep were exposed to 5–20 shots from 730 cui airgun array with average SEL 175–180 dB re μPa^2·s to mimic a 2D survey (Popper *et al.* 2005). Airguns were 1.8 m deep and approx. 1900 psi. Results showed substantial differences for different species of fish, as species with most sensitive hearing had greatest TTS measured. TTS occurred for two of the three species, and hearing recovery was within 18–24 hours of exposure. The third species had no observable TTS. No impacts were observed on internal organs, including swim bladders which were fully intact. No substantial impacts were concluded to be likely, but caution should be used when extrapolating these results to other species in deeper waters or longer durations as sound propagates differently in shallow and deep water, with low frequencies transmitting less in shallow water. Therefore, this study presents the best available data for fish exposed to seismic sounds measured in SEL. As such, TTS recovery is possible for some fish species following exposure to seismic sounds. Furthermore, fish are unlikely to be exposed to 20 shots from a seismic source, and actual sound exposure depends on vessel speed and fish movements.

In addition, 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. However, these effects were not considered 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
- seismic surveys are not expected to result in destruction or adverse modification of critical or essential fish habitat.

In the NWS region of the Nightcap MSS operational area, site-attached fish species are predominantly associated with the reef shoal edges and plateaus, while the surrounding seafloor of the outer mid-shelf is covered by a relatively featureless, sandy-mud seabed with a sparse covering of sessile organisms dominated by filter-feeding heterotrophs. As the acoustic source will not be discharged closer than 9 km from the reef edge (i.e. 250 m contour), it will be discharged over the seafloor and not over sensitive environments (such as the shoals tops/plateaus). No seismic activities will occur within the boundary of the MRCMR. Also, Mermaid Reef has a steep slope of ~3 km from the reef edge, with water depths rising from the seafloor >350 m deep. Furthermore, the proposed survey activities within the operational area and closest to the MRCMR boundary will be in waters >300 m deep. Underwater acoustic modelling predicted that the sensitive environments located on the upper parts of Mermaid Reef (~11 km away) are in an area of reduced sound amplitude resulting from the steep incline and seabed topography at the reef (Section 1.3.4; Figure 1.5). The acoustic modelling results demonstrated that received SELs <140 dB re 1 $\mu Pa^2 \cdot s$ are likely to occur over the reef and shoals at Mermaid Reef, and thus not likely to induce behavioural changes, TTS, PTS or mortality for fish.

The Nightcap MSS operational area does not contain environmental habitats or conditions that could result in fish being trapped (e.g. site-attached species) and unable to move away from the noise source. The majority of the benthic habitat is sand/mud containing limited infauna. In the open waters of the operational area, fish and other marine fauna have the ability to move away from increased noise levels and are unlikely to be significantly affected by seismic sound exposure. Also, there will be no seismic data acquisition (i.e. shot points) in water depths <100 m. Furthermore, acoustic modelling results estimated accumulated SELs over 24 hours of a representative seismic survey line closest to the MRCMR (i.e. closest sensitive habitat for marine fauna) and demonstrated that acoustic thresholds for fish TTS are not reached at any of the three receiver locations (Section 1.3.4; Figure 3.4). Therefore, based on the lack of sensitive benthic habitats or restricted environments, it is unlikely that the proposed survey activities will have significant acoustic impacts on fish within the operational area.



Source: McPherson *et al.* 2016

Figure 3.4 – Predicted SEL accumulated over 24 hours at: (a) Site 1 MRCMR; (b) Site 2 on the 250 m isobath; and (c) Site 3 on the 30 m isobath. Red dashed lines indicate acoustic threshold for fish TTS. Black dashed lines indicate closest point of approach.

A range of potential control measures to reduce acoustic impacts to fish were considered. From this assessment, Pathfinder will implement the use soft-start procedures and acquire seismic data in water >100 m. Therefore, based on the scientific evidence presented above, the estimated sound levels from acoustic modelling, the transient nature of the sound source and the control measures implemented, it is reasonable to conclude that underwater noise from the seismic acoustic source will not have a significant impact upon any fish or site-attached fauna species.

Acoustic Impacts on Seabirds and Shorebirds

Underwater noise from seismic surveys is not anticipated to have a direct effect on seabird or shorebird species, due to the method of the activity and the transient nature of birds and vessels within the operational area. Only bird species that plunge dive (such as the white-tailed tropicbird) could potentially be exposed to underwater noise, although little or no impact is expected. However, only a single pair of white-tailed tropicbirds are known to occur at the Rowley Shoals (DSEWPaC 2012a), and if this pair foraged within the Nightcap MSS operational area, this species is capable of traveling significant distances (>1,660 km) and would not be restricted in its foraging resources. Thus, significant impacts to this pair/species are unlikely to occur as a result of exposure to the seismic acoustic source.

In general, it is unlikely that adverse impacts will significantly affect the survival of seabird populations within the vicinity of a seismic survey. Stemp (1985, cited in LGL 2012) conducted observations on the effects of seismic exploration on seabirds and did not demonstrate any negative effects. Lacroix *et al.* (2003 as cited in LGL 2012) investigated the effect of nearshore seismic surveys on moulting long-tailed ducks in the Beaufort Sea, Alaska, and also failed to detect any negative effects. This study noted that seismic activity did not appear to change the diving intensity of the ducks significantly. Additionally, the *EPBC Act Policy Statement 3.21* did not identify any impacts and risks to shorebirds from offshore seismic activities (Department of the Environment and Energy

2016d). However, it is likely that some species may be affected indirectly through localised, temporary displacement and modified prey abundance.

Seabirds may be displaced physically by vessels or as a result of increased noise at the surface of the water only. However, as a result of acoustic source directivity being focused downwards towards the seabed, sound levels are thereby reduced with increasing distance from the source. Thus any potential displacement is anticipated to be temporary and insignificant. Pelagic seabirds (e.g. terns, shearwaters and frigatebirds) cover large areas when foraging (>100 km), and any displacement is limited to the area close to the vessel. Based on the sound source's acoustic properties of a downward signal and the temporary nature, any impact is anticipated to be temporary and no more than slight behavioural changes.

Prey abundance could either increase or decrease as a result of seismic activities. If seismic activities disorients prey species (such as fish and invertebrates) or increases the availability of prey species to marine birds, a seismic survey may attract birds, as often observed by MFOs. Alternatively, if prey species exhibits avoidance of the vessels or source, it is expected to be temporary and limited to a very small portion of a bird's foraging range. Seismic effects on prey species are expected to be limited to short-term behavioural displacement (see above). Therefore, it is unlikely that seabird prey species will be affected by seismic activities to a significant degree that affects the foraging success of birds, particularly at the population level. No additional controls will be implemented as impacts and risks to seabirds and shorebirds have been identified as acceptable and ALARP.

Acoustic Impacts on Sharks

The available evidence indicated that sharks will generally avoid seismic sources, and that the likely impacts on sharks are expected to be limited to short-term behavioural responses, possibly including avoidance of the operating acoustic source. It is highly unlikely that the underwater noise emissions from the acoustic source would cause any pathological effects (e.g. lethal and sub-lethal injuries), with no immediate and delayed mortality and physiological effects on grey nurse or white sharks.

It is expected that the potential effects to whale sharks resulting from exposure to underwater noise will be the same as other pelagic fish species, resulting in minor and temporary behavioural change (such as avoidance). Although there are no known studies on the auditory bandwidth for whale sharks, their hearing sensitivity is likely to be similar to that of other sharks. As such, the large hearing structure of the whale shark will be most responsive to long-wave, low-frequency sound (Myberg 2001) in the range of 20 and 800 Hz. While the *Whale Shark Recovery Plan* (DEH 2005) identified numerous possible threats to whale sharks, those applicable to seismic surveys within the Nightcap MSS operational area include pollution and marine debris or interference. Acoustic damage was not identified.

A foraging BIA for the whale shark overlaps a small proportion of the southern corner of the Nightcap MSS operational area, and it is possible that whale sharks may be encountered during individual surveys, particularly during the months from July–November (TSSC 2015b). During these months, operation of the seismic source within the whale shark BIAs (as identified on the NCVA) will comply with all requirements of the EPBC Act Policy Statement 2.1 Part A Standard Management Procedures. Also, interactions between vessels and whale sharks within the operational area will be consistent with the *Whale Shark Management Plan* (Program 57; DPaW 2013), and as such, vessels will not knowingly approach closer than 400 m of a whale shark. Therefore, based on the likely rare and infrequent occurrence of whale sharks throughout most of the operational area, as well as the transient nature of the seismic acoustic source and implemented management controls, potential impacts from the proposed seismic acoustic source to whale sharks will likely be temporary and infrequent.

Acoustic Impacts on Marine Turtles

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 400–1,000 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 vocalisation abilities, which are also in the low frequency range (100–700 Hz). Electrophysiological responses, specifically auditory evoked potentials (AEPs), are the most widely-accepted technique for measuring hearing in situations in which behavioural testing is

impractical. AEP studies on hearing have been conducted on various species and stages of life, and indicated that the best hearing range for marine turtles is in the range 100–700 Hz, which overlaps with the frequency range of maximum energy in the horizontally propagating component of a seismic array 'shot' (McCauley 1994).

Bartol *et al.* (1999 as cited in BOEM 2014) found that juvenile loggerhead turtles detect sounds in the low frequency range, between 250–1,000 Hz, with the most sensitive around the 250 Hz. Bartol and Ketten (2006) studied hatchling and juvenile loggerhead and juvenile green turtles, and found that juvenile turtles responded to 100–400 Hz. In that study, all turtles responded to sounds in the low frequency range from 100–900 Hz. However, hatchling loggerheads had the greatest range of hearing (100–900 Hz), while the larger juveniles responded to a much narrower range (100–400 Hz). Hearing sensitivity of green turtles also varied with size: smaller green turtles had a broader range of hearing (100–800 Hz) than that the larger subjects (100–500 Hz). Piniak *et al.* (2012) found that leatherback sea turtle hatchlings are able to detect sounds between 50 and 1,200 Hz, with maximum sensitivity between 100 and 400 Hz. Like other species of marine turtle, they appeared to have a relatively narrow, low-frequency range of hearing sensitivity.

Lavender *et al.* (2012) detected no significant differences in behaviour-derived auditory thresholds or AEP-derived auditory thresholds between post-hatchling and juvenile loggerhead turtles. Marine turtles reside in different acoustic environments for each life history stage and may have different hearing capacity throughout ontogeny. However, research indicated that hearing frequency range (50–1,100 Hz) and highest sensitivity (100–400 Hz) were consistent, indicating that that post-hatchling and juvenile loggerhead sea turtles are low-frequency specialists, exhibiting little differences in threshold sensitivity and frequency bandwidth despite residence in acoustically distinct environments throughout ontogeny. Subsequently, the effects of seismic sounds on marine turtle hatchlings are anticipated to be similar to those of juveniles and adults.

Surveys in shallow waters (<15 m) near nesting beaches may expose both mating and internesting females as well as hatchlings to increased sound levels. Mating turtles and internesting females are not thought to favour deeper waters (>15 m), and while the air gun discharges may be audible in the deeper water, it is unlikely that the received sound levels would be of sufficient intensity to cause a startle response in the animals (Pendoley 1997). There will be no seismic data acquisition (i.e. shotpoints) in water depths <100 m.

Similarly, Pendoley (1997) concluded that it was unlikely that the noise associated with seismic discharges would override the biologically imprinted drive in turtle hatchlings to complete the initial 24-hour 'swim frenzy' that takes them out to sea as quickly as possible. At most, the sound may cause the hatchlings to deviate from their course to sea. Given the very high mortality rate in hatchlings, it was unlikely that the effects of seismic discharge on them would be measurable (Pendoley 1997). Observations of turtle behaviour were made during a seismic survey in North West Shelf and showed no signs of panic or distress in the turtles in the vicinity of the vessel during discharge of the air guns. The observed behaviour consisted of either 'steady swimming' or 'diving' to avoid the vessel.

Despite some variation in test results, the hearing ranges overlap the frequency range of maximum energy in the horizontally propagating component of a seismic array 'shot' (McCauley 1994). Studies indicated that marine turtles may begin to show behavioural responses to an approaching seismic array at received sound levels of ~166 dB re 1 µPa (rms), and avoidance at around 175 dB re 1 µPa (McCauley *et al.* 2003). Eckart *et al.* (2004) used GPS and Time Depth Recorders (TDR) to track movement and behaviour of two leatherback turtles exposed to seismic source noise. They found no change in behaviour or movement from previous turtles that were not exposed to seismic survey noise. Weir (2007) carried out observations from on-board a seismic survey vessel during a 10-month 3D survey offshore from West Africa. She concluded that:

"*..There was indication that turtles occurred closer to the source during guns-off than full-array, with double the sighting rate during guns-off in all distance bands within 1,000 m of the array.*"

The reduction in number of turtles observed within 1,000 m during operation of a full airgun array (Weir 2007) is reasonably consistent with the observations of McCauley *et al.* (2003), which indicated a behavioural response threshold of SPL 166 dB re 1 µPa. As such, marine turtles may possibly be exposed to noise levels sufficient to

cause physical damage if acoustic sources start suddenly with turtles nearby. Based on current information, it would appear that significant impacts on marine turtle populations resulting from seismic survey noise are likely to be restricted to:

- short ranges and high sound intensities
- surveys during sensitive periods close to areas important for feeding, breeding and nesting
- surveys during sensitive periods close to areas that constitute narrow, restricted migratory paths.

From airgun exposure tests on a caged green turtle and loggerhead turtle (Table 3.11) that were extrapolated to response levels for a typical airgun array operating at full power in 100 m water depth, McCauley *et al.* (2003) concluded that turtles would, in general, probably show behavioural responses at 2 km and avoidance behaviour at 1 km 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 nesting beaches, where transmission losses are typically much greater than in deeper, open water areas.

Table 3.11 – Results of airgun exposure to marine turtles

Species	Received level (dB re 1 µPa rms)	Effect	Source
Loggerhead turtle	175-176	Avoidance response	O'Hara and Wilcox (1990)
One green and one loggerhead turtle	166	Noticeable increase in swimming behaviour, presumed avoidance response	McCauley *et al.* (2003)
One green and one loggerhead turtle	175	Behaviour becomes increasingly erratic, presumed alarm response	McCauley *et al.* (2003)

There is no evidence implying that turtles actively avoid or are attracted to close-range (less than 500 m) encounters with operating airgun arrays. However, Moein *et al.* (1994) tested if hearing sensitivity of caged loggerhead turtles altered after exposure to several hundred pulses within 30–65 m of a single airgun (pulse numbers and received sound levels not stated). Hearing was tested before, within a day, and then two weeks after exposure. Approximately 50% of the exposed individuals indicated altered hearing sensitivity when tested within a day of their exposure, but compared to the pre-exposure tests, none provided any sign of altered hearing two weeks later.

Despite the lack of overlap between the Nightcap MSS operational area and any critical habitat or BIA for marine turtles (>190 km away) and the deep water depth (>80 m), the acoustic modelling results predicted that at Site 3 on the 30 m isobath at Mermaid Reef (i.e. closest possible foraging area for marine turtles), the maximum SPL values both throughout the water column (151.3 dB re 1 µPa) and at the seafloor (148.8 dB re 1 µPa) would be less that the sound levels known to cause behavioural changes in marine turtles. Therefore, it is unlikely that acoustic impacts from the seismic source would cause adverse impacts to marine turtles foraging at Mermaid Reef, and the potential environmental risk is reduced to ALARP and acceptable levels.

However, acoustic modelling results demonstrated that sound levels which may result in a behavioural change for marine turtles (i.e. SPL 166 dB re 1 µPa) are likely to occur within 9.5 km from a single shot of the acoustic source modelled at a location within the operational area (McPherson *et al.* 2016). If marine turtles are travelling within 9.5 km of the acoustic source in the operational area and become disturbed, the unrestricted area allows for individuals to readily move away from the source of noise. In addition to EPBC Act Policy Statement 2.1 Part A Standard Management Procedures (e.g. monitoring precaution zones and soft-start procedures), Pathfinder will implement a turtle-specific management control: if a marine turtle is observed within 500 m of the acoustic source during pre start-up visual observations, soft-start procedures will not commence for 30 minutes after the sighting occurred. As marine turtles are expected to be transiting through the operational area at a low occurrence, this delay will allow the individuals additional time to move further away from the acoustic source. These control measures will reduce potential impacts to marine turtles and meet the objectives and actions outlined within the Recovery Plan for marine turtles in Australia (EA 2003). In particular, the Recovery Plan's conservation actions (as it relates to seismic surveys) will be achieved based on the implemented management controls for the proposed seismic activities. Therefore, based on the rare and infrequent occurrence of marine

turtles in the operational area, the estimated received sound levels from acoustic modelling (Section 1.3.4), as well as the transient nature of the seismic acoustic source and the management controls, it is unlikely that the proposed survey activities will result in significant impacts on marine turtles.

Disturbance to Cetaceans

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). Combined with studies of their hearing structures, scientific evidence suggests that their hearing is also best adapted for low frequency sound (McCauley 1994, Richardson *et al.* 1995). Baleen whales make individual sounds that may last for up to 16 seconds (Richardson *et al.* 1995), while humpback whales are known to "sing" for longer periods. These sounds are thought to be used in social interactions and communication between individuals and groups. Richardson *et al.* (1995) summarised published baleen whale sound characteristics. Table 3.13 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) reported humpback whale song components reaching SPL 192 dB re 1µPa, as well as SPL 180–190 dB re 1µPa for humpback pectoral fin slapping and breaching sounds.

Table 3.12 - Sounds produced by baleen whales that may be encountered within the Nightcap operational area

Species	Frequency (Hz)	Dominant frequency (Hz)	Estimated source level (dB re 1µPa.m)
Blue whale	12-31,000	16-25 6,000–8,000	130–188
Humpback whale	25–8,200	25–4,000	144–192
Minke whale	60-20,000	60-12,000	151-175
Bryde's whale	70–950	700-900	152-174

Physical damage to the auditory system of cetaceans may occur at noise levels of 198 dB re 1 $\mu Pa^2 \cdot s$ (Southall *et al.* 2007), which is equivalent to a distance of about 20 m from the sound source (McPherson *et al.* 2016). However, with implementation of management controls (e.g. monitoring precaution zones and soft start procedures), it is highly unlikely that any marine mammals will be exposed to levels likely to cause pathological damage.

Noise associated with seismic acoustic arrays can cause behavioural changes in whales (McCauley 1994). Behavioural responses to airgun noise include swimming away from the source, rapid swimming on the surface and breaching (McCauley *et al.* 2000). The sound level at which a behavioural response is elicited varies between species and between individuals within a species (Richardson *et al.* 1995). Stone (2003) suggested that different groups of cetaceans adopted different strategies for responding to acoustic disturbance from seismic surveys, with baleen and killer whales displaying localised avoidance, pilot whales showing few effects and sperm whales showing no observed effects. Richardson *et al.* (1995) notes that:

"Baleen whales seem quite tolerant of low and moderate level noise pulses from distant seismic surveys. They usually continue their normal activities when exposed to pulses with received levels as high as 150 dB re 1µPa, and sometimes even higher".

A comprehensive study carried out by McCauley *et al.* (2000) monitored the effects of 3D seismic survey noise on humpback whales in the Exmouth Gulf, WA. Data were collected with aerial surveys, induvial focal follows and acoustic recordings, the results of which had the following conclusions:

- No significant or large-range displacement observed, but rather localised speed and course changes at 3–4 km away from operating vessels, at which received SPL were ~157–164 dB re 1µPa (rms), thus indicating that potential impacts associated with the seismic survey were confined to a short period and small range displacement.

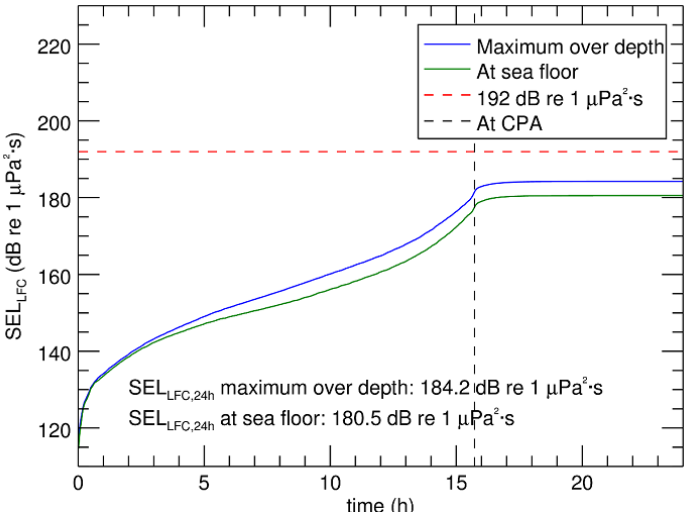
- At 157–164 dB re 1µPa (rms), humpback whales generally avoided the operating seismic vessel, however resting cow/calf pods showed avoidance at lower levels (a mean sound level 140 dB re 1µPa (rms) and a mean standoff range at 143 dB re 1µPa (rms)).
- In close proximity (i.e. within 100 m), received SPL was estimated at 192 dB re 1µPa (p-p), and humpback whales were observed at the surface, likely utilising the 'sound shadow' near the surface and avoiding the majority of sound energy projected downward.

Baleen whales are generally observed avoiding operating seismic vessels over distances that are highly variable between and within species. This avoidance behaviour represents only a minor effect on either the individual or the species, unless avoidance results in displacement of whales from nursery, resting or feeding areas, at an important period for the species.

For baleen whales, seismic acoustic emissions can cause behavioural changes, such as avoidance behaviour and breaching (McCauley *et al.* 2003). Blue whales altered their vocal behaviour when exposed to low intensity sounds (average received SEL 114 dB re 1 $\mu Pa^2 \cdot s$; 30–500 Hz) during a seismic survey (Di Iorio & Clark 2010). Passive acoustic monitoring (PAM) techniques recorded the blue whales' discrete, audible calls (likely for socialising and feeding) consistently more on seismic exploration days than on non-exploration days, suggesting that the whales were altering their calling behaviours to compensate for elevated ambient noise levels from the seismic survey. Similarly, a different PAM study recorded steady decreases in the received levels of fin whale songs and behavioural avoidance during exposure to a seismic survey (Castellote *et al.* 2012). The observed acoustic modifications and temporary displacement indicated both compensation for and sensitization to increased ambient noise during seismic surveys. Finally, another PAM study investigated seismic survey sound impacts on humpback whales and found that the number of singing whales decreased significantly with increasing received level of seismic survey pulses (Cerchio *et al.* 2014). The authors concluded that the humpback whales' breeding behaviours (e.g. vocal display) were disrupted by the seismic survey activity, and that potential cumulative impacts on individuals or the population were unknown.

From these data, it is not possible to predict how baleen whale vocal behaviour alterations may affect the individual's fitness, or ultimately, the population's survival. It is reasonable to presume that increased ambient noise will reduce an animal's ability to detect socially relevant signals and disrupt biologically important processes. However, sensitivity to seismic noise and propensity for avoidance behaviour are subject to interspecies differentiation. Baleen whales are broadly considered to continue their normal activities when exposed to pulses with received levels as high as 150 dB re 1 µPa (McCauley *et al.* 2003, Richardson *et al.* 1995).

Avoidance behaviour represents only a temporary effect unless avoidance results in displacement of whales from nursery, resting or feeding areas, or during an important period for the species. The Nightcap MSS operational area does not overlap with known critical habitats (e.g. feeding, breeding, calving, resting aggregation, narrow/restricted migratory pathway) for any cetacean species (DEWHA 2008b). The operational area lies beyond the biologically important area for humpback whales, whose migration corridor <30 km from shore (DSEWPaC 2012b). For pygmy blue whales, their migration and distribution areas overlap with the Nightcap MSS operational area. This pathway comprises the Australian continental shelf and coastal waters, is not narrow and cannot be considered critical habitat. Despite the lack of scientific evidence to validate significant, adverse impacts to baleen whale population survival from exposure to seismic acoustic sources, acoustic injury thresholds for baleen whales (i.e. low-frequency cetaceans) were estimated at SEL_{cum} >198 dB re 1 $\mu Pa^2 \cdot s$ (Southall *et al.* 2007) and SEL_{24h} >192 dB re 1 $\mu Pa^2 \cdot s$ (Wood *et al.* 2012). At the MRCMR boundary (~4 km away from modelled acoustic source), these levels are not exceeded according to the acoustic modelling results from SEL accumulated over 24 hours, which predicted SEL_{24h} received of 184.2 dB re 1 $\mu Pa^2 \cdot s$ (Table 1.6 and Figure 3.5). Furthermore, the acoustic modelling predicted that the per-pulse (i.e. single shot) sound field beyond 3 km from the acoustic source will not exceed the acoustic threshold likely to cause a behavioural disturbance according to the EPBC Act Policy Statement 2.1 (Table 1.5). Thus, based on the unrestricted corridor of the BIA, the transient nature of the seismic source and the management controls implemented, it is reasonable to conclude that any impacts to whales transiting through the operational area will be temporary and insignificant behavioural effects.



Source: McPherson *et al.* 2016

Figure 3.5 – Predicted SEL accumulated over 24 hours for low-frequency cetaceans at Site 1 (MRCMR boundary). Red dash lines indicate acoustic thresholds for PTS (cetaceans). Black dash lines indicate closest point of approach.

Toothed Whales

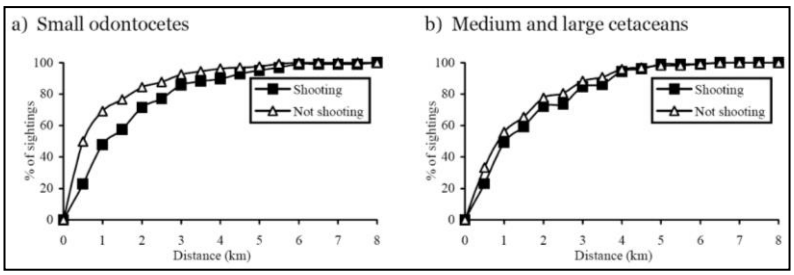
Toothed whales produce a wide range of whistles, pulsed sounds and echolocation clicks. The frequency range of toothed whale sounds excluding echo location clicks are mostly <20 kHz with most of the energy typically around 10 kHz, although some calls may be as low as 100–900 Hz. Source levels range from 100–180 dB re 1 µPa (Richardson *et al.* 1995). Other than echolocation clicks, the sounds produced are very complex in many species and used for communication between members of a pod in socialising and coordinating feeding activities.

For toothed whales that are 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 was ~195 dB re 1 µPa. This is consistent with the review and calculations by Richardson and Moulton (2006), who considered the TTS threshold to be 192–202 dB re 1 µPa and reasonably consistent with the value presented by DEWHA (2008b) of 186 dB re 1 µPa. Acoustic modelling predicted a per-pulse (i.e. single shot) sound field of SPL 190 dB re 1 µPa within a horizontal distance of 580 m (Table 1.5). Therefore, with precaution zones and management measures implemented, the potential for TTS is extremely low, as it would require a whale to be <600 m from the acoustic source and to remain within this range as the vessel traversed a distance of 4–5 knots.

There are little systematic data on the behavioural response of toothed whales to seismic surveys. Richardson *et al.* (1995) reported that sperm whales reacted by moving away from surveys and ceased calling even at great distances from a survey. However, in a 2003 study (Jochens & Biggs 2003), two controlled exposure experiments were carried out (including an experiment with three simultaneously tagged whales) to monitor the response of sperm whales to seismic source. The whales were exposed to a maximum received SPL 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 of the tagged sperm whales.

Smaller toothed cetaceans have poor hearing in the low frequency range of acoustic source noise (10–300 Hz), and seismic operators sometimes report dolphins and other small toothed whales near operating acoustic sources. However, there is a component of seismic pulses in the higher spectrum, and in general, most toothed whales show some limited avoidance of operating seismic vessels. Goold (1996) studied the effects of 3D seismic surveys on common dolphins 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 airguns (Figure 3.6).

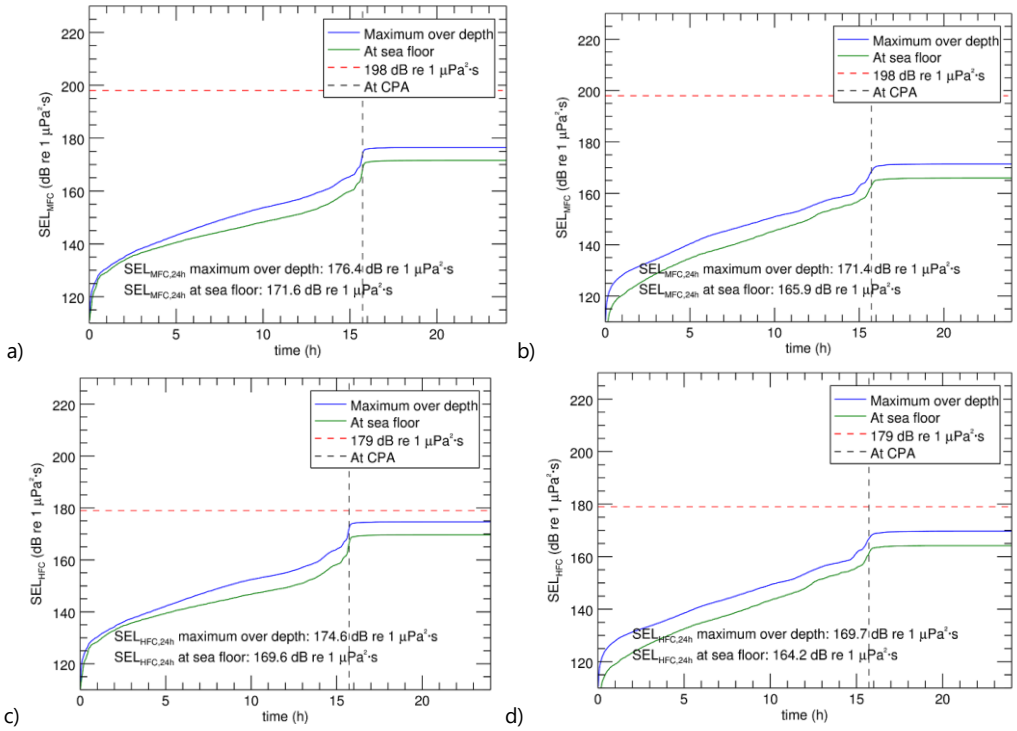


Source: Stone (2003)

Figure 3.6 - Proportion of marine mammal sightings occurring within specified distances of the airguns during seismic surveys.

The hearing capability of the majority of larger toothed whales is unknown. Generally, larger mammals have more sensitive hearing in the lower frequencies than the smaller toothed cetaceans, such as killer whales whose most sensitive hearing range extends to as low as 18 kHz (Szymanski *et al.*1999). However, this frequency range is still substantially higher than the frequency range of the proposed seismic acoustic source with most of its energy <700 Hz (McPherson *et al.* 2016). Thus, it is highly unlikely that seismic acoustic sources would adversely impact larger toothed whales.

Therefore, potentially adverse effects (i.e. TTS) on toothed whales from seismic acoustic sounds would only occur if the whale is within close range (i.e. <600 m). As stated above, scientific research estimated injury criteria thresholds for whales at SEL_{cum} >198 dB re 1 $\mu Pa^2 \cdot s$ (Southall *et al.* 2007) and SEL_{24h} >192 dB re 1 $\mu Pa^2 \cdot s$ (Wood *et al.* 2012). For the Nightcap MSS, the acoustic modelling predicted that the per-pulse (i.e. single shot) sound field beyond 3 km from the acoustic source will not exceed the acoustic thresholds likely to cause a behavioural disturbance according to the EPBC Act Policy Statement 2.1. Furthermore, based on acoustic modelling of sound exposure from a representative survey line, the accumulated SEL over 24 hours did not exceed the injury criteria thresholds for mid or high-frequency cetaceans at locations on the MRCMR boundary (~4 km away from the sound source in 310 m water depth) or at the 250 m isobath (~9 km away from the sound source; Figure 3.7). Therefore, considering the rare occurrence of toothed whales in the operational area, the estimated sound levels from acoustic modelling, the transient nature of the seismic acoustic source and the implementation of management controls (e.g. use of MFOs, monitoring precaution zones and soft-start procedures), the impact of seismic noise on toothed whales is considered minimal, no more than behavioural and thus ALARP.



Source: McPherson *et al.* 2016

Figure 3.7 – Predicted SEL accumulated over 24 hours for: a) mid-frequency cetaceans at Site 1 (MRCMR boundary); b) mid-frequency cetaceans at Site 2; c) high-frequency cetaceans at Site 1; and d) high-frequency cetaceans at Site 2. Red dash lines indicate acoustic thresholds for PTS (cetaceans). Black dash lines indicate closest point of approach.

Disturbance to Recreational Diving

The potential impacts to recreational divers from exposure to seismic sounds were assessed in Section 3.2.2. Recreational diving is generally restricted to waters less than 40 m, and the closest diving area is the MRCMR at ~9 km from the operational area. The underwater acoustic modelling predicted that the received SEL is anticipated to be ~138 dB re 1µPa^2·s (Section 1.3.4). As divers will be primarily within the reef shoals and lagoon (~11 km away from operational area at its closest point), the potential received SELs are predicted to be further reduced, especially as the steep incline and topography of Mermaid Reef will prevent most of the sound from entering the shallow waters inside the reef and lagoon (Section 1.3.4). Seismic acquisition will not occur within the boundaries of the MRCMR or the Rowley Shoals Marine Park, ensuring that the proposed survey activities do not interfere or overlap with recognised dive locations. As such, no interaction with recognised, recreational diving activities is anticipated. Therefore, based on the predicted sound exposure levels at the Mermaid Reef, the temporary nature of the seismic sound source and the low level of diving activity (peak season from September–November), the likely impacts to divers from underwater noise (e.g. when divers are moving in and out of a dive location or along the shoal edge) are expected to be low and insignificant.

As an overly conservative approach for proposed individual surveys located adjacent to MRCMR during peak tourism season (from September–November), Pathfinder will consider the following mitigation methods during pre-survey planning stakeholder consultation, and thus, acoustic impacts to recreational divers is considered acceptable and ALARP:

- identify current recreational diving areas
- discuss a simultaneous operations (SIMOPS) plan accordance with Diving Medical Advisory Committee guidelines on Safe Diving Distance from Seismic Surveying Operations (DMAC) guidelines to ensure either there is either a safe minimum spatial or temporal separation maintained between operations.

If new information regarding the CMRs and relevant to the Nightcap MSS are present, an internal risk assessment will be conducted.

Disturbance to Heritage and Conservation Values

Underwater acoustic modelling predicted the received SEL values at three receiver locations closest to sensitive habitats, thus presenting a precautionary approach to the environmental risk assessment from seismic noise. At a location on the MRCMR boundary that was closest to the operational area (~4 km away), in deep water (310 m) and with no site-attached species or critical habitats, acoustic modelling predicted that received sound levels were below acoustic thresholds known to cause serious injury and mortality to marine fauna, including sound levels from both a single shot and accumulated after 24 hours from a representative seismic survey line (Section 1.3.4). Marine fauna associated with reef communities (e.g. foraging turtles, sharks and site-attached fish) are likely to occur along the outer slope edge of Mermaid Reef, and at receiver locations at both the 250 m and 30 m isobaths, acoustic modelling results predicted further reduced sound levels, with most of the sound blocked by the topography of the reef and thus not entering the shallower lagoons. Reducing the seismic discharge in the operational area adjacent to Mermaid Reef would be unnecessary and with no substantial environmental benefit. Therefore, significant acoustic impacts from seismic sound levels entering the MRCMR are unlikely to occur.

Within the KCMR, the Nightcap MSS operational area overlaps a small corner of the Multiple Use Zone IUCN Category VI (<7% of total KCMR) in deep water (~80–200 m deep), where the major conservation values include the benthic communities and habitats of the continental shelf, slope, plateau and other deep-water seafloor features. The KCMR major conservation values also include two KEFs: the Ancient Coastline at 125 m and the Continental Slope Demersal Fish Communities, both of which overlap the Nightcap MSS operational area in very deep water. Seismic data acquisition will be restricted to water depths >100 m, and received sound levels in this water depth are will attenuate to reduced levels. It is likely that and received sound levels at the seafloor in water >100 m will be below acoustic thresholds known to cause serious injury or mortality to marine fauna. The overall shape and sound fields of the modelled seismic array at a location closest to MRCMR predicted the sound propagation characteristics toward the open ocean, demonstrating that sound will transmit long distances but at low sound levels that are below injury criteria thresholds for marine fauna. Also, it is unlikely that whales travelling through the KCMR and outside a survey's Observation Zone will be exposed to sound levels known to cause behavioural impacts (i.e. >160 dB re 1uPa^2·s). Finally, cumulative impacts from multiple surveys within the operational area are unlikely, as Pathfinder will not undertake surveys that overlap each other either spatially or temporally. Therefore, significant acoustic impacts from seismic sound levels within the KCMR are unlikely to occur.

Thus, when assessed against the IUCN Reserve Management Principles (Table 3.13), significant acoustic impacts from sound levels entering the MRCMR and KCMR (including the two KEFs) are reduced to ALARP and acceptable levels. Based on the acoustic modelling results, the transient nature of the sound source and the implementation of management controls (e.g. precaution zones, soft-start procedures, etc.), it is unlikely that significant acoustic impacts will affect the conservation values of the MRCMR and KCMR. All survey activities will be consistent with the relevant Australian IUCN reserve management principles and management plan objectives.

Table 3.13 - IUCN Reserve Management Principles Category VI (Multiple Use Zone), relevant survey control measures and environmental risk assessment within the Nightcap MSS Operational Area

IUCN Reserve Management Principles Category VI (Multiple Use Zone)	Relevant Survey Control Measures	Environmental Risk Assessment

7.01 The reserve or zone should be managed mainly for the ecologically sustainable use of natural ecosystems based on the following principles.
 	
7.02 The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long-term.
 	
7.03 Management practices should be applied to ensure ecologically sustainable use of the reserve or zone.
 	
7.04 Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.
	The following survey control measures will be applied to ensure the ecologically sustainable use of the reserve/zone and demonstrate consistency with IUCN Management Principles (including but not limited to):
	• EPBC Act Policy Statement 2.1
	  ○ Part A Standard Management Procedures
	  ○ Part B Additional Management Procedures
	  ○ Part B Adaptive Management Procedures
	• No discharge of seismic source outside the Nightcap MSS operational area
	• Vessel operations will comply with all relevant maritime legislation
	• Vessels will not undertake full seismic acquisition activities within 50 km of another vessel also acquiring data
	• No seismic acquisition in water shallower than 100 m
	• No survey within one month of a previous Pathfinder survey over the same area.
	• In the event of fuel or oil spills to sea, the vessel's Shipboard Oil Pollution Emergency Plan (SOPEP) and this EP's OPEP procedures will be followed
		The biological diversity and other natural values of the zone will be protected and maintained in the long-term, and thus the environmental risk is low based on:
		• Implementation of control measures
		• No environmental impacts to marine fauna, including:
		  ○ Benthic invertebrates
		  ○ Fish and sharks
		  ○ Seabirds and shorebirds
		  ○ Marine turtles
		  ○ Cetaceans
		• Substantial distance from operational area to:
		  ○ KCMR National Park Zone (IUCN Category II) - >95 km away
		  ○ KCMR Habitat/Species Management Zone (IUCN Category IV) - >160 km away
		  ○ Small overlap with KCMR Multiple Use Zone (IUCN Category VI) - <7% of total KCMR
		• No significant environmental impacts expected in deep water (>80 m) of KCMR Multiple Use Zone, including the continental shelf, slope, plateau, and deep hole/valley seafloor features
		• No significant environmental impacts to KEFs, both of which are in deep water (>80 m)
		• No cumulative impacts from multiple surveys based on:
		  ○ acoustic modelling results
		  ○ recovery periods for marine fauna with a one-month break
		  ○ separation distance 50 km from another survey
		  ○ sufficient time and space to allow recovery, particularly for site-attached species or sedentary sensitivities and values.
		By implementing this EP and the controls and mitigation measures within, potential environmental impacts to the values, sensitivities and management principles of the KCMR are considered ALARP and acceptable, thus ensuring that proposed activities are consistent with relevant IUCN principles.
		If a KCMR Management Plan is approved during the EP assessment, EP valid period, pre-survey planning, Pathfinder will comply with all requirements and this EP will be updated accordingly. If a survey is underway and the approved management plan has implications for the current survey operations (e.g. a change in an overlapping IUCN Zone that does not allow seismic activities within the current survey area), Pathfinder will stop the current survey and undertake an internal risk assessment to evaluate the risks and impacts of the activities being undertaken within the survey area.

3.2.4.3 Simultaneous Operations and Cumulative Impacts

The cumulative impacts from seismic impulses within the marine environment are difficult to quantify because the acquisition of seismic data requires the temporary creation of sound pressure waves (i.e. airgun-derived) that dissipate and soon disappear when the sound energy source has stopped or moved away from the area. There may be a temporary additive effect if sounds from one activity coincide and overlap spatially and temporally with another concurrent activity. However, this "added sound" will disappear once one of the sound-generating sources stops or passes out of the area of concern. A review of seismic-related literature revealed no documented instances of the negative effects of cumulative seismic energy source on any marine organism.

It would be unnecessary for a petroleum block titleholder to obtain data from more than one seismic survey of the title, which in turn would render mobilisation of multiple surveys highly unlikely and commercially non-viable, irrespective of whether environmental approval had been obtained for more than one survey over the same area. Subsequently, although multiple seismic surveys may be proposed, not all will commence as block titleholders will allocate work to one seismic company only. In the broad and general scope of all seismic surveys, there are three possible scenarios when seismic surveys may overlap:

- a 3D survey being undertaken after an initial 2D survey
- shooting over open acreage that another survey has covered
- overlapping sail lines within the same survey as a result of undertaking 'infill' activities or 2D lines crossing each other.

In general, if a 3D MSS was to be undertaken after a 2D MSS, it would be months between the surveys, at which point cumulative impacts would be negligible. Shooting over open acreage may occur, as these are within the southern portion of the Nightcap MSS operational area. However, the chances of two seismic companies targeting the same open acreage is extremely unlikely. Furthermore, Pathfinder will not undertake surveys that overlap each other either spatially or temporally.

If a vessel ceased operations in an area for a time, several hours would pass before the infill activities could re-commence, as (at the very least) the vessel needs time to turn around and initiate required soft start procedures. It is anticipated that the time for a vessel to return to a location to undertake infill activities will be at least three hours before the return would occur. Usually, a sail line will be completed, and the infills are left to the end of a survey, once seismic data has been partially processed and all infill locations located.

Data acquisition lines are typically kilometres apart on a relatively sparsely spaced grid of lines and usually over a large area. Lines within this grid may cross each other, thus resulting in the same area being surveyed twice and subject to repeat exposure. However, in this scenario, it will be hours if not days and possibly weeks, before the sound source crosses back over an already-completed sail line. Furthermore, as shotpoints are ~25 m apart, it is extremely unlikely that they will occur exactly over each other. Again, when taking into consideration that a line must be completed, the vessel turn and then recommence, even if two lines cross each other immediately, it would be at least three hours in between.

Marine megafauna (e.g. pygmy blue whales and whale sharks) may be present in the Nightcap MSS operational area. However, with proposed mitigation in place (e.g. exclusion zones, shut-down zones, MFOs, etc.), it is not anticipated that marine megafauna will be in close proximity (i.e. <3 km) to the seismic source, which equates to SEL 160 dB re 1 $\mu Pa^2 \cdot s$ (Section 1.3.4). Furthermore, based on accumulated SELs from 24 hours of a representative survey line at a receiver location ~4 km away, acoustic modelling results predicted that received sound levels would not exceed thresholds known to cause serious injury or mortality to any marine fauna species (Section 1.3.4). Therefore, adverse, long-term effects at a population level for any marine fauna species are not anticipated, and likely no more than TTS or behavioural changes to a few individuals may occur, based on the following:

- minimal time that the acoustic source will be over any particular site

- all animal tissues, if damaged, start to recover as soon as the stimulus is removed
- it will likely be hours before the sound source overlaps the exact same area again
- any areas that may experience repeat exposure would be very small and localised
- the operational area is not known to have site-attached species associated with it and so fish can swim away
- marine megafauna are free-swimming, and with the minimal period that a source will overlap the same area, are unlikely to be adversely impacted.

For the proposed survey activities, shot points will be ~25 m apart (i.e. 10.8 seconds) from a moving sound source, and thus would not occur exactly over each other. Within Mermaid Reef, the single-shot and accumulated SEL from a seismic survey will never reach the predicted received levels likely to cause mortality in marine turtles, eggs and larvae (Popper *et al.* 2014). Based on the best available scientific evidence, fish that experienced TTS after seismic airgun exposure had normal hearing levels recovered within 18–24 hours (Popper *et al.* 2005). As outlined previously, invertebrates are unlikely to experience negative effects unless within very close proximity to the source (<10 m). Pelagic and demersal fish can move away from the source. While the MRCMR is known for its high biological diversity, high localised productivity and important habitats for fish species, the likely impacts from potential sound exposure during infill activities or overlapping sail lines will be insignificant, temporary and discountable.

As pointed out in Popper *et al.* (2014), it is difficult to determine cumulative SEL (SEL_{cum}) for a moving source, such as a towed seismic airgun array. The approach of using SEL_{cum} is based on an assumption that all the shots along a section of line are acquired at the same instant, which is obviously not the case. It does not, therefore, take into account the temporal spread of acquisition (a shot occurring every 10.8 seconds for 25 m shotpoint interval along each line), and an interval of hours to days between adjacent lines. Thus, the potential for fish to recover from a TTS or recoverable injury, either between shots or between lines, is not taken into account. The US National Marine Fisheries Service (NMFS) applies a "resetting" of SEL_{cum} after 12 hours of non-exposure (Stadler and Woodbury 2009), and similarly, the SEL_{cum} for a fish exposed to a pile driving operation is reset to 0 for the next set of exposures if there is a 12-hour period between the end of one pile driving operation and the start of the next. Therefore, it is highly unlikely that any of the SEL_{cum} exposure guidelines in Popper *et al.* (2014) would be exceeded with the use of an acoustic source with an overall broadband SPL (peak) of 248 dB re 1 µPa at 1m (horizontal) for an individual survey within the Nightcap MSS operational area. Furthermore, the exposure guidelines for seismic airguns presented in Popper *et al.* (2014) are based on pile driving exposure data, in which the strike frequency in pile driving operations is one strike every 1-2 seconds at a single location, compared to a 10.8 second impulse interval for a moving source, as is the case of this proposed seismic data acquisition.

Any areas that may experience repeat exposure will be very small and localised. Due to the deep water depths and very short timeframe that an organism may experience repeat exposure, any effects that are likely to occur will be temporary and possibly no more than TTS or a short-term behavioural responses. Subsequently, the costs associated with not performing these standard practices, or by placing an extended time limit on returning to the exact same area, are grossly disproportionate to the environmental benefit. Pathfinder will commit to not undertaking a survey within one month of another survey over the same area. Based on anticipated received SEL and the likely recovery periods for marine fauna, a one-month break is considered more than sufficient to allow recovery, particularly for site-attached species or sedentary sensitivities and values.

Regarding spatial impacts from simultaneous or cumulative operations, the Programmatic Environmental Assessment of Arctic Ocean OCS Seismic Surveys (2006) established pro-active measures for simultaneous seismic surveys with a minimum spacing of 24 km (15 nmi) between seismic source vessels (BOEM 2014). This final environmental review of geological and geophysical survey activities off the mid and South Atlantic coast included a recommendation of a 40-km geographic separation distance between the sources of simultaneous seismic surveys. This distance will minimise the impacts to marine life by providing a sufficient 'corridor' between vessels that is below SPL 160 dB re 1 µPa (which was recognised as the behavioural limit for most marine megafauna) and approaching ambient levels such that marine fauna may pass through rather than

traveling larger distances to go around the survey vessels. The report indicated a typical radius for a 160-dB threshold for a large airgun array was no more than 10 km (BOEM 2014). Consequently, the implementation of a 50-km geographic spacing between survey vessels working simultaneously is a very conservative approach, as this would leave a potential 30 km 'corridor' between vessels, rather than the recommended10 km 'corridor' (BOEM 2014).

From the acoustic modelling results, received SPLs of 160 dB re 1 µPa are not predicted at horizontal distances >20 km away from the sound source. Thus, a 50-km separation distance is a conservative and acceptable approach between the Pathfinder survey vessel undertaking full data acquisition activities simultaneously with a non-Pathfinder contracted vessel. It is expected that SELs associated with simultaneous acquisition activities will attenuate well below known, behavioural avoidance response levels for marine fauna at the closest distance to concurrent surveys. Subsequently, concurrent seismic exploration activities are unlikely to result in a significant impacts to matters of NES.

In summary, Pathfinder will not undertake surveys that overlap each other either spatially or temporally. Prior to commencement of a Nightcap MSS, Pathfinder will confirm with the NOPSEMA website if any seismic surveys may potentially occur in the area. Pathfinder will consult with other geophysical companies operating in Australian waters, and/or titleholders of petroleum titles adjacent to the operational area, to ascertain if there are any other seismic surveys proposed for areas adjacent to the survey area and over the same time period. In the event that the timing of any proposed seismic survey overlaps the Pathfinder Nightcap MSS, the survey vessels will ensure a minimum distance of 50 km is maintained during full seismic acquisition to minimise potential cumulative impacts on marine fauna and to minimise noise interference that may affect seismic data quality.

With the development and implementation of both EPBC Act Policy Statement 2.1 Part A Standard Management Procedures and Part B Additional Management Procedures (see below), cumulative impacts would be further reduced to negligible levels. Also, once a survey is complete, any resonant noise within the operational area or surrounding marine environment would diminish. Thus, the potential effects from increased sound exposure to marine mammals and fauna would cease, and animals would most likely return to preferred habitat.

Mitigation Measures

Pathfinder will undertake pre-survey planning to mitigate potential impacts from underwater noise. Pre-survey planning will include a review of existing information in relation to any component of the receiving environment described in Section 2.2, particularly risks of the activity to migrating pygmy blue whales and whale sharks. This includes review and consideration of any new issues raised by stakeholders, available scientific literature, CMR status and relevant IUCN principles, information from other MSS surveys and potential cumulative impacts from past or proposed surveys, if known. If new information regarding the receiving environment relevant to the Nightcap MSS is present, then an internal risk assessment will be conducted. If new information regarding whale migration periods is available, the information will be used in planning the timing of individual surveys within the Nightcap MSS operational area. Considering that the three BIAs that overlap the operational area and the various timings for peak periods (Figure 3.8), it is unlikely that all sensitivities can be avoided either physically or temporally.

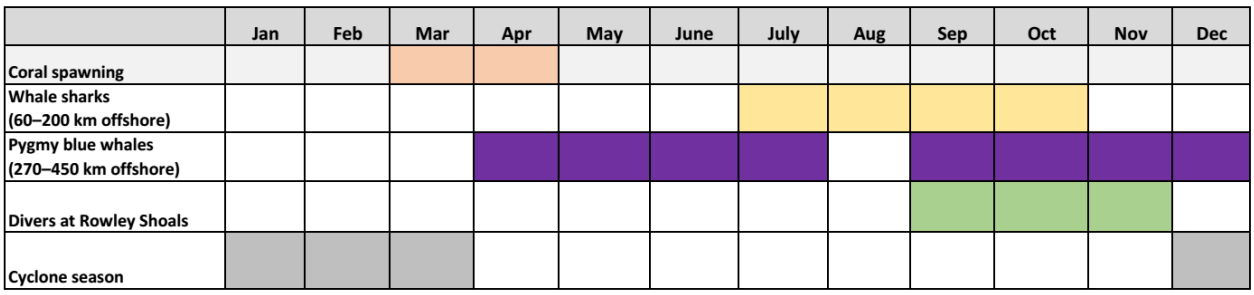


Figure 3.8 – Overview of sensitive periods in the Nightcap MSS Operational Area

The Nightcap MSS operational area does not overlap any critical habitat (e.g. breeding, calving, etc.) or narrow migration corridors for protected marine fauna. However, as identified in the Department of Environment and Energy National Conservation Values Atlas (Department of the Environment and Energy 2016e), the Nightcap MSS operational area overlaps three BIAs: pygmy blue whale migration and whale shark foraging. As the validation period of this EP extends for 12 months, it is possible that some acquisition may coincide with peak periods for either species. As far as practicable, Pathfinder will plan survey timing to avoid BIAs during peak periods for pygmy blue whales and whale sharks. To further ensure that the potential impacts to migrating pygmy blue whales and whale sharks are ALARP, additional mitigation measures (e.g. use of MFOs, increased precaution zones and buffer zones) will be applied.

Based on limited knowledge of distribution and abundance, critical habitats are not defined for pygmy blue whales in Australia (DoE 2015a). Recognised foraging areas for the pygmy blue whale in WA are located in the Perth Canyon and in Geographe Bay, with possible foraging areas off Exmouth and Scott Reef. However, the marine environments off Exmouth and Scott Reef are >700 km and >70 km away, respectively, and thus a foraging pygmy blue whale would be highly unlikely within the operational area. Furthermore, as a precautionary approach, Pathfinder will apply selected EPBC Act Policy Statement 2.1 Part B Additional Management Procedures during pygmy blue whale peak migration periods, for individual surveys located within the migratory pathway and possible foraging BIAs.

A small proportion of the whale shark foraging BIA overlaps the southern corner of the Nightcap MSS operational area, and so it is possible that a low occurrence of whale sharks may be encountered during individual surveys undertaken from July–November. However, given the low numbers of whale sharks and wide migration corridor (110 km at its narrowest point) the potential for significant impact is considered Low. While the *Whale Shark Recovery Plan* (2005-2010; DEH 2005a) identified numerous possible threats to whale sharks, those applicable to surveys within the Nightcap MSS operational area include pollution and marine debris, or interference; acoustic impacts were not identified as a specific threat. The recent, whale shark conservation advice from the TSSC did not identify any new information or impacts from seismic activities on whale sharks (TSSC 2015b).

While Pathfinder will endeavour to conduct the surveys outside known pygmy blue whale and whale shark BIAs and peak periods, the proposed survey activities have not been restricted spatially or temporally, with the exception of adaptive management procedures. This will provide flexibility when contracting a suitable seismic vessel, and to allow for weather restrictions (e.g. cyclones) or time constraints due to client requirements of acquiring data in permitted areas that overlap the BIA. For example, costs associated with placing a vessel that was part way through a survey on 'stand-by' for up to 45 days until a migration period is completed could equate to ~$18,000,000 ($400,000/day), and this cost is grossly disproportionate to the benefits. This same reasoning can be applied to undertaking an activity within a BIA during a sensitive period, then stopping activity and moving to another location to allow a fauna 'recovery' period. Furthermore, adaptive management measures shall be implemented to mitigate against potential increased risk of noise impacts on whales as a result of increased presence outside of known BIAs or peak migration periods.

Based on telemetry data (Double *et al.* 2014), individual pygmy blue whales are likely to transit through the Nightcap MSS operational area on their southbound migration from late September to December, and on their northbound migration from April to May. As per the *EPBC Act Policy Statement 2.1,* the operation of the seismic source at all times during the survey must comply with the following requirements of the Part A Standard Management Procedures of the *EPBC Act Policy Statement 2.1* (DEWHA 2008b), the information below is taken directly from the legislation (A.3. During Surveys) and will be implemented for all surveys within the Nightcap MSS operational area:

- A.3.1 Pre Start-up-Visual Observation
- A.3.2 Soft Start Procedure (also known as ramp-up)
- A.3.3 Start-up Delay Procedure
- A.3.4 Operations Procedure

- A.3.5 Stop Work Procedure
- A.4 Compliance and Sighting Reports.

The following precaution zones will be implemented for all individual surveys within the Nightcap MSS operational area:

- *Observation* zone: 3+ km horizontal radius from the acoustic source.
- *Low power* zone: 2 km horizontal radius from the acoustic source.
- *Shut-down* zone: 500 m horizontal radius from the acoustic source

Within the Nightcap MSS operational area, the following EPBC Act Part B Additional Management Procedures will be implemented to ensure that potential impacts with whales are avoided and/or minimised to ALARP and acceptable levels (Table 6.12). Two experienced and dedicated MFOs will be on the survey vessel for the entire duration of the survey, which will increase the likelihood that high quality observation data are collected, provide assistance to other observers (e.g. trained crew), reduce fatigue during long survey days (>12 hours) and provide environmental advice, should whales be encountered. Also, during the identified pygmy blue whale peak migration periods (1 April–31 July and 1 September–31 December), pre-start visual observation time will increase to 45 minutes, as longer time between surfacing events (i.e. whale 'down-times') are expected, and the Shut-down zone will extend for 2 km from the acoustic source. Thus, for any whales that may be encountered during individual surveys within the Nightcap MSS operational area, adverse physiological effects are extremely unlikely, and potential disturbance would be minimised.

As a practical and minimum standard, *EPBC Act Policy Statement 2.1* management controls will serve as initial indicators that a low density of whales is in the survey area. However, Pathfinder proposes to use a more conservative approach: if there are three or more sightings within the preceding 24 hours within the power-down/shut-down zone, the density of whales in the area is deemed to be sufficiently high to cause either of the following management measures to be implemented (Figure 3.9):

- Relocation - survey vessel will relocate to another survey line >20 km from location of last whale sighting and will not return within 24 hours
- Cessation - no survey operations in current location for 24 hours.

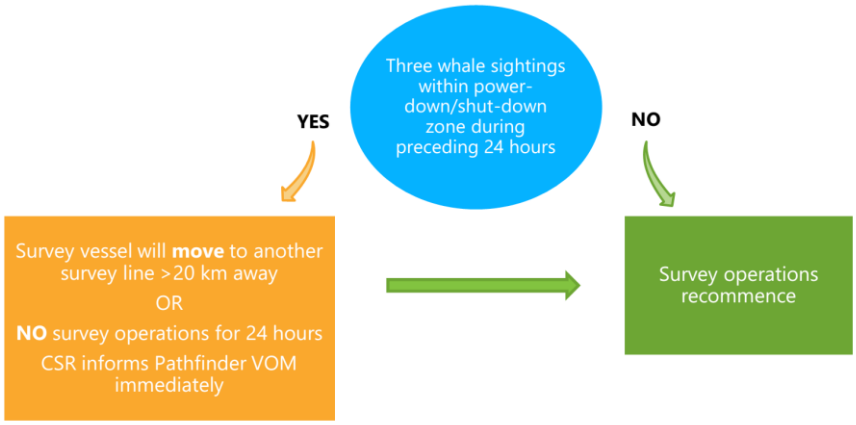


Figure 3.9 – Adaptive Management Procedures to Avoid and/or Mitigate Impacts to Whales

With relocation, the survey vessel will move to another survey line >20 km away from location of last whale sighting. This is a conservative approach that reduces potential impacts and risks to whales from repeated sound exposure, especially as the SEL of the acoustic source is predicted to be ~138 dB re 1µPa·s^2 at distances >11 km away (Section 1.3.4). Survey vessels may return to this location after 24 hours, subsequently providing fauna species with a sufficient recovery period, which is expected to occur within 12–24 hours following sound exposure dependent on the species (Popper *et al.* 2005, Stadler and Woodbury 2009). If the survey vessel cannot move to another survey line, ceasing operations is the alternative method of reducing the impact on

the fauna species likely in the area. At this point, if less than three whale sightings occurred in the power-down/shut-down zone within the preceding 24 hours, the survey operations may recommence with start-up procedures as per *EPBC Act Policy Statement 2.1*.

Based on industry experience, it is rare for more than three power-downs/shut-downs to occur within 24 hours. Rather, one or two power-downs/shut-downs may be implemented within 24 hours, which is usually followed by gap periods of no observations, demonstrating that a low density of whales may be transiting through the survey area and not necessarily an increased population of whales. Two key indicators of an increase in whale density in the survey area include:

a) sightings indicator: an increase in the number of sightings within the power-down or shut-down zone
b) occurrence rate indicator: an increase in the rate of occurrence (i.e. percentage of sightings over 24-hour period).

3.2.5 Discharge of Bilge Water, Sewage and Food Wastes

3.2.5.1 Description of Risk

For survey activities in the Nightcap MSS operational area, the survey and support vessels will routinely discharge (i.e. on a daily basis) relatively small volumes of sewage and food wastes to the ocean. These discharges will occur in accordance with the requirements of the MARPOL 73/78 Convention and as implemented in Commonwealth waters by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. Additionally, the survey and support vessel may need to discharge bilge water during the survey. As such, routine discharges of bilge water, sewage and food wastes from the survey and support vessels have the potential to cause a localised reduction in water quality.

3.2.5.2 Potential Environmental Impacts

Routine discharge of bilge water, sewage and food wastes to the ocean will cause a negligible, localised and temporary increase in nutrient concentrations and reduction in water quality, including that of the MRCMR. The total nutrient loading from vessel operations during survey activities in the Nightcap MSS operational area will be insignificant in comparison to the natural daily nutrient flux that occurs in marine waters within the region. No significant impacts are anticipated because of the minor quantities involved, localised area of impact, high level of dilution into deep oceanic waters and high biodegradability/low persistence of the wastes.

Bilge tanks receive fluids from many parts of the vessel. Thus, bilge water may contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals. Treatment of bilge water will be conducted using an oily water separator. However, if not treated prior to discharge, there would be potential for a negligible and localised increase in nutrient concentrations. Therefore, potential environmental impacts from routine discharges of bilge water, treated or untreated sewage and food wastes are expected to be negligible.

3.2.6 Atmospheric Emissions

3.2.6.1 Description of Risk

Atmospheric emissions from the proposed survey include greenhouse gas (GHG), nitrogen oxide (NOx), sulphur oxide (SOx), carbon monoxide (CO) and particulate matter (i.e. dark smoke) emissions from:

- use of survey and support vessel main engines for propulsion
- use of survey and support vessel main and emergency power generation equipment
- use of aviation fuel for transport of personnel via helicopters
- use of marine diesel by the survey vessel workboat
- incineration of oily sludges aboard the survey vessel.

3.2.6.2 Potential Environmental Impacts

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. Incineration of oily sludges 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. A very low relative volume of GHG emissions would result from fuel consumption aboard the survey vessel compared to other sources of GHG emissions in the area (e.g. commercial shipping traffic), and the operational area doesn't overlap with sensitive receptors that could be impacted by atmospheric emissions generated during the proposed survey activities. Furthermore, all vessels will operate in accordance with the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and the *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994*, particularly Marine Orders – Part 97: Marine Pollution Prevention – Air Pollution. Thus, the potential impacts of atmospheric emissions are expected to be low based on the localised and temporary reduction in air quality from release of emissions.

3.3 ACTIVITIES (ACCIDENTS/INCIDENTS)

3.3.1 Collision between Vessels/Towed Array and Marine Fauna

3.3.1.1 Description of Risk

The survey and support vessels may present a potential physical hazard likely to cause an environmental impact (e.g. animal displacement or vessel strike) to marine fauna, including cetaceans, turtles or whale sharks. Additionally, the tail buoys that are attached to the end of seismic streamers can represent a potential entanglement risk for turtles.

3.3.1.2 Potential Environmental Impacts

The impact from vessel interactions with marine fauna can be as minimal as behavioural changes to severe impacts, such as mortality resulting from vessel strikes. Vessel collisions contribute to the mortality of marine fauna, notably turtles (Lutcavage *et al.* 1997, Hazel & Gyuris 2006, Hazel *et al.* 2007) and large cetaceans (Knowlton & Kraus 2001, Laist *et al.* 2001, Jensen & Silber 2003). Stranding records for Queensland indicated that 14% of dead marine turtles were struck by vessels (Hazel & Gyuris 2006). These records were largely from populated areas of the state and comprised an unknown proportion of the total mortality. A report on vessel strikes in Queensland (DoE 2007) indicated that "both commercial and recreational boats have been responsible for striking marine animals. Recreational vessels, however, account for 96.9% and commercial vessels only 0.001% of registered vessels in Queensland in 2003."

Marine seismic surveys involve the use of two or more vessels travelling at slow speed (~4 knots) along defined paths. The timing and location of surveys within the Nightcap MSS operational area may coincide with sensitive periods, such as humpback whale, pygmy blue whale and whale shark migrations. Given the susceptibility of cetaceans, whale sharks and marine turtles to vessel strikes, only potential impacts on these fauna groups were considered. Other marine fauna (such as birds, fish and sea snakes) are likely to avoid vessels operating in the area and so are considered at low risk of potential strike.

Cetaceans

The likelihood of a lethal vessel/whale collision is influenced by vessel speed: the greater the speed at impact, the greater the risk of mortality (Laist *et al.* 2001, Jensen & Silber 2003). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots. During seismic data acquisition, the survey vessel will be moving at a speed of ~4 knots. At a speed of 4 knots, the data of Vanderlaan and Taggart (2007) estimated the risk of a vessel-whale collision resulting in lethal outcome to be <10%. Vessel/whale collisions at this speed are uncommon, and based on reported data contained in the US National Ocean and Atmospheric Administration database (Jensen & Silber 2003), there were only two known instances of collisions when the vessel was travelling <6 knots. Both of these were from whale-watching vessels that were deliberately placed amongst whales.

The *Australian National Guidelines for Whale and Dolphin Watching 2005* are currently being reviewed to ensure that they represent best practice. Pathfinder shall confirm the status of these guidelines and ensure that survey activities are consistent with the guidelines in force. The Nightcap MSS operational are overlaps with the distribution areas for the pygmy blue whale and the humpback whale, and sightings are likely to occur during migration periods. However, considering the wide and unrestricted section of the BIA that overlaps the operational area, the slow operating speed of the survey and support vessels (unless in an emergency) and compliance with the regulatory guidelines, the potential for a vessel strike to impact significantly on a cetacean during the proposed survey activities is expected to be low.

Marine Turtles

Marine turtles on the sea surface or in shallow coastal waters were observed to avoid approaching vessels by typically moving away from the vessels track, which was suggested as an avoidance behaviour based primarily on visual cues despite the vessel noise being within range of turtle hearing (Hazel *et al.* 2007). Therefore, the success of this behaviour in avoiding a vessel strike is largely dependent on the speed of the approaching vessel and the prevailing water clarity, rather than vessel type. While the potential for vessel strikes at various speeds has not been quantified, the success of avoidance behaviour is a factor of the response time available (i.e. visual observation distance/vessel speed). Hazel *et al.* (2007) suggested that higher vessel speed is more likely to cause impacts, particularly in shallow waters where turtles are abundant. Thus, there is less opportunity for turtles to avoid vessels travelling at higher speeds in turbid waters. Additionally, vessel draft may also contribute to the risk of vessel strikes, as vessels with less draft provide a greater clearance distance between the turtle and the vessel. In the event of a collision, the turtle's carapace provides a level of protection from serious injury, although the type and severity of the injuries would be dependent on the force of the collision, the structure of the vessel and whether the animal was struck by the hull or propellers.

Turtle entrapment with streamer tail buoys have the potential to cause mortalities (Ketos Ecology 2007, 2009), which has been a concern particularly for MSS off the west coast of Africa. In recent years, geophysical acquisition companies and seismic contractors designed and implemented "turtle guards", which are modifications to the tail buoys that minimise the potential for turtle entrapment. More recently, developments in the design of tail buoys reduced the potential for turtle entrapment. An example of these tail buoys is the PartnerPlast 900L, which skim along the surface with just a single chain extending beneath the surface. The survey vessel to be used for surveys within the Nightcap MSS operational area shall either be fitted with the abovementioned tail buoys or turtle guards to prevent entrapment.

Although the polygon does not overlap any recognised turtle BIA, marine turtles may be encountered while en route to their nesting areas along the northwest coastline. Rare and infrequent observations of individual turtles present in the outer limits of the operational area are likely to occur. In addition to *EPBC Act Policy Statement 2.1 Part A Standard Management Procedures* (e.g. monitoring precaution zones and soft-start procedures), Pathfinder will implement a turtle-specific management control: if a marine turtle is observed within 500 m of the acoustic source during pre start-up visual observations, soft-start procedures will not commence for 30 minutes after the sighting occurred. As marine turtles are expected to be transiting through the operational area at a low occurrence, this delay will allow the individuals additional time to move further away from the acoustic source. Therefore, considering the rare occurrence of marine turtles as well as the survey modifications to prevent entrapment and control measures, the likelihood of a vessel strike with a marine turtle during the proposed survey activities is expected to be low.

Whale Sharks

Although the whale shark's skin is thicker and tougher than any other shark species, the species may be behaviorally vulnerable to boat strike. As a significant amount of time is spent close to the water surface, several whale sharks bear scars that have probably been caused by boat contact (DEH 2005, Norman 1999). In other regions, several reports documented whale sharks impaled on the bows of larger ships (Norman 1999). DPaW developed a code of conduct for commercial vessels that engage in whale shark watching to minimise the risk of disturbance to normal whale shark behaviour and boat strike (DPaW 2013). These measures have been used to develop minimum requirements for vessels within the Nightcap MSS operational area, and vessels shall not approach closer than 400 m from a whale shark.

The Nightcap MSS operational area overlaps with a small portion of the foraging BIA for whale sharks. As their occurrence within the operational area is likely to be rare and infrequent, and given the slow operating speed of the survey and support vessels (unless in an emergency), the likelihood that a vessel strike will impact significantly a whale shark in the operational area is assessed to be low.

3.3.2 Equipment Dragging or Loss

3.3.2.1 Description of Risk

The accidental dragging or loss of seismic streamer equipment has the potential to cause minor physical damage to benthic habitats and biological communities. Due to depth and location of the operational area, environmental risks associated with vessel grounding or use of anchors are not relevant and thus not assessed via the detailed risk assessment.

3.3.2.2 Potential Environmental Impacts

The potential and significance of impacts caused by loss of equipment is dependent partly on the type of receiving environment. Soft sediment, benthic areas that are relatively devoid of sensitive habitats and consisting of sandy/silt substrate is the predominant benthic receiving environment within and adjacent to the Nightcap MSS operational area. The proposed surveys will be operating at depths and distances from emergent land that preclude any possible contact, i.e. vessel will be at least 9 km from nearest emergent land and in minimum water depth of 100 m.

Equipment dragging and Loss

In the unlikely event of damage to or loss of a 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 and vanes 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 will pass a certain water depth at which point the buoys inflate and bring the equipment back to the surface, where it can be retrieved by the seismic and/or support vessels.

Dragging of the streamer along the seabed may result in localised physical disturbance of substrates, benthic habitats and communities. However, given that the proposed surveys in Nightcap MSS operational area will not operation in water depth <100 m and the absence of shallow waters (<30 m depth) or emergent features, the risk of significant impacts resulting from equipment dragging or loss is considered to be low. Furthermore, the survey vessel will not transit the MRCMR or the Rowley Shoals Marine Park with the seismic equipment deployed, as per the MRCMR transitional management arrangements (DNP 2000).

3.3.3 Accidental Release of Hazardous or Non-hazardous Materials

3.3.3.1 Description of Risk

The survey and support vessels will store and use a variety of hazardous materials, such as paints, cleaning chemicals and batteries. Both vessels will also produce a variety of other non-hazardous solid and liquid wastes, including packaging and domestic wastes, such as aluminium cans, bottles, paper and cardboard.

3.3.3.2 Potential Environmental Impacts

Hazardous Materials

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 L 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 or equivalent for vessels <400 GRT) 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, although the realistic worst case volume would be 25 L.

Therefore, based on the small quantities and the appropriate SOPEP and clean-up procedures in place, an accidental release of hazardous materials is unlikely to have a significant impact on the marine environment, and the risk is considered to be low.

Non-hazardous Materials

These materials could potentially impact the marine environment if accidentally released in significant quantities resulting in a reduction in water quality and physical impacts on marine fauna, such as becoming entangled in waste plastics. However, based on the small quantities and the appropriate SOPEP and clean-up procedures in place, an accidental release of non-hazardous materials is unlikely to have a significant impact on the marine environment, and the risk is considered to be low.

3.3.4 Hydrocarbon Release Caused by Topsides (Vessel) Loss of Containment

3.3.4.1 Description of Risk

The survey and support vessels store and use small quantities of lubricating oils and hydraulic fluid, which have the potential to spill if not appropriately managed. Hydraulic fluid may also potentially be spilled from a leak in hoses or lines on hydraulic equipment such as cranes or winches.

3.3.4.2 Potential Environmental Impacts

Hydrocarbons may be stored on deck (or within below-deck storage) on the survey and support vessels and include lubricating oils or hydraulic fluids. The size of potential spills to deck of these substances are likely to be between 50 and 200 L (0.05 m^3 and 0.2 m^3, respectively), based on expected volumes of fluids available on deck typically stored in 50–200 L steel drums. Storage of these fluids on-board the vessels would be within a designated storage room or a contained (i.e. bunded) area on deck.

Volumes of hydrocarbons >200 L (0.2 m^3) include main engine lubricating oils, waste engine oil and hydraulic fluid, and would normally be stored below deck in designated storage tanks. Thus, these hydrocarbons do not represent a direct hazard for deck spills, unless smaller volumes are being used on deck directly from a container.

Credible spill scenario

Secondary containment measures (i.e. bunds, containment lips, or absorbent booming) will be applied to the storage of drums or containers that are present on deck to prevent direct discharge to the marine environment. In the event of an accidental spill or leaking container, it is most likely that spilled material will be contained aboard (e.g. via use of scupper plugs) and recovered with minimal risk of material entering the marine environment through overboard drains or scuppers. For a spill on deck to result in a release to the marine environment, there would need to be an un-confined spill, which was subsequently allowed to flow overboard and since use of oils or other chemicals on deck would be confined within areas with deck combing or bunds. This is highly unlikely to occur.

Spills or leaks from hydraulic hoses on cranes, winches or other hydraulically operated equipment are possible, although typically involve only very small volumes of fluid loss (<1 L). These spills or leaks are typically contained within a bund or drip tray under the equipment mounted on deck. A burst hydraulic hose on an extended crane could potentially result in hydraulic fluid being sprayed in a fine jet out over the water. However, this would only result in a small volume (<1–25 L) before the problem was noticed, equipment shut-down and the leak stopped.

In the event a loss to sea does occur, impacts to the marine environment would be minimal, due to the small potential volumes released, and spilt hydrocarbons will rapidly evaporate, disperse and weather. The potential environmental impacts are outlined further in Section 3.3.5. Therefore, based on the small volumes and proper storage procedures, the risk of an accidental hydrocarbon release (topside) is considered to be low.

3.3.5 Hydrocarbon Release Caused by Vessel Collision between Survey Vessel and Chase Vessel or Third-Party Vessel

3.3.5.1 Description of Risk

The most credible hazards associated with hydrocarbon fuel and oil spills during the proposed survey activities are:

- loss of up to 3,091 litres (~3 m^3) of diesel during refuelling operations, as a result of hose failure
- loss of up to 300 m^3 diesel resulting from ruptured fuel storage tank from a vessel collision.

3.3.5.2 Potential Environmental Impacts

The accidental discharge of diesel oil has the potential to cause toxic effects on marine fauna and flora and a localised reduction in water quality. Marine species may come into contact with surface hydrocarbon slicks and potentially be affected. If surface slicks or entrained diesel were to contact shallow waters or emergent features adjacent to the operational area, then a range of benthic habitats and communities would be at risk of adverse impacts. Commercial fishing, tourism and shipping activities in the area would also be impacted from a major diesel spill.

The frequency of spills exceeding 1 tn per year can be broken down into eight different accident types to (DNV 2011), with the most dominant being transfer (19.9%), drift grounding (21.6%) and powered grounding (19.1%), whilst the spill frequency for vessel collisions is 11.6%. Therefore, transfer spills have a much greater potential to occur rather than vessel collisions. For a refueling accident, the amount of diesel that is most likely to be spilled is less than that involved in a vessel collision. The realistic worst case volume of diesel spilled during refuelling operations is 3,091 litres (3 m^3), arising from the total loss of the contents of the transfer hose (e.g. 5" hose of 244 m length). In the event of hose failure, dry break couplings would prevent any more than the hose volume being spilled. In reality, a more likely scenario is a pin hole leak or a large hole in the hose from abrasion or mechanical damage that results in a highly visible sheen on the sea surface, which would thus requrie action to stop the leak by the operation supervisor(s) before more than a few litres would be spilled. Thus, modelling results for a vessel collision only are presented and used to determine the zone of potential impact (ZPI). The likelihood of a hydrocarbon spill occurring is a combination of the probability that:

- a spill occurs and the volume of that spill is at source (i.e. primary risk)
- a spill reaches a sensitive part of the environment (i.e. secondary risk).

Vessel collision spill risk levels from the proposed survey activities are no different from those presented by any other routine shipping operating in waters off the north-west Australian coastline. Based on a review of the Australian Transport Safety Bureau's marine safety database (ATSB 2016), there are no recorded instances of collisions, grounding or sinking of a seismic vessel or its support vessels in Australian waters in at least the last 30 years. While there are commercial fishing and shipping activity in some areas of the Nightcap MSS operational area, a collision between the survey and/or support vessels and another vessel unconnected with the activity is unlikely, given the comprehensive control and mitigation measures in place to manage the risk of vessel collisions. Further, there is no possibility of the survey or support vessels grounding within or immediately adjacent to the Nightcap MSS operational area, given that the deep water depths (80–1,300 m), the absence of any shallow water or emergent features and the proposed mitigation measures. However, there is a remote possibility of a collision between the survey vessel and the support vessel during occasions when both vessels are manoeuvring close to each other.

Vessel tanks are never filled to 100% capacity but rather to 90% capacity. For the proposed survey activities, the survey vessel will have a maximum fuel storage volume of 330 m^3. In the extremely unlikely and improbable event of a ruptured fuel tank as a result of collision, the maximum spill size possible would be in the order of ~300 m^3 of MGO (i.e. 90% capacity). However, this could only occur in the event of a rupture of the vessels' largest MGO tanks and complete loss of all of its contents. In such a scenario, the volume of the

fuel lost to the marine environment would be expected to be less than the total capacity of the tank based on:

- the MGO tanks are never filled to maximum capacity
- if the tank location is below the water line, it will leak down to a level equivalent to the water line
- emergency procedures implemented to transfer the contents of the tank to other MGO tanks on-board the vessel.

Therefore, it is not expected that the full volume would be released to the marine environment. Accordingly, spill modelling results are based on 90% capacity of the maximum possible volume (i.e. 300 m^3) to represent an overly conservative and therefore worst case scenario in the hydrocarbon spill risk assessment.

3.3.5.3 Spill Modelling

For the proposed survey activities, indicative modelling was undertaken using the Automated Data Inquiry for Oil Spills (ADIOS2) modelling software, which forecasts weathering processes (e.g. spreading, evaporation, dispersion, sedimentation and emulsification) and oil slick characteristics to simulate different types of release scenarios (Lehr *et al.* 2002). The ZPI resulting from a 3 m^3 refuelling incident would be much smaller than the 300 m^3 spill from a vessel collision. Furthermore, as no refuelling will occur within 25 km from emergent land (including the Rowley Shoals Marine Park and Commonwealth Marine Reserves), the potential impacts on sensitive marine habitats from an accidental hydrocarbon spill during transfer will be reduced. As such, the remainder of this section focuses on the potential environmental impacts associated with the larger spill size (300 m^3).

Table 3.14 - ADIOS2 Oil Budget Table for 300 m^3 Spill of MGO within the Nightcap MSS Operational Area

Summer				
Hours into spill	**Released (m^3)**	**Evaporated (%)**	**Dispersed (%)**	**Remaining (%)**
1	50	4	0	96
2	100	5	1	94
4	200	8	2	89
6	300	11	5	84
8	300	18	10	72
10	300	23	18	59
12	300	28	27	45
14	300	32	38	30
18	300	35	55	12
24	300	36	62	2
30	300	36	63	1
Autumn				
Hours into spill	**Released (m^3)**	**Evaporated (%)**	**Dispersed (%)**	**Remaining (%)**
1	50	4	0	96
2	100	5	1	94
4	200	8	2	89
6	300	11	5	84
8	300	17	11	72
10	300	22	18	60
12	300	27	26	47
14	300	31	35	34
18	300	35	53	12
24	300	36	62	2
30	300	36	63	1
Winter				
Hours into spill	**Released (m^3)**	**Evaporated (%)**	**Dispersed (%)**	**Remaining (%)**
2	100	8	8	84
4	200	11	20	69
6	300	14	31	56
7	300	16	40	43
8	300	19	51	31
9	300	20	61	19
12	300	22	77	1

Spring				
Hours into spill	**Released (m^3)**	**Evaporated (%)**	**Dispersed (%)**	**Remaining (%)**
1	50	4	0	96
2	100	6	1	94
4	200	9	2	89
6	300	12	4	84
8	300	19	7	74
10	300	25	13	63
12	300	29	19	52
14	300	33	26	41
22	300	40	48	12
30	300	41	55	4
36	300	41	57	2
48	300	41	58	1

Notes:

Summer
Wind Speed = constant at 6 m/s
Water temperature = 30°C
Current speed = 0.1 m/s

Autumn
Wind Speed = constant at 6 m/s
Water temperature = 28°C
Current speed = 0.08 m/s

Winter
Wind Speed = constant at 10 m/s
Water temperature = 25°C
Current speed = 0.1 m/s

Spring
Wind Speed = constant at 5 m/s
Water temperature = 28°C
Current speed = 0.08 m/s

Summer Predictions

- ~99% of a slick may disperse and evaporate within about 30 hours of the spill in 6 m/s strong warm winds and conservative current speed of 0.1 m/s.
- A surface slick is calculated to travel a maximum distance of 30 km within 30 hrs. Therefore the ZPI for an oil spill resulting from a vessel collision could have a potential radius of 30 km (Figure 3.10).
- After 30 hours, dispersion is likely to account for ~63% of the loss, and evaporation ~36%.
- Both dispersion and evaporation will likely be enhanced due to the warm prevailing air and sea temperatures within the NWS region.

Autumn Predictions

- ~99% of a slick may disperse and evaporate within about 30 hours of the spill in 6 m/s strong warm winds and conservative current speed of 0.08 m/s.
- A surface slick is calculated to travel a maximum distance of 28 km within 30 hrs. Therefore the ZPI for an oil spill resulting from a vessel collision could have a potential radius of 28 km (Figure 3.10).
- After 30 hours, dispersion is likely to account for ~63% of the loss, and evaporation ~36%.

Winter Predictions

- ~99% of the slick will either disperse or evaporate within about 12 hours of the spill in 10 m/s strong cooler winds and conservative current speed of 0.1 m/s.
- A surface slick is calculated to travel a maximum distance of 17 km within 12 hrs. Therefore, the ZPI for an oil spill occurring during the winter could have a potential radius of 17 km (Figure 3.10).
- During winter, after 12 hours, dispersion is likely to account for ~77% of the loss, and evaporation ~22%.
- Evaporation is less likely due to the cooler temperatures.

Spring Predictions

- ~99% of the slick will either disperse or evaporate within about 48 hours of the spill in 5 m/s warm winds and conservative current speed of 0.08 m/s.
- A surface slick is calculated to travel a maximum distance of 40 km within 48 hrs. Therefore, the ZPI for an oil spill occurring during the winter could have a potential radius of 40 km.
- During winter, after 48 hours, dispersion is likely to account for ~58% of the loss, and evaporation ~41%.

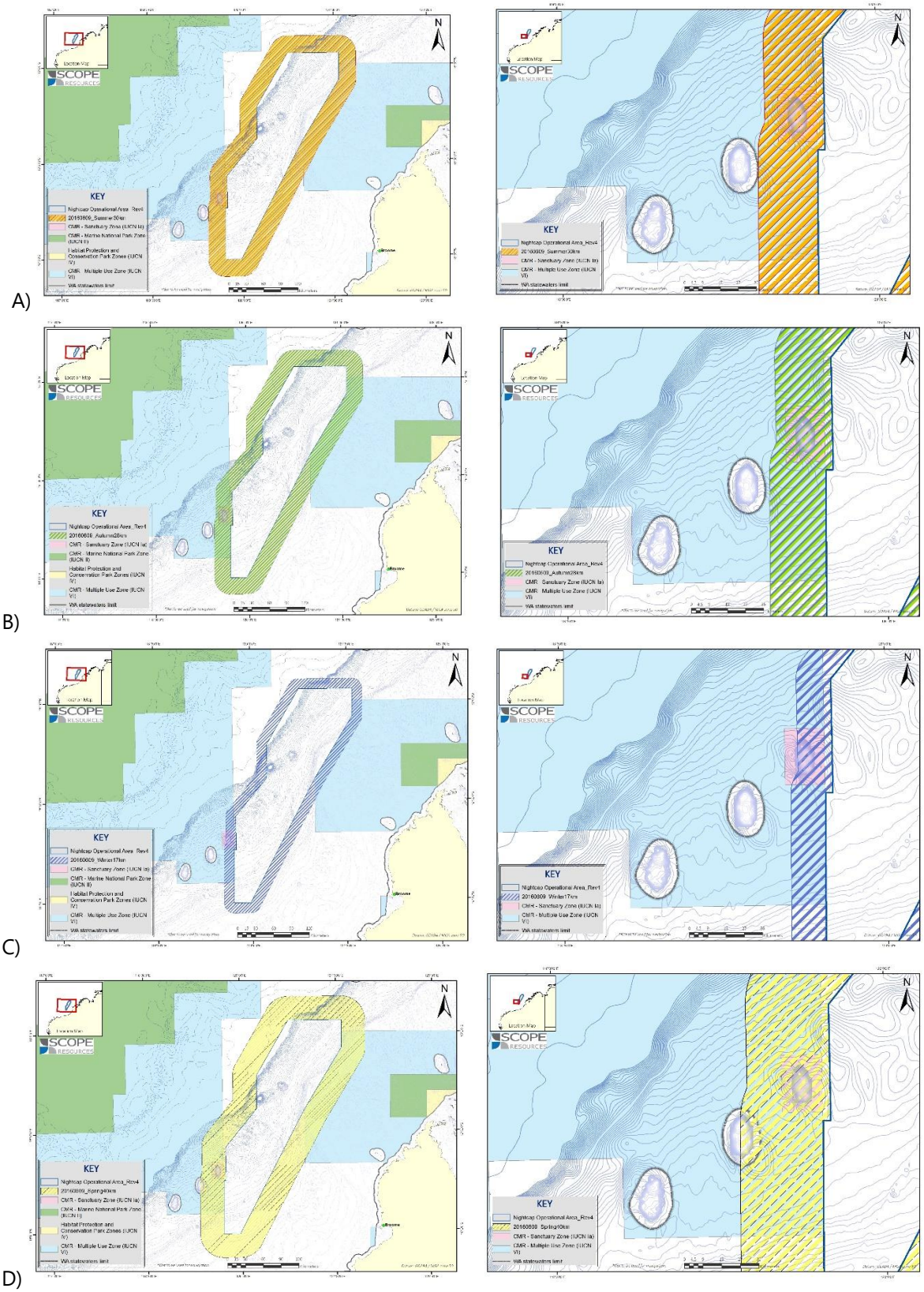


Figure 3.10 –ADIOS2 modelling ZPI predictions for a potential hydrocarbon spill of 300 m^3 near the Rowley Shoals all four seasons: A) summer; B) autumn; C) winter; and D) spring.

Using the standard assumption that a surface slick would move at 3% of wind speed and 100% current, a spring (i.e. September–November) surface slick is calculated to travel a maximum distance of 40 km within 48 hours of an oil spill event. As shown in Figure 3.10, the ZPI for a 300 m^3 spill during spring is predicted to impact Mermaid Reef and the deeper waters around Clerke Reef (Figure 3.10). Therefore, based on this worst-case scenario of a spring oil spill resulting from a vessel collision, Pathfinder will commit to no data acquisition or close proximity procedures between survey and support vessels within 40 km of the MRCMR and Rowley Shoals Marine Park boundaries during the months of September–November (Figure 3.11).

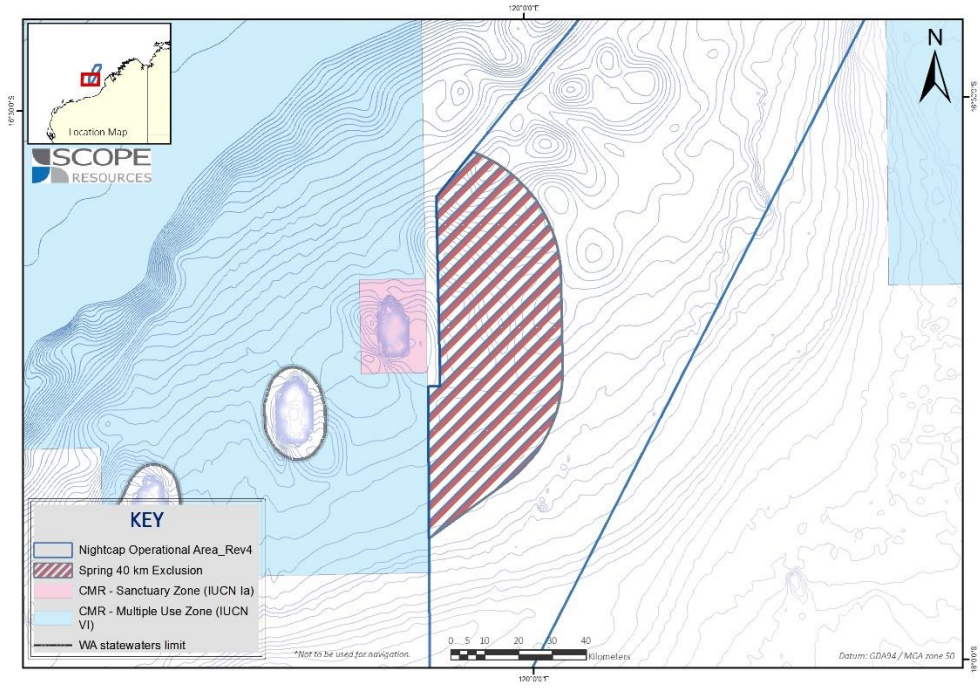


Figure 3.11 – Spring Season (September–November) Exclusion Zone of 40 km to Mermaid Reef Commonwealth Marine Reserve and Rowley Shoals Marine Park Boundaries

3.3.5.4 Sensitivities that may be affected

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. 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. Table 3.15 outlines what sensitivities may be impacted.

Table 3.15 – Summary of sensitive receptors impacted based on ADIOS2 modelling

Emergent Features or Sensitive Receptors	Key Features	Summer ZPI 30 km	Autumn ZPI 28 km	Winter ZPI 17 km	Spring ZPI 40 km
Mermaid Reef CMR	• pristine character and coral reefs • enhanced productivity and high species richness	YES	YES	YES	YES
Rowley Shoals State Marine Park	• attract a range of migratory pelagic species such as dolphins, tuna, billfish and sharks • foraging area for loggerhead turtle • resting and foraging area for various seabirds	YES	NO	NO	YES
Argo-Rowley Terrace CMR	• important area for sharks • communities and habitats of the deeper offshore waters of the region in depth ranges from 220 m to over 5,000 m • seafloor features including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope • communities and seafloor habitats of the Northwest Transition and Timor Province provincial bioregions • connectivity between the existing Mermaid Reef Marine National Nature Reserve and reefs of the Western Australian Rowley Shoals Marine Park and the deeper waters of the region • foraging areas for migratory seabirds and the endangered loggerhead turtle • KEF - the canyons linking the Argo Abyssal Plain with the Scott Plateau (unique seafloor feature with enhanced productivity and feeding aggregations of species)	NO	NO	NO	NO
	• KEF - Mermaid Reef and the Commonwealth waters surrounding Rowley Shoals (an area of high biodiversity with enhanced productivity and feeding and breeding aggregations)	YES	YES	YES	YES
Kimberley CMR	• communities and habitats of waters offshore of the Kimberley coastline ranging in depth from less than 15–800 m • continental shelf, slope, plateau, pinnacle, terrace, banks and shoals and deep hole/valley seafloor features • communities and seafloor habitats of the Northwest Shelf Transition, Northwest Shelf Province and Timor Province provincial bioregions along with the Kimberley, Canning, Northwest Shelf and Oceanic Shoals meso-scale bioregions • adjacent to important foraging and pupping areas for sawfish and important nesting sites for green turtles • Two KEFs are included in the reserve: o ancient coastline (an area of enhanced productivity attracting baitfish which, in turn, supplies food for migrating species) o continental slope demersal fish communities (the second richest area for demersal fish species in Australia)	NO	NO	NO	NO
	• foraging areas for migratory seabirds, migratory dugongs, dolphins and threatened and migratory marine turtles • important migration pathway and nursery areas for the protected humpback whale	YES	YES	YES	YES
KEF - Ancient coastline at 125 m depth contour	• prominent seabed features in water depth >125 m • contribute to higher diversity and enhanced species richness • facilitate increased availability of nutrients off the Pilbara • enhanced productivity may attract larger marine life such as whale sharks and large pelagic fish • humpback whales appear to migrate along the ancient coastline	YES	YES	YES	YES
KEF - Continental Slope Demersal Fish Communities	rich assemblage of ▪500 fish species and high endemicity in 225–1,000 m water depth	NO	NO	NO	NO

The environmental sensitivities and values most at risk from a large diesel spill are benthic habitats and communities associated with shallow subtidal and intertidal waters surrounding shallow shoals and reefs including:

- coral reefs
- seagrass
- sandy beaches
- commercial fishing
- recreational fishing
- marine-based tourism.

Protected marine fauna at risk within or adjacent to the Nightcap MSS operational area as a result of a 300 m^3 release of marine diesel includes:

- cetaceans
- whale sharks
- marine turtles
- seabirds.

As the Nightcap MSS operational area is ~4 km from the boundary of MRCMR, the closest distance to the 250 m isobath is ~9 km and to the inner lagoon is ~11 km. At this distance, the ADIOS2 modelling results for the spring season (i.e. worst case scenario estimated that MGO would potentially reach the outer edge of the reef within ~11 hours after the release with 63% remaining (Table 3.16). MFO is not predicted to enter the inner lagoon waters in winter until 14 hours after the release with 41% remaining. During the winter season (i.e. June–August), modelling results estimated that a surface slick would reach the outer reef edge quicker (7 hours) but with a smaller quantity of MGO remaining (43%).

Mermaid and Clerke Reefs have an outer reef rim which fully encloses an inner lagoon. The lagoon is only accessible through one navigable passage on the northern side and through which tides of up to 4.5 m ebb and flow. Mermaid Reef has no landforms above high water mark. The reef platform and small sandbank at the northern end of the lagoon are both completely covered at high water, with Clerke Reef being dry for only about 1.5 hours either side of low water level (DEC 2007). The small sandbank at the northern end of the lagoon of Mermaid Reef is located within the ZPI for all seasons. Clerke Reef contains emergent sand cays at the northern end, and a reef flat encircles an inner lagoon around 10 m deep. Around Clerke Reef, the seafloor rises steeply from 390 m deep.

The Nightcap MSS operational area is >30 km away from the boundary of Rowley Shoals at Clerke Reef and >70 km from the boundary at Imperieuse Reef. Based on these distances, the modelling predicted that spilled MGO is likely to enter the state water boundary at Clerke Reef during the spring after 37 hours from release with 2% remaining (Table 3.16). Less than 1% of the spilled diesel is likely to enter water shallower than 250 m after 43 hours from release. During summer, a very small amount of spilled MGO (1% remaining) is likely to reach the State water boundary of Clerke Reef after 30 hours following a spill event. However, no amount of spilled oil is predicted to enter the reef lagoon at Imperieuse Reef at any time of the year. Therefore, it is unlikely that significant impacts to the marine habitats of Clerke and Imperieuse Reefs are likely to occur from spilled diesel resulting from a vessel collision.

Table 3.16 – Oil spill modelling results for a vessel collision near the Rowley Shoals

Location	Distance (km)	Winter				Spring				Summer				Autumn			
		Time (hours)	Evaporated (%)	Dispersed (%)	Remaining (%)	Time (hours)	Evaporated (%)	Dispersed (%)	Remaining (%)	Time (hours)	Evaporated (%)	Dispersed (%)	Remaining (%)	Time (hours)	Evaporated (%)	Dispersed (%)	Remaining (%)
Mermaid Reef – 250 m contour	~9	7	16	40	43	11	25	13	63	9	18	10	72	10	22	18	60
Mermaid Reef – 40 m contour (lagoon)	~11	8	19	51	31	14	33	26	41	11	23	18	59	12	27	26	47
Clerke Reef – boundary	>30	No contact				37	41	57	2	30	36	63	1	No contact			
Imperieuse Reef – boundary	>70	No contact															

3.3.5.5 Assessment of Consequences

As stated above, based on this worst-case scenario of a spring oil spill resulting from a vessel collision, Pathfinder will commit to no data acquisition or close proximity procedures between survey and support vessels within 40 km of the MRCMR and Rowley Shoals Marine Park boundaries during the months of September–November (Figure 6.7). Nonetheless, should an accidental hydrocarbon release resulting from a vessel collision, the sensitivities at risk within and adjacent to the Nightcap MSS operational area are (Table 3.17):

- protected marine fauna such as seabirds, cetaceans, whale sharks and marine turtles
- the benthic habitats and communities (primarily corals) of shallow water reef platforms encompassing the lagoons of all Mermaid Reef and Clerke Reef (spring only)
- the sandy beaches of the emergent sand cays within Mermaid Reef (which shift with tides), and of Bedwell Island in Clerke Reef (spring only), which is used for feeding/roosting/nesting by seabirds and turtles
- commercial fisheries
- recreational fishing and marine-based tourism (diving/snorkelling) at the Mermaid and Clerke Reefs.

While surface diesel slicks have the potential to impact protected marine fauna, significant mortalities are considered unlikely given the overall low species density within the operational area. The elevated concentrations of dissolved aromatic hydrocarbons associated with surface diesel slicks would likely be acutely toxic to pelagic organisms present in surface waters within the area of a major diesel spill. However, due to the characteristics of diesel and its rapid natural degradation and dispersion in the open ocean, the temporal and spatial extent of any adverse effects is likely to be limited. Entrained hydrocarbons may pose different risks to habitats and fauna compared to a surface slick. Due to the dilution of entrained oil in the water column compared to a surface slick, toxic impacts are likely to be less. Entrainment associated with diesel will generally be limited to the top few metres of the water column and ultimately depend on environmental conditions. Subsequently, benthic environments in deeper waters are not affected.

A summary of the sensitive receptors from a potential oil spill, and the potential impacts of both surface slicks and entrained oil, are outlined in Table 3.17. Although the amount of entrained oil to be generated is minimal and so its effects negligible, an overview is provided. Overall, the impact of surface and/or entrained hydrocarbons on protected areas is considered Medium. Furthermore, the nature of diesel in the marine environment is highly evaporative and dispersive and is not expected to persist for more than 12 hours in winter, 30 hours in summer and autumn and 48 hours in spring (Table 3.14).

Protected Marine Fauna

Contact with hydrocarbon slicks can have lethal or sub-lethal physical and toxic effects to seabirds, cetaceans, whale sharks and turtles due to external and internal exposure. Air breathing marine fauna (e.g. cetaceans and turtles) would be at greater risk through inhalation of hydrocarbons if they surfaced within a fresh slick, although the extent and duration of potential exposure would be limited due to the rapid evaporation rates for volatile components of diesel. While surface slicks and entrained diesel (minimal with MGO) have the potential to impact individual seabirds, cetaceans, whale sharks or turtles, significant mortalities are considered unlikely given the overall low abundance in species density likely to be encountered within the operational area.

The Nightcap MSS operational area does not contain any critical habitats (e.g. calving, nursing, resting, breeding, feeding area, narrow restricted migratory pathways) for any cetacean species (Table 3.17). Marine mammals are highly mobile, and anecdotal evidence indicates whales and dolphins may be able to detect and avoid surface slicks. Marine mammals may have direct physical contact with surface slicks and entrained oil from surface fouling or through ingestion of hydrocarbons and/or inhalation of toxic vapours. Irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system or neurological damage is likely to occur (Etkins 1997). Marine mammals are generally able to metabolise and excrete limited amounts of hydrocarbons, but acute or chronic exposure poses greater

toxicological risks (Grant & Ross 2002). Such impacts may include changes in behaviour and reduced activity, including inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage (Geraci & St. Aubin 1990). As the operational area overlaps a small portion of the known distribution BIA and migration BIA for pygmy blue whales, it is unlikely that significant numbers of whales would be exposed to surface diesel slicks in the event of a diesel spill within the very short timeframe prior to natural weathering of these slicks. Based on the spill modelling predictions (Table 3.14), ~99% of a surface slick will have dispersed and evaporated within 48 hours in spring season (i.e. worst case scenario).

Seabirds are particularly vulnerable to hydrocarbon spills, owing to the high potential for contact with the sea surface or shoreline where they feed, rest or moult. As most fish survive beneath floating slicks, they will continue to attract foraging seabirds, which typically do not exhibit avoidance behaviour. Whale sharks often feed on dense aggregations of prey (e.g. krill and bait fish) close to the sea surface (Colman 1997). By filter-feeding their prey, whale sharks may likewise ingest oil directly as well as associated dispersants (Campagna *et al.* 2011). However, based on the rare and infrequent occurrence of whale sharks within the Nightcap MSS operational area, it is unlikely that a high density of whale sharks could come into contact with surface diesel slicks.

Whilst in the water or onshore, marine turtles are vulnerable to the effects of hydrocarbon spills at all life stages: eggs, post hatchlings, juveniles and adults (NOAA 2010a). Contact with hydrocarbons can have lethal or sub-lethal physical or toxic effects or impair mobility. Marine turtles are in frequent contact with the sea surface and they may also feed at or below the water surface or rest at the surface. This frequent contact and a lack of avoidance behaviour makes turtles susceptible to coating with spilled hydrocarbons and inhalation of toxic hydrocarbon vapours. On contact with surface slicks, turtles may experience irritation and injury to airways or lungs, eyes and mucous membranes of the mouth and nasal or other cavities (NOAA 2010a). The ZPI for a 300 m^3 diesel spill in spring for the Nightcap MSS operational area does not overlap islands that represent defined BIA for any turtle species in the region (Table 3.17). Furthermore, the emergent features within Clerke Reef does not represent a critical habitat for large numbers of turtles. Thus, a worst case scenario of an oil spill near Clerke Reef during spring would not impact a known critical habitat for marine turtles.

Bedwell and Cunningham Islands represent a BIA (resting) for the little tern, and a BIA (breeding) for the white-tailed tropicbird, and the management plan for the Rowley Shoals Marine Park (DEC 2007) identified Bedwell Island as the site of the second largest breeding colony of red-tailed tropicbirds in WA. Whilst both red-tailed and white-tailed tropicbirds breed during the period from May–July, these species nest in hollows located well above high water mark. Furthermore, after 37 hours following a winter spill event, 2% of spilled diesel is expected to reach the outer State water boundary at Clerke Reef. Thus, birds nesting on Bedwell and Cunningham Islands would not be exposed to significant amounts of surface diesel.

In the event of an oil spill near Mermaid Reef, the most vulnerable coral colonies predicted to have direct contact with surface slicks would be those close to the shoreline or periodically exposed at spring low tides (NOAA 2010b). Below a depth of 3-4 m, coral colonies would be separated from surface slicks by the overlying waters. Although not subject to smothering by surface slicks, these sub-tidal corals may be subject to contact with dispersed hydrocarbon droplets (i.e. entrained oil) introduced into the water column by wave action on surface slicks (NOAA 2010b). Exposure to hydrocarbon in the water column is much less than from direct contact with a slick, and as such, there is a potential for lethal impacts, particularly to some sensitive species (Table 3.17). Impacts to corals will depend on species' tolerance as well as exposure concentrations and length of exposure. Experimental studies and field observations in the aftermath of hydrocarbon spills indicated that contact with hydrocarbons may result in no observable injury through to complete or partial mortality of the colony with tissue death occurring on the coral colony's surface where oil has adhered (NOAA 2010b). Furthermore, based on the predicted worst-case scenario of a spring oil spill resulting from a vessel collision, Pathfinder will commit to no data acquisition or close proximity procedures between survey and support vessels within 40 km of the MRCMR and Rowley Shoals Marine Park boundaries during the months of September–November. As such, the likelihood of an oil spill is low, and potential impacts to the coral communities are reduced.

Sandy Beaches

Sandy beaches have a relatively low biodiversity, although they do provide important habitats for nesting turtles and breeding and foraging seabirds. They also provide habitat for polychaetes, molluscs, marine crustaceans, semi-terrestrial crustaceans and insects. The sandy beaches and shorelines potentially at risk from surface diesel slicks or entrained hydrocarbons are on Bedwell Island (Clerke Reef) and the emergent sand cays at the northern tip of Mermaid Reef, which shift due to tidal influences (Table 3.17). As diesel is less viscous or sticky when compared to black oils, the diesel tends to penetrate porous sediments quickly but also may be washed off quickly by waves and tidal flushing. In approximately two months, diesel oil is readily and completely degraded by naturally occurring microbes (NOAA 2012). Following a diesel spill, Norwegian shorelines resulted in a thickness of 1–10 mm diesel exposure. Following clean-up however, no significant differences between contaminated and reference uncontaminated locations were found (SINTEF 2006). Furthermore, based on the predicted worst-case scenario of a spring oil spill resulting from a vessel collision, Pathfinder will commit to no data acquisition or close proximity procedures between survey and support vessels within 40 km of the MRCMR and Rowley Shoals Marine Park boundaries during the months of September–November. As such, the likelihood of an oil spill is low, and potential impacts to sandy beaches are reduced.

Socio-economic Environment

As described in Section 2.3, there are a number of commercial fisheries that could be operating within or adjacent to the Nightcap MSS operational area. The potential impacts from a surface slick would be indirect, e.g. exclusion of fishers from areas they normally fish due to the presence of surface diesel slicks, and/or oiling of vessel hulls and trap gear (e.g. traps, buoys, lines) if the equipment is deployed or retrieved through surface slicks (Table 3.17). Direct toxicity effects on target species would not occur, as the target species of these fisheries generally forage and breed close to hard substrate features on the seabed.

Given the proximity of the operational area to the Rowley Shoals, there is the possibility of impacts from a major diesel spill, especially if surface slicks were to contact the waters surrounding the reefs and enter the lagoons within the reefs (spring only) during periods when charter vessels are visiting the area for fishing, diving and snorkelling activities (Table 3.17). Exclusion zones surrounding spills will reduce access for recreational fishing and snorkelling/diving on intertidal and sub-tidal reefs. Stranding of oil on sandy beaches may impact some tourism activities. Also, any changes to the marine environment at the Rowley Shoals are likely to reduce the quality and experience of marine tourism activities. Therefore, based on the predicted worst-case scenario of a spring oil spill resulting from a vessel collision, Pathfinder will commit to no data acquisition or close proximity procedures between survey and support vessels within 40 km of the MRCMR and Rowley Shoals Marine Park boundaries during the months of September–November. As these months are also the peak period for marine tourism activities at Rowley Shoals, the likelihood of an oil spill is low, and potential impacts to marine tourism are unlikely and reduced to ALARP and acceptable levels.

Table 3.17 - Summary of Potential Impacts to Sensitive Receptors within the Nightcap MSS Operational Area

Receptor	Potential Exposure	Potential Impacts	
		Surface Slicks	**Entrained Oil**
Marine Fauna			
Cetaceans	Marine mammals are highly mobile and anecdotal evidence indicates whales and dolphins may be able to detect and avoid surface slicks. EPBC listed species 24 cetacean species were identified by the EPBC Protected Matters search (Table 2.2) as potentially occurring in the Nightcap MSS operational area. Of these, the blue whale is listed as Endangered and the humpback whale is listed as Vulnerable. BIA The Nightcap MSS operational area overlaps the BIA (migration north and south) for both the humpback whale and pygmy blue whale. Planning will be undertaken to try and avoid these peak sensitive periods, but it is possible that activities will overlap.	• Marine mammals are highly mobile • Marine mammals may have direct physical contact with surface slicks and entrained oil from surface fouling or through ingestion of hydrocarbons and/or inhalation of toxic vapours. • Irritation of sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impairment of the immune system or neurological damage. • Generally able to metabolise and excrete limited amounts of hydrocarbons • Acute or chronic exposure poses greater toxicological risks, including changes in behaviour and reduced activity, including inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, and neurological damage	
		Surfacing within a hydrocarbon slick may lead to a toxic level of exposure. However, cetaceans have a thickened epidermis that greatly reduces the likelihood of hydrocarbon toxicity from skin contact with oiled waters (Geraci 1990, O'Shea & Aguilar 2001). For surface oil, inhalation of vapours at the water surface and ingestion of hydrocarbons during feeding (in particular, surface skimming baleen whales) are more likely pathways of exposure (National Marine Fisheries Service 2008). Pygmy blue whales Migrating pygmy blue whales may be exposed to surface diesel slicks, if the slicks overlap spatially and temporally with feeding activity. Humpback whales Humpback whales migrating north at the start of the northbound season may be exposed to surface diesel slicks. A low number of transient individuals may be present within the area affected by a spill.	As described for surface oil, acute or chronic exposure, through skin contact, inhalation or ingestion can result in toxicological risks. However, the concentration of entrained hydrocarbons will be less in comparison to surface slicks, due to the effects of dilution with sea water and inability for some hydrocarbon residues to entrain. This behaviour of entrained diesel combined with a thick epidermis layer means cetaceans are unlikely to be effected greatly from skin contact with entrained hydrocarbons. Further, inhalation will not be a significant exposure pathway for entrained oil. However, entrained oil can be ingested during feeding, in particular by gulp feeding whales. Pygmy blue and humpback whales It is possible that migrating whales could be exposed to entrained oil. However, there is no evidence of extensive feeding activity taking place during the migration.
		Low numbers of humpback and pygmy blue whales may encounter surface slicks and entrained oil. The potential consequences of contact are minor (as assessed above). Furthermore, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, potential impacts of surface slicks and entrained oil on these species are considered to be low.	
Marine Reptiles	EPBC listed species Six migratory turtle species were identified by the EPBC Protected Matters search (Table 2.2) as potentially occurring in the Nightcap MSS operational area. Three of these species are listed as Endangered and three are listed	Marine turtles are vulnerable to the effects of hydrocarbon spills at all life stages (e.g. eggs, post hatchlings, juveniles and adults) whilst in the water or onshore (NOAA 2010a). Contact with hydrocarbons can have lethal or sub-lethal physical or toxic effects or impair mobility. Marine turtles are in frequent contact with the sea surface and they may also feed at or below the water surface or rest at the surface. This frequent contact with the sea surface or oils entrained in the upper surfaces and a lack of avoidance behaviour makes turtles susceptible to coating with spilled hydrocarbons and inhalation of toxic hydrocarbon vapours.	

Receptor	Potential Exposure	Potential Impacts	
		Surface Slicks	**Entrained Oil**
	as Vulnerable. Fourteen species of sea snake and none of which are listed with a Threatened status. Given the survey water depths are greater than 30 m, it is unlikely that sea snakes will be encountered.	The main pathways for hydrocarbon surface slick exposure include ingestion and inhalation of vapours. Turtles are particularly prone to ingestion of surface oil, especially where it forms solid masses such as tar balls. Hydrocarbons ingested by a turtle do not pass rapidly through its digestive tract, it may be retained for several days, increasing internal contact and the likelihood that toxic compounds will be absorbed. The risk of gut impaction also increases for turtles that have ingested oil. Marine turtles' diving behaviour also puts them at risk. They rapidly inhale a large volume of air before diving and continually resurface over time, therefore turtles in an oil spill would experience both extended physical exposure to the oil and prolonged exposure to hydrocarbon vapours. Hatchlings are particularly prone to surface slicks as they have little mobility and are unable to change direction in response to a spill. They also spend a greater proportion of time on the sea surface than adults. Hatchlings coated with oil residue may have reduced mobility, rendering them more vulnerable to predation, in addition to the toxic impacts described above (NOAA 2010a).	Entrained oil presents fewer impacts to turtles. While skin contact with entrained oil may occur, the entrained hydrocarbons will be at lower concentrations, due to dilution with water in the water column, and thus reducing the toxicity. Smaller quantities of hydrocarbons may be ingested, but concentrations, and resulting toxicity, will be less than surface oil. Further, the impacts of inhaling hydrocarbon vapours are not applicable to entrained oil.
		While the consequences of marine turtles encountering a surface slick can be severe, only low numbers of turtles are expected to occur within areas affected by surface slicks. Hatchlings are unlikely to be impacted given the separation distances between the Nightcap MSS operational area and turtle nesting sites in the region. Furthermore, ~two days after a spill, less than 60% is forecast to entrain and a further 40% is forecast to have evaporated, leaving only a small proportion of oil (<1%) floating on the water surface. As such, the potential impacts of surface slicks on turtles is considered low.	Since the effects of entrained oil on marine turtles are less severe than surface slicks, and given that large numbers of marine turtles are not expected within areas where entrained oil concentrations are expected to be highest (i.e. close to the spill source), the potential impacts of entrained oil are considered low.
		Sea snakes may experience sub-lethal impacts (as described above) and in extreme cases, there may be lethal impacts. However, as sea snakes are unlikely to occur in the deep waters of the Nightcap MSS operational area, the potential impacts of surface slicks or entrained oil are considered to be negligible.	
Seabirds	<u>EPBC listed species</u> Four migratory seabird species were identified by the EPBC Protected Matters search (Table 2.2) as potentially occurring in the Nightcap MSS operational area. None of these species area listed with a Threatened status. The operational area is does not contain any critical habitat or BIA for seabirds or shorebirds. The closest BIA for white-tailed tropicbird is at Bedwell Island connected to Clerke Reef (>11 km) away.	Seabirds are particularly vulnerable to surface hydrocarbons. As most fish survive beneath floating slicks, they will continue to attract foraging seabirds, which typically do not exhibit avoidance behaviour. Direct contact with surface hydrocarbons can lead to irritation of skin and eyes. Smothering can lead to reduced water proofing of feathers leading to hypothermia. Smothering of feathers can also lead to excessive preening, diverting time away from other behaviours leading to starvation and dehydration. Preening of oiled feathers will also result in to ingestion of hydrocarbons and the associated impacts of toxicity and potential illness. However, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, significant impacts from surface slicks to seabirds are unlikely to occur.	Entrained oil does not pose the same high risk of smothering as surface slicks as the effects of smothering on feathers are lower, reducing the amount of hydrocarbons ingested through preening. Seabirds may still encounter entrained hydrocarbons leading to irritation of skin and eyes, and also lower levels via ingestion and the associated toxicity effects.
		The impacts of surface oil on seabirds can be severe. However, there are no BIAs within the Nightcap MSS operational area. Therefore, significant impacts are not likely to occur to seabirds of these species in the area of a potential surface slicks.	The effects of entrained oil on seabirds are less severe than those posed by surface slicks. Significant impacts could occur for those species that plunge feed below the surface where the birds, and the fish they are feeding on, would be exposed to entrained oil.
		Given the lack of a BIA for seabird species within the Nightcap MSS operational area, any birds foraging in the area of surface slicks would be temporarily exposed to potentially significant impacts from surface oil, and to a lesser extent, entrained oil. However, these impacts are not expected to have significant impacts for seabird populations that may be transiting through the Nightcap MSS operational area.	
Fish	<u>EPBC listed species</u>	Fish and sharks do not generally break the sea surface. Approximately two days after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is	Hydrocarbon droplets can physically affect sharks and fish exposed for an extended duration (weeks to months). Smothering through coating of gills can lead to the

Receptor	Potential Exposure	Potential Impacts	
		Surface Slicks	**Entrained Oil**
(sharks and rays)	Eight species of sharks and rays, including four Vulnerable species, were identified by the EPBC Protected Matters search (Table 2.2) as potentially occurring in the Nightcap MSS operational area. Sawfish species are unlikely to be present given the significant distance from the Nightcap MSS operational area to known BIAs. BIA The polygon overlaps the BIA for the whale shark.	forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface.	lethal and sub-lethal effects of reduced oxygen exchange, and coating of body surfaces may lead to increased incidence of irritation and infection. Fish may also ingest hydrocarbon droplets or contaminated food leading to reduced growth, and hydrocarbon tainting of their flesh, making them unfit for human consumption. There is potential for localised mortality of fish eggs and larvae due to reduced water quality and toxicity. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest.
		Due to the low probability of contact with surface oil, the impact of surface oil on sharks and fish will be negligible.	Although entrained hydrocarbons can have negative impacts on fish and fish eggs/larvae, considering the small volume of entrained hydrocarbons potentially encountered, the low persistence of diesel and the large extent of suitable marine habitat, the impact on populations is considered low.
		The BIA for the migration route of whale sharks overlaps the Nightcap MSS operational area and consequently a low density of individuals may be present. Whale sharks may ingest oil and dispersants (if used) directly as they filter-feed their prey from the shallow waters near the surface. However, due to the low population abundance estimate and unknown and irregular movements, it is not expected that whale sharks will be encountered in significant numbers, and any observation of whale sharks are likely to be rare and infrequent. Thus, significant impacts to whale sharks from an oil spill are expected to be low.	
Crustaceans	All substrates and habitats. Most at risk in shallow waters.	Crustaceans are less at risk of being affected by an oil spill as the diesel fuel would form a surface slick and routes of exposure to organisms living in the water column or on the ocean floor would be limited. However, these animals can be affected in some circumstances when oil spills enter shallow or confined waters.	
Plankton	The elevated concentrations of dissolved aromatic hydrocarbons associated with surface diesel slicks would likely be acutely toxic to pelagic organisms present in surface waters in the area of a major diesel spill. The elevated concentrations of dissolved aromatic hydrocarbons associated with surface diesel slicks would likely be acutely toxic to pelagic organisms present in surface waters in the area of a major diesel spill.		
Marine habitats			
Intertidal and submerged coral reefs	Areas of intertidal reefs in shallow waters of the Rowley Shoals may be impacted by surface and entrained hydrocarbons. The minimum separation distance between these intertidal reefs and the Nightcap MSS operational area is 9 km.	Surface hydrocarbons may make contact with Mermaid Reef should reef features become emergent, for example during low tide. Impacts of contact with surface oil can include impaired feeding, fertilisation, larval settlement and metamorphosis, larval and tissue death and decreased growth rates (Villanueva *et al.* 2008). Surface oil also has the potential to impact marine fauna (e.g. marine turtles, cetaceans and sea birds) as outlined above. Below a depth of 3-4 m, coral colonies associated with submerged reefs would be separated from surface slicks by the overlying waters. Thus, the likelihood of surface oil contacting submerged reefs and shoals is low.	Physical effects from entrained oil have the potential to coat contacted coral reefs. The phenomena of smothering of exposed coral surfaces or polyps by oil spills has only been reported where very large oil spill quantities, or very sticky oil slicks, have been encountered. Response to hydrocarbon exposure can include impaired feeding, fertilisation, larval settlement and metamorphosis, larval and tissue death and decreased growth rates (Villanueva *et al.* 2008). There may be increased mortality of early life stages, particularly in coral larvae as the reproductive life stages of corals are reported to be more susceptible to hydrocarbon toxicity (Negri & Heyward 2000). Entrained oil also has the potential to impact reef fauna (fish, turtles, and marine mammals) as outlined in rows above. Submerged reefs may be subject to contact with dispersed hydrocarbon droplets (i.e. entrained oil) introduced into the water column by wave action on surface slicks (NOAA 2010b).
		While entrained hydrocarbons can have negative impacts on intertidal reefs, given the distance between the potential spill locations and the closest reefs, concentrations of entrained oil is expected to be low. However, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, significant impacts from surface slicks to intertidal and submerged coral reef habitats are unlikely to occur. As such, the impact of entrained oil on intertidal reef communities is considered likewise to be low.	
Seagrasses and Macroalgae	Sparse seagrass is found within subtidal coral reef communities and not considered a major habitat type at the Rowley Shoals or Mermaid Reef	Seagrasses and macroalgae could be vulnerable to oil slicks when exposed at low tide and also by providing a barrier to sunlight required for photosynthesis. Seagrass patches associated with the shallow reef habitats may also be exposed to entrained hydrocarbons and exhibit toxicity effects. Scientific investigations demonstrated that the temperate Australian seagrass recovered from three months of light stress (McMahon *et al.* 2011). Based on modelling predictions, the longest estimated exposure time to spilled hydrocarbon would be 48 hours during spring, at which time <1% oil would remain. Thus, based on the short exposure and relatively small volume of spilled hydrocarbon, significant impacts to seagrass are not likely. Given the distance between the potential spill locations and the closest seagrass and macroalgae, concentrations of entrained oil is expected to be low. Furthermore, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, significant impacts from surface slicks to subtidal seagrass or macroalgae are unlikely to occur. As such, the impact of entrained oil on subtidal seagrass or macroalgal communities is considered likewise to be low.	

Receptor	Potential Exposure	Potential Impacts	
		Surface Slicks	**Entrained Oil**
Sponges	Limited to hard substrate mostly in waters >10 m. Known to occur in Rowley Shoals.	Small particles and emulsions (generally associated with 'heavier' oils) may be ingested or block the feeding mechanisms of invertebrates such as oysters, starfish, sponges and corals. These particles also may have toxic components, so the effects can be physical, chemical or both. Sponges are not expected to be affected by oil spills as they are found in submerged waters, usually at depths greater than 10 m. Below a depth of 3-4 m, benthic sponges would be separated from surface slicks by the overlying waters. Thus, the likelihood of surface oil contacting benthic sponges is low.	
Socio-economic			
Commercial fisheries	The polygon overlaps a number of commercial fisheries licence areas. There may be both direct and indirect impacts on these fisheries in the unlikely event of a large diesel spill occurring within the Nightcap MSS operational area.	Surface hydrocarbons will have negligible impacts on fish (see above) but exclusion zones surrounding a spill can directly impact fisheries by restricting access for fishermen, leading to financial losses. Other impacts can occur via oiling of vessel hulls and trap gear (e.g. traps, buoys, lines) if the equipment is deployed or retrieved through surface slicks.	Entrained hydrocarbons can have toxic effects on fish and fish spawning (as outlined above) reducing catch rates and rendering fish unsafe for consumption, leading to financial losses.
		The impact of restricted access for fishermen is considered low as surface diesel slicks would only persist for periods up to ‥ hours in the worst case scenario. Furthermore, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface.	Entrained oil may reduce catch rates and impact on the quality of the fish caught, rendering them unfit for human consumption. The effects could be medium to long-term and given the length of the fishing seasons for some of the fisheries potentially effected (e.g. the deep sea crustacean fishery which is year-round), the impacts are considered to be moderate.
Shipping	There are several commercial shipping routes that overlap the polygon, with a moderate to high frequency of vessel traffic.	Exclusion zones surrounding a spill will reduce access for vessels. Some vessels would have to take large detours leading to potential delays.	Entrained oil will have no impacts on shipping.
		As several shipping routes overlap the Nightcap MSS operational area, potential impacts to commercial shipping could be low. Furthermore, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface.	The impacts of entrained oil on shipping are likely to be negligible.
Marine tourism and recreation	There are low levels of marine tourism and recreation (e.g. recreational fishing) in the waters adjacent to the Nightcap MSS operational area at the Rowley Shoals. Diving charters operate for a limited season between September and December.	Exclusion zones surrounding spills will reduce access for recreational fishing and snorkelling/diving on emergent and intertidal reefs.	Effects of entrained oil on fish may reduce recreational fishing in the area (see above). The impacts of entrained oil on intertidal and submerged reefs (as also described above) will impact snorkelling and diving activities.
		`The Rowley Shoals are a popular tourism destination. If a spill was to reach these emergent areas, tourism may be affected. However, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, significant impacts from surface slicks to marine tourism and recreation are unlikely to occur, and given the nature and scale of a diesel spill in this area and the limited number of tourists that would be present, the impact is expected to be minor.	
Protected areas			
Marine Parks, Reserves and KEFs	• Mermaid Reef CMR • Rowley Shoals Marine Park – Clerke Reef (spring only) • Proposed Kimberley CMR • Argo-Rowley CMR • Ancient Coastline 125 m depth contour KEF • Continental Slope Demersal Fish Communities KEF	The key sensitivities and values of Marine Parks, Reserves and KEFs are described in Section 2.3.2. The potential impacts of surface slicks and entrained oil will not affect sensitivities and values that are below the surface and in deep water (as described in the rows above in this table). The modelling suggests that the furthest a diesel spill may travel is ~40 km during spring, and, therefore, it is possible that a diesel spill may enter the waters of some marine parks, reserves and KEFs. However, within 48 hours after the worst-case spill scenario, less than 58% is forecast to entrain and a further 41% is forecast to have evaporated, leaving only a small proportion (1%) of oil floating on the water surface. Therefore, a surface slick is likely to impact the emergent sensitivities and values of the reefs and islands. However, the nature of diesel in the marine environment is highly evaporative and dispersive, and the relatively small amount is not expected to persist for more than 48 hours. Overall, the impact of spilled hydrocarbons on protected areas is considered Medium.	

4 ARRANGEMENTS FOR ON-GOING MONITORING OF ENVIRONMENTAL PERFORMANCE

Environmental and other information will be monitored and recorded during surveys conducted within the Nightcap MSS operational area. In addition to the control measures implements, the following will be monitored:

Parameter	Monitoring	Record Keeping	Frequency
HSE Management System & Environment Policy	Pathfinder environmental management framework	Internal audit of procedures	Annually
	Contractor HSE system	Contractor audit against Pathfinder HSE management system	Annually or with every new contractor, whichever is more frequent

Environmental performance of all proposed surveys within the Nightcap MSS operational area will be reviewed to ensure that:

- all significant environmental aspects of the activity are covered in the EP
- that environmental management measures (including Pathfinder environmental management framework) to achieve EPO and EPS are being implemented, reviewed and where necessary amended
- identification of potential non-conformances and opportunities for continuous improvement
- that all EPO and EPS have been met before completing the activity
- that all environmental commitments contained in the ECR have been fulfilled.

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

- A summary of the Environmental Performance Outcomes, Environmental Performance Standards and Measurement Criteria for the activity will be distributed aboard the survey and support vessels. These will be monitored on a weekly basis for each phase, by the SEA via mechanisms such as audits and inspections.
- An inspection(s) of the vessels will be carried out before or during each phase of the activity to ensure that procedures and equipment for managing routine discharges and emissions are in place to ensure compliance with the EP.
- An inspection(s) of the vessels will be carried out annually or with every new contractor (whichever is more frequent) to ensure that contractor HSE management systems are in accordance with all relevant requirements of Pathfinder environmental management framework and HSE management system.
- A test of the oil spill emergency response arrangements will be conducted during the mobilisation phase of the survey (unless a test has already been undertaken in Australian waters within a month prior to mobilisation) to ensure vessel SOPEP is current and applicable.

Any non-conformances shall be reported, tracked and closed-out in accordance with Section 4.1.

The collection of data from audits, inspections and response tests will form the basis of demonstration that the Environmental Performance Outcomes and Standards are being met, that specified mitigation measures are in place to manage environmental risks, and that they remain working, and contribute to continually reducing risks and impacts to ALARP. Pathfinder Management will review environmental performance, including the implementation strategy, upon completion of each phase of the activity. As part of each review, any new developments in the scientific understanding and knowledge of relevant impact and risks will be reviewed. The results of the review and any identified improvements or recommendations will be incorporated into processes and procedures for future surveys to help facilitate continuous improvement.

4.1 MANAGEMENT OF NON-CONFORMANCE

Non-conformances from audits, inspections or response testing shall be tracked and monitored by the Client Site Representative until closed. Pathfinder employees and contractors are required to report all environmental incidents and any non-conformance with an EPO or EPS detailed in the EP as well as Pathfinder's environmental management framework and contractor HSE systems.

An internal risk assessment will be carried out where non-conformances suggest that specified mitigation measures no longer adequately demonstrate that the activity is managed to ALARP or where new developments in the scientific understanding and knowledge of impacts and risks is present. Any inadequacies and opportunities for improvements will be amended via a Management of Change to ensure that environmental impact and risks of the activity are continually identified and reduced to a level that is ALARP and acceptable.

Incidents and non-conformances are reported in accordance with the vessel operator internal HSE incident reporting procedures, using an Incident and Hazard Report Form that includes details of the event, immediate action taken to control the situation, and corrective actions to prevent reoccurrence. Detailed investigations will be undertaken by Pathfinder for all high potential environmental incidents, and these investigations will include the Master, Party Chief, SEA and Client Site Representative, as appropriate. The regulatory reporting requirements for this activity are outlined in this EP. In the event of an environmental incident, crew management and relevant shore-based personnel will consult both the vessel specific environmental systems as well as the survey EP to determine the appropriate action. The risk assessment process is outlined in the EP.

4.2 PRE-SURVEY PLANNING

Prior to individual surveys, Pathfinder shall undertake pre-survey planning that will review and consider the following at a minimum:

- changes to all relevant legislation or regulatory guidelines
- seismic source modelling to determine ideal acoustic array volume to be used
- existing information and available scientific literature in relation to any component of the receiving environment described in Section 2 (including BIAs)
- CMR status (including any changes in status) and relevant IUCN principles
- overlap with specific charter and dive operators and if SIMOPS will be required
- information from previous surveys regarding:
    - fauna migration routes
    - frequency of fauna sightings
    - avoidance of multiple surveys undertaken in same area in less than one month apart
    - potential for cumulative impacts from past or proposed surveys, if known
- new issues raised by stakeholders
- oil spill response available throughout survey, including third-party response provider if survey will occur <40 km from a CMR.

If new information regarding the receiving environment relevant to the Nightcap MSS is present, then an internal risk assessment will be conducted as described in this EP. If sighting data are available from previous Pathfinder surveys, or if new information regarding whale migration periods is available, the information will be used in planning the timing of individual surveys within the Nightcap MSS operational area.

4.3 ENVIRONMENT PLAN REVISION AND RESUBMISSION

As required under Regulation 17 of the Environment Regulations, Pathfinder will submit a revision of this EP to NOPSEMA if any of the following criteria are met:

- The commencement of any new activity, or any significant modification, change, or new stage of an existing activity, not provided for in this EP

- The occurrence of any:
  - significant new environmental impact or risk
  - series of new environmental impacts or risks
  - significant increase in an existing environmental impact or risk
  - series of increases in existing environmental impacts or risks
- Any significant change to the receiving physical, biological or socio-economic environment within or immediately adjacent to the Nightcap MSS operational area
- The identification of any:
  - KEF not already described in this EP
  - threatened species of cetacean, marine reptile, sharks and ray-finned fish and seabirds not already described in this EP
  - critical habitat/BIA for threatened species not already described in this EP, which has spatial overlap with the Nightcap MSS operational area
- Internal risk assessment results during pre-survey planning (as described in this EP) suggest that the residual risk ranking for any part of the activity has increased.

A risk assessment will be undertaken for all changes in scope to assess potential environmental impacts of the change. If the change meets any of the criteria detailed above, a revision/re-submission of the EP will occur, and the proposed change to the activity will not commence until the revised EP has been accepted by NOPSEMA. If required, notification to other government authorities will be undertaken by the Pathfinder VOM. Notifications will include details of the change and procedures that will be undertaken for managing or mitigating the additional or modified risks.

5 RESPONSE ARRANGEMENTS IN THE OIL POLLUTION EMERGENCY PLAN

The OPEP for seismic surveys undertaken within the Nightcap MSS operational area, taking into account the nature and scale of the activity and the potential spill risks involved comprises components of a survey vessel's SOPEP (i.e. being *all* vessels over 400 GRT involved in the MSS) that manage the environmental impacts of a spill and operational monitoring, supported as required by applicable established, statutory OPEPs. Support vessels <400 GRT that are not obligated to have a SOPEP must have a spill response plan (or equivalent) that is accepted by Pathfinder and covers spill response arrangements and spill monitoring. As such, the following plans are in place as a contingency in the unlikely event of an oil spill, which as a whole, represent the OPEP for this activity:

- survey or support vessel(s) >400 GRT SOPEP - deals with hydrocarbon spills which are either contained on the vessel or which can be dealt with from/by the vessel
- survey or support vessel(s) <400 GRT spill management plan - deals with spills which are either contained on the vessel or which can be dealt with from/responded by the vessel
- National Plan for Maritime Environmental Emergencies (NATPLAN) - AMSA is the Jurisdictional Authority (JA) and Control Agency (CA) for spills from vessel which affect Commonwealth waters, i.e. outside of 3 nmi from the coast (AMSA 2014)
- WA State Emergency Management Plan for Marine Oil Pollution (WestPlan-MOP) and DoT Oil Spill Contingency Plan (OSCP) - deals with spills from the vessels which affect WA State waters.

5.1 DRILLS AND TRAINING

A drill test of the oil spill emergency response arrangements (i.e. SOPEP and OPEP) will be conducted during the mobilisation phase prior to commencement of operations of the survey. Support vessel SOPEP/spill management plans will also be tested during the mobilisation phase as part of the OPEP. As required under 14(8C), response arrangements shall be tested if they are significantly amended. All drill tests will be reported as per MARPOL Annex I (Regulation 15) requirements and reviewed after each drill as part of the ongoing monitoring and improvement of emergency control measures. Identified improvements or recommendations shall be addressed. The objectives of testing are to ensure that:

- the vessel SOPEP is current and applicable (including contact details) for dealing with a spill specific to the nature and location associated with an individual survey conducted within the Nightcap MSS operational area.
- Type II 'Operational Monitoring', such as spill surveillance and tracking, specific to the nature and location associated with an individual survey conducted within the Nightcap MSS operational area, is appropriate, understood and practiced.

In compliance with Regulation 14(4) and 14(5), a designated personnel will be trained to ensure that they are familiar with their tasks and the equipment in the event of an oil spill. Implementation and testing of the survey vessel's SOPEP/spill management plan, plus adherence to the additional spill response and reporting measures detailed in Section 3.3.5, will enable Pathfinder to demonstrate that environmental risks from fuel and oil spills during the proposed survey have been reduced to ALARP.

5.2 INITIAL ACTIONS

As soon as an oil spill has been identified, the vessel master will initiate immediately the vessel SOPEP/spill management plan and first strike, initial actions. Due to the nature and scale of the activity, credible spill scenarios and characteristics of diesel, the initial response to any spill will be to monitor and evaluate. The preferred strategy for diesel spills will be to allow small spills to disperse and evaporate naturally, and to monitor the position and trajectory of any surface slicks. Physical break-up using prop wash from the support vessel and repeated transits through the slick may be considered for larger slicks (following consultation with the CA - AMSA or DoT). Priority actions in the event of a fuel or oil spill are to make the area safe, to stop the

leak and to ensure that further spillage is not possible. All deck spills on-board vessel(s) will be cleaned-up immediately, using appropriate equipment from the on-board spill response kits (e.g. absorbent materials, etc.), and any likelihood of discharge of spilt hydrocarbons or chemicals to the sea will be minimised. Following clean-up, a PMS will be implemented on the survey vessel to ensure that all equipment used during operations is in full working order and does not represent a hydrocarbon spill risk.

5.2.1 Commonwealth Waters

In the event of an oil spill in Commonwealth waters, initial actions will be undertaken immediately by the survey vessel, and actions determined following immediate contact with relevant authorities under NATPLAN. AMSA is the responsible Control Agency for oil spills from vessels within the Commonwealth jurisdiction and will respond in accordance with its Marine Pollution Response Plan as approved by the AMSA Executive. Upon immediate notification of an incident, AMSA will assume control of the incident (AMSA 2014).

5.2.2 State Waters

If surface slicks appear likely to enter WA State waters, response actions will be determined following consultation with the DoT under the WestPlan–MOP and the Oil Spill Contingency Plan. The DoT is the designated Hazard Management Agency for oil spills from vessels within the WA State jurisdiction. Consultation will take place within immediately following the incident identification. DoT is a signatory to the Inter-governmental agreement under AMSA's NATPLAN. The DoT response network is comprised of two spate units: Maritime Environmental Emergency Response and the State Response Team.

5.2.3 Type I Operational Monitoring

In the event of an accident that resulted in a diesel spill to the waters surrounding the survey or support vessels, Pathfinder would be responsible for undertaking Type I "Operational Monitoring" (unless AMSA as control agency directs otherwise) with the primary objective of spill surveillance and tracking. This monitoring will be implemented to:

- determine the extent and character of a spill
- track the movement and trajectory of surface diesel slicks
- identify areas/resources potentially affected by surface slicks
- determine sea conditions/other constraints.

This Type I monitoring will be restricted to daylight hours only, when surface slicks will be visible from the vessel. The information gathered from this monitoring will be passed on to AMSA via the POLREP form, but also via ongoing SITREP reports following the initial spill notification to RCC Australia.

5.2.4 Type II Scientific Monitoring

ADIOS2 spill modelling indicated that surface slicks, and possibly entrained oil, from an MGO spill of 300 m^3 may contact MRCMR and the Rowley Shoals Marine Park. During the pre-survey planning phase and prior to the commencement of individual surveys located near a sensitive area, Pathfinder will have an agreement in-place with a third-party response provider to undertake Type II scientific monitoring appropriate to the nature and scale of the event. In the event of an oil spill, Pathfinder will work with the relevant stakeholders during the initial action and communications to develop and implement appropriate Type II "Scientific Monitoring" to understand the impacts of the spill on the marine environment and any response activities appropriate to the nature and impact of the spill. This scientific monitoring will focus on relevant environmental and social receptors.

Incorporating the results of pre-survey planning and Type I Operational Monitoring, the scientific monitoring will focus on documenting and reporting all potential impacts to key environmental and social values and sensitive receptors, including (but not limited to):

- sediment and water quality, particularly for the pristine waters of the Rowley Shoals Marine Park and MRCMR
- benthic primary producer habitat:
    - coral reef communities

    - macro algal and seagrass communities
- intertidal reef platform communities
- subtidal soft-bottom communities
- whales
- whale sharks
- turtles
- seabirds
- finfish
- benthic invertebrates
- commercial and recreational fishing
- tourism.

A long-term management key performance indicator for the Commonwealth Marine Reserves and the Rowley Shoals Marine Park is to ensure that no change will occur to the biodiversity and pristine marine habitats compared to background (i.e. baseline) levels. Therefore, prior to survey commencement near to Commonwealth Marine Reserves or the Rowley Shoals Marine Park, Pathfinder will establish effective response and recovery processes to maintain these biodiversity management goals in the unlikely event of an accidental hydrocarbon spill.

6 STAKEHOLDER CONSULTATION

Consultation with stakeholder groups, primarily within the commercial fishing industry, concerning the proposed Nightcap MSS operational area occurred prior to and during the preparation of this EP. The stakeholder consultation will be undertaken in phases as described below:

- Phase 1 Preparatory Consultation - stakeholders notified of the proposed Nightcap MSS operational area
- Phase 2 Pre-survey Consultation - stakeholders notified of individual surveys, including location within the Nightcap MSS operational area, timing and duration
- Phase 3 Ongoing Consultation - includes complying with requests from stakeholders for additional information, survey updates, etc.
- Phase 4 Post-survey Notifications- includes complying with requests from stakeholders for notification of the completion of individual surveys.

6.1 PHASE 1 PREPARATORY CONSULTATION

To prepare for stakeholder consultation, relevant persons were identified based on the following information:

- Commonwealth and WA State government agencies under relevant legislation
- Non-government organisations that have interest/activities in operational area
- GIS shapefiles of commercial fishery license areas
- current status reports of WA fisheries and aquatic resources (Fletcher & Santoro 2015)
- current status reports of Commonwealth fisheries and aquatic resources (ABARES 2015)
- current list of license holders extracts (provided by DoF)
- scientific literature
- information provided directly through previous stakeholder consultation.

The following stakeholders (including fisheries bodies and organisations, and State and Commonwealth government departments) were initially informed of the survey via letters or emails sent on 31 December 2015:

- Absolute Ocean Charters
- Australian Customs Services (Coastwatch)
- Australian Fisheries Management Authority (AFMA)
- Australian Hydrographic Service (AHS)
- Australian Maritime Safety Authority (AMSA)
- Blue Sun 2 boat charter
- Broome Fishing Club
- Centre for Whale Research (CWR)
- Commonwealth Fisheries Association (CFA)
- Department of Defence (DoD)
- Department of the Environment and Energy
- Kimberley Boat Cruises
- Kimberley Expeditions
- Kimberley Professional Fishermen's Association (KPFA)
- Kimberly Quest
- Lindblad Expeditions
- MG Kailis Group
- Northern Wildcatch Seafood Australia (NWSA)
- Odyssey Expeditions
- Recfishwest
- Reel Teaser Fishing Adventures
- Sealife Charters

- The Great Escape Charter Company
- True North – North Star Cruises Australia
- WA Department of Fisheries (DoF)
- WA DMP
- WA DoT
- Western Australian Fishing Industry Council (WAFIC)
- WestMore Seafoods.

Additionally, on 31 December 2015, entities or individuals currently holding licences for the following commercial fisheries were contacted and informed of the proposed operations:

- North West Slope Trawl Fishery (NWSTF)
- Mackerel Managed Fishery (MMF)
- Northern Demersal Scalefish Managed Fishery (NDSF)
- Pilbara Trap Fishery (PTF)
- Pilbara Line Fishery (PLF)
- West Coast Deep Sea Crustacean Managed Fishery (WCDSCF).

All Commonwealth managed fisheries are administered through AFMA. As outlined on the AFMA website, the CFA and WAFIC are fishing associations that represent the North West Slope Trawl and Western Tuna Billfish Fishery (among other Commonwealth fisheries). The CFA is the peak body representing the collective rights, responsibilities and interests of their relevant fisheries, and WAFIC represent WA professional fishing, pearling and aquaculture enterprises. As such, they are the primary industry association contacts.

An example of the letter sent to all stakeholders is included in this EP. The letter provided information concerning the location, timing and nature of the proposed activities, a link to further information regarding seismic activities and its impacts so that relevant persons may determine if the proposed activity would impact their activities or interests, and contact details should stakeholders wish to seek further information.

6.1.1 Stakeholder Responses

Responses were received from seven stakeholders who were contacted during Phase 1 – Preparatory Consultation. A summary of stakeholder consultation is provided in Table 6.1, while details stakeholder feedback and Pathfinder's assessment of any concerns or claims and responses are provided in Table 6.2. Full copies of all stakeholder responses are provided in the EP. For stakeholders that did not provide a response, other means of communication were undertaken. In February 2016, follow-up phone calls were made to each individual tour operator. In September 2016, a second invitation to comment was sent only to stakeholders who did not provide an initial response and used a different methods of communication (e.g. postal address, another email address, etc.). However, for stakeholders with no other contact information (i.e. most fishery licence holders have postal addresses only), there was no alternate communication method. Pathfinder is aware that stakeholders may still respond. As such, all stakeholder responses shall be assessed and address accordingly.

Table 6.1 – Summary of Phase 1 Preparatory Consultation

Organisation	Contact Name	Date of First Contact	Response Date	Response Assessment	Future Consultation Actions
WA State fisheries with license area in the operational area					
Western Australian Fishing Industry Council (WAFIC)	John Duffy, Communications and Program Officer	31 December 2015	31 December 2015	Email read receipt received; second invitation to comment sent 30 September 2016	Pathfinder will send update letters every six months and pre-survey letters (four weeks prior to survey).
MG Kailis Group	Alex Kailis, Operations Manager	31 December 2015	31 December 2015	Email read receipt received; second invitation to comment sent 30 September 2016	
Mackerel Managed Fishery (MMF)	All registered licence holders	31 December 2015	No response received	No other contact information for license holders; potential impact with MMF is low based on small overlap (~6% Area 2) and reduced fishing effort mostly in coastal areas	
West Coast Deep Sea Crab Managed Fishery (WCDSCF)	All registered licence holders	31 December 2015	No response received	No other contact information for license holders; potential impact with WCDSCF is low based on small overlap (~6%) and reduced fishing effort	
Pilbara Trap Fishery (PTMF)	All registered licence holders	31 December 2015	No response received	No other contact information for license holders; potential impact with PTMF is low based on small overlap (~3% fishery area) and reduced fishing effort	
Northern Demersal Scalefish Fishery (NDSF)	All registered licence holders	31 December 2015	No response received	No other contact information for license holders; potential impact with NDSF is low based on small overlap (<7% fishery area) and reduced fishing effort	
Pilbara Line Fishery (PLF)	All registered licence holders	31 December 2015	No response received	No other contact information for license holders; potential impact with (PLF) is low based on small overlap (~16% operational area) and reduced fishing effort	
Westmore Seafoods	Simon Little	31 December 2015	No response received	Second invitation to comment sent 30 September 2016	
Northern Wildcatch Seafood Australia	Grant Barker	31 December 2015	No response received	Second invitation to comment sent 30 September 2016	
Recfishwest	Matt Gillett, Regional Policy Officer	31 December 2015	27 January 2016	Email read receipt received; second invitation to comment sent 30 September 2016	
Commonwealth fisheries with licence area in operational area					
Australian Fisheries Management Authority (AFMA)	Giulia Porro, Environment Officer Policy, Environment, Economics and Research Section	31 December 2015	No response received	No response received; second invitation to comment sent 30 September 2016	Pathfinder will send update letters every six months and pre-

Organisation	Contact Name	Date of First Contact	Response Date	Response Assessment	Future Consultation Actions
	Paul Ryan, Environmental Policy Section				survey letters (four weeks prior to survey).
Commonwealth Fisheries Association (CFA)	Renee Vajtauer, Chief Executive Officer	31 December 2015	No response received	No response received; second invitation to comment sent 30 September 2016	
Marine Tour Operators					
Absolute Charters		31 December 2015	Follow-up call February 2016	On-going (**Table 6.2**)	Pathfinder will send update letters every six months and pre-survey letters (four weeks prior to survey).
Blue Sun 2			Follow-up call February 2016		
The Great Escape Charter Company	Kylie		Follow-up call February 2016		
Odyssey Expeditions	Mike		Follow-up call February 2016		
Kimberley Boat Cruises	Kevin		Follow-up call February 2016		
Kimberley Quest	Eva Puado		Follow-up call February 2016	No tours to Rowley Shoals	
Kimberley Expeditions	Lori		Follow-up call February 2016	On-going (**Table 6.2**)	
True North Cruises	Stacey Newton		Follow-up call February 2016		
Lindbald Expeditions			Follow-up call February 2016	No tours to Rowley Shoals	
Reel Teaser Fishing Adventures	Tracey Rushford		23 January 2016	Email confirmed no issues with proposed survey.	
Sealife Charters			No response received	No other contact information	
Commonwealth government agency under relevant legislation or providing response to maritime & border activities					
Australian Maritime Safety Authority (AMSA)	Pilbara Ports, John Finch	31 December 2015	31 December 2015	Email read receipt received	Pathfinder will send update letters every six months and pre-survey letters (four weeks prior to survey).
	Trish Malone, Response Planning Officer		4 January 2016		
	Nautical Advice		1 April 2016	On-going (**Table 6.2**)	
Parks Australia, Marine Protected Areas	Bianca Priest	31 December 2015	27 July 2016		
Australian Hydrographic Service (AHS)	Mark Bolger, Nautical Assessment Officer Bianca Spouszta	31 December 2015	13 January 2016		

Organisation	Contact Name	Date of First Contact	Response Date	Response Assessment	Future Consultation Actions
	Mel Clarke				
	Glen Cook		5 January 2016		
Australian Customs Services (Coastwatch)		31 December 2015	No response received	No response received; second invitation to comment sent 30 September 2016	
Strategic Border Command (SBC)		31 December 2015	No response received	No response received; second invitation to comment sent 30 September 2016	
WA State Agencies					
WA Department of Fisheries (DoF)	Sustainability and Environment Aquatic Biodiversity	31 December 2015	25 January 2016	On-going (**Table 6.2**)	Pathfinder will send update letters every six months and pre-survey letters (four weeks prior to survey).
WA Department of Transport	Matt Verney	31 December 2015	31 December 2015	Email read receipt received; second invitation to comment sent 30 September 2016	
WA DMP	Petroleum Division	31 December 2015	No response received	No response received; not in proximity to State waters; consultation completed	
Department of Parks and Wildlife	Gerard Ots	31 December 2015	No response received	No response received	
	Alison McCarthy		4 January 2016	Email read receipt received	
	Todd Quartermaine, Kimberley Region Office		31 December 2015	Email read receipt received	
	Sue Osborne, Perth Office		1 February 2016	On-going (**Table 6.2**)	
WA Department of Environment Regulation (DER)	Pilbara Region	31 December 2015	No response received	No response received; not in proximity to State waters; consultation completed	
	Head Office				
Non-government Organisations					
Center for Whale Research	Curt Jenner	31 December 2015	31 December 2015	Email read receipt received.	Pathfinder will send update letters every six months and pre-survey letters (four weeks prior to survey).
IFAW Oceania	Matt Collis, Marine Campaigner	31 December 2015	No response received	No response received; second invitation to comment sent 30 September 2016	
Broome Fishing Club	Derek Albert, President	31 December 2015	2 January 2016	On-going (**Table 6.2**)	
Kimberley Professional Fishermen's Association	Bob Masters	31 December 2015	No response received	No other contact information	

Table 6.2 – Details of Phase 1: Preparatory Consultation with Stakeholder Feedback and Pathfinder Assessment

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
Derek Albert (Broome Fishing Club)	Email 2 January 2016	Thanks for providing the information and opportunity to provide feedback regarding this scope of work. Given the location of the proposed survey is a considerable distance offshore, and there is limited numbers of our members that would be traveling through this area I am not aware of any issues that would be of concern to our members.	No response was provided as this email assured Pathfinder that no issues would be of concern to members of the Broome Fishing Club.
Glenn Cook (AHS)	Email 5 January 2016	Thanks for the information. Please keep us informed once you have some firm dates to allow us to promulgate Notice to Mariners action	19 January 2016: Thank you for your response. We will be sure to contact AHS should a survey commence and provide as much details as possible to develop an appropriate Notice to Mariners.
Bianca Spouszta (AHS)	Email 13 January 2016	Noted, Hydro will issue a notice to mariners for relevant nautical products. Please forward works details 2-3 weeks prior to commencement.	19 January 2016: Thank you for your response. Should a survey commence, we will be sure to contact AHS 2-3 weeks prior and provide as much details as possible to develop an appropriate Notice to Mariners.
Luke Pugsley (AMSA *Nautical and Regulation)*	Email 11 January 2016	Thank you for providing the opportunity to consult on the Nightcap Multi-client Marine Seismic Survey. The attached files display your survey boundary and operational area in relation to the north-west shipping fairways. It should be noted that heavy traffic will be encountered in the western section of the survey area due to the shipping fairway. Heavy support traffic for nearby offshore infrastructure will also be encountered. Given the length of the 12 MSS streamers, any support / chase vessel in cooperation with the survey vessel will need to be active and maintain exceptional communications with all commercial shipping, should they be encountered, in the survey area noting there will be a considerable speed difference between commercial shipping and the survey vessel whilst the latter is conducting operations. 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. Please notify AMSA's Joint Rescue Coordination Centre (JRCC) for AUSCOAST warning broadcasts 24-48 hours before operations commence. AMSA's JRCC will require the vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone) and area of operation and need to be advised when the survey starts and ends. Additionally, the Australian Hydrographic Service must be contacted through hydro.ntm@defence.gov.au no less than 4 working weeks before operations commence for the promulgation of related Notices To Mariners (NTM). At the conclusion of the survey, please be in touch to comment on the operations and the interaction with commercial shipping at the time of the survey (i.e. Any lessons learned). A suggested way of creating this information is via a marine traffic log, whereby any close encounters and communications are commented upon.	4 February 2016: Thank you very much for your response and feedback regarding the proposed Nightcap Multi-client Marine Seismic Survey. The figure with the AIS data is very helpful and will be included in the Environment Plan (EP) descriptions and risk assessment. The EP will consider your advice regarding the heavy traffic likely to be encountered in the western section of the survey area. Also, the Nightcap MC MSS EP will specify that any support vessel in cooperation with the survey vessel will be active and maintain exceptional communications with all commercial shipping encountered. The environmental performance standards and controls will consider the considerable speed differences between commercial shipping and the survey vessel whilst the latter is conducting operations. In addition, the EP will have commitments that the seismic vessel will display appropriate day shapes, lights and streamers and reflective tail buoys, all of which will indicate that the vessel is towing and is therefore restricted in her ability to manoeuvre. Visual and radar watches will be maintained on the bridge at all times, and this commitment will be included in the EP. Furthermore, Pathfinder Energy will ensure that the following notifications will be submitted before survey commencement: 1. AMSA's JRCC for AUSCOAST warning broadcasts 24–48 hours prior to survey commencement, including a. vessels details (including vessel name, call sign and Maritime Mobile Service Identity (MMSI)) b. satellite communications details (including INMARSAT-C and satellite telephone) c. area of operation d. survey start and end dates. 2. Australian Hydrographic Service contacted through hydro.ntm@defence.gov.auno less than four working weeks before operations commence for the promulgation of related Notices To Mariners (NTM). 3. At the conclusion of the survey, a marine traffic log will be completed and include interactions with commercial shipping during the survey (i.e. any lessons learned). If AMSA has any further concerns or advice, please feel free to contact me. The advice and information provided by AMSA are greatly appreciated.
	Email 4 February 2016	Thanks for the response and taking AMSA's feedback into consideration for the proposed Nightcap MSS.	
Tracey Rushford (Reel Teaser Fishing Adventures)	Email 23 January 2016	Thank you for this information We do have a number of charters scheduled to depart Broome and travel to the Rowley Shoals throughout 2016/2017, however we do not have any issues with the proposed survey.	27 January 2016: Thank you for your email response. Please be assured that we will include your scheduled charters (departing from Broome and traveling to the Rowley Shoals throughout 2016/2017) in the proposed Nightcap Marine Seismic Survey Environment Plan, as well as your comment regarding no issues with the proposed survey. Also, as part of Pathfinder Energy's standard stakeholder consultation procedures, all relevant persons will be contacted before a specific survey commences. As such, if a survey is planned in the future, you will receive further information of survey details with additional opportunities to provide comments and feedback. If you have any questions or concerns regarding the proposed activities, please feel free to contact us at Scope Resources.
Carli Telfer (DoF)	Phone call 25 January 2015	DoF inquired about the area size of the Nightcap MC MSS operational area.	27 January 2016: As per your phone conversation with my colleague Vanessa Boladeras, I am following-up to your enquiries regarding the area size of the proposed Nightcap Multi-client Marine Seismic Survey Environment Plan. I apologise for the delay in my response. We have since confirmed with our client, Pathfinder Energy, that the proposed operational area is 31,200 km^2, whereas the proposed seismic survey acquisition area is 4,500 km^2. At this time, the actual survey details (including location, timing, etc.) are not available, and as such, the EP will assess all possible environmental risks for the larger operational area. Please know that we would appreciate any advice and feedback from the Department of Fisheries regarding the greater operational area. If you have further questions or concerns regarding the proposed Nightcap EP, please feel free to contact me. I would be happy to discuss further and assist in any way possible.
	Email 9 February 2016	Thank you for your request for comment on the 31 December 2015, on behalf of Pathfinder Energy, for the proposal to undertake a seismic survey between Q2 2016 and Q4 2017. The Department of Fisheries (Department) considers itself a 'relevant person' for the proposed activity, and therefore provides the following advice. The advice below is valid for a period of six months from the date this letter is signed. If the proposed activities commence within this six month period, this advice will be valid for the duration of the Environment Plan (EP). If however, the proposed activities do not commence within six months, the Department required Pathfinder Energy to initiate further consultation on this proposal a minimum of three months prior to the commencement date. Please note that the Department reserves the right to provide further advice to the proponent and regulator should any significant management or environmental changes occur during the approvals process or operational period. 1. Consultation Seismic surveys have the potential to affect fish populations and the operations of fishers who harvest these resources. Because	23 February 2016: Thank you for your letter (dated 9 February 2016) regarding the Nightcap Multi-client (MC) Marine Seismic Survey (MSS) Environment Plan (EP). On behalf of our client, Pathfinder Energy (Pathfinder), please know that the advice provided in your response are appreciated and have been carefully considered. We understand and agree with the Department of Fisheries (the Department) advice, and as the EP is still being prepared, we are providing the following response to address all potential impacts to fisheries, fish and fish habitats as per the Department's concerns. 1. Consultation a. The Department requests that Pathfinder Energy consults with the Western Australian Fishing Industry Council (WAFIC), the Pearl Producers Association of WA, Recfishwest and individual licensed fishers regarding the overall proposal, including methods, and to incorporate comments from this consultation in the EP submission. Consultation with stakeholder groups, primarily within the commercial fishing industry occurred prior to and during the preparation of this

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
		of this potential impact, the Department requests that Pathfinder Energy consults with the Western Australian Fishing Industry Council (WAFIC), the Pearl Producers Association of WA, Recfishwest and individual licensed fishers regarding the overall proposal, including methods, and to incorporate comments from this consultation in the EP submission. In line with the Department's guidance statement on undertaking seismic surveys in WA waters (available from http://www.fish.wa.gov.au), we request that Pathfinder Energy identifies a full range of mitigation strategies in the EP. It is expected that all feasible mitigation strategies will be implemented.	EP. The initial consultation letter provided information concerning the location, timing and nature of the proposed activities, a link to further information regarding seismic activities and its impacts, and contact details should stakeholders wish to seek further information. On 31 December 2015, emails or posted letters were sent to the following relevant persons: • Australian Fisheries Management Authority • Broome Fishing Club • Commonwealth Fisheries Association • Kimberley Professional Fishermen's Association • MG Kailis Group • Northern Wildcatch Seafood Australia • Recfishwest • WA Department of Fisheries • Western Australian Fishing Industry Council • WestMore Seafoods. Additionally, entities or individuals currently holding licences for the following commercial fisheries were contacted and informed of the proposed operations: • North West Slope Trawl Fishery (NWSTF) • Mackerel Managed Fishery (MMF) • Northern Demersal Scalefish Managed Fishery (NDSF) • Pilbara Trap Fishery (PTF) • Pilbara Line Fishery (PLF) • West Coast Deep Sea Crustacean Managed Fishery (WCDSCF). Consultation with individual licence holders in the Pearl Oyster Managed Fishery (POMF) is via the peak industry body for this fishery – Pearl Producer Association (PPA). The Nightcap MC MSS operational area overlaps Zone 3 of the POMF, which comprises two licensees (Fletcher & Santoro 2015). In 2014, no cultured shells were caught in Zone 3, especially since divers are physically restricted to water depths <40 m. The operational area's water depth is >80 m. Furthermore, the PPA previously advised Scope Resources that they wish to be considered a 'relevant person' for seismic surveys that are located within the 100 m contour adjacent to Eighty Mile Beach, which is >190 km away from the operational area. Therefore, as the majority of the operational area is located significantly offshore from primary fishery areas, the PPA were deemed 'not-relevant person' for this EP, and in efforts to reduce stakeholder consultation fatigue, the POMF was not included in the Nightcap MC MSS ERA or stakeholder consultation plan. b. In line with the Department's guidance statement on undertaking seismic surveys in WA waters, we request that Pathfinder Energy identifies a full range of mitigation strategies in the EP. It is expected that all feasible mitigation strategies will be implemented. Please be assured that the full range of mitigation strategies to reduce potential impacts to fish, fish habitats and fisheries will be assessed and evaluated in the EP. Regulation 13(7) of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 requires that an EP include environmental performance outcomes (EPO), environmental performance standards (EPS) and measurement criteria that address legislative and other controls to manage the environmental impacts and risks of the activity. For proposed surveys, the EPOs and EPSs set the standards against which Pathfinder will measure environmental performance, and the implementation of appropriate measurement criteria will determine whether the associated EPO was achieved. As such, the EPOs, EPSs and measurement criteria are consistent with legislative requirements and Pathfinder policies, standards and procedures. They were developed based on the legislation, codes and standards, good industry practice, professional judgement, risk-based analysis, company and societal values. Any breach of an EPO or EPS will constitute a 'Recordable Incident' under the Environment Regulations. The Nightcap MC MSS EP identified 12 EPOs that will describe the measurable level of performance required for the management of environmental aspects to ensure that the environmental impacts and risks will be of an acceptable level. From these 12 EPOs, the following 10 are designed to reduce impacts to fish, fish habitats and fisheries: 1. Zero incidents of interference or negative interactions with commercial fishing, recreational fishers, tourism activities or shipping during the activity 2. Zero incidents of introduction of IMS from ballast water exchange during surveys within the operational area 3. Zero incidents of introduction of IMS from biofouling of survey and support vessels' hull, other niches and immersible equipment during surveys within the operational area 4. Prevent adverse noise impacts to marine fauna and divers from discharge of the airgun array 5. Zero incidents of non-compliant discharges of bilge water, sewage and putrescible wastes from the survey and support vessels within the operational area 6. Zero incidents of physical damage to benthic habitats and communities from dragging or loss of the streamers and associated equipment 7. Zero incidents of accidental release of hazardous or non-hazardous material to the sea from the survey and support vessels 8. Zero incidents of release of hydrocarbons to the marine environment resulting from spill to deck 9. Zero incidents of release of hydrocarbons to the marine environment resulting from vessel collision or fuel transfer spills 10. Implementation of SOPEP/OPEP for all hydrocarbon spills of to sea within the Nightcap MC MSS operational area.
		2. Fishing activities in the area The Department advised that the following commercial fishing interests exist in, or in close proximity to, the areas associated with the proposed activities:	2. Fishing activities in the area: the Department advises that the following commercial fishing interests exist in, or in close proximity to, the areas associated with the proposed activities: Customary, recreational and charter fishing may also occur within the proposed area of activities.

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response

Permit Area	Bioregion and Province	Commercial Fishing Interests
Boundary coordinates provided by Pathfinder Energy	North Coast Bioregion, Northwest Shelf Province	Abalone Fishery, Beche de mer Fishery, Broome Prawn Managed Fishery Mackerel Managed Fishery, Marine Aquarium Fish Managed Fishery, Nickol Bay Prawn Limited Entry Fishery North Coast Shark Fishery Northern Demersal Scalefish Managed Fishery Pearl Oyster Fishery, Pilbara Developing Crab Fishery Pilbara Fish Trawl Interim Managed Fishery, Pilbara Line Fishery, Pilbara Trap Managed Fishery, Specimen Shell Managed Fishery West Coast Deep Sea Crustacean

Customary, recreational and charter fishing may also occur within the proposed area of activities.

For the Nightcap MC MSS EP, a thorough investigation of the WA state fisheries was undertaken to determine the fisheries authorised to operate within the proposed operational area, primarily based on the following resources:

- GIS shapefiles of license areas (provided by the Department)
- current status reports of the fisheries and aquatic resources of WA (Fletcher & Santoro 2015)
- current list of license holders extracts (also provided by the Department)
- scientific literature
- information provided directly by fishers through our stakeholder consultation process.

From this assessment, the following fisheries were omitted from inclusion in the EP. Both the Abalone and Beche-de-mer Fisheries do not have license areas that overlap with the Nightcap MC MSS operational area, and according to GIS files and fishery status reports, the Abalone Fishery doesn't appear to be listed within the North Coast Bioregion. While the Marine Aquarium Fish and Specimen Shell Managed Fisheries are considered to have a state-wide occurrence, both fisheries are limited to dive-based operations in shallow waters, have relatively low catch volumes and effort levels and are managed with a low risk level (Fletcher & Santoro 2015). As such, these fisheries were also omitted from consideration in the EP.

The following fisheries may be authorised to operate within the Nightcap MC MSS operational area but were omitted from the EP for various reasons:

- The North Coast Shark Fishery had zero catch effort reported for the since 2013, and there continues to be no activities in this fishery.
- Four fisheries comprise the North Coast Prawn Managed Fishery: Broome Prawn Managed Fishery (BPMF), Onslow Prawn Managed Fishery (OPMF) and the Nickol Bay Prawn Managed Fishery (NBPMF), none of which were included in the Nightcap MC MSS ERA or stakeholder consultation plan. The Nightcap operational area overlaps the BPMF's greater fishery licence area that is designated as a 'prohibited fishing area', and no fishing occurred in 2014 (Fletcher & Santoro 2015). The actual trawl area is contained within a delineated small area >150 km from the Nightcap MC MSS operational area. With negligible fishing effort in 2014, the OPMF's trawled areas and size managed fishing grounds are close to shore and not located within the operational area. Similarly, the boundaries of the NBPMF's nursery areas, trawled areas and size managed fishing grounds are close to shore and not overlapping with the operational area. Therefore, these fisheries were deemed 'not-relevant persons' for this EP, and in efforts to reduce stakeholder consultation fatigue were not included in the Nightcap MC MSS consultation plan.
- The Nightcap MC MSS operational area overlaps ~5% of the Pilbara Fish Trawl Interim Managed Fishery in Area 6 in Zone 2 of the fishery, which has been closed to fishing since 1997 (Fletcher & Santoro 2015). Therefore, as there is no fishing from the PFTIMF in the small proportion that overlaps the operational area, this fishery was not included in the Nightcap MC MSS ERA or stakeholder consultation.
- For reasons stated above, the POMF was not included in this EP.

The WA state fisheries that were included in the EP's environmental risk assessment and stakeholder consultation include the following:

- Mackerel Managed Fishery (MMF)
- Northern Demersal Scalefish Managed Fishery (NDSF)
- Pilbara Demersal Scalefish Fisheries (PDSF)
- Pilbara Trap Managed Fishery (PTMF)
- Pilbara Line Fishery (PLF)
- West Coast Deep Sea Crustacean Managed Fishery (WCDSCF).

Finally, identified through the Department of Parks and Wildlife, seven commercial tour operators (e.g. charter fishing and dive operators) were engaged as part of the EP's environmental risk assessment and stakeholder consultation. On 31 December 2015, letters were initially emailed or posted and contained information about the proposed survey activities. Subsequently in February 2016, each operator was called individually to follow-up on receipt of the initial letters and to provide another opportunity to raise concerns or issues regarding the Nightcap MC MSS.

3. Fishing spawning

Seismic surveys may alter fish behaviour during spawning and pre-spawning periods. The Department therefore requests that Pathfinder Energy specifically includes strategies in the EP to minimise the impacts of the survey activities on fish spawning. The strategies may include (but are not limited to) minimum required acoustic intensity and exposure time to achieve objectives. It is also requested that, where possible, seismic survey activities do not occur during the times of the year that follow key fish species may be spawning within your proposed area of activities:

Bioregion	Key Fish Species within zone	Spawning / Aggregation times
North Coast	Blacktip shark *(Carcharhinus tilstoni and C. limbatus)*	November - December
North Coast	Goldband snapper *(Pristipomoides multidens)*	January - April
North Coast	Pink snapper *(Chrysophrys auratus)*	May - July

Bioregion	Key Fish Species within zone	Spawning / Aggregation times
North Coast	Rankin cod *(Epinephelus multiinotatus)*	August - October
North Coast	Red emperor *(Lutjanus sebae)*	October - March
North Coast	Sandbar shark *(Carcharhinus plumbeus)*	October - January
North Coast	Spanish mackerel *(Scomberomorus commerson)*	August - November

3. Fish Spawning: Seismic surveys may alter fish behaviour during spawning and pre-spawning periods. The Department therefore requests that Pathfinder Energy specifically includes strategies in the EP to minimise the impacts of the survey activities on fish spawning. The strategies may include (but are not limited to) minimum required acoustic intensity and exposure time to achieve objectives. It is also requested that, where possible, seismic survey activities do not occur during the times of the year that follow key fish species may be spawning within your proposed area of activities:

As stated above, the Nightcap MC MSS EP identified 12 EPOs that will describe the measurable level of performance required for the management of environmental aspects to ensure that the impacts and risks will be of an acceptable level. Regarding impacts on fish spawning, Pathfinder will commit to using the minimum required acoustic source and exposure time to achieve survey objectives. However, regarding temporal restrictions on seismic activities during the times of the year that key fish species may be spawning (listed above), there is currently no scientific data indicating specific locations of fish spawning grounds or nursery areas within the Nightcap MC MSS operational area. Without this information, mitigation measures to avoid spawning would be impossible to establish or undertake. Pathfinder welcomes any information that the Department can provide regarding fish spawning grounds within the operational area and will consider any appropriate mitigation measure to reduce impacts, including exclusion periods.

Despite unknown spawning grounds within the Nightcap operational area, it is reasonable to conclude that the Rowley Shoals are the closet marine habitat likely to support fish spawning. As such, the EP evaluated and assessed the biological values and sensitivities of the Rowley Shoals, as well as potential environmental impacts that may result from underwater noise generated by the seismic source. The Nightcap operational area is in close proximity to the boundary of the Mermaid Reef Commonwealth Marine Reserve (~4 km) and to the reef's 250 m contour (~9 km), while the shallow inner lagoon is ~11 km away. Therefore, based on acoustic modelling of the seismic source, the maximum received sound exposure levels (SELs) at Mermaid Reef is predicted to be <153 dB re 1 μPa^2·s. Based on the best available scientific evidence, the SEL likely to cause egg and larvae mortality is SELcum 210 dB re 1μPa^2·s (Popper *et al.* 2014). When converted to SELcum, >190,000 seismic shots would be required to result in levels that are likely to cause egg and larvae mortality, which will ever occur. Shot points will be

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
			~25 m apart (i.e. every 10.8 seconds) and thus would not occur exactly over each other. Therefore, the predicted SELs received at the closest distance to Mermaid Reef at Rowley Shoals will never reach thresholds likely to cause mortality in eggs and larvae.
		4. Biosecurity For vessels moving into WA waters from overseas or interstate for this activity, the Department requests you use its new biofouling risk assessment tool Vessel Check (https://vesselcheck.fish.wa.gov.au) and complete the actions to manage any related vessels to a LOW/ACCEPTABLE risk rating. This will demonstrate that Pathfinder Energy has taken reasonable measures to minimise the change of committing offences under the *Fish Resources Management Act 1994* and associated regulations related to transferring live non-endemic or noxious fish into WA. Alternatively, so Pathfinder Energy can demonstrate the above, the Department requests the active use of a biofouling management plan and record book that meets all requirements under Appendix 2 of the current edition of the International Maritime Organisation's Guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species. The Department also requests that Pathfinder Energy plan how it intends to ensure all vessels remain at a low risk after arrival in WA waters. Any equipment coming from overseas or interstate for this activity should also be either new, or thoroughly cleaned, then dried for at least 24 hours. Equipment should be inspected for marine pests before use in WA waters. The Department requests that the presence of any suspected marine pest or disease be reported within 24 hours by email (biosecurity@fish.wa.gov.au) or telephone (FishWatch tel 1800 815 507). This includes any organism listed in the Western Australian Prevention List for Introduced Marine Pests (see: http://www.fish.wa.gov.au/Documents/biosecurity/epa_introduced_marine_pests.pdf), and any other non-endemic organism that demonstrates invasive characteristics. Please ensure the requests above are forwarded directly to all vessel operators associated with the project.	4. Biosecurity a. For vessels moving into WA waters from overseas or interstate for this activity, the Department requests you use its new biofouling risk assessment tool Vessel Check (https://vesselcheck.fish.wa.gov.au) and complete the actions to manage any related vessels to a LOW/ACCEPTABLE risk rating. This will demonstrate that Pathfinder Energy has taken reasonable measures to minimise the change of committing offences under the *Fish Resources Management Act 1994* and associated regulations related to transferring live non-endemic or noxious fish into WA. Alternatively, so Pathfinder Energy can demonstrate the above, the Department requests the active use of a biofouling management plan and record book that meets all requirements under Appendix 2 of the current edition of the International Maritime Organisation's Guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species. The Department also requests that Pathfinder Energy plan how it intends to ensure all vessels remain at a low risk after arrival in WA waters. The potential biofouling risk presented by the survey and support vessels within the Nightcap MSS operational area will relate to the length of time that these vessels have already been operating in Australian waters or, if operating outside Australian waters, the location/s of the surveys undertaken, the length of time spent at these location(s), and whether the vessels have undergone hull inspections, cleaning and application of new antifoulant coating prior to operating in Australian waters. At this stage, the survey and support vessels are not confirmed. Vessels may be contracted from companies operating either within or outside Australia. On this basis, Pathfinder shall ensure that all contracted vessels complete an invasive marine species (IMS) risk assessment prior to arriving in Australia, as well as all of the necessary clearances to operate within Australia waters, as required. This includes meeting the biosecurity standards of the Department as well as the Department of Agriculture and Food. Pathfinder is aware that any vessel or marine infrastructure destined for WA waters is required to meet the aquatic biosecurity standards set out under the Fisheries Resources Management Act 1994, including a Marine Biosecurity Inspection for the presence of known and potential IMS to ensure compliance with Regulation 176. Target marine species of concern to Australian waters can be observed during the in-water inspection in order to ensure the vessel will be considered to pose a low risk of introducing any IMS of concern to Australian waters. Vessels will be coated in an appropriate antifouling system that is considered suitable for both coastal and deep-sea vessels and is compliant with the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (IMO document AFS/CONF/26). The survey vessel chosen for an individual survey will be assessed using the Department's Vessel Check tool: https://vesselcheck.fish.wa.gov.au. Furthermore, Pathfinder will ensure that the survey and support vessels uphold the guidelines detailed in the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry, and the IMO Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species, including the use of a biofouling management plan and record book for the survey and support vessels. Pathfinder Energy will also ensure that all vessels remain at a low risk after arrival in WA waters by achieving the following EPSs: • Ballast water discharges for the survey and support vessels must comply with the requirements of the Australian Ballast Water Management Requirements (as enforced under the *Quarantine Act 1908* [Section 27A] and Quarantine Regulations 2000). • Vessels must have a Ballast Water Management Plan that complies with Regulation B-1 of the International Convention for the Control and Management of Ship's Ballast Water and Sediments 2004, and the Plan will be prepared in accordance with the IMO Guidelines for Ballast Water Management and the Development of Ballast Water Management Plans (IMO Resolution MEPC.127(53). • The risks of introducing IMS via biofouling into WA waters and ports will be managed in accordance with marine pest management guidelines (as enforced under the *WA Fish Resources Management Act 1994* and *Fish Resources Management Regulations 1995*) for the survey and support vessels. • Application of Department of Agriculture's guideline that full ballast, high risk, exchanges are conducted as far as possible away from shore and in water at least 200 m deep. • Application of guidelines detailed in the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry, and the IMO Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species implemented for the survey and support vessels, including the use of a biofouling management plan and record book for the survey and support vessels. • The survey and support vessels will have a recent dry dock, IMS inspection or antifoulant application prior to mobilising to Australian waters. • If the survey and/or support vessels has to leave Australian waters before completion of the survey, it will be required to undergo a further IMS inspection and cleaning (if required), prior to re-entering Australian waters to complete the survey. b. Any equipment coming from overseas or interstate for this activity should also be either new, or thoroughly cleaned, then dried for at least 24 hours. Equipment should be inspected for marine pests before use in WA waters. The Department requests that the presence of any suspected marine pest or disease be reported within 24 hours by email (biosecurity@fish.wa.gov.au) or telephone (FishWatch tel 1800 815 507). This includes any organism listed in the Western Australian Prevention List for Introduced Marine Pests (see: http://www.fish.wa.gov.au/Documents/biosecurity/epa_introduced_marine_pests.pdf), and any other non-endemic organism that demonstrates invasive characteristics. Please ensure the requests above are forwarded directly to all vessel operators associated with the project. For the proposed survey activities within the Nightcap MSS operational area, Pathfinder will ensure that the risks of introducing IMS via biofouling into WA waters and ports will be managed in accordance with marine pest management guidelines (as enforced under the *WA Fish Resources Management Act 199*4 and *Fish Resources Management Regulations 1995*). As such, immersible equipment and the survey vessel hull, sea chests and other niches will be 'clean' before the survey vessel enters WA waters and ports. Also, the suspected or confirmed presence of any marine pests or disease must be reported within 24 hours by email (biosecurity@fish.gov.au) or telephone (FishWatch tel: 1800 815 507). This includes any organism listed on the WA Prevention List of Introduced Marine Pests, and any other non-indigenous organism that demonstrates invasive characteristics.
		1. Expectation/Implementation	As per the Department's advice and the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (as amended

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
		The Department requests a written response that addresses all potential impacts to fisheries, fish and fish habitats described in this letter, and strategies that Pathfinder Energy will implement to mitigate or minimise these impacts. The Department also requests that all impacts, as described above, and any objections or claims raised by stakeholders, including those raised by the Department, are included in the EP submission. Should we have any further queries regarding your response we will notify you at this time.	December 2011), the Nightcap MSS EP will include all impacts (as described above) and any objections or claims raised by stakeholders (including the Department). Furthermore, please note that EPs are living documents and as such, may be modified throughout the course of their validation period. Even after acceptance by the regulator, if newly available information indicates that there is a potential for increased environmental risk, Pathfinder will assess the new information and revise the EP as required.
Sue Osborne (DPaW)	Phone call 1 February 2016	DPaW inquired about the Nightcap MSS EP and informed that original email received by Broome office only. Will review consultation letter once received.	Scope Resources confirmed that the original email was sent to the proper email address and re-sent the original consultation letter as requested.
	Phone call 3 February 2016	DPaW asked for confirmation on distance from operational area to Scott Reef, and informed of primary concerns regarding environmental impacts to pygmy blue whales and Rowley Shoals Marine Park. Will send formal letter of concerns.	Scope Resources confirmed that closest distance from operational area to Scott Reef is greater than 70 km and discussed risk assessment approach and conclusions regarding impacts to pygmy blue whales and the Rowley Shoals Marine Park.

	Email 3 February 2016	Thank you for the opportunity to comment on the proposal by Pathfinder Energy to undertake a multi-client seismic survey in the Roebuck and Browse basins located immediately east and north-east of the Western Australian Rowley Shoals Marine Park. To inform the assessment of the Nightcap Multi-Client Marine Seismic Survey, Parks and Wildlife recommends that you clarify and interpret the following information to the satisfaction of the regulator:
		• maximum received sound energy levels (SELs) in Rowley Shoals Marine Park;
		• a comparison between the received SELs within Rowley Shoals Marine Park, and levels likely to cause injury, or trigger the behavioural disturbance of specially protected or threatened species that inhabit or migrate through, the marine park;
		• survey design and operational management procedures that will be implemented in order to avoid, or minimise impacts on specially protected or threatened wildlife and other reserve values;
		• the potential cumulative impacts of multiple seismic surveys by Pathfinder Energy and other operators during, and in the vicinity of cetacean migration pathways.
			19 February 2016:
			Thank you for your email (dated 3 February 2016) regarding the Nightcap Multi-client (MC) Marine Seismic Survey (MSS) Environment Plan (EP). On behalf of our client, Pathfinder Energy (Pathfinder), please know that the concerns raised in your response are appreciated and have been carefully considered. We understand and agree with the Department of Parks and Wildlife (the department) recommendations to clarify and interpret various aspects of the proposed survey activities. As the EP is still being prepared, we are providing the following details which will be included in the final EP and hopefully address the department's concerns.
			1. To inform the assessment of the Nightcap Multi-Client Marine Seismic Survey, Parks and Wildlife recommends that you clarify and interpret the following information to the satisfaction of the regulator:
			a. maximum received sound energy levels (SELs) in Rowley Shoals Marine Park
			Pathfinder proposes to use a 4,100 in^3 airgun array for survey activities within the Nightcap MSS operational area. Based on available modelling results, the maximum predicted sound exposure level (SEL) in the crossline direction (i.e. the maximum sound propagation) is:
			• 157 dB re 1 $\mu Pa^2 \cdot s$ at 3 km
			• 153 dB re 1 $\mu Pa^2 \cdot s$ at 4 km
			• 142 dB re 1 $\mu Pa^2 \cdot s$ at 9 km.
			The closest distance from the operational area to the Marine Park is ~3 km at the Clerke Reef boundary, ~7 km to the Clerke Reef 250 m contour and ~11 km to the shallow inner lagoon. Therefore, the maximum received SELs in the Marine Park is predicted to be <157 dB re 1 $\mu Pa^2.s$. These results align well with the Centre for Marine Science and Technology's (CMST) empirical measurements that compared several seismic airgun sources in western and southern Australian waters. According to CMST's results, a 4,000 in^3 airgun array is expected to generate SELs ~155–150 dB re 1$\mu Pa^2.s$ within 4 km and ~143–145 dB re 1$\mu Pa^2.s$ within 9 km of the source, thus providing a useful validation of modelling predictions presented in the Nightcap MSS EP and that the seismic sound levels generated will be similar to levels from other surveys in Australian waters.
			b. a comparison between the received SELs within Rowley Shoals Marine Park, and levels likely to cause injury, or trigger the behavioural disturbance of specially protected or threatened species that inhabit or migrate through, the marine park.
			An environmental risk assessment was undertaken to understand and manage potential impacts from underwater noise generated by the seismic acoustic source. Based on the best available scientific evidence, the level of sound exposure that causes a temporary injury or threshold shift (TTS) varies widely and can be affected by factors such as repetition rate of the sound, pressure level, frequency, duration, health of the organisms and many other factors. By definition, hearing recovers after TTS. The following received cumulative SEL are guidelines (Popper *et al.* 2014 , Southall *et al.* 2007) to estimate various physiological effects on:
			• Fish
			  ○ Recoverable injury (i.e. not likely to result in mortality) SELcum 203–216 dB re 1$\mu Pa^2 \cdot s$
			  ○ TTS SELcum at 186 dB re 1$\mu Pa^2 \cdot s$
			• Marine turtles, eggs and larvae mortality SELcum 210 dB re 1$\mu Pa^2 \cdot s$
			• Cetaceans
			  ○ Serious injury or permanent threshold shifts (PTS) SEL 198 dB re 1$\mu Pa^2 \cdot s$
			  ○ TTS SEL 183 dB re 1$\mu Pa^2 \cdot s$.
			The predicted SEL received at the Marine Park boundary at Clerke Reef (i.e. closest point) is 157 dB re 1 $\mu Pa^2.s$. When converted to SELcum, >35,000 seismic shots would be required to result in levels that are likely to cause recoverable injury for fish, while >700 seismic shots would be required to cause TTS in fish, neither of which will ever occur. Shot points will be ~25 m apart (i.e. every 10.8 seconds) and thus would not occur exactly over each other. Furthermore, the predicted sound levels received within the Marine Park will never reach thresholds likely to cause mortality in marine turtles, eggs and larvae.
			Regarding cetaceans, the predicted SELs are far less than the levels known to cause serious injury, PTS or TTS. Therefore, it is reasonable to conclude that potential acoustic impacts to threatened or protected marine fauna (including eggs and larvae) within the Rowley Shoals Marine Park will be insignificant and temporary.
			c. survey design and operational management procedures that will be implemented in order to avoid, or minimise impacts on specially protected or threatened wildlife and other reserve values
			Regulation 13(7) of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 requires that an EP include environmental performance outcomes (EPO), environmental performance standards (EPS) and measurement criteria that address legislative and other controls to manage the environmental impacts and risks of the activity. For proposed surveys, the EPOs and EPSs set the standards against which Pathfinder will measure environmental performance, and the implementation of appropriate measurement criteria will determine whether the associated EPO was achieved. As such, the EPOs, EPSs and measurement criteria are consistent with legislative

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
			requirements and Pathfinder policies, standards and procedures. They were developed based on the legislation, codes and standards, good industry practice, professional judgement, risk-based analysis, company and societal values. Any breach of an EPO or EPS will constitute a 'Recordable Incident' under the Environment Regulations. The Nightcap MSS EP identified 12 EPOs that will describe the measurable level of performance required for the management of environmental aspects to ensure that the environmental impacts and risks will be of an acceptable level, and thus reduce impacts on specially-protected or threatened wildlife and other reserve values: 1. Prevent adverse impacts from survey and support vessel noise emissions on cetaceans, turtles and whale sharks 2. Zero incidents of interference or negative interactions with commercial fishing, recreational fishers, tourism activities or shipping during the activity 3. Zero incidents of introduction of IMS from ballast water exchange during surveys within the operational area 4. Zero incidents of introduction of IMS from biofouling of survey and support vessels' hull, other niches and immersible equipment during surveys within the operational area 5. Prevent adverse noise impacts to marine fauna and divers from discharge of the airgun array 6. Zero incidents of non-compliant discharges of bilge water, sewage and putrescible wastes from the survey and support vessels within the operational area 7. No collisions with cetaceans, turtles or whale sharks from vessels and towed equipment 8. Zero incidents of physical damage to benthic habitats and communities from dragging or loss of the streamers and associated equipment 9. Zero incidents of accidental release of hazardous or non-hazardous material to the sea from the survey and support vessels • Zero incidents of release of hydrocarbons to the marine environment resulting from spill to deck • Zero incidents of release of hydrocarbons to the marine environment resulting from vessel collision or fuel transfer spills • Implementation of SOPEP/OPEP for all hydrocarbon spills of to sea within the Nightcap MSS operational area. d. the potential cumulative impacts of multiple seismic surveys by Pathfinder Energy and other operators during, and in the vicinity of cetacean migration pathways The cumulative impacts from seismic impulses within the marine environment are difficult to quantify, especially since the acquisition of seismic data requires the temporary creation of sound pressure waves (i.e. airgun-derived) that dissipate and soon disappear when the sound energy source is stopped. There is no bioaccumulation of sound pressure within the marine environment. Nonetheless, there may be a temporary additive effect if sounds from one activity coincide and overlap spatially and temporally with another concurrent activity. However, this "added sound" will disappear once one of the sound-generating sources stops or passes out of the area. A review of seismic-related literature revealed no documented instances of the negative effects of cumulative seismic energy source on any marine organism. Please be assured that Pathfinder is not planning repetitive seismic surveys over the same area, as there are no such work program commitments or exploration programs. If other seismic surveys are conducted by different operators in the general area, the surveys are likely to be separated by tens of kilometres and occur at least one year apart. Under these circumstances, cumulative impacts would be negligible. Shooting over open acreage could occur, as these are within the southern portion of the Nightcap MSS operational area and adjacent to the Rowley Shoals Marine Park. However, the chances of two seismic companies targeting the same open acreage at the same time is extremely low. Pathfinder will not undertake surveys that overlap another survey either spatially or temporally. Furthermore, if there were two survey vessels operating in the area, Pathfinder would ensure that they maintain a minimum distance of 50 km from another seismic vessel to minimise potential cumulative impacts on marine fauna and to minimise noise interference that may affect seismic data quality.
		The department advises that pygmy blue whales (*Balaenoptera musculus brevicauda*) are threatened fauna (ranked endangered) under the provisions of the *Western Australian Wildlife Conservation Act 1950*, and their migration through Rowley Shoals Marine Park is a significant value of the reserve. The department requests that survey planning and operational procedures focus on the protection of this threatened species.	2. The Nightcap MSS operational area overlaps the known distribution and migration areas for pygmy blue whales. Thus, migrating pygmy blue whales may be encountered throughout the operational area on their southbound migration from September to December, and on their northbound migration from April to June. As stated above, the proposed survey activities will have EPOs, EPS and measurement criteria to protect pygmy blue whales by reducing potential impacts from vessel noise, vessel collisions, underwater noise and accidental hydrocarbon spills to the whales and their marine habitats.
		The department notes that your Environment Plan will include an Oil Pollution Emergency Plan (OPEP). It is the department's expectation that operators maintain an independent capacity to respond to oiled wildlife. Parks and Wildlife is not responsible for implementing an oiled wildlife response on behalf of petroleum operators in Commonwealth waters.	3. In the rare and unlikely event of an accidental hydrocarbon spill within the Nightcap MC MSS operational area, Pathfinder, in combination with their seismic contractors, will have insurance policies in-place to cover the costs of Type I operational monitoring and Type II scientific monitoring required, or required to cover the costs of any clean-up or remediation activities following a spill. These policies cover activities in Australian Commonwealth and State waters, including the Nightcap MC MSS operational area.
		In the event of an oil spill, the department draws your attention to the possible movement of oiled wildlife, in particular sea birds, some distance away from the area of direct impact; e.g. to offshore reefs and islands, potentially including Rowley Shoals Marine Park. It is recommended that your OPEP give consideration to the identification and monitoring of sites where oiled wildlife may congregate and to the logistics and protocols of mounting a response to oiled wildlife at sites within Western Australian. Parks and Wildlife, in consultation with other Western Australian Government agencies and industry has prepared a guidance document outlining operational procedures and standards for the treatment and rehabilitation of oiled wildlife. This information, which is contained within the state-wide oiled wildlife response plan, is located at https://www.dpaw.wa.gov.au/management/marine/marine-wildlife. Please contact me if you have any queries in relation to this advice.	4. Pathfinder is fully aware that in the rare and unlikely event of an accidental hydrocarbon spill, marine fauna and habitats may be contaminated by oil. Thus, the OPEP's Type II 'Scientific Monitoring' Plan includes identification and monitoring of important areas and habitats where the oiled fauna species (e.g. sea birds) may congregate. Furthermore, please note that EPs are living documents and as such, may be modified throughout the course of their validation period. After acceptance by the regulator, if newly available information indicates that there is a potential for increased environmental risk, Pathfinder will assess the new information and revise the EP as required. We hope that this information provides the department with increased confidence that Pathfinder will undertake the proposed activity in a manner that will minimise impacts to the marine environment to as low as reasonably practicable. We are very mindful and aware of our precious marine environment and look forward to working with the department in the future. If you have any further comments, or if you would like to schedule a meeting, please feel free to contact me at Scope Resources.
Absolute Charters	Follow-up call	No issues/concerns and advised that main tourism season would be 15 September-early December	No further response required until pre-survey planning.

Stakeholder	Consultation	Stakeholder feedback	Pathfinder assessment on feedback and response
	3 February 2016		
Blue Sun2/Kimberley Boat Cruises	Follow-up call 3 February 2016	No issues/concerns and advised that main season for fishing Aug-Nov and that little traffic in the area at the moment	No further response required until pre-survey planning.
The Great Escape Charter Company	Follow-up call 3 February 2016	Receptionist will pass on message to General Manager	No further response required until pre-survey planning.
Odyssey Expeditions	Follow-up call 3 February 2016	No answer – left message	No further response required until pre-survey planning.
Kimberley Expeditions	Follow-up call 11 February 2016	No issues/concerns but will forward email to Kimberley Marine Tourism Association	No further response required until pre-survey planning.
True North Cruises	Follow-up call 11 February 2016	No issues/concerns and advised that cruises at Rowley Shoals usually scheduled for 3 weeks in September; discussed whales and seismic surveys in general; understand that effects on divers not likely based on distance away from shoals.	No further response required until pre-survey planning.
Elise Clark (Marine Protected Areas, Parks Australia)	Email 27 July 2016	I note that the Nightcap MC MSS EP is currently under assessment by NOPSEMA. In light of this, I am providing the below correspondence on this EP despite the extended delay between now and your initial correspondence. I note that the proposed survey area for this EP is adjacent to the Mermaid Reef CMR (IUCN category 1a) for which transitional management arrangements currently apply. Can you please confirm whether seismic streamers (active or inactive) will incur into this CMR? Prior to the election the Government made a commitment that management plans for all reserves currently under transitional management arrangements will be in place within the next 12 months. When future management plans come into effect, the Director of National Parks expects that titleholders will consider the need to revise and amend environment plans accordingly.	1 August 2016: Thank you for your response and feedback (dated 27 July 2016) regarding the Nightcap Marine Seismic Surveys Environment Plan (EP). On behalf of our client, Pathfinder Energy (Pathfinder), we appreciate the advice provided and will include this in the next version of the EP. Especially useful is the commitment that in the next 12 months, management plans will be in-place for all Commonwealth Marine Reserves currently under transitional management arrangements. Please be assured that when these management plans come into effect, Pathfinder will revise and amend the Nightcap EP accordingly. The Nightcap operational area overlaps a small portion (<7%) of the Kimberley Commonwealth Marine Reserve Multiple Use Zone IUCN Category VI (see map attached). Furthermore, the Nightcap operational area does not overlap or intersect the Mermaid Reef Commonwealth Marine Reserve (MRCMR), and the operational area is ~4 km from the reserve boundary, ~9 km from the reef slope and ~11 km from the reef flat. In the Nightcap EP, Pathfinder completed a robust environmental risk assessment that recognised the values of the MRCMR, determined that potential impacts to the MRCMR are as low as reasonably possible (ALARP) and made the commitment to not tow deployed equipment through or undertake seismic acquisition activities within the MRCMR. Therefore, the following environmental performance standard was contained in the Nightcap EP: the survey vessel is not permitted to transit the Mermaid Reef Commonwealth Marine Reserve or the Rowley Shoals Marine Park with the seismic equipment deployed, as per the transitional management arrangements. We hope that this information gives the Director of National Parks and Parks Australia assurance that, under the Nightcap EP, potential impacts to the marine environment (including Commonwealth Marine Reserves) will be reduced to ALARP and acceptable levels. Also, Pathfinder will include all stakeholder correspondence in subsequent versions of the EP. If you have any further questions or concerns, please feel free to contact us at Scope Resources.
	Email 2 August 2016	Thank you for your below advice. Kind regards	No further response required until pre-survey planning.

6.2 PHASE 2 PRE-SURVEY CONSULTATION

Pathfinder are mindful of identifying new stakeholders and of affording as long as notification period as possible in relation to proposed surveys. As such, Pathfinder shall notify relevant stakeholders of a potential survey that may affect their interests or activities. Unfortunately, due to the fluid nature of the seismic industry, not all information (e.g. vessels, timing, duration, exact location, etc.) may be finalised until months in advance. However, as soon as final details are known, these shall be communicated with the relevant stakeholders.

As soon as a survey is considered likely to occur, Pathfinder will commit to notifying relevant stakeholders with the information that is available, which is at a minimum, the likely timeframe and location of the survey. This will give stakeholders an opportunity to identify a narrowed timeframe and location than that previously supplied as part of the EP notification. Stakeholders will be offered the opportunity for face-to-face meetings once again. As more details become available, Pathfinder shall supply updates to relevant stakeholders. The end result will ensure that information will be supplied to all relevant persons as part of a staged process.

It is anticipated that by four weeks prior to commencing any survey within the Nightcap MSS operational area, Pathfinder will contact relevant stakeholders to provide information for the proposed activity, including:

- the size, location and geographical coordinates for the survey
- the timing and duration
- parameters for the towed seismic array (e.g. acoustic source and streamer spread)
- details of the survey and support vessels
- overview of potential risks and impacts
- proximity to any dive sites
- an offer of a 7–10 day forecast to all relevant stakeholders
- contact details to submit a concern.

At any point during this notification process, stakeholders will have a further opportunity to raise with Pathfinder any specific concerns or issues regarding the proposed survey (Table 6.3). These will be assessed as outlined below.

Through their combined experience in the industry, Pathfinder and their environmental management team (i.e. Scope Resources) have good knowledge and understanding of the stakeholders within the area covered by the Nightcap MSS operational area and their potential areas of concern. Thus, Pathfinder are confident that the approach and timeframes outlined above are acceptable to allow any claims or objections to be raised and appropriately dealt with. Pathfinder can provide a 7–10 day forecast prior to commencement of survey activities to commercial fisheries and aquaculture upon request.

Four weeks prior to the commencement of a proposed survey, Pathfinder will consult a number of additional stakeholders, primarily within the offshore exploration and petroleum industry. These consultations will include, as far as possible, other geophysical companies operating in Australian waters, plus titleholders of petroleum titles adjacent to the proposed Nightcap MSS operational area. The primary objective of this consultation will be to ascertain if there are any other seismic surveys proposed for areas adjacent to the Nightcap MSS operational area over the same time period. Concurrent surveys usually require a minimum separation distance of 50 km between the two operating survey vessels to avoid noise interference with the received signals. If separation distances between the survey vessels are closer than 50 km, then the two proponents will work out procedures for simultaneous operations to eliminate or minimise the potential for noise interference and data corruption, for instance, a time-sharing arrangement over a 24-hour period during which time each vessel will acquire for a period of 12-hours whilst the acoustic sources of the other vessel are shutdown.

6.3 PHASE 3 ON-GOING CONSULTATION

Consultation with relevant stakeholders will be ongoing while the Nightcap MSS EP is valid, and as per the schedule outlined in Table 6.3. Pathfinder will comply with requests by stakeholders for additional information and requests for updates during individual surveys undertaken within the Nightcap MSS operational area. In addition, stakeholders will be notified of any changes to scope of the EP that may affect their interests or activities four weeks in advance of a survey. Significant changes to scope will trigger a revision of the EP, as described in Section 4.3. Any notification to stakeholders will contain contact details of where any claims/objections/queries or concerns may be directed. Contact details will include the EP liaison person, telephone number and email address.

As required under sub regulation 16(b), Pathfinder shall assess the merits of any new claims or objections made by a relevant stakeholder whereby they believe the activity may have adverse impacts upon their interest or activities. If the claim has merit and where appropriate, Pathfinder shall modify management of the activity. The assessment will be done using the methodology outlined for the internal risk assessment.

Also if the claim has merit and where appropriate, Pathfinder shall modify management of the activity. Pathfinder shall finalise the assessment of merit of any claim or objection received and undertake any resulting management of change actions as soon as practicable. The assessment of merit and any resulting management of change actions shall be shared with the concerned stakeholder. If the outcome of the assessment of merit of a claim or objection received during a survey suggests that impacts and risks are new or increased (i.e. if the residual risk ranking has changed), this will trigger a revision to the EP, given that under subregulation 8(1) it is an offence for a titleholder to continue if a new impact or risk, or increase in the impact or risk, is not provided for in the EP in force.

If a significant new or increased impact or risk is identified as a result of an internal risk assessment and it is not already appropriately covered under the EP, as required under subregulation 17(6), Pathfinder shall submit a proposed revision to the EP. Pathfinder shall determine at the time of the internal risk assessment, whether a risk or impact is considered 'significant' (i.e. has resulted in an increased residual risk ranking) based on information available at that time (e.g. reviewed scientific information, stakeholder claims or concerns). Notification to stakeholders of significant new or increased risks will be issued prior to submission of the revised EP as part of a new consultation process for the revised EP.

6.3.1 Regular Updates

Pathfinder shall ensure that approximately every six months, all stakeholders have been provided with an update of activities associated with the Nightcap MSS EP, including completed surveys and potential new locations for surveys (if known). As part of this process, Pathfinder shall check that identified stakeholders are still relevant and correct, and also identify new stakeholders (e.g. via organisational bodies such as AFMA, AMSA, DoF, lessons learnt, etc.). This action will ensure that stakeholders have a greater opportunity to identify areas of concern, and minimise the chances of being 'surprised' if a shorter timeframe for notification occurs as a result of a survey being finalised with minimum lead-in time. Stakeholders will be offered the opportunity for face-to-face meetings. Updates may be a stand-alone notice or part of a notification associated with a survey.

6.4 PHASE 4 POST-SURVEY NOTIFICATION

On completion of individual surveys, a completion notification that summarises survey activities (e.g. survey dates, area surveyed, summary of environmental performance and compliance, etc.) will be sent to relevant stakeholders.

Table 6.3 – Details of stakeholder consultation plan for the Nightcap MSS EP

Organisation	Division/Title	Objective	Method of Communication	Frequency	Timeframe
A Raptis & Sons		●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used -navigation plots for importing into sea charts such as C-Map -online login for fisheries licence holders who register to allow access to real time ship positions, to plan fishing and try to avoid unnecessary disruption and costs ●To provide an update of the projects progress and inform of any future changes ●Determine if diving SIMOPS plan is required (pearl divers only) ●6-month updates of activities within the scope of the EP	●Email ●Meetings if requested	●During planning of individual surveys ●6-month updates	● As soon as an approximate location and timeframe is known and if the individual survey area overlaps the respective fishery that the organisation represents, known details will be provided ● Minimum 3 weeks prior to the commencement of an individual survey being undertaken, (if the survey overlaps the respective fishery that the organisation represents) all details will be provided. ● 7-10 day forecast
Australian Fisheries Management Authority (AFMA)	Project Manager Petroleum				
	Environmental Policy Section				
	Northwest Slope Trawl Fishery				
	Western Tuna and Billfish Fishery				
Commonwealth Fisheries Association (CFA)	Chief Executive Officer				
MG Kailis Group	Operations Manager				
Tuna West Indian Ocean Tuna Association	IOTC Secretariat				
WestMore Seafoods					
WA Department of Fisheries (DoF)	Sustainability and Environment Aquatic Biodiversity	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●To provide an update of the projects progress and inform of any future changes ●To provide an update of activities within the scope of the EP	Online submission	●During planning of ALL individual surveys ●6-month updates ● 7-10 day forecast	●Minimum of 3 weeks prior to the commencement of ALL individual surveys ● DoF have requested that they be contacted minimum 3 months. ● 7-10 day forecast provided to WAFIC
Western Australian Fishing Industry Council (WAFIC)	Executive Officer Resource Access		Email		

Organisation	Division/Title	Objective	Method of Communication	Frequency	Timeframe
WA DoF Licence Holders		●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Letter or email	●During planning of ALL individual surveys ●6-month updates ● 7-10 day forecast	● As soon as an approximate location and timeframe is known and if the individual survey area overlaps the fishery of the licence holder, known details will be provided ●Minimum of 3 weeks prior to the commencement of individual surveys, if the survey area overlaps the respective fishery of the licence holder, all relevant information will be supplied ● 7-10 day forecasts
Australian Hydrographic Service (AHS)	Nautical Assessment Officer	●To enable AHS to issue a Notice to Mariners (NTM) ●Supply vessel details and area of operation ●To details survey start and end dates ●6-month updates of activities within the scope of the EP	Email	●Prior to the commencement of ALL individual surveys ●6-month updates	Minimum of four weeks Prior to the commencement of ALL individual surveys being undertaken
		To comment on the operations and the interaction with commercial shipping at the time of the survey (i.e. any lessons learned)	Email	On completion of each survey	On completion of each survey
Department of Defence	Property Acquisition, Mining and Native Title, Property Management Branch	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	●During planning of individual surveys ●Prior to the commencement of ALL individual surveys ●6-month updates	Minimum of 14 days Prior to the commencement of individual surveys being undertaken, if the survey area overlaps defence restricted space areas.
Centre for Whale Research	Managing Director	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	●During planning of individual surveys ●6-month updates	● As soon as an approximate location and timeframe is known details will be provided ● Minimum 3 weeks prior to the commencement of an individual survey being undertaken, all details will be provided
IFAW	Marine Campaigner				

Organisation	Division/Title	Objective	Method of Communication	Frequency	Timeframe
Australian Maritime Safety Authority (AMSA)	Nautical Advice SAR Operations, Emergency Response Division	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	●Prior to the commencement of ALL individual surveys ●6-month updates	● As soon as an approximate location and timeframe is known, known details will be provided ● Minimum four weeks prior to the commencement of an individual survey being undertaken, all details will be provided to AHS ● RCC (SAR) requires notice as vessel is about to commence activities only.
Australian Customs Services (Coastwatch)	Department of Immigration and Border Protection	●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	●Prior to the commencement of ALL individual surveys ●If any changes/developments occur ●6-month updates	Prior to the commencement of ALL individual surveys
Strategic Border Protection Command - Customs	SBC External Engagement SBC Operations Performance and Practice				
Pilbara Ports	Harbour Master	Notification of start and end dates so agents and ship owners can be advised in advance	Email	Prior to the commencement of ALL individual survey	Minimum of four weeks prior to the commencement of ALL individual surveys
Geophysical companies active in offshore seismic activities		To ascertain if there are any other seismic surveys proposed for areas within and adjacent to the survey area over the same time period	●Email ●via vessel's radio protocol's (COLREGS)	During planning of individual surveys	●Prior to the commencement of ALL individual surveys ●Throughout survey operations for the entire duration of the project
Petroleum Operators		To let FPSO operator know that the vessel is undertaking activities adjacent, but outside, the gazetted PSZ	Vessel Radio	As required when adjacent to FPSO	As required when adjacent to FPSO
Absolute Charters		●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	●Email ●Phone calls	●During planning of individual surveys ●6-month updates	● As soon as an approximate location and timeframe is known details will be provided ● Minimum 3 weeks prior to the commencement of an individual survey being undertaken, all details will be provided
Blue Sun 2					
The Great Escape Charter Company					
Reel Teaser Fishing Adventures					

Organisation	Division/Title	Objective	Method of Communication	Frequency	Timeframe
Odyssey Expeditions		●If seismic operations occur between 1 Sept and 30 Nov and overlaps charter vessel operated dive/snorkelling tours within Mermaid Reef Commonwealth Marine Reserve or Rowley Shoals Marine Park, Pathfinder will undertake a joint risk assessment and, if required, jointly develop and implement a SIMOPS plan in consultation with dive and charter vessel operators.			
Kimberley Expeditions					
True North Cruises					
Recfishwest	Regional Policy Officer	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●To provide an update of the projects progress and inform of any future changes ●6-month updates of activities within the scope of the EP	Email	●During planning of individual surveys ●7-10 day forecasts ●6-month updates	● As soon as an approximate location and timeframe is known, known details will be provided ● Minimum 3 weeks prior to the commencement of an individual survey being undertaken, all details will be provided ● 7-10 day forecasts
NOPTA		To obtain the necessary titles (Access Authority [AA] and /or Special Prospecting Authority [{SPA]	●Email ●Letter	During planning of individual surveys	Prior to the commencement of ALL individual surveys is titles are needed
WA DMP	Environment Officer	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	During planning of individual surveys	Prior to the commencement of ALL individual surveys
WA DPaW	Environmental Management Branch	●During the planning of operations once specific survey areas have been identified to address any potential issues raised ●To provide data on each individual survey such as size, location, coordinates, timing and duration, and seismic parameters used ●6-month updates of activities within the scope of the EP	Email	During planning of individual surveys	Prior to the commencement of individual surveys that are adjacent to the WA State Waters boundary
	Pilbara Office				
WA DoT	Oil Spill Response Coordinator, Marine Pollution Branch	●Get advice and discussion regarding response techniques and protection priorities in State waters ●6-month updates of activities within the scope of the EP	Email/ discussion	●During planning of individual surveys ●6-month updates	During the OPEP planning phase

Organisation	Division/Title	Objective	Method of Communication	Frequency	Timeframe
		Provide accepted copy of the OPEP	Email	Prior to mobilisation	When OPEP has been accepted
		●Notification of any change of activity that may affect DoT ●Notify DoT of an incident	Telephone: 9480 9924	When identified	When identified

7 DETAILS OF TITLEHOLDER AND LIAISON PERSON

As required under Regulation 15, details for Pathfinder as both the Titleholder and nominated liaison person (the same person) are as follows:

Contact: Ian Boserio, Technical Director
Name: Pathfinder Energy Pty Ltd
Business address: 41- 47 Colin Street
West Perth, WA 6005
Telephone: +61 8 6500 3264
Email address: i.boserio@pfenergy.com.au.

The Regulator will be notified according to the requirements of Regulation 15(3), of changes to the titleholder or nominated liaison. Pathfinder will submit in writing to the Regulator and within 30 days of the change, information regarding a change in:

- the titleholder
- the titleholder's nominated liaison person
- contact details for the titleholder
- contact details for the liaison person.

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