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Houtman Sub-basin 2D seismic survey
Environment Plan Summary

November 2014

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Acronyms and Abbreviations

AHO	Australian Hydrographic Office
AIS	Automatic identification system
ALARP	As Low As Reasonably Practicable
AMBA	Area that May Be Affected
AMFA	Australian Fisheries Management Authority
AMSA	Australian Maritime Safety Authority
AMSA RCC	Australian Maritime Safety Authority Rescue Coordination Centre
APPEA	Australian Petroleum Production and Exploration Association
DAHs	Dissolved Aromatic Hydrocarbons
ENVID	Environmental Impact Identification
EP	Environment Plan
EPBC	Environment Protection and Biodiversity Conservation
GA	Geoscience Australia
GHG	Greenhouse Gases
IAP	Incident Action Plan
IMO	International Maritime Organisation
IMP	Invasive Marine Pest
IMS	Invasive Marine Species
IOPP	International Oil Pollution Prevention
JSA	Job Safety Analysis
KEFs	Key Ecological Features
MAH	Monoaromatic Hydrocarbon
MARPOL	Marine Pollution (convention)
MGO	Marine Gas Oil
MMO	Marine Mammal Observer
MODU	Mobile Offshore Drilling Unit
MSDS	Material Safety Data Sheet
NMSC	National Marine Safety Committee
NOPSEMA	National Offshore Petroleum Safety and Environment Authority
NOPTA	National Offshore Petroleum Titles Administrator
ODS	Ozone Depleting Substance
PAH	Polycyclic Aromatic Hydrocarbon
PMS	Planned Maintenance System

PMST	Protected Matters Search Tool
PSI	pounds per square inch
PTS	Permanent Threshold Shift
QPRO	Quality Procedure
SEL	Sound Exposure Level
SMS	Safety Management System
SMPEP	Shipboard Marine Pollution Emergency Plan
SOLAS	Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	Sound Pressure Level
STP	Sewage treatment plant
TTS	Temporary Threshold Shift
VRASS	Vessel Risk Assessment

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1. Overview

1.1 Proposed Activity

Geoscience Australia (GA) proposes to undertake a 2D seismic survey using a single vessel off the northern Houtman Sub-basin, part of the Perth Basin off the coast of Western Australia. New data will supplement existing geological knowledge of the region, underpin petroleum prospectivity evaluation, and ultimately support the discovery of new oil and gas resources.

1.2 Compliance and Purpose of this Report

This Environment Plan (EP) summary has been prepared as per the requirements of Regulation 11 (7) and (8) of the Environment Regulations. This document summarises the Houtman Sub-basin 2D Seismic Survey Plan EP, as accepted under Regulation 11(1) of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Commonwealth) (Environment Regulations) by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.3 Operator Contact Details

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2. Description of the Activity

2.1 Activity Overview

As part of the Offshore Energy Program, GA plans to acquire pre-competitive 2D seismic data in the northern part of the Houtman Sub-basin. Structural characteristics of the northern Houtman Sub-basin are not well understood and cannot be resolved without additional seismic data. Acquisition of a regional seismic grid will enable the development of geological knowledge in this frontier area, underpinning petroleum prospectivity evaluation and supporting exploration for new oil and gas resources.

2.2 Survey Activities

The Activity will comprise two phases: acquisition of data from a pre-defined Priority 1 area and acquisition of data from a Priority 2 area.

GA has identified approximately 3,800 line kilometres of Priority 1 seismic data to be acquired, using a combination of a 10 x 10 km grid in the north and a 20 x 20 km grid in the south (Figure 2-1, Table 2-1). Priority 2 seismic data is comprised of approximately 1,200 line kilometres in a 20 x 20 km grid. If time is constrained, acquisition of data from the Priority 2 dip lines (lines 1 – 6) will be prioritised over the Priority 2 strike lines (lines 7 – 12).

Seismic data will be collected by the *MV Duke*, a purpose built exploration survey vessel. While acquiring data, the vessel will be required to travel at slow speeds. The survey is planned such that each survey line will only need to be travelled once; in the unlikely event that data gaps are identified, portions of a survey line may be reacquired.

As the *MV Duke* travels along the survey lines a series of noise pulses will be directed down through the water column and seabed. The noise pulses will be reflected at geological boundaries and returning pulses recorded by hydrophones mounted on a streamer towed behind the vessel in the upper water column. Depths of geological strata will be calculated based on time elapsed between sound generation and detection of the reflected signal. At the end of each line the vessel will turn, during which the streamers may be towed outside of the data acquisition area shown in (Figure 2-1).

The seismic energy source will be a single airgun array, comprising 28 active guns which will be fired simultaneously and 4 inactive guns. The array will have a total capacity of 4,280 cubic inches. Individual airgun volumes range from 40 cubic inches to 300 cubic inches. Operating pressure of the airgun array will be approximately 2,000 pounds per square inch (psi). The hydrophone streamer system adopted for the survey will be one solid foam streamer 8,100 m in length. Water depths across the entire proposed acquisition area range from 700 m to 3,500 m. The airgun array will be used to generate noise pulses with sound levels at the source ranging from 237-262 dB re 1 µPa@m; most energy is expected to be within the 10-200 Hz range.

2.3 Activity Location

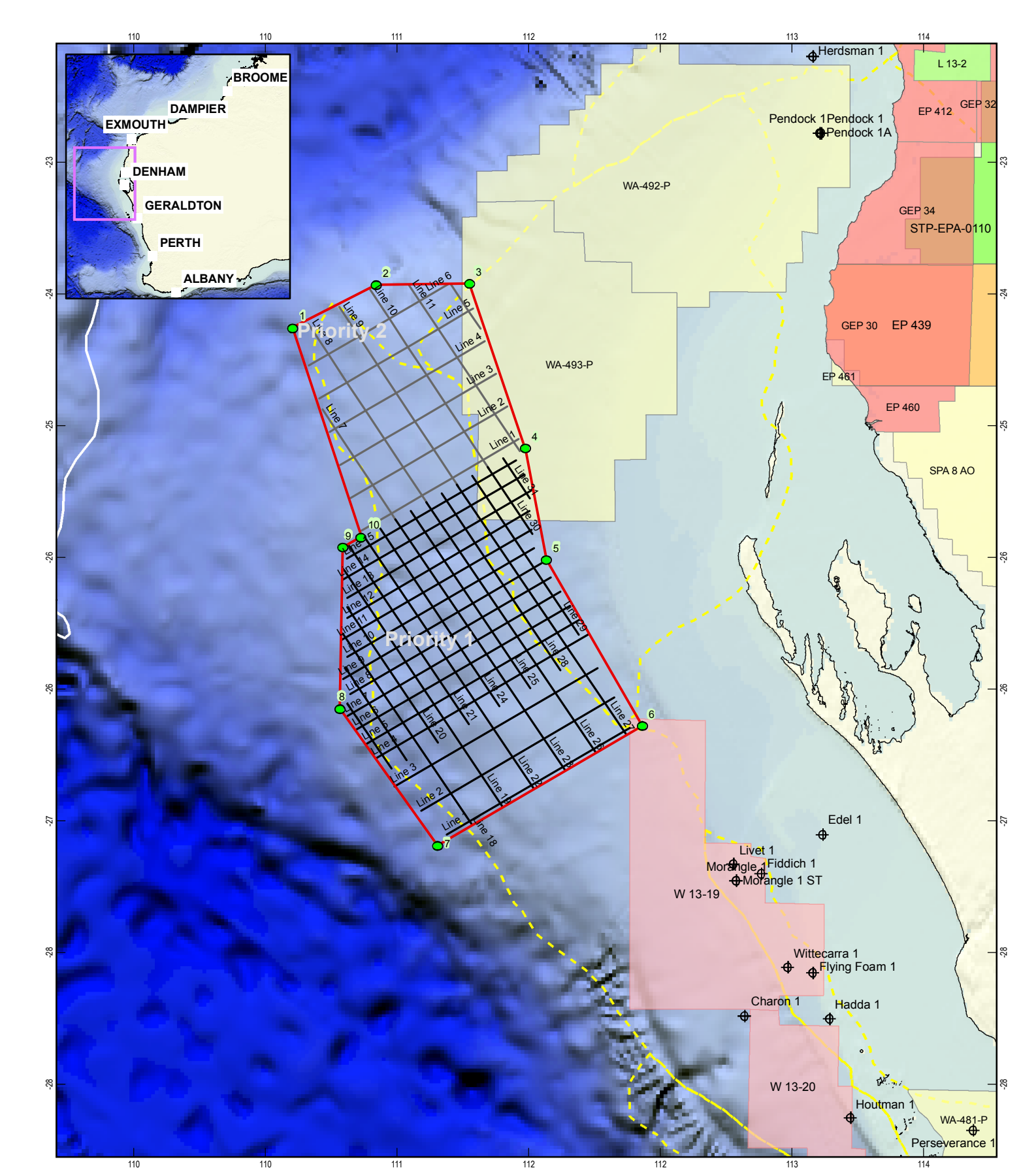
The Operational Area defines the geographical boundary of the Activity (Figure 2-1). This area includes a buffer zone of up to 12 km in which the seismic source may be discharged at or below full capacity for the purpose of run outs, source testing, soft-starts and line turns. The coordinates for the Operational Area are provided in Table 2-1.

Table 2-1 Operational Area coordinates

Map Point (Figure 2-1)	Longitude	Latitude
1	110.486	-24.344
2	110.943	-24.111
3	111.451	-24.104
4	111.757	-25.005
5	111.874	-25.613
6	112.396	-26.521
7	111.279	-27.175
8	110.744	-26.424
9	110.759	-25.545
10	110.863	-25.486

2.1 Activity Schedule

The Activity is scheduled to commence from approximately the 8th November 2014 and be concluded by 31st January 2015. The survey comprises approximately 48 days of survey activity and 8 days of transit to and from the permit areas during mobilisation (2 days transit), crew change port of call (4 days transit) and demobilisation (2 days transit).



LEGEND

- Operational area coordinates
- Petroleum exploration wells
- Houtman survey lines
- Additional survey lines
- Operational area
- Australian offshore sedimentary basins

1:3,000,000 Paper Size A4

0 10 20 40 60 80

Kilometres

Horizontal Datum: GDA 1994
Grid: GCS GDA 1994

N

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Houtman sub-basin 2D seismic survey

Location and Operational Area of the Activity

Job Number	41-27838
Revision	A
Date	31 Oct 2014

Figure 2-1

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G:\41\27838\GIS\Maps\Deliverables\41-27838_007_rev_0.mxd

Data source: GA: Survey information/2012, Survey Outline/2012, Australian Offshore sedimentary basins/2012, Acreage areas/2013; DMP: Petroleum information/2014; GHD: Coordinates/2014, Operational Area/2014. Created by: AJ

3. Description of the Environment

3.1 Regional Setting

Located in waters off Western Australia, the Operational Area for the proposed seismic survey lies within the Houtman Basin, approximately 100 km from the closest mainland coast and approximately 230 km from Carnarvon (Figure 2-1). The area lies directly west of Shark Bay, and occurs within waters approximately 700 m to 3,500 m depth.

3.2 Physical Environment

The Operational Area is dominated by the Leeuwin Current (moving from north to south) and the Western Australian current (turning anti-clockwise and moving water from south to north). The region would be subjected to the east Indian Ocean swells which occur frequently, being recorded as <0.1 m for less than 1% of the time. The swell direction is predominantly from the southerly direction, being driven by low pressure systems from the southern Ocean.

Water temperatures and salinity profiles within the Operational Area are likely to demonstrate a similar pattern to waters off the coast of southern Western Australia. Temperature (°C) and salinity (ppt) values generally decrease with depth, and begin to taper off beyond 2,000 m.

The region is likely to be exposed to relatively rough sea conditions. This is due to the dominant weather systems being generated in the Southern Ocean that force large and long range swells onto south-west and central Western Australia. Wave heights far in excess of average conditions, and northerly swells are expected during tropical cyclone events.

3.3 Biological Environment

The benthic habitats within the Operational Area are likely to comprise of a range of sands and gravels with infauna and epifauna are expected to be primarily comprised scavengers, detrital feeders and filter feeding organisms (Department of the Environment Heritage and the Arts, 2007).

Within the Operational Area there are no shorelines or other emergent features, however in the surrounding area, a range of benthic and shoreline environments are present. These include coral reefs, sandy coastline, rocky reefs, mangroves and macroalgae and seagrass beds. These habitats exist extensively throughout the mid-west region of Western Australia in the fringing areas of land masses, including many of the islands and shoals.

Notable marine and shoreline habitats exist at and around Dorre and Dirk Hartog Island, Shark Bay, the Abrolhos Islands and the Kalbarri and Geraldton region. These areas include sandy beaches that are known to support nesting turtles, and also some coral and rocky reefs. The Abrolhos Islands are also known to support a number of threatened marine species.

Using the online Protected Matters Search Tool (PMST), a search of the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) Protected Matters Database was undertaken for the Operational Area. This identified three threated cetaceans, four threated marine reptiles, three threated sharks and 12 threated birds that may occur within, or are relevant to the Operational Area (Table 3-1), and information provided following). A further 58 species listed as migratory and/or marine may occur within, or are relevant to the Operational Area (Table 3-2).

Two Key Ecological Features (KEFs), the Continental shelf habitats (upper, mid and lower) and the Commonwealth marine environment surrounding the Houtman Abrolhos Islands, lie within

the Operational Area. A further three KEFs occur in the region: Wallaby Saddle, Western demersal slope and associated fisheries, and the Western rock lobster fishery.

Table 3-1 Listed threatened species

Value/sensitivity		EPBC Act status			
Common Name	Scientific Name	Endangered	Vulnerable	Migratory	Marine
Marine Mammals					
Blue whale	*Balaenoptera musculus*	✓		✓	✓
Southern right whale	*Eubalaena australis*	✓		✓	✓
Humpback whale	*Megaptera novaeangliae*		✓	✓	✓
Marine Reptiles					
Loggerhead turtle	*Caretta caretta*	✓		✓	
Leatherback turtle	*Dermochelys coriacea*	✓		✓	
Green turtle	*Chelonia mydas*		✓	✓	
Flatback turtle	*Natator depressus*		✓	✓	
Sharks					
Whale shark	*Rhincodon typus*		✓	✓	
Grey nurse shark (west coast population)	*Carcharias taurus*		✓		
Great white shark	*Carcharodon carcharias*		✓	✓	
Marine Birds					
Amsterdam albatross	*Diomedea exulans amsterdamensis*	✓		✓	✓
Tristan albatross	*Diomedea exulans exulans*	✓		✓	✓
Southern giant-petrel	*Macronectes giganteus*	✓		✓	✓
Australian lesser noddy	*Anous tenuirostris melanops*		✓		✓
Wandering albatross	*Diomedea exulans (sensu lato)*		✓	✓	✓
Northern giant-petrel	*Macronectes halli*		✓	✓	✓
Soft-plumaged petrel	*Pterodroma mollis*		✓		✓
Indian yellow-nosed albatross	*Thalassarche carteri*		✓	✓	✓
Shy albatross	*Thalassarche cauta cauta*		✓	✓	✓
White-capped albatross	*Thalassarche cauta steadi*		✓	✓	✓
Black-browed albatross	*Thalassarche melanophris*		✓	✓	✓
Campbell albatross	*Thalassarche melanophris impavida*		✓	✓	✓

Threatened species relevant to the Operational Area

Blue whale

The blue whale consists of three sub-species – the southern blue whale (*Balaenoptera musculus intermedia*), pygmy blue whale (*Balaenoptera musculus brevicauda*) and northern blue whale (*Balaenoptera musculus musculus*; only found in the northern hemisphere) (Department of the Environment, 2014e). As the southern blue whale occurs south of 60 °S, and the pygmy blue whale occurs north of 55 °S, it is likely that only the pygmy blue whale potentially occurs within the Operational Area.

Blue whales typically feed as individuals or in small groups. In Australia, there are only two known feeding aggregations at Perth Canyon off the coast of southern Western Australia and the Bonney Upwelling, which runs along the coast of South Australia into Victoria.

Pygmy Blue Whales have been observed during the summer months in Western Australian waters (Bannister and Burton, 2000; Bannister, 1993; McCauley *et al.*, 2001), in particular within the Perth Canyon (22 km west of Rottnest Island). The species is frequently observed in this area swimming in large (0.5 - 1 km) circles with consistent dive patterns associated with foraging (Attard *et al.*, 2010). The canyon-like bathymetry and strong surface currents in the area may be favourable at times for the upwelling of cold, nutrient-rich water which may in turn support an abundance of prey organisms (McCauley *et al.*, 2001)

The Activity will coincide both spatially and temporally with blue whale migration. The existing migration route for blue whales overlaps with the shallower portions of the Operational Area; the migratory pathway of blue whales is known to occur within 100 km of the coastline (Double *et al*., 2014). The north and south bound pygmy blue whale migrations have been observed from noise loggers and satellite tracking information. Data indicate that pygmy blue whales move along the shelf break, in deep water along the 500 m to 1,000 m depth contour on the edge of the slope (Woodside, 2012). Within Western Australian waters, migration periods for this whale are between April to July (north) and October to January (south).

The migratory route is extensive and whales transit this area to access breeding waters. Recent satellite tracking of this species during its annual migration detected this species transiting through the Operational Area during cooler months of the year (between April and July) to reach the breeding waters to the north by summer months (Double *et al*., 2014). While satellite tracking of individuals did not record the return migration for all animals tagged, one animal was tracked for a period of 145 days and was detected in Indonesian waters during September and in southern Australian waters in December (Double *et al.,* 2014). Transit distances (swim speeds) varied for the tagged animals during the monitored migration period, however, tagged animals travelled approximately 50 to 75 km per day.

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The Activity will coincide both spatially and temporally with blue whale migration. The existing migration route for blue whales overlaps with the shallower portions of the Operational Area. The Operational Area is not considered to be a confined migratory route for the pygmy blue whale. The Operational Area is not located in breeding, calving or resting areas, or in a confined feeding area. The area is used for transitory migration. As such, the Operational Area is not considered to be a biologically important habitat for this species (as defined by the EPBC Act Policy Statement 2.1).

Southern right whale

Southern right whales (*Eubalaena australis*) are large whales that are known to occur on a seasonal basis within the coastal waters of Australia (Bannister *et al.*, 1996). Major calving areas are generally restricted to coastal, inshore waters off the southern coastline of Western Australia (east of Albany), South Australia and Victoria (Department of the Environment, 2014f). No specific feeding areas are known for southern right whales, as they generally depend on variable prey distribution and abundance and will migrate according to prey location (Baumgartner *et al.*, 2006; Best and Schell, 1996).

Although the species is known from nearshore coastal waters in Australia, it is possible for this species to be in the proximity of the Activity. However, given that major calving areas and aggregations occur in Western Australia in proximity to the Great Australian Bight, southern right whales are unlikely to be present in high numbers within the Operational Area.

Humpback whale

The humpback whale (*Megaptera novaeangliae*) is a moderately sized baleen-bearing whale well known for its annual migrations. Along the Australian coastline humpback whales have a number of key calving, migration and resting areas. Feeding occurs primarily in the colder waters south of 55 °S, with krill forming the majority of diet (Department of the Environment, 2014i).

Along the coast of Western Australia, migration pathways occur through Geraldton/Abrolhos Islands and Point Cloats to North West Cape, with known resting areas in Exmouth Gulf, Shark Bay, Geographe Bay, and waters adjacent to the Houtman Abrolhos Islands (Department of the Environment, 2014i). Additionally, surveys have demonstrated that along the Western Australian coastline, humpback whales primarily occur within 30 km of the coastline around Shark Bay and Exmouth (Jenner *et al.*, 2001).

Given their migration pathways and resting areas overlap with the Operational Area and MGO spill AMBA, it is possible that the species may occur within the proposed Activity. However peak migration period (July – October) proceeds the activity.

Loggerhead turtle

The loggerhead turtle (*Caretta caretta*) is a widely distributed marine reptile, occurring throughout Australian coastal and offshore zones, including warm temperate areas to tropical areas (Department of the Environment, 2014k). Nesting sites for the species occur throughout northern Australia from southern Queensland through to Shark Bay in WA (Limpus, 2008a). The loggerhead turtle inhabits coral reefs, rocky reefs, seagrass beds and inshore embayments like Shark Bay. The species also faces a number of threats, including commercial fishing bycatch, boat strike, marine debris, indigenous harvest, feral animal predation and degradation of nesting beaches.

Within Western Australia, nesting occurs from Shark Bay to the North West Cape. Although the species is known to occur in offshore areas, the species largely occurs within coastal waters, particularly in association with coral or rocky reefs. Therefore, interactions with this species in the Operational Area are not likely.

Leatherback turtle

The leatherback turtle (*Dermochelys coriacea*) is circum-globally distributed in warm temperate seas to tropical seas, occurring in open ocean basins. It is the largest known marine turtle, reaching 1.6 m in curved carapace length (Department of the Environment, 2014l). No major nesting has been recorded in Australia, however isolated nesting (1 -3 nests per annum) occurs in central-Queensland and the Northern Territory (Department of the Environment, 2014l). Few

records exist of the species within Western Australia, but it is known from offshore waters along the Perth to Geraldton coastline (Limpus, 2009). Throughout its range, the species faces similar threats as other marine turtles, including contact with commercial fishing gear as bycatch, ingestion of plastics, boat strikes and degradation of nesting beaches.

Leatherback turtles spend the majority of their lives in pelagic waters, as such, it is possible that interactions with this species will occur within the Operational Area. However, given the leatherback turtle's low abundance and lack of records from Western Australia, such interactions are likely to be infrequent.

Green turtle

The green turtle (*Chelonia mydas*) is found throughout Australian coastal warm temperate to tropical seas. Western Australia has an estimated 20,000 individuals within its waters, which is among the largest population in the Indian Ocean (Limpus, 2008b). Juveniles of the species are predominantly carnivorous and become herbivorous upon adulthood (Limpus, 2008b). Nesting occurs throughout northern Australia from central Queensland waters through to Exmouth. Following hatching, neonate and juvenile turtles remain in pelagic and offshore waters drifting on ocean currents until they reach approximately 30 to 40 cm carapace length (Department of the Environment, 2014m). Migrations between feeding and nesting grounds can cover distances greater than 2,600 km (Department of the Environment, 2014m).

Given the adult's diet and habitat preferences, mature specimens are commonly encountered in seagrass beds and in proximity to macroalgal benthic habitats. The species has undergone population decline due to degradation of nesting beaches, boat strikes, marine debris, and contact with fishing gear (Department of the Environment, 2014m).

Within Western Australia, known nesting locations are occur in the Dampier Archipelago, Lacepede Islands, Ningaloo and Jurabi Coasts, Serrurier Island, Thevenard, Barrow, Lowendal and Montebello Island, Northwest Cape, Exmouth Gulf and Muiron Islands (Department of the Environment, 2014m). Of these areas, the Lacepede Islands, near Broome have been identified as critical nesting and internesting areas, supporting the largest known population of the species in Western Australia.

As the species is found along the majority of the Western Australian coastline, and the hatchlings and juveniles are found in offshore waters, the species would be likely to occur within the Operational Area.

Flatback turtle

The flatback turtle (*Natator depressus*) has a restricted distribution in Australia between central and northern Western Australia and Queensland's central east coast (Department of the Environment, 2014n). The species feeds primarily on soft corals, holothurians, and jellyfish (Limpus, 2007) Within Western Australia, nesting beaches are known from north of Shark Bay (Limpus, 2007). Throughout its range, the flatback turtle faces threats including contact with fishing gear as bycatch, boat strike, urbanisation and degradation of nesting beaches.

Within Western Australian waters, the species has important nesting areas within the Kimberley region, Cape Dommett, Lacrosse Island and along the coastal waters of the Northwest Shelf (Department of the Environment, 2014n). Unlike other turtles, the species tends to occur primarily within the continental shelf.

This species is likely to occur along inshore regions of the Operational Area.

Grey nurse shark (west coast population)

The grey nurse shark (*Carcharias taurus*) is a large (up to 3 m in length) bodied shark from the family Odontaspididae. Although the species is distributed throughout Australian coastal waters, the largest populations come from sub-tropical and temperate areas along eastern and western Australia (Last and Stevens, 2009). The life history of the grey nurse shark makes it particularly susceptible to population decline. For example, the species exhibits a reproductive cycle known as oophagy, where a single pup is born from each uterus following *in utero* cannabilism of siblings. This reproductive strategy results in an extremely low fecundity. Additionally, with a gestation of between 9 to 12 months, the productivity of the species is considered to be extremely low (Last and Stevens, 2009).

From an ecological perspective the grey nurse shark is susceptible to localised depletion (Bansemer and Bennett, 2008). Within Western Australian waters, they are known from southern waters through to waters in proximity to Port Headland.

Although this species is known to occur in offshore waters, it is more commonly encountered in coastal waters particularly around rocky outcrops. As such, it is unlikely to be encountered within the Operational Area.

Great white shark

The great white shark (*Carcharodon carcharias*) is a large bodied shark (up to 6 m in length) within the family Lamnidae and is currently listed as vulnerable under the EPBC Act (Department of the Environment, 2014o). Like many other large bodied shark species, the great white shark is susceptible to population decline due its life history traits of slow growth, late maturation and low fecundity (Last and Stevens, 2009). The great white shark is distributed predominantly throughout temperate Australia, with individuals known to migrate into sub-tropical and tropical waters (Bruce *et al.*, 2006).

The species is known to occur along the entire Western Australian coastline, particularly in central and southern waters. Tracking studies indicate that the species undertakes large scale migrations, including within offshore and pelagic waters (Bruce *et al.*, 2006).

Given the species occurs along the length of the Western Australian coastline, and undertakes pelagic and offshore movements, it is likely to occur within the Operational Area.

Whale shark

The whale shark (*Rhincodon typus*) is the largest fish species worldwide and grows to approximately 15 m length. The species inhabits coastal areas, the pelagic zone and open ocean basins (Department of the Environment, 2014p). Due to its body size and solitary nature, little is known of the species biology. However, the species is thought to have high fecundity, producing up to 300 pups which are born at 40 – 50 cm (Last and Stevens, 2009). Although heavily fished in parts of its worldwide distribution, within Australia the species does not form a component of any targeted fishery.

The species is known to occur in Western Australia; with one of the more well-known aggregation sites is located at Ningaloo Reef. Tracking studies indicated that a small number of the Western Australian population migrate through the northwest region into the Indian Ocean (Wilson *et al.*, 2006).

As the species undertakes pelagic movements, it is possible that it will occur in close proximity to the Operational Area. However, interactions are likely to be infrequent due to the species predominant distribution to the north of the Operational area.

Amsterdam albatross

The Amsterdam albatross (*Diomedea exulans amsterdamensis*) is a non-resident visitor to Australia and may occur in south-west and southern Australian waters (Department of the Environment, 2014t). The species is a marine seabird which forages in open water and sleeps and rests on ocean waters when not breeding (Marchant and Higgins, 1990).The number of visiting albatross to Australian waters is unknown. However, given that the total global population is estimated at 130 individuals, migration numbers are likely to be extremely low.

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Tristan albatross

The Tristan albatross (*Diomedea exulans exulans*) is a large albatross with a 3.5 m wingspan. The majority of breeding takes place on Gough Island (several pairs bred on Inaccessible Island), off the coast of South Africa in the South Atlantic Ocean. Breeding is bi-annual, and occurs in colonies of several thousand birds (Marchant and Higgins, 1990). Fledging occurs in January and February (Swales, 1965). The foraging grounds of this species are off the Cape of Good Hope in the Atlantic Ocean (Department of the Environment, 2014u).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Southern giant-petrel

The southern giant-petrel (*Macronectes giganteus*) is the largest petrel, and is an aggressive scavenger and successful predator. It is associated with penguin and seal colonies, which provide an abundant food resource for the southern giant-petrel (Department of the Environment, 2014v). However, it is generally found in low densities across Antarctic waters in summer, and is thought to move to areas north of 50°S in winter (Department of the Environment, 2014v). This species is widespread, but the population is in rapid decline, with an estimated reduction of 20 percent since 1985 (Patterson *et al.*, 2008).

The southern giant-petrel breeds on several islands in the Southern Ocean (Heard Island, Macquarie Island and McDonald Island) and Australian Antarctic Territory (specifically, Giganteus Island, Frazier Island and Hawker Island) (among others) (Department of the Environment and Water Resources, 2006; Patterson *et al.*, 2008). Colonies of the species are formed on open sloping areas along the coast, often near steep descents (Department of the Environment, 2014v). Breeding occurs annually, with laying commencing in September. Nests are generally simple and constructed from vegetation, small stones and small bones (Department of the Environment, 2014v).

The species would have limited impacts from the project as it would fly over and not be directly affected by a moving vessel through the Operational Area.

Australian lesser noddy

The Australian Lesser Noddy (*Anous tenuirostris melanops*) is an Australian endemic and is typically only encountered in and around its breeding islands in the Abrolhos Islands of Western Australia (Storr *et al.*, 1986). The species roosts in white mangroves which densely fringe the shoreline of coral-limestone islands (Department of the Environment, 2014r). They are thought to be mainly sedentary and reside near their breeding islands, but may leave for short periods to forage at sea (Higgins and Davies, 1996).

The Abrolhos Islands lie approximately 200 km south east of the Operational Area; the species would have limited impacts from the project as it would fly over and not be directly affected by a moving vessel through the Operational Area.

Wandering albatross

Wandering albatross (*Diomedea exulans* (*sensu lato*)) are well-known for their long wingspan (up to 3.5 m) and extensive circumpolar migrations (Department of the Environment, 2014w; Imber, 1992). This species undertakes shallow dives and surface-snatching to capture prey predominately comprising fish, squid, crustaceans and carrion (Clarke *et al.*, 1981; Marchant and Higgins, 1990). Breeding areas are confined to Antarctic and sub-Antarctic islands in the Atlantic Ocean, Indian Ocean and waters off the southern coast of New Zealand (Marchant and Higgins, 1990). Breeding sites are often on marshy areas, but are generally located on ridges, slopes or hills. Nests are formed on moss terraces amongst tussock grasses, although vegetation must be open to allow access by adult birds (Marchant and Higgins, 1990; Warham and Bell, 1979). Juveniles migrate from their natal grounds to the subtropical Indian Ocean and Tasman Sea (Weimerskirch *et al.*, 2006). Adults undertake circumpolar migrations east (Marchant and Higgins, 1990). However, there are a number of wandering albatross that migrate during the non-breeding season to the coastal waters off Wollongong (Nicholls and Robertson, 2007).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Northern giant-petrel

The northern giant-petrel (*Macronectes halli*) is a large petrel with a wingspan of up to 2.1 m (Department of the Environment, 2014y). Breeding starts in August in sub-Antarctic islands and in South Georgia, where the species builds cup-shaped nests in sheltered areas of heavy vegetation or rough terrain (Marchant and Higgins, 1990). This species is a scavenger and hunter, and feeds mostly on carrion, seal placentae, crustaceans, cephalopods, fish and other seabirds (Marchant and Higgins, 1990). Adult northern giant-petrels generally remain close to breeding areas year-round; however, juveniles undertake long dispersal events, although these movements are not well-understood (Marchant and Higgins, 1990).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Soft plumaged petrel

The soft-plumaged petrel (*Pterodroma mollisis*) a marine bird found over both temperate and sub-Antarctic waters (Department of the Environment, 2014aa). The population in Australia is currently unknown. Its diet is believed to consist of cephalopods, some fish and crustaceans captured through surface-seizing (Department of the Environment, 2014aa). Breeding is believed to take place on southern Australian islands and there is a general northerly dispersion after chicks fledge during May to June.

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Indian yellow nosed albatross

The Indian yellow-nosed albatross (*Thalassarche chlororhynchos bassi*) forages mostly in the southern Indian Ocean particularly off the southern Western Australian coastline (Department of the Environment, 2014ac). The species has been observed over waters of surface temperatures ranging from 10-23°C but is more abundant over warm waters, particularly over coastal

upwellings and continental shelves. During the non-breeding period, the albatross migrates north of 37°S whilst some adults escorting young move further east of WA and may transit through the area.

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Shy albatross

The shy albatross (*Thalassarche cauta cauta*) is described as being the largest black-backed albatross with a wingspan of up to 2.56 m (Department of the Environment, 2014ad; Marchant and Higgins, 1990). This species occurs in Australian waters below 25°S, but is most frequently observed off south-east Australia and Tasmania (Brothers *et al.*, 1997; Hedd *et al.*, 2001). Shy albatross are less oceanic than most species, and are described as being more frequent inshore than offshore (Marchant and Higgins, 1990).

Breeding areas are in the Bass Strait and off southern Tasmania (Marchant and Higgins, 1990). The shy albatross breeds annually, with the breeding season lasting from September to April. It appears that the dispersal of juveniles from the natal site is variable, with fledglings moving to different areas, but includes southern Western Australia (Department of the Environment, 2014ad; Marchant and Higgins, 1990). While the shy albatross is described as being endemic to Australia, and known to be sedentary, it does undertake migrations throughout the southern oceans, from Africa through to South America (Marchant and Higgins, 1990).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

White-capped albatross

The white-capped albatross (*Thalassarche cauta steadi*) is thought to be common off the coast of southeast Australia (Department of the Environment, 2014ae), and is generally the most abundant albatross off the New Zealand shelf (Department of the Environment, 2014ae). However, juveniles are rarely observed in this area, and are more common off the coast of South Africa and south-east Australia (Marchant and Higgins, 1990). Breeding takes place on vegetated slopes in the Auckland Islands off the south coast of New Zealand (Marchant and Higgins, 1990). Little is known of the breeding biology or migration patterns of this species (Department of the Environment, 2014ae).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Black-browed albatross

The black-browed albatross (*Thalassarche melanophris*) is a pelagic, gregarious albatross that occurs throughout Antarctic, sub-Antarctic and sub-tropical waters (Marchant and Higgins, 1990). Breeding occurs on sub-Antarctic and Antarctic islands on rocky islets or vegetated shelves of cliffs or slopes (Marchant and Higgins, 1990). This species nests in columns and pedestals of grass, with laying commencing in October (Department of the Environment, 2014af). Diet consists mostly of fish, cephalopods and krill, which it captures by snatching from beneath the water surface, or through short dives (Marchant and Higgins, 1990). The black-browed albatross migrates to the continental shelves of South America, South Africa, New Zealand and Australia during the winter months (Marchant and Higgins, 1990).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Campbell albatross

Campbell albatross (*Thalassarche melanophris impavida*) are a sub-species of the black-browed albatross (Department of the Environment, 2014ag). The Campbell albatross does not breed in Australian waters, but is known to forage over the continental shelf off NSW, Victoria and Tasmania (Department of the Environment, 2014ag). Migration to these areas is thought to occur after the breeding season (Marchant and Higgins, 1990). The only known breeding area for this species is Campbell Island, off the southern coast of New Zealand (Department of the Environment, 2014ag; Marchant and Higgins, 1990). Breeding is annual, and commences in late August, with laying starting in late September (Department of the Environment, 2014ag).

The species would have limited impacts from the project as it would fly over and not be directly affected by a vessel moving through or any seismic works within the Operational Area.

Table 3-2 Listed migratory and/or marine species

Value/sensitivity Common Name	Scientific Name	EPBC Act status Migratory	Marine
Marine Mammals			
Minke whale	*Balaenoptera acutorostrata*		✓
Antarctic Minke whale	*Balaenoptera bonaerensis*	✓	✓
Bryde's whale	*Balaenoptera edeni*	✓	✓
Common dolphin	*Delphinus delphis*		✓
Pygmy Killer whale	*Feresa attenuata*		✓
Short-finned Pilot whale	*Globicephala macrorhynchus*		✓
Long-finned Pilot whale	*Globicephala melas*		✓
Risso's dolphin	*Grampus griseus*		✓
Pygmy Sperm whale	*Kogia breviceps*		✓
Dwarf Sperm whale	*Kogia simus*		✓
Fraser's dolphin	*Lagenodelphis hosei*		✓
Dusky dolphin	*Lagenorhynchus obscurus*	✓	✓
Blainville's beaked whale	*Mesoplodon densirostris*		✓
Gray's Beaked Whale	*Mesoplodon grayi*		✓
Killer whale	*Orcinus orca*	✓	✓
Melon-headed whale	*Peponocephala electra*		✓
Sperm whale	*Physeter macrocephalus*	✓	✓
False killer whale	*Pseudorca crassidens*		✓
Spotted Dolphin	*Stenella attenuata*		✓
Striped Dolphin	*Stenella coeruleoalba*		✓
Long-snouted Spinner Dolphin	*Stenella longirostris*		✓
Rough-toothed Dolphin	*Steno bredanensis*		✓
Bottlenose Dolphin	*Tursiops truncatus s. str*		✓
Cuvier's Beaked Whale	*Ziphius cavirostris*		✓
Marine Reptiles			
Olive seasnake	*Aipysurus laevis*		✓
Shark bay seasnake	*Aipysurus pooleorum*		✓
Spectacled seasnake	*Disteira kingii*		✓
Olive-headed seasnake	*Disteira major*		✓
North-western Mangrove seasnake	*Ephalophis greyi*		✓
Yellow-bellied seasnake	*Pelamis platurus*		✓

Value/sensitivity Common Name	Scientific Name	EPBC Act status Migratory	Marine
Sharks			
Shortfin mako	*Isurus oxyrinchus*	✓	✓
Longfin mako	*Isurus paucus*	✓	✓
Porbeagle	*Lamna nasus*	✓	✓
Giant manta ray	*Manta birostris*	✓	✓
Birds			
Great skua	*Catharacta skua*	✓	✓
Osprey	*Pandion haliaetus*		✓
Grey plover	*Pluvialis squatarola*	✓	✓
Great-winged petrel	*Pterodroma macroptera*		✓
Little Shearwater	*Puffinus assimilis*		✓
Fleshy-footed shearwater	*Puffinus carneipes*	✓	✓
Bridled tern	*Sterna anaethetus*	✓	✓
Sooty tern	*Sterna fuscata*		✓
Fish			
Gale's pipefish	*Campichthys galei*		✓
Pig-snouted pipefish	*Choeroichthys suillus*		✓
Ladder pipefish	*Festucalex scalaris*		✓
Tiger pipefish	*Filicampus tigris*		✓
Brock's pipefish	*Halicampus brocki*		✓
Ribboned pipefish	*Haliichthys taeniophorus*		✓
Western spiny seahorse	*Hippocampus angustus*		✓
Spiny seahorse	*Hippocampus histrix*		✓
Flat-face seahorse	*Hippocampus planifrons*		✓
Prophet's pipefish	*Lissocampus fatiloquus*		✓
Bonyhead pipefish	*Nannocampus subosseus*		✓
Gunther's pipehorse	*Solegnathus lettiensis*		✓
Robust ghostpipefish	*Solenostomus cyanopterus*		✓
Rough-snout ghost pipefish	*Solenostomus paegnius*		✓
Spotted pipefish	*Stigmatopora argus*		✓
Widebody pipefish	*Stigmatopora nigra*		✓
Double-ended Pipehorse	*Syngnathoides biaculeatus*		✓
Bentstick Pipefish	*Trachyrhamphus bicoarctatus*		✓

3.4 Socio-economic Environment

3.4.1 Commercial Fisheries

There are four Commonwealth managed commercial fisheries with licences to operate within or in the vicinity of Operational Area. These include:

- Western Skipjack Tuna Fishery
- Western Deep-water Trawl
- Western Tuna and Billfish Fishery
- Southern Bluefin Tuna Fishery

WA State Fisheries

There are three State managed commercial fisheries with licences to operate within or in the vicinity of Operational Area. These include:

- Charter boat fishing activities
- Gascoyne Demersal Scalefish Managed Fishery
- West Coast Deep Sea Crustacean Managed Fishery

3.4.2 Tourism

Tourism activities have not been identified to occur within the Operational Area. A number of marine-based tourism operations occur in the surrounding region. These include boating, diving and fishing near the coast and islands off of the western shoreline of Shark Bay through to Geraldton and the Abrolhos Islands (Figure 2-1).

3.4.3 Oil and Gas Industry

The Operational Area is not located in proximity to any mapped offshore wells; the closest wells are located greater than 50 km to the southeast of the Operational Area (Figure 2-1).

3.4.4 Commercial Shipping

There are recognised shipping fairways off the southern and central Western Australia coastline; however none of the fairways intersect the Operational Area. Stakeholder consultation with the Australian Marine Safety Authority identified that shipping outside these fairways occurs, and that heavy traffic is likely to be encountered across the Operational Area.

3.4.5 Cultural Heritage

The HMAS Sydney II and HSK Kormoran shipwreck sites lie within the Operational Area. In the surrounding region the western shoreline of Shark Bay has been identified as an area of cultural heritage.

3.4.6 Defence

There are no defence areas within the Operational Area.

3.4.7 Commonwealth and State Marine Parks and Reserves

The Operational Area does not lie within or immediately adjacent to any Commonwealth or State marine park or reserve. Nearby Commonwealth marine reserves include that at the Abrolhos Islands and Shark Bay. Shark Bay Marine Park is the nearest State marine park.

3.5 Environmentally sensitive windows

Sensitive time windows for key (including threatened) ecological and socio-economic sensitive receptors within the spill AMBA that exhibit seasonality are summarised Table 3-3. Some species have not been included due to lack of conclusive life cycle or migratory information.

Table 3-3 Summary of activity windows for ecological and socio-economic sensitivities

Receptor	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ecological												
Humpback whale (Department of the Environment, 2014a)							From S to N		From N to S			
Blue whale (Woodside, 2012)				From S to N						From N to S		
Southern Right Whale (Bannister *et al.*, 1996)					From S to N			From N to S				
Sharks and rays (Last and Stevens, 2009), (Bruce *et al.*, 2006), (Wilson *et al.*, 2006)												
Sea snakes (Department of the Environment, 2014aq, 2014ar, 2014as)												
Loggerhead turtle[1] (Department of the Environment, 2014d)												Nesting
Leatherback turtle[2] (Department of the Environment, 2014e)												
Green turtle[1] (Department of the Environment, 2014f)												Nesting
Flatback turtle[1] (Department of the Environment, 2014g)												Nesting
Seabirds (Department of the Environment, 2014q, 2014r, 2014s, 2014t, 2014u, 2014v)												
Socio-economic												
Commercial Fisheries (Commonwealth) (Australian Fisheries Management Authority, 2014)	-Skipjack Tuna Fisheries -Southern Bluefin Tuna						-Western Deepwater Trawl Fishery -Western Tuna and Billfish Fishery					
Commercial Fisheries (State) (Information provided by Department of Fisheries during stakeholder consultation)	-Abalone managed fishery -Beche de mer (sea cucumber) fishery -Charter boat fishing activities -Gascoyne demersal scalefish managed fishery -Mackerel managed fishery -Marine aquarium fish managed fishery						-Shark bay prawn limited entry fishery. -Shark bay scallop limited entry fishery. -Specimen shell managed fishery -West Coast deep sea crustacean managed fishery -West Coast rock lobster managed fishery					
Oil and gas activity												
Shipping activity												
Tourism/ recreational fishing												

Colour code

Colour	Activity
	Peak activity, presence reliable and predictable
	Lower level of abundance/activity/presence
	Activity/sensitivity can occur throughout the year
	Activity/sensitivity not occurring
1	Turtle hatchlings emerge ~ 60 days after nesting
2	No breeding/nesting activity recorded in WA

4. Stakeholder Consultation

GA's stakeholder consultation strategy has been based around the establishment of long-term and meaningful dialogue with those stakeholders who have an interest in the Operational Area.

GA has developed and implemented a stakeholder consultation strategy in line with NOPSEMA's requirements, contacting identified relevant authorities, persons and organisations to inform the preparation of the EP and Oil Pollution Emergency Plan (OPEP). To achieve this, GA clearly articulates engagement and consultation standards, goals, and mechanisms, seeks to effectively manage change during the life of its projects and activities, and strives to continuously improve all aspects of its stakeholder engagement processes.

Initial consultation occurred between late 2013 and early 2014. All correspondence with external stakeholders was recorded (refer Table 4-1); no major concerns were raised by stakeholders.

GA will remain available before, during and after completion of the Activity. Any concerns not previously addressed will be listed against contact details for the relevant project personnel and consultation material provided to relevant personnel.

GA considers that consultation with regulators and key stakeholders has been adequate; GA have been active in trying to engage all stakeholders and relevant in regard to the Activity. GA has detailed communication procedures for the proposed Activity and will maintain two-way communications with stakeholders regarding the Activity and all current or proposed activities.

Table 4-1 Summary of stakeholder consultation information

Stakeholder	Summary of Response	Assessment of Merits of Adverse Claim/Objection including responses to each and ongoing communications
Activity Administrator		
National Offshore Petroleum Titles Authority (NOPTA)	Email response (31/10/2013): Recommendation that GA should apply for a Greenhouse Gas Research Consent for proposed survey.	GA has submitted an application for a Greenhouse Gas Research Consent.
Regulator		
The Department of the Environment	Meeting (17/08/2013) DoE noted that GA should consider Key Ecological Features and whale activity in the area when planning survey timing and location.	Information has been incorporated into the EP. The survey occurs >70 km from nearest World Heritage Area and does not intersect any Commonwealth Marine Reserves.
	Acknowledgement received (17/1/2014) of submission of permits to enter exclusion zones for two shipwrecks located in the Operational Area.	Information has been incorporated into the EP.
Government agencies		
WA Department of Fisheries	Response (22/1/2014) noting Commercial fisheries possibly intersecting area and requesting consultation, assessment and mitigation measures to be included in EP for Seismic during spawning/aggregation times, and requesting, biosecurity information be communicated directly to vessel operator.	Information has been incorporated into the EP; biosecurity information has been communicated to the vessel operator.
WA Department of Finance – Public Utilities Office	No response	Not applicable
WA Department of Mines and Petroleum	Response (20/1/2014) noting that as the survey is in commonwealth waters they have no comment, but request to be kept informed of the final location and timing of the survey so they can brief the Minister.	GA will provide survey details prior to mobilisation.
WA Department of Parks and Wildlife	No response	Not applicable
WA Department of Premier and Cabinet	Response (10/2/2014) requesting advice on which other State Government Departments had been consulted but otherwise no comment.	List of State Government stakeholders provided by GA (10/2/2014)

Stakeholder	Summary of Response	Assessment of Merits of Adverse Claim/Objection including responses to each and ongoing communications
WA Environment Protection Authority	Phone call response (7/1/2014) noting they would only become involved in assessing the activity if a proposal was referred by the DMP, but this was unlikely unless the area was modified to include state waters.	Information noted.
WA Department of Transport	Response (17/1/2014) requesting updated information on final survey location and timing when this becomes available. They request that information also be provided to regional office and navigational safety contacts. As the survey occurs in Commonwealth waters, the Department notices will be issued by the AHS.	GA will provide survey details prior to mobilisation.
Commercial fisheries		
Australian Fisheries Management Authority (AFMA)	Email Response (24/1/2014): AFMA advised that in recent years fishing effort has been minimal in the proposed survey area but recommended comprehensive engagement with the fishing industry.	Refer following for information regarding fishing industry consultation.
Australian Marine Safety Authority (AMSA)	Email Response (24/01/2014) noting that a major traffic route runs through the South east end of the survey area, and heavy traffic is likely to be encountered across much of the survey area. AMSA recommends that the Master of the survey vessel/s report all survey activities and movements to AMSA's Rescue Coordination Centre (RCC) to ensure navigation warning are issued and up to date. AMSA request GA to engage with the AHS to allow appropriate warning and notification to be issued to other vessels using the area.	Information has been incorporated into the EP.
Australian Southern Bluefin Tuna Industry Association	Initial email bounced from address. No response to second email.	Not applicable
A. Raptis and Sons	No response	Not applicable
Austral Fisheries	No response	Not applicable
Commonwealth Fisheries Association	No response	Not applicable
Dongara professional	No response	Not applicable

Stakeholder	Summary of Response	Assessment of Merits of Adverse Claim/Objection including responses to each and ongoing communications
Fishermen's Association		
Geraldton professional fishermen's association	No response	Not applicable
Geraldton fishermen's co-operative	No response	Not applicable
Jamaclan Marine Services	No response	Not applicable
Kimberley Professional Fishermen's Association	No response	Not applicable
Northern Fishing Companies Association	No response from WAFIC	Not applicable
Northern Wildcatch Seafood Australia	No response	Not applicable
TunaWest	No response from WAFIC	Not applicable
Western Australian Fishing Industry Council	Meeting (27/2/2014): WAFIC noted minimal fishing activity expected in such deep water but agreed to provide feedback on GA's list of potentially affected fisheries and individual contacts.	Lists of fisheries and contacts provided to WAFIC on 3/3/2014 and 5/3/2014.
Western Australian Northern Trawl Owners Association	No response	Not applicable
Westmore Seafoods	No response	Not applicable
Recreational fisheries		
Recfishwest	No response	Not applicable
Western Australian Game Fishing Association/ Broome Fishing Club	Response email (24/1/2014) proposed activity does not coincide with members' fishing areas.	Information has been incorporated into the EP.
Shipping and Safety		

Stakeholder	Summary of Response	Assessment of Merits of Adverse Claim/Objection including responses to each and ongoing communications
Australian Customs and Border Protection Service	Email response (2201/2014) confirming no issues with the proposed activity and requesting GA communicate restrictions on access to the area >14 days prior to survey.	Information has been incorporated into the EP.
Department of Defence – Defence Support and Reform Group	Response (05/02/2014): Noting no planned activities in the area.	Information has been incorporated into the EP.
Research Institutions		
Australian Institute of Marine Science (AIMS)	Response email (23/1/2014) noting receipt of information and forwarding to the appropriate operational contacts for offshore activities.	Information noted.
Centre for Whale Research	No response	Not applicable
Curtin University	No response	Not applicable
Communication		
Australian Communications and Media Authority	Not Applicable	Not applicable
Australian Hydrographic Service (AHS)	Email outlining that AHS will issue a notice to mariners once final survey dates have been finalised.	Information has been incorporated into the EP; GA will provide survey details prior to mobilisation.
Department of Broadband Communication and the Digital Economy (DBCDE)	Email Response (03/03/2014): noting proposed cables and recommending GA contact Telstra (refer to records below).	Information noted.
Telstra	Email Response (14/03/2014) confirming cables area outside acquisition area and Telstra have no concerns with the proposed survey.	Information noted.
Heritage		
National Native Title Tribunal (NNTT)	Email Response (21/01/2014): No relevant Native Title claims in the research area	Information has been incorporated into the EP.
Oil and Gas proponents		
APPEA	No response	Not applicable

Stakeholder	Summary of Response	Assessment of Merits of Adverse Claim/Objection including responses to each and ongoing communications
Midwest Development Commission	No response	Not applicable
Murphy Australia Oil	No response	Not applicable
Total E&P Australia	Formal letter received indicating that Total was interested in exploring collaborative options to reduce data acquisition costs. Their proposed acquisition timeframe in WA-493-P is 2015. Formal letter received providing permission to acquire and release data from the permit area.	Information noted.
Hydrographic organisations		
CGG	CGG propose to acquire regional 2D data in the Houtman and request GA consider joining the multi-client survey.	Information noted.

5. Environmental Impacts and Risks Evaluation Methodology

The impact assessment of planned activities and assessment of risk of unplanned events are undertaken using similar processes. These processes are used to demonstrate that the adopted control measures reduce the environmental impacts and risks to ALARP and acceptable levels. The key steps used in these processes are provided following.

The severity of a potential impact was assessed according to the 'Definition of Consequence' shown in Table 5-1. A likelihood rating was allocated to the environmental hazard according to the categories given in the 'Definition of Likelihood' (Table 5-2). Environmental hazards were risk ranked using GA's risk ranking shown in Table 5-3. Each likelihood and consequence combination results in an environmental risk ranking; corresponding descriptions and responses are presented in Table 5-4. The risk ranking is indicative of the acceptability level based on the ALARP triangle shown in Figure 5-1.

Steps in the environmental impact assessment process of planned events

1. Environmental hazard identification: a process used to define and describe the hazard associated with the activity.
2. Impact analysis: assessment of potential environmental impacts to the values and sensitivities identified within the area that may be affected by the Activity.
3. Pre-treatment consequence ranking: subjectively ranks the level of 'inherent consequence' for each hazard without management controls in place.
4. Management control: describes the proposed control measures to reduce the level of impact to ALARP and acceptable.
5. Acceptability and ALARP demonstration: presents the available information to demonstrate that post-treatment environmental consequence will be of an acceptable level and that further controls would not substantially reduce the impact without being grossly disproportionate.
6. Post-treatment consequence ranking: subjectively ranks the post treatment consequence of the hazard with management controls in place.
7. Environmental impact and risk monitoring and review: provides ongoing assurance that control measures are adequate to maintain an acceptable and ALARP level of risk.
8. Environmental impact and risk communication and consultation: information gained from stakeholder consultation is incorporated into the impact assessment for each relevant hazard.

Steps in the environmental risk assessment process of unplanned events

1. Environmental hazard identification: a process used to define and describe the hazard associated with the activity.
2. Impact Analysis: assessment of potential environmental impacts to the values and sensitivities identified within an area that may be affected by the Activity.
3. Pre-treatment risk ranking: ranks the inherent risk level combining the likelihood of the hazard occurring and the potential consequence rating without management controls in place.

4. Management control: describes the proposed control measures to reduce the likelihood and/or the consequence of the hazard to ALARP and acceptable levels.
5. Acceptability and ALARP demonstration: presents the available information to demonstrate that post-treatment of risk of the hazard occurring and/or the subsequent environmental impact will be of an acceptable level and that further controls would not substantially reduce the impact or risk without being grossly disproportionate.
6. Post-treatment risk ranking: ranks the risk level combining the likelihood of the hazard occurring and the potential consequence rating with management controls in place.
7. Environmental impact and risk monitoring and review: provides ongoing assurance that control measures are adequate to maintain an acceptable and ALARP level of risk.
8. Environmental impact and risk communication and consultation: information gained from stakeholder consultation is incorporated into the impact assessment for each relevant hazard.

Table 5-1 Definition of consequence

Consequence	Description
5. Very Serious	Safety: Multiple Fatalities or significant irreversible effects to one or more people
	Environment: Very serious long-term environmental impairment of the ecosystem, significant recovery work over years/decades, Tier 3 Oil Spill (> 1,000 tonnes)
	Reputation: Extreme adverse public, political or media outcry resulting in international media coverage; critical impact on reputation
4. Serious	Safety: Single Fatality and/or severe irreversible disability to one or more people
	Environment: Serious medium term environmental effects, recovery work over a few months, Tier 2 oil spill (10 – 1,000 tonnes)
	Reputation: Significant impact on reputation and/or national media exposure; local community complaint
3. Moderate	Safety: Moderate irreversible disability or impairment to one or more persons. Significant Injury (Lost Time Injury (LTI) or Restricted Work Day Case (RWDC))
	Environment: Moderate environmental impact with recovery work over a few days/weeks, Tier 1 oil spill (< 10 tonnes), Impact/damage to item of National Environmental Significance (NES)
	Reputation: Serious local adverse public media attention or complaints; local user concern; moderate to small impact on reputation
2. Minor	Safety: Reversible disability requiring hospitalisation or Medical Treatment Injury
	Environment: Minor Impact on biological/physical environment, Negligible remedial/recovery work, <1BBl oil spill
	Reputation: Public awareness but no public concern beyond local users; Minor impact on reputation
1. Negligible	Safety: Slight Injury (First Aid Treatment)
	Environment: Negligible Impact, Effect contained locally
	Reputation: Negligible Impact on Reputation; no public or regulator interest

Table 5-2 Definition of likelihood

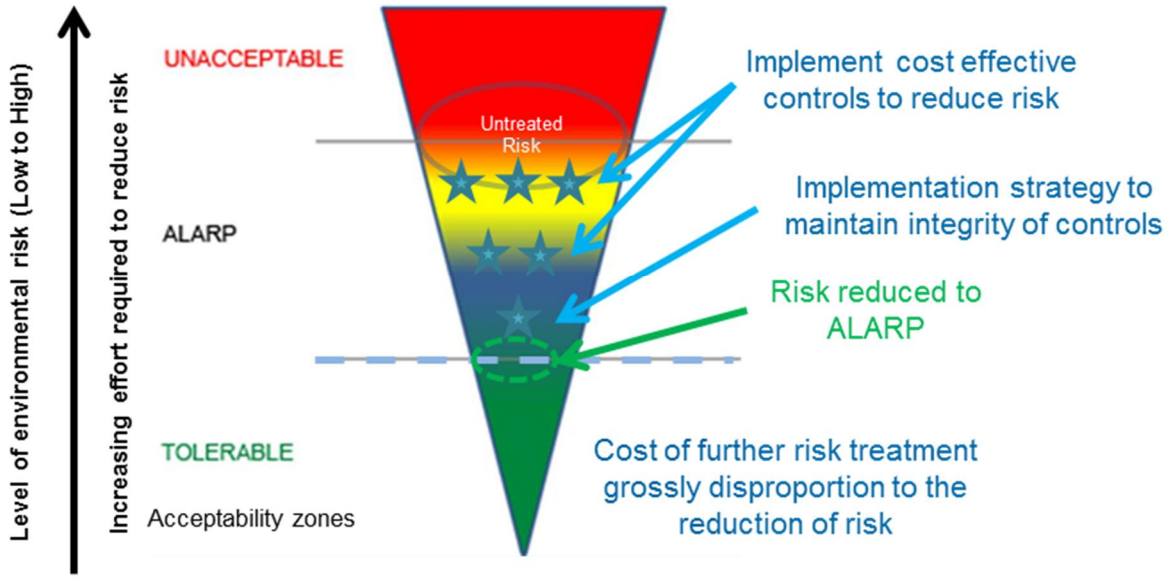
Consequence	Description
A. Very likely	Common occurrence in this type of industry
B. Probable	May occur in our business
C. Possible	Possibility of occurring. Has happened in similar businesses
D. Unlikely	Unlikely to occur. A rare event by standards of industry
E. Very Unlikely	Unlikely to happen here or elsewhere. Conceivable under extreme circumstances

Table 5-3 GA qualitative risk matrix

		Likelihood				
		A: Very Unlikely	B: Unlikely	C: Possible	D: Likely	E: Very Likely
Consequence	5. Very Serious					
	4. Serious					
	3. Moderate					
	2. Minor					
	1. Negligible					

Table 5-4 Definition of risk and management response

Category	Description and response
High	High Risk: Considered intolerable: Work cannot proceed as currently planned. Urgent remedy and resources required for immediate risk reduction.
Significant	Significant Risk: Undesirable. Upper management decision to accept or reject risk for the operation to continue.
Medium	Medium Risk: Risk reduction measures needed to be considered to reduce risks to a level which is as low as reasonably practicable. Generally acceptable level of risk where further risk reduction is not shown to be practicable.
Low	Low Risk: Risks are sufficiently low to be acceptable (i.e. at ALARP). Manage for continuous improvement by management.



Source: Image is based on concepts presented by NOPSEMA in N-04300-GN0166 Rev 4 (2012)

Figure 5-1 ALARP triangle diagram

6. Risk assessment of planned activities

6.1 Noise

6.1.1 Description of hazard

Noise	
Hazard	Noise generated by the *MV Duke* during steaming may result in physiological or behavioural impacts to marine fauna, especially to cetacean species that use sound for navigation and communication. Seismic survey of the seabed which forms the primary activity to be undertaken will also generate multiple pulses of high intensity noise which may impact on certain marine fauna species.
Extent	Localised around the vessel and seismic array, extending up to 3 km from the array for seismic influences.
Duration	Duration of the Activity for vessel steaming is 48 days slow steam (4.5 knots) and a total of eight days for transit.

Notes on noise emitting activities

Vessel steaming

Noise will be transferred into the marine environment as a result of vessel steaming. Noise will be generated by the propeller and diesel engines and can mask communication between animals within close proximity. For example, an underwater noise assessment in Townsville recorded that a vessel travelling at 7 kts, passing at a distance of 50 m, produces noise in the range of 100 - 140 dB re 1μPa@m (GHD, 2012). As the vessel will operate 24/7, it is expected that noise will be released into the marine environment for a minimum of 48 days during the survey and eight days in transit.

Seismic Survey

As described under Section 2 the proposed seismic survey activity will collect data from pre-planned seismic survey lines. As summarised in Table 6-1, a single airgun array will be used to generate noise pulses with sound levels at the source ranging from 237-262 dB re 1μPa@m. Most energy is expected to be within the 10-200 Hz range, with lower levels in the 100-200 Hz range. Species which utilise this auditory frequency range for communication are the low frequency cetaceans; the mysticete (baleen) whales, pinnipeds in water, and the mid frequency cetaceans including the odontocete dolphins and a number of species of larger toothed, beaked and bottlenose whales.

The produced energy level from the seismic array will decrease markedly with distance from the source. A number of different underwater noise assessments are informative for this study. These include studies completed in Townsville (GHD, 2012), and modelling studies completed by Woodside for drilling activities at Scott Reef, both of which inform the decay of noise energy from point source release (Woodside, 2008). The Woodside study identified that, in the horizontal plane, maximum sound pressures of 190 dB re 1 μPa/Hz in the 5–100 Hz range decreased to 160 dB re 1 μPa/Hz within 20 m of the source. These results are not dissimilar to different noise source releases measured in Townsville. As such, results indicate that a conservative estimated distance of 3 km is required to achieve background noise levels. Accordingly, a distance of 3 km is recommended as a relevant distance for this survey in light of potential influence to marine fauna sensitive to seismic operations.

Acoustic energy generated by the seismic array will be directed at the seabed and not directed horizontally. The cetaceans which may be influenced by this energy and sound pressure are medium frequency animals only.

The survey of both Priority 1 and 2 areas is predicted to take 48 days in total with survey operations conducted 24/7.

Table 6-1 Acoustic characteristics of proposed seismic survey

Survey Instrument	Frequency	Estimated Sound Pressure Levels at Source (dB re 1 µPa at 1 m)	Applicable Cetacean Types	Reference
Seismic gun array	10-200 Hz	237-262	Medium Frequency cetaceans Pinnipeds in water	Southall *et al.*, (2007)

6.1.2 Impact analysis

Potential receptors: Marine fauna including fish, cetaceans and marine reptiles.

The use of sound in the underwater environment is important for some marine fauna species (particularly cetaceans) to navigate, communicate and forage effectively. Underwater noise generated from anthropogenic sources may impact marine fauna by:

- Causing behavioural changes including displacement from biologically important habitat areas (such as breeding, feeding, calving and nursery sites)
- Masking or interfering with other biologically important sounds such as communication or echolocation systems used by certain cetaceans for location of prey and navigation
- Causing physical injury to hearing organs
- Indirectly impacting on predator or prey species, leading to impacts on trophic systems

The seismic survey activities and vessel steaming are expected to produce noise emissions which have the potential to impact upon cetaceans that may use the area or migrate through the area of survey. The extent of the impacts from underwater noise on marine fauna will depend upon the frequency range, duration and intensity of the noise produced and sensitivity of the animal affected.

Criteria for assessing impact from noise on cetaceans

The auditory and behavioural effects of anthropogenic marine noise on cetaceans have been extensively reviewed, with threshold criteria determined for the potential impact to marine mammals based upon sound exposure levels. It is acknowledged that the level of behavioural disturbance experienced will be dependent upon the noise source and the behaviour of the animal at the time of the disturbance. There are a number of growing studies examining the behavioural responses of cetaceans to different auditory disturbances (e.g. Finneran *et al.*, 2000, 2005; Lucke *et al.*, 2007; Popov *et al.*, 2013). However, the criteria proposed by Southall *et al*. (2007) currently remain applicable for assessing whether injury or temporary hearing loss may occur from a proposed activity. Those criteria are summarised in Table 6-2 for pulses of sound for the applicable cetacean species.

Table 6-2 Criteria for avoidance of Temporary and Permanent Threshold Shifts for cetaceans from Southall *et al.* (2007)

Impact	Unit of Measure	Multiple Pulses
Temporary Threshold Shift (TTS)	Sound Pressure Level (SPL) Re: 1 µPa (un-weighted Peak)	224 dB
	Sound Exposure Level (SEL) Re: 1 μPa^2-s (M-weighted)	183 dB
Permanent Threshold Shift (PTS)	SPL Re: 1 µPa (un-weighted Peak)	230 dB
	SEL Re: 1 μPa^2-s (M-weighted)	198 dB

Southall *et al.* (2007) reported that odontocetes have been shown to experience TTS onset at lower respective exposure levels if the sound is a pulse as opposed to a continuous sound. Accordingly, in an applied noise management context, TTS criteria are used in preference to PTS criteria to minimise the risk of irreversible auditory damage. As such, the criteria in Table 6-2 can then be simplified to an exposure guideline of 183 dB SEL RE: 1 μPa^2-s for accumulated sound energy, which is relevant to continuous pulse noise to be released from the seismic vessel.

Cetaceans

Baleen whales (e.g. humpbacks, blue, and minke) communicate using low frequency sounds and are therefore considered to be the most sensitive of the cetaceans to anthropogenic sources of low frequency noise. Baleen whales produce a rich and complex range of underwater sounds ranging in frequency from approximately 12 hertz (Hz) to 8 kHz, with the most commonly produced frequencies below 1 kHz (McCauley, 1994); studies of baleen whale hearing also suggest that their hearing is best adapted for low frequency sounds (McCauley, 1994; Richardson *et al.*, 1995). Hearing ranges in toothed whales (e.g. sperm whales, orcas) has been estimated between 150 Hz and 160 kHz (Southall *et al.*, 2007), these are considered mid-frequency cetaceans in Southall et al. (2007). Research has indicated that toothed whales are most sensitive to sounds above approximately 10 kHz (NRC, 2003). Below about 10 kHz sensitivity deteriorates with decreasing frequency and below 1 kHz sensitivity appears to be poor.

Observed cetacean disturbance responses to anthropogenic sounds can include altered swimming patterns; increased swimming speed, including pronounced ‘startle’ reactions; changes to surfacing, breathing and diving patterns; avoidance of the sound source area and other behavioural changes (NRC, 2003). The occurrence and intensity of such responses, however, are highly variable and depend on a range of factors relating to the animal and situation (NRC, 2003).

Underwater noise produced by seismic survey and associated vessel operations may interfere with the ability of marine animals to detect naturally produced sounds including communication signals. This effect is termed ‘auditory masking’ and has the potential to impact on marine animals by inhibiting their ability to detect predators and prey, altering navigational ability and their ability to communicate.

There is a paucity of information available regarding ‘call masking’ in whales (Richardson *et al.*, 1995), although it has been suggested that an observed lengthening of calls in response to low-frequency noise in humpback whales and orcas may be a response to auditory masking (Foote *et al.*, 2004; Fristrup *et al.*, 2003). Toothed whales detect frequencies predominantly below those of the noise sources from the proposed seismic survey program and are therefore unlikely to be susceptible to auditory masking.

Cetaceans are not likely to be significantly affected by vessel transit noise, although the sound emitted from transit may induce avoidance behaviour and result in minor route alterations. Avoidance behaviour may occur within proximity of the vessel and is likely to be highly localised; most cetaceans would likely move away from the noise source, so any potential impacts would likely be minimal. The effects on whales from vessel movements are, therefore, not predicted to have long-term consequences to cetaceans.

Physiological damage from noise, such as hearing loss, may, however, result if cetaceans occur in close proximity to intense sounds from high energy sources. As discussed in Section 6.1.1, noise generated from the seismic array may be detectable up to 3 km from the vessel survey location. The

threshold of 183 dB for potential damage will be exceeded by the proposed seismic testing given the estimated sound pressure levels of 237-262 dB estimated for the proposed seismic array. As identified by modelling studies completed by Woodside, these sound pressures decay rapidly and are expected to be below this damage threshold within tens of meters from the gun array. As such, an animal would have to be in close proximity to the vessel to be at risk of a TTS impact. As they are expected to avoid interacting with the vessel and seismic array, it is considered unlikely that a TTS impact would result in direct physical trauma in cetaceans. Given the survey activities are expected to occur for 48 days, behavioural avoidance of the survey area by migrating species may occur with species moving closer to shore or further offshore or transiting through the area without resting.

Marine Reptiles (turtles)

There is little information available in relation to noise impacts on turtles. Turtles have been shown to respond to low frequency sound, with indications that they have the highest hearing sensitivity in the frequency range between 100 – 700 Hz (Bartol and Musick, 2003). Reported responses of turtles to high levels of anthropogenic noise include increased swimming activity and erratic swimming patterns (McCauley *et al.*, 2002).

The seismic survey operations will occur in waters ranging from 700 m to 3500 m. Marine turtles are most likely to occur in shallower waters near the coastal area. Marine turtles are, therefore not expected to be significantly affected by the proposed operations. Any influence from the survey is predicted to be limited to small behavioural changes mainly linked to visual disturbance as opposed to auditory disturbances.

Fish

Fish sensitivity and resilience to underwater noise varies greatly depending on the species, hearing capability, habits, proximity to the noise source, and the timing of the noise (i.e. the noise may occur during a critical part of the fish's lifecycle) (McCauley and Salgado-Kent, 2008). Most marine fish are hearing generalists (Amoser and Ladich, 2005) with relatively poor hearing. Hearing generalists are not as sensitive to noise and vibration as hearing specialists, which have developed hearing specialisations and can be particularly vulnerable to intense sound vibrations because many possess an air-filled swim bladder (Gordon *et al.*, 2004). There are a number of commercially important fish species in the region with unknown noise sensitivities including red emperor, rock cod, sweetlip, goat fish, trigger fish, snapper, mackerel and tuna.

A number of shark species may also occur in the region, including the EPBC Act listed whale shark. Elasmobranchs (rays, skates, sharks) rely on low frequency sound to locate prey (Myrberg, 1978). The hearing sensitivity of sharks are known to be in the frequency range between 40 Hz to 800 Hz (Myrberg, 2001).

There is uncertainty about the behavioural response of fish species to underwater noise and the differing levels of sensitivity which different species may have. A study by Mitson (1995) indicated that fish show an avoidance reaction to vessels when the radiated noise level exceeds a hearing threshold of 30 dB or more. As such, behavioural avoidance would be expected by fish which encounter the seismic operations. The avoidance is predicted to be temporary without any long term significant impacts.

6.1.3 Pre-treatment consequence ranking – vessel steaming

Negligible *– Negligible impact, effect contained locally*

Noise generated by the vessel steaming is not expected to significantly impact on marine fauna species in the vicinity of the vessel, given the relatively small area of potential impact and the common behaviour of most species to avoid any obtrusive noise sources. Small temporary alterations in marine fauna migratory pathways may result from the noise produced from the various activities, but this is not expected to affect the overall behaviour (including migratory) of impacted fauna, especially given the short duration of the Activity (48 days, plus two days transit each way (total eight days transit)).

6.1.4 Pre-treatment consequence ranking – seismic survey

Minor *– Minor Impact on biological/physical environment.*

Noise generated by the seismic survey activity is not expected to result in any direct physical trauma to marine fauna. It is predicted to result in behavioural avoidance of the seismic survey area and up to 3 km from the survey vessel. This may include alterations in the migratory pathway of cetaceans but this is not expected to affect the overall ability of species to migrate as they will be able to avoid and pass by the activity.

6.1.5 Control measures and environmental performance

Environmental Performance Outcome	• Vessel machinery maintained to minimise noise emissions. • No adverse vessel interactions with cetaceans or whale sharks. • No harm to cetaceans or whale sharks due to acoustic emissions associated with seismic operations.	
Aspect	**Control Measures and Performance Standards**	**Measurement Criteria**
Machinery maintenance	Noise emissions minimised by maintaining vessel machinery and survey equipment in accordance with required maintenance standards	Vessel and equipment maintenance records
Crew training	Vessel and survey crew to attend environmental induction containing basic information on procedures to manage interactions between survey vessel, survey equipment and marine fauna	Vessel and survey crew signed environmental induction attendance sheets
Vessel operation	Compliance with Part 8 of EPBC Regulations (Vessels)	Vessel master signed environmental induction attendance sheets Marine fauna sighting datasheets are completed
Seismic survey operation	Seismic survey activities will implement mitigation measures outlined in EPBC Act Policy Statement 2.1 Part A (DEWHA, 2008) as appropriate for the Activity, for cetaceans and whale sharks: • Precaution zones will be implemented (Observation (3+ km), Low Power (2 km) and Shut down (500 m)) • Pre-start up visual observation of precaution zones (>30 mins before soft start) • Seismic survey line pass will not commence if cetaceans/whale sharks are within low power or shut-down zone within intended passage of vessel – alternative route will need to be selected • Two marine mammal observers will maintain vigilant observation for marine cetaceans within precaution zones and vessel planned path throughout seismic survey • Seismic array will be shut down if cetacean or whale shark enters shut-down zone • Relevant crew members are briefed on EPBC Act Policy Statement requirements, soft start, start-up delay, operations and stop work procedures, night time and low visibility procedures.	Seismic survey records completed and signed, detailing hours of operation and crew undertaking observations for fauna Marine fauna sighting datasheets are completed Department of Environment's Cetacean Sighting Application used to record all sightings.

6.1.6 Environmental outcome

Acceptability

Given the management controls in place to the reduce the operating noise of the Activity, including vessel operational protocols, adherence to the fauna interaction management stated in Part 8 of the Environment Protection and Biodiversity Conservation Regulations 2000, general noise emitted for the duration of the Activity from these sources are not expected to significantly impact on marine fauna within the receiving environment. The negligible impacts expected from these noise sources are considered environmentally acceptable.

Use of seismic equipment during the Activity is not expected to significantly impact on sensitive marine fauna if protocols are followed during its operation. The strict implementation of EPBC Act Policy Statement 2.1 Part A during seismic survey activities will be the primary control point in preventing impacts to marine fauna species. A large mitigating factor in the use of the seismic equipment will be the relatively short time frame any one area of the seabed is exposed during the survey. The vessel will continually traverse the survey area at a slow speed of approximately 4.5 kts and its continual movement will limit the exposure time of noise generated to the environment in any one location. This will support the ability of fauna to migrate away from the vessel and to pass around the activity.

Any effects to sensitive species are therefore likely to be restricted to behavioural impacts rather than physiological effects, such as avoidance and course change during movement, which will be restricted to short time window in any point source location. Any impacts to behaviour will be limited to transient individuals in the vicinity of the survey to a maximum distance of 3 km, as the survey area of the Activity is not a significant resting or calving area for sensitive cetaceans. Migrating species that may pass through the area will be able to navigate around any point source disturbance.

With adherence to the management controls proposed during the operation of seismic survey equipment, potential impacts are considered environmentally acceptable in this case.

ALARP

It is not possible to remove all sources of noise if the Activity is to proceed. The purpose of the survey is to acquire seismic data, which requires the use of the airguns. The planned seismic survey lines are widely spaced (10 to 20 km apart) minimising the impact on the environment. If noise emitting equipment is maintained as required, the risks of machinery impacting on sensitive environmental receptors is reduced to ALARP.

6.1.7 Post-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

6.2 Light

6.2.1 Description of hazard

Light	
Hazard	During the Activity, safety lighting on the *MV Duke* will generate light emissions that may affect marine fauna behaviour. Lighting typically consists of bright white (metal halide, halogen, fluorescent) lights. Minimum lighting is required for safety and navigational purposes on board so it cannot be eliminated from the proposed Activity.
Extent	Direct light spill on surface waters will be limited to the area directly adjacent to the *MV Duke* and would not directly affect any areas outside of the Operational Area. Depending on weather conditions, vessel lighting (particularly at night-time) will be visible at distances of at least 10 kilometres, with intensity attenuating with distance.
Duration	Artificial lighting will be required on a 24-hour basis for the duration of the Activity (48 days) to maintain safe visibility of the vessel at night.

6.2.2 Impact analysis

Potential receptors: Marine fauna including fish, marine turtles and seabirds.

Continuous lighting in the same location for an extended period of time may result in alterations to normal marine fauna behaviour, as discussed below for each fauna group.

Fish

The response of fishes to light emissions varies according to both species and occupied habitat. Light trap experiments have found that some fishes and various zooplankton species are attracted to light sources, with traps drawing catches from up to 90 m away (Milicich *et al.*, 1992). A study of artificial lighting generated by a Mobile Offshore Drilling Unit (MODU) demonstrated that there was an increased abundance of clupeids (herring and sardines) and engraulids (anchovies) surrounding the structure, as these species are known to be highly photopositive (Lindquist *et al.* 2005). As consequence, juvenile scombrids (tunas) and carangids (trevallies), which are highly predatory, may have been preying upon higher than usual concentrations of zooplankton that were attracted to a MODU's light field (Shaw *et al.* (2002).

Overall, a short-term localised increase in fish activity as a result of the offshore lighting generated by the *MV Duke* may occur. However, as the vessel will be more mobile than a MODU, localised effects will be reduced.

Marine turtles

The most significant risk posed to marine turtles from artificial lighting is the potential for disorientation of hatchlings following hatching and emergence from nests. Hatchlings use the light of the oceanic horizon to orientate themselves seaward as the oceanic horizon is almost always brighter than the elevated landward horizon (Environmental Protection Authority, 2010). Hatchling behaviour may therefore be affected when exposed to an artificial light source at certain intensities and distributions, potentially leading to disorientation when attempting to migrate to the ocean.

In a study of light impacts from on green turtle hatchling behaviour, the artificial lighting from a moored tanker vessel approximately 20 km offshore was not shown to alter or effect turtle hatchling behaviour (Pendoley, 2005). As the Activity occurs at approximately 100 km from land, light impacts on hatchlings will be negligible.

Adult turtles undergoing nesting behaviour may also be disorientated by artificial light, as adults have a preference for non-illuminated beaches (Environmental Protection Authority, 2010). A conservative estimate of an area of influence on marine turtles from a light source was demonstrated to be around 1.5 km (Environmental Protection Authority, 2010); Given the distance offshore of the Activity, the impacts of the artificial light from the *MV Duke* on adult turtles will be negligible.

Potential receptors: Marine fauna including fish, marine turtles and seabirds.
Seabirds Previous studies have demonstrated that artificial light was the reason that birds were attracted to and accumulated around illuminated offshore infrastructure (Marquennie *et al.*, 2008), and that lighting can attract birds from large catchment areas (Marquennie *et al.*, 2008; Montevecchi, 2006). Birds may either be directly attracted to the light source itself, or indirectly as light sources in oceanic environments can also attract marine life at all tropic levels, creating food sources and providing artificial shelter for seabirds (Surman, 2002). The light sources associated with the *MV Duke* may provide enhanced capability for seabirds to forage at night. **Other marine fauna** Evidence is lacking to suggest that artificial light sources adversely affect the migratory, feeding or breeding behaviours of cetaceans. As cetaceans predominantly use acoustic senses to monitor their environment rather than visual cues (Simmonds *et al.*, 2004), artificial light impacts would be negligible.

6.2.3 Pre-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

Impacts from lighting are likely to be restricted to behavioural changes in some fish species and potentially some bird species with direct contact with the *MV Duke*. Impacts to other fauna groups are not expected to occur. Any impacts to fauna behaviour from lighting will be short-term, with impacts ceasing at the completion of the Activity.

6.2.4 Control measures and environmental performance

Control measures		
Environmental Performance Outcome	• *MV Duke* managed in accordance with navigational and safety requirements	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Lighting operations	• Deck spot lights not required for safety purposes will be turned off or directed inboard. • Non-safety lights to be shielded and pointed inboard or at the deck where possible. • Cables and rigging on the vessel will be restricted where possible and illuminated to limit interaction with seabirds	Environmental inspections confirm deck lighting standard being met.

6.2.5 Environmental outcome

Acceptability

The potential consequences of an anthropogenic light source in the area of Activity are likely to be insignificant in nature and restricted to limited number of fish and bird species. A number of seabirds listed on the EPBC Act potentially occur within the Operational Area, however known migration periods do not coincide with the project timeframe. Individual fish and birds that encounter the vessel may display short term behavioural changes.

There is not expected to be a significant impact to turtle hatchlings or nesting behaviour of adult marine turtles due to the Activity occurring approximately 100 km from land, where nesting occurs.

With control measures in place, including directional management of lighting, and the temporary nature of the Activity (approximately 48 days), the impacts of lighting to the receiving environment are considered environmentally acceptable.

ALARP

There are no safe alternatives to the use of artificial lighting on the *MV Duke*. A baseline level of artificial lighting is required on a 24-hour basis for navigational safety in the area and additional light is required to allow the Activity to proceed safely on a 24-hour basis for occupational health and safety reasons. To reduce lighting at night to a baseline level that would restrict the seismic survey to day light hours only would result in the Activity taking approximately twice as long to complete. Such an increase in project timing would double the cost of the survey and increase the impact or chance of the impact on the environment in other areas. A longer survey would result in an increase in the amount of waste produced, the navigational hazards, the risk of vessel collision and the amount of fuel/refuelling trips required to run the Activity. Increasing the risk of having a potentially larger impact on the environment is therefore deemed as unacceptable.

It is considered therefore that the risks of using 24-hour artificial lighting at an intensity to allow work to proceed are ALARP.

6.2.6 Post-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

6.3 Planned discharges

6.3.1 Description of hazard

Planned discharges	
Hazard	In order to operate the *MV Duke*, a number of routine discharges to the marine environment will be required as outlined below. **Food waste** In accordance with MARPOL Annex V requirements, the Activity is located greater than 12 nautical miles from the territorial baseline, food wastes are permitted to be discharged into the marine environment. However, food must be comminuted or ground prior to release. **Sewage** The volume of sewage and food waste is directly proportional to the number of persons onboard the *MV Duke*. Approximately 30-40 L of sewage will be generated per person per day. Untreated sewage is permitted to be discharged within the Operational Area, as the area is more than 12 nm from land. **Brine** Brine generated from the water supply systems on board the *MV Duke* will be discharged to the ocean at a salinity of approximately 10% higher than seawater. The volume of the discharge is dependent on the requirement for fresh (or potable) water based off the number of people onboard. **Cooling water** Seawater is used as a heat exchange medium for the cooling of machinery engines. Seawater is drawn from the ocean and flows counter-current through closed-circuit heat exchangers, transferring heat from the vessel engines and machinery to the seawater.

Planned discharges	
	The seawater is then discharged to the ocean (i.e. it is a once-through system). Cooling water temperatures vary dependent upon the vessels engines work load and activity. **Anti-scalant** The potable water supply system is dosed with Alpacon Altreat (with Ameroyal as an alternative) that is injected into the water maker evaporation chamber for descaling Potassium Maleate at a rate of approximately 1,400 ml/day. It is injected via the seawater side which flows through the evaporator heat exchanger plates in an effort to prevent scaling of the plate. The resultant brine is then extracted overboard to sea via the ejector (see 'Brine' above). Chlorine is added via injection to the potable water system for purification at a rate of 4 L/day. Chlorine will not be discharged to sea. Ameroyal or Saf Acid is used for cleaning of which the active cleaning agent is Sulfamic acid (NH_2SO_3H). The Saf Acid is mixed up with water in a bath and the water maker plates are immersed in the solution. This water is discharged into the ocean after completion of the cleaning process. **Deck drainage** Deck drainage from rainfall or wash-down operations would discharge to the marine environment. The deck drainage would contain particulate matter and residual chemicals such as cleaning chemicals, oil and grease. Assessment of the spillage of hydrocarbons and other environmentally hazardous chemicals and liquid waste is discussed in Section 7.6. **Oily water discharges** The *MV Duke* may discharge oily water after treatment to 15 ppm in a MARPOL approved oily water filter system.
Extent	The small volumes of non-hazardous discharges may cause nutrient enrichment, organic and particulate loading, thermal impacts and increased salinity primarily in surface (<5 m) waters. Altered water quality conditions are predicted to not go beyond 100 m from the vessel (Woodside, 2008).
Duration	During the Activity, localised impacts to water quality will occur; however water quality conditions will return to normal within minutes to hours of cessation of discharges.

6.3.2 Impact analysis

Potential Receptors: fish (pelagic); marine mammals; marine turtles; and seabirds.
Planned non-hazardous discharges will be small and in some cases continuous, with volumes dependent on a range of variables. The discharge of non-hazardous wastes to the marine environment may result in a localised reduction in water quality. This would be expected to be temporary (minutes to hours), localised and limited to surface waters (<5 m). The discharges are expected to be dispersed and diluted rapidly, with concentrations of wastes falling significantly with distance from the discharge point. Changes to ambient water quality outside of the Operational Area are considered unlikely to occur. Specifics of potential impacts to water quality from the discharge of non-hazardous wastes are as follows. **Toxicity** Discharge of anti-scalant dosed into the potable water system will be periodic when maintenance is required. The chemical used for this process is diluted prior to discharge within the potable water system and as small volumes are released at the sea surface (1,400 ml/day) and it is mixed with the water in the system, it is diluted prior to discharge. Based on this, acute toxicity is unlikely to occur at

Potential Receptors: fish (pelagic); marine mammals; marine turtles; and seabirds.
ecologically significant or detectable levels at the discharge site. **Salinity increases** The desalination of seawater results in a discharge of brine with a slightly elevated salinity (around 10% higher than seawater). On discharge to the sea, the desalination brine, being of greater density than seawater, will sink and disperse in the currents. On average, seawater has a salt concentration of 35 ppt. The volume of the discharge is dependent on the requirement for fresh (or potable) water and would be dependent on the number of crew. Most marine species are able to tolerate short-term fluctuations in salinity in the order of 20–30% (Walker and McComb, 1990), and it is expected that most pelagic species would be able to tolerate short-term exposure to the slight increase in salinity caused by the discharged brine. Given the relatively low volume of discharge, low salinity increase and deep, open-sea in the Operational Area, impact on water quality at the survey locations is expected to be negligible. **Changes in temperature** Cooling water will be discharged at a temperature above ambient seawater temperature. Upon discharge it will be subjected to turbulent mixing and transfer of heat to the surrounding waters. Cooling water discharge points vary for each vessel, however, they all adopt the same discharge design that permits cooling water to be discharged above the water line, in order to facilitate cooling and oxygenation of this wastewater stream before mixing with the surrounding marine environment. Given the relatively low volume of cooling water, temperature differential, the deep, open-sea of the Operational Area, impact on water quality is expected to be negligible. **Ballast water** The *MV Duke* will operate out of the Port of Dampier, resulting in a negligible risk of transfer of invasive species to the area of the Activity. The *MV Duke* will be obligated to comply with AQIS ballast water exchange management requirements, including record keeping requirements and maintaining all necessary AQIS Clearance documentation. **Oily water** Oily water discharged from the *MV Duke* will be treated to a concentration that will be unlikely to lead to any impacts to the receiving environment.

6.3.3 Pre-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

Impacts to water quality will be experienced in the discharge mixing zone which will be localised and will occur only as long as the discharges occur (i.e. no sustained impacts), therefore recovery will be measured in hours to days.

6.3.4 Control measures and environmental performance

Control measures		
Environmental Risk	Routine vessel discharges of treated sewage, food waste and wastewater.	
Environmental Performance Outcome	• Sewage and food waste released offshore meets legislated treatment and/or discharge requirements • If required, onshore disposal of sewage, food waste and oily water meets jurisdictional waste management legislation.	
Aspect	Control Measures and	Measurement Criteria

Control measures		
	Performance Standards	
Untreated sewage disposal	Untreated sewage will be stored onboard and only discharged at a distance of more than 12 nautical miles from the territorial baseline in accordance with Regulation 11 of MARPOL Annex IV or disposal at a reception facility	Quantity, time and location of the disposal are recorded
Treated sewage disposal	Treated sewage will be discharged in compliance with Regulation 11 of MARPOL Annex IV.	Current International Sewage Pollution Prevention Certificate
Sewage (treatment) system	Sewage system compliant with Regulation 9 of MARPOL Annex IV.	Current International Sewage Pollution Prevention Certificate
		Current Certificate of Type Approval for sewage treatment plant (STP)
	Sewage system maintained in accordance with PMS.	*MV Duke* PMS
		Sewage system maintenance records
Sewage waste streams	Persons onboard do not exceed the maximum carrying capacity of the *MV Duke's* sewage system.	Persons onboard manifest
		Current International Sewage Pollution Prevention Certificate
Waste management plans	Food waste collected, stored, processed and disposed of in accordance with the *MV Duke* operation plan. Garbage Management Plan as required under Regulation 9 of MARPOL; and/or Shipboard Waste Management Plan as required under AMSA Marine Order 95: Marine Pollution Prevention – Garbage.	Approved Shipboard Waste Management Plan or Garbage Management Plan
Garbage Disposal	In accordance with MARPOL Annex V regulation 9.1, AMSA placards will be displayed on the *MV Duke* to provide guidance on garbage disposal requirements.	AMSA placards displayed in appropriate locations
Food waste disposal	Food waste will be stored onboard and only discharged at a distance of more than 12 nautical miles from the territorial baseline in accordance with Regulation 3 of MARPOL Annex V or disposal at a reception facility.	Quantity, time and location of the disposal/transfer are recorded in Garbage Record Book
Deck drainage	Scupper plugs or equivalent deck drainage control measures available where chemicals and hydrocarbons are stored and frequently handled.	Weekly chemical and hydrocarbon storage inspection checklist
	Only non-hazardous, biodegradable detergents used for deck washing.	Chemical manifest for each chemical used onboard

Control measures		
	Secondary containment shall be available for all machinery or equipment with potential to leak chemicals or hydrocarbons to the marine environment	Weekly Inspection Checklist.
Oily water disposal	As required by MARPOL Annex I Regulations, while in the Operational Area, the *MV Duke* may discharge oily water after treatment to 15 ppm in a MARPOL compliant oily water filter system.	Current IOPP certificate
	If a MARPOL approved OWS is not present/functioning, the *MV Duke* will store machinery space oily water which will be shipped to shore for appropriate disposal at a reception facility or to a carrier licensed to receive the waste.	Quantity, time and location of the disposal are recorded in the *MV Duke* Oil Record Book

6.3.5 Environmental outcome

Acceptability

Treated sewage, brine, cooling water, anti-scalant and oily water will be generated during the Activity. Release of these non-hazardous discharges into the sea from vessels in Australian waters is permissible under the *Protection of the Sea* (Prevention of Pollution from Ships) *Act 1983*, which reflects MARPOL Annex IV, V and I requirements respectively.

The planned discharges are unlikely to significantly impact on the receiving environment if management actions are implemented, including complying with all MARPOL requirements. The MARPOL standard is considered to be the most appropriate standard to adhere to in this environment given the nature and scale of the Activity. These standards are internationally accepted and utilised industry wide, therefore compliance with the relevant and appropriate MARPOL requirements and standards are expected to reduce the potential for environmental impacts to a level which is considered environmentally acceptable.

ALARP

The use of the *MV Duke* is required to undertake the Activity. On board treatment of most wastes and their subsequent discharge to the marine environment is considered to be the most environmentally sound method of disposal, considering that the waste streams will either be treated to a level unlikely to cause significant environmental harm or will be of a nature not considered to pose significant risk to the receiving environment.

The collection, storage and transport of these waste streams to onshore disposal facilities would require a significant logistical effort. The resulting environmental footprint is unlikely to produce a net environmental benefit, given the significant amounts of fuel that would be required by a transporting vessel (a dedicated vessel would be required). Additionally, discharges will adhere to the MARPOL convention at all times. The additional fuel usage would result in releases of CO_2, NOx's and SOx's into the atmosphere. There are also the additional risks of spillage of waste streams during vessel transfer, and the introduction of safety risks arising from the significant reduction in available deck space on board the *MV Duke* (risk of personnel being trapped or crushed among the skips).

With adherence to the proposed management controls, the risk to the environment from these waste streams has been reduced to ALARP.

6.3.6 Post-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

6.4 Atmospheric emissions

6.4.1 Description of hazard

Atmospheric Emissions	
Hazard	The use of fuel (specifically Marine Gas Oil) to power the *MV Duke* engines, generators and mobile and fixed plant and equipment will result in emissions of greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), along with non-GHG such as sulphur oxides (SOx) and nitrous oxides (NOx). Vessels may use ozone-depleting substances (ODS) in closed-system rechargeable refrigeration systems.
Extent	Gaseous emissions will under normal circumstances, quickly dissipate into the surrounding atmosphere.
Duration	During the Activity (48 days)

6.4.2 Impact analysis

Potential Receptors: Seabirds and humans
Hydrocarbon combustion may result in a temporary, localised reduction of air quality in the environment immediately surrounding the discharge point during the Activity. Non-GHG emissions, such as NOx and SOx, and GHG emissions can lead to a reduction in local air quality which can impact humans and seabirds in the immediate vicinity and add to the national GHG loadings. As the Activity will occur in offshore waters, the combustion of fuels in such remote locations will not impact on air quality in coastal towns. The quantities of gaseous emissions are relatively small and will under normal circumstances, quickly dissipate into the surrounding atmosphere. Accidental release and fugitive emissions of ODS has the potential to contribute to ozone layer depletion. Maintenance of refrigeration systems containing ODS is on a routine, but infrequent basis, and with controls implemented, the likelihood of an accidental ODS release of material volume is considered rare.

6.4.3 Pre-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

Given the remoteness of the Activity location and distance from sensitive receptors, in conjunction with the emissions being constrained to the duration of the Activity with no sustained impacts expected, the likely impacts are considered negligible.

6.4.4 Control measures and environmental performance

Control measures		
Environmental Risk	Routine vessel discharge of atmospheric emissions.	
Environmental Performance Outcome	• Atmospheric emissions will be managed to meet legislated emission standards.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Waste incineration	No incineration will take place onboard the *MV Duke*	No waste incineration recorded in the *MV Duke* Garbage Record Book.
Fuel oil type	Sulphur content of fuel oil complies with Regulation 14 of MARPOL Annex VI.	Marine fuel with sulphur content less than 3.50% m/m is the only fuel oil recorded on the fuel bunkering register.

Engine emission control	The *MV Duke* engines meet NOx emission levels as required by Regulation 13 of MARPOL Annex VI.	International Air Pollution Prevention Certificate
Ozone-depleting substance management	Ozone-depleting substances managed in accordance with Regulation 13 of MARPOL Annex VI.	Records contained in the ODS Record Book
Vessel Maintenance	Machinery maintained in accordance the PMS.	*MV Duke* PMS

6.4.5 Environmental outcome

Acceptability

Atmospheric emissions from vessels are permissible under the *Protection of the Sea* (Prevention of Pollution from Ships) *Act 1983*, which reflect MARPOL Annex VI requirements. The *MV Duke* will use Marine Gas Oil (MGO), which is low in sulphur oxide (rather than heavy fuel oil). The fuel oil will meet regulated sulphur content levels in order to control emission quality. As an internationally accepted standard that is utilised industry wide, compliance with MARPOL standards are considered to be an appropriate management measure in this case.

The Operational Area is located in an area where air emissions will disperse and rapidly assimilate and will not reach settlements on shore. The impacts from the emissions are not anticipated to have a significant direct impact to species or land masses in the vicinity of the Operational Area and emissions will be temporary, in line with the time required to complete the Activity. The overall impacts to the atmosphere and sensitive receptors are expected to be negligible if the emission management mentioned above is adhered to and impacts from emissions that are generated by the Activity are considered environmentally acceptable.

The use of ODS in closed-system refrigerant systems is also deemed acceptable under MARPOL Annex VI.

ALARP

Power generation through combustion of fossil fuels is essential to undertaking the Activity. Practical and reliable alternative fuel types and power sources for the *MV Duke* have not been identified nor are they practical. With the implementation of management controls mentioned above the risks from the release of atmospheric emissions are considered ALARP.

Lack of refrigeration systems on board the *MV Duke* would lead to unacceptable workplace conditions (i.e. climate control) and poor food hygiene standards, limiting the ability of the *MV Duke* to undertake the activities, therefore there is no practical solution to the use of refrigeration. Given the routine maintenance of these closed-systems by suitably qualified personnel, all practicable management measures are considered to have been implemented and the likelihood of significant impacts occurring have been reduced to ALARP.

6.4.6 Post-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

6.5 Interference with other users of the sea

6.5.1 Description of hazard

Interference with Other Users of the Sea	
Hazard	Interference of other users of the sea through undertaking the Activity. The presence of the *MV Duke* within the Operational Area could potentially inhibit commercial shipping and fishing activities and increase the chance of a collision risk to these operations.
Extent	Operational Area
Duration	During the Activity (48 days)

6.5.2 Impact analysis

Potential Receptors: commercial fishers and shipping traffic
Potential impacts to commercial fisheries include temporary loss of fishing area, and a potential inconvenience to fishing practices. The presence of the *MV Duke* within the Operational Area during the Activity may be an obstacle for shipping traffic in the region and may disrupt commercial fishing operations. These impacts can include a loss of access to the area as well as navigational hazards and a collision risk. Stakeholder consultation with commercial fishing industry representatives has been undertaken; consultation has confirmed that it is unlikely commercial fishing operators will be in this area during the Activity. Impacts to the fishing industry are therefore unlikely to occur. There are recognised commercial shipping routes adjacent to the Operational Area. As such, shipping traffic may be encountered across Operational Area; therefore impacts to shipping may occur.

6.5.3 Pre-treatment consequence ranking

Minor *– Minor impact, negligible remedial/recovery work*

Given the greater area of similar available fish habitat, impacts to the commercial fishing community are considered negligible. Minor impacts to commercial shipping, in the form of course alterations may occur.

6.5.4 Control measures and environmental performance

Control measures		
Environmental Risk	Disruption to commercial shipping and fishing activities.	
Environmental Performance Outcome	No collisions/incidents with other vessels in the Operational Area.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Stakeholder notification	AMSA RCC notified of Operational Area, activity and duration prior to mobilisation, which triggers RCC to issue an AusCoast Warning.	• GA correspondence to AMSA RCC • AMSA RCC AusCoast Warning
	Relevant stakeholders identified and notified of Operational Area, activity and duration prior to mobilisation.	GA correspondence to relevant stakeholders
Navigational equipment and procedures	Navigation equipment and vessel procedures compliant with all marine navigation and vessel safety requirements under the International Convention of the	Monthly environmental checklist Class survey certificate

Control measures		
	Safety of Life at Sea (SOLAS) 1974 and Navigation Act 2012 (or equivalent).	
	Vessel equipped with an automatic identification system (AIS) and an ARPA system which can identify, track and project the closest approach for any vessel (time and location) within the Operational Area and radar range (<70 km away).	Valid Certificate of Survey
Vessel bridge-watch	Bridge-watch on vessel 24 hours per day.	Watch list on bridge

6.5.5 Environmental outcome

Acceptability

A review of shipping data indicates that the Activity will occur within a commercial shipping area. There may be some commercial fishing activities occurring in the area, but this is likely to be negligible. Industry standard measures have been adopted for the Activity, including stakeholder consultation and marine user notifications to advise and reduce impacts to commercial operations. Stakeholder consultation undertaken to date is described in Section 3.6.

If third party operations avoid the exclusion zone as required by law, there should be no additional risk of collision and this risk is therefore acceptable.

The small amount of area covered by the exclusion zone is not expected to significantly affect commercial fishing operations given the amount of similar habitat available in the surrounding areas, therefore the affects to commercial fishing operations are thought to be negligible, if not non-existent. The risk level of inhibiting commercial fishing operations is therefore considered acceptable in this case.

ALARP

No alternative options to the use of the *MV Duke* are possible in order to undertake the Activity. If the management controls mentioned above are adhered to then the risk of interfering with other users of the sea will have been reduced to ALARP.

6.5.6 Post-treatment consequence ranking

Negligible *– Negligible impact, effect contained locally*

7. Risk assessment of unplanned events

The environmental risk identification procedure identified seven potential sources of environmental impact associated with the unplanned events. The results of the consequence assessments are summarised in Table 7-1. The consequence assessment for each hazard and the subsequent control and management measures proposed by GA to reduce risks of impacts are detailed in the following sub-sections.

Table 7-1 Summary of the environmental impact for hazards associated with unplanned events

Hazard		Pre-treatment ranking	Post-treatment ranking
Introduction of invasive marine species		Medium	Low
Seabed disturbance		Low	Low
Solid wastes	Non-hazardous solids	Low	Low
	Hazardous solids	Medium	Low
Dropped objects		Medium	Low
Marine fauna collisions		Medium	Low
Spillage of environmentally hazardous chemicals and liquid wastes (excluding fuel) to the sea		Low	Low
Hydrocarbon spill from ruptured fuel tank		Significant	Medium

7.1 Introduction of invasive marine species

7.1.1 Description of hazard

Introduction of Marine Pest Species	
Hazard	Introduced marine species (IMS) can be introduced into the Operational Area and surrounds by the *MV Duke* from external biological fouling, internal systems (sea chests, seawater systems etc.), on marine equipment (anchors, survey equipment etc.), or through ballast water exchange. Cross contamination between vessels can also occur.
Extent	Localised (seabed and water column near the *MV Duke*) to widespread if successfully translocated to new areas via ocean currents or vessel transit.
Duration	Temporary (duration of the Activity) to long-term (in the event of successful translocation).

7.1.2 Consequence assessment

Potential Receptors: Marine ecosystem as a whole and commercial / recreational users of the marine environment

IMS are marine plants, animals and algae that have been introduced into a region that is beyond their natural range but have the ability to survive, and possibly thrive (Department of Agriculture Fisheries and Forestry, 2011).

Some IMS pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports and tourism (Department of Agriculture Fisheries and Forestry, 2011)). When IMS achieve pest status, they are commonly referred to as introduced marine pests (IMP). IMPs can cause a variety of adverse effects in a receiving environment, including:

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

New species introductions are commonplace, but the success of IMP establishment is complex and dependent upon a number of factors such as the physical, chemical and biological conditions that the species has been translocated to.

7.1.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Unlikely	*Moderate*	Medium
It is possible that the *MV Duke* could harbour potential marine pest species. However, the likelihood of a marine pest species establishing in the waters of the Operational Area is considered unlikely as habitat diversity is low in the direct Operational Area (i.e. bare sediment) and is located on the continental shelf margin and beyond.	If established, a marine pest species may have the potential to spread and disturb native ecosystems and commercial fisheries.	

7.1.4 Control measures and environmental performance

Control measures		
Environmental Risk	Introduction of invasive marine species	
Environmental Performance Outcome	No marine pest species introduced into the Operational Area.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Vessel operation	Vessel anti-foulant systems are maintained in compliance with International Convention on the Control of Harmful Anti-fouling Systems on Ships.	Vessel in possession of Current International Anti-fouling System Certificate
	MV Duke has AQIS clearance to be in Australian waters	Record of formal AQIS quarantine clearance
Biofouling risk assessment	A biofouling vessel risk assessment (VRASS) is completed prior to mobilisation to Australia as defined within the National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (Commonwealth of Australia, 2009) and ranked as "low".	Completed VRASS demonstrates vessel has a low risk of introducing marine pests to Australian and West Australian waters
Ballast water exchange	Vessels shall exchange 'high-risk' ballast water, as defined in Australian Ballast Water Management Requirements (Australian Quarantine Inspection Service, 2011), outside Australian territorial seas and in waters at least 200 m deep.	Onboard ballast water exchange logs detailing uptake and discharge volumes and position and water depth of exchange

7.1.5 Environmental outcome

Acceptability of Risk

The *MV Duke* has been active within WA State waters or Commonwealth waters since their previous dry-dock cleaning or inspection.

The majority of known IMPs require shallow water environments and or permanent hard substrates. Given the depth at the location (beyond 700 m), it is unlikely that IMS would be able to successfully translocate from the vessel to the Operational Area. The *MV Duke* will be required to adhere to strict Commonwealth quarantine requirements and practices consistent with the National Biofouling Management Guidance for Petroleum Production and Exploration Industry (Australian Quarantine Inspection Service, 2011); adherence to these regulation will reduce the risk of species translocation to a level that is considered acceptable in the maritime industry.

ALARP

The proposed management controls for IMPs are considered appropriate to manage the risk of pest introduction in this case. Further controls for IMPs are available, including undertaking an IMP inspection of each vessel and piece of equipment prior to mobilisation to site or in-situ cleaning at port prior to mobilisation. Use of these management techniques would certainly be beneficial for vessels and equipment entering Australian waters from a foreign environment, but given all resources in this case will already have been assessed for IMP risk, it is not seen as a necessary or beneficial use of resources in this case. The management controls proposed are thought to bring the chance of pest introduction to ALARP in this case.

7.1.6 Post-treatment risk ranking

Likelihood	*Consequence*	Ranking
Very Unlikely	*Moderate*	Low
Reduced: Based on the listed management controls, the likelihood of introduction of marine pest species decreases to rare.	**Unchanged:** The consequence remains unchanged as if environmental conditions were suitable for the establishment of a marine pest species then long-term effects on the ecosystem could occur. Control or eradication of marine pest species is likely to be difficult.	

7.2 Seabed disturbance

7.2.1 Description of hazard

Dropped objects	
Hazard	Disturbance of the seabed habitat from anchoring
Extent	Direct impacts due to the anchor making contact with the seabed would be restricted to within the Operational Area
Duration	The hazard will exist throughout the timeframe of the Activity. Anchoring is not a planned activity for the Activity, and would only be undertaken in an emergency situation.

7.2.2 Consequence assessment

Potential receptors: Benthic habitats and fisheries.
The area of potential disturbance due to seabed disturbance would be restricted to the Operational Area. The seabed within the Operational Area is assumed to be soft sediment with a sparsely distributed infaunal invertebrate population; this habitat type is widely distributed and well represented in the Operational Area and surrounds. While soft sediment benthic habits will not be destroyed, disturbance of the communities on and within them (i.e. the infauna) will occur in the event of seabed disturbance through anchoring (Great Barrier Reef Marine Park Authority, 2014). Depressions may remain on the seabed for some time after retrieval of the anchor as it gradually infills over time.

7.2.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Very Unlikely	*Minor*	Low
The likelihood of a seabed disturbance is considered low. There is a low likelihood of an emergency situation requiring the deployment of an anchor. Additionally, the length of anchor chain will likely not exceed the water depths encountered in the Operational Area of between 700 m to 3,500 m.	Given the greater area of similar available habitat and the duration of the Activity, the consequence is considered 'minor'.	

7.2.4 Control measures and environmental performance

Control measures		
Environmental Risk	Seabed disturbance	
Environmental Performance Outcome	No disturbance to the seabed during the Activity.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Anchoring	The *MV Duke* will only anchor in an emergency situation.	Incident report
Equipment maintenance	Material handling and lifting equipment maintained in accordance with the operation of the anchor winch.	*MV Duke* Operational Procedures and maintenance records

	Lifting equipment certified.	Lifting equipment certification valid and current
	Anchor chain to be well maintained and in working order as to prevent separation of the anchor and the chain during vessel activities and emergency anchoring.	*MV Duke* Operational Procedures and maintenance records

7.2.5 Environmental outcome

Acceptability of Risk

Disturbance of the seabed will only occur during emergency procedures from the deployment of the anchor. All equipment required for deployment and retrieval of the anchor to be maintained as per the *MV Duke* operational procedures. Through implementation of the proposed management controls, the risk of emergency anchoring is reduced to a level that is considered acceptable. Potential environmental impacts from a seabed disturbance would most likely be minor and related to indents in the soft sediment habitat assumed to be within the Operational Area. Given the habitat would not likely be destroyed, the potential impacts area considered environmentally acceptable.

ALARP

The management controls proposed are thought to be sufficient to reduce the risk of seabed disturbance to ALARP. The anchor will only be deployed during emergency situations, and the depths of water encountered may exceed the length of anchor chain on the *MV Duke*. Other than ensuring the safe working practice of the vessel and maintenance of parts, no other management controls are considered necessary for the prevention of disturbance to the seabed.

7.2.6 Post-treatment risk ranking

Likelihood	*Consequence*	Ranking
Very Unlikely	*Negligible*	Low
Unchanged: With treatment controls in place, such as adherence to safe vessel conduct and avoidance of collision, the likelihood of seabed disturbance through the deployment of the anchor into the marine environment remains very unlikely.	Reduced: The consequence is reduced to negligible with the implementation of management and mitigation controls in place, as these are aimed at reducing the risk of the event occurring as opposed to the severity of the consequence.	

7.3 Solid wastes

7.3.1 Description of hazard

Release of non-hazardous or hazardous solid wastes to the marine environment	
Hazard	Non-hazardous solid wastes including paper, plastics and packaging and hazardous solid wastes such as batteries, fluorescent tubes, medical wastes and aerosol cans may be released unintentionally to the marine environment, potentially impacting on sensitive receptors. Release of these waste streams may occur as a result of overfull and/or uncovered bins, incorrectly disposed items or spills during transfers of waste between the *MV Duke* and receptacle.
Extent	The hazard originates within the Operational Area and all non-buoyant waste material is expected to remain within the Operational Area. Buoyant waste material would potentially move beyond the Operational Area.
Duration	An unplanned release of waste may occur throughout the Activity and impacts may occur until the waste degrades.

7.3.2 Consequence assessment

Potential Receptors: Benthic habitats, fish, marine mammals, marine reptiles and seabirds.
Non-hazardous solid wastes such as plastics have the potential to smother benthic environments and harm marine fauna through entanglement or ingestion (Derraik, 2002). Marine turtles and seabirds are particularly at risk from entanglement. Marine turtles may mistake plastics for food; once ingested, plastics can damage internal tissues and inhibit physiological processes, which can both potentially result in fatality (Derraik, 2002). Release of hazardous solid wastes may result in the pollution of the immediate receiving environment, leading to detrimental health impacts to marine flora and fauna. Physiological damage can be through ingestion or absorption may occur to individual fish, cetaceans, marine reptiles or seabirds.

7.3.3 Pre-treatment risk ranking

Non-hazardous solids

Likelihood	*Consequence*	Ranking
Possible	*Negligible*	Low
It is possible that in the absence of controls, non-hazardous solid wastes could be unintentionally lost to the environment.	Although this waste stream does not present toxicity risks to the environment, other than localised reductions in water quality, physical impacts to marine flora and fauna from smothering, ingestion or entanglement could occur. Any impacts would be restricted to low numbers of individuals owing to the small volumes of waste stored on the *MV Duke*.	

Hazardous solids

Likelihood	*Consequence*	Ranking
Unlikely	*Moderate*	Medium
It is unlikely that in the absence of controls, non-hazardous solid wastes could be unintentionally lost to the environment.	This waste stream could cause localised impacts to water quality and the benthic environment if released, leading to impacts on localised flora and fauna species. Only small volumes of this waste stream would be generated during the Activity, as a result, any accidental loss to the environment would be minimal. Pollutants would likely rapidly disperse to non-toxic concentrations in the water column and any impacts would be restricted to a small number of individuals in the immediate area of the spill, if any.	

7.3.4 Control measures and environmental performance

Control measures		
Environmental Risk	Non-routine discharge of solid non-hazardous and hazardous wastes overboard.	
Environmental Performance Outcome	• No loss of solid non-hazardous or hazardous waste to marine waters. • Appropriate disposal of wastes onshore	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Waste management plans	Non-hazardous and hazardous wastes collected, stored, processed and disposed of in accordance with the *MV Duke* Garbage Management Plan, as required under Regulation 9 of MARPOL Annex V.	Garbage Management Plan
Waste storage	Hazardous wastes separated, labelled and stored onboard within secondary containment (e.g. bin located in a bund) and non-hazardous waste is stored within suitably enclosed bins.	Weekly environmental inspection checklist shows wastes stored correctly
	All scrap metal to be collected in bins for appropriate onshore disposal.	Weekly environmental inspection checklist shows wastes stored correctly
	Bunding around stored bulk wet chemicals or hazardous waste storage areas are continuous around the entire area.	Weekly environmental inspection includes bunding checks
Onshore waste disposal	Solid non-biodegradable and hazardous waste will be disposed of onshore at a suitable waste facility or to a carrier licensed to receive the waste if required by legislation.	Garbage Record Book indicates volume and location of wastes disposed
Incident investigation	Accidental release of waste to the marine environment is reported and investigated and corrective actions are implemented.	Completed Incident Report

7.3.5 Environmental outcome

Acceptability of Risk

Storage of solid waste streams on board the *MV Duke* in fully enclosed containers is considered good practice within the petroleum industry. A spill of non-hazardous and hazardous solid waste through inadequate containment and handling is considered unlikely to occur with control measures. In the event a spill did occur, significant impacts will be unlikely because of the very small volumes of waste and the offshore location of the Operational Area.

During the Activity, given the management controls listed for this waste stream, it is considered that all practical waste management measures will be implemented to reduce the risk of a solid waste spill to an acceptable level.

ALARP

The solid waste streams that will be generated during the Activity are unavoidable if the Activity is to proceed successfully and safely. It is thought that the management controls proposed are sufficient to reduce the risk of solid waste spills to a level that is ALARP. There are no additional management strategies that would reduce the chance of spill of this waste stream.

7.3.6 Post-treatment risk ranking

Release of non-hazardous solids

Likelihood	*Consequence*	Ranking
Unlikely	*Negligible*	Low
Reduced: Based on the listed management controls, the likelihood of an accidental release of non-hazardous solid wastes decreases to very unlikely.	Unchanged: All risk management options have been considered, providing assurance that the Low ranking is environmentally acceptable and that risks have been lowered to ALARP.	

Release of hazardous solids

Likelihood	*Consequence*	Ranking
Very Unlikely	*Moderate*	Low
Reduced: Based on the listed management controls, the likelihood of an accidental release of hazardous solid wastes decreases to rare.	Unchanged: All risk management options have been considered, providing assurance that the Low ranking is environmentally acceptable and that risks have been lowered to ALARP.	

7.4 Dropped objects

7.4.1 Description of hazard

Dropped objects	
Hazard	An object dropped overboard from the *MV Duke* has the potential to damage benthic habitats and associated biota that lie directly within the footprint of the dropped object.
Extent	Direct impacts from a dropped object will be restricted to within the Operational Area
Duration	The hazard will exist throughout the timeframe of the Activity. Potential impacts may continue to occur until dropped objects degrade or become stable (stationary) in the environment.

7.4.2 Consequence assessment

Potential receptors: Benthic habitats, fish and fisheries.
The area of potential disturbance from a dropped object will be restricted to the Operational Area. The seabed within the Operational Area is assumed to be soft sediment with a sparsely distributed infaunal invertebrate population; this habitat type is widely distributed and well represented in the Operational Area and surrounds. While soft sediment benthic habits will not be destroyed, disturbance of the communities on and within them (i.e. the infauna) will occur in the event of a dropped object and depressions may remain on the seabed for some time after removal of the dropped object as it gradually infills over time. Dropped objects could also impact water quality and lead to potential injury to fauna depending on the contents of the object, if any. Impacts from lost solid or liquid materials / wastes are discussed in Sections 7.3,7.6 and 7.7.

7.4.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Possible	*Minor*	Medium
It is possible that in the absence of controls an object may be dropped overboard.	Given the greater area of similar available habitat and the duration of the Activity, the consequence is considered 'minor'.	

7.4.4 Control measures and environmental performance

Control measures		
Environmental Risk	Dropped objects	
Environmental Performance Outcome	• No objects dropped into the marine environment during the Activity.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Anchoring	The *MV Duke* will only anchor in an emergency situation.	Incident report
Equipment maintenance	Material handling and lifting equipment maintained in accordance with the operation of the seismic equipment.	*MV Duke* Operational Procedures and maintenance records

	Lifting equipment certified.	Lifting equipment certification valid and current
Dropped objects prevention	All lifts to be completed in accordance with the MC Duke safety case.	Completed PTW (where applicable) or JSA in line with *MV Duke* procedures; detailed records of any equipment lost overboard completed
	Equipment securely sea fastened prior to *MV Duke* being underway.	Incident log indicates no dropped objects during *MV Duke* movements
	Compliance with equipment handling and lifting procedures demonstrated by mitigation measures being included in JSA.	Completed JSAs indicate equipment handling procedures adhered to

7.4.5 Environmental outcome

Acceptability of Risk

All lifting of objects will be performed as per the procedures in place for the specific activity. All equipment required for lifting will be maintained as per the *MV Duke* operational procedures. Through implementation of the proposed management controls, the risk of dropping an object is reduced to a level that is considered acceptable. Potential environmental impacts from a dropped object would most likely be extremely minor and related to indents in the soft sediment habitat assumed to be within the Operational Area. Given the habitat would not likely be destroyed, the potential impacts area considered environmentally acceptable. The dropping of objects that contain hazardous waste streams are covered in Sections 7.3 and 7.6, and anchoring covered in Section 7.2.

ALARP

The management controls proposed are thought to be sufficient to reduce the risk of an object being dropped to ALARP. Objects will need to be moved around the deck of the *MV Duke* during operational procedures. Other than ensuring the safe handling and storage of objects, no other management controls are considered necessary for the prevention of objects being dropped.

7.4.6 Post-treatment risk ranking

Likelihood	*Consequence*	Ranking
Unlikely	*Minor*	Low
Reduced: With treatment controls in place, such as adherence to procedures during lifting activities, equipment maintenance, and appropriate training, the likelihood of an object dropping into the marine environment is considered to be unlikely.	Unchanged: Given the greater area of similar available habitat and the duration of the Activity, the consequence is considered 'minor'.	

7.5 Marine fauna collisions

7.5.1 Description of hazard

Vessels colliding with marine fauna	
Hazard	There is the potential for the *MV Duke* to collide with marine fauna including cetaceans, fish, marine reptiles and seabirds. The main collision risk associated with the Activity is through collision with large, slow moving cetaceans or whale sharks potentially resulting in severe injury or mortality.
Extent	Restricted to immediate area around the *MV Duke* while underway within, and during transit to/from the Operational Area.
Duration	For the duration of the Activity.

7.5.2 Consequence assessment

Potential receptors: Fish, cetaceans; marine reptiles and seabirds
Cetaceans are naturally inquisitive marine mammals that are often attracted to vessels underway; for example, dolphins commonly 'bow ride' with vessels. Collisions between vessels and cetaceans are most frequent on continental shelf areas where high vessel traffic and cetacean habitat occur simultaneously (Whale and Dolphin Conservation Society, 2006). There have been recorded instances of cetacean deaths as a result of vessel collisions in Australian waters, though the data indicates this is likely to be associated with container ships and fast ferries. Species such as humpback whales have been shown to react to vessel movements, and alter their course to avoid collisions (Whale and Dolphin Conservation Society, 2006). The reaction of whales to the approach of a ship is quite variable. Some species remain motionless when in the vicinity of a ship while others are known to be curious and often approach ships that have stopped or are slow moving (Richardson *et al.*, 1995). Whale sharks may be behaviourally vulnerable to boat strike. They spend a significant amount of time feeding in surface waters (Norman, 1999) and scars have been observed on several whale sharks that have likely been caused by boat collision (DEH, 2005). There have also been several reports of whale sharks being struck by bows of larger ships in other regions where whale sharks occur (Norman, 1999). Considering the low vessel speed that will be employed during the Activity (approximately 4.5 knots), it is unlikely that the *MV Duke* will have a significant impact on migratory species or other transitory marine fauna that may be present.

7.5.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Unlikely	*Moderate*	Medium
This ranking assumes the Activity will overlap the whale migration period. The Australian National Marine Safety Committee (NMSC) reports that during 2009, there was one report of a vessel collision with a marine animal in Western Australian waters (species not defined) (Australian National Marine Safety Committee, 2010). During operation, the *MV Duke* will be moving very slowly (4.5 kts) whilst inside the Operational Area, posing a low risk of collision with marine fauna. Whilst no speed restrictions are in place within the Operational Area, it is common practice to maintain a slow vessel speed during normal operations for the collection of seismic data.	Worst-case possibility is a fatality to an EPBC Listed marine fauna species.	

7.5.4 Control measures and environmental performance

Control measures		
Environmental Risk	Vessel collision with marine fauna species	
Environmental Performance Outcome	• No marine fauna injury caused by vessel collision.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
Marine fauna observation	Marine fauna identification posters and Marine Fauna Sighting Datasheets to be made available on board the *MV Duke*. Trained crew will maintain vigilant observation for marine cetaceans within precaution zones and vessel planned path throughout seismic survey (24/7 operations).	Fauna identification posters and Marine Fauna Sighting Datasheets presence checked
Vessel operation	In accordance with Part 8 of EPBC Regulations (Vessels), all vessels must travel at less than 6 knots and minimise noise within the caution zone of a cetacean (150 m radius for dolphins, 300 m for whales) known to be in the area.	Completed marine fauna sighting datasheet, detailing vessel speed and distance from cetacean at sighting

7.5.5 Environmental outcome

Acceptability of Risk

Application of the proposed management and adherence to Commonwealth regulations reduces the likelihood of vessel interactions with marine fauna. While the potential exists for a collision to occur, it considered a rare scenario. The *MV Duke* will be travelling at low speeds within the Operational Area, also reducing the likelihood of fauna strike. In the unlikely event that an impact did occur, it would highly probable that only a single individual would be contacted. The risk and consequence are therefore deemed acceptable in this case.

ALARP

The *MV Duke* will be required to undertake the Activity. Other than restricting speed within the Operational Area and observing for marine fauna, no additional management controls would likely reduce the already low likelihood of a collision occurring, therefore it is thought that the risk of a collision occurring has been reduced to ALARP.

7.5.6 Post-treatment risk ranking

Likelihood	*Consequence*	Ranking
Very Unlikely	*Moderate*	Low
Reduced: With treatment controls in place for this risk, the likelihood of a marine fauna collision still occurring was assessed as being very unlikely to occur.	Unchanged: Worst-case possibility is a fatality to an EPBC Listed marine fauna species.	

7.6 Spillage of environmentally hazardous chemicals and liquid-waste (excluding fuel) to the sea

7.6.1 Description of hazard

Spillage of hydrocarbons, environmentally hazardous chemicals, or liquid-waste to the marine environment	
Hazard	Hazardous liquids including biocides, corrosion inhibitors and hydraulic oil as well as a variety of miscellaneous chemicals and waste streams (e.g. lubricating oils, cleaning and cooling agents, oily water, recovered solvents, stored or spent chemicals) will be used or stored on board the *MV Duke* during the Activity. These substances will be stored in barrel sizes of 160 L or less. Accidental loss of liquid wastes to the marine environment could occur via tank pipework failure or rupture, inadequate bunding and/or storage, insufficient fastening or inadequate handling (e.g. during bunkering). Such instances may result in impacts to water quality and hence sensitive environmental receptors. Large scale spills of hydrocarbons are addressed separately in Section 7.7.
Extent	The maximum volume of hazardous substances that could be released during routine operations (excluding fuel tank rupture – refer Section 7.7) is likely to be limited to small volume on-deck spills. In the event that the spill is not contained on deck, there would be a release to the marine environment, which would be likely to rapidly disperse and evaporate. Large scale spills of hydrocarbons are addressed separately in Section 7.7.
Duration	During the Activity.

7.6.2 Consequence assessment

Potential receptors: Fish, cetaceans, marine reptiles and seabirds
Environmentally hazardous chemicals and wastes lost to the marine environment may lead to contamination of the water column in the vicinity of the survey location. The potential impacts will most likely be highly localised and restricted to the immediate area surrounding the spill, with rapid dispersal to concentrations below impact thresholds likely to occur in the open area of ocean. The changes to water quality that may result could potentially lead to short-term impacts on marine fauna (e.g. pelagic fish, cetaceans, marine reptiles and seabirds), with chronic impacts not expected because of the likely short exposure times. The area that may be affected by this risk for the majority of spilt material will most likely be restricted to a small area within the Operational Area. Discharge of chemicals from spills is unlikely to have widespread ecological effects given the small volumes that could be released, and the water depth and exposure of the Operational Area.

7.6.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Unlikely	*Minor*	Low
In the absence of mitigation and management controls, spills of fluids may occur through equipment malfunction, equipment corrosion, inadequate storage and bunding of fluids.	Lubricating oil and hydraulic oils spilled at very small volumes (less than 1 L) would be cleaned up immediately without reaching the marine environment. Impacts from small volumes discharged to the marine environment to water quality will be short-term and localised; only pelagic fauna present in the immediate vicinity of the spill will likely be at risk of impact.	

7.6.4 Control measures and environmental performance

Control measures		
Environmental Risk	Environmentally hazardous chemical and hydrocarbon spills	
Environmental Performance Outcome	• No release of environmentally hazardous chemicals, wastes or hydrocarbons to the marine environment.	
Aspect	**Control Measures and Performance Standards**	**Measurement Criteria**
Material storage	Chemicals and hydrocarbons packaged, marked, labelled and stowed in accordance with MARPOL Annex III.	Ship certificate or declaration as required by MARPOL Annex III
	Chemicals (environmentally hazardous) and hydrocarbons stored in bunded areas.	Weekly environmental inspection checklist
	Chemicals and hydrocarbons stored in accordance with relevant MSDS.	MSDS for each chemical and hydrocarbon
	All hazardous wastes stored in a bunded area.	Weekly environmental inspection checklist
Vessel inspections	Chemical and hydrocarbon storage areas inspected weekly.	Weekly environmental inspection checklist
Spill response	Contaminated material contained onboard for onshore disposal in accordance with Environmental Protection (controlled waste) Regulations (2004).	Incident report
		Waste transfers recorded in Garbage Record Books
	All shipboard chemical spills and hydrocarbon spills managed in accordance with SOPEP/SMPEP.	Current SOPEP/SMPEP
		MV Duke vessel incident report
		Records in the *MV Duke* log
Spill response equipment	Spill clean-up equipment located where chemicals and hydrocarbons are stored and frequently handled.	Weekly environmental inspection checklist
Deck drainage and bunding	Scupper plugs or equivalent deck drainage control measures available where chemicals and hydrocarbons are stored and frequently handled.	Weekly environmental inspection checklist
	Only non-hazardous, biodegradable detergents used for deck washing.	MSDS for each chemical used onboard
	Secondary containment shall be available for all machinery or equipment with potential to leak chemicals or hydrocarbons to the marine environment	Weekly environmental inspection checklist
	Following rainfall events, bunded areas on open decks of the vessels will be cleared of rainwater.	
Equipment maintenance	Maintenance records on the *MV Duke* indicate that all machinery and equipment containing hydrocarbons and equipment involved in the discharge and transfer of liquids have maintenance scheduled on their respective PMS.	*MV Duke* machinery maintenance records
Equipment maintenance	Transfer of fuel to and from the *MV Duke* in compliance with the *MV Duke*'s fuel transfer procedure.	PTW compliant with the *MV Duke*'s fuel transfer procedure
Untreated oily water disposal	All *MV Duke* machinery space oily water waste disposed of at a licensed onshore reception facility or to a carrier licenced to receive the waste.	Oil transfers recorded in Oil Record Book.

7.6.5 Environmental outcome

Acceptability of Risk

A thorough set of mitigation and management controls and checks have been proposed to ensure that the risks of spills and leaks occurring and subsequent impacts are minimised. This includes ensuring correct storage and handling procedures are followed as well as ensuring the maintenance of equipment is consistently undertaken, together with ensuring that the chemicals and hydrocarbons used pose the lowest risk possible to the environment.

The magnitude of a worst-case spill in this case is unlikely to be greater than 160 L, the size of a standard storage barrel. This volume negates the need for any further contingencies to be in place that are included for the larger MGO spill scenario associated with the Activity (refer Section 7.7).

The resulting impacts to marine fauna that could potentially result from a spill of this size would be negligible, with impacts restricted to a small number of individuals within the immediate area. With the controls in place to prevent accidental spills and the negligible impacts predicted from a spill of this size, the environmental risk of using and handling the required chemicals is considered acceptable.

ALARP

Hazardous substances assessed under this section are inevitably required to undertake the Activity, so their removal from the operation is not viable. No beneficial additional controls where identified to further reduce the risk of this hazard. The extensive management and mitigation controls outlined above reduce the risk to a level considered ALARP.

7.6.6 Post-treatment risk ranking

Likelihood	*Consequence*	Ranking
Very Unlikely	*Minor*	Low
Reduced: With the implementation of the management and mitigation controls, including the handling and storage requirements of the environmentally hazardous materials, the chance of a spill occurring is reduced.	Unchanged: The consequence rating remains unchanged with treatment controls in place as potential maximum spill volumes of hazardous substances remain unchanged.	

7.8 Hydrocarbon spill from ruptured fuel tank

7.8.1 Description of hazard

Hydrocarbon spills from ruptured fuel tank	
Hazard	Several potential hazards have been identified for vessel operations associated with the Activity. In regards to hydrocarbon spill hazards, a hydrocarbon spill from a ruptured vessel fuel tank in a collision scenario is the most likely to occur. Spills of Marine Gas Oil (MGO) have the potential to impact the marine environment through reductions in water quality and exposure of hydrocarbons to fauna and habitats. There is a possibility of vessel collision occurring between the *MV Duke* and a commercial vessel or fishing vessel within the Operational Area. The worst-case environmental incident resulting from a vessel collision is the rupturing of a vessel fuel tank that results in the release of a maximum 450 m^3 of MGO to the environment. There are no additional collision hazards (such as infrastructure or shallow reef areas) within the Operational Area.
Extent	Estimates of the distribution of MGO in the marine environment as a result of the credible spill scenario were simulated through stochastic modelling of the event[1]. SINTEF's oil spill model OSCAR[2] was used to carry out over 800 simulations over a five year period assuming a 450 m^3 MGO spill released over a 12 hour duration that utilised regional scale water currents[3], tidal currents[4] and winds[5] for inputs. The area that may be affected (AMBA) for surface hydrocarbons above the adopted threshold of 10 g/m^2 are predicted to remain offshore for this event with no contamination of sensitive environmental receptor sites (Figure 7-1). Similarly, the total water accommodated fraction (entrained + dissolved hydrocarbons) above the adopted threshold of 500 ppb did not extend beyond 120 km for the ensemble of 800+ simulations (Figure 7-2). Of the 800+ simulations, there were only 2 simulations that have substantial hydrocarbons ashore on the western shoreline of Dirk Hartog Island with 1-1.6 tonnes of hydrocarbons ashore in 5-7 days. All other hydrocarbons ashore events were <200 kg along the western coastline from Dorre Island to Geraldton/Abrolhos Islands as summarised in in Table 7-2. The AMBA for MGO spills is derived from these simulations. In summary, three island groups and two mainland regions were identified as areas that under rare conditions (probability ≤ 1%) potentially had oil ashore. Depending on the region and prevailing conditions, it is predicted that the hydrocarbons will take 4 – 18 days to reach shorelines, if at all.

[1] GA has utilised stochastic modelling for this event, as it gives a much more credible worst case consequence assessment of the AMBA. Utilisation of ADIOS does not predict oil ashore and only a limited areal extent of impact.
[2] OSCAR is a system of integrated models that can be applied to quantitatively assess the fate and transport of hydrocarbons in the environment, as well as evaluate the efficacy of particular response measures. The system consists of oil weathering model, a physical transport, a strategic response and a biological exposure models (Reed *et al.*, 2001, 2004).
[3] HYCOM simulated regional currents were utilised. HYCOM is a three-dimensional global ocean circulation model operated by the HYCOM consortium; a broad partnership of academic, government and private institutions sponsored by the National Oceanographic Partnership Program (NOPP). HYCOM incorporates data assimilation techniques for satellite altimetry measurements and satellite measurements of sea surface temperature (SST) as well as *in situ* temperature and salinity, and drifter trajectories. Most of the data assimilation therefore focusses on the sea surface, which is often the primary concern for hydrocarbon spills. HYCOM reanalysis data sets are available at a daily time step from November 2003 to (near) present. The spatial resolution in the Indian and Pacific Oceans is 1/12 of a degree - approximately 9 km (Chassignet *et al.*, 2009).
[4] Estimates of tidal currents were made with TPXO7.2, which is a global tidal model supported by Oregon State University (Egbert and Erofeeva, 2002). The model treats the eight primary (M2, S2, N2, K2, K1, O1, P1, Q1), two long period (Mf, Mm) and 3 non-linear (M4, MS4, MN4) harmonic tidal constituents on a two-dimensional global grid with 1/4 degree horizontal resolution (approximately 25 km). TPXO has been shown to accurately predict tides across the NWS (Rayson *et al.*, 2011).
[5] The Reanalysis Project a global atmospheric model run as a cooperative venture between the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) (Kalnay *et al.*, 1996; Kistler *et al.*, 2001). This system assimilates data from rawinsonde observations, aircraft observations, land surface meteorological observations, oceanic observations and satellite tracking of clouds. The output is available at 6-hourly intervals with 2.5 degree resolution (approximately 250 km).

Hydrocarbon spills from ruptured fuel tank

Table 7-2 Summary of OSCAR MGO spill model results

Geographic Features	Probability of exposure (%)	Maximum loading (tonnes)	Arrival time (days)
Mid West Islands and Reefs			
Dorre Island	<1	<0.1	18
Abrolhos Islands	<1	<0.1	8 - 17
Dirk Hartog Island	<1	1.6	4 - 14
Mid West Mainland Regions			
Shark Bay Region	1	0.1	5 - 17
Geraldton Region	<1	<0.1	7 - 16

Duration	Evaporation is the dominant process contributing to the fate of spilled MGO from the sea surface and will account for the majority of the net oil balance. For a MGO spill of 450 m^3, it is estimated through modelling that evaporation and dispersion of 90% of the release volume will occur within approximately 24 hours. Residual components may remain within the environment for a number of weeks at very low concentrations.

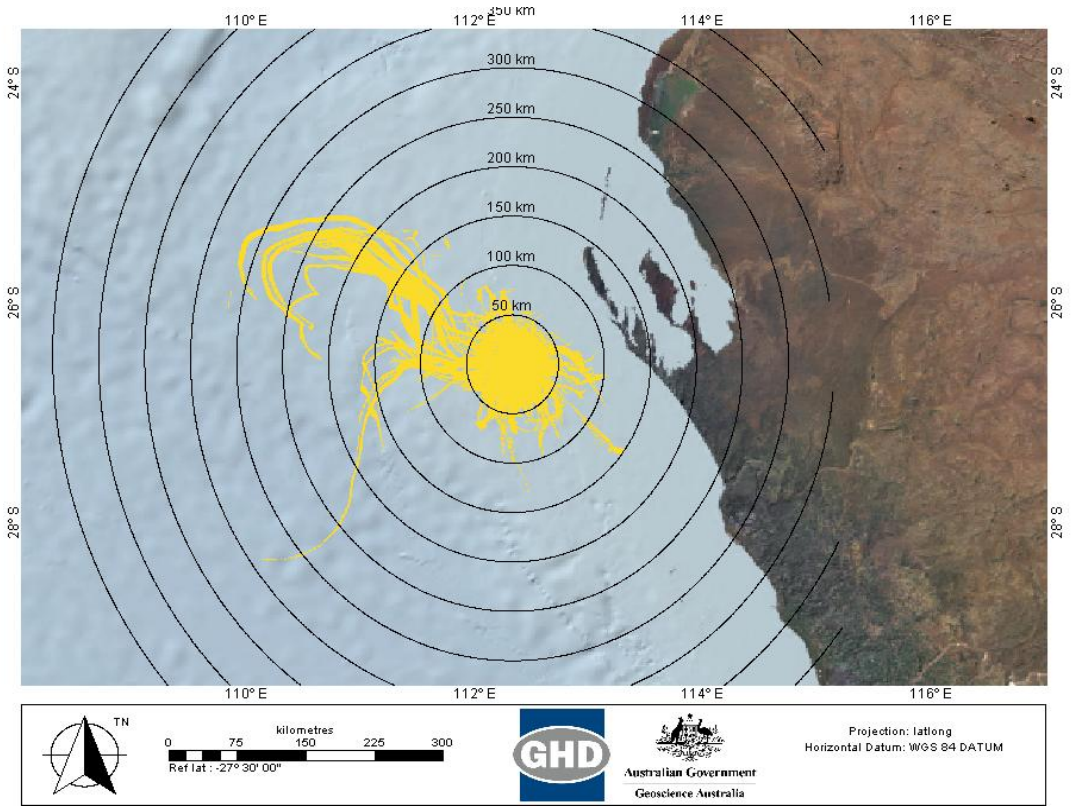


Figure 7-1 Houtman sub-basin seismic survey surface hydrocarbon zone of potential impact for contamination above 10 g/m^2

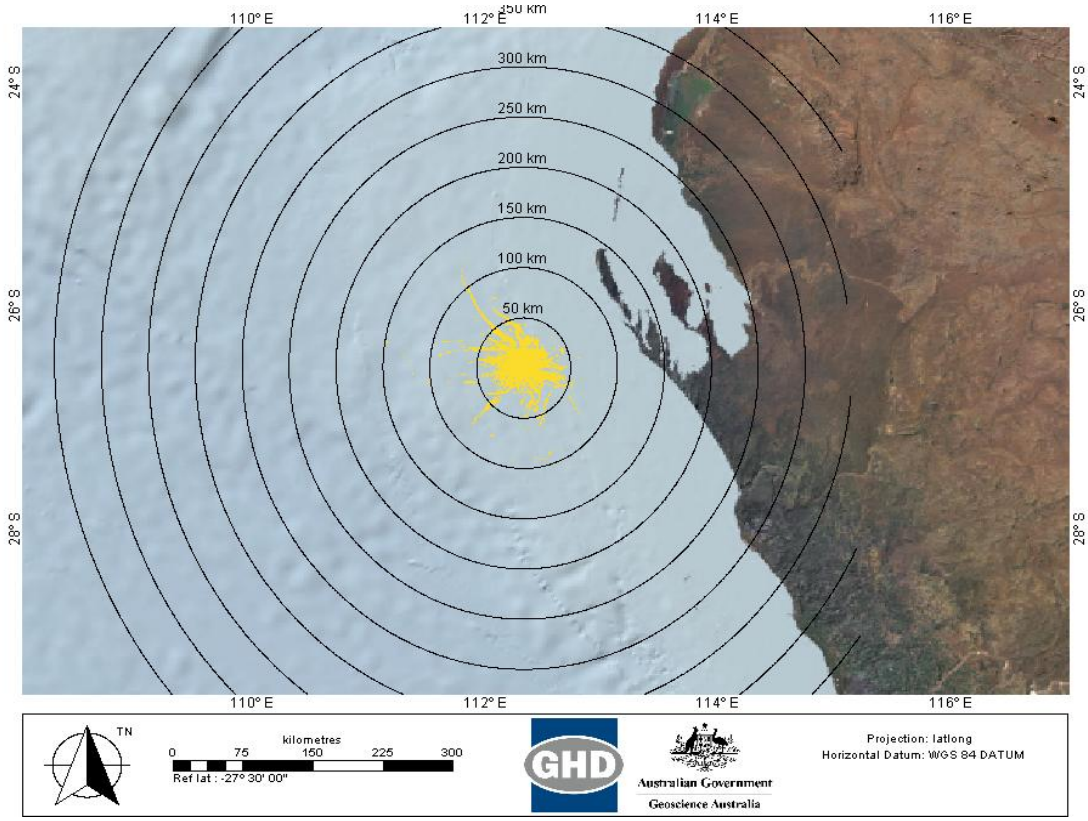


Figure 7-2 Houtman sub-basin seismic survey total water accommodated fraction of potential impact for contamination above 500 ppb

Notes on oil spill modelling thresholds

Surface oil (10 g/m^2)

The threshold concentration for exposure to surface oil is derived from levels likely to cause adverse impacts to species and habitats:

- Surface oil can coat emergent habitats such as coral or rocky reefs, intertidal vegetation or shoreline habitats and
- Marine mammals, reptiles and birds can be exposed to oil when at the water surface.

Estimates for the minimum oil thickness that will harm seabirds (through ingestion from preening of contaminated feathers or loss of thermal protection of their feathers) range from at 10 g/m^2 (O'Hara and Morandin, 2010) to 25 g/m^2 (Koops *et al.*, 2004).

A conservative threshold for impact of 10 g/m^2 was applied to the modelling; this is the concentration used by the Natural Resource Damage Assessment protocol in the USA.

The surface hydrocarbon threshold is used to determine the area of potential impact to turtles, sea snakes, marine mammals and seabirds (NRDAMCME, 1997) and is also applied (with shoreline contact data) to determine the risk of impacts of surface oils to emergent habitat such as coral reefs.

Total oil in water (500 ppb)

Marine organisms may be exposed to entrained oil through a number of pathways. Physical and chemical effects of entrained oil droplets have been demonstrated through direct contact with organisms, for example through physical coating of gills, adsorption to body surfaces and ingestion

(NRMMC, 2005). Toxicological impacts of dissolved hydrocarbons have been demonstrated using standard methodologies by Aurand and Coelho (2005).

Published scientific literature does not provide much evidence on the relative toxicity of dissolved and entrained hydrocarbons, instead reporting the toxicity of total oil. Total oil toxicity has been reported with acute effects of total oil for molluscs with LC_{50} (concentration required to kill half a sample population) values (the concentration that causes mortality in 50% of the test population over a 96 hour period) ranging from 500 to 2,000 ppb (Clark *et al.*, 2001; Long and Holdway, 2002). Wider exposure sensitivities were shown for species of crustacean and fish with LC_{50} values ranging from 100 to 258,000,000 ppb (Clark *et al.*, 2001; Gulec and Holdway, 2000; Gulec *et al.*, 1997) and 45 to 465,000,000 ppb (Barron *et al.*, 2004; Gulec and Holdway, 2000).

The variation in the methodology for mixing the water accommodated fraction may account for the observed wide variation in results which also depend on the test organism, duration of exposure, oil type and the initial oil mixture (i.e. nominal loading rates of oil versus measured concentrations).

From the published scientific literature reviewed by NOAA in 2001, entrained oil concentrations below the parts per million (ppm) concentrations in marine waters have not been associated with any observed stress, degradation or death of corals. This is supported by research by Shafir *et al.* (2007) where the water soluble fraction of crude oil showed no impact on survival or growth of sensitive branching corals in 50 days following a 24 hour exposure. NOAA (2010) stated that branching corals are more sensitive to oil impacts than plate corals.

Aurand and Coelho (2005) suggest that, based on the wide variation of toxicity data, a threshold of 1,000 ppb will represent a reasonable level for protection of more sensitive life stages of organisms residing in the water column. However, to provide an additional level of confidence for protection of sensitive environmental receptors, the threshold value in this case has been reduced to 500 ppb.

Therefore, a contact threshold of 500 ppb was considered appropriate and sufficiently conservative for assessing environmental consequences resulting from total oil in the water column.

Dissolved aromatic hydrocarbons (100 ppb)

French-McCay (2002) states that it is the more volatile and soluble components of oil that cause toxicity to aquatic organisms. Toxicity is usually related to the low molecular weight aromatics including the monoaromatic hydrocarbon (MAH) compounds with a single benzene ring such as those from the BTEX group (benzene, toluene, ethyl benzene, and xylenes); and 2 to 4 benzene ring Polycyclic Aromatic Hydrocarbons (PAH) such as naphthalenes and phenanthrenes.

MAHs are highly volatile and tend to be lost quickly from the water column (Neff *et al.*, 2000). While MAH compounds would contribute significantly to the toxicity of a subsea release, PAHs, which are more toxic and less volatile, tend to be the primary toxicant in the water accommodated fraction of a spill (French, 2000).

A literature review by French (2000) stated that the toxicity of PAH from an oil spill under low energy conditions typical of surface releases has LC_{50}s ranging from 300–1,000 ppb. These results were further refined when French-McKay (2002) reported a 96 h LC_{50} for dissolved PAHs ranging from 30 ppb for sensitive species (2.5th-percentile species) to 2,260 ppb for insensitive species (97.5th-percentile species), with an average of about 250 ppb. The range of LC_{50}s for PAHs obtained under turbulent conditions (this includes fine oil droplets) was 6 ppb to 410 ppb with an average of 50 ppb (French-McCay, 2002). These results show that the receiving environment conditions, water–hydrocarbon equilibrium and turbulence are important factors in dissolved hydrocarbon toxicity. French-McCay (2002) also reported that the predicted total aromatic hydrocarbons (MAH + PAH)

LC_{50}s range from 220 ppb to 16,000 ppb for 95% of the species with an average of 2,000 ppb under low energy conditions.

It is clear from the LC_{50} data presented above that the toxicity of total aromatic hydrocarbons is variable and related to many factors. The threshold derived for this assessment is based on the toxicity results from a "worst case scenario" of a high pressure subsea release with turbulent conditions. Therefore, a contact threshold of 100 ppb is considered an appropriate and suitably conservation concentration threshold for the assessment of impacts from dissolved aromatic hydrocarbons at the spill location.

7.8.2 Consequence assessment

Sensitive Receptors	Potential Impacts from MGO
Marine Fauna	
Marine Mammals Several EPBC Act listed species have the potential to occur within the MGO spill AMBA. For a full list of species identified see Table 3-1 and Table 3-2.	Whales and dolphins are smooth skinned, hairless mammals, so hydrocarbons tend not to adhere to their skin, limiting the potential impacts of oiling. Given the low adhesive potential of MGO, significant impacts are not anticipated. Hydrocarbon tends to adhere to rough surfaces on fauna, such as hair, feathers or calluses. In the immediate spill areas, marine fauna interacting with surface waters may be exposed to MGO on the surface at concentrations about the threshold of 10 g/m^2 used for oiling impacts to sensitive receptors. The susceptibility of marine mammal species to physiological effects through ingestion of surface and water column hydrocarbon varies with the feeding mechanism of each species: • Whales with a baleen mechanism filter nutrient-rich waters containing food such as plankton and small fish over the baleen (a sieve type structure) before subsequently moving the food to the oesophagus using the tongue; • Baleen whales that skim surface waters and the water column (e.g. southern right whales) are more likely to be affected by surface hydrocarbons than other whales that 'gulp' feed such as the humpback whale; • Toothed whales are also less susceptible to impacts owing to gulp feeding behaviour (Geraci, 1990). The relatively high volatility of the MGO will result in the rapid evaporation and loss of the more toxic aromatic components thereby reducing toxicity threat to marine fauna with time. For marine mammals that may be exposed to the more toxic aromatic components of the MGO, chemical effects are considered unlikely since these species are mobile and therefore will not be constantly exposed for extended durations that would be required to cause any major toxic effects. Clogging of baleen structures and toxicological effects from ingestion, although recorded, is sparse in the literature (Geraci, 1990). Given the size of the spill scenarios and expected rapid evaporation and dispersion expected to occur, impacts to marine mammals are expected to be minimal.

Sensitive Receptors	Potential Impacts from MGO
Fish Several EPBC Act listed species have the potential to occur within the MGO spill AMBA. For a full list of species identified see Table 3-1 and Table 3-2. As well as listed species, many species and classes of fish including reef, pelagic, benthic and demersal species are known to occur within the AMBA.	Near the sea surface, fish are able to detect and avoid contact with surface slicks and as a result, fish mortalities rarely occur in open waters from surface spills (Kennish, 1997; Scholz *et al.*, 1992). Pelagic fish species are therefore generally not highly susceptible to impacts from hydrocarbon spills. In offshore waters near to the release point, pelagic fish are at risk of exposure to the more toxic aromatic components of the MGO. Pelagic fish in offshore waters are highly mobile and comprise species such as tunas, sharks and mackerel. Due to their mobility, it is unlikely that pelagic fish would be exposed to toxic components for long periods in this spill scenario. The more toxic components would also rapidly evaporate and concentrations would significantly diminish with distance from the spill site, limiting the potential area of impact. Given the size of the spill scenarios and expected rapid evaporation and dispersion predicted, impacts to pelagic fish are expected to be minimal.
Marine Reptiles Several EPBC Act listed species have the potential to occur within the MGO spill AMBA. For a full list of species identified, see identified see Table 3-1 and Table 3-2.	Marine turtles may be exposed to surface hydrocarbons and water column hydrocarbons through direct ingestion, consumption of contaminated food sources or through vapour inhalation. Exposure through ingestion may lead to physiological effects such as disruption of digestion. Given the size of the spill scenarios and expected rapid evaporation and dispersion predicted, impacts to marine turtles are expected to be minimal.
Birds Several EPBC Act listed species have the potential to occur within the MGO spill AMBA. For a full list of species identified, see identified see see Table 3-1 and Table 3-2.	Seabirds may come into contact with surface and water column hydrocarbons while searching for food (diving) below the sea surface. However, exposure times would be very short, limiting the opportunity for oiling of feathers. Additionally, surface oil films would be below thresholds for oiling for the vast majority of the AMBA. Ingestion of water column oil or contaminated prey may cause short-term physiological effects. Seabirds may also come into contact with MGO around shorelines as it percolates through the beach profile during feeding, breeding and roosting activities. This may result in chemical impacts to feathers and exposed skin from the MGO.
Intertidal soft sediments / sandy beaches	Soft sediment intertidal habitat may become contaminated by heavy residual compounds from the MGO as it percolates through sediment in shallow areas, potentially resulting in toxic effects to benthic infauna and foraging bird species. Given the high energy climate of the intertidal areas within the MGO spill AMBA impacts are expected to be minimal.
Intertidal coral reefs, macroalgalae/seagrass beds, rocky reefs, hard substrate epiflora/fauna	During high tide, intertidal habitats may be inundated by waters affected by MGO. This may result in toxic affects to both the habitat (in the case where the habitat is biological) and associated flora and fauna. The degree of impact will depend on several variables, including the duration of exposure to dissolved aromatic hydrocarbons (DAHs) and other MGO components, and prevailing conditions at the time of exposure. Persistent components of the MGO may also strand on the habitat which may become concentrated during the low tide period, resulting in more acute affects to the habitat. However, following inundation at high tide, particularly in the lower shore areas, it is likely that any residual hydrocarbons would be volatilised or removed by the movement of the water column, thus limiting the

Sensitive Receptors	Potential Impacts from MGO
	potential impacts in comparison to thicker hydrocarbons. If sensitive receptors such as corals are present within the shallow intertidal zone they may be affected by shoreline oiling; toxic impacts to symbiotic zooxanthellae may occur. Subtidal corals are not predicted to be impacted by the spill scenario. Seagrasses and macroalgae may experience a phytotoxic effect caused by absorption of DAHs from the water column. The hydrocarbon molecules can concentrate in membranes of aquatic plants, inhibiting photosynthetic efficiency (Runcie *et al.*, 2004). Recovery of low shore habitats experiencing chronic effects are expected within weeks to months of return to ambient water quality. High shore habitats, particularly those that are inundated only during the largest tides are likely to require a period of months to years to recover (Stevens *et al.*, 2012). Epifauna associated with hard substrates such as ascidians and sponges may experience direct toxicity through ingestion.
Mangroves	Mangrove communities exposed to waters contaminated with MGO at the sediment / mangrove root interface may be acutely or chronically impacted through uptake of these contaminants into tissues, which may severely interfere with cellular processes, including respiration.
Socioeconomic Fisheries	
State and Commonwealth Demersal Fisheries	Demersal fisheries may be affected by DAHs, as outlined above in the Fish section of this table.
State and Commonwealth Pelagic Fisheries	Pelagic fisheries may be affected by tainting of fish stocks (see Fish), sub-lethal and lethal impacts to juvenile/adult fish stocks and to pelagic eggs and larvae.
Socioeconomic: Other	
Commercial Shipping	Shipping operations are unlikely to be affected by a MGO spill.
Oil and Gas Industry	The oil and gas industry is unlikely to be affected by a MGO spill.
Tourism	The tourism industry is unlikely to be affected by a MGO spill.
Heritage	Heritage values are unlikely to be affected by a MGO spill.

7.8.3 Pre-treatment risk ranking

Likelihood	*Consequence*	Ranking
Unlikely	*Serious*	Significant
In the absence of management controls, significant fuel spills are considered unlikely to occur.	Worst-case scenario of release (450 m^3 – Tier 2) of MGO to the offshore marine environment.	

7.8.4 Control measures and environmental performance

Control measures		
Environmental Risk	Non-routine oil spill due to ruptured fuel tank.	
Performance Objective	• No spillage of hydrocarbons to the marine environment from ruptured fuel tank.	
Aspect	**Control Measures and Performance Standards**	**Measurement Criteria**
Stakeholder notification of the Activity to reduce the likelihood of a vessel collision	Notification provided to key stakeholders including relevant Australian Government agencies.	Records of Geoscience Australia correspondence to relevant stakeholders
	Australian Hydrographic Office (AHO) (including hydro.NTM@defence.gov.au) notified of Operational Area, exclusion zone, activity and duration prior to mobilisation, which triggers AHO to issue 'Notice to Mariners'.	GA correspondence to AHO (including hydro.NTM@defence.gov.au). AHO 'Notice to Mariners'
	AMSA RCC notified of Operational Area, exclusion zone, activity and duration prior to mobilisation, which triggers RCC to issue an AusCoast Warning.	GA correspondence to AMSA RCC GA correspondence to relevant stakeholders
	Australian Fisheries Management Authority (AFMA), Department of Fisheries and commercial fishing stakeholders notified prior to mobilisation.	Geoscience Australia correspondence to relevant stakeholders
Navigational equipment and procedures	Navigation equipment and vessel procedures compliant with all marine navigation and vessel safety requirements under the International Convention of the Safety of Life at Sea (SOLAS) 1974 and Navigation Act 2012 (or equivalent).	Class survey certificate
	MV Duke equipped with an automatic identification system (AIS) and an ARPA system which can identify, track and project the closest approach for any vessel (time and location) within the Operational Area and radar range (<70 km away).	Valid Certificate of Survey
Vessel operating procedures	All refuelling to occur while vessel is in port.	Completed PTW documentation *MV Duke* log
Vessel bridge watch	Bridge-watch on vessel 24 hours per day.	Watch list on bridge
Fuel oil type and storage	Sulphur content of fuel oil complies with Regulation 14 of MARPOL Annex VI in order to control SO_X and particulate matter emissions.	MGO with sulphur content less than 3.50% m/m is the only fuel oil recorded on the fuel bunkering register
Equipment maintenance	Diesel storage tanks and fluid transfer hose maintenance (including replacement of refuelling hoses every six months and base oil transfer lines	*MV Duke* PMS *MV Duke* maintenance records.

Control measures		
Environmental Risk	Non-routine oil spill due to ruptured fuel tank.	
Performance Objective	• No spillage of hydrocarbons to the marine environment from ruptured fuel tank.	
Aspect	Control Measures and Performance Standards	Measurement Criteria
	at least every 12 months) undertaken in accordance with the PMS.	
Certification	In line with MARPOL Annex I, *MV Duke* will have a current Shipboard Oil Pollution Emergency Plan (SOPEP) in place and a valid IOPP certificate.	SOPEP and valid IOPP certificate
		MV Duke log records spill exercises.
Oil spill response	Oil spill response executed in accordance with the Activity OPEP.	Review of incident response and Activity OPEP in the event of a spill
	Oil spill response executed in accordance with the vessel's SOPEP as required under MARPOL.	Review of incident response and SOPEP in the event of a spill
		Current IOPP certificate
	Oil spill exercise conducted prior to the commencement of the Activity and then every three months thereafter.	Spill exercises recorded in *MV Duke* log
		Daily environment report details dates of last exercise and the next exercise

7.8.5 Environmental outcome

Acceptability of Risk

In the unlikely event that a MGO spill did occur within the Operational Area, the potential impacts to the environment would be greatest within several kilometres from the spill when the toxic aromatic components of the fuel will be at their highest concentration and when the hydrocarbon is at its thickest on the surface of the receiving waters. The potential sensitive receptors in the surrounding areas of the spill will include fish, marine mammals, marine reptiles and seabirds at the sea surface, which may ingest the MGO or become coated. The number of receptors present at the immediate Activity location are expected to be limited to a small number of transient individuals, given the distance from the nearest shoreline is approximately 100 km and no significant areas of habitat are present in the immediate vicinity of the Operational Area.

As MGO is a relatively high volatile substance, the impacts to receptors would decline rapidly with time and distance. Additionally, it is anticipated that a spill would only reach shorelines under very rare circumstances (≤ 1 % probability).

Although there is potential shipping traffic within the Operational Area, the management controls in place are considered to result in a low risk of a collision occurring. Given the management controls in place to prevent a vessel collision, and the low frequency of significant volume spills that occur in the industry, the risk of either event occurring is considered acceptable.

ALARP

The *MV Duke* is required to undertake the Activity. There are no suitable alternatives to the use of this vessel to complete the Activity. It is considered that the industry standard and activity-specific controls to reduce collision risks that have been proposed and the contingencies in place in the event of the

hazard occurring reduce the likelihood and potential impacts from a loss of fuel as a result of a vessel collision to ALARP.

With the management controls in place and the refuelling methodology proposed, the risks from this hazard are considered ALARP.

7.8.6 Post-treatment risk ranking

Hydrocarbon spill from vessel collision

Likelihood	*Consequence*	Ranking
Very Unlikely	*Serious*	Medium
Reduced: With treatment controls in place, including adherence to AMSA regulatory requirements, 'Notices to Mariners' produced by the AHO and radar watches, vessel collisions resulting in hydrocarbon spills are considered less likely than the untreated risk.	Unchanged: The procedures for isolating a ruptured fuel tank will reduce the potential volume of MGO released to the marine environment and the implementation of other spill procedures will reduce the potential impacts to the marine environment to ALARP. Worst case scenario of a Tier 2: 450 m^3 spill remains unchanged.	

8. Monitoring of Environmental Performance

The environmental implementation strategy outlines the approach for the environmental management of non-hydrocarbon spill related impacts associated with the Activity. Hydrocarbon spills are addressed separately in the Oil Pollution Emergency Plan (Section 9). The primary goals of the environmental implementation strategy are to direct, review and manage activities so that environmental impacts and risks are continually being reduced to as low as reasonably practicable (ALARP), and performance objectives and performance standards are met over the duration of the Activity. The implementation strategy includes:

- Details on the systems, practices and procedures to be implemented
- Key roles and responsibilities
- Training, competencies and on-going awareness
- Monitoring, auditing and management of non-conformances
- Record management
- Stakeholder consultation
- Routine and Incident Reporting.

8.1 Systems, Practices and Procedures

Table 8-1 details specific systems, practices and/or procedures (environmental operational controls) that will be followed to avoid, reduce to ALARP, or mitigate the identified environmental risks and impacts of the Activity. It provides either specific details of the requirements or provides sufficient detail to ensure that the performance objectives, performance standards and measurement criteria detailed in the EP can be achieved.

Table 8-1 Approaches to ensure implementation of environmental operational controls achieve best practice environmental protection

Approach	Best Practice
Leadership	• Activities will be undertaken in accordance with GA's Environmental Management Policy. • Senior GA and contractor managers will be accountable for environmental performance. • Vessel Master to take a leadership role in ensuring that the environmental operational controls are in place on the survey vessel.
Planning	• Incident response will be regularly tested. • All personnel will undertake the relevant environmental induction/s prior to accessing the vessel and annually thereafter. • Monitoring, inspection and audit schedules will be developed. (Section 8.4 provides further detail)
Control	• GA undertakes scheduled audit/s of the Activity including to

Approach	Best Practice
	ensure on-going compliance such as: – Opportunities for improvement and suggested remedial actions are provided. – Non-conformances are effectively acted upon and closed out. • Common environmental operational controls, detailed in this environmental plan, are used as the basis to the audit. • Audits confirm relevant Environmental Operational Controls are in place. • Audit actions are closed by the vessel contractor to the satisfaction of GA.
Review	• Any identified actions and lessons learnt will be included in the environmental management of the on-going Activity as soon as practicable and their application considered at other GA operational sites. • This provides GA with a means of continuous environmental management improvement

8.2 Key Roles and Responsibilities

A delineated chain of command that includes the responsibility and accountability for the implementation, management and review of the EP has been established. The allocation criteria used has been based on authority level and ability to release resources. The chain of command encompasses roles across GA and Gardline (the vessel contractor). The key roles for ensuring the implementation of this plan, protection of the environment and associated responsibilities are detailed in Table 8-2.

Table 8-2 Chain of command, key roles and responsibilities to ensure implementation of the EP

Role	Responsibilities
Vessel Master	• Ensures completion of daily and weekly reporting from the vessel. • Implements and ensures compliance with relevant environmental legislative requirements, EP commitments and operational procedures on the vessel. • Maintains clear communication with the crew (e.g. daily Toolbox meetings). • Communicates hazards and risks to the workforce and the importance or following good work practices. • Maintains their vessel in a state of preparedness for emergency response. • Ensures daily reports include environmental reporting requirements of this EP. • Reports environmental incidents to the GA Client Representative

Role	Responsibilities
	and ensures follow-up actions are carried out. • Applies appropriate enforcement mechanisms to prevent breaches of this EP.
Vessels Personnel and Contractors	• Adhere to commitments within this EP as required. • Report sightings of cetaceans to GA Marine Mammal Observer (MMO). • Encourage improvement wherever possible. • Report incidents and Hazard Observations to the Vessel Master. • The vessel operator will ensure that the vessel is manned with qualified engineers and officers, in accordance with Standards of Training, Certification and Watchkeeping (STCW95)

8.3 Training, Competencies and On-going Awareness

Training and competency requirements are reinforced by GA management staff to all personnel working offshore on a regular basis, such as through the environmental induction and general information sessions. Contractor personnel also participate and assist in information dissemination where appropriate, and will be involved in activity-specific inductions during pre-activity HSE meetings.

The environmental induction is mandatory for all vessel personnel, and is delivered either on the vessel or onshore prior to mobilisation. The induction includes the following:

- An overview of the EP
- Regulatory and procedural requirements
- GA's Environment Management Policy
- The vessel contractors Safety Management System (SMS)
- Environmental sensitivities of the area and
- Environmental management procedures including:
  - Housekeeping
  - Waste management
  - Incident reporting
  - Oil spill response and
  - Marine fauna observation recording.

Inducted personnel will sign a Quality Procedure (QPRO) form prior to undertaking the activity and will include an acknowledgment and understanding of the content, requirements and responsibilities of the EP. All vessel-based personnel will be issued with the vessel contractors' Safety Management System booklet which includes guidance of company policies for protection of the environment.

In addition, key onshore and offshore personnel will undertake a more detailed induction that will focus on ensuring that key personnel fully understand the 'mechanics' of the EP. The induction will include an in-depth focus on the implementation of the EP. In particular the induction will focus on:

- Activity description

- Planned and unplanned events and their associated performance objectives, performance standards and mitigation measures
- Monitoring and inspection requirements
- Auditing requirements and approach
- Incident reporting requirements and
- Key roles and responsibilities of offshore personnel.

Regular drills and exercises are carried out on the vessel in line with the IMO (e.g. SOLAS and MARPOL) requirements to refresh the crew in using response equipment and implementing incident response procedures. This is aimed at increasing emergency response efficiency and the effectiveness of procedures and to detect any failures in equipment. These drills include, but are not limited to, spill response, collision and grounding, fire and explosion and helicopter emergency.

Daily toolbox meetings serve to reinforce environmental awareness during the Activity. A toolbox meeting is attended by all personnel undertaking the task at the start of each shift. This meeting;

- Reviews the Activity
- Reinforces appropriate measures to be adopted to prevent environmental and safety incidents from occurring
- Discusses any HSE incidents from the previous shift and
- Will be minuted, attendees recorded and supplied the onboard GA Client Representative.

Crew undertaking tasks that carry a specific risk of environmental impact will be made aware of any risks through the environmental induction and any relevant legislative or procedural controls that must be adhered to reduce the risk. Examples of such tasks and their environmental risks are:

- Acoustic survey (acoustic disturbance to marine fauna)
- Lifting (dropped objects) and
- Vessel operation (fauna collision, acoustic disturbance).

8.4 Monitoring, Auditing, Management of Non-conformance and Review

The implementation strategy provides for the monitoring, audit, management of non-conformance and review of GA's environmental performance and of the implementation strategy.

8.4.1 Monitoring Environmental Performance

During the period that activities described in the EP are undertaken, GA will ensure environmental performance is managed through an inspection and monitoring programme undertaken by the GA Client Representative based on the vessel. This will include daily and weekly monitoring and is recorded via a number of checklists and inspection documents that are sent to the GA Project Manager. These detailed vessel activities whereby the monitoring items are correlated with the risks they manage, and actions for ensuring environmental performance are being managed to meet the requirements of this EP. Feedback from the ongoing monitoring also informs the development of future EPs for survey activities.

8.4.2 Auditing

GA has a scheduled audit program that includes a pre-mobilisation and mid-survey audit of the contracted vessel. The audits use common environmental operational controls as their basis (in place for the Activity). Audits, undertaken by the GA Project Manager or GA Client Representative, ensure that all Activity scenarios are considered and assessed, and that environmental performance objectives and performance standards are being implemented.

Feedback from the audit is provided to key project personnel, including survey vessel personnel and GA employees. Audit findings, any opportunities for improvement and, in some instances, corrective action requests will be communicated. Where corrective action requests are made, a formal document will be provided to relevant personnel to ensure actions are commenced immediately.

Non-conformance corrective action requests are included on an Action Register to enable the Vessel Master to address and close out any items in an agreed timeframe. The GA Project Manager monitors progress through to when items are closed out in the Action Register. The corrective action request applicable to the vessel can only be closed out when verified by the GA Client Representative/GA Project Manager.

Any non-conformances are noted and communicated immediately to the GA Client Representative/ vessel master as well as being documented in the audit report. Addressing the non-conformance assumes highest priority and every effort is made for the issue to be addressed immediately. The GA Project Manager ensures that a follow up is made with the vessel within two weeks of notifying of a non-conformance to confirm that remedial actions have been actioned and remain in place.

Additionally, as part of the vessel contractors Shipboard Safety Management Manual, safety management audits will be completed periodically to determine the effectiveness of the SMS in meeting specific standards of safety and protection of the environment, as required by the ISM Code. Audit observations will be documented and any non-conformities will be reported to the Marine Safety Superintendents.

8.5 Record management

As a minimum, GA/Gardline will store and maintain the following records for a period of five years.

8.5.1 Vessel Generated Records

- Garbage Record Book
- Ozone-Depleting Substances (ODS) Record Book
- Oil Record Book and
- Fuel Usage Log.

8.5.2 GA/Gardline Generated Records

- Daily and weekly environmental monitoring checklists
- EP, EP revisions and supporting documentation
- Reportable and recordable incident details (and investigation reports where applicable)
- Audit and inspection reports
- Stakeholder Consultation Logs.

These records will be available to the regulator upon request.

9. Oil Pollution Emergency Plan (OPEP) Response Arrangements

9.1 Overview

As part of the implementation strategy of the EP, GA has developed an Oil Pollution Emergency Plan (OPEP) unique to the Activity. The OPEP is the key control measure to be implemented in the event that a hydrocarbon release occurs in the marine environment as a result of the Activity and has been developed to be compliant with the OPGGS(E) Regulations.

GA's approach to hydrocarbon spill response in Australia is based on GA's operational experience coupled with current industry standards, such as those identified in the National Plan for Maritime Environmental Emergencies (National Plan), managed by AMSA. The following documents were also consulted for guidance in the preparation of the OPEP:

- NOPSEMA Environmental Guidance Note on oil spill contingency planning (N-04750-GN1394 Rev O 28 February 2014)
- AMSA's Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities (March 2013) and
- International Petroleum Industry Environmental Conservation Association's (IPIECA) report series on Oil Spill Preparedness and Response (1990-2008).

The OPEP was developed to address the types of hydrocarbons that may be accidently released during the Activity, namely:

- **Marine Gas Fuel Oil**: Expected to rapidly spread at sea and slicks to break up quickly and disperse. Most of the spill would evaporate in the first 24 hours and
- **Hydraulic and Lubricating Oils**: Rapidly spreading oils that tend to emulsify at sea. Small volume spills will rapidly dissipate. Response will be based on vessel SOPEP.

9.2 Incident Jurisdiction

During a hydrocarbon spill response there are Statutory and Combat agencies assigned to the release at all tiers. A summary of jurisdiction over a spill for each tier, consistent with the National Plan, is displayed in Table 9-1.

Table 9-1 Statutory, combat and support agencies specific to the Activity

Tier	Statutory Agency	Combat Agency	Support Agencies
1	NOPSEMA (Commonwealth Waters)	AMSA (Commonwealth Waters)	Not required
2	DoT (State Waters)	DoT (State Waters)	AMSA AMOSC DoT

9.2.1 Statutory Agency

- NOPSEMA will be the Statutory agency for vessel-based spills in Commonwealth Waters, including in the Operational Area of the Activity.
- The WA Department of Transport (DoT) is the Statutory Agency for vessel-based spills in WA state waters.

9.2.2 Combat Agency

The Combat Agency has operational responsibility in accordance with the relevant contingency plan to take action to respond to a hydrocarbon release into the marine environment.

According to AMSA's Marine Pollution Response Plan, which is the operational response plan for the management of ship-sourced incidents, AMSA is the designated Combat Agency for hydrocarbon released from vessels within the Commonwealth jurisdiction. For spills from vessels within WA State waters, the DoT, as the Hazard Management Authority (HMA) for the implementation of the State Emergency Plan for Marine Oil Pollution (WestPlan – MOP) will be the assigned combat agency.

In the event of a hydrocarbon release as a result of the Activity, GA will immediately implement first strike responses to reduce or eliminate further release of hydrocarbons to the environment. These actions would occur concurrently with the notification to AMSA/DoT of the spill.

9.3 Credible Spill Scenarios and Incident Response Outline

The OPEP has been prepared to be adaptable up to worst case credible spill scenarios, and contains escalation and de-escalation procedures to adapt responses accordingly. GA will use a tiered approach structure, outlined in Table 9-2, to categorise a hydrocarbon spill volume and incident complexity, which in turn assists in informing the appropriate level of response. The OPEP has been developed primarily to manage and mitigate Tier 2 hydrocarbon releases. Tier 1 hydrocarbon releases, owing to their small volume and complexity can generally be managed onsite using the vessel's SOPEP; however some response procedures within the OPEP may still be applicable. A valid vessel SOPEP is in place and is available on request.

GA's specific approach to hydrocarbon spill response is summarised by the following steps:

1. Manage the safety of personnel on the vessel and in the operational area
2. Vessel master (On-scene Commander) is notified of the hydrocarbon incident
3. Gain current situational awareness
4. First Strike Responses are activated
   - If a Tier 1 incident- SOPEP is implemented by On-scene Commander and an Incident Management Team is formed
   - If a Tier 2 incident- OPEP is implemented and Emergency Response Team, and Emergency Management Team is formed
5. Alert all response support agencies (if applicable) and notify regulatory authorities
6. Incident Action Planning is initiated.

This process aims to develop an Incident Action Plan (IAP) to meet set response objectives that are developed on an ongoing basis. The IAP is comprised of a combination of response strategies selected from a pool pre-selected by GA and based on credible hydrocarbon release scenarios and proximal environmental sensitivities for the Activity. As constant on-going situational assessment is undertaken on-site (e.g. metocean conditions or hydrocarbon spill surveillance), response objectives and IAPs are updated.

Table 9-2 Worst-case credible hydrocarbon spills for the Activity and associated tier level

Worst- case Credible Spill Scenarios	Hydrocarbon Spill Tier
Small spill of stored hydrocarbons (<160 L)	Tier 1 (<10 m^3) • Will not have a direct adverse effect on the public • Will have an adverse effect on the environment and • Can be controlled via the application of local or initial resources available on the vessel concerned.
Hydrocarbon spill from ruptured fuel tank through collision or grounding (450 m^3)	Tier 2 (10 – 1,000 m^3) • Will have a direct adverse effect on the public or the environment and • May require additional support beyond the application of local or initial resources which may involve state or national resources.

9.4 Incident Management

9.4.1 Response Overview

Tier 1 Spills

These spills are the lowest tier and demand the lowest response effort. It is considered that onsite response equipment and personnel are sufficient to mitigate these spills and that the process is manageable under the relevant vessel Shipboard Oil Pollution Emergency Plan (SOPEP) rather than needing to implement the OPEP; the OPEP directs responders towards the use of the relevant SOPEP as the primary management plan (shown in the procedure in Figure 9-1). Spills that require this tier of response may arise from blown hydraulic hoses, dropped or leaking drums of fuel or lubricant or minor refuelling accidents where less than approximately 10 m^3 are lost to the environment.

Tier 2 Spills

The OPEP has been designed to manage tiers in these categories, where required responses are outside the capabilities of onsite resources. An overview of GA's response strategy to these spills is presented in Figure 9-1.

The response strategy for all tier 2 spills follows the same initial set of immediate actions that need to be undertaken. This includes actions to control the source of the spill as a priority, monitor the spill, mobilise first strike response resources and to notify key regulatory other necessary stakeholders. Following these immediate steps, a response plan is developed, tailored to the requirements of the spill, following the Incident Action Plan development process, as outlined in the EP.

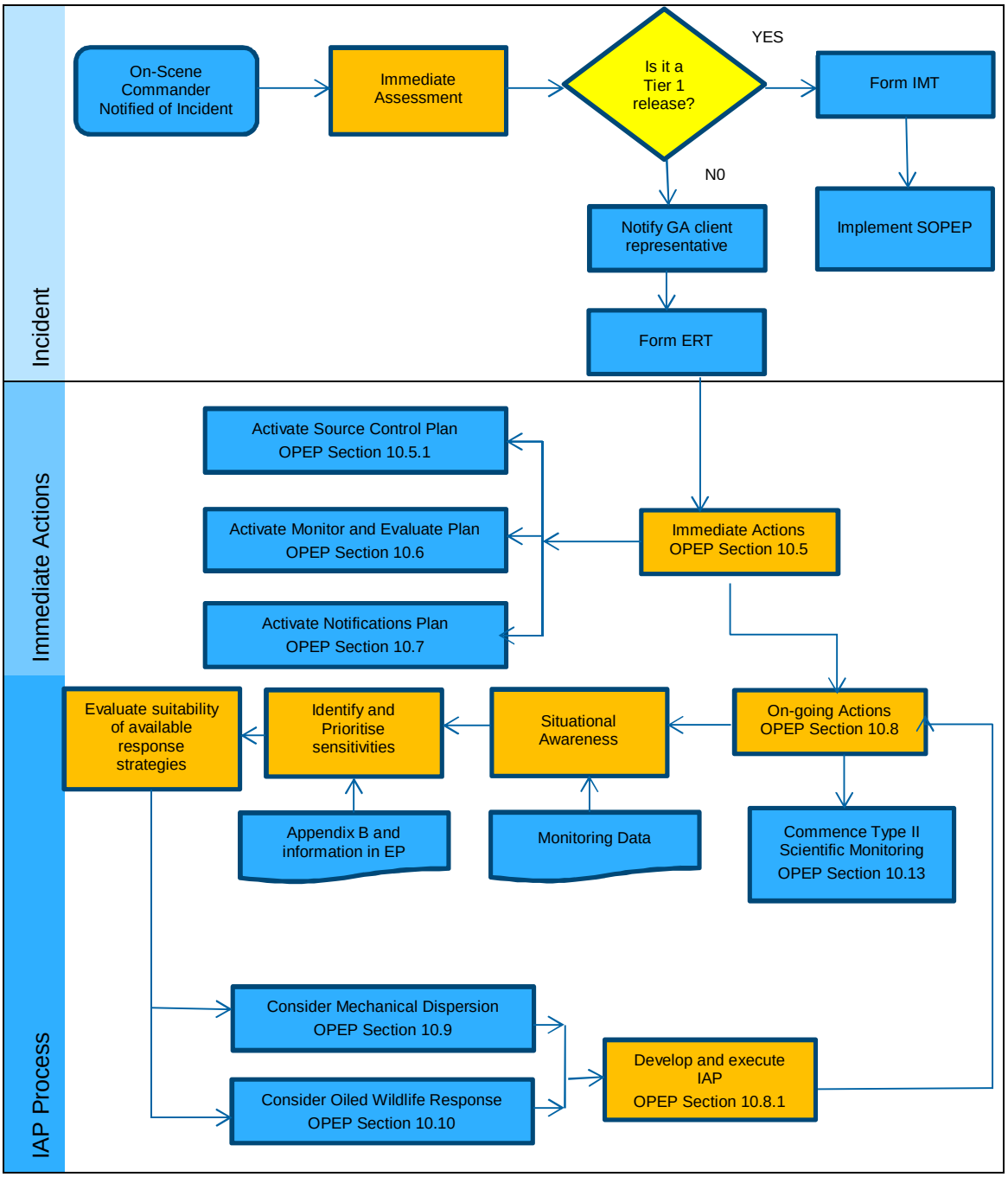


Figure 9-1 GA response strategy overview

9.4.2 Initial Internal Notification Process

All on-board vessel personnel will have received an environmental induction that includes nomination of specific roles and responsibilities in the event of an incident. The vessel master will be notified initially who will then notify the on-board **GA client representative**. The **GA client representative** is responsible for advising the **GA Project Manager** of the incident (Figure 9-3**).**

9.4.3 Situational Awareness

Once notified, a rapid initial assessment of the situation is undertaken by the **Vessel Master** from the vessel to determine the Tier of the spill, including:

1. The source of the release
2. If the source under control
3. The type of hydrocarbon has been released
4. The volume of hydrocarbons released
5. Position of any surface hydrocarbons
6. Description of surface hydrocarbons (colour, area etc.)
7. Direction of surface slick movement and
8. Metocean conditions.

After immediate data acquisition, the **GA client representative** immediately notifies **GA Project Manager** as outlined in Figure 9-2.

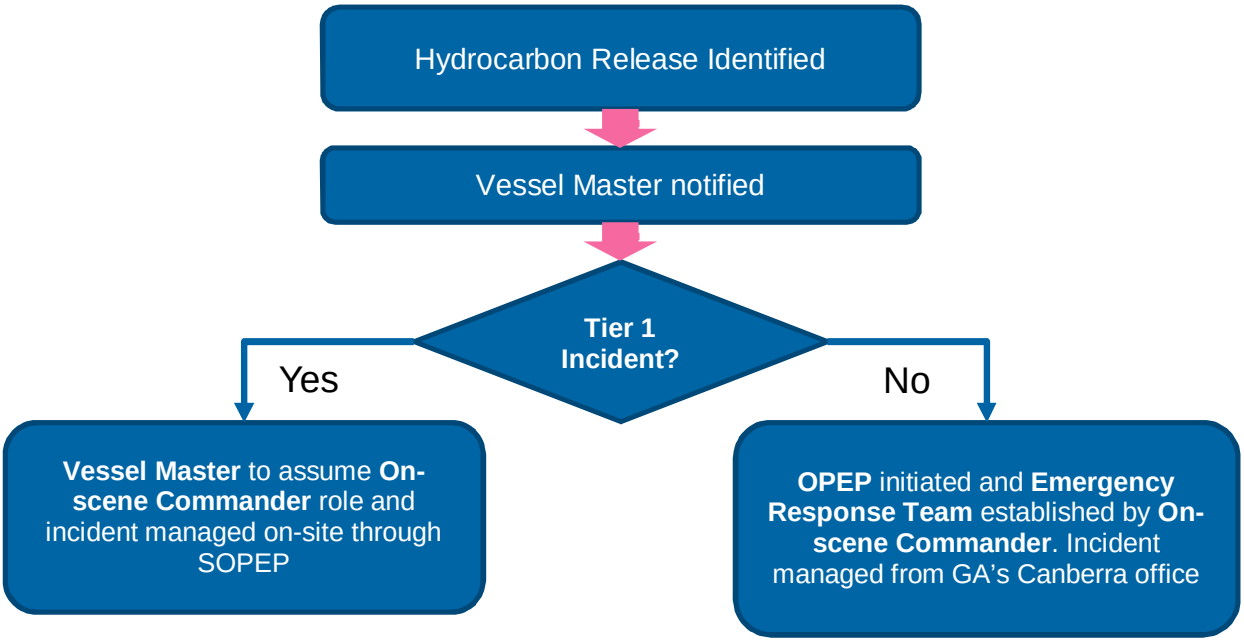


Figure 9-2 Notification process

Responsibility for Tier 1 spills will be assigned to the **Vessel Master**, who will manage the release in accordance with the vessel SOPEP. For Tier 2 releases, the **Vessel Master** will lead the OPEP response.

9.4.4 GA Response Structure to an Incident

GA's response structure reflects the Australian Interagency Incident Management System (AIIMS) and consists of key roles required to effectively coordinate and execute a response under emergency conditions, including logistical, environmental and human resourcing roles and higher levels roles for management of areas such as media and government relations (if required).

GA's response structure for a Tier 2 incident includes:

- A vessel-based **Incident Management Team (IMT)** who is responsible for initiating the Incident Action Plan and emergency procedures as detailed in the OPEP.
- A shore-based **Emergency Response Team (ERT)** whose primary duty is to ensure that the Vessel Master is fully supported, and to engage with regulatory authorities and relevant resources as detailed in the OPEP. This may include logistics support and telecommunications, safety, planning, finance, insurance, and legal support.
- A Canberra-based **Emergency Management Team (EMT)** monitors the incident and provides support and action (as required) to AMSA, the **ERT** and the **Vessel Master**. The EMT also provides updates to affected stakeholders (as necessary). This team will be utilised as required.

GA's response structure for a Tier 1 incident includes:

- A vessel-based **Incident Management Team (IMT)** who is responsible for initiating the Incident Action Plan and emergency procedures as detailed in the vessel's SOPEP.

The overall organisational structure of GA's incident response is shown in Figure 9-3. The specific procedures for forming the response teams, including contact details, are located in the OPEP.

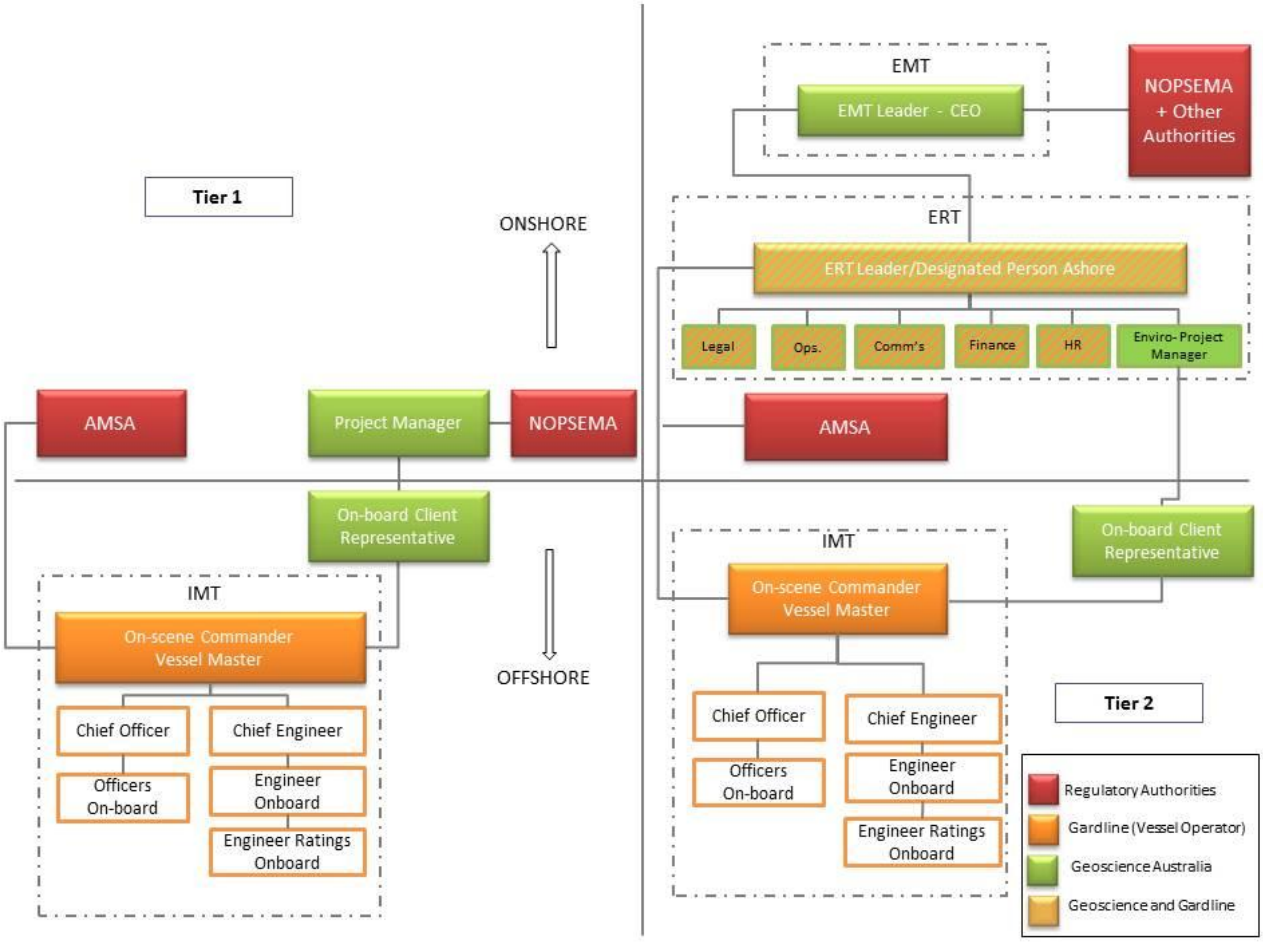


Figure 9-3 GA's emergency response structure

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